GUIDE

TO

THE STUDY OF INSECTS,

AND A TREATISE ON THOSE

INJURIOUS AND BENEFICIAL TO CROPS:

FOR THE USE OF

COLLEGES, FARM-SCHOOLS, AND AGRICULTURISTS.

BY

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WITH ELEVEN PLATES AND SIX HUNDRED AND FIFTY WOOD-CUTS.

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PREFACE.

THIS introduction to the study of insects is designed to teach the beginner the elements of entomology, and to serve as a guide to the more elaborate treatises and memoirs which the advanced student may wish to consult. Should the book, imperfect as the author feels it to be, prove of some service in inducing others to study this most interesting and useful branch of natural history, the object of the writer will have been fully attained.

In order to make it of value to farmers and gardeners, whose needs the writer has kept in view, and that it may be used as a text book in our agricultural colleges, concise accounts have been given of insects injurious or beneficial to vegetation, or those in any way affecting human interests.

When the localities of the insects are not precisely given, it is to be understood that they occur in the Eastern Atlantic States from Maine to Pennsylvania, and the more northern of the Western States. When the family names occur in the text they are put in spaced Italics, to distinguish them from the generic and specific names which are Italicized in the usual way.

The succession of the suborders of the hexapodous insects is that proposed by the author in 1863, and the attention of zoölogists is called to their division into two series of suborders, which are characterized on page 104. To the first and highest may be applied Leach's term METABOLIA, as they all agree in having a perfect metamorphosis; for the second and lower series the term HETEROMETABOLIA is proposed, as the four suborders comprised in it differ in the degrees of completeness of their metamorphoses, and are all linked together by the structural features enumerated on page 104.

The classification of the Hymenoptera is original with the author, the bees (Apidæ) being placed highest, and the sawflies and Uroceridæ lowest. The succession of the families of the Lepidoptera is that now generally agreed upon by entomologists. Loew's classification of the Diptera, published in the "Miscellaneous Collections" of the Smithsonian Institution, has been followed, with some modifications. Haliday's suggestion that the Pulicidæ are allied to the Mycetophilidæ gives a clue to their position in nature among the higher Diptera. Leconte's classification of the Coleoptera is adopted as far as published by him, *i.e.*, to the Bruchidæ. For the succeeding families the arrangement of Gerstaecker in Peters and Carus' "Handbuch der Zoologie" has been followed, both being based on that of Lacordaire. The Hemiptera are arranged according to the author's views of the succession of the families. The classification of the Orthoptera is that proposed by Mr. S. H. Scudder. This succession of families is the reverse of what has been given by recent authors, and is by far the most satisfactory yet presented. The arrangement of the Neuroptera (in the Linnæan sense) is that of Dr. Hagen, published in his "Synopsis," with the addition, however, of the Lepismatidæ, Campodeæ and Poduridæ.

The usual classification of the Arachnida is modified by placing the Phalangidæ as a family among the Pedipalpi, and the succession of families of this suborder is suggested as being a more natural one than has been previously given.

The arrangement of the Araneina, imperfect as authors have left it, is that adopted by Gerstaecker in Peters and

Carus' "Handbuch der Zoologie." In the succession of the families of the Acarina, the suggestions of Claparède, in his "Studien der Acariden," have been followed, and in the preparation of the general account of the Arachnids the writer is greatly indebted to Claparède's elaborate work on the "Evolution of Spiders."

In the preparation of this "Guide" the author has consulted and freely used Westwood's invaluable "Introduction to the Modern Classification of Insects;" Gerstaecker's "Arthropoden" in Peters and Carus' "Handbuch der Zoologie;" Siebold's "Anatomy of the Invertebrates" (Burnett's translation, 1854); Newport's Article "Insecta" in Todd's Cyclopædia of Anatomy and Physiology; and Dr. T. W. Harris' "Treatise on Insects injurious to Vegetation." He would also acknowledge his indebtedness to Professor L. Agassiz for many of the general ideas, acquired while the author was a student in the Museum of Comparative Zoology at Cambridge, regarding the arrangement of the orders and classes, and the morphology of the Articulates.

For kind assistance rendered in preparing this book, the author is specially indebted to Baron R. von Osten Sacken, who kindly read the proof sheets of the chapter on Diptera; to Mr. F. G. Sanborn for the communication of many specimens and facts; and also to Messrs. Edward Norton, S. H. Scudder, J. H. Emerton, C. T. Robinson, A. R. Grote, G. D. Smith, E. T. Cresson, P. R. Uhler, C. V. Riley, Dr. J. L. Leconte, Dr. Hagen, W. C. Fish, and E. S. Morse. For much kind assistance and very many favors and suggestions, and constant sympathy and encouragement during the printing of the work, he is under special obligation to his valued friend, Mr. F. W. Putnam. The types of the new species noticed here are deposited in the Museum of the Peabody Academy of Science. He would also express his thanks to the American Entomological Society, the Society of Natural History at Boston, the Secretary of the Massachusetts Board of Agriculture, the Essex Institute, the Smithsonian Institution, the Secretary of the Maine Board of Agriculture, and to Mr. R. Hardwicke, the publisher of "Science-Gossip," Prof. Sanborn Tenney, the author of "A Manual of Zoölogy," and to his coeditors of the "American Naturalist," for the use of many of the cuts, a list of which may be found on the succeeding pages.

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FIGS. 3, 4, 6, 7, 8, 33, 34, 35, 38, 39, 40, 84, 86, 87, 91, 93–106, 124, 126, 130, 131, 132, 142, 144, 146, 151, 180, 191–196, 201, 202, 204, 205, 206, 207, 208*b*, 209, 212, 213, 215, 219, 220, 221, 224, 225, 226, 246, 256–260, 267, 320, 321, 332, 333, 379, 404, 408, 409, 421, 422, 442, 455, 480, 481, 484, 485, 487, 493, 500, 501, 502, 509, 513, 518, 519, 521, 531, 534, 535, 552, 561, 562, 576, 579, 593, 601 and 651, were borrowed from the American Entomological Society, at Philadelphia.

FIGS. 2, 14, 15–24, 27, 48, 63–67, 69, 181, 216, 217, 222, 230, 231, 233–235, 247, 369, 389, 420, 424, 427, 435, 436, 438, 497, 508, 578, 630 and 631 were loaned by the Boston Society of Natural History.

FIGS. 25, 36, 37, 55, 83, 128, 136, 237, 242, 269, 350, 352–357, 362, 368, 372, 373, 380, 511, 512, 514, 542, 543, 544, 545, 546, 556, 585–587, 589, 590, 591, 594, 602, 603, 604 and 605, were borrowed from the report of the Massachusetts State Board of Agriculture for 1862.

FIGS. 155–165, 169–179, 270, 271, 285–296, 300, 303–306, 345–348, 358, 359, 632, 633 and 634, were loaned by the Smithsonian Institution.

FIGS. 1, 5, 8, 10, 30, 31, 32, 51, 52, 57, 58, 62, 64, 68, 72, 79, 80, 81, 82, 85, 89, 92, 110–121, 127, 185, 186, 227, 228, 239, 248, 250, 252, 262, 263, 273, 278, 298, 307–314, 317–319, 322, 324–327, 329–331, 334–343, 361, 363*a*, 375, 387, 412, 413, 425, 426, 428, 430, 432, 433, 437, 439, 447–451, 456–458, 463, 464, 474, 475, 504, 516, 576, 577, 580–584, 588, 592, 608, 613, 615, 627, 636, 637, 638, 639, 641, 642, 646–649, were taken from the "American Naturalist."

FIGS. 41, 70, 71, 88, 129, 138, 143, 152, 200, 232, 249, 253, 255, 349, 492, 554, 618, and 645 were borrowed from the "Report of the Maine Board of Agriculture for 1862."

FIGS. 73–78, were kindly loaned by Prof. Jeffries Wyman.

FIGS. 570, 571, 574, 575, 617 and 635, were loaned by the Illinois Geological Survey.

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Electrotypes of Figs. 119, 261, 281, 281c–284, 328, 344, 351, 360, 363, 367, 374, 376, 414, 429, 434, 452–454, 466, 468–471, 477, 479, 494, 506^1, 506^2, 510, 522–526, 530, 532, 533, 536–541, 547–551, 564, 568, 595–598, were purchased of the publishers of the "American Entomologist."

The following figures were engraved expressly for the work, viz: Figs. 11, 12, 13, 26, 28, 29, 42, 43–47, 49, 50, 53, 54, 56, 59–61, 80, 107–

109, 122, 123, 125, 133–135, 137, 139–141, 145, 148–151, 166–168, 182–184, 187, 188, 197, 203, 208, 210, 211, 214, 218, 223, 236, 243, 244, 254, 264–266, 272, 280, 297, 299, 301, 302, 308, 310, 364–366, 370, 371, 377, 378, 381–386, 388, 390–397, 399-403, 405–407, 410, 411, 415–419, 423, 431, 440, 441, 443–446, 459–462, 465, 467, 472, 473, 476, 478, 482, 483, 485*a*, *b*, 488, 489, 490, 491, 495, 496, 498, 499, 503, 505, 507, 515, 520, 527–529, 555, 558–560, 565, 572, 599, 600, 612, 614, 619, 623–626, 643, 644 and 650. Of these, 119 were drawn from nature, mostly by Mr. J. H. Emerton, and a few by Messrs. C. A. Walker and L. Trouvelot. These are numbered: 11, 12, 13-20, 26, 28, 29, 42, 51, 52, 57–63, 64–67, 79–82, 90, 107–109, 122, 123, 125, 133, 137, 139, 141, 145, 148, 149–151, 166, 167, 168, 182–184, 187, 188, 197, 203, 208 *a*, *b*, 210 *a*, 211, 214, 218, 236, 254, 265, 266, 299, 301, 308, 316, 364–366, 378, 383, 384, 386, 392, 393, 396, 397, 400, 402, 403, 405, 413, 415, 419, 423, 431, 443, 441, 443–446, 465, 473, 476, 482 *a*, 483, 485 *a*, *b*, 489, 490, 491, 496, 498, 499, 503, 505, 507, 515, 520, 555, 560, 565, 599, 600, 612, 614, 619.

Of the remainder, Figs. 134, 459–462, 495, 506, were copied from Harris; 43, 45, from Leidy; 46, 47, 49, 50, from Straus-Durckheim; 44, 53, 54 and 650, from Newport; 135, 140, from Fitch; 223, 243, 244, 528, 529, from Glover; 264, 467, from Curtis; 623–626, from Claparède; 643, 644, from Doyère; 56 from Gerstaecker; 297, from Mecznikow; 302, from Brauer; 417, 418, from Leprieur; 527, 558 559, from Guérin-Méneville; 572 from Dohrn; 394, from Blisson; 388, from Candéze; 377, 381, 382, 385, 390, 391, 395, 399, 401, 406, 407, 410, 472 and 488, from Chapuis and Candéze.

Plates 1, 2, 3, 4, 6, 7, 9, 10 and 11, were taken from the "American Naturalist." Plates 5 and 8, are original, and drawn from nature by Mr. J. H. Emerton.

Explanation of Plate 8.

Fig. 1. Empretia stimulea; 1 *a*, larva.
Fig. 2. Leucania unipuncta; 2 *a*, larva.
Fig. 3. Xanthoptera semicrocea; 3 *a*, larva.
Fig. 4. Catocala ultronia; 4 *a*, larva.
Fig. 5. Angerona crocataria, male; 5 *a*, larva.
Fig. 6. Ennomos subsignaria; larva.
Fig. 7. Nematocampa filamentaria; 7 *a*, larva (enlarged twice).
Fig. 8. Abraxas ribearia, male.
Fig. 9. Anisopteryx vernata, male; 9 *a*, female (enlarged), 9 *b*, larva.
Fig. 10. Cidaria diversilineata; 10 *a*, larva.
Fig. 11. Galleria cereana.
Fig. 12. Lozotænia rosaceana; 12 *a*, larva.
Fig. 13. Penthina pruniana.
Fig. 14. Depressaria robiniella. [its mine.
Fig. 15. Lithocolletis geminatella; *a*, larva; *b*, pupa (enlarged three times), 15 *c*,
Fig. 16. Bucculatrix pomifoliella.
Fig. 17. Coleophora; larva.
Fig. 18. Lyonetia saccatella; 18 *a*, larva; 18 *b*, case (enlarged).
Fig. 19. Lithocolletis nidificansella (enlarged); 19 *a*, cocoon.
Fig. 20. Aglossa cuprealis.
Fig. 21. Anchylopera vacciniana.
Fig. 22. Penthina vitivorana (enlarged).
Fig. 23. Pterophorus periscelidactylus; *a*, larva; *b*, pupa (enlarged three times).

GUIDE TO THE STUDY OF INSECTS.

THE CLASS OF INSECTS.

THAT branch of the Animal Kingdom known as the ARTICULATA, is so called from having the body composed of rings or segments, like short cylinders, which are placed successively one behind the other. Cuvier selected this term because he saw that the plan of their entire organization, the essential features which separate them from all other animals, lay in the idea of articulation, the apparent joining together of distinct segments along the line of the body. If we observe carefully the body of a Worm, we shall see that it consists of a long cylindrical sac, which at regular intervals is folded in upon itself, thus giving a ringed (annulated, or articulated) appearance to the body. In Crustaceans (crabs, lobsters, etc.) and in Insects, from the deposition of a peculiar chemical substance called *chitine*, the walls of the body become so hardened, that when the animal is dead and dry, it readily breaks into numerous very perfect rings.


Fig. 1.

Though this branch contains a far greater number of species than any other of the animal kingdom, its myriad forms can all be reduced to a simple, ideal, typical figure; that of a long slender cylinder divided into numerous segments, as in Fig. 1, representing the larva of a Fly. It is by the unequal development and the various modes of grouping them, as well as the differences in the number of the rings themselves, and also in the changes of form of their appendages, *i.e.* the feet, jaws, antennæ, and wings, that the various forms of Articulates are produced.

FIG. 1. Worm-like larva of a Fly, *Scenopinus.* — *Original.*

Articulated animals are also very distinctly *bilateral*, *i.e.* the body is symmetrically divided into two lateral halves, and not only the trunk but the limbs also show this *bilateral symmetry*. In a less marked degree there is also an *antero-posterior symmetry*, *i.e.* each end of the body is opposed, just as each side of the body is, to the other.* The line separating the two ends is, however, imaginary and vague. The antennæ, on the anterior pole, or head, are represented by the caudal, or anal, stylets (Fig. 2), and the single parts on the median line of the body correspond. Thus the labrum and clypeus are represented by the tergite of the eleventh segment of the abdomen.

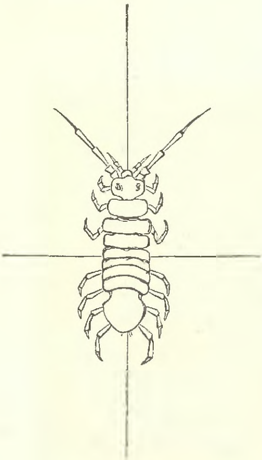


Fig. 2.*

In all Articulates (Fig. 3) the long, tubular, alimentary canal occupies the centre of the body; above it lies the "heart," or dorsal vessel, and below, upon the under side, rests the nervous system. The breathing apparatus, or "lungs," in Worms consists of simple filaments, placed on the front of the head; or of gill-like processes, as in the Crustaceans, which are formed by membranous expansions of the legs; or, as in the Insects (Fig. 4), of delicate tubes (tracheæ), which

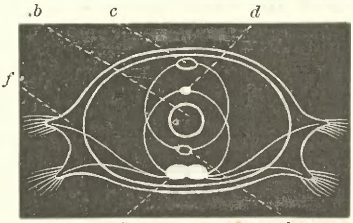


Fig. 3.

* Professor Wyman (On Symmetry and Homology in Limbs, Proceedings of the Boston Society of Natural History, 1867) has shown that antero-posterior symmetry is very marked in Articulates. In the adjoining figure of *Jæra* (Fig. 2) the longitudinal lines illustrate what is meant by bilateral symmetry, and the transverse lines "fore and aft" symmetry. The two antero-posterior halves of the body are very symmetrical in the Crustacean genera *Jæra*, *Oniscus*, *Porcellio*, and other Crustacea, and also among the Myriapods, *Scutigera*, *Polydesmus*, "in which the limbs are repeated oppositely, though with different degrees of inequality, from the centre of the body backwards and forwards." "Leuckart and Van Beneden have shown that Mysis has an ear in the last segment, and Schmidt has described an eye in the same part in a worm, *Amphicora*."—*From Wyman.*

FIG. 3 represents an ideal section of a Worm. *f* indicates the skin, or muscular body-wall, which on each side is produced into one or more fleshy tubercles, usually tipped with bristles or hairs, which serve as organs of locomotion, and ramify throughout the whole interior of the animal, and connect with breathing pores (stigmata) in the sides of the body. They do not breathe through the mouth as do the higher animals. The tracheæ and blood-vessels follow closely the same

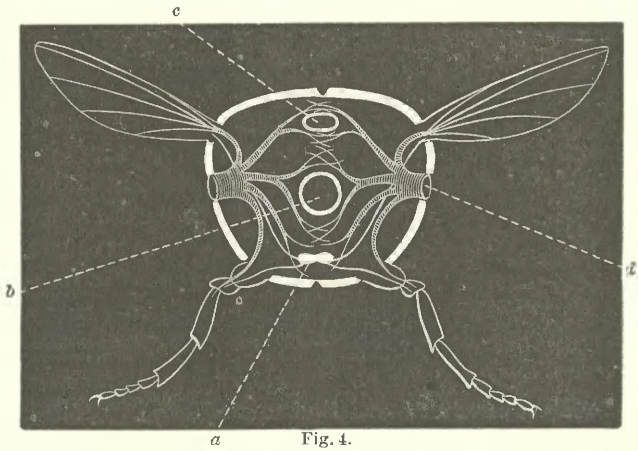


Fig. 4.

course, so that the aëration of the blood goes on, apparently, over the whole interior of the body, not being confined to a single region, as in the lungs of the vertebrate animals.

Thus it is by observing the general form of the body-walls, and the situation of the different anatomical systems, both in relation to themselves and the walls of the body, or crust, which surrounds and protects the more delicate organs within, that we are able to find satisfactory characters for isolating, in our definitions, the articulates from all other animals.

We shall perceive more clearly the differences between the three classes of Articulates, or jointed animals, namely, the WORMS, CRUSTACEANS, and INSECTS, by examining

often as lungs. The nervous cord (*a*) rests on the floor of the cylinder, sending a filament into the oar-like feet (*f*), and also around the intestine or stomach (*b*), to a supplementary cord (*d*), which is situated just over the intestine, and under the heart or dorsal vessel (*c*). The circle *c* and *e* is a diagram of the circulatory system; *c* is the dorsal vessel, or heart, from the side of which, in each ring, a small vessel is sent downwards and around to *e*, the ventral vessel. — *Original.*

FIG. 4. An ideal section of a Bee. Here the crust is dense and thick, to which strong muscles are attached. On the upper side of the ring the wings grow out, while the legs are inserted near the under side. The tracheæ (*d*) enter through the *stigma*, or breathing pore, situated just under the wing, and their branches subdivide and are distributed to the wings, with their five principal veins as indicated

their young stages, from the time of their exclusion from the egg, until they pass into mature life. A more careful study of this period than we are now able to enter upon would show us how much alike the young of all articulates are at first, and how soon they begin to differ, and assume the shape characteristic of their class.

Most Worms, after leaving the egg, are at first like some infusoria, being little sac-like animalcules, often ciliated over nearly the entire surface of the infinitesimal body.

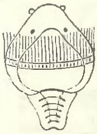


Fig. 5.

Soon this sac-like body grows longer, and contracts at intervals; the intervening parts become unequally enlarged, some segments, or rings, formed by the contraction of the body-walls, greatly exceeding in size those next to them; and it thus assumes the appearance of being more or less equally ringed, as in the young *Terebella* (Fig. 5), where the ciliæ are restricted to a single circle surrounding the body. Gradually (Fig. 6) the ciliæ disappear and regular locomotive organs, consisting of minute paddles, grow out from each side; feelers (antennæ), jaws, and eyes (simple rudimentary eyes) appear on the few front rings of the body, which are grouped by themselves into a sort of head, though it is difficult, in a large proportion of the lower worms, for unskilled observers to distinguish the head from the tail.

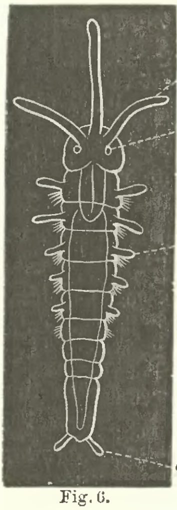


Fig. 6.

Thus we see throughout the growth of the worm, no attempt at subdividing the body into regions, each endowed with its peculiar functions; but only a more perfect system of rings, each relatively very equally developed,

in the figure, also to the dorsal vessel (*c*), the intestine (*b*), and the nervous cord (*a*). The tracheæ and a nervous filament are also sent into the legs and to the wings. The tracheæ are also distributed to the dorsal vessel and intestine by numerous branches which serve to hold them in place.— *Original.*

FIG. 5. Young *Terebella*, soon after leaving the egg.— *From A. Agassiz.*

FIG. 6 represents the embryo of a worm (*Autolytus cornutus*) at a later stage of growth. *a* is the middle tentacle of the head; *e*, one of the posterior tentacles; *b*, the two eye-spots at the base of the hinder pair of feelers; *c* is one of a row of oar-like organs (*cirri*) at the base of which are inserted the locomotive bristles, but all becoming respectively more complicated. For example, in the Earth-worm (*Lumbricus*), each ring is distinguishable into an upper and under side, and in addition to these a well-marked side-area, to which, as for example in marine worms (e. g. *Nereis*), oar-like organs are attached. In most worms eye-spots appear on the front rings, and slender tentacles grow out, and a pair of nerve-knots (ganglia) are apportioned to each ring.

In the Crustaceans, such as the fresh-water Crawfish (*Astacus*), as shown by the German naturalist Rathke; and also in the earliest stages of the Insect, the body *at once* assumes a worm-like form, thus beginning its embryonic life from the goal reached by the adult worm.

The young of all Crustaceans (Fig. 7) first begin life in the egg as oblong flattened worm-like bodies, each end of the body being alike. The young of the lower Crustaceans, such as the Barnacles, and some marine forms like the *Jæra* and some lowly organized parasitic species inhabiting the gills of fishes, are hatched as microscopic embryos which would readily be mistaken for young mites (*Acarina*). In the higher Crustaceans, such as the fresh-water Crawfish, the young, when hatched, does not greatly differ from the parent, as it has passed through the worm-like stage within the egg.

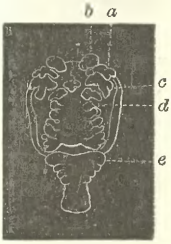


Fig. 7.

Fig. 7 represents the young of the fresh-water Lobster (Crawfish) before leaving the egg. The body is divided into rings, ending in lobes on the sides, which are the rudiments of the limbs. *b* is the rudiment of the eye-stalk, at the end of which is the eye; *a* is the fore antennæ; *c* is the hind antennæ; *d* is one of the maxilla-feet; *e* is the first pair of true feet destined in the adult to form the large "claw." Thus the eye-stalks, antennæ, claws, and legs are moulded upon a common form, and at first are scarcely distin-

with the cirri serving as swimming and locomotive organs; *d*, the caudal styles, or tail-feelers. In this figure we see how slight are the differences between the feelers of the head, the oar-like swimming organs, and the caudal filaments; we can easily see that they are but modifications of a common form, and all arise from the common limb-bearing region of the body. The alimentary canal, with the proventriculus, or anterior division of the stomach, occupies the middle of the body; while the mouth opens on the under side of the head.—*From A. Agassiz.*

FIG. 7. Embryo of the Crawfish.—*From Rathke.*

guishable from each other. Here we see the embryo divided into a head-thorax and a tail.

It is the same with Insects. Within the egg at the dawn of life they are flattened oblong bodies curved upon the yolk-mass. Before hatching they become more cylindrical, the limbs bud out on the sides of the rings, the head is clearly demarked, and the young caterpillar soon steps forth from the egg-shell ready armed and equipped for its riotous life.

As will be seen in Fig. 8, the legs, jaws, and antennæ are first started as buds from the side of the rings, being simply elongations of the body-wall, which bud out, become larger, and finally jointed, until the buds arising from the thorax or abdomen become legs, those from the base of the head become jaws, while the antennæ and palpi sprout out from the front rings of the head. Thus while the bodies of all articulates are built up from a common embryonic form, their appendages, which are so diverse, when we compare a Lobster's claw with an Insect's antenna, or a Spider's spinneret with the hinder limbs of a Centipede, are yet but modifications of a common form, adapted for the different uses to which they are put by these animals.

Fig. 8.

FIG. 8. A Caddis, or Case-fly (*Mystacides*) in the egg, with part of the yolk (x) not yet inclosed within the body-walls. a, antennæ; between a and b the mandibles; b, maxilla; c, labium; d, the separate eye-spots (ocelli), which afterwards increase greatly in number and unite to form the compound eye. The "neck" or junction of the head with the thorax is seen at the front part of the yolk-mass; e, the three pairs of legs, which are folded once on themselves; f, the pair of anal legs attached to the tenth ring of the abdomen, as seen in caterpillars, which form long antenna-like filaments in the Cockroach and May-fly, etc. The rings of the body are but partially formed; they are cylindrical, giving the body a worm-like form. Here, as in the other two figures, though not so distinctly seen, the antennæ, jaws, and last pair of abdominal legs are modifications of but a single form, and grow out from the side of the body. The head-appendages are directed forwards, as they are to be adapted for sensory and feeding purposes; the legs are directed downwards, since they are to support the insect while walking. It appears that the two ends of the body are perfected before the middle, and the under side before the upper, as we see the yolk-mass is not yet inclosed and the rings not yet formed above. Thus all articulates differ from all vertebrates in having the yolk-mass situated on the back, instead of on the belly, as in the chick, dog, or human embryo.—*From Zaddach.*

The Worm is long and slender, composed of an irregular number of rings, all of very even size. Thus, while the *size* of the rings is fixed, their *number* is indeterminate, varying from twenty to two hundred or more. The outline of the body is a *single* cylindrical figure. The organs of locomotion are fleshy filaments and hairs (Fig. 2, *f*) appended to the sides.

In one of the low intestinal worms, the Tape-worm (*Tænia*), each ring, behind the head and "neck," is provided with organs of reproduction, so that when the body becomes broken up into its constituent elements, or rings (as often occurs naturally in these low forms for the more ready propagation of the species, since the young are exposed to many dangers while living in the intestines of animals), they become living independent beings which "move freely and somewhat quickly like Leaches," and until their real nature was known they were thought to be worms. This and other facts prove, that, in the Worm, the vitality of the animal is very equally distributed to each ring. If we cut off the head or tail of some of the low worms, such as the Flat Worms (*Planaria*, etc.), the pieces will become a distinct animal, but an Insect or Crab sooner or later dies when deprived of its head or tail (abdomen).

Thus, in the Worm the vital force is very equally distributed to each zoölogical element, or ring of the body; no single part of the body is much honored above the rest, so as to subordinate and hold the other parts in subservience to its peculiar and higher ends in the animal economy.

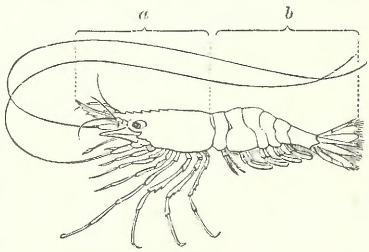


Fig. 9.

The Crustacean, of which the Shrimp (Fig. 9) is a typical example, is composed of a determinate number (21) of rings which are gathered into two regions; the head-thorax (cephalothorax) and hind-body, or abdomen. In this class there is a broad distinction between the anterior and posterior ends of the body. The rings are now grouped into two regions, and the hinder division is subordinate in its structure and

FIG. 9. A Shrimp. *Pandalus annulicornis*. *a*, cephalothorax; *b*, abdomen.

uses to the forward portion of the body. Hence the nervous power is transferred in some degree towards the head; the cephalothorax containing the nervous centres from which nerves are distributed to the abdomen. Nearly all the organs performing the functions of locomotion and sensation reside in the front region; while the vegetative functions, or those concerned in the reproduction and nourishment of the animal, are mostly carried on in the hinder region of the body (the abdomen).

The typical Crustacean cannot be said to have a true head, in distinction from a thorax bearing the organs of locomotion, but rather a group of rings, to which are appended the organs of sensation and locomotion. Hence we find the appendages of this region gradually changing from antennæ and jaws to foot-jaws, or limbs capable of eating and also of locomotion; they shade into each other as seen in Fig. 9. Sometimes the jaws become remarkably like claws; or the legs resemble jaws at the base, but towards their tips become claw-like; gill-like bodies are sometimes attached to the foot-jaws, and thus, as stated by Professor J. D. Dana in the introduction to his great work on the Crustacea of the United States Exploring Expedition, the typical Crustaceans do not have a distinct head, but rather a "head-thorax" (cephalothorax).

When we rise a third and last step into the world of Insects, we see a completion and final development of the articulate plan which has been but obscurely hinted at in the two lowest classes, the Worms and Crustaceans. Here we first meet with a true head, separate in its structure and functions from the thorax, which, in its turn, is clearly distinguishable from the third region of the body, the abdomen, or hind-body. These three regions, as seen in the Wasp (Fig. 10), are each provided with three distinct sets of organs, each having distinct functions, though all are governed by and minister to the brain force, now in a great measure gathered up from the posterior rings of the body, and in a more concentrated form (the brain being larger than in the lower articulates) lodged in the head.

Fig. 10.

Here, then, is a centralization of parts headwards; they are

FIG. 10. *Philanthus ventilabris* Fabr. A Wood-wasp.—*From Say.*

brought as if towards a focus, and that focus the head, which is the meaning of the term "cephalization," proposed by Professor Dana.* *Ring* distinctions have given way to *regional* distinctions. The former characterize the Worm, the latter the Insect. In other words, the division of the body into three parts, or regions, is in the insect, on the whole, better marked than the division of any one of those parts, except the abdomen, into rings.

COMPOSITION OF THE INSECT-CRUST. Before describing the composition of the body-wall, or crust, of the Insect, let us briefly review the mode in which the same parts are formed in the lower classes, the Worms and Crustaceans. We have seen that the typical ring, or segment (called by authors *zoönule*, *zoönite*, or *somite*, meaning parts of a body, though we prefer the term *arthromere*, denoting the elemental part of a jointed or articulate animal), consists of an upper (tergite), a side (pleurite), and an under piece (sternite). This is seen in its greatest simplicity in the Worm (Fig. 2), where the upper and ventral arcs are separated by the *pleural region*. In the Crustacean the parts, hardened by the deposition of chitine and therefore thick and unyielding, have to be farther subdivided to secure the necessary amount of freedom of motion to the body and legs. The upper arc not only covers the back of the animal, but extends down the sides; the legs are jointed to the *epimera*, or flanks, on the lower arc; the *episternum* is situated between the epimerum and sternum; and the sternum, forming the breast, is situated between the legs. In the adult, therefore, each elemental ring is composed of six pieces. It should, however, be borne in mind that the tergum and ster-

* In two papers on the Classification of Animals, published in the *American Journal of Science and Arts*, Second Series, vol. xxxv, p. 65, vol. xxxvi, July, 1863, and also in his earlier paper on Crustaceans, "the principle of cephalization is shown to be exhibited among animals in the following ways:

1. By a transfer of members from the *locomotive* to the *cephalic* series.

2. By the anterior of the locomotive organs participating to some extent in cephalic functions.

3. By increased abbreviation, concentration, compactness, and perfection of structure, in the parts and organs of the anterior portion of the body.

4. By increased abbreviation, condensation, and perfection of structure in the posterior, or gastric and caudal portion of the body.

5. By an upward rise in the cephalic end of the nervous system. This rise reaches its extreme limit in Man."

num each consist, in the embryo, of two lateral parts, or halves, which, during development, unite on the median line of the body. Typically, therefore, the crustacean ring consists primarily of eight pieces. The same number is found in all insects which are wingless, or in the larva and pupa state ; this applies also to the Myriapods and Spiders.

In the Myriapoda, or Centipedes, the broad tergum overlaps the small epimera, while the sternum is much larger than in the Spiders and Insects. In this respect it is like the broad flat under-surface of most worms. Hence the legs of the Centipede are inserted very far apart, and the "breast," or sternum, is not much smaller than the dorsal part of the crust. In the *Julus* the dorsal piece (tergum) is greatly developed over the sternum, but this is a departure from what is apparently the more typical form of the order, *i. e.* the Centipede. In the Spiders there is a still greater disproportion in size between the tergum and the sternum, though the latter is very large compared with that of Insects. The epimera and episterna, or side-pieces of the Spiders, are partially concealed by the over-arching tergum, and they are small, since the joints of the legs are very large, Audouin's law of development in Articulates showing that one part of the insect crust is always developed at the expense of the adjoining part. In the Spider we notice that the back of the thorax is a single solid plate consisting originally of four rings consolidated into a single hard piece. In like manner the broad solid sternal plate results from the reunion of the same number of sternites corresponding, originally, to the number of thoracic legs. Thus the whole upper side of the head and thorax of the Spider is consolidated into a single hard horny immovable plate, like the upper solid part of the cephalothorax of the Crab or Shrimp. Hence the motions of the Spiders are very stiff compared with those of many Insects, and correspond to those of the Crab.

The crust of the winged insect is modified for the performance of more complex motions. It is subdivided in so different a manner from the two lower orders of the class, that it would almost seem to have nothing in common, structurally speaking, with the groups below them. It is only by examining the lowest wingless forms such as the Louse, Flea, *Podura*, and Bark-lice, where we see a transition to the Orders of Spiders and Myriapods, that we can perceive the plan pervading all these forms, uniting them into a common class.

A segment of a winged six-footed insect (Hexapod) consists typically of eight pieces which we will now examine more leisurely. Figure 12 represents a side-view of the thorax of the *Telea Polyphemus*, or Silk-worm moth, with the legs and wings removed. Each ring consists primarily of the *tergum*, the two side-pieces (epimerum and episternum) and the *sternum*, or breast-plate. But one of these pieces (sternum) remains simple, as in the lower orders. The tergum is divided into four pieces. They were named by Audouin going from before backwards, the *præscutum*, *scutum*, *scutellum*, and *postscutellum*.

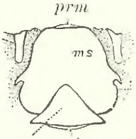
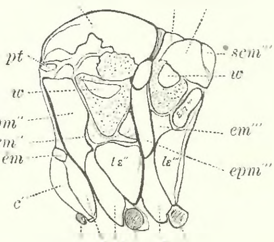


Fig. 11.

Fig. 12.


The scutum is invariably present and forms the larger part of the upper portion (tergum) of the thorax; the scutellum is, as its name indicates, the little shield so prominent in the beetle, which is also uniformly present. The other two pieces are usually minute and crowded down out of sight, and placed between the two opposing rings. As seen in Fig. 11, the præscutum of the moth is a small rounded piece, bent vertically down, so as not to be seen from above. In the lowly organized *Hepialus*, and some

FIG. 11. Tergal view of the middle segment of the thorax of *Telea Polyphemus*. *prm*, præscutum; *ms*, scutum; *scm*, scutellum; *ptm*, postscutellum; *pt*, patagium, or shoulder tippet, covering the insertion of the wings. — *Original*.

FIG. 12. Side view of the thorax of *T. Polyphemus*, the hairs removed. 1, Prothorax; 2, Mesothorax; 3, Metathorax, separated by the wider black lines. Tergum of the prothorax not represented. *ms*, mesoscutum; *scm*, mesoscutellum; *ms''*, metascutum; *scm'''*, metascutellum; *pt*, a supplementary piece near the insertion of patagia; *w*, pieces situated at the insertion of the wings and surrounded by membrane; *em*, epimerum of prothorax, the long upright piece above being the episternum; *epm''*, episternum of the mesothorax; *em''*, epimerum of the same; *epm'''*, episternum of the metathorax; *em'''*, epimerum of the same, divided into two pieces; *c'*, *c''*, *c''*, coxæ; *te*, *le'*, *le''*, trochantines; *tr*, *tr*, *tr*, trochanters. — *Original*.

Neuroptera, such as the *Polystœchotes* (Fig. 13 *a*), the præscutum is large, well developed, triangular, and wedged in between the two halves of the scutum. The little piece succeeding the scutellum, *i. e.* the postscutellum, is still smaller, and rarely used in descriptive entomology. Thus far we have spoken of the middle, or mesothoracic, ring, where these four pieces are most equally developed. In the first, or prothoracic, ring, one part, most probably the scutum, is well developed, while the others are aborted, and it is next to impossible to trace them in most insects. The prothorax in the higher insects, such as the Hymenoptera, Lepidoptera, and Diptera is very small, and often intimately soldered to the succeeding or meso-thoracic ring. In the lower insects, however, such as the Coleoptera, the bugs (Hemiptera), grasshoppers and their allies (Orthoptera), and the Neuroptera, the large broad prothorax consists almost entirely of this single piece, and most writers speak of this part under the name of "thorax," since the two posterior segments are concealed by the wings when the animal is at rest. The *metathorax* is usually very broad and short. Here we see the scutum split asunder, with the præscutum and scutellum wedged in between, while the postscutellum is aborted.

Fig. 13.

On the side are two pieces, the upper (epimerum) placed just beneath the tergum, which is the collective name for the four tergal, or dorsal, pieces enumerated above. In front of the epimerum and resting upon the sternum, as its name implies, is the *episternum*. These two parts (pleurites) compose the flanks of the elemental ring. To them the legs are articulated. Between the two episterna is situated the breast-piece (sternum), which shows a tendency to grow smaller as we ascend from the Neuroptera to the Bees.

In those insects provided with wings, the epimera are also subdivided. The smaller pieces, hinging upon each other, as it were, give play to the very numerous muscles of flight

FIG. 13. *a*, tergal view of thorax of *Hepialus* (*Sthenopis*); 1, prothorax; 2, mesothorax; 3, metathorax. The prothorax is very small compared with that of *Polystœchotes* (13 *a*, 1), where it is nearly as long as broad. — *Original.*

needed by the insect to perform its complicated motions while on the wing.

The insertion of the fore wing is concealed by the "shoulder tippets," or *patagia* (Fig. 11), which are only present in the mesothorax. The external opening of the spiracles just under the wing perforates a little piece called by Audouin the *peritreme.*

A glance at Figures 11 and 12 shows how compactly the various parts of the thorax are agglutinated into a globular mass, and that this is due to the diminished size of the first and third rings, while the middle ring is greatly enlarged to support the muscles of flight. There are four tergal, four pleural, two on each side (and these in the Hymenoptera, Lepidoptera, and Diptera subdivide into several pieces), and a single sternal piece, making nine for each ring and twenty-seven for the whole thorax, with eight accessory pieces (the three pairs of *peritremes* and the two *patagia*), making a total of thirty-five for the entire thorax; or, multiplying the four tergal pieces by two, since they are formed by the union of two primitive pieces on the median line of the body, we have thirty-nine pieces composing the thorax.

TABLE OF THE PARTS OF THE THORAX APPLIED TO THE PRO-, MESO-, AND METATHORAX, RESPECTIVELY.

Thorax	Dorsal Surface	Præscutum, Scutum, Scutellum. Postscutellum.
	Pleural Surface	Epimerum, Episternum, Episternal apophysis, Stigma, Peritreme.
	Sternal Surface	Sternum.

We must remember that these pieces are rarely of precisely the same form in any two species, and that they differ, often in a very marked way, in different genera of insects. How simple, then, is the typical ring, and how complex are the various subdivisions of that ring as seen in the actual, living insect, where each part has its appropriate muscles, nerves, and tracheæ!

We have seen how the thorax is formed in Insects generally, let us now advert to the two types of thorax in the six-footed insects. In the higher series of suborders, comprising the Diptera, Lepidoptera and Hymenoptera, placing the highest last, the thorax shows a tendency to assume a globular shape; the upper side, or tergum, is much arched, the pleural region bulges out full and round, while the legs conceal at their insertion the sternum which is minute in size.

In the lower series, embracing the Coleoptera, Hemiptera, Orthoptera, and Neuroptera, the entire body tends to be more flattened; in the thorax the tergum is broad, especially that of the prothorax, while the pleurites (episterna and epimera) are short and bulge out less than in the higher series, and the sternum is almost invariably well developed, often presenting a large thick breast-plate bearing a stout spine or thick tubercle, as in *Œdipoda.* We can use these characters, in classifying insects into suborders, as they are common to the whole order. Hence the use of characters drawn from the wings and mouth-parts (which are sometimes wanting), leads to artificial distinctions, as they are *peripheral* organs, though often convenient in our first attempts at classifying and limiting natural groups.

The abdomen. In the hind body, or third region of the trunk, the three divisions of the typical ring (arthromere), are entire, the tergum is broad and often not much greater in extent than the sternum; and the pleurites also form either a single piece, or, divided into an epimerum and episternum, form a distinct lateral region, on which the stigmata are situated. The segments of the abdomen have received from Lacaze-Duthiers a still more special name, that of *urite*, and the different tergal pieces belonging to the several rings, but especially those that have been modified to form the genital armor have been designated by him as *tergites.* We have applied this last term to the tergal pieces generally. The typical number of abdominal segments is eleven. In the lowest insects, the Neuroptera, there are usually eleven; as we have counted them in the abdomen of the embryo of *Diplax.* In others, such as the Hymenoptera and Lepidoptera, there may never be more than ten, so far as present observation teaches us.

The formation of the sting, and of the male intromittent organ, may be observed in the full-grown larva and in the incomplete pupa of the Humble-bee, and other thin-skinned Hymenopterous larvæ, and in a less satisfactory way in the young Dragon-flies.

If the larva of the Humble-bee be taken just after it has become full-fed, and as it is about to enter upon the pupa state, the elements (*sterno-rhabdites* Lacaze-Duthiers), or tubercles, destined to form the ovipositor, lie in separate pairs, in two groups, exposed distinctly to view, as in Figures 14–18. The ovipositor thus consists of three pairs of slender non-articulated tubercles, situated in juxtaposition on each side of the mesial line of the body. The first pair arises from the eighth abdominal ring, and the second and third pair grow out from the ninth ring. The ends of the first pair scarcely reach beyond the base of the third pair. With the growth of the semi-pupa, the end of the abdomen decreases in size, and is

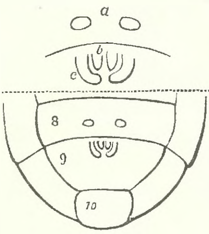


Fig. 14.

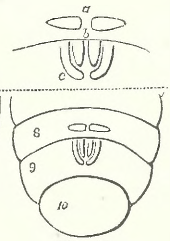


Fig. 15.

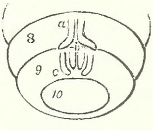
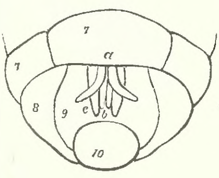
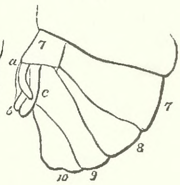


Fig. 16.

Fig. 17.



17*a*.



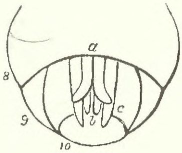
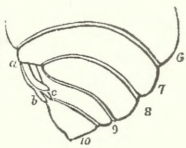


Fig. 18.



18*a*.

FIG. 14. Rudiments of the sting, or ovipositor, of the Humble-bee. 8, 9, 10, sternites of eighth, ninth, and tenth abdominal rings in the larva. *a*, first pair, situated on the eighth sternite; *b*, second and inner pair; and *c*, the outer pair. The lettering is the same in figures 14–22. The inner pair (*b*), forms the true ovipositor, through which the eggs are supposed to pass when laid by the insect, the two outer pairs, *a* and *c*, sheathing the inner pair.

FIG. 15. The same a little farther advanced.

FIG. 16. The same at a later stage, the three pairs approximating.

FIG. 17. The three pairs now appear as if together growing from the base of the ninth segment: 17*a*, side view of the same, showing the end of the abdomen growing smaller through the diminution in size of the under side of the body.

FIG. 18. The three pairs of rhabdites now nearly equal in size, and nearly ready to unite and form a tube; 18*a*, side view of the same; the end of the abdomen still more pointed; the ovipositor is situated between the seventh and tenth rings, and is partially retracted within the body.

gradually incurved toward the base (Fig. 18), and the three pairs of rhabdites approach each other so closely that the two outer ones completely ensheath the inner, until a complete extensible tube is formed, which is gradually withdrawn entirely within the body.

The male genital organ is originally composed of three pairs (two pairs, apparently, in *Æschna*, Fig. 19) of tubercles all arising from the *ninth* abdominal ring, being sternal outgrowths and placed on each side of the mesial line of the body, two being anterior, and very unequal in size, and the third pair nearer the base of the abdomen. The external genital organs cannot be considered as in any way homologous with the limbs, which are articulated outgrowths budding out between the sternal and pleural pieces of the *arthromere*.*

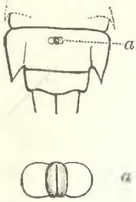


Fig. 19.

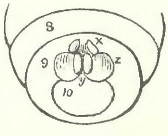


Fig. 20.

This view will apply to the genital armor of all Insects, so far as we have been able to observe. It is so in the pupa of *Æschna* (Fig. 21), and the pupa of *Agrion* (Fig. 22), which completely repeats, in its essential features, the structure of the ovipositor of *Bombus*. Thus in *Æschna* and *Agrion* the ovipositor consists of a pair of closely appressed ensiform processes which grow out from under the posterior edge of the eighth abdominal ring, and are embraced between two pairs

Fig. 21.

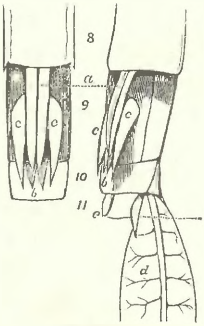


Fig. 22.

* This term is proposed as better defining the ideal ring, or primary zoölogical element of an articulated animal than the terms *somite* or *zoönite*, which seem too vague; we also propose the term *arthroderm* for the outer crust, or body walls, of Articulates, and *arthropleura* for the pleural, or limb-bearing region, of the body, being that portion of the arthromere situated between the tergite and sternite.

FIG. 19. The rudiments of the male intromittent organ of the pupa of Æschna, consisting of two flattened tubercles situated on the ninth ring; the outer pair large and rounded inclosing the smaller linear oval pair.

FIG. 20. The same in the Humble-bee, but consisting of three pairs of tubercles, x, y, z; 8, 9, 10, the last three segments of the abdomen.

FIG. 21. The rudimentary ovipositor of the pupa of *Æschna*, a Dragon-fly.

FIG. 22. The same in pupa of *Agrion*, a small Dragon-fly. Here the rudiments of the eleventh abdominal ring is seen. d, the base of one of the abdominal false gills.—*Figs.* 14–22 *original.*

of thin lamelliform pieces of similar form and structure, arising from the sternite of the ninth ring. These sternal outgrowths do not homologize with the filiform, antennæ-like, jointed appendages of the eleventh ring, as seen in the Perlidæ and most Neuroptera and Orthoptera (especially in *Mantis tessellata* where they (Fig. 23) closely resemble antennæ), which, arising as they do from the arthropleural, or limb-bearing region of the body, *i. e.* between the sternum and episternum, are strictly homologous with the abdominal legs of the Myriapoda, the "false legs" of caterpillars, and the abdominal legs of some Neuropterous larvæ (*Corydalis*, *Phyganeidæ*, *etc.*).

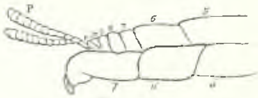


Fig. 23.

It will thus be seen that the attenuated form of the tip is produced by the decrease in size of certain parts, the actual disappearance of others, and the perfection of those parts to be of future use. Thus towards the extremity of the body the pleurites are absorbed and disappear, the tergites overlap on the sternites, and the latter diminish in size and are withdrawn within the body, while the last, or eleventh sternite, entirely disappears.* Meanwhile the sting grows larger and larger, until finally we have the neatly fashioned abdominal tip of the bee concealing the complex sting with its intricate system of visceral vessels and glands.

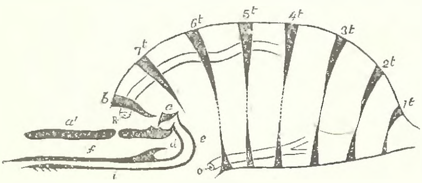


Fig. 24.

The ovipositor, or sting, of all insects, therefore, is formed on a common plan (Fig. 24). The solid elements of the arthro-

*In *Ranatra*, however, Lacaze-Duthiers has noticed the curious fact that in order to form the long respiratory tube of this insect, the tergite and sternite of the pregenital (eighth) segment are aborted, while the pleurites are enormously enlarged and elongated, so as to carry the stigmata far out to the end of the long tube thus formed.

FIG. 23. End of the abdomen of *Mantis tessellata*; *p*, many-jointed anal style resembling an antenna. 5–11, the seven last abdominal segments; the 8–11th sternites being obsolete.—*From Lacaze-Duthiers.*

FIG. 24. Ideal plan of the structure of the ovipositor in the adult insect. 1–7t, the tergites, connected by dotted lines with their corresponding sternites. *b*, the eighth tergite, or anal scale; *c*, epimerum; *a'*, *a*, two pieces forming the outer pair of rhabdites; *i*, the second pair, or stylets; and *f*, the inner pair, or sting; *d*, the

mere are modified to form the parts supporting the sting alone. The external opening of the oviduct is always situated between the eighth and ninth segments, while the anal opening lies at the end of the eleventh ring. So that there are really, as Lacaze-Duthiers observes, three segments interposed between the genital and anal openings.

The various modifications of the ovipositor and male organ will be noticed under the different suborders.

The Structure of the Head. After studying the composition of the thorax and abdomen, where the constituent parts of the elemental ring occur in their greatest simplicity, we may attempt to unravel the intricate structure of the head. We are to determine whether it is composed of one, or more, segments, and if several, to ascertain how many, and then to learn what parts of the typical arthromere are most largely developed as compared with the development of similar parts in the thorax or abdomen. In this, perhaps the most difficult problem the entomologist has to deal with, the study of the head of the adult insect alone is only guesswork. We must trace its growth in the embryo. Though many writers consider the head as consisting of but a single segment, the most eminent entomologists have agreed that the head of insects is composed of two or more segments. Savigny led the way to these discoveries in transcendental entomology by stating that the appendages of the head are but modified limbs, and homologous with the legs. This view at once gave a clue to the complicated structure of the head. If the antennæ and biting organs are modified limbs, then there must be an elemental segment present in some form, however slightly developed in the mature insect, to which such limbs are attached. But the best observers have differed as to the supposed number of such theoretical segments. Burmeister believed that there were two only; Carus and Audouin thought there were three; McLeay and Newman four, and Straus-Durckheim recognized seven. From the study of the semipupa of the Humble-bee (*Bombus*)

support of the sting; *e*, the support of the stylet (*i*). *R*, the anus; *O*, the outlet of the oviduct. The seventh, eighth, and ninth sternites are aborted.—*From Lacaze-Duthiers.*

and several low Neuropterous forms, as the larva of *Ephemera*, but chiefly the embryo of *Diplax*, a dragon-fly, we have concluded that there are seven such elemental segments in the head of insects.

That there are four corresponding to the jointed appendages, *i. e.* the labium, or second maxillæ, the first maxillæ, the mandibles, and the antennæ, seems indisputable. But where else are we to look for jointed appendages in an insect's head? We must go out of the class of Insects and study the stalk-eyed Crustacea, such as the Lobster, where the eye is supported on a two-jointed stalk, which has been homologized with the limbs. While, therefore, the eyes of insects are never "stalked," as in the Lobster and Shrimp, they are evidently developed, as in the Crustacean, upon a separate segment (or its rudiments), which may be called the "ophthalmic ring," and which is, therefore, the fifth cephalic ring. In advance of the eyes are normally placed the three ocelli, though in the highest Insects (the Diptera, Lepidoptera, and Hymenoptera) they appear to be situated in the rear of the eyes.

Each of these three ocelli is situated upon a distinct piece; but we must consider the anterior single ocellus as in reality formed of two, since in the immature pupa of Bombus the anterior ocellus is differently shaped from the two posterior ones, being transversely ovate, resulting, as I think, from the fusion of two originally distinct ocelli, and not round like the other two. There are, therefore, two pairs of ocelli, and hence they grow from the rudiments of a sixth and seventh ring respectively.

Now, since the *arthropleural* is the limb-bearing region in the thorax, it must follow that this region is largely developed in the head, to the bulk of which the sensory and digestive organs bear so large a proportion; and as all the parts of the head are subordinated in their development to that of the appendages of which they form the support, it must follow logically that the larger portion of the body of the head is *pleural*, and that the *tergal*, and especially the *sternal*, parts are either very slightly developed, or wholly obsolete. Thus each region of the body is characterized by the relative development of the three parts of the arthromere. In the abdomen the upper (tergal) and under (sternal) surfaces are most equally developed, while the pleural line is reduced to a minimum. In the thorax the pleural region is much more developed, either quite as much, or often more than the upper, or tergal portion, while the sternal is reduced to a minimum. In the head the pleurites form the main bulk of the region, the sternites are reduced to a minimum, and the tergites may be identified in the occiput, the clypeus, and labrum.

TABLE OF THE SEGMENTS OF THE HEAD AND THEIR APPENDAGES, BEGINNING WITH THE MOST ANTERIOR.*

	Preoral.	
(*Hypothetical*),	Tergal,	Labrum, epipharynx, clypeus.
First Segment (*First Ocellary*),	Pleural,	Anterior ocellus (originally double).
Second Segment (*Second Ocellary*),	Pleural,	Two posterior ocelli.
Third Segment (*Ophthalmic*),	Pleural,	Eyes.
Fourth Segment (*Antennary*),	Pleural,	Antennæ.
	Postoral.	
Fifth Segment (*Mandibular*),	Pleural,	Mandibles.
Sixth Segment (*First Maxillary*),	Pleural,	First maxillæ.
Seventh Segment (*Second Maxillary, or Labial*),	Tergal (occiput), Pleural (gena), Sternal (gula),	Second maxillæ (Labium).

The Appendages. We naturally begin with the thoracic appendages, or *legs*, of which there is a pair to each ring. The leg (Fig. 25) consists of seven joints, the basal one, the *coxa*, in the Hymenoptera, Lepidoptera, and Diptera, consisting of two

*In the first column are enumerated the seven rings, or segments, composing the head. The tergal parts (*i. e.* the labrum, epipharynx, and clypeus), situated in front of the ocelli, are left out in enumerating the seven segments, as they are not supposed by the author to belong to either of those segments.

In the first column the seven rings are named (in brackets) according to the sort of appendages they bear. In the second column is given the part, or parts, of the ideal segment supposed actually to exist in an insect's head; and in the third column are to be found the names of the organs attached to their corresponding segments, beginning with the front and going back to the base of the head.

pieces, *i.e.* the coxa and *trochantine* (see Fig. 12); the *trochanter;* the *femur;* the *tibia*, and, lastly, the *tarsus*, which is subdivided into from one to five joints, the latter being the normal number. The terminal joint ends in a pair of claws between which is a cushion-like sucker called the *pulvillus.* This sucking disk enables the Fly to walk upside down and on glass.

Fig. 25.

In the larva, the feet are short and horny, and the joints can be still distinguished. In Myriapods, each segment of the abdomen has a pair of feet like the thoracic ones. We must consider the three pairs of spinnerets of Spiders, which are one to three-jointed, as homologous with the jointed limbs of the higher insects. In the six-footed insects (Hexapoda), the abdominal legs are deciduous, being present in the Coleopterous grub, the Dipterous maggot, the caterpillar, and larva of the Saw-fly, but disappearing in the pupa state. They are often, as in most maggots, either absent, or reduced in number to the two anal, or terminal, pair of legs; while in the Saw-flies, there are as many as eight pairs. These "false" or "prop-legs" are soft and fleshy, and without articulations. At the retractile extremity is a crown of hooks, as seen in caterpillars or the hind-legs of the larva of *Chironomus* (Fig. 26), in which the prothoracic pair of legs is reduced to inarticulate fleshy legs like the abdominal ones.

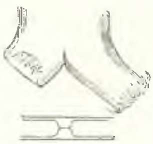


Fig. 26.

The *position* of the different pairs of legs deserves notice in connection with the principle of "antero-posterior symmetry." The fore-legs are directed forwards like the human arms, but the two hinder pairs are directed backwards. In the Spiders, three pairs of abdominal legs (spinnerets) are retained throughout life: in the lower Hexapods, a single pair, which is appended to the eleventh segment, is often retained, but under a form which is rather like an antenna, than limb-like. In some Neuropterous larvæ (*Phryganea*, *Corydalus*, etc.) the anal pair of limbs are very well marked; they constitute the "anal forceps" of the adult insect. They sometimes become true, many-jointed appendages, and are then remarkably like

FIG. 25. A, coxa; B, trochanter; C, femur; D, tibia; F, tibial spurs; E, tarsus, divided into five tarsal joints, the fifth ending in a claw.—*From Sanborn.*

antennæ, as in the instance of *Mantis tessellata* described by Lacaze-Duthiers (Fig. 23). In the Cockroach these appendages, sometimes called "anal cerci," resemble the antennæ of the same insect. In the Lepidoptera and Hymenoptera they do not appear to be jointed, and are greatly aborted.

The Wings. The wings of insects first appear as little soft vascular sacs permeated by tracheæ. They grow out in the preparatory stages (Fig. 27) of the pupa from the side of the thorax and above the insertion of the legs, *i.e.* between the epimerum and tergum. During the pupa state they are pad-like, but when the pupa skin is thrown off they expand with air, and in a few minutes, as in the Butterfly, enlarge to many times their original size. The wings of insects, then, are simple expansions of the crust, spread over a framework of horny tubes. These tubes are really double, consisting of a central trachea, or air tube, inclosed within a larger tube filled with blood, and which performs the functions of the veins. Hence the aeration of the blood is carried on in the wings, and thus they serve the double purpose of lungs and organs of flight.

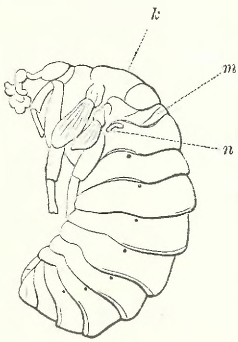


Fig. 27.

The number and situation of these veins and their branches (veinlets) are of great use in separating genera and species. The typical number of primary veins is five. They diverge outward at a slight angle from the insertion of the wing, and are soon divided into veinlets, from which cross veins are thrown out connecting with others to form a net-work of veins and veinlets, called the *venation* of the wing (Figs. 28, 29). The interspaces between the veins and veinlets are called *cells*.

At a casual glance the venation seems very irregular, but in many insects is simple enough to enable us to trace and name the veinlets. The five main veins, most usually present, are

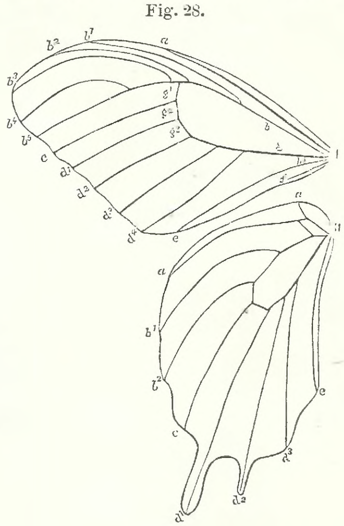
FIG. 27. The semipupa of *Bombus*, the larva skin having been removed, showing the two pairs of rudimentary wings growing out from the mesothorax (k), and metathorax (m). n and the seven succeeding dots represent the eight abdominal stigmata, the first one (n) being in the pupa situated on the thorax, since the first ring of the abdomen is in this stage joined to the thorax. — *Original.*

called, going from the *costa*, or front edge, the *costal*, *subcostal*, *median*, *submedian*, and *internal*, and sometimes the median divides into two, making six veins. The costal vein is undivided; the subcostal and median are divided into several branches, while the submedian and internal are usually simple.

The venation of the fore-wings affords excellent marks in separating genera, but that of the hind wings varies less, and is consequently of less use.

The wings of many insects are divided by the veins into three well-marked areas; the *costal*, *median*, and *internal*. The costal area (Fig. 31 *b*) forms the front edge of the wing and is the strongest, since the veins are nearer together than elsewhere, and thus afford the greatest resistance to the air

Fig. 28.



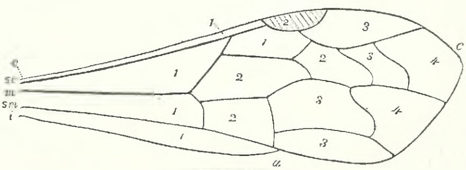


Fig. 29.

FIG. 28. Fore and hind wings of a Butterfly, showing the venation. I. fore wing: *a*, costal vein; *b*, subcostal vein; *b* 1, *b* 2, *b* 3, *b* 4, *b* 5, five subcostal veinlets; *c*, independent vein (it is sometimes a branch of the subcostal, and sometimes of the median vein); *d*, median vein; *d* 1, *d* 2, *d* 3, *d* 4, four median veinlets; *e*, submedian vein; *f*, internal vein; *h*, interno-median veinlet (rarely found, according to Doubleday, except in Papilio and Morpho); *b* and *d* are situated in the "discal cell;" *g* 1, *g* 2, *g* 3, the upper, middle, and lower discal veinlets. In the Bombycidæ and many other moths *g* 1 and *g* 2 are thrown off from the subcostal and median veins respectively, meeting in the middle of the cell at *g* 2. They are sometimes wholly absent.

II. The hind wing; the lettering and names of the veins and veinlets the same as in the fore wing.—*Slightly changed from Doubleday.*

FIG. 29. Fore wing of a Hymenopterous insect. *c*, costal vein; *sc*, subcostal vein; *m*, median vein; *sm*, submedian vein; *i*, internal vein; *c*, 1, 2, 3, the first, second, and third costal cells; the second frequently opaque and then called the *pterostigma*. *sc*, 1, 2, 3, 4, the four subcostal cells; *m*, 1, 2, 3, 4, the median cells; *sm*, 1, 2, 3, the three submedian cells; *i* 1, the internal cell; this is sometimes divided into two cells, and the numbers of all but the costal cells is inconstant, the outer row of cells (4, 4, 3) being the first to disappear.

The *costal edge* extends from *c* to *c*; the outer *c*, the *apex*; the *outer edge* extends from the apex (*c*) to *a*, and the *inner edge* extends from *a*, the inner angle, to the insertion of the wing at *i*.—*Original.* Figs. 30–32 *from Scudder.*

during flight. The median area (Fig. 31 a) is the largest. It is in the grasshoppers and crickets sometimes modified to form a

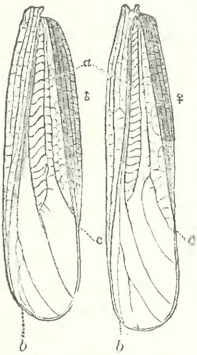


Fig. 31.

musical organ, being drum-like, as in the *Œcanthus* (Fig. 30), or rasp-like, as in *Archyptera* (Fig. 31 a). The internal area (c) is the smallest, and less distinctly marked than the

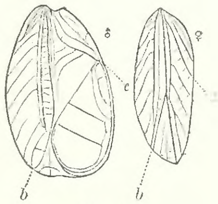


Fig. 30.

two other regions; the musical file-like organ of *Orchelimum vulgare*, a common grasshopper (Fig. 32 d) is situated on this area.

The limits of the edges of the wing vary in almost every genus, and their comparative length afford excellent generic characters. The front edge (Fig. 29) is called

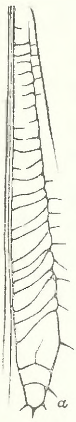


Fig. 31 a.

the *costal*, its termination in the outer angle of the wing is called the *apex;* the *outer edge* is situated between the apex and the *inner angle*, between which and the base of the wing is the inner, or *internal*, edge. These distinctions are of most use in describing the butterflies and moths.

The Appendages of the Head. These organs are divided into two groups, the first of which comprise the sensory organs, *i. e.* the ocelli,

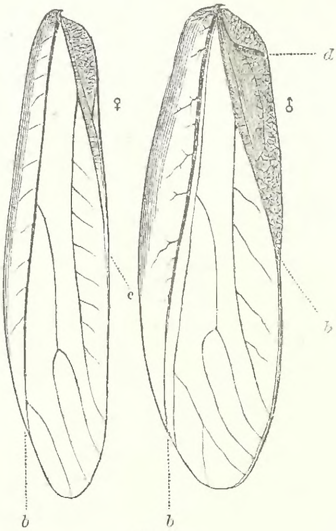


Fig. 32.

eyes, and antennæ, which are attached to the region in front of the mouth, or *preoral* region of the head. The second group consists of the sensorio-digestive appendages, combining the power of finding and seizing the food and preparing it for digestion. They are inserted behind the mouth and belong to the *postoral* region of the head.

We will first describe the ocelli, going backwards to the basal appendages, the labium (second maxillæ) being the hindermost.

The simple eye, *Ocellus*, or *Stemma*, is the simplest form of the eye. Its most elementary form (seen in the larva of the Bot-fly and the Cecidomyian larva of *Miastor*) is that of a brown spot, or group of pigment-cells lodged under the skin and against which a nerve-filament impinges. Over this spot Newport states that the tegument is transparent and convex, resembling a true cornea, or eye-lens. A well-developed ocellus consists, according to Newport, of a "very convex, smooth, single cornea, beneath which is a spherical crystalline lens, resting upon the plano-convex surface of the expanded vitreous humor, the analogue of the transparent cones of the compound eyes." Muller believes that the function of the ocelli is the perception of nearer objects, while that of the compound eyes is to see more distant objects. The ocelli constitute the only visual organs in the Myriapods (except *Cermatia*), the Arachnida, and the larvæ of many Six-footed Insects; they are usually from one to six on a side. In adult insects they are generally three in number, and are generally present except in the large majority of Coleoptera. Their *normal* site is in front of the eyes, but they are usually thrown back, during the growth of the insect, behind the eyes, on the vertex, or topmost part of the head (Fig. 33).

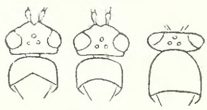


Fig. 33.

The Compound Eyes are a congeries of simple eyes. During the growth of the insect the simple eyes of the larva increase in number, and finally coalesce to form the compound eye, or compound cornea, the surface of which is very convex and protuberant in the predaceous insects, or those requiring an extended field of vision.


Fig. 34.

The number of facets, or corneæ, vary from fifty (in the Ant) to 3,650, the latter number being counted by Geoffroy in the eye of a Butterfly. These facets are usually hexagonal, as in the Dragon-fly (Fig. 34), or, rarely, quadrangular.

FIG. 33. Ocelli of three species of Sand-wasps, *Pompilus*. — *From Cresson.*

FIG. 34. Three hexagonal facets of the compound eye of a fossil Dragon-fly, greatly magnified. — *From Dawson.*

The *Antennæ* (Figs. 35, 36) are inserted usually in the adult insect between, or in front of the eyes, though normally the antennary is posterior to the ophthalmic ring. It is normally a long, filiform, slender, many-jointed appendage, undergoing great changes in form. When it is highly specialized, as in Coleoptera and Hymenoptera, it is divided into three parts, the basal or *scape*, the middle or *pedicel*, and the terminal part or *flagellum*, or *clavola*, which usually comprises the greater part of the antenna.

Fig. 35.

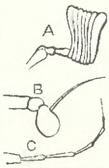


Fig. 36.

It is believed by some that the sense of hearing is lodged in the antennæ, though Siebold has discovered an auditory apparatus situated at the base of the abdomen of some, and in the fore-legs of other species of Grasshoppers.

Mr. J. B. Hicks has made the latest studies on the auditory apparatus. According to him "it consists first of a cell, sac, or cavity filled with fluid, closed in from the air by a membrane analogous to that which closes the *foramen ovale* in the higher animals; second, that this membrane is, for the most part, thin and delicate, but often projects above the surface, in either a hemispherical, conical, or canoe-shaped, or even hair-like form, or variously marked; thirdly, that the antennal nerve gives off branches which come in contact with the inner wall of the sacs; but whether the nerve enters, or, as is most probable, ends in the small internally projecting papilla which I have shown to exist in many of these sacs, it is very difficult to say. The principal part of the nerve proceeds to these organs, the remaining portion passing to the muscles, and to the roots of the hairs, at least to those of the larger sort." On the other hand, Lefebvre, Leydig, and Gerstaecker regard this so-called "auditory apparatus" as an organ of smell.

The antennæ have also the sense of touch, as may readily be observed in Ants, Bees, and the Grasshopper and Cockroach. "The Honey-bee, when constructing its cells, ascertains their proper direction and size by means of the extremities of these

FIG. 35. Filiform antenna of *Amphizoa*.—*From Horn*.

FIG. 36. A, lamellate antenna of a Lamellicorn Beetle; B, antenna of a Fly, with the bristle thrown off from the terminal joint; C, bristle-like antenna of a Dragon-fly, *Libellula*.—*From Sanborn*.

organs; while the same insect, when evidently affected by sounds, keeps them motionless in one direction, as if in the act of listening." (Newport.)

After cutting off one or both antennæ of the June beetle, *Lachnosterna*, the insect loses its power of directing its flight or steps, wheeling about in a senseless manner. Dr. Clemens observed that the Cecropia moth was similarly affected after losing its antennæ.

The Mandibles (Fig. 37) are inserted on each side of the mouth-opening. They usually consist of but a single joint,

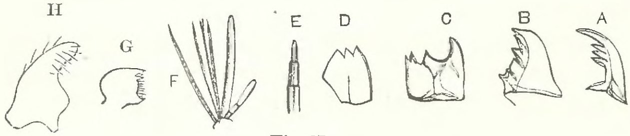
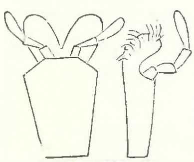


Fig. 37.

representing probably the basal part of the ideal limb. This part, however, is often subdivided by two longitudinal furrows into three parts, each ending in a "tooth" of unequal size for tearing and cutting the food. This tripartite form of the mandibles, to which attention has been called by Mr. Scudder, is more fully carried out in the maxilla, where each portion is highly specialized. The mandibles vary greatly in form and size. The two cutting edges are usually opposed to each other, or frequently overlap in the carnivorous forms. Their base is


a Fig. 38. *b*

often concealed by the clypeus and labrum. Their motion is transverse, being the reverse of the motion of the jaws of Vertebrates.

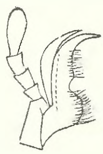


Fig. 39.

The Maxillæ (Figs. 38 *b*, 39) are much more complicated organs than the mandibles. They are

FIG. 37. Different forms of mandibles. A, mandible of *Cicindela purpurea*; B, *Phylloptera*, a green grasshopper; C, *Libellula trimaculata*; D, *Vespa maculata*, or paper-making Wasp; E, "rostrum" or jointed sucker of the Bed-bug, *Cimex lectularius*, consisting of mandibles, maxillæ, and labium; F, proboscis, or sucker, of a Mosquito, *Culex*, in which the mandibles are long and bristle-like.— *From Sanborn.* G, mandible of *Amphizoa*; H, mandible of *Acratus*, a genus of Cockchafers.— *From Horn.*

FIG. 38. *a*, mentum and labial palpi; *b*, one maxilla, with its palpus, of *Acratus*.— *From Horn.*

FIG. 39. Maxilla of *Amphizoa*, with the two lobes (stipes and lacinia), and the palpifer bearing the four-jointed palpus.— *From Horn.*

inserted on the under side of the head and just behind the mouth. The maxilla consists of a basal joint, or *cardo*, beyond which it is subdivided into three lobes, the *stipes*, or footstalk; the *palpifer*, or palpus-bearer; and the *lacinia*, or blade. The stipes forms the outer and main division of the organ. The lacinia is more membranaceous than the other parts, and its upper surface is covered with fine hairs, and forms a great part of the side of the mouth. It is divided into two lobes, the superior of which is called the *galea*, or helmet, which is often a thick double-jointed organ edged with stiff hairs, and is used as a palpus in the Orthoptera and many Coleoptera. The inferior lobe is attached to the internal angle of the lacinia. It terminates in a stiff minute claw, and is densely covered with stout hairs. The *maxillary palpi* are long, slender, one to four-jointed organs, very flexible and sensitive.

The maxillæ vary greatly in the different groups. Their office is to seize the food and retain it within the mouth, and also to aid the mandibles in comminuting it before it is swallowed. This function reminds us of that of the tongue of vertebrate animals.

The *labium*, or *second maxillæ* (Fig. 40), is placed in front of the *gula*, which forms the under part of the head, and is bounded on each side by the *genæ*, or cheeks, and posteriorly by the occiput. The genæ are bounded laterally by the epicranium and the under side of the eyes. In front are situated the basal parts of the labium, or second maxillæ, which embraces the *submentum* and *mentum* (or labium proper). The labial palpi are inserted into the mentum, but often the latter piece is differentiated into two, the anterior of which takes the name of *palpiger*, called by Dr. Leconte (Smithsonian Miscellaneous Collections) the ligula, and the palpi originate from them. The *ligula* is the front edge of the labium, being the piece forming the under lip. It is often a fleshy organ, its inner surface being continuous

Fig. 40.

FIG. 40. Ligula and labial palpi of *Amphizoa*, an aquatic beetle. It is quadrate and without paraglossæ; *a*, mentum of the same, being deeply incised, and with a tooth at the bottom of the excavation.—*From Horn.*

with the soft membrane of the mouth. In the Bees, it is enormously developed and covered with soft hairs. It is often confounded with the palpiger. In *Hydrous* it is divided into two lobes. In most of the *Carabidæ* and Bees it is divided into three lobes, the two outer ones forming the *paraglossæ* (Fig. 41 *m*), and acting as feelers, while the middle, usually much longer, forms the *lingua*, or tongue, being the continuation of the ligula. In the bees, where the ligula is greatly developed, it performs the part of the tongue in Vertebrates, and aids the maxillæ in collecting nectar and pollen.

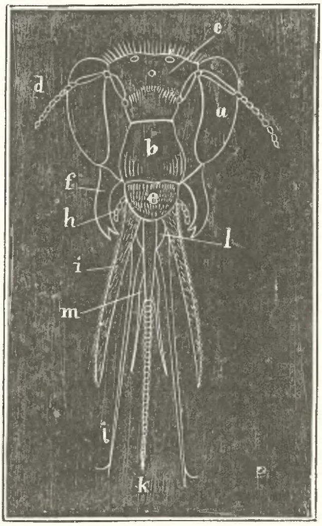


Fig. 41.

The roof of the mouth is formed by the *labrum* and the *epipharynx* (Fig. 42 *c*), a small fleshy tubercle concealed beneath the labrum. It is seen in the bees on turning up the labrum. It probably corresponds to the "labellum" of Schiödte. The labrum (Fig. 41 *e*) is usually transverse and situated in front of the *clypeus* (Fig. 41 *b*). The shield-like *clypeus* is the broad, visor-like, square piece forming usually the front of the head. Behind it is the *clypeus posterior*, or *supra-clypeus*, a subdivision of the clypeus, and especially observable in the Hymenoptera. The *epicranium* forms a large part of the head; it is bounded posteriorly by the *occiput*, on the sides by the eyes, and in front by the clypeus, and though usually described as a single piece, is really composed of several. The ocelli often appear to be situated upon it, though in reality they are placed upon a distinct piece or pieces. The "epicranial suture" is the line of junction of the two "procephalic lobes" (Huxley).

FIG. 41. Front view of the head of a bee, *Anthophora*. *a*, compound eyes; c, three simple eyes, situated upon the epicranium; *b*, clypeus; *e*, labrum; *d*, antennæ; *f*, mandibles; *i*, maxillæ; *h*, maxillary palpi; *l*, palpifer; *j*, labial palpi; *m*, paraglossæ; *k*, ligula.—*From Newport.*

(These lobes will be explained farther on when speaking of their development in the embryo.) Behind the epicranium is the *occiput*, or base of the head. It belongs to the labial, or second maxillary segment, and helps to form a complete ring, articulating with the thorax. It is perforated by a foramen to afford a connection between the interior of the head and thorax. It is sometimes, as in many Coleoptera, Orthoptera, and Hemiptera, elongated behind and constricted, thus forming a "neck." It will be seen beyond, that the labrum and clypeus are in the embryo developed from a "tongue-like process whose inferior part eventually becomes the labrum, while superiorly it sends a triangular process (the rudiment of the clypeus) into the interval between the procephalic lobes."* This part (*i.e.* the clypeus and labrum) is the most anterior part of the head, and in the embryo, as in the adult, is normally situated in front of the ocelli, and may be compared with the "anal plate," or eleventh tergite, of the larva.†

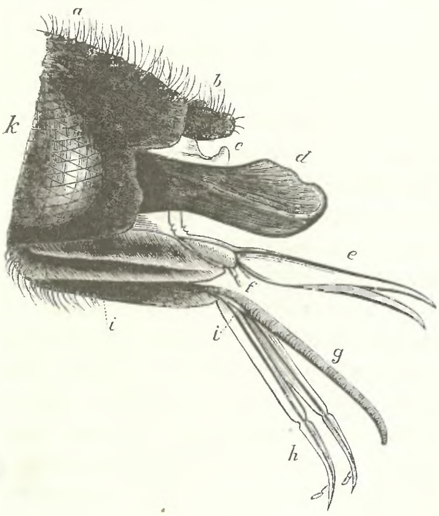


Fig. 42.

FIG. 42. Side view of the front part of the head, together with the mouth-parts of the Humble-bee (Bombus). *a*, clypeus covered with hairs; *b*, labrum; *c*, the fleshy epipharynx partially concealed by the base of the mandibles (*d*); *e*, lacinia, or blade of the maxillæ, with their two-jointed palpi (*f*) at the base; *j*, the labium to which is appended the ligula (*g*); below are the labial palpi; *h*, the two basal joints, being greatly enlarged; *k*, the compound eyes.—*Original.*

* These lobes are folded back upon the top of the base of the head, and they seem to form the *tergal* portion of the hypothetical, elemental ring, or rings, to which they respectively belong, and do not seem to us to be the *sternal* portion, as suggested by Huxley, for they are apparently developed in front of the mouth-opening, and form the roof of the mouth.

† "Lastly, there are certain parts developed singly in the median line in the *Articulata.* Of this nature are the frontal spines of *Crustacea*, their telson, and the sting

In describing Insects the *vertex*, or crown, of the head is the highest part; and the *front* is the part usually in front of the insertion of the antennæ.

The Muscular System lies just beneath, and is continuous with the integument. It consists of numerous "distinct isolated straight fibres, which are not gathered into bundles united by common tendons, or covered by aponeuroses [or tendinous sheaths] to form distinct muscles, as in the Vertebrata, but remain separate from each other, and only in some instances are united at one extremity by tendons." (Newport.) These minute fibres form layers, which Newport regards as separate muscles. "Each fibre is composed of a great number of very minute fibrillæ, or fasciculi of fibrillæ," and has been observed by Wagner and Newport to be often striated as in Vertebrates. The muscular system is simplest in the lower insects and the larvæ of the higher forms, and is more complex in the head than elsewhere, and more complex in the thorax than in the abdomen. These minute muscles are excessively numerous. "Lyonnet, in his immortal work on the anatomy of the larva of *Cossus ligniperda*, found two hundred and twenty-eight distinct muscles in the head alone, and, by enumerating the fibres in the layers of the different segments, reckoned 1,647 for the body, and 2,118 for the internal organs, thus making together 3,993 muscles in a single larva. In the larva of *Sphinx ligustri* we have found the muscles equally numerous with those discovered by Lyonnet in the Cossus." (Newport.)

The muscular system corresponds to the jointed structure of insects, as do the other internal systems of organs. Of the muscles belonging to a single ring, some stretch from the front edge of one segment to the front edge of the next, and others

of the Scorpion, whose mode of development appears to be precisely similar to that of a telson. In the same category we must rank the labrum in front of the mouth, which in the *Crustacea* (at least) appears to be developed from the sternum of the antennary, or third somite, the metastoma (or so called labium, or lingua) of *Crustacea*, and the lingua of *Insecta*, behind the oral aperture.

"However much these appendages may occasionally simulate, or play the part of appendages, it is important to remember, that, morphologically, they are of a very different nature, and that the confusing them with true appendages must tend completely to obscure the beautiful relations which obtain among the different classes of the *Articulata*."—*Huxley*, Linnæan Transactions, vol. xxii. London.

to the hinder edge; there are also sets of dorsal and ventral muscles going in an oblique or vertical course. The muscles are either colorless and transparent, or yellowish white and of a soft, almost gelatinous consistence. In form they are simply flat and thin, straight, band-like, or pyramidal, barrel or feather-shaped. They act variously as *rotators*, *elevators*, *depressors*, *retractors*, *protrusors*, *flexors*, and *extensors*.

The *muscular power* of insects is enormous. The Flea will leap two hundred times its own height. Certain beetles can support enormous weights. Newport cites the case of *Geotrupes stercorarius* which is "able to sustain and escape from beneath a pressure of from twenty to thirty ounces, a prodigious weight when it is remembered that the insect itself does not weigh even so many grains." Some beetles have been known to gnaw through lead-pipes, and the Stag-beetle of Europe, *Lucanus cervus*, has, as stated by Mr. Stephens, gnawed "a hole an inch in diameter through the side of an iron canister in which it was confined."

"The *motions* of the insect in walking as in flying are dependent, in the perfect individual, entirely upon the thoracic segments, but in the larva chiefly upon the abdominal. Although the number of legs in the former is always six, and in the latter sometimes so many as twenty-two, progression is simple and easy. Müller states (Elements of Physiology, p. 970, Translation) that on watching insects that move slowly he has distinctly perceived that three legs are always moved at one time, being advanced and put to the ground while the other three propel the body forwards. In perfect insects, those moved simultaneously are the fore and hind feet on one side, and the intermediate foot on the opposite; and afterwards the fore and hind feet on that side, and the middle one on the other, so that, he remarks, in two steps the whole of the legs are in motion. A similar uniformity of motion takes place in the larva, although the whole anterior part of the body is elevated and carried forwards at regular distances, the steps of the insect being almost entirely performed by the 'false,' or abdominal legs."

"In *flight* the motions depend upon the meso- and metathoracic segments conjointly, or entirely upon the former. The sternal, episternal, and epimeral pieces, freely articulated together, correspond in function with the sternum, the ribs, and the clavicles of birds.* The thorax is expanded and contracted at each motion of the wings, as in birds and other animals, and becomes fixed at each increased effort as a fulcrum or point of resistance upon which the great muscles of the wings are to act, thus identifying this part of the body in function as in structure with that of other animals." (Newport.)

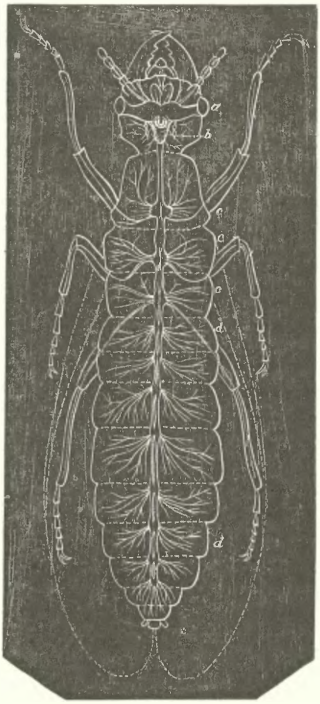


Fig. 43.

THE NERVOUS SYSTEM. In its simplest form the nervous system consists of two longitudinal cords, each with a swelling (nerve-knot, or ganglion,) corresponding to each segment (Fig. 43). This cord lies on the ventral side of the body, but in the head it passes upwards, sending a filament from each side to surround the œsophagus.† As in the Vertebrates, the nervous cord of insects is composed of two distinct columns of fibres placed one upon the other. "The under or *external* column, which is nearest to the exterior of the body, is that in which the ganglia, or enlargements, are situated. The upper one, or that which is *internal* and nearest to the viscera, is entirely without ganglia, and passes directly over the ganglia of the under column without forming part of them, but in very

* Bennet on the Anatomy of the Thorax in Insects, and its Function during Flight. Zoölogical Journal, vol. i, p. 394.

† The brain of insects is formed of several pairs of ganglia, corresponding, probably, to the number of primitive segments composing the head. The nervous cord is thus, in the head, massed together and compacted to form a brain.

FIG. 43. Nervous System of *Corydalus cornutus*. *a*, "cerebrum;" *b*, "cerebrellum;" *c*, thoracic ganglia, which distribute a nerve to each leg; *d*, eight pairs of abdominal ganglia. The dotted lines represent the wings.—*From Leidy.*

close approximation to them." Newport also believes that the ganglionless upper, or internal, column of fibres is analogous to the *motor* column of Vertebrata, while the external, or under one, corresponds to the *sensitive* column, thus representing the cerebro-spinal system of the Vertebrata.

From each pair of ganglia are distributed special nerves to the various organs. In the larva of *Sphinx* the normal number of double ganglia is thirteen, and the nervous cord of the Neuroptera and other lowly organized and attenuated forms of insects corresponds in the main to this number. In the adult insect, especially in the Coleoptera, Diptera, Lepidoptera, and Hymenoptera, the three thoracic ganglia are fused together, following the fusion and general headwise development of the segments of the tegument. Besides the central nervous cord, corresponding to the spinal cord of the Vertebrates, there is a *vagus*, or *visceral nerve*, representing the sympathetic nerve of higher animals. This nerve "arises, in the larva, from the anterior part of the cerebrum, and, forming a ganglion on the upper surface of the pharynx, always passes backward beneath the brain, along the middle line of the œsophagus." In its microscopic structure the nervous cord, like that of Vertebrata, consists of a central "white" substance, and an outer or peripheral part, the "gray" substance.

In the embryo the ganglia are very large and close together, the commissures, or connecting filaments being very short, and small in proportion.

ORGANS OF NUTRITION. These consist of the alimentary canal and its appendages, or accessory glands (Fig. 44). We have already treated of the external appendages (mouth-parts) which prepare the food for digestion. The simplest form of the alimentary canal is that of a straight tube. In the larva of *Stylops*, and the sedentary young of Bees it ends in a blind sac, as they live on liquid food and expel no solid excretions. When well developed, as in the adult insect, it becomes a long convoluted thick muscular tube, subdivided into different parts which perform different functions and have distinct names, taken from analogous organs in the vertebrate animals. This digestive tube is composed of three coats, the outer, or *peri-*

toneal; the middle, or *muscular;* and the inner, or *mucous.* The mucous coat is variously modified, being plaited or folded; or,

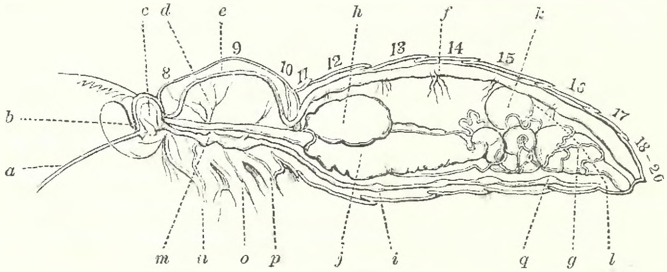


Fig. 44.

as in the Orthoptera and carnivorous Coleoptera, it is solidified and covered with rows of strong horny teeth, forming a sort of gizzard. The alimentary canal is held in place by retractor muscles, but principally by exceedingly numerous branches of the main tracheæ.

This canal (Fig. 45) is subdivided into the *mouth* and *pharynx*, the *œsophagus*, supplementary to which is the *crop*, or "sucking stomach" of Diptera, Lepidoptera, and Hymenoptera. The *proventriculus*, or gizzard; the *ventriculus*, or true stomach succeed, and the intestine consists of the *ileum*, or short intes-

FIG. 44. Anatomy of *Sphinx ligustri.* *m*, *i*, *q*, the nervous cord resting on the floor of the body; at *c*, the ganglia form a brain-like organ, much larger than the ganglia of the thorax (*m*) and abdomen (*q*). From the brain is sent off the subœsophageal nerve which surrounds the gullet into which the food is conveyed by the maxillæ, or spiral tongue (*a*), which, when at rest, is rolled up between the labial palpi (*b*).

From the nervous cord is also thrown off a pair of nerves to each pair of legs (as at *n*, *o*, *p*) and a branch, *d*, is sent off from above, distributing nerves to the muscles of flight.

The heart, or dorsal vessel (*e*, *f*), lies just beneath the median line of the body, and is retained in place by muscular bands (as at *f*) as well as by small tracheal branches.

The alimentary canal (*h*, *j*, *g*), forms a straight tube in the head and thorax; *h*, the crop, or sucking stomach, which opens into the œsophagus; *j*, the true, chyle-forming stomach, which contracts posteriorly, and then dilates near its anal outlet into a *cloaca* (indicated at *g*, but not distinctly, as it is concealed by the numerous urinary vessels). The urinary vessels also indicated at *g*, form long tubes (which correspond to the kidneys of Vertebrates), opening into the pyloric end of the stomach. The position of the testes (*k*) is the same as that of the ovary, and the dotted line *l* shows the course of the efferent duct (*vas deferens*) and also of the oviduct of the female.

The numerals indicate the number of segments of the body, which in the Lepidoptera, consists of twenty, the 21st, or 11th abdominal, being absent.—*From Newport.*

tine, and the *colon* and *rectum*. The latter part, as well as the crop and proventriculus, is sometimes absent.

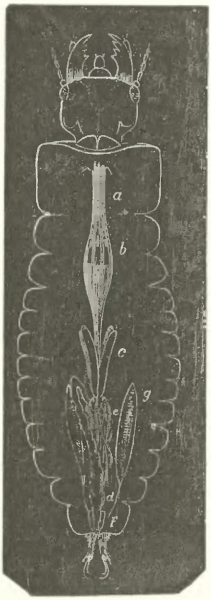


Fig. 45.

Of the *appendages of the canal*, the first are the *salivary glands*, which are usually long simple tubes, which in the larva, according to Newport, form the *silk vessels*. They "empty themselves by a single duct through the spinneret on the floor (labium) of the mouth." In the Ant-lion (*Myrmeleon*) the silk is spun from "a slender telescopic-like spinneret, placed at the extremity of its body," and Westwood also states that the larva of *Chrysopa* spins a cocoon "from the spinneret, at the extremity of the body."

These silk glands when taken out of the larva, just as it is about ready to transform, are readily prepared as "gut" for fish-lines, etc., by drying on a board.

In the Bees these glands are largely developed to produce a sufficient amount of salivary fluid to moisten the dry pollen of flowers, before it enters the œsophagus. "Bee-bread" consists of pollen thus moistened and kneaded by the insect. The Honey-bee also dissolves, by the aid of the salivary fluid, the wax used in making its cells. Newport believes this fluid is alkaline, and forms a solvent for the otherwise brittle wax, as he has seen this insect "reduce the perfectly transparent thin white scales of newly secreted wax to a pasty or soapy consistence, by kneading it between its mandibles, and mixing it with a fluid from its mouth, before applying it to assist in the formation of part of a new cell."

Insects have no true *liver;* its functions being performed "by the walls of the stomach, the internal tunic of which is composed of closely-aggregated hepatic cells." (Siebold.) In the Spiders and Scorpions, however, there is a liver distinct from the digestive canal. In the Spiders it is very large, enveloping most of the other viscera.

FIG. 45. Alimentary tube of *Corydalus cornutus*. *a*, œsophagus; *b*, proventriculus; *c*, ventriculus; *d*, large intestine; *e*, urinary tubes; *f*, cœcum; *g*, testis or ovary.—*From Leidy.*

Siebold states that in some insects the ileum has glandular appendages whose product is perhaps analogous to the *pancreatic fluid*. In the larva of insects is found the *corpus adiposum*, or fat-body, in the form of large lobes of fat-cells which spread through the intervals of the viscera in the general cavity of the body. It is interpenetrated and retained in place by numerous tracheæ.

THE CIRCULATORY SYSTEM. The vascular, or circulatory, system is not a closed sac as in the Worms and Vertebrates. The organs of circulation consist of a contractile, articulated dorsal vessel, or so-called "heart," which terminates in a cephalic aorta. The dorsal vessel receives the veinous current through the lateral valvular openings and pumps the blood into its prolongation or cephalic aorta, whence it escapes, traversing the body in all directions, in regular currents, which do not have, however, vascular walls. "In this way, it penetrates the antennæ, the extremities, the wings, and the other appendages of the body, by arterial currents, and is returned by those of a veinous nature. All the veinous currents empty into two lateral ones, running towards the posterior extremity of the body, and which enter, through lateral orifices, the dorsal vessel." (Siebold.)

"The *blood* of the Insecta is usually a colorless liquid, though sometimes yellowish, but rarely red. In this liquid are suspended a few very small, oval, or spheroidal corpuscles, which are always colorless, have a granular aspect, and are sometimes nucleated.

"The *dorsal vessel*, which is constricted at regular intervals, is always situated on the median line of the abdomen, being attached to the dorsal wall of its segments by several triangular muscles whose apices point outwards. Its walls contain both longitudinal and transverse fibres, and, externally, are covered by a thin peritoneal tunic. Internally, it is lined by another very fine membrane, which, at the points of these constrictions, forms valvular folds, so that the organ is divided into as many chambers as there are constrictions. Each of these chambers has, at the anterior extremity on each side, a valvular orifice which can be inwardly closed. The returning blood is accumulated about the heart and enters into it during the diastole of each of its chambers, through the lateral orifices (Fig. 46 *i*). It then passes, by the regularly successive

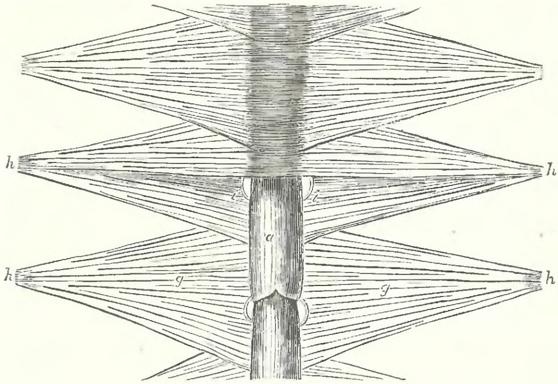


Fig. 46.

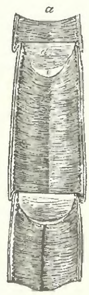


Fig. 47.

contractions of the heart, from behind forwards into the aorta, which is only a prolongation of the anterior chamber. This aorta consists of a simple, small vessel, situated on the dorsal surface of the thorax (Fig. 44 *e*, *f*), and extending even to the cephalic ganglion, where it either ends in an open extremity, or divides into several short branches which terminate in a like manner. The length of the dorsal vessel depends, in all the three states of insects, upon that of the abdomen. The number of its chambers is very variable, but is, most usually, eight.

"The blood, after leaving the aorta, traverses the body in currents which are also extravascular, and in this way bathes all the organs. The newly-prepared nutritive fluid passes through the walls of the digestive canal in which it is found, into the visceral cavity, and thence directly into the blood. Latterly, this extravascular circulation has been called in question, but its presence may be easily and directly observed

FIG. 46. Part of the dorsal vessel or heart of *Lucanus cervus*; *a*, the posterior chambers (the anterior chambers are covered by a part of the ligaments which hold the heart in place). *i*, the auriculo-ventricular openings; *g*, *g*, the lateral muscles fixed by the prolongations *h*, *h*, to the upper side of the abdomen.—*From Straus Durckheim.*

FIG. 47. Interior of the dorsal vessel; *a*, the inner walls with their circular fleshy fibres; *c*, the auriculo-ventricular opening; with its semilunar valve (*c*), in front of which is *d*, the interventricular valvule.—*From Straus Durckheim.*

with very many perfect Insecta and their larvæ. The vascular walls, supposed to have been seen at certain points, are, undoubtedly, the result of some error of observation or interpretation. This is also true of the pulsatile organs supposed to have been observed in the legs of many water-bugs, and which were thought to affect the circulation."

Blanchard and Agassiz believe in a "peritracheal circulation," and other observers agree that the course of the circulation is along the tracheæ, *i.e.* that the blood circulates in the space between the loose peritoneal envelope and the trachea itself. Professor H. J. Clark objects to this view that the blood disks are too large to pass through such an exceedingly minute space as the distance between the trachea and its enveloping, or peritoneal, wall.

Newport thinks that there are actual blood vessels distributed from the heart and "passing transversely across the dorsal surface of each segment in the pupa of *Sphinx*. If they be not vessels distributed *from* the heart, it is a somewhat curious circumstance that the whole of the blood should be first sent to the head of the insect, and the viscera of the abdominal region be nourished only by the returning blood, which has in part passed the round of the circulation."

Newport also describes in *Sphinx* the *supra-spinal*, or great ventral vessel which lies in the abdomen just over the nervous cord, and which is also found in the Scorpion and Centipede. He believes "this vessel to be the chief means of returning the blood from the middle and inferior portion of the body to the posterior extremity of the dorsal vessel or heart." He strongly suspects that anteriorly this great ventral vessel is connected with the aorta. The circulation of Insects, therefore, is probably as much a closed one as in the Myriapods, for he states that the "blood certainly flows in distinct vessels, at least in some parts of the body in perfect insects, and that vessels exist even in the larva." Observations on the vascular system are exceedingly difficult from the delicate structure of the vessels, and the subject needs renewed observations to settle these disputed points.

The blood is forced through the vessel into the body by regular pulsations. Herold counted thirty to forty in a minute in a full-grown caterpillar; we have counted about sixty a minute in the recently hatched larva of *Diplax*. During excitement, the number of pulsations increases in rapidity. Newport found the pulsations in a bee, *Anthophora*, when quiet, to be eighty a minute; but when "the insects were quite lively, and had been exposed to the sun for an hour or two, the number of pulsations amounted to one hundred and forty."

He found that the *number* of pulsations decreased after each moult of the larva of *Sphinx ligustri*, but increased in *force;* when it was full grown and had ceased feeding it was thirty. "After it had passed into the pupa state the number fell to twenty-two, and afterwards to ten or twelve, and, during the period of hibernation, it almost entirely ceases; but in the perfect insect it rose from forty-one to fifty, and when excited by flight around the room it was from one hundred and ten to one hundred and thirty-nine."

Organs of Respiration. All insects breathe air, or, when they live in the water, respire, by means of branchiæ, the air mixed mechanically with water. Respiration is carried on by an intricate system of tubes (pulmonary tracheæ) which open by pores (spiracles or stigmata) in the sides of the body; or, as in aquatic insects, by branchiæ, or gill-like flattened expansions of the body-wall penetrated by tracheæ (branchial tracheæ).

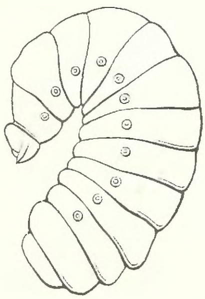


Fig. 48.

There are sometimes eleven spiracles, or breathing-holes (Fig. 48), on each side of the body; each consisting of an oval horny ring situated in the peritreme and closed by a valve, which guards the orifice (Fig. 49). Within this valve is a chamber closed within by another valve which covers the entrance into the tracheæ. The air-tube itself (Fig. 50) consists of "an external

Fig. 48. Larva of the Humble-bee just beginning to change to a pupa, showing eleven pairs of stigmata. In the adult bee, only the fourth pair is apparent, the remaining pairs being concealed from view, or in part aborted. In most insects there are usually only nine pairs of stigmata. — *Original.*

serous, and an internal mucous membrane, inclosing between them a spirally convoluted fibre, thus giving great strength and flexibility to the tube."

Nearly all the air enters through the thoracic and first abdominal spiracles, so that on pinching most insects on the thorax they can be easily deprived of breath and killed.

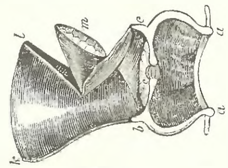


Fig. 49.

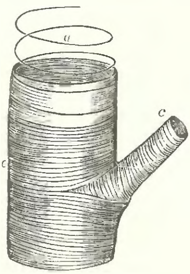


Fig. 50.

"In some aquatic larvæ such as those of *Dyticidæ*, *Eristalis* (Fig. 51, pupa), and *Ephydra*, and also in some perfect insects, as in *Nepa* and *Ranatra*, the parts supporting the stigmata are prolonged into slender tubes, through which the insect, on rising to the surface, breathes the atmospheric air.

Agrion (Fig. 52) affords a good instance of branchiæ or gill-like expansions of the crust, or skin. It is supposed that these false gills, or branchiæ, "absorb the air from the water, and convey it by the minute ramifications of the tracheal vessels, with which they are abundantly supplied, and which terminate in single trunks, into the main tracheæ, to be distributed over the whole body, as in insects which live in the open atmosphere." (Newport.)

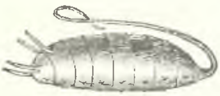


Fig. 51.

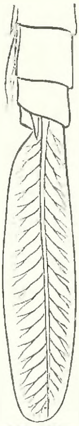


Fig. 52.

Of branchiæ there are three kinds. The first, as in the larvæ and pupæ of Gnats, consist of slender filaments arranged in tufts arising from a single stem. In the larva of *Gyrinus* and the aquatic caterpillar of a moth,

FIG. 49. Chamber leading into the trachea; *a*, *a*, external valve protecting the outer opening of the stigma, or breathing hole; *b*, *c*, *c*, inner and more complicated valve closing the entrance into the trachea (*l*, *k*); *m*, conical occlusor muscle closing the inner orifice.— *From Straus Durckheim.*

FIG. 50. Portion of a trachea divested of its peritoneal envelope. *a*, spirally convoluted fibre, closely wound around the trachea, as at *c*; *c*, origin of a secondary tracheal branch.— *From Straus Durckheim.*

FIG. 52. One of the three gill-like appendages to the abdomen of the larva and pupa of *Agrion* enlarged, consisting of a broad leaf-like expansion, permeated by tracheæ which take up by endosmosis the air contained in water.— *Original.*

Hydrocampa stratiolata, they form short stiff bristles placed along the side of the body. *Agrion* and *Ephemera*, in their larval stages, afford the second kind of branchiæ, and *Libellula* the third kind, or internal gill, situated in the colon. The Mosquito breathes both by branchiæ which form large club-shaped organs, and by lateral filaments.

In those insects that fly, most of the tracheæ are often dilated into *air-vesicles*, so that by filling and emptying them of air the insect can change its specific gravity. That their use is also to lighten the body is shown by their presence in the heavy mandibles and head of the male of *Lucanus cervus*. In the adult Humble-bee there are two very large vesicles at the base of the abdomen. These vesicles are not found in the larvæ, or in the adult forms of creeping insects.

The *act of respiration* consists in the alternate dilation and contraction of the abdominal segments, the air entering the body chiefly at the thoracic spiracles. As in the Vertebrates the frequency of the acts of breathing increases after exertion. "When an insect is preparing itself for flight, the act of respiration resembles that of birds under similar circumstances. At the moment of elevating its elytra and expanding its wings, which are, indeed, acts of respiration, the anterior pairs of spiracles are opened, and the air rushing into them is extended over the whole body, which, by the expansion of the air-bags, is enlarged in bulk, and rendered of less specific gravity; so that when the spiracles are closed at the instant the insect endeavors to make the first stroke with and raise itself upon its wings, it is enabled to rise in the air, and sustain a long and powerful flight with but little muscular exertion. In the pupa and larva state respiration is performed more equally by all the spiracles, and less especially by the thoracic ones."

During hibernation the act of breathing, like the circulation of the blood, almost entirely ceases, and the heat of the body is greatly lowered. Indeed Newport has shown that the *development of heat* in Insects, just as in Vertebrates, depends on the "quantity and activity of respiration, and the volume and velocity of the circulation." The Humble-bee, according to Newport, possesses the *voluntary power* of generating heat by breathing faster. He says, confirming Huber's observations, "the manner in which the bee performs her incubatory office is by placing herself upon the cell of a nymph (pupa) that is soon to be developed, and then beginning to respire at first very gradually. In a short time the respirations become more and more frequent, until at length they are increased to one hundred and twenty, or one hundred and thirty per minute. The body of the insect soon becomes of a high temperature, and, on close inspection, is often found to be bathed with perspiration. When this is the case the temperature of the insect soon becomes reduced, and the insect leaves the cell, and another bee almost immediately takes her place. When respiration is performed less violently, and consequently less heat is evolved, the same bee will often continue on a cell for many hours in succession. This extreme amount of heat was evolved entirely by an act of the will in accelerating the respiratory efforts, a strong indication of the relation which subsists between the function of respiration and the development of animal heat."

ORGANS OF SECRETION. The urinary vessels, or what is equivalent to the kidneys of the higher animals, consist in Insects of several long tubes which empty by one or two common secretory ducts into the posterior or "pyloric" extremity of the stomach. There are also *odoriferous glands*, analogous to the cutaneous glands of vertebrates. The liquid poured out is usually offensive, and it is used as a means of defence. The Bees, Wasps, Gall-flies, etc., and Scorpions, have a poison-sac (Fig. 54 *g*) developed in the tip of the abdomen. The bite of the Musquito, the Horse-fly, and Bed-bug is thought by Newport to be due to the simple act of thrusting their lancet-like jaws through the skin, and it is not known that these and other insects which bite severely eject any poison into the wound. But in the spiders a minute drop of poison exudes from an orifice at the end of the mandibles, "which spreads over the whole wound at the instant it is inflicted." This poison is secreted by a gland lodged in the celphalo-thorax, and which is thought by Audouin to correspond in position to the salivary apparatus and the silk glands of the Winged Insects.

ORGANS OF GENERATION. We have already described the external parts. The internal parts of the male insect consist, first, of the *ductus ejaculatorius*, which opens into the external intromittent organ. This duct extends backwards, connecting with the *vesiculæ seminales*, which lead by the *vasa differentia* to the *testes* (Fig. 53). The latter are usually rounded glandular bodies, sometimes, as in *Melolontha* and *Lucanus*, numbering six on a side. These organs lie in the abdominal cavity, usually above and on each side of the alimentary canal.

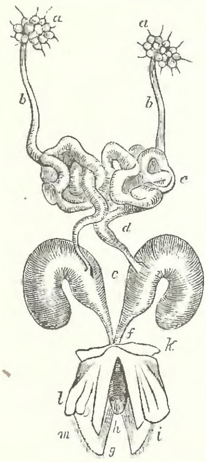


Fig. 53.

The sperm, or fertilizing fluid, contains very active spermatic particles which are developed in large cells in the testes, where they are united into bundles of various forms.

In the female, the internal reproductive organs (Fig. 54) are more simple than those of the other sex. The external opening of the female is situated at the end of the oviduct, that leads by two tubes to the ovary, which consists of two or more tubes (in the Queen Bee one hundred and sixty to one hundred and eighty) in which the ova are developed. On the upper side

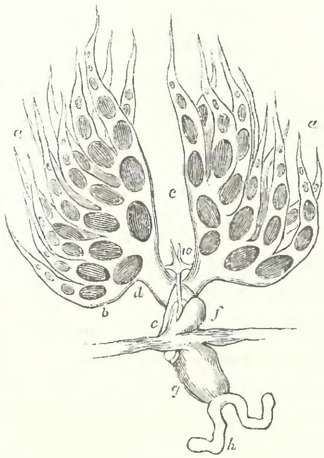


Fig. 54.

FIG. 53. Male organs of *Athalia centifoliæ*. *h*, the penis, or external portion, in which the *ductus ejaculatorius* (*f*) terminates, which extends backwards, and is connected with the *vesiculæ seminales* (*e*), and *vasa differentia* (*d*) which are connected with the *epididymis* (*b*), and the *testes* (*a*). *i* and *l*, two pairs of horny plates, surrounded by a horny ring (*k*). *i*, horny prehensile hooks attached to *k*. *m*, two elongated muscular parts inclosing the penis (*h*). — *From Newport.*

FIG. 54. Female organs of generation of *Athalia centifoliæ*. *a*, *b*, *c*, the eighteen ovarial tubes originating from each of the two oviducts (*e*), and containing the immature eggs; *f*, the spermatheca; *g*, poison-sac, the poison being secreted in the secretory vessels *h*. The poison flows through the oviduct into the sting and thence into the wound made by the sting. 10, the terminal ganglia of the nervous cord. — *From Newport.*

of the oviduct are from one to five appendages, the most important of which is the *spermatheca* (the others being sebaceous glands), which receives the fertilizing fluid of the male during sexual union, and in which, according to Darwin, the male element "is enabled to keep alive four or five years."

Insects bisexual. With the exception of the *Tardigrades*, which are doubtfully referred to the Mites (*Acarina*), there are no hermaphrodites among Insects, that is, there are no individuals having both male and female organs, and capable of self-impregnation. On the contrary, the sexes are distinct; Insects are bisexual.

Hermaphrodites, so-called. Cases not unfrequently occur in which from arrest of development of the embryo, the sexual organs are imperfectly developed, so as to present the appearance of being both male and female. "Siebold has investigated some hermaphrodite Honey-bees belonging to the Italian race, obtained from a Dzierzon hive at Constance. He found in many of them a combination of sexual characters, not only in the external parts, but also in the generative organs. The mixture of the external characters is manifested sometimes only in the anterior or posterior part of the body, sometimes in all parts of the body, or only in a few organs. Some specimens present male and worker characters on the two sides of the body. The development of the internal organs is singularly correlated with these peculiarities of external organization. The sting, with its vesicle and gland, is well developed in hermaphrodites with the abdomen of the worker; soft in those with the drone-abdomen. The seminal receptacle, when present, is empty. The ovaries contain no ova. In the hermaphrodites with the drone-abdomen, the male sexual organs are well developed, and the testes contain spermatozoids. Frequently with testicular and ovarian organs present on each side, the epididymis and copulatory apparatus are well developed, and an imperfect poison-apparatus exists. In these cases the tube contains spermatozoids, but there are no ova in the ovaries. The hermaphrodites are thrown out of the cell by the workers as soon as they emerge, and speedily perish. Siebold ascribes the production of these hermaphrodites to an imperfect fecundation of the ovum." (Zeitschrift für Wissenschaftliche Zoologie, 1864, p. 73. See Günther's Zoölogical Review for 1864.)

Mr. Dunning describes a specimen of *Fidonia piniaria*, "which was sexually a female, and the abdomen was apparently distended with eggs; the general color was midway between the colors of the ordinary male and female, but the size and markings were those of the male. (Transactions Entomological Society, London, Aug. 7, 1865.) Professor Westwood states that "he had an Orange-tip Butterfly (*Anthocharis cardamines*), which was female in every respect, except that on the tip of one fore-wing were about a dozen of the bright orange scales which characterize the male."

THE EGG. Professor H. J. Clark (Mind in Nature) defines an egg to be a globule surrounded by the vitelline membrane, or yolk-envelope, which is protected by the *chorion*, or egg-shell, consisting of "two kinds of fluid, *albumen* and *oil*, which are always situated at opposite sides or poles." "In the earliest stages of all eggs, these two poles shade off into each other," but in the perfectly developed egg the small, or albuminous pole, is surrounded by a membrane, and forms the Purkinjean (germinal) vesicle; and thirdly and last, the innermost of the three globules is developed. This last is the Wagnerian vesicle, or *germinal dot*. The oily matter forms the *yolk*. Thus formed, the egg is the *initial animal*. It becomes an animal after contact with the male germs (unless the product of organic reproduction), and the egg-shell or chorion is to be considered as a protection to the animal, and is thrown off when the embryo is hatched, just as the larva throws off its skin to transform into the pupa. So that the *egg-state* is equivalent to the larva state, and hence there are four stages in the life of an insect, *i. e.* the egg, the larva, the pupa, and the imago, or adult state.

The egg is not always laid as a perfect egg (Clark). It sometimes, as in the Ants, continues to grow after it is laid by the parent, like those of frogs, which, according to Clark, "Are laid before they can hardly be said to have become fully formed *as eggs*." Again, others are laid some time after the embryo has begun to form; and in some, such as *Melophagus* and *Braula*, the larva is fully formed before it is expelled from the oviduct.

Eggs are usually small in proportion to the size of the parent; but in many minute forms (*i.e. Pulex*, *Pediculus*, etc.) they are proportionately much larger. In shape eggs are either spherical or oblong. In some there are radiating appendages at one end, as in those of *Nepa* and *Ranatra*; or they are provided with a single stalk, as in *Chrysopa*, *Cynips*, and *Ophion*.

The eggs of most Hymenoptera, Diptera, and many Coleoptera are usually cylindrical; those of Lepidoptera are more generally spherical. The eggs of the Mosquito are laid in a boat-shaped mass, which floats on the surface of quiet pools, while those of the *Chrysopa*, or Lace-winged Fly (Fig. 55), are supported on long pedicels. They are almost invariably laid near or upon objects destined to be the food of the future larva. Thus the *Copris*, or "Tumble-bug," places its egg in a ball of dung which it rolls away to a secure place; the Flesh-fly oviposits on meat; and all vegetable-feeders lay their eggs on the food-plant where the larva, upon its exit from the egg, shall readily find an ample supply of food.

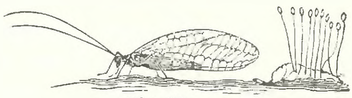


Fig. 55.

The posterior end of the egg is more often the fixed one, and it may thus be distinguished from the anterior pole. In the eggs of some Diptera and Orthoptera, the ventral side of the embryo, according to Gerstaecker, corresponds to the convex side of the egg, and the concave side of the latter corresponds to the dorsal region of the embryo.

The surface of the chorion, or egg-shell, which is dense and brittle, is often covered by a mosaic-work of more or less regular facets. In many small eggs the surface is only minutely granulated, or ornamented with ribs and furrows, as in those of many Butterflies.

The Micropyle. On the anterior end (though sometimes at both ends) of the egg is one or more pores of exceeding minuteness, through which the spermatozoa (more than one of which, according to Darwin, is requisite to fertilize an ovule) enter to fertilize the egg-contents. In some cases these micropyles are scattered over the whole surface of the egg. Fig. 56 *a* represents the micropyles of *Nepa cinerea*, consisting of a whorl of long bristles. Those of *Locusta viridissima* (Fig. 56 *b*) slightly resemble toodstools. Fig. 56 *c* represents the anterior pole of the egg with the micropyles of *Pyrhocoris apterus*. — (*From Gerstaecker.*)

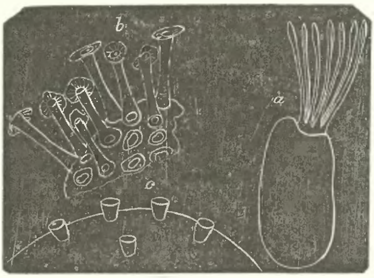


Fig. 56.

This contact of a male sperm-cell with the yolk is the fertilization of the egg. From this moment begins the life of the embryo. Fertilization of the female germ by means of the male sperm, through the congress of the sexes, is the rule with bisexual animals, but there are exceptions among insects. An embryo may start into being without the interposition of the male; to this mode of generation has been applied by Leuckart the term *Parthenogenesis*. Among certain species of insects there are some individuals which, by a sort of budding process, and without the aid of the male element, throw off summer broods, consisting of "asexual" individuals, which, as winter approaches, are succeeded by a brood of true males and females, the latter of which lay eggs. This phenomenon, called by Steenstrup "alternation of generations," has been observed among a comparatively few species, and the apparent design of such an anomalous mode of reproduction is to afford an immense number of individuals, thus providing for the continuance of the species. The individuals in whom this budding process takes place are called "asexual" because, though they may resemble the female sex outwardly, their sexual organs are only partially developed. This budding process is the same in kind with that observable in the Jelly-fish, which throw off by parthenogenesis, or alternations of generations, summer broods of immense extent, but in winter propagate by true eggs. Huxley has studied the development of Aphis by parthenogenesis, the anomalous nature of which has previously been discovered by Bonnet, Trembly, Lyonet, Degeer, Kyber, and others, and arrives at the following conclusions:

"1. Ova deposited by impregnated female *Aphides* in autumn are hatched in the spring.

2. From these ova viviparous, and, in the great majority of cases, apterous forms proceed.

3. The broods to which these give rise are either winged or apterous, or both.

4. The number of successive broods has no certain limit, but is, so far as we know at present, controlled only by temperature and the supply of food.

5. On the setting in of cold weather, or in some cases on the failure of nourishment, the weather being still warm, males and oviparous females are produced.

6. The males may be either winged or apterous.

7. So far as I am aware, there is no proof of the existence of any exception to the law that the oviparous female is apterous.

8. Viviparous *Aphides* may hybernate, and may co-exist with oviparous females of the same species." (Linnæan Transactions, xxii, p. 198.)

The origin of the viviparous, asexual, or *agamic* (from the Greek *a*, without; *game*, marriage) individual, as it may be more properly called, is, up to a certain stage, the same as that of the true egg, *i.e.* until the germ (*pseudovum*) of the former is detached from the false ovary (pseudovarium). "From this point onwards, however, the fate of the pseudovum is different from that of the ovum. The former begins at once to be converted into the germ; the latter accumulates yelk-substance, and changes but little. Both bodies acquire their membranous investment rather late; within it the pseudovum becomes a living larva, while the ovum is impregnated, laid, and remains in a state of rest for a longer or shorter period.

"Although, then, the pseudovum and the ovum of *Aphis* are exceedingly similar in structure for some time after they have passed out of the condition of indifferent tissue, it cannot be said that the sole difference between them is, that the one requires fecundation and the other not. When the ovum is of the size of a pseudovum which is about to develop into an embryo, and, therefore, long before fecundation, it manifests its inherent physiological distinctness by becoming, not an embryo, but an ovum. Up to this period the influence of fecundation has not been felt; and the production of ova, instead of pseudova, must depend upon a something impressed upon the constitution of the parent before it was brought forth by its viviparous progenetrix." (Huxley.)

Siebold has also shown that the "ova of the Queen-bee produces females or males, according as they are fecundated or not. The fecundated ovum produces a queen or a neuter according to the food of the larva and the other conditions to which it is subjected; the unfecundated ovum produces a drone." This is analogous to the agamic reproduction of Aphis, and "demonstrates still more clearly the impossibility of drawing any absolute line of demarcation histologically between ova and buds."

This process of reproduction is not known in the Myriapods. It occurs among the mites (*Acarina*), and occurs in isolated genera of Hemiptera (*Aphis*, *Chermes*, *Lecanium*, and *Aspidiotus* according to Gerstaecker).

Among Lepidoptera the Silk-moth sometimes lays fertile eggs without previous sexual union. This very rarely happens, for M. Jourdain found that, out of about 58,000 eggs laid by unimpregnated silk-moths, many passed through their early embryonic stages, showing that they were capable of self-development, but only twenty-nine out of the whole number produced caterpillars. (Darwin.) Several other moths* have been found to lay fertile eggs without previous sexual union, and among Hymenoptera, *Nematus ventricosus*, *Cynips*, *Neuroterus*, perhaps *Apophyllus* (according to Gerstaecker), and *Cynips spongifica* (according to Walsh, Proceedings of

*We give a list from Gerstaecker (Bronn's Classen und Ordnungen des Thierreichs) of all the known cases of agamic reproduction in this suborder, with the number of times the phenomenon has been observed, and the names of the observers.

Sphinx ligustri, once (Treviranus).
Smerinthus populi, four times (Nordmann).
Smerinthus ocellatus, once (Johnston).
Euprepia caja, five times (Brown, etc.).
" *villica*, once (Stowell).
Telea Polyphemus, twice (Curtis).
Gastropacha pini, three times (Scopoli, etc).
Gastropacha quercifolia, once (Basler).
" *potatoria*, once (Burmeister).
Gastropacha quercus, once (Plieninger).
Liparis dispar, once (Carlier).
"*Egger moth*" (? *Liparis dispar*), (Tardy, Westwood).
Liparis ochropoda, once (Popoff).
Orgyia pudibunda, once (Werneburg).
Psyche apiformis, once (Rossi).
" *helix* (Siebold).
Solenobia lichenella (Siebold).
" *triquetrella* (Siebold).
Bombyx mori, several times.

The subject has been also discussed by Siebold in his work entitled, A true Parthenogenesis in Lepidoptera and Bees; by Owen, in his "Parthenogenesis," and by Sir J. Lubbock in the Philosophical Transactions, London, vol. 147, pt. 1.

the Entomological Society of Philadelphia). Parthenogenesis, or agamic reproduction, is, then, the result of a budding process, or cell-growth. This process is a common mode among the Radiates, the low Worms, and the Crustaceans. Metamorphosis is simply a series of marked stages, or periods, of growth; and hence growth, metamorphosis, and agamic reproduction are morphologically identical. All animals, therefore, as well as plants, grow by the *multiplication of cells.*

After hearing the surprising revelations of Bonnet, Reaumur, Owen, Burnett, and Huxley on the asexual mode of generation in the Aphis, we are called to notice still a new phase of reproduction. None of the observers just mentioned were accustomed to consider the virgin aphis as immature, but rather as a wingless *adult* Plant-louse. But Nicolas Wagner, Professor of Zoology at Kasan,* supported by able vouchers for the truth of his assertions, both in Russia and in Germany, who have repeated and thoroughly tested his observations, has observed an asexual reproduction in the *larva* of a Cecidomyian fly, *Miastor metraloas* Meinert, and Meinert has observed it in this species and the *Oligarces paradoxus* Meinert.

Says Dr. R. Leuckart, whose article† we have drawn largely upon in the present account, "This reproduction was said to commence in autumn, to continue through the winter and spring, giving origin, during the whole of this period, to a series of successive generations of larvæ, until, finally, in June, the last of them were developed into perfect and sexually mature animals. The flies, then, as usual, after copulation, lay eggs, and thus recommence the developmental cycle just described."

Professor Leuckart has observed these facts anew in the larvæ of a species of dipterous gall-fly, and which he believes distinct from the Russian species, found under the bark of a half dead apple-tree that was attacked by fungi. The young are developed within the body of the larva-like parent from a

*K. E. Von Baer, "Report on a New Asexual Mode of Reproduction observed by Professor Wagner in Kasan." Bull. Acad. St. Petersburg, 1863, pt. vi, p. 239. Also, Wagner in the Journal of the University of Kasan, 1861.

†On the Asexual Reproduction of Cecidomyia Larvæ. Annals and Magazine of Natural History, March, 1866. Translated from Zeitschrift für Wissenschaftliche Zoologie, Bd. xiv.

"germ-ball" essentially agreeing with the ovary, and the asexual larvæ begin life as egg-like bodies developed from this germ-ball, just as eggs are developed in the little tubes of which the ovary is an aggregation. Hence these worms *bud* out from the germ-stock, just as we have seen in the case of the Aphides. Leuckart and Wagner farther agree, that "the so-called chorion never being formed in either of them, the vitellus [yolk] remains without that envelope which has so remarkable and peculiar a development in the true egg of insects." . . . . "The processes of embryo-formation agree in all essential points with the ordinary phenomena of development in a fecundated egg, exactly as has been proved (by Huxley) to be the case in the *Aphides*." . . . . "The only difference consists in the germ-chambers of the Cecidomyide larvæ separating from the germ-stock, and moving about freely in the cavity of the body, whilst in the Aphides they remain permanently attached, and constitute an apparatus which, in its form and arrangement, reproduces the conditions of the female organs."

Thus we can neither pronounce these so-called *larvæ* to be larvæ so long as they produce young, neither are they actual males or females; they are what Leuckart calls *asexual* forms, which produce false-eggs (pseudova of Huxley, as restricted by Leuckart). This is paralleled by the asexual Aphides, and among Hymenoptera by the worker Ants, and worker, or, as they were formerly called, neuter Bees, the latter of which have been known to produce young without the interposition of the male; thus the two sexes, at least the females, are *dimorphic*, *i. e.* for certain exigencies of life they are specialized into two distinct forms, one (as in the asexual *Aphis*) to produce an unlimited number of young during the summer; the other and sexual, normal form to produce in the autumn a comparatively limited number of eggs.

Dimorphism is intimately connected with agamic reproduction. Thus the asexual Aphis, and the perfect female, may be called dimorphic forms. Or the perfect female may assume two forms, so much so as to be mistaken for two distinct species. Thus *Cynips quercus-spongifica* occurs in male and female broods in the spring, while the fall brood of females were described as a separate species, *C. aciculata.* Mr. B. D. Walsh considers the two sets of females as dimorphic forms, and he thinks that *O. aciculata* lays eggs which produce *C. quercus-spongifica.*

Huber supposes there are two sizes of the three forms (*i. e.* male, female, and worker) of *Bombus*, one set being a little larger than the other.

Alfred Wallace has discovered that there are two forms of females of *Papilio Memnon* of the East Indies; one is normal, having its wings tailed and resembles a closely allied species, *Papilio Coon*, which is not dimorphous, while the other is tailless, resembling its tailless male. *Papilio Pammon* has three sorts of females, and is hence "trimorphic." One of its forms predominates in Sumatra, and a second in Java, while a third, (described as *P. Romulus*) abounds in India and Ceylon. *P. Ormenus* is trimorphic, as Mr. Wallace obtained in the island of Waignion, "a third female quite distinct from either of the others, and in some degree intermediate between the ordinary male and female." Much the same thing occurs in the North American *P. Turnus. Papilio Glaucus* is now known to be a dimorphic form of the former butterfly, both having, according to Mr. Uhler, been bred from the same batch of eggs. The ordinary form of the female of *P. Turnus* occurs north of lat. 37°, while the dimorphic form, *P. Glaucus*, occurs south of 42°.

The male sex also presents dimorphic forms. Mr. Pascoe (Proceedings of the Entomological Society of London, 1862, p. 71) states that there are dimorphic forms of *Anthribidæ;* that they occur in the male of *Stenocerus* and *Micoceros.* Six species of *Dytiscus* have two female forms, the most common having the elytra deeply sulcate, while in the rarer forms the elytra are smooth as in the male.

There is a tendency, we would observe, in the more abnormal of the two sexual forms, to revert to a lower type. Thus the agamic Aphis is more generally wingless, and the tailless female butterfly mimics the members of a lower genus, *Pieris.* The final cause of Dimorphism, like that of agamic reproduction, is the continuance of the species, and is, so far as yet known, an exceptional occurrence.

Mimetic forms. Many insects often resemble, in a remarkable manner, those of other groups. They are called mimetic forms. Insects are related to each other by analogy and affinity. Thus the truly tailless species of *Papilio*, *i. e.* those where the tail is absent in both sexes, are related by affinity to *Pieris*, which has rounded hind wings. They also stand next to *Pieris* in the system of Nature. But there are, on the other hand, mimetic forms, which borrow the features of groups far above them in the natural system. Thus the *Sesia* resembles a Bee, *Bombylius* and *Laphria* resemble *Bombus;* the Syrphus flies are easily mistaken for Wasps. So in the second series of suborders of Insects, *Forficula* resembles the *Staphylinus; Termes* resembles the true Ant; *Psocus*, the *Aphis; Ascalaphus* resembles *Papilio ; Mantispa* recalls the Orthopterous *Mantis*, and *Panorpa* reminds us of the *Tipulæ* (*Bittacus* being strikingly analogous to the Dipterous *Bittacomorpha*). Thus these lower, more variable groups of insects strive, as it were, to connect themselves by certain analogous, mimetic forms, with the more stable and higher groups.

Comprehensive types are mimetic forms which combine the characters of other and generally higher groups. Thus each Neuropterous family contains mimetic forms which ally them strongly with some one of the six other suborders of insects. The early fossil insects are remarkable for combining the characters of groups which appear ages after. The most remarkable comprehensive type is a Carboniferous insect, the *Eugereon Boeckingi* mentioned farther on.

HYBRIDITY. Hybrids are sometimes produced between different species, but though it is known that different genera unite sexually, we know of very few authentic instances of the production of hybrids therefrom. One is related by Mr. Midford, who exhibited at the March 4th (1861) meeting of the London Entomological Society, hybrids produced from a male *Phigalia pilosaria*, and a female *Nyssia hispidaria*. "The males resemble *N. hispidaria*, but in color have the lighter and greener tint and transparency of wing of *P. pilosaria*."

THE DEVELOPMENT OF INSECTS. Immediately after the fertilization of the egg, the first act in the organization of the future embryo is the formation of the germinal layer, or *blastoderm* (from the Greek, meaning primitive skin). This layer is formed at the surface out of a surface-layer of larger, often nucleolated, cells which nearly encompass the yolk-mass. At one point there is a break in this cellular layer, and the yolk granules reach to the surface, so that it appears darker than the other parts of the egg. This cellular layer is soon resolved into the blastoderm, or germinal layer, which thickens and narrows, forming a longitudinal band. This is the first stage of the embryo, which lies as a thin layer of cells upon the outer surface of the yolk. Both ends of the body are alike, and we shall afterwards see that its back lies next to the centre of the egg, its future ventral side looking outwards. The embryo is thus bent on itself backwards.

In the next stage the blastoderm divides into a certain number of segments, or joints, which appear as indentations in the body of the embryo. The head can now be distinguished from the posterior end chiefly by its larger size, and both it and the tail are folded back upon the body of the embryo, the head especially being sunk backwards down into the yolk-mass.

In a succeeding stage, as we have observed in the embryo of *Diplax*, a Dragon-fly (Fig. 57), the head is partially sketched

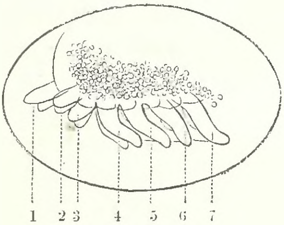


Fig. 57.

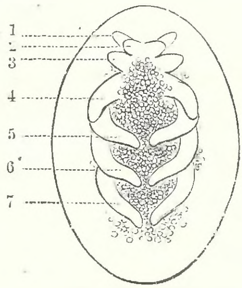


Fig. 58.

out, with the rudiments of the limbs and mouth-parts; and the sternites, or ventral walls, of the thorax and of the two basal rings of the head appear. The anterior part of the head, including the so-called "procephalic lobes" overhangs and con-

FIG. 57. Side view of embryo. The procephalic lobes are not shown. 1, antennæ; 2, mandibles; 3, maxillæ; 4, second maxillæ (labium); 5-7, legs. These numbers and letters are the same in all the figures from 57-60. The under-side (sternum) of six segments are indicated. FIG. 58. Ventral view of the same.

ceals the base of the antennæ. It is probable that more careful observation would have shown the end of the abdomen folded back upon the *dorsal* region, as usual at this period in the embryos of those insects whose embryology has been studied.

The antennæ, mandibles, and maxillæ form a group by themselves, while the second maxillæ (or labium) are very much larger and turned backwards, being temporarily grouped with the legs.

There are traces only of the two basal sterna of the abdomen. This indicates that the basal abdominal segments grow in succession from the base of the abdomen, the middle ones appearing last. The post-abdomen (Fig. 59 A) has probably been developed synchronous with the procephalic lobes, as it is in all insect and crustacean embryos yet observed. As stated by Zaddach, these two lobes in their development are exact equivalents; antero-posterior symmetry is very clearly demarked, the two ends of the body at first looking alike. But in this stage, after the two ends of the body have been evolved from the primitive cell-layer, development in the post-abdominal region is retarded, that of the head progressing with much greater rapidity.

In the next stage (not figured) the yolk is completely walled in, though no traces of segments appear on the back or side of the embryo. The revolution of the embryo has taken place; the post-abdomen being curved *beneath* the body, and the back presenting outwards.

The rudiments of the eyes appear as a darker, rounded mass of cells indistinctly seen through the yolk-granules, and situated at the base of the antennæ. They consist of a few epithelial cells of irregular form, the central one being the largest.

The second maxillæ are a little over twice the length of the first maxillæ and are grouped with the legs, being curved backwards. They are, however, now one-third shorter than the anterior legs. The second maxillary sternum is still visible.

The tip of the abdomen (or post-abdomen) consists of four segments, the terminal one being much the larger, and obscurely divided into two obtuse lobes.

The abdominal sternites are now well marked, and the nervous cord is represented by eight or nine large oblong-square (seen sideways) ganglia, which lie contiguous to each other.

The formation of the eyes, the post-abdomen, the sternites, and median portion of the nervous cord seems nearly synchronous with the closing up of the dorsal walls of the body, though the division of the tegument into segments has not apparently taken place over the yolk-mass.

The succeeding stage (Fig. 59) is signalized by the appearance of the rudiments of the intestine, while the second maxillæ are directed more anteriorly.

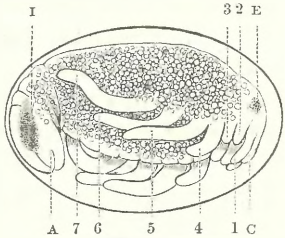


Fig. 59.

In form the body is ovate-cylindrical, and there is a deep constriction separating the post-abdomen from the anterior part of the abdomen.

The terminal (eleventh) ring is immensely disproportioned to its size in the embryo just previous to hatching (see Fig. 61, where it forms a triangular piece situated between its appendages, the anal stylets). At a later period of this stage two more abdominal segments have been added, one to the end of the main body of the abdomen, and another to the post-abdomen. They have been apparently *interpolated* at the junction of the post-abdomen to the abdomen proper. Should this observation be proved to be correct, it may then be considered as a rule that, after reaching a certain number of segments, all additional ones are interpolated between the main body of the abdomen and its terminal segment or segments. This is the law of increase in the number of segments in Worms, and in Myriapods (*Iulus*, according to Newport's observations), in Arachnids (Claparede), and Crustacea (Rathke).

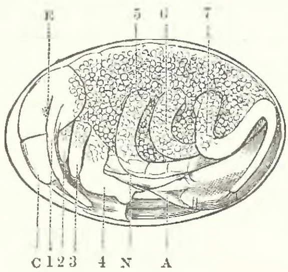


Fig. 60.

The next stage (Fig. 60), is characterized by the differentia-

FIG. 59. An embryo much farther advanced. C, clypeus; E, eye; A, bi-lobed extremity of the abdomen; I, the rudiments of the intestines.

tion of the head into the rudiments of the ophthalmic ring, and the supraclypeal piece, and clypeus, together with the approximation of the second pair of maxillæ, which, when united, form the labium, the extremities of which are now situated in the middle of the body.

The antennæ now extend to the middle of the labium, just passing beyond the extremities of the mandibles and maxillæ. The œsophagus can now be seen going from the mouth-opening situated just beneath the labium. It curves around just behind the eyes. There are at this period no appearances of movable blood-disks or of a dorsal vessel.

The abdomen is now pointed at the extremity and divided into the rudiments of the two anal stylets, which form large, acute tubercles. The yolk-mass is now almost entirely inclosed within the body walls, forming an oval mass.

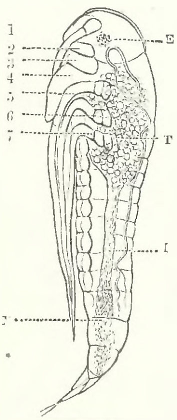


Fig. 61.

Another embryo, observed July 27th, had reached about the same stage of growth. The front of the head, including the antennary segment, is farther advanced than before. The entire head is divided into two very distinct regions; *i. e.* one *before* the mouth-opening (the *preoral* region, including the *ocellary*, or first and second segments; the *ophthalmic*, or third segment, and *antennary*, or fourth segment of the head); and the other *behind* the mouth (*postoral*, consisting of the *mandibular*, or fifth segment, the *first maxillary*, or sixth segment, and the *second maxillary*, or *labial*, being the seventh and last cephalic ring.

At a later period the embryo is quite fully formed, and is about ready to leave the egg. The three regions of the body are now distinct. The articulations of the tergum are present, the yolk-mass being completely inclosed by the tergal walls.

FIG. 61. The embryo taken from the egg, but nearly ready to hatch. T, the dotted line crosses the main trachea, going through the yolk-mass, now restricted to the thoracic region. At X, the tracheæ send off numerous branches around an enlargement of the intestine (colon), where the blood is aerated; better seen in fig. 62. The abdomen consists of eleven segments, the last being a minute triangular piece.

The body is so bent upon itself that the extremities of the second maxillæ just overlap the tip of the abdomen.

The two limbs of the labium are now placed side by side, with the prominent spinous appendage on the outer edges of the tip. These spines are the rudiments of the labial palpi.

The general form of the embryo at a still later period (Fig. 61), on being taken from the egg and straightened out, reminds us strikingly of the Thysanura, and, in these and other respects, tend to prove that the Poduræ and Lepismæ, and allied genera, are embryonic, degraded forms of Neuroptera, and should therefore be considered as a family of that suborder. Seen laterally, the body gradually tapers from the large head to the pointed extremity. The body is flattened from above downwards. At this stage the appendages are still closely appressed to the body.

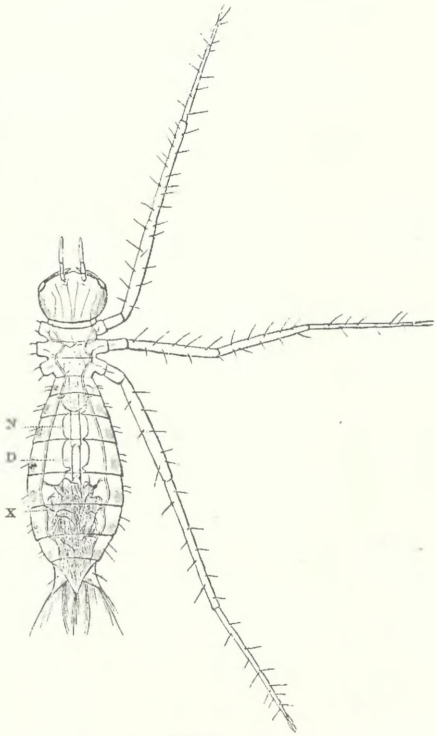


Fig. 62.

Just before the exclusion of the embryo, the legs and mouth-parts stand out freer from the body. The labium, especially, assumes a position at nearly right angles to the body. The antennæ, mandibles, and maxillæ have taken on a more definite form, being like

Fig. 62. The larva just hatched and swimming in the water. N, ventral cord or nervous ganglia; D, dorsal vessel, or "heart," divided into its chambers. The anal valves at the end of the abdomen, which open and shut during respiration, are represented as being open. Both of the dotted lines cross the tracheæ. X, network of the tracheæ, surrounding the cloaca.

that of the young larva, and stand out free from the body. The head is much smaller in proportion to the rest of the body, and bent more upon the breast.

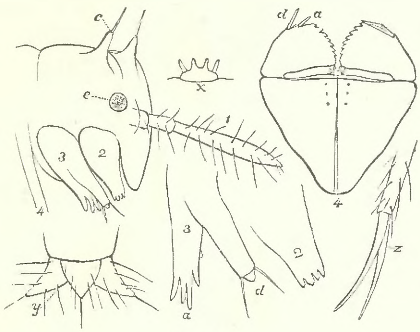


Fig. 63.

The Larva (Fig. 62) when hatched is about five hundredths of an inch in length. The head is now free and the antennæ stand out free from the front. The thorax has greatly diminished in size, while the abdomen has become wider, and the limbs very long; and the numerous minute tubercles, seen in the preceding stage, have given origin to hairs. The dorsal vessel can now, for the first time, be seen. When in motion, the resemblance to a spider is most striking. The flow of blood to the head, and the return currents through the lacunar or venous circulation along the side of the body were easily observed. The vessels were not crowded with blood disks, the latter being few in number, only one or two passing along at a time. Two currents, passing in opposite directions, were observed in the legs.


Fig. 64.

FIG. 63. Side view of the head of the larva of Diplax before the first moult. *c*, deciduous tubercles terminating in a slender style; their use is unknown; they have not been observed in the full-grown larva. *e*, the compound eyes. 1, the three jointed antennæ, the terminal joint nearly three times as long as the two basal ones. 2, the mandibles, and also enlarged, showing the cutting edge divided into four teeth. 3, maxillæ divided into two lobes: *d*, the outer and anterior lobe, 2-jointed, the basal joint terminating in two setæ; and *a*, the inner lobe concealed from view, in its natural position, by the outer lobe, *d*. 4, the base or pedicel of the second maxillæ, or labium, the expanded terminal portion being drawn separately; *d* and *a*, two movable stout styles representing, perhaps, the labial palpi; the lobe to which they are attached is multidentate, and adapted for seizing prey; on the right side the two styles are appressed to the lobe. *x* represents, perhaps, the ligula; but we have not yet studied its homologies carefully: this part is attached to a transversely linear piece soldered to the main part of the labium. *y*, the 11th abdominal ring, with its pair of conical anal styles. *z*, the last tarsal joint and pair of long slender claws.

FIG. 64. The pupa of Diplax, having rudimentary rings, in which the eyes are much larger, and the legs much shorter than in the recently hatched larva; introduced to be compared with the young larva. Figs. 57–64, *original*.

On review it will be seen how remarkable are the changes in form of the insect before it is hatched, and that all are the result of simple growth. We have seen that the two ends of the body are first formed, and that the under side of the body is formed before the back; that the belly is at first turned outwards, and afterwards the embryo reverses its position, the back presenting outwards. All the appendages are at first simple protrusions from the body-walls, and new segments are interpolated near the tip of the abdomen. These changes take place very rapidly, within a very few days, and some of the most important and earlier ones in a few hours. We can now better understand that the larva and pupa stages are the result of a similar mode of growth, though very marked from being in a different medium, the insect having to seek food and act as an independent being.

TRANSFORMATIONS OF THE INSECT. We have seen that during the growth of the embryo, the insect undergoes remarkable changes of form, the result of simple growth. The metamorphoses of the animal within the egg are no less marked than those which occur after it has hatched. It will also be seen that the larva and pupa stages are not always fixed, definite states, but only pauses in the development of the insect, concealing beneath the larva and pupa skins the most important changes of form.

The process of hatching. No other author has so carefully described the process of hatching as Newport, who observed it in the larva of Meloë. "When the embryo larva is ready for its change, the egg-shell becomes thinned and concave on that side which covers the ventral surface of the body, but is much enlarged, and is more convex on the dorsal, especially towards the head. The shell is then burst longitudinally along the middle of the thoracic segments, and the fissure is extended forwards to the head, which then, together with the thoracic segments, is partially forced through the opening, but is not at once entirely withdrawn. The antennæ, parts of the mouth, and legs are still inclosed within separate envelopes, and retain the larva in this covering in the shell. Efforts are then made to detach the posterior segments of the body, which are gradually released, and with them the antennæ, palpi, and legs, and the larva removes itself entirely from the shell and membranes. In this process of evolution the young *Meloë* throws off two distinct coverings: first, the shell with its lining membrane, the analogue of the membrane in which, as I have elsewhere shown,* the young Myriapod is inclosed, and retained several days after the bursting of the ovum, and which represents in the Articulata, not the allantois, but apparently the amnion, of Vertebrata; next, the first, or fœtal deciduation of the tegument, analogous probably to the first change of skin in the Myriapod, after it has escaped from the amnion, and also to the first change which the young Arachnidan invariably undergoes a few days after it has left the egg, and before it can take food. This tegument, which, perhaps, may be analogous to the *vernix caseosa* of Vertebrata, thrown off at the instant of birth, is left by the young Meloë with the amnion in the shell; and its separation from the body, at this early period, seems necessary to fit the insect for the active life it has commenced." (Linn. Trans. xx. p. 306, etc.)

The larva state. The larva (Latin *larva*, a mask) was so-called because it was thought to mask the form of the perfect insect. The larvæ of Butterflies and Moths are called *caterpillars;* those of Beetles, *grubs;* and those of the two-winged Flies (Diptera) *maggots;* the larvæ of other groups have no distinctive common names.

As soon as it is hatched the larva feeds voraciously, as if in anticipation of the coming period of rest, the pupa state, for which stores of fat (the fatty bodies) are developed for the supply of fat globules out of which the tissues of the new body of the pupa and imago are to be formed.

Most larvæ moult, or change their skin, four or five times. In the inactive thin-skinned larvæ, such as those of Bees, Wasps, and Gall-flies, the moults are not apparent; as the larva increases in size it out-grows the old skin, which comes off in thin shreds. But in the active larvæ, such as caterpillars, grasshoppers, and grubs, from the rapid deposition of chitine in the outer layers of the skin, just before the change,

* Philosophical Transactions, Pt. 2, 1841, p. 111.

it becomes hard and dry, and too small for the growing insect, and is then cast off entire.

A series of bee-larvæ can be selected showing a graduation in size and form from the egg and recently hatched larva up to the full-grown larva. In the caterpillar and other active larvæ, there are usually four or five stages, each showing a sudden and marked increase in size. Newport states that the caterpillar of *Sphinx ligustri* moults six times, and at the last moult becomes a third larger than at any earlier period; the larva of *Arctia caja* moults from five to ten times.

A few days before the assumption of the pupa state, the larva becomes restless, stops eating, and deserts its food, and usually spins a silken cocoon, or makes one of earth, or chips, if a borer, and there prepares for the change to the pupa state. During this semipupa period (lasting, in many insects, only for a day or several days, but in some Saw-flies through the winter) the skin of the pupa grows beneath that of the quiescent larva. While the worm-like larva exhibits no triregional distinctions, the muscles of the growing pupa contract and enlarge in certain parts so as to modify the larva form, until it gradually assumes the triregional form of the adult insect, with the differentiation of the body into a head, thorax, and abdomen.

In a series of careful studies, abundantly illustrated with excellent plates, Weismann has recently shown that Swammerdam's idea that the pupa and imago skins were in reality already concealed under that of the larva is partially founded in truth. Swammerdam states, "I can point out in the larva all the limbs of the future nymph, or *Culex*, concealed beneath the skin," and he also observed beneath the skin of the larvæ of bees just before pupating, the antennæ, mouth-parts, wings, and limbs of the adult. (Weismann.)

During its transformations the pupa skin is developed from the *hypodermis*, or inner layer of skin. This peals off, as it were, from the inner layer of the old larva skin, which soon dries and hardens, and is thrown off. Meanwhile the muscles of the body contract and change in form, thus causing the original segments of the larva to infold and contract at certain parts, gradually producing the pupa form. If, during this period, the insect be examined at intervals, a series of slight changes of form may be seen, from the larva to the imago state. In some cases each change is accompanied by a moult, as in the "active" Ephemera, where Lubbock counted twenty moults.

As a general rule, then, it may be stated that the body of the larva is transformed into that of the imago; ring answering to ring, and limb to limb in both, the head of the one is homologous with that of the other, and the appendages of the larva are homologous with the appendages of the imago.

Weismann has shown that in the larva of the Meat-fly, *Musca vomitoria*, the thorax and head of the imago are developed from what he calls "imaginal disks." These disks are minute isolated portions of the hypodermis, which are formed in the embryo, before it leaves the egg, and are held in place within the body-cavity of the larva by being attached either to nerves or tracheæ, or both. After the outer layer of the larva skin dries and hardens, and forms the cask-shaped *puparium*, the use of which corresponds to the cocoon of moths, etc., these imaginal disks increase in size so as to form the tegument of the thorax and head. The abdomen of the Meat-fly, however, is formed by the direct conversion of the eight hinder segments of the body of the larva, into the corresponding segments of the imago.

Accompanying this change in the integument there is a destruction of all the larval system of organs; this is either total or effected by the gradual destruction of tissues. Now we see the use of the "fatty body;" this breaks up, setting free granular globules of fat, which, as we have seen in the embryo, produces by the multiplication of cells the new tissues of the pupa. Thus the larva-skin is cast aside, and also the softer organs within, but the formation of new tissues keeps even pace with the destruction of the old, and the insect preserves its identity throughout. The genital glands, however, are indicated even in the embryo, and are gradually developed throughout the growth of the insect, so that this *histolysis*, or destruction of tissues, is not wholly complete. The quiescent pupa-state of Musca is long-continued, and its vitality is latent, the acts of respiration and circulation being almost suspended. (Weismann.)

In the metamorphosis of *Corethra*, a Mosquito-like Fly, which is active both in the larva and pupa states, "the segments of the larva are converted directly into the corresponding segments of the body of the imago, the appendages of the head into the corresponding ones of the head of the imago; those of the thorax are produced after the last moult of the larva as *diverticula* of the hypodermis round a nerve or trachea, from the cellular envelope of which the formation of tissue in the interior of the appendages issues. The larval muscles of the abdominal segments are transferred unchanged into the imago; the thoracic muscles peculiar to the imago, as also some additional abdominal muscles, are developed in the last larval periods from indifferent cellular cords which are indicated even in the egg. The genital glands date back to the embryo, and are gradually developed; all the other systems of organs pass with little or no alteration into the imago. Fatty body none or inconsiderable. Pupa-state short and active." (Weismann.)

As the two types are most clearly discriminated by the presence or absence of true imaginal disks, Weismann suggests that those insects which undergo a marked metamorphosis might be divided into *Insecta discota* (or Insects with imaginal disks), and those without, into *Insecta adiscota*.

The metamorphosis of *Corethra* may prove to be a type of that of all insects which are active in their preparatory stages; and that of *Musca* typical of all those that are quiescent in the pupa-state, at least the Lepidoptera and those Diptera which have a coarctate* pupa, together with the Coleoptera and those Neuroptera in which the metamorphosis is complete, as *Phryganea*, *Hemerobius*, etc.

The transformations of the Humble-bee are easily observed by taking a nest after the first brood have matured, when we shall find individuals in all stages of development from the larva to the imago state. The figures below show four stages, but in reality there is every gradation between these stages.

* The larvæ of some of the higher Diptera spin a slight cocoon, while the true flies, such as the Muscidæ and Syrphidæ, etc., change to pupæ within the larva skin which contracts into a cylindrical "puparium" corresponding in use to the cocoon; such pupæ are called "coarctate."

Fig. 64 shows what we may call the semipupa, concealed by the larval skin. There are eleven pairs of stigmata, three thoracic and eight abdominal. The head of the semi-pupa lies under the head (*a*) and prothoracic ring (*b*). The basal ring of the abdomen (*c*), or fourth ring from the head, is unchanged in form. This figure also will suffice to represent

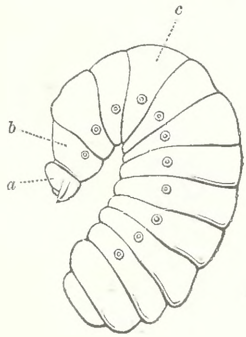


Fig. 64.

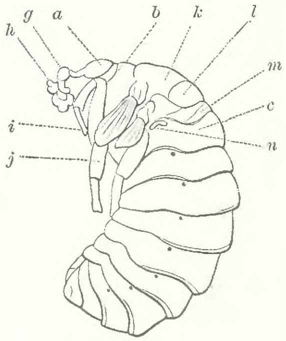


Fig. 65.

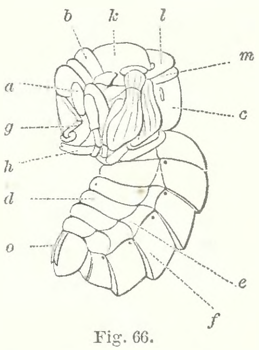


Fig. 66.

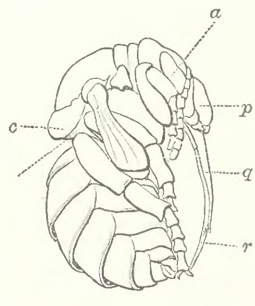


Fig. 67.

the larva, though a little more produced anteriorly than in its natural form.

In another stage (Fig. 65) of the semi-pupa, the larval skin is entirely sloughed off, the two pairs of wing-pads lying parallel, and very equal in size, like the wings of Neuroptera. The thoraco-abdominal ring, or *propodeum* (*c*), is distinguished by its oblong spiracle (*n*), essentially differing from those on the abdomen. At this point the body contracts, but the head and thorax together are yet, as still more in the previous stage, much smaller than in the pupa, and there is still a continuous curve from the tip of the abdomen to the head. (*g*, antenna; *h*, lingua, maxillæ, and palpi; *i*, fore-legs; *j*, middle legs; *k*, meso-scutum; *l*, meso-scutellum; *n*, spiracle of the propodeum.)

In a succeeding stage (Fig. 66) of the semi-pupa, the head and thorax together nearly equal in size the abdomen, and the propodeum (*c*) has become entirely transferred to the thorax. The head has become greatly enlarged; the rings are very unequal, the hinder pair are much smaller, and overlaid by the anterior pair; the three terminal pair of abdominal rings, so large in Fig. 65, have been absorbed, and partially inclosed in the cavity of the abdomen; and there has been a farther differentiation of the ring into the sternite (*d*), pleurite (*e*), and tergite (*f*). (*a*, eye; *h*, lingua; *o*, ovipositor, two outer rhabdites exposed to view.) The abdominal spiracles in Figs. 65 and 66, are represented by a row of dots. In the pupa they are concealed by the tergites, which overlap the sternites.

Fig. 67 represents the pupa state, where the body has become much shorter, and the appendages of the head and thorax greatly differentiated; the external genital organs are wholly retracted within the cavity of the abdomen; the head is freer from the body, and the whole bulk of the head and thorax together, including the appendages, greater than that of the abdomen. These changes of form, assumed by the insect in its passage from the larva to the pupa state, are nearly as striking as the so-called "hypermetamorphosis" of *Meloë* and *Sitaris* described by Newport and Fabre. (*l*, mesoscutellum; *p*, clypeus; *q*, maxillæ with the palpi; *r*, lingua.)

We have also observed similar changes in the semi-pupa of a Tineid larva, which we found in the mud-cells of *Odynerus albophaleratus*. There were over a dozen specimens in different stages of growth from the larva to the pupa, which were but partially paralyzed by the well-directed sting of the intelligent wasp, so that some continued to transform into perfect pupæ. The following changes were noticed: the larva straightened out, and became a little shorter, the prothoracic ring remaining the same; the head of the pupa being beneath it; the mesothoracic ring enlarged, swelling and rounding above and on the sides, and with this increase in size drawing the meta-thorax forwards. The first visible portion of the pupa beneath is the meso-thorax. The thoracic legs of the larva are now constricted at their base, and have become useless.

In the next stage, the most important change noticed is in the meta-thorax, which now becomes broadly heart-shaped. In a succeeding stage, the whole thorax bulges out, and is much larger and clearly distinguished from the head and abdomen. The prothorax of the larva disappears, and that of the pupa takes its place. The occiput of the pupa, just before the larva-skin is thrown off, can be distinctly seen under the larval occiput, pushing aside each half of the latter.

In the last stage of *Bombus* just before the imago leaves its cell, the body and limbs are surrounded by a thin pellicle. This pellicle also envelops the moth, just before it leaves the pupa, and which is cast off when it moults the pupa-skin. This is probably identical with the skin cast by the active subimago of *Ephemera*, soon after it has taken its flight. Westwood also considers this subimago skin identical with that covering the bodies of coarctate Diptera, as in *Eristalis*.

Newport states, that when the imago of *Sphinx* is about to cast off the pupa-skin the abdominal segments are elongated beyond their original extent, this being the first part of the insect that is entirely freed from its attachment within the pupa-case. After this the thorax slits down, and the body is drawn out of the rent. In the Butterfly the wings mature in a few moments, but those of *Sphinx* being thicker, require two or three hours.

Newport (Philosophical Transactions, London, 1832 and 1834) has detailed with great minuteness the internal changes of *Sphinx ligustri* while transforming. The most marked changes are in the nervous and digestive systems.

Several anomalous modes of metamorphosis have been observed, one in Diptera and the other in *Sitaris* and *Meloë*. The development of the latter insect will be noticed beyond.

Sir John Lubbock has described the singular metamorphosis of *Lonchoptera*, which he considers to be allied to *Sargus*, though the adult stages differ greatly. The larva is oblong ovate, flattened, with four long setæ in front and two behind, with the sides of the body emarginate and spinulated. They were found under logs. "When the larva is full grown, it detaches itself from the skin, which retains its form, and within which the insect changes into a white opaque fleshy grub consisting apparently of thirteen segments which gradually diminish in size from one end to the other. There are no limb-cases. According to analogy the pupa should be 'incomplete;' it is probable, therefore, that the legs and wings make their appearance at a later stage. If this be so the perfect form is only attained after passing through three well-marked stages. I regret, however, that the specimens at my disposal did not enable me to decide this point." (Trans. Ent. Soc. London, Third Ser. i, 1862.)

Haliday states that *Thrips* goes through a *propupa* and pupa stage. There are five well-defined stages in the Homopterous *Typhlocyba*, and more than three in *Aphis*. Yersin has noticed several stages in the development of *Gryllus campestris*, and the genus *Psocus* has four such stages.

The duration of the different stages vary with the changes of the seasons. Cold and damp weather retards the process of transformation. Réaumur kept the pupa of a Butterfly two years in an ice-house before, on being removed to a warm place, it changed to a butterfly. Chrysalids survive great alternations of heat and cold; they may be frozen stiff on ice, and then, on being gradually exposed to the heat, thaw out and finish their transformations.

Retrograde Development. There are certain degradational forms among the lowest members of each group of Insects which imitate the group beneath them. The *Tardigrades* (which are considered by some authors to be allied to the Mites) are mimicked by the low parasitic worm-like *Demodex folliculorum*; the low Neuroptera, such as *Lepisma*, imitate the Myriapoda; and the wingless Lice remind us of the larva of the Neuropterous *Hemerobius*.

Among the Coleoptera, the history of *Stylops* affords a striking example. The active six-footed larva is transformed into the strange bag-like female which takes on the form of a cylindrical sac, the head and thorax being consolidated into a minute flattened portion. The process of degradation here seems carried out to its farthest limit.

Thus the degraded forms of the lower series of Hexapods take on a Myriapod aspect. In the more highly cephalized Diptera, Lepidoptera, and Hymenoptera the degraded forms are modelled on a higher articulate type. The idea of a division into three regions is involved. Thus the wingless forms of Flies, such as the Bird-louse, *Nirmus;* the Bat-tick, *Nycteribia;* the Bee-louse, *Braula;* and *Chionea* resemble strikingly the biregional Arachnids.

In the wingless female of *Orgyia* and the Canker-worm moth, the head is free, but the thorax is merged into the abdomen. The resemblance to the lower insects is less striking. The worker ants and wingless Ichneumons, *Pezomachus*, still more strictly adhere to the type of their suborder, and in them the triregional form of the body persists. Among the first of the examples here cited we have seen the workings of a law, by which most degraded forms of insects (and this law is exerted with greater force in Crustacea) tend to revert to the worm-like, or, as we may call it, the *archetypal*, form of all Articulata.

We have seen that many winged forms mimic the groups above them, whereas the wingless degraded species revert to a worm-like form. In either case, the progress is towards a higher or a lower form. The latter is the more exceptional, as the evolution and growth of all animals is upwards towards a more specialized, differentiated form.

The Imago. After completing its transformations the adult insect immediately seeks to provide for the propagation and continuance of the species. The sexes meet, and, soon after, the male, now no longer of use in the insect economy, perishes. The female hastens to lay her eggs either in, upon, or near what is to be the food of the young, and then dies. This period generally occurs in the summer and autumn, and during the winter the species is mostly represented by the egg alone. Rarely does the adult insect hibernate, but in many species the pupa hibernates to disclose the adult in early summer. The larva seldom, as such, lives through the winter.

Réaumur kept a virgin butterfly for two years in his hothouse. From this it would seem that the duration of the life of an insect may be in this way greatly prolonged. Most insects live one year. Hatching from the egg in early summer, they pass through the larva state, and in the autumn become pupæ, to appear as imagos for a few days or weeks in the succeeding summer. Many Lepidoptera are double-brooded, and some have even three broods, while the parasitic insects such as Lice and Fleas, and many Flies, keep up a constant succession of broods. Warmth, Mr. R. C. R. Jordan remarks in the Entomologists' Monthly Magazine, has much to do with rapidity of development, as insects may be forced artificially into having a second brood during the same season. Some Coleoptera, such as the Lamellicorns, are supposed to live three years in the larva state, the whole time of life being four years. The Cockchafer (*Melolontha*) of Europe is three years in arriving at the perfect state, and the habits of the Goldsmith Beetle (*Cotalpa lanigera*), according to Rev. Samuel Lockwood (American Naturalist, vol. 2, p. 186), and of the June Beetle, and allied genera, are probably the same.

Geographical Distribution. The *insect-fauna* of a country comprises all the insects found within its limits. The Polar, Temperate, and Tropical zones each have their distinct insect-fauna, and each continent is inhabited by a distinct assemblage of insects. It is also a curious fact that the insect-fauna of the east coast of America resembles, or has many analogues in, that of the Eastern hemisphere, and the west coast of one repeats the characteristics of the west coast of the other. Thus some California insects are either the same species or analogues (*i.e.* representative species) of European ones, and the Atlantic coast affords forms of which the analogues are found in Eastern Asia and in India. This is correlated with the climatic features, which are repeated on alternate sides of the two hemispheres.

The limits of these faunæ are determined by temperature and natural boundaries, *i.e.* the ocean and mountain ranges. Thus the insect-fauna of the polar regions is much the same in Europe, Asia, and North America; certain widely spread polar species being common to all three of these continents.

When we ascend high mountains situated in the temperate zone, and whose summits reach near the snow-line, we find a few insects which are the same or very similar to those of the polar regions; such an assemblage is called an Alpine fauna.

The insect-fauna of each great continent may be divided into an *Arctic*, or polar, a *Temperate*, and a *Tropical* fauna, and an *Alpine* fauna if there are mountains in the warm latitudes which reach near the snow-line. Mountain barriers, inland seas, deserts, and peculiarities in the flora (or collection of plants peculiar to a certain district), are boundaries of secondary importance in limiting the distribution of species.

On the other hand insects are diffused by winds, rivers, oceanic currents, and the agency of man. By the latter important means certain insects become cosmopolitan. Certain injurious insects become suddenly abundant in newly cultivated tracts. The balance of nature seems to be disturbed. and insects multiplying rapidly in newly settled portions of the country, become terrible pests. In the course of time, however, they seem to decrease in numbers and moderate their attacks.

Insect-faunæ are not limited by arbitrary boundaries, but fade into each other by insensible gradations corresponding in a general way to the changes of the temperature of different portions of the district they inhabit.

The subject of the geographical distribution of insects, of which we have as yet but given the rudiments, may be studied to great advantage in North America. The Arctic insect-fauna comprises Greenland, the arctic American Archipelago, and the northern shores of the continent beyond the limit of trees. A large proportion of the insects found in this region occur in arctic Europe and arctic Asia, and are hence called circumpolar, while other species are indigenous to each country. Again, the arctic fauna of Labrador and Hudson's Bay differs from that of the arctic portions of the region about Behring's Straits, certain species characterizing one side of the continent being replaced by representative species which inhabit the opposite side.

The Alpine fauna of the White Mountains consists, besides a very few peculiar to them, of circumpolar species, which are now only found in Labrador and Greenland, and which are supposed to be relics of a glacial fauna which formerly inhabited the northern part of the temperate zone, and in former times followed the retreat of a glacial, or arctic climate from the low-lands to the alpine summits. These patches, or outliers, of an arctic fauna, containing however a preponderance of *subarctic* forms, also occur in the colder parts of New England.

The subarctic fauna is spread over British North America, stretching north-westerly from the interior of Labrador and the northern shores of the St. Lawrence, following the course of the isothermal lines which run in that direction, and north of which no cereals grow. There are subarctic forms which inhabit the shores of the Bay of Fundy, especially about Eastport, Maine, where the fogs and cold arctic marine currents lower the climate.

Dr. J. L. Leconte, in a paper on the Coleoptera of Kansas and Eastern New Mexico (Smithsonian Contributions to Knowledge), thus subdivides the Coleopterous fauna of the United States, and gives a useful map to which the reader is referred.

"The whole region of the United States is divided by meridional, or nearly meridional lines into three, or perhaps four, great zoölogical districts, distinguished each by numerous peculiar genera and species, which, with but few exceptions, do not extend into the contiguous districts. The eastern one of these extends from the Atlantic Ocean to the arid prairies on the west of Iowa, Missouri, and Arkansas, thus embracing (for convenience merely) a narrow strip near the sea-coast of Texas. This narrow strip, however, belongs more properly to the eastern province of the tropical zoölogical district of Mexico.

"The central district extends from the western limit of the eastern district, perhaps to the mass of the Sierra Nevada of California, including Kansas, Nebraska, Utah, New Mexico, Arizona, and Texas. Except Arizona, the entomological fauna of the portion of this district west of the Rocky Mountains, and in fact that of the mountain region proper, is *entirely* unknown; and it is very probable that the region does in reality constitute two districts bounded by the Rocky Mountains, and the southern continuation thereof.

"The western district is the maritime slope of the continent to the Pacific, and thus includes California, Oregon, and Washington Territories.

"These great districts are divided into a number of provinces, of unequal size, and which are limited by changes in climate, and therefore sometimes distinctly, sometimes vaguely defined."

"The method of distribution of species in the Atlantic and Pacific districts, as already observed by me in various memoirs, is entirely different. In the Atlantic district, a large number of species are distributed over a large extent of country; many species are of rare occurrence, and in passing over a distance of several hundred miles, but small variation will be found in the species obtained. In the Pacific district, a small number of species are confined to a small region of country; most species occur in considerable numbers, and in travelling even one hundred miles, it is found that the most abundant species are replaced by others, in many instances very similar to them; these small centres of distribution can be limited only after careful collections have been made at a great number of localities, and it is to be hoped that this very interesting and important subject of investigation may soon receive proper attention from the lovers of science of our Pacific shores.

"In the Central district, consisting, as it does to a very large extent, of deserts, the distribution seems to be of a moderate number of species over a large extent of country, with a considerable admixture of local species; such at least seems to be the result of observations in Kansas, Upper Texas, and Arizona."

There are a very few species which range from New England to Brazil, and fewer still (*Xyleutes robiniæ*, according to Boisduval, is found in California) range from New England to California. *Junonia cœnia*, according to authors, is found both in the Southern States and California, and *Pyrrharctia isabella* of the Eastern States would be easily confounded with *P. Californica.*

Variation. Islands afford more variable forms than continents; the Madeiran insects and those of Great Britain vary more than the same species found on the continent of Europe.

A species spread through two zones of temperature also varies; many European species, according to McLachlan, becoming "melanized" in going northward, while others become paler. Such varieties have been described as different species.

Mr. Alfred Wallace finds that the most constant forms of species are those the most limited in their geographical range as to a particular island, while those species, which range over a large part of the Malayan Archipelago, vary very considerably. It is a general rule throughout the animal and vegetable world, that the most widely spread species are those capable of withstanding the greatest climatic changes, and adapting themselves to the greatest diversities of topography.

While the most widely distributed species are thought to be the most variable, Mr. Scudder finds in the genus *Chionobas* that *C. semidea*, restricted to the summit of Mt. Washington varies almost as much as *C. Oeno*, which is circumpolar, being found both in Labrador and Northern Europe.

Mr. Wallace (Transactions of the Linnæan Society, xxv, 1865, p. 14) mentions the following facts "as showing the special influence of locality in giving a peculiar *facies* to the several disconnected species that inhabit it."

"On examining the closely allied species, local forms, and varieties distributed over the Indian and Malayan regions, I find that larger or smaller districts, or even single islands. give a special character to the majority of their Papilionidæ. For instance: 1. The species of the Indian region (Sumatra, Java, and Borneo) are almost invariably smaller than the allied species inhabiting the Celebes and Moluccas; 2. The species of New Guinea and Australia are also, though in a less degree, smaller than the nearest species or varieties of the Moluccas; 3. In the Moluccas themselves the species of Amboyna are largest; 4. The species of Celebes equal or even surpass in size those of Amboyna; 5. The species and varieties of Celebes possess a striking character in the form of the anterior wings, differing from that of the allied species and varieties of all the surrounding islands; 6. Tailed species in India or the Indian region become tailless as they spread eastward through the archipelago."

Variety breeding. Varieties may be produced artificially: thus negro varieties of insects may be raised "from parents more or less tainted with melanism, and according to Knaggs, there is a "frequent recurrence of individuals wanting a hind-wing, which may be noticed even at large in *Macaria notata*." "Few species are liable to the same extent of variation, and many apparently to none at all." Certain species vary "according as they may have reproduced, generation after generation, on a chalky, peaty, gravelly, or other soil." Food also exerts an influence in inducing variation, according as caterpillars of the same species feed on different plants; this occurs most commonly in the Micro-lepidoptera. (Knaggs, in the Entomologist's Monthly Magazine, London.)

Introduced species of insects, like those of plants, often thrive more vigorously than the native forms. This is instanced by native insects which abound in unusual numbers in newly cleared districts where the former presence of forests and their natural foes kept them under. The Potato-beetle, Canker-worm, and *Clisiocampa* must have lived formerly in moderate numbers on our native plants, where now countless hosts affect our introduced plants. Among species introduced from a foreign country we have only to instance the Hessian Fly, the Wheat-midge, the Coddling-moth, the Clothes-moth, the Apple Bark-louse, and the Grain-weevil. Mr. W. T. Brigham informs us that some of the most abundant insects in the Hawaiian Islands are introduced species carried by vessels from Europe. *Vanessa Antiopa*, *Pyrameis cardui*, and *P. Atalanta*, so abundant in this country, are supposed to be introduced butterflies. *Aphodius fimetarius*, found by us living in dung on Mt. Washington, is one of our most common beetles, and the Asparagus-beetle, introduced from Europe a few years since, is common in gardens in Eastern New York, while Mr. Walsh has recorded the appearance of the European Gooseberry Saw-Fly, which ravages the Gooseberry and Currant. *Pieris rapæ*, the Cabbage-butterfly, introduced from Europe into Quebec about 1859, soon became abundant within a circle of forty miles radius about that city, and has even spread into Maine and Vermont along the railroads leading from Quebec.

Insect Years. There are insect years as well as "apple years," seasons when insects most abound. Every collector knows that there are certain years when a particular species of insect is unusually common. The Army-worm, *Leucania unipuncta*, swarms in countless numbers in a summer following a dry and warm spring. After a cold and rainy spring, insects are less abundant. Mr. F. Smith remarks that in England the summer and autumn of 1860 were unusually wet, which disabled the bees, wasps, and fossorial hymenoptera generally, in building their nests. We know how ants are hindered from building their nests by rain, and in a very rainy season numbers probably die. A succession of rainy seasons caused the Andrenæ, or Spring bees, to disappear from the vicinity of London. While a severe winter, if the cold be continuous, is not injurious to insects, mild periods in winter, when it is warm enough to rouse them from torpidity, are as fatal to insects as to vegetation, should severe cold immediately follow.

Geological Distribution. The geological distribution of insects corresponds generally with that of other animals, though insect-remains are few in number, owing naturally to the difficulty with which their fragile forms are preserved in the rocks. Professor C. F. Hartt has discovered near St. John, New Brunswick, the oldest insect-remains in the world. They occur in some plant-beds of the Upper Devonian formation, and consist of six species of Neuroptera. Mr. Scudder, who has referred to them in vol. 1 of the American Naturalist, states that with the exception of one or two Ephemeridæ, or May-flies, they mostly represent families which are now extinct. He describes a gigantic May-fly, *Platephemera antiqua* (Pl. 1, fig. 3); *Lithentomum Harttii* (Pl. 1, fig. 5); *Homothetus fossilis* (Pl. 1, fig. 7); and *Xenoneura antiquorum* which is supposed to bear a stridulating organ like that of the Grasshoppers, so that he "is inclined to believe there were chirping Neuroptera in those days."

Ascending to the Carboniferous rocks, insect-remains appear more abundant. At Morris, Illinois, have been collected some remarkable forms. Among them are *Miamia Bronsonii* Dana (Pl. 1, fig. 1), allied to the White Ants and *Hemeristia occidentalis* Dana, allied to *Hemerobius* and *Chrysopa;* with these occurred remains supposed by Professor Meek to be those of a caterpillar (Fig. 68).

In the Coal-beds of New Brunswick and Nova Scotia, Dr. Dawson, Mr. Barnes, and Professor O. C. Marsh have discovered several interesting Neuropterous and Orthopterous insects; among them a Cockroach, *Archimulacris Acadica* (Pl. 1,* fig. 2). In Europe, Carboniferous insects have been discovered at Wettin, Saarbrück, etc.

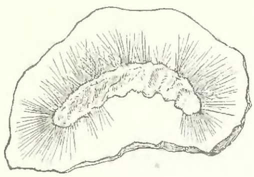


Fig. 68.

The insects from these two formations show a tendency to assume gigantic and strange shapes. They are also *comprehensive types*, combining the characters of different families and even different suborders. The most remarkable instance is the *Eugereon Boeckingii* Dohrn, from the Coal Formation of Germany. It has been referred by Dr. Hagen, with some doubt, to the Hemiptera, from its long immense rostrum into which all the mouth-parts are produced, the labium ensheathing them as usual in the Hemiptera. Its fore-legs are large and raptorial; but the filiform many-jointed antennæ, and the net-veined wings are Neuropterous characters. Hence Dohrn considers it as a comprehensive type uniting

* EXPLANATION OF PLATE 1.

Fig. 1. *Miamia Bronsoni.* A Neuropterous insect found in iron-stone concretions in the Carboniferous beds at Morris, Illinois. The figure is magnified one-third, and has all its parts restored; the dotted lines indicate the parts not existing on the stone. Reduced from a figure in the Memoirs of the Boston Society of Natural History, Vol. I.

Fig. 2. *Archimulacris Acadica.* Wing of a Cockroach observed by Mr. Barnes in the coal-formation of Nova Scotia.

Fig. 3. *Platephemera antiqua.* A gigantic May-fly obtained by Mr. Hartt in the Devonian rocks of New Brunswick.

Fig. 4. *Xylobius sigillariæ.* The Myriapod (or Gally-worm) found in the coal-formation of Nova Scotia, by J. W. Dawson. Copied from a figure in Dr. Dawson's Air-breathers of the Coal-period. Magnified.

Fig. 5. *Lithentomum Hartii.* A Neuropterous insect, the specimen first discovered by Mr. Hartt in the Devonian rocks of New Brunswick. This fossil, and those accompanying it, are the oldest insect-remains in the world.

Fig. 6. Three facets from the eye of an insect, considered by Dr. Dawson a Dragon-fly. It was found in coprolites of reptiles in the rocks containing the Myriapod, represented in Fig. 4. Copied from Dr. Dawson's figure, greatly magnified.

Fig. 7. *Homothetus fossilis.* A Neuropterous insect from the Devonian rocks of New Brunswick; it was discovered by Mr. Hartt.

Fig. 8. *Haplophlebium Barnesii.* A curious Neuropterous insect, of large size, probably allied to our May-flies; taken by Mr. Barnes from the coal of Cape Breton.

These figures, with the exception of 1, 4, and 6, are of life size, and borrowed from the new edition of Dr. Dawson's Acadian Geology.

Fig. 1

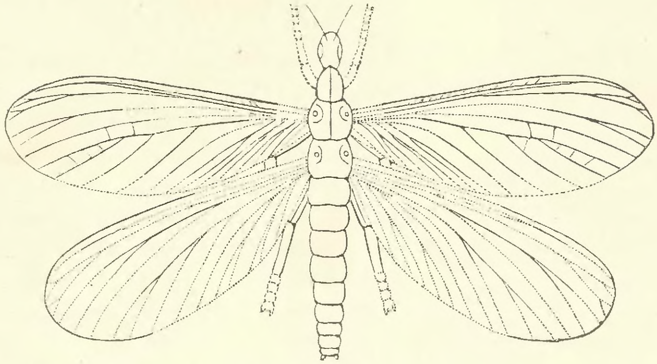


Fig. 2.

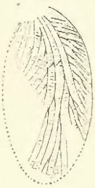


Fig. 3.

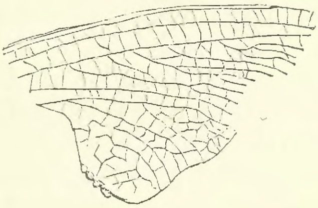


Fig. 4.

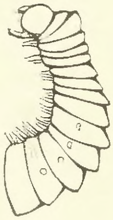


Fig. 5.

Fig. 6.

Fig. 7.

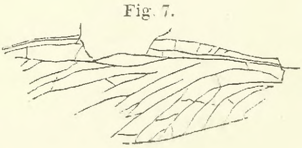
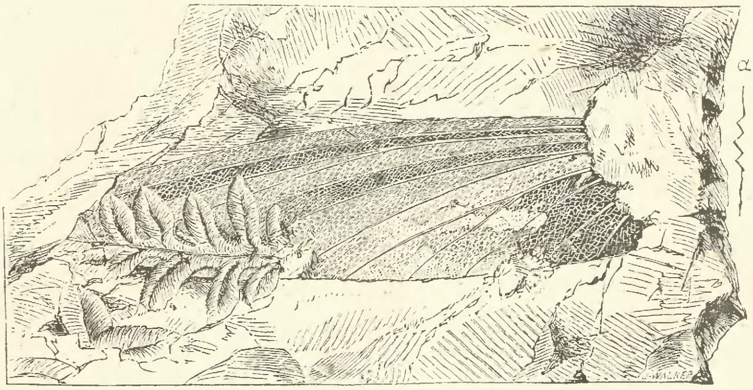


Fig. 8.



the characters of the Neuroptera and Hemiptera. It is gigantic, spreading eight or nine inches; its body must have measured six inches in length.

In the Mesozoic rocks, the celebrated Solenhofen locality in Bavaria is rich in Liassic insect-remains. Dr. Hagen (Entomologist's Annual, London, 1862) states that among the Solenhofen fossils the Neuroptera and Orthoptera are most largely represented; as out of four hundred and fifty species of insects, one hundred and fifty are Neuroptera, of which one hundred and thirty-six are Dragon-flies, and besides "there is a *Corydalus*, one *Chrysopa*, a large *Apochrysa*, and a beautiful *Nymphes*. The last two genera, which do not seem very remote from *Chrysopa*, are now found only in the Southern Hemisphere, *Nymphes* is peculiarly an Australian genus."

The Lias of England is very rich in fossil insects, especially the Purbeck and Rhoetic Beds (see Brodie's Work on Fossil Insects and also Westwood in the Geological Journal, etc. Vol. X.).

In the Trias, or New-Red Sandstone of the Connecticut Valley, Professor Hitchcock has found numerous remains of the larva of an aquatic insect.

The insects of the Tertiary formation more closely resemble those of the present day. The most celebrated European locality is Œningen in Switzerland.

According to Professor O. Heer, over five thousand specimens of fossil insects have been found at Œningen, comprising 844 species, of which 518 are Coleopterous. From all Tertiary Europe there are 1,322 species, as follows: 166 Hymenoptera, 18 Lepidoptera, 166 Diptera, 660 Coleoptera, 217 Hemiptera, 39 Orthoptera, and 56 Neuroptera.

"If we inquire to what insect-fauna of the present period the Tertiary fauna is most analogous, we shall be surprised to find that most of the species belong to genera actually found in the old and the new world. The insect-fauna of Œningen contains 180 genera of this category, of which 114 belong to the Coleoptera. Of these last, two (*Dineutes* and *Caryborus*) remain in Europe, while all the others are now found living both in Europe and in America. The whole number of Coleopterous genera furnished by Œningen, and known to me, amount to

158; those that are common to both hemispheres forming then more than two-thirds of the whole number, while of the actual Coleopterous fauna of Europe, according to the calculation of M. Lacordaire, there is only one-third. The genera found to-day in both parts of the world have then during the Tertiary epoch played a more important part than is the case now; hence the knowledge of the character of the fauna is rendered more difficult. We find at Œningen but a very small number (five) of genera exclusively European; seventeen are found to-day in Europe, in Asia, and in Africa, but not in America. For the most part they belong to the Mediterranean fauna (comprising eight genera) and give to the insect-fauna of Œningen a strong proportion of Mediterranean forms. In this fauna I only know of one exclusively Asiatic genus; two are peculiar to Africa, and two others (*Anoplites* and *Naupactus*) are American.

"There are now living, however, in Europe certain genera which, without being exclusively American, since they are found in Asia and in Africa, belong more peculiarly to America; such are *Belostomum*, *Hypselonotus*, *Diplonychus*, *Evagorus*, *Stenopoda*, *Plecia*, *Caryborus*, and *Dineutes*. . . . The genera peculiar to our fauna of Tertiary insects amount to forty-four, of which twenty-one belong to the Coleoptera; among the Orthoptera there is one, and six Hymenoptera, six Diptera, and eleven Hemiptera. They comprise 140 species." (Heer.)

An apparently still richer locality for Tertiary insects has been discovered by Professor Denton west of the Rocky Mountains, near the junction of the White and Green Rivers, Colorado. According to Mr. Scudder "between sixty and seventy species of insects were brought home, representing nearly all the different suborders; about two-thirds of the species were Flies, — some of them the perfect insect, others the maggot-like larvæ, — but, in no instance, did both imago and larva of the same insect occur. The greater part of the beetles were quite small; there were three or four kinds of Homoptera (allied to the tree-hoppers), Ants of two different genera, and a poorly preserved Moth. Perhaps a minute *Thrips*, belonging to a group which has never been found fossil in any part of the world, is of the greatest interest."

He thus sums up what is known of American fossil insects.

"The species of fossil insects now known from North America, number eighty-one: six of these belong to the Devonian, nine to the Carboniferous, one to the Triassic, and sixty-five to the Tertiary epochs. The Hymenoptera, Homoptera, and Diptera occur only in the Tertiaries; the same is true of the Lepidoptera, if we exclude the Morris specimen, and of the Coleoptera, with one Triassic exception. The Orthoptera and Myriapods are restricted to the Carboniferous, while the Neuroptera occur both in the Devonian and Carboniferous formations. No fossil Spiders have yet been found in America." (American Naturalist, vol. 1, p. 630.) One species of Spider has been found in the Coal-measures of Europe, and a large number in Prussian Amber.

The Diseases of Insects have attracted but little attention. They are so far as known mostly the result of the attacks of parasitic plants and animals, though epidemics are known to break out and carry off myriads of insects. Dr. Shimer gives an account of an epidemic among the Chinch bugs, which "was at its maximum during the moist warm weather that followed the cold rains of June and the first part of July, 1865."

Species of microscopic plants luxuriate in infinitesimal forests within the alimentary canal of some wood-devouring insects, and certain fungi attack those species which are exposed to dampness, and already enfeebled by other causes. Among the true *entophyta*, or parasitic plants, which do not however ordinarily occasion the death of their host, Professor Leidy describes *Enterobryus elegans*, *E. spiralis*, *E. alternatus*, *Arthromitus cristatus*, *Cladophytum comatum*, and *Corynocladus radiatus*, which live mostly attached to the mucous walls of the interior of the intestine of *Julus marginatus* and two other species of *Julus*, and *Passalus cornutus*. *Eccrina longa* Leidy, lives in *Polydesmus Virginiensis;* and *E. moniliformis* Leidy in *P. granulatus*.

But there are parasitic fungi that are largely destructive to their hosts. Such are *Sphaeria* and *Isaria*. "These fungi grow with great rapidity within the body of the animal they attack, not only at the expense of the nutritive fluids of the latter, but, after its death, all the interior soft tissues appear to be converted into one or more aerial receptacles of spores." (Leidy.) These fungi, so often infesting caterpillars, are hence called "caterpillar fungi." They fill the whole body, distending even the legs, and throw out long filaments, sometimes longer than the larva itself, giving a grotesque appearance to the insect. Leidy has found a species which is very common in the Seventeen-year Locust, *Cicada septendecim*. He found "among myriads of the imago between twelve and twenty specimens, which, though living, had the posterior third of the abdominal contents converted into a dry, powdery, ochreous-yellow, compact mass of sporuloid bodies." He thinks this Cicada is very subject to the attacks of these fungi, and that the spores enter the anal and genital passages more readily than the mouth; thus accounting for their development in the abdomen.

The most formidable disease is the "*Muscardine*," caused by a fungus, the *Botrytus Bassiana* of Balsamo. It is well known that this disease has greatly reduced the silk crop in Europe. Balbiani has detected the spores of this fungus in the eggs of *Bombyx mori* as well as in the different parts of the body of the insect in all stages of growth. Extreme cleanliness and care against contagion must be observed in its prevention.

Among plants a disease like Muscardine, due to the presence of a minute fungus (*Mucor mellitophorus*), fills the stomach of some insects, including the Honey-bee, with its colorless spores, and greatly weakens those affected. Another fungus, *Sporendonema musca*, infests the common House-fly.

Another Silk-worm disease called "*Pebrine*," carries off many silk-worms. Whether it is of pathological or vegetable origin is not yet settled.

There are also a few intestinal worms known to be parasitic in insects. The well-known "Hair-worm" (*Gordius*) in its young state lives within the body of various insects including the Spiders. The tadpole-like young differs greatly from the parent, being short, sac-like, ending in a tail. Upon leaving the egg they work their way into the body of insects, and there live on the fatty substance of their hosts, where they undergo their metamorphosis into the adult hair-like worm, and make their way to the pools of water in which they live and beget their species, and lay "millions of eggs connected together in long cords." Leidy thus writes regarding the habits of a species which infests grasshoppers.

"The number of *Gordii* in each insect varies from one to five, their length from three inches to a foot; they occupy a position in the visceral cavity, where they lie coiled among the viscera, and often extend from the end of the abdomen forward through the thorax even into the head; their bulk and weight are frequently greater than all the soft parts, including the muscles, of their living habitation. Nevertheless, with this relatively immense mass of parasites, the insects jump about almost as freely as those not infested.

"The worms are milk-white in color, and undivided at the extremities. The females are distended with ova, but I have never observed them extruded. When the bodies of Grasshoppers, containing these entozoa, are broken and lain upon moist earth, the worms gradually creep out and pass below its surface."

Goureau states that *Filaria*, a somewhat similar worm, inhabits *Hibernia brumata* and *Vanessa prorsa*. (Ann. Ent. Soc. France.)

Siebold describes *Gordius subbifurcus* which infests the Honey-bee, especially the drones, though it is rather the workers, which frequent the pools where the Gordii live, that we would expect to find thus infested. Another entozoan is *Mermis albicans* of Siebold, which is a very slender whitish worm much like *Gordius*, and about five inches long. It is found in the drone of the honey-bee and in some other insects.

Deformities of Insects. Numerous instances of supernumerary legs and antennæ are recorded. The antennæ are sometimes double, but more commonly the legs. "Of these Asmuss has collected eight examples, and it is remarkable that in six of them the parts on one side are treble." Newport, from whom we have quoted, states that "the most remarkable example is that given by Lefebvre of *Scarites Pyrachmon* in which from a single coxa on the left side of the prosternum two trochanters originated. The anterior one, the proper trochanter, supported the true prothoracic leg; while the posterior one, in the form of an oblong lanceolate body, attached to the base of the first, supported two additional legs equally well formed as the true one."

The wings are often partially aborted and deformed; this is especially noticeable in the wings of butterflies and moths.

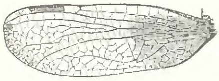


Fig. 69.

Mr. F. G. Sanborn has described and figured a wing of a female of *Libellula luctuosa* Burm. (Fig. 69), in which among other deformities "the pterostigma is shorter and broader than that of the opposite wing, and is situated about one-eighth of an inch only from the nodus, only *one* cubital vein occurring between them, instead of fourteen as in the opposite wing. (Proceedings of the Boston Society of Natural History, vol. xi, p. 326.)

Directions for Collecting and Preserving Insects. Insects differ sexually in that the female generally appears to have one abdominal ring less (one ring disappearing during the semi-pupa state, when the ovipositor is formed), and in being larger, fuller, and duller colored than the males, while the latter often differ in sculpture and ornamentation. In collecting, whenever the two sexes are found united they should be pinned upon the same pin, the male being placed highest. When we take one sex alone, we may feel sure that the other is somewhere in the vicinity; perhaps while one is flying about so as to be easily captured, the other is hidden under some leaf, or resting on the trunk of some tree near by, which must be examined and every bush in the vicinity vigorously beaten by the net. Many species rare in most places have a *metropolis* where they occur in great abundance. During seasons when his favorites are especially abundant the collector should lay up a store against years of scarcity.

At no time of the year need the entomologist rest from his labors. In the winter, under the bark of trees and in moss he can find many species, or on trees, etc., detect their eggs, which he can mark for observation in the spring when they hatch out.

He need not relax his endeavors day or night. Mothing is night employment. Skunks and toads entomologize at night. Early in the morning, at sunrise, when the dew is still on the leaves, insects are sluggish and easily taken with the hand;

so at dusk, when many species are found flying, and in the night, the collector will be rewarded with many rarities, many species flying then that hide themselves by day, while many caterpillars leave their retreats to come out and feed, when the lantern can be used with success in searching for them.

Wollaston (Entomologist's Annual, 1865) states that sandy districts, especially towards the coast, are at all times preferable to clayey ones, but the intermediate soils, such as the loamy soil of swamps and marshes are more productive. Near the sea, insects occur most abundantly beneath pebbles and other objects in grassy spots, or else at the roots of plants. In many places, especially in Alpine tracts, as we have found on the summit of Mt. Washington and in Labrador, one has to lay down and look carefully among the short herbage and in the moss for Coleoptera.

The most advantageous places for collecting are gardens and farms, the borders of woods and the banks of streams and ponds. The deep, dense forests, and open, treeless tracts are less prolific in insect life. In winter and early spring the moss on the trunks of trees, when carefully shaken over a newspaper or white cloth, reveal many beetles and Hymenoptera. In the late summer and autumn, toadstools and various fungi and rotten fruits attract many insects, and in early spring when the sap is running we have taken rare insects from the stumps of freshly cut hard-wood trees. Wollaston says, "Dead animals, partially-dried bones, as well as the skins of moles and other vermin which are ordinarily hung up in fields are magnificent traps for Coleoptera; and if any of these be placed around orchards and inclosures near at home, and be examined every morning, various species of *Nitidulæ*, *Silphidæ*, and other insects of similar habits, are certain to be enticed and captured.

"Planks and chippings of wood may be likewise employed as successful agents in alluring a vast number of species which might otherwise escape our notice, and if these be laid down in grassy places, and carefully inverted every now and then with as little violence as possible, many insects will be found adhering beneath them, especially after dewy nights and in showery weather. Nor must we omit to urge the importance of examining the under sides of stones in the vicinity of ants' nests, in which position, during the spring and summer months, many of the rarest of our native Coleoptera may be occasionally procured." Excrementitious matter always contains many interesting forms in various stages of growth.

The trunks of fallen and decaying trees offer a rich harvest for many wood-boring larvæ, especially the Longicorn beetles, and weevils can be found in the spring, in all their stages. Numerous carnivorous Coleopterous and Dipterous larvæ dwell within them, and other larvæ which eat the dust made by the borers. The inside of pithy plants like the elder, raspberry, blackberry, and syringa, are inhabited by many of the wild bees, *Osmia*, *Ceratina*, and the wood-wasps, *Crabro*, *Stigma*, etc., the habits of which, with those of their Chalcid and Ichneumon parasites, offer endless amusement and study.

Ponds and streams shelter a vast throng of insects, and should be diligently dredged with the water-net, and stones and pebbles should be overturned for aquatic beetles, Hemiptera, and Dipterous larvæ.

The various sorts of galls should be collected in spring and autumn and placed in vials or boxes, where they may be reared, and the rafters of out-houses, stone-walls, etc., should be carefully searched for the nests of Mud-wasps.

Collecting Apparatus. First in importance is the *net.* This is made by attaching a ring of brass wire to a handle made to slide on a pole six feet long. The net may be a foot in diameter, and the bag itself made of thin gauze or musquito-netting (the finer, lighter, and more durable the better), and should be about twenty inches deep. It should be sewed to a narrow border of cloth placed around the wire. A light net like this can be rapidly turned upon the insect with one hand. The insect is captured by a dexterous twist which also throws the bottom over the mouth of the net. The insect should be temporarily held between the thumb and fore-finger of the hand at liberty, and then pinned through the thorax while in the net. The pin can be drawn through the meshes upon opening the net. The *beating-net* should be made much stouter, with a shallower cloth bag and attached to a shorter stick. It is used for beating trees, bushes, and herbage for beetles and Hemiptera and various larvæ. Its thorough use we would recommend in the low vegetation on mountains and in meadows. The *water-net* may be either round or of the shape indicated in Fig. 70. The ring should be made of brass, and the shallow net of grass-cloth or coarse millinet. It is used for collecting aquatic insects.

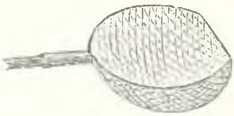


Fig. 70.

Various sorts of *forceps* are indispensable for handling insects. Small delicate narrow-bladed forceps with fine sharp points in use by jewellers, and made either of steel or brass, are excellent for handling minute specimens. For larger ones long curved forceps are very convenient. For pinning insects into boxes the forceps should be stout, the blades blunt and curved at the end so that the insect can be pinned without slanting the forceps much. The ends need to be broad and finely indented by lines so as to firmly hold the pin. With a little practice the forceps soon take the place of the fingers. They will have to be made to order by a neat workman or surgical-instrument maker. Some persons use the ordinary form of pliers with curved handles, but they should be long and slender. A spring set in to separate the handles when not grasped by the hand is a great convenience.

Various pill-boxes, vials, and bottles must always be taken, some containing alcohol or whiskey. Many collectors use a wide-mouth bottle, containing a sponge saturated with ether, chloroform, or benzine, or bruised laurel leaves, the latter being pounded with a hammer and then cut with scissors into small pieces, which give out exhalations of prussic acid strong enough to kill most small insects.

Besides these the collector needs a small box lined with corn-pith, or cork, and small enough to slip into the coat-pocket; or a larger box carried by a strap. Most moths and small flies can be pinned alive without being pinched (which injures their shape and rubs off the scales and hairs), and then killed by pouring a little benzine into the bottom of the box.

Killing Insects for the Cabinet. Care in killing affects very sensibly the looks of the cabinet. If hastily killed and distorted by being pinched, with the scales rubbed off and otherwise mangled, the value of such a specimen is diminished either for purposes of study or the neat appearance of the collection.

Besides the vapor of ether, chloroform, and benzine, the fumes of sulphur readily kill insects. Large specimens may be killed by inserting a pin dipped in a strong solution of oxalic acid. An excellent collecting bottle is made by putting into a wide-mouth bottle two or three small pieces of cyanide of potassium, which may be covered with cotton, about half-filling the bottle. The cotton may be covered with paper lightly attached to the glass and pierced with pin-holes; this keeps the insect from being lost in the bottle. For Diptera, Loew recommends moistening the bottom of the collecting box with creosote. This is excellent for small flies and moths, as the mouth of the bottle can be placed over the insect while at rest; the insect flies up into the bottle and is immediately suffocated. A bottle well prepared will, according to Laboulbène, last several months, even a year, and is vastly superior to the old means of using ether or chloroform. He states, "the inconvenience of taking small insects from a net is well known, as the most valuable ones usually escape; but by placing the end of the net, filled with insects, in a wide-mouthed bottle, and putting in the cork for a few minutes, they will be suffocated."

Pinning Insects. The pin should be inserted through the thorax of most insects. The Coleoptera, however, should be pinned through the right wing-cover; many Hemiptera are best pinned through the scutellum. The specimens should all be pinned at an equal height, so that about one-fourth of the pin should project above the insect.

The best pins are those made in Berlin by Klager. They are of five sizes, No. 1 being the smallest; Nos. 1, 2, and 5 are the most convenient. For very minute insects still smaller pins are made. A very good but too short pin is made by Edleston and Williams, Crown Court, Cheapside, London. Their Nos. 19 and 20 may be used to impale minute insects upon, and then stuck through a bit of cork, or pith, through which a No. 5 Klager pin may be thrust. Then the insect is kept out of the reach of devouring insects. Still smaller pins are made by cutting off bits of very fine silvered wire at the right length, which may be thrust by the forceps into a piece of pith, after the insects have been impaled upon them.

Small insects, especially beetles, may be mounted on cards or pieces of mica through which the pin may be thrust. The French use small oblong bits of mica, with the posterior half covered with green paper on which the number may be placed. The insect may be gummed on the clear part, the two sexes together. The under side can be seen through the thin mica.

Others prefer triangular pieces of card, across the end of which the insect may be gummed, so that nearly the whole under side is visible.

Mr. Wollaston advocates gumming small Coleoptera upon cards. Instead of cutting the pieces of cards first, he gums them promiscuously upon a sheet of card-board. "Having gummed thickly a space on your card-board equal to, at least, the entire specimen when expanded, place the beetle upon it, drag out the limbs with a pin, and. leaving it to dry, go on with the next one that presents itself. As the card has to be cut afterwards *around* your insect (so as to suit it), there is no advantage in gumming it precisely *straight upon your frame*, — though it is true that a certain amount of care in this respect lessens your after labor of cutting-off very materially. When your frame has been filled, and you are desirous of separating the species, cut out the insect with finely pointed scissors."

For mending broken insects, *i.e.* gumming on legs and antennæ which have fallen off, inspissated ox-gall, softened with a little water, is the best gum.

For gumming insects upon cards Mr. Wollaston recommends a gum "composed of three parts of tragacanth to one of Arabic, both in powder; to be mixed in water containing a grain of corrosive sublimate, without which it will not keep, until of a consistency just thick enough to run. As this gum is of an extremely absorbent nature, nearly a fortnight is required before it can be properly made. The best plan is to keep adding a little water (and stirring it) every few days until it is of the proper consistency. It is advisable to dissolve the grain of corrosive sublimate in the water which is poured *first* upon the gum."

Preservative Fluids. The best for common use is alcohol, diluted with a little water; or whiskey, as alcohol of full strength is too strong for caterpillars, etc., since it shrivels them up. Glycerine is excellent for preserving the colors of caterpillars, though the internal parts decay somewhat, and the specimen is apt to fall to pieces on being roughly handled.

Laboulbène recommends for the preservation of insects in a fresh state plunging them in a preservative fluid consisting of alcohol with an excess of arsenic acid in fragments, or the common white arsenic of commerce. A pint and a half of alcohol will take about fourteen grains (troy) of arsenic. The living insect, put into this preparation, absorbs about $\frac{3}{1000}$ of its own weight. When soaked in this liquor and dried, it will be safe from the ravages of Moths, *Anthrenus*, or *Dermestes*. This liquid will not change the colors of blue, green, or red beetles if dried after soaking from twelve to twenty-four hours. Hemiptera and Orthoptera can be treated in the same way.

A stay of a month in this arseniated alcohol mineralizes the insect, so that it becomes very hard, and, after drying, becomes glazed with a white deposit which can, however, be washed off with alcohol. In this state the specimens become too hard for dissection and study, but will do for cabinet specimens designed for permanent exhibition.

Another preparation recommended by Laboulbène is alcohol containing a variable quantity of corrosive sublimate, but the latter has to be weighed, as the alcohol evaporates easily, the liquor becoming stronger as it gets older. The strongest solution is one part of corrosive sublimate to one hundred of alcohol; the weakest and best is one-tenth of a part of corrosive sublimate to one hundred parts of alcohol. Insects need not remain in this solution more than two hours before drying. Both of these preparations are very poisonous and should be handled with care. The last-named solution preserves specimens from mould, which will attack pinned insects during damp summers.

A very strong brine will preserve insects until a better liquor can be procured. Professor A. E. Verrill recommends two simple and cheap solutions for preserving, among other specimens, the larvæ of insects "with their natural color and form remarkably perfect." The first consists of two and a half pounds of common salt and four ounces of nitre dissolved in a gallon of water, and filtered. Specimens should be prepared for permanent preservation in this solution by being previously immersed in a solution consisting of a quart of the first solution and two ounces of arseniate of potash and a gallon of water. (Proceedings Boston Society Nat. Hist. Vol. 10, p. 257.)

The nests, cocoons, and chrysalids of insects may be preserved from injury from other insects by being soaked in the arseniated alcohol, or dipped into benzine, or a solution of carbolic acid or creosote.

Preparing Insects for the Cabinet. Dried insects may be moistened by laying them for twelve or twenty-four hours in a box containing a layer of wet sand, covered with one thickness of soft paper. Their wings can then be easily spread. *Setting-boards* for spreading the wings of insects may be made by sawing deep grooves in a thick board, and placing a strip of pith or cork at the bottom. The groove may be deep enough to allow a quarter of the length of the pin to project above the insect. The setting-board usually consists of thin parallel strips of board, leaving a groove between them wide enough to receive the body of the insect, at the bottom of which a strip of cork or pith should be glued. The end of the strips should be nailed on to a stouter strip of wood, raising the surface of the setting-board an inch and a half so that the pins can stick through without touching. Several setting-boards can be made to form shelves in a frame covered with wire gauze, so that the specimens may be preserved from dust and destructive insects, while the air may at the same time have constant access to them. The surface of the board should incline a little towards the groove for the reception of the insect, as the wings often gather a little moisture, relax and fall down after the insect is dried. Moths of medium size should remain two or three days on the setting-board, while the larger thick-bodied Sphinges and *Bombycidæ* require a week to dry. The wings can be arranged by means of a needle stuck into a handle of wood. They should be set horizontally, and the front margin of the fore-wings drawn a little forward of a line perpendicular to the body, so as to free the inner margin of the hind wings from the body, that their form may be distinctly seen. When thus arranged, they can be confined by pieces of card pinned on the board as indicated in the figure 71, or, as we prefer, by square pieces of glass laid upon them.

After the insects have been thoroughly dried they should not be placed in the cabinet until after having been in quarantine to see that no eggs of Dermestes or Anthrenus, etc., have been deposited on them.

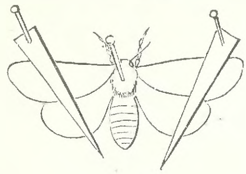


Fig. 71.

For preserving dried insects in the cabinet Laboulbène recommends placing a rare insect (if a beetle or any other hard insect) in water for an hour until the issues be softened. If soiled, an insect can be cleansed under water with a fine hair-pencil, then submit it to a bath of arseniated alcohol, or, better, alcohol with corrosive sublimate. If the insect becomes prune-colored, it should be washed in pure alcohol several times. This method will do for the rarest insects; the more common ones can be softened on wet sand, and then the immersion in the arseniated alcohol suffices. After an immersion of an hour or a quarter of an hour, according to the size of the insect, the pin is not affected by the corrosive sublimate, but it is better to unpin the insect previous to immersion, and then pin it when almost dry.

For cleaning insects ether or benzine are excellent, rubbed on with a hair-pencil; though care should be taken in using these substances which are very inflammable.

After the specimens are placed in the cabinet, they should be farther protected from destructive insects by placing in the drawers or boxes pieces of camphor wrapped in paper perforated by pin-holes, or bottles containing sponges saturated with benzine. The collection should be carefully examined every month; the presence of insects can be detected by the dust beneath them. Where a box of insects is much infested with destructive insects, benzine should be poured into the bottom of the box or drawer, when the fumes and contact of the benzine with their bodies will kill them. The specimens themselves should not be soaked in the benzine if possible, as it renders them brittle.

Insect-cabinet. For permanent exhibition, a cabinet of shallow drawers, protected by doors, is most useful. A drawer may be eighteen by twenty inches square, and two inches deep in the clear, and provided with a tight glass cover. For constant use, boxes made of thin, well-seasoned wood, with tight-fitting covers, are indispensable. For Coleoptera, Dr. Leconte recommends that they be twelve by nine inches (inside measurement). For the larger Lepidoptera a little larger box is preferable. Others prefer boxes made in the form of books, which may be put away like books on the shelves of the cabinet, though the cover of the box is apt to be in the way.

The boxes and drawers should be lined with cork cut into thin slips for soles; such slips come from the cork-cutter about twelve by four inches square, and an eighth of an inch thick. A less expensive substitute is paper stretched upon a frame. Mr. E. S. Morse has given in the American Naturalists (Vol. 1, p. 156) a plan which is very neat and useful for lining boxes in a large museum, and which are placed in horizontal show-cases (Fig. 72). "A box is made of the required depth, and a light frame is fitted to its interior. Upon the upper and under surfaces of this frame, a sheet of white paper (drawing or log-paper answers the purpose) is securely glued.

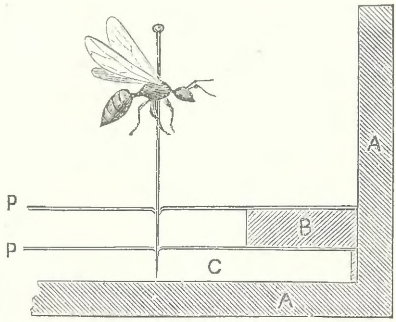


Fig. 72.

The paper, having been previously dampened, in drying contracts and tightens like a drum-head. The frame is then secured about one-fourth of an inch from the bottom of the box, and the pin is forced down through the thicknesses of paper, and if the bottom of the box be of soft pine, the point of the pin may be slightly forced into it. It is thus firmly held at two or three different points, and all lateral movements are prevented. Other advantages are secured by this arrangement besides firmness; when the box needs cleaning or fumigation, the entire collection may be removed by taking out the frame, or camphor, tobacco, or other material can be placed on the bottom of the box, and concealed from sight. The annexed figure represents a transverse section of a portion of the side and bottom of the box with the frame. A, A, box; B, frame;

P, P, upper and under sheets of paper; C, space between lower sheet of paper and bottom of box."

Other substitutes are the pith of various plants, especially of corn; and palm wood, and "inodorous felt" is used, being cut to fit the bottom of the box.

Leconte recommends that "for the purpose of distinguishing specimens from different regions, little disks of variously colored paper be used; they are easily made by a small punch, and should be kept in wooden pill-boxes ready for use; at the same time a key to the colors, showing the regions embraced by each, should be made on the fly-leaf of the catalogue of the collection." He also strongly recommends that the "specimens should all be pinned at the same height, since the ease of recognizing species allied in characters is greatly increased by having them on the same level."

He also states that "it is better, even when numbers with reference to a catalogue are employed, that the name of each species should be written on a label attached to the first specimen. Thus the eye is familiarized with the association of the species and its name, memory is aided, and greater power given of identifying species when the cabinet is not at hand." For indicating the sexes the astronomical sign ♂ (Mars) is used for the male, and ♀ (Venus) for the female, and ☿ for the worker.

Transportation of Insects. While travelling, all hard-bodied insects, comprising many Hymenoptera, the Coleoptera, Hemiptera, and many Neuroptera should be thrown, with their larvæ, etc., into bottles and vials filled with strong alcohol. When the bottle is filled new liquor should be poured in, and the old may be saved for collecting purposes; in this way the specimens will not soften and can be preserved indefinitely, and the colors do not in most cases change. Leconte states that "if the bottles are in danger of being broken, the specimens, after remaining for a day or two in alcohol, may be taken out, partially dried by exposure to the air, but not so as to be brittle, and these packed in layers in small boxes between soft paper; the boxes should then be carefully closed with gum-paper or paste, so as to exclude all enemies."

Lepidoptera and Dragon-flies and other soft-bodied insects may be well preserved by placing them in square pieces of paper folded into a triangular form with the edges overlapping. Put up thus, multitudes can be packed away in tin boxes, and will bear transportation to any distance. In tropical climates, chests lined with tin should be made to contain the insect-boxes, which can thus be preserved against the ravages of white ants, etc.

In sending live larvæ by mail, they should be inclosed in little tin boxes, and in sending dry specimens, the box should be light and strong, and directions given at the post-office to stamp the box lightly. In sending boxes by express they should be carefully packed in a larger box, having an inter-space of two inches, which can be filled in tightly with hay or crumpled bits of paper. Beetles can be wrapped in pieces of soft paper. Labels for alcoholic specimens should consist of parchment with the locality, date of capture, and name of collector written in ink. A temporary label of firm paper with the locality, etc., written with a pencil, will last for several years.

Preservation of Larvæ. Alcoholic specimens of insects, in all stages of growth, are very useful. Few collections contain alcoholic specimens of the adult insect. This is a mistake. Many of the most important characters are effaced during the drying process, and for purposes of general study alcoholic specimens, even of Bees, Lepidoptera, Diptera, and Dragon-flies are very necessary.

Larvæ, generally, may be well preserved in vials or bottles of alcohol. They should first be put into whiskey, and then into alcohol. If placed in the latter first, they shrivel up and become distorted. Mr. E. Burgess preserves caterpillars with the colors unchanged, by immersing them in boiling water thirty or forty seconds, and then placing them in equal parts of alcohol and water. It is well to collect larvæ and pupæ indiscriminately, even if we do not know their adult forms; we can approximate to them, and in some cases tell very exactly what they must be.

Rearing Larvæ. More attention has been paid to rearing Caterpillars than the young of any other suborder of insects, and the following remarks apply more particularly to them, but very much the same methods may be pursued in rearing the larvæ of Beetles, Flies, and Hymenoptera. Subterranean larvæ have to be kept in moist earth, aquatic larvæ must be reared in aquaria, and carnivorous larvæ must be supplied with flesh. The larvæ of Butterflies are rare; those of moths occur more frequently, while their imagos may be scarce. In some years many larvæ, usually rare, at other times occur in abundance, when they should be reared in numbers. In hunting for caterpillars bushes should be shaken and beaten over newspapers or sheets, or an umbrella; herbage should be swept, and trees examined carefully for leaf-rollers and miners. The best specimens of moths and butterflies are obtained by rearing them from the egg, or from the larva or pupa. In confinement the food should be kept fresh, and the box well ventilated. Tumblers covered with gauze, pasteboard boxes pierced with holes and fitted with glass in the covers, or large glass-jars, are very convenient to use as cages. The bottom of such vessels may be covered with moist sand, in which the food-plant of the larva may be stuck and kept fresh for several days. Larger and more airy boxes, a foot square, with the sides of gauze, and fitted with a door, through which a bottle of water may be introduced, serve well. The object is to keep the food-plant fresh, the air cool, the larva out of the sun, and in fact everything in such a state of equilibrium that the larva does not feel the change of circumstances when kept in confinement. Most caterpillars change to pupæ in the autumn; and those which transform in the earth should be covered with earth, kept damp by wet moss, and placed in the cellar until the following summer. The collector in seeking for larvæ should carry a good number of pill-boxes, and especially a close tin box, in which the leaves may be kept fresh for a long time. The different forms and markings of caterpillars should be noted, and they should be drawn carefully together with a leaf of the food-plant, and the drawings and pupa skins, and perfect insect, be numbered to correspond. Descriptions of caterpillars cannot be too carefully made, or too long. The relative size of the head, its ornamentation, the stripes and spots of the body, and the position and number of tubercles, and the hairs, or fascicles of hairs, or spines and spinules, which arise from them, should be noted, besides the general form of the body. The lines along the body are called *dorsal*, if in the middle of the back, *subdorsal;* if upon one side, *lateral*, and *ventral* when on the sides and under surface, or *stigmatal* if including the *stigmata* or breathing pores, which are generally parti-colored. Indeed, the whole biography of an insect should be ascertained by the observer; the points to be noted are:

1. Date, when and how the *eggs* are laid; and number, size, and marking of the eggs.

2. Date of hatching, the appearance, food-plant of *larva*, and number of days between each moulting; the changes the larva undergoes, which are often remarkable, especially before the last moulting, with drawings illustrative of these; the habits of the larva, whether solitary or gregarious, whether a day or night feeder; the Ichneumon parasites, and their mode of attack. Specimens of larvæ in the different moultings should be preserved in alcohol. The appearance of the larvæ when full-fed, the date, number of days before pupating, the formation and description of the cocoon, the duration of larvæ in the cocoon before pupation, their appearance just before changing, their appearance while changing, and alcoholic specimens of larvæ in the act, should all be studied and noted.

3. Date of pupation; description of the pupa or chrysalis; duration of the pupa state, habits, etc.; together with alcoholic specimens, or pinned dry ones. Lepidopterous pupæ should be looked for late in the summer or in the fall and spring, about the roots of trees, and kept moist in mould until the imago appears. Many Coleopterous pupæ may also occur in mould, and if aquatic, under submerged sticks and stones, and those of borers under the bark of decaying trees.

4. Date when the insect escapes from the pupa, and method of escape; duration of life of the imago; and the number of broods in a season.

ENTOMOLOGICAL WORKS. The titles of a few of the most important works on Insects are given below. The more advanced student should, however, possess Dr. Hagen's Bibliotheca Entomologica, 8vo, 2 vols., Leipzig, 1862–3, which contains a complete list of all entomological publications up to the year 1862. Besides these he should consult the annual reports on the progress of Entomology published in Wiegmann's Archiv fur Naturgeschichte, begun in 1834, and continued up to the present time; and also Gunther's Zoological Record (8vo, Van Voorst, London), beginning with the year 1864. Occasional articles are also scattered through the various government reports, and those of agricultural societies and agricultural papers.

GENERAL WORKS.

The works of *Swammerdam, Malphighi, Leeuwenhoek, Lyonnet, Serres, Meckel, Ramdohr, Suckow, Merian*, and *Herbst*.

Reaumur, René Ant. de. Memoires pour servir à l'Histoire des Insectes. Paris, 1734–1742, 7 vols. 4to.

Roesel, Aug. Joh. Der monatlich herausgegeben Insekten-Belustigung. Nurnberg, 1746–1761, 4 vols. 4to, illustrated.

Geer, Carl de. Memoires pour servir à l'Histoire des Insectes, 1752–1778, 7 vols. 4to.

Linnæus, Carolus. Systema Naturæ, 1735. 12th edition, 1766–1768.

Fabricius, Joh. Christ. Systema Entomologiæ, 1775, 8vo.

——. Genera Insectorum, 1777, 8vo.

——. Species Insectorum, 1781. 2 vols. 8vo.

——. Mantissa Insectorum, 1787, 2 vols. 8vo.

——. Entomologia Systematica, 4 vols. 8vo, 1792–94.

Cramer, P. Papillons exotiques des trois parties du monde. 4 vols. 4to, 1775–82.

Stoll, Casper. Supplement to Cramer's Papillons exotiques. 4to, Amsterdam, 1787–91.

Smith, J. E., and *Abbot, John.* The Natural History of the Rarer Lepidopterous Insects of Georgia. Fol. Plates. London, 1797.

Latreille, Pierre André. Precis des caracteres générique des Insectes, 1796, 8vo.

——. Genera Crustaceorum et Insectorum, 4 vols. 8vo, 1806–1809.

——. Considération générales sur l' Ordre naturel des Animaux composant les Classes des Crustacés, des Arachnides et des Insectes.

——. In Cuvier's Regne animal, 8vo, 1810.

——. Familles naturelles du Regne animal, 8vo, 1825.

——. Cours d' Entomologie, 8vo, 1831.

Fabricius, Otho. Fauna Groenlandica. Hafniæ, 1780, 8vo. Contains *Libellula virgo* (erroneously), *Phryganea rhombica, Termes divinatorium*, etc.

Drury, Drew. Illustrations of Natural History, etc. London, 1770–1782, 4to, 3 vols. (ed. Westwood, 1837). Numerous species are figured and described.

Treviranus, G. R. Vermischte Schriften anatomischen und physiologischen Inhalts Bd. 1 u. 2. Göttingen, 1816–17, 4to.

Mac Leay, W. S. Horæ Entomologicæ, 2 vols. London, 1819.

Meigen, F. W. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insecten. 7 vols. Aachen and Hamm, 1818–1835. (Although this work contains only European species, many of them are common to both continents.)

Say, T. American Entomology. 3 vols. With plates. Philadelphia, 1824, 25, 28.

——. Complete Writings on the Entomology of North America, edited by J. L. Leconte, M.D. 2 vols. 8vo, colored plates. New York, 1859.

Baer, K. E. v. Beitrage zur Kentniss der niederen Thiere. (Extracted from Nova Acta Acad. Leopold. Carolin. xiii. 2, 1827.)

Palisot de Beauvais, A. J. Insectes recueillis en Afrique et en Amerique, dans les royaumes d' Oware et de Benin, a Saint-Domingue et dans les Etats-Unis, pendant les années, 1786-97. Fol. with 90 plates, Paris, 1805-21.

Savigny, J. C. de. Description de l' Egypte. Histoire naturelle. Crustacés, Arachnides, Myriapodes et Insectes, 53 pl. in gr. fol. Paris, 1809-1838. Explication sommaire des planches par J. V. Audouin, Paris, 1826, fol.

Curtis, John. Description of the Insects brought home by Commander James Clark. Ross's Second Voyage. App. Nat. Hist., 1831, 4to, plates. (Several Arctic species are described.)

Kirby, W. & W. Spence. An Introduction to Entomology; or, Elements of the Natural History of Insects. 4 vols. 8vo, 1828. Seventh edition (comprising vols. 3 & 4 of the early editions). London, 1856, post 8vo.

Wiedemann, C. R. W. Aussereuropäische Zweiflügelige Insecten. 2 vols. Hamm, 1828-30. With plates.

Curtis, John. Farm Insects; being the Natural History and Economy of the Insects injurious to the Field Crops of Great Britain and Ireland. 8vo. With plates and wood-cuts. 1860.

Chevrolat, Aug. Coléoptères du Mexique. Strasbourg, 1834-5.

Stephens, J. F. Illustrations of British Entomology. London, 8vo, 1835. Several species of European Insects mentioned in this work have been found in North America.

Kirby, W. Fauna boreali-Americana, etc. Norwich, 1837, 4to.

Kollar, V. Naturgeschichte der schaedlichen Insekten. Wien, 1837, 4to. Contains *Termes flavipes*, injurious in the hot-houses of Schœnbrunn and Vienna. This description has been omitted in the translation of this work by Mr. Loudon, London, 1840.

Macquart, J. Diptères Exotique nouveaux ou peu connus. 2 vols. en 5 parties, et 5 supplements, Paris, 1838-55. With numerous plates. (Published originally in the Memoires de la Société des Sciences et des Arts de Lille, 1838-55.)

Burmeister, H. Manual of Entomology, translated by W. E. Shuckard. London, 8vo, 1836.

Burmeister, Hermann. Zoologischer Hand Atlas. Berlin, 1836-43 fol., 41 plates.

Westwood, J. O. An Introduction to the Modern Classification of Insects. 2 vols. 8vo. London, 1839-40.

Cuvier, G. Le Règne animal distribué d'aprés son Organisation. Nouvelle édition, accompagnée de planches gravées, représentant les types de tous les Genres,etc., publiée par un reunion de Disciples de G. Cuvier. Paris, 1849, 8vo. Insectes, Arachnides, Crustacés par *Audouin, Blanchard, Doyère, Milne-Edwards* et *Dugès*. 4 vols. Texte et 4 vols. atlas.

Guérin-Méneville, F. E. Iconographie du Regne Animal de G. Cuvier, ou représentation d'apres nature de l'une des espèces les plus remarquables et souvent non encore figurées de chaque genre d' animaux, vols. 6 et 7: Annelides, Crustacés, Arachnides et Insectes, Paris, J. B. Baillière, 1829-44, 104 pl. 8vo.

Griffith, E. The Animal Kingdom, described and arranged in conformity with its organization. London, 1824-33, 8vo. Class Insecta, 2 vols. with 140 pl. 1832. Classes Annelida, Crustacea et Arachnida. 1 vol. with 60 pl.

Suites a Buffon et Nouvelles suites a Buffon. Formant avec les Œuvres de cet auteur un Cours complet d'Histoire naturelle. Paris, Dufart, 1798-1807. Paris, Roret, 1834-1864, 8vo. (Insectes, Crustacés, Arachnides etc., par *Latreille, Lacordaire, Amyot, Audinet-Serville, Boisduval, Guénée, Rambur, Lepeletier de St. Fargeau, Macquart, Milne-Edwards, Walkenaer, et Gervais*).

Gosse, P. H. Canadian Naturalist. London, 1840.

Zetterstedt, J. W. Insecta Lapponica. Lipsiæ, 1840, 4to. Several species from Lapland have been found in the Arctic regions of North America.

Pictet, F. Histoire naturelle, etc., des insectes Neuroptères, Part I, Perlides; Part II, Ephemerines. Geneve, 1841-45, 8vo, with colored plates.

Doubleday, E., and Westwood, J. O. The Genera of Diurnal Lepidoptera. 86 colored plates, 2 vols. fol. London, 1846–52.

Walker, F. List of the specimens of Lepidopterous, Dipterous, Neuropterous, and Homopterous Insects in the Collection of the British Museum. London, 1848–67.

Amyot, C., and *Serville, A.* Hemipteres. 8vo, Paris, Roret, 1843.

Ratzeburg, J. T. C. Die Forstinsekten. 4to, 3 vols. Berlin, 1837–44.

Van der Hœven, J. Handbook of Zoölogy, English translation. 2 vols. 8vo, 1850.

Gerstaecker, A. Handbuch der Zoölogie (in connection with V. Carus), 2 vols. 8vo. (vol. 2, Arthropoda). Leipzig, 1863.

De Selys Longchamps, E. Revue des Odonates ou Libellules d'Europe avec la collaboration de H. Hagen. Paris, 1850, 8vo. (Memoir. Soc. R. Science de Liege, vol. vi.) (Two species, *Lib. Hudsonica*, p. 53, and *Agrion Doubledayi*, p. 209, are described in this work.)

Hagen, H. Revue des Odonates; Monographie des Calopterygines; Monographie des Gomphines (cf. Selys Longchamps).

Agassiz, L. Lake Superior, its Physical Character, its Vegetation, and its Animals, Boston, 1850. With Catalogue of Coleoptera, by Dr. J. L. Leconte, and of the Lepidoptera, by Dr. T. W. Harris.

Lacaze-Duthiers, H. Recherches sur l'armure génitale femelle des Insectes. Plates. 8vo. Paris, 1853.

Melsheimer, F. E. Catalogue of the described Coleoptera of the United States. Smithsonian Institution. 8vo, 1853.

Dallas, W. S. Catalogue of Hemipterous Insects in the British Museum. 1, 2. Illustrated. London, 1852.

Fitch, Asa. The noxious, beneficial, and other Insects of the State of New York. Reports 1–8, 1856–66.

Smith, Frederic. Catalogue of Hymenoptera in the British Museum. Parts i–vi. Plates. London, 1857–58.

Fallen, C. F., *Stal, C.*, and *Fieber.* Various papers on Hemiptera in Scandinavian and German periodicals.

Hübner, J. Sammlung Exotischer Schmetterlinge. 5 vols. 4to. Plates. 1806.

Guenée, A. Species général des Lépidoptères. (Noctuidæ, Phalænidæ and Pyralidæ) Suite a Buffon. Paris, 8vo, 1852–57.

Stainton, H. T. The Natural History of the Tineina. 8vo, with many plates. London, vols. 1–8, 1855–64, 8vo.

Lacordaire, J. T. Genera des Coléoptères. 8vo, tomes 1–7. Paris, Roret, 1854.

Boisduval, J. A. Histoire générale et Iconographie des Lépidoptères et des Chenilles de l'Amérique septentrionale. 8vo. Paris, Roret, 1829–42.

———. Species générale des Lépidoptères. 8vo. Roret, Paris, 1856.

———. Essai sur l'Entomologie horticole. 8vo. Paris, 1867.

Practical Entomologist. Entomological Society of Philadelphia. Vols. 1, 2, 4to, 1865–67.

Harris, T. W. A Treatise on some of the Insects of New England, which are injurious to Vegetation. Third edition, illustrated. Boston, 1862.

Leconte, J. L. Classification of the Coleoptera of North America. Part I, 1861–2. Smithsonian Institution.

———. List of Coleoptera of North America. 8vo, 1863–6. Smithsonian Institution.

———. New Species of North American Coleoptera. 8vo. Part I, 1863–6. Smithsonian Institution.

———. Coleoptera of Kansas and Eastern New Mexico. 4to. 3 plates. 1859. Smithsonian Institution.

Hagen, H. Synopsis of the Neuroptera of North America. 8vo. 1861. Smithsonian Institution.

Morris, J. G. Catalogue of the described Lepidoptera of North America. 8vo, 1860. Smithsonian Institution.

Osten Sacken, R. Catalogue of the described Diptera of North America. 1858. Smithsonian Institution.

Loew, H., and *Osten Sacken, R.* Monograph of the Diptera of North America. Parts 1, 2, 8vo, 1862–64. Smithsonian Institution.

Trimble, I. P. A Treatise on the Insect Enemies of Fruit and Fruit Trees. The Curculio and Apple moth. 4to. Plates. New York, 1865.

MORPHOLOGY.

Savigny, J. C. Mémoires sur les Animaux sans Vertèbres. 1 Partie. Description et Classification des Animaux invertébrés et articulés, 1. Fascicule. Théorie des Organes de la Bouche des Crustacés et des Insectes. Paris, 1816.

Audouin, J. V. Recherches anatomiques sur le Thorax des animaux articulés et celui des Insectes hexapodes en particulier. (Annales d. Scienc. natur. 1, 1824, p. 97 and 416.)

Eschscholtz, J. F. Beschreibung des inneren Skeletes einiger Insekten aus verschiedenen Ordnungen. Dorpat, 1820, 8vo, p. 24–49, 2 Taf.

Baer, K. E. V. Ueber das äussere und innere Skelet (Meckel's Archiv. f. Anatom. u. Physiol. 1826, p. 327–374).

Erichson, W. F. Ueber zoölogische Charaktere der Insekten, Arachniden und Crustaceen. (Entomographien, S. 1–28.) Berlin, 1840, 8vo.

Brullé, A. Recherches sur les Transformations des Appendices dans les Articulés (Annales des Sciences naturelles, 3. sér. II, 1844, p. 271–374).

Leuckart, R. Ueber die Morphologie und die Verwandtschaftsverhältnisse der Wirbellosen Thiere. Braunschweig, 1848, 8vo.

ANATOMY AND PHYSIOLOGY.

Straus-Dürckheim, H. Considérations générales sur l'Anatomie comparée des Animaux articulés, auxquelles on a joint l'Anatomie descriptive du Melolontha vulgaris. Paris, 1828, 4to. 10 pl.

Dufour, L. Numerous anatomical papers in the Annales des Sciences naturelles, Paris.

Siebold, C. Th. v. Lehrbuch der Vergleichenden Anatomie der wirbellosen Thiere. Berlin, 1848, 8vo. Translated by W. I. Burnett. Boston, 1851, 8vo.

Gegenbaur, C. Grundzüge der vergleichenden Anatomie. Leipzig, 1859, 8vo.

Geoffroy St. Hilaire, Etienne. Considérations philosophiques sur la détermination du Système solide et du Système nerveux des Animaux articulés. (Annal. d. scienc. natur. II, 1824, p. 295 ff., III, p. 199 u. p. 453 ff.)

Newport, G. On the Structure, Relations, and Development of the nervous and circulatory Systems, and on the existence of a complete Circulation of the Blood in Vessels, in Myriapoda and Macrourous Arachnida. (Philosoph. Transact. 1843, p. 243–302.)

——. On the Structure and Development of the Blood, I. ser. The Development of the Blood Corpuscle in Insects and other Invertebrata, and its Comparison with that of Man and the Vertebrata. (Annals of Nat. Hist. XV, 1845, p. 281–284.)

——. On the Nervous System of the Sphinx ligustri Lin. and on the Changes which it undergoes during a Part of the Metamorphoses of the Insect. (Philosoph. Transact. 1832, p. 383–398, and 1834, 389–423.)

——. On the Temperature of Insects and its Connexion with Functions of Respiration and Circulation in this class of Invertebrated Animals. (Philosoph. Transact. 1837, p. 259–338.)

Blanchard, E. Recherches anatomiques et zoölogiques sur le Système nerveux des Animaux sans vertèbres. Du système nerveux des Insectes. (Annal. d. scienc. natur. 3. sér. V, 1846, p. 273–379.)

Blanchard, E. Du Système nerveux chez les Invertébrés dans ses rapports avec la Classification de ces Animaux. Paris, 1849, 8vo.

Milne-Edwards, H. Leçons sur la Physiologie et l'Anatomie comparée de l'Homme et des Animaux. Paris, Masson 1857-64, 8vo.

EMBRYOLOGY.

Rathke, H. Untersuchungen über die Bildung und Entwickelung des Flusskrebses, Leipzig, Voss. 1829, Fol. mit 5 Taf.

———. Zur Morphologie, Reisebemerkungen aus Taurien. Riga, 1837, 4to, mit 5 Taf.

Herold, J. M. Exercitationes de animalium vertebris carentium in ovo formatione I. De generatione Aranearum in ovo.—Untersuchungen über die Bildungsgeschichte der Wirbellosen Thiere im Ei. 1. Th. Von der Erzeugung der Spinnen im Ei. Marburg, Krieger, 1824, fol. mit 4 Taf.

———. Disquisitiones de animalium vertebris carentium in ovo formatione. De generatione Insectorum in ovo. Fasc. I, II, Frankfurt a Main, 1835-38, fol.

Kölliker, A. Observationes de prima Insectorum genesi, adjecta articulatorum evolutionis cum vertebratorum comparatione. Dissert. inaug. Turici, Meyer et Zeller, 1842, 4to, c. tab. 3.

Zaddach, G. Untersuchung über die Entwickelung und den Bau der Gliederthiere. Heft 1. Die Entwickelung des Phryganiden-Eies. Berlin, Reimer. 1854, 4to, c. tab. 5.

Leuckart, R. Die Fortpflanzung und Entwickelung der Pupiparen nach Beobachtungen an Melophagus ovinus. (Abhandl. d. naturf. Gesellsch. zu Halle IV, 1858, S. 145-226.)

Huxley, T. On the agamic Reproduction and Morphology of Aphis (Transact. Linnean Soc. of London, XXII, p. 193-236.)

Lubbock, J. On the Ova and Pseudova of Insects (Philosophical Transactions of the Royal Soc. 1859, p. 341-369.

Claparede, E. Recherches sur l'evolution des Araignées. 4to. Utrecht, 1862.

Weismann, A. Ueber die Entstehung des vollendeten Insekts in Larve und Puppe. Ein Beitrag zur Metamorphose der Insekten, Frankfurt a Main, 1863, 4to.

———. Die Entwickelung der Dipteren im Ei, nach Beobachtungen an Chironomus, Musca vomitoria und Pulex canis (Zeitschrift für Wissenschaftliche Zoologie XIII, p. 107-204.)

———. Die nachembryonale Entwickelung der Musciden nach Beobachtungen an Musca vomitoria und Sarcophaga carnaria. (The same, XIV, p. 187-336.)

FOSSIL INSECTS.

Giebel, C. Fauna der Vorwelt mit steter Berücksichtigung der lebenden Thiere. 2. Bd. Gliederthiere. 1. Abtheilung. Die Insekten und Spinnen der Vorwelt mit steter Berücksichtigung der lebenden Insekten und Spinnen. Leipzig, 1856, 8vo.

Berendt, C. G. Die im Bernstein befindlichen organischen Reste der Vorwelt, gesammelt und in Verbindung mit Mehreren herausgegeben. 1. Band. 2, Abth. Die im Bernstein befindlichen Crustaceen, Myriapoden, Arachniden und apteren der Vorwelt, bearbeitet von *C. L. Koch* und *C. G. Berendt.*—2. Band. Die im Bernstein befindlichen Hemipteren, Orthopteren, und Neuropteren der Vorwelt, bearbeitet von *E. F. Germar*, *F. J. Pictet*, und *H. Hagen.* Berlin, 1854-56, fol.

Heer, O. Die Insecten-fauna der Tertiaergebilde von Œningen und Radoboj. Leipzig, 1849, 4to, 2 vols.

Scudder, S. H. An inquiry into the Zoölogical Relations of the first discovered Traces of fossil Neuropterous Insects in North America. From the Memoirs of the Boston Society of Natural History, Vol. I, 1867, with a plate.

PERIODICAL WORKS (now in course of publication).

Edwards, W. H. Butterflies of North America. Colored plates. Commenced 1868.
Annales de la Société entomologique de France, Paris. Commenced 1832.
Transactions of the Entomological Society of London. Commenced 1834.
L' Insectologie Agricole, Monthly Journal, Paris. Commenced 1867.
Zeitung. Entomologische Verein, Stettin. Commenced 1840.
Linnæa entomologica. Entomologische Verein, Berlin. Commenced 1846.
Zeitschrift. Entomologische Verein, Berlin. Commenced 1857.
Annales de la Société entomologique Belge, Brussels. Commenced 1857.
Proceedings of the Academy of Natural Sciences, Philadelphia. Commenced 1819.
Journal of the Academy of Natural Sciences, Philadelphia. Commenced 1817.
Transactions of the American Philosophical Society. New Series. Commenced 1818.
Proceedings of the Boston Society of Natural History. Commenced 1834.
Journal of the Boston Society of Natural History. Commenced 1834.
Annals of the Lyceum of Natural History of New York. Commenced 1824.
Proceedings and Transactions of the American Entomological Society, Philadelphia. Commenced 1861.
Proceedings and Communications of the Essex Institute, Salem. Commenced 1848.
American Naturalist, Salem. Commenced March, 1867.

Entomological Journal. Every collector should keep a daily journal of his captures and observations, noting down every fact and hint that falls under his notice. In this book, commenced as soon as the season opens in early spring, can be placed on record the earliest appearance, the time of greatest abundance, and the disappearance of every insect in any of its stages. Also the descriptions of larvæ, with sketches, and observations upon their habits; though drawings had better be kept upon separate pieces of paper for easier reference. The insects, when captured and unnamed should be numbered to agree with corresponding numbers in the note-book. At the close of the season one will be surprised to see how much material of this kind has accumulated. He can then make a *calendar of appearances* of perfect insects and larvæ, so as to have the work of the next season portioned out to him; he will thus know when and where to look for any particular insect or caterpillar.

The Number of Species of Insects. Oswald Heer estimates that the Insects comprise four-fifths of the whole animal kingdom. While there are about 55,000 species of animals known, excluding the Insects, the number of this last single class amounts to upwards of 190,000 known species, according to

Gerstaecker's estimate. He reckons that there are at least 25,000 species of Hymenoptera, from 22,000 to 24,000 Lepidoptera, about 24,000 Diptera, and 90,000 Coleoptera; the number of the other suborders cannot be easily estimated. Besides these there are about 4,600 Arachnida, and 800 Myriapods.

Grouping of Insects into Orders and Suborders. Before beginning an account of the Six-footed Insects, we present the following tabular view of the Classification of Insects. The idea that the Myriapods, Spiders, and Six-footed Insects formed orders and not classes was first proposed by R. Leuckart in 1848, and afterwards supported by Agassiz and Dana. The arrangements proposed by these and other authors are put in tabular form on page 106.

The Class of Insects.

Order I.—Segments grouped into three distinct regions; eyes compound and simple; two pairs of wings:* three pairs of thoracic legs; one pair of jointed abdominal appendages. A more or less complete metamorphosis, ...	Hexapoda (Six-footed Insects).
Order II.—Segments grouped into two regions, a false cephalothorax† and an abdomen; no antennæ; eyes simple; wingless; four pairs of thoracic legs; three pairs of jointed abdominal appendages (spinnerets) often present. No metamorphosis, . .	Arachnida (Spiders).
Order III.—Body cylindrical, worm-like. Segments not grouped into regions (except in the recently hatched young). Head free; eyes simple; antennæ present; wingless; yolk-sac present for a short period after hatching. No metamorphosis,	Myriapoda (Centipedes).

The Order of Six-footed Insects‡ (*Hexapoda*).

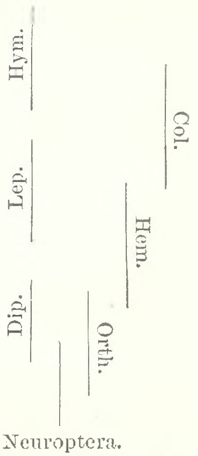
First and higher series. Body usually cylindrical; prothorax small; mouth-parts more generally haustellate (formed for sucking); metamorphosis complete; pupa inactive; larva usually cylindrical, very unlike the adult, ...	Hymenoptera. Lepidoptera. Diptera
Second and lower series. Body usually flattened; prothorax large and squarish; mouth-parts usually adapted for biting; metamorphosis incomplete; pupa often inactive; larva flattened, often resembling the adult, ...	Coleoptera. Hemiptera. Orthoptera. Neuroptera.

*The number of wingless forms is comparatively few. The Diptera have but one pair.

†The so-called "cephalothorax" of Spiders is not like that region in the Crabs, the head being much freer from the thorax.

‡Leuckart's classification is an advance on others in his considering the Hexapoda, Arachnida, and Myriapoda as orders instead of classes, but he says nothing

The following diagram shows, in a rude way, the relative rank and affinities of the seven suborders, and of the two series of Six-footed Insects.



Through *Lepisma*, and *Podura* which are wingless Neuropterous insects, the lower series is connected with the Myriapods, the minute degraded myriapod, *Pauropus* of Lubbock, perhaps forming the connecting link; and through the wingless flies, *Braula*, *Chionea*, and *Nycteribia*, the Diptera, belonging to the higher series, assume the form of the Spiders, the head being small, and sunken into the thorax, while the legs are long and slender. The first and highest series culminates in *Apis*, the Honey-bee; and the second, or lower, in *Cicindela*, the Tiger-beetle.

regarding the rank and value of the minor groups. Professor Agassiz extended Leuckart's views in considering the seven grand divisions of the order of Hexapods as suborders. In 1863 (How to Observe and Collect Insects, Maine Scientific Survey, and Synthetic Types of Insects, Boston Journal of Natural History), we proposed a new classification of these suborders, by which they are thrown into two main groups headed by the Hymenoptera and Coleoptera respectively. These two groups, as represented in the diagram, are nearly equivalent in value, and stand in a somewhat parallel relation. There is nothing like a linear series in the animal kingdom, but rather a net-work. The higher series of suborders form more of a linear series than the lower series, so that in the diagram the Neuroptera, Orthoptera, Hemiptera, and Coleoptera form a more broken series than the Hymenoptera, Lepidoptera, and Diptera. A Bee, Butterfly, and House-fly are much more closely allied to each other than a Beetle, a Squash-bug, a Grasshopper, and a Dragon-fly are among themselves. The Neuroptera are the most independent, and stand at the bottom of and between the two series, though by the Orthoptera they are very intimately linked with the Hemiptera and Coleoptera.

TABULAR VIEW of the principal Entomological Systems proposed since the time of Ray.

RAY, 1705.	LINNÆUS, 1735.	FABRICIUS, 1775.	FABRICIUS, 1799.	LATREILLE, 1796.	AGASSIZ, 1849.	PACKARD, 1863.	DANA, 1864.
Metamorphota. (Coleoptera, Aneloptera, Diptera, Tetraptera). *Ametamorphota* (Hexapoda).	Orders 1–6. Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera. Order 7. Aptera (six-footed).	Orders 1. Eleuterata. 2. Ulonata. 3. Synistata (in part). (4. Agonata= Crustacea). 5. Unogata (in part). 6. Glossata. 7. Rhyngota. 8. Antliata.	Classes 1–5. Eleuterata, Ulonata, Synistata, Piezata, Odonata. Classes 11–13. Glossata, Rhyngota, Antliata.	Orders 1–10. Coleoptera, Orthoptera, Hemiptera, Neuroptera, Hymenoptera, Lepidoptera, Diptera, Suctoria, Thysanura, Parasita.	Suborders 1–7. Lepidoptera, Diptera, Hemiptera, Hymenoptera, Orthoptera, Coleoptera, Neuroptera.	Suborders 1–7. Hymenoptera, Lepidoptera, Diptera, Coleoptera, Hemiptera, Orthoptera, Neuroptera.	1. *Ctenopters.* Hymenoptera, Diptera, Aphaniptera, Lepidoptera, Homoptera, Trichoptera, Neuroptera. 2. *Elytropters.* Coleoptera, Hemiptera, Orthoptera. 3. *Thysanures.*
Ametamorphota polypoda (in part).	Order 7 (in pt.) Aptera (with numerous feet)	Order 5. Unogata (in part).	Class 6. Mitosata.	Order 14. Myriapoda.	*Arachnida.* Suborders 1–2. Araneæ, Acari.	*Arachnida.* Suborders 1–3. Araneæ, Scorpions, Acarina.	*Arachnida.* Suborders 1–3. Araneoids, Scorpionoids, Acaroids.
Ametamorphota octopoda.	Order 7 (in pt.) Aptera (with 8—14 feet).	Order 5. Unogata (in part).	Class 7. Unogata.	Order 11. Acephala.	*Myriapoda.*	*Myriapoda.* Suborders 1–2. Chilopoda, Chilognatha.	*Myriapoda.* Suborders 1–2. Chilopods, Diplopods.

HYMENOPTERA.

The Bees, Wasps, Saw-flies, Ants, and other members of this suborder differ from all other insects in having, in the higher and more typical forms, the basal joint of the abdomen thrown forward upon and intimately united with the thorax. The head is large, with large compound eyes, and three ocelli. The mouth-parts are well developed both for biting, and feeding on the sweets of plants, the ligula especially, used in lapping nectar, being greatly developed. The other regions of the body are more distinct than in other insects; the wings are small but powerful, with comparatively few and somewhat irregular veins, adapted for powerful and long-sustained flights; and the genital appendages retracted, except in the Ichneumon parasites and Saw-flies, within the body, are in the female modified into a sting.

The transformations of this suborder are the most complete of all insects; the larvæ in their general form are more unlike the adult insects than in any other suborder, while the pupæ, on the other hand, most clearly approximate to the imago. The larvæ are short, cylindrical, footless (excepting the young of the Saw-flies, the lowest family, which are provided with abdominal legs like Lepidopterous larvæ), worm-like grubs, which are helpless, and have to be fed by the prevision of the parent. The pupa has the limbs free, and is generally contained in a thin silken cocoon; that of the Saw-flies, however, being thick.

The Hymenoptera exhibit, according to Professor Dana, the *normal size* of the insect-type. "This archetypic size is be-

Note to page 106. — Ray divided the Hexapods into *Coleoptera* and *Aneloptera*, the latter division embracing all the other suborders except the Coleoptera. His *Ametamorphota Hexapoda* contained the wingless hexapoda; while the *Ametamorphota polypoda* comprise the Myriapods, and the *A. octopoda* the Arachnids. Linnæus' *Aptera* (with numerous feet) are equivalent to the Myriapods, and his *Aptera* (with 8–14 feet) to the Arachnids. In Fabricius' system the *Eleutherata* are equivalent to the Coleoptera; the *Ulonata* to the Orthoptera; the *Synistata* to the Neuroptera; the *Piezata* to the Hymenoptera; the *Odonata* to the Libellulidæ; the *Glossata* to the Lepidoptera; the *Rhyngota* to the Hemiptera; the *Antliata* to the Diptera. The *Mitosata* are the Myriapods, and the *Unogata*, the Arachnids. In Latreille's system the *Suctoria*, or Fleas, are now referred to the Diptera; the Parasita or Lice, to the Hemiptera, and the *Thysanura* to the Neuroptera.

tween eight and twelve lines (or twelfths of an inch) in length, and two and a half and three lines in breadth." This size is probably a smaller average than in any other suborder; thus the Hymenoptera while being the most cephalized, consequently comprise the most compactly moulded insectean forms.

Besides these structural characters, as animals, endowed with instincts and a kind of reason differing, perhaps, *only in degree* from that of man, these insects outrank all other Articulates. In the unusual differentiation of the individual into males and females, and, generally sterile workers, with a farther dimorphism of these three sexual forms, such as Huber has noticed in the Humble-bee, and a consequent subdivision of labor among them; in dwelling in large colonies, thus involving new and intricate relations with other insects (such as Aphides, ant-hill-inhabiting beetles, and the peculiar bee-parasites); their wonderful instincts, their living principally on the sweets and pollen of flowers, and not being essentially carnivorous (*i.e.* seizing their prey like the Tiger-beetle) in their habits, as are a large proportion of the other suborders, with the exception of Lepidoptera; and in their relation to man as a domestic animal, subservient to his wants,—the Bees, and Hymenoptera in general, possess a combination of characters which are not found existing in any other suborder of insects, and which rank them first and highest in the insect series.

The body-wall of the Hymenoptera is unusually dense and hard, smooth and highly polished, and either naked, or covered with hair as in a large proportion of the bees. The head is large, not much smaller than the thorax, and its front is vertical. The antennæ are short, filiform, often geniculate, very rarely pectinated. The mandibles are large, stout, toothed, and the maxillæ are well developed into their three subdivisions, the palpi being usually six-jointed; the labial palpi are usually four-jointed, and the prolongation of the under lip, or ligula, is highly developed, being furnished with a secondary pair of palpi, the paraglossæ, while in the pollen-gathering species the ligula is of great length, and thus answers much the same purpose as the spiral tongue (maxillæ) of the Lepidoptera.

Réaumur states that the Bee does not suck up the liquid sweets, but laps them up with its long slender hairy tongue.

"Even in the drop of honey the bee bends the end of its tongue about, and lengthens and shortens it successively, and, indeed, withdraws it from moment to moment." The liquid passes along the upper surface of the pilose tongue, which is withdrawn between its sheaths, the palpi and maxillæ, and thus "conveys and deposits the liquid with which it is charged within a sort of channel, formed by the upper surface of the tongue and the sheaths which fold over it, by which the liquid is conveyed to the mouth." (Shuckard.)

The thorax forms a rounded compact oval mass, with the prothorax and metathorax very small, the mesothorax being large, and also the propodeum, to which the pedicel of the abdomen is attached. The pleurites are large and bulging, while the sternum is minute. The coxæ and trochantines are large, and quite free from the thorax; and the trochanters are small, while the rather slender legs are subject to great modifications, as they are devoted to so many different uses by these insects; thus, in the Sand-wasps they are strongly bristled for the purpose of digging, and in the Bees, the basal joint of the tarsi is much enlarged for carrying honey.

"The manner in which the bee conveys either the pollen, or other material it purposes carrying home, to the posterior legs, or venter, which is to bear it, is very curious. The rapidity of the motion of its legs is then very great; so great, indeed, as to make it very difficult to follow them; but it seems first to collect its material gradually with its mandibles, from which the anterior tarsi gather it, and that on each side passes successively the grains of which it consists to the intermediate legs, by multiplicated scrapings and twistings of the limbs; this, then, passes it on by similar manœuvres, and deposits it, according to the nature of the bee, upon the posterior tibiæ and tarsi, or upon the under side of the abdomen. The evidence of this process is speedily manifested by the posterior legs gradually exhibiting an increasing pellet of pollen. Thus, for this purpose, all the legs of the bees are more or less covered with hair. It is the mandibles which are chiefly used in their boring or excavating operations, applying their hands, or anterior tarsi, only to clear their way; but by the constructive, or artisan bees, they are used both in their building and mining operations, and are worked like trowels to collect moist clay, and to apply it to the masonry of their habitations." (Shuckard.)

The four wings are present, except in rare instances. They are small; the hinder pair long, narrow, ovate, lanceolate. The costal edge of the fore-wing (Fig. 29), is generally straight, becoming a little curved towards the apex, which is obtusely subrectangular; the outer edge is bent at right angles, while the inner edge of the wing is long and straight. The veins are often difficult to trace, as in the outer half of the wing they break up into a system of net-veins, which are few in number, yet the continuations of the subcostal, median, and submedian veins can be distinguished after careful study.

In some low *Ichneumonidæ*, the *Proctotrupidæ*, and *Chalcididæ*, the veins show a tendency to become obsolete, only the simple subcostal vein remaining; and in *Pteratomus*, the veins are entirely obliterated, and the linear feather-like wings are in one pair fissured, reminding us of the Plume-moths, *Pterophorus*.

The abdomen is composed in the larva state of ten segments, but in the adult stinging Hymenoptera, of six complete segments in the females, and seven in the males; while in the lower families the number varies, having in the *Tenthredinidæ*, eight tergites on the upper side and six sternites on the lower side. The remaining segments are, during the transformations of the insect, aborted and withdrawn within the body. The ovipositor and corresponding parts in the male have been described on pp. 14–18.

The nervous system consists in the larvæ of eleven ganglia, in the adult five or six of these remain as abdominal ganglia, while the remainder, excluding the cephalic ganglia, are placed in two groups in the thorax. The cerebral ganglia are well developed, evincing the high intellectual qualities necessary in presiding over organs with such different uses as the simple and compound eyes, the antennæ, and lingua and palpi, and mandibles, especially in those sociable species which build complete nests.

The digestive system, in those bees which sip up their food, consists, besides the external mouth-parts, of a "long œsophagus which dilates into a thin-walled sucking stomach," which in the *Apiariæ* and *Vespidæ* may be simply a lateral fold, or, as in many *Crabronidæ*, "attached solely by a short and narrow peduncle." In *Formica*, *Cynips*, *Leucospis*, and *Xyphidria* there is a globular uncurved callous gizzard, which is enveloped by the base of the stomach, according to Siebold, who also states that "those Hymenoptera which are engaged during a long and active life in labors for the raising and support of their young, have a pretty long and flexuous stomach and intestine, and the first has, usually, many constrictions;" while the *Cynipidæ*, *Ichneumonidæ*, and *Tenthredinidæ*, which take no care of their young, have only a short small stomach and intestine. The salivary glands consist of two rather short ramified tufts, often contained entirely in the head.

The tracheæ consist, as in other insects, of two main branches, from which numerous transverse anastomosing branches are given off, with numerous vesicular dilatations. Two such vesicles of immense volume are situated at the base of the abdomen, which according to Hunter and Newport "serve chiefly to enable the insect to alter its specific gravity at pleasure during flight, and thus diminish the muscular exertion required during these movements."

The urinary vessels are very numerous in the Hymenoptera; they are usually short and surround the pylorus in numbers of from twenty to one hundred and fifty.

The two poison glands (Fig. 54, *h*, *g*) are composed of long ramose tubes, resembling the salivary glands in their minute structure. The poison is poured from these into a pyriform sac lodged near the base of the sting, which is provided with a peculiar muscular apparatus for its sudden extension and withdrawal. The poison, in the Ants, Bees, and Wasps, consists, according to Will, of "formic acid, and a whitish, fatty, sharp residuum, the former being the poisonous substance." (Burnett.)

Whether the wax-secreting apparatus consists of special glands (as Milne-Edwards supposes) or not, as Dufour, Siebold, and others contend, is not yet a settled question. Siebold, the eminent German physiologist, from whose work on the anatomy of Invertebrata we have drawn so largely, suggests that the wax "is produced by an exudation from the thin membranes which connect the different parts of the legs. Moreover, many other Insects (*Coccidæ* and *Aphidæ*, *Flata*, etc.) have secretory products which transude through the skin without the existence of any special glandular apparatus, and which are hardened by the air like wax. These products are usually whitish, pulverulent, filamentous, or flocculent substances, which catch upon the surface of bodies." He also states that there are no such glands (as are supposed by some to secrete this substance) in the bee-workers; but if certain Andrenidæ are examined, there will be found, on each side of their posterior tibiæ, a small pyriform follicle with an excretory duct, and which secretes an oily substance." Gerstæcker states that the wax is produced on the under side of the abdominal segments. It is formed by chemical changes in the food during the process of nutrition.

The honey is elaborated by an unknown chemical process, from the food contained in the proventriculus, or crop, and which is regurgitated into the honey-cells.

The ovaries consist of many-chambered, four, six, or a hundred, short tubes. "The *receptacula seminis* is nearly always simple, round or ovoid, and necked, and is prolonged into a usually short seminal duct." The *glandula appendicularis* consists of a bifurcate tube which opens into the *ductus seminalis*, and only rarely into the *capsula seminalis* itself.

In the *Tenthredinidæ*, "this apparatus is formed on a different type; the seminal vesicle is a simple diverticulum of the vagina, and more or less distinct from it, besides it is deficient in the accessory gland. The copulatory pouch is absent in all the Hymenoptera, as are also the sebaceous glands with those females which have a sting and a poison gland," while in other insects the sebaceous glands are present, and it would be naturally inferred, therefore, that the two are homologous, but modified for diverse functions.

The two testes of the male are "composed of long follicles, fasciculate and surrounded, together with a portion of the torose deferent canal, by a common envelope; but more commonly the two testes are contained in a capsule situated on the median line of the body." (Siebold.)

The eggs are usually long, cylindrical, and slightly curved in the Bees; in the Wasps they are more globular, and affixed by their smaller somewhat pedicelled end to the side, near the bottom of the cell in which they are laid. The eggs of the lower families tend to assume a spherical form. The eggs of different species of *Bombus* present no appreciable differences.

The larvæ of the Bees and Wasps, especially the social species, which live surrounded by their food, are of a very persistent form, the various genera differing but slightly, while the species can scarcely be separated. Such we have found to be the case in the Bees and Wasps (*Vespidæ*) and Fossorial Wasps. The sexes of the species with a very thin tegument, such as *Apis*, *Bombus*, and *Vespa*, can be quite easily distinguished, as the rudiments of the genital armor can be seen through.

The Hymenoptera are mostly confined to the warmer and temperate regions of the earth; as we approach the poles, the Bees disappear, with the exception of *Bombus*, and perhaps its parasite *Apathus*; a species of *Vespa* is found on the Labrador coast, which has a climate like that of Greenland. No fossorial species of Wasps are known to us to occur in the arctic regions, while a few species of Ants, and several *Chalcididæ* and *Ichneumonidæ* are not uncommon in Northern Labrador and Greenland. Our alpine summits, particularly that of Mt. Washington, reproduces the features of Northern Labrador and Greenland as regards its Hymenopterous fauna. The tropics are, however, the home of the Hymenoptera, and especially of the Bees.

There are estimated to be about twenty-five thousand living species of this suborder, and this is probably a much smaller number than are yet to be discovered.

In geological history, the Hymenoptera do not date far back compared with the Neuroptera and Orthoptera, and even the Coleoptera. Indeed they were among the last to appear upon the earth's surface. The lower forms, so far as the scanty records show, appeared first in the Jura formation; the Ants appear in the Tertiary period, especially in amber.

As we have noticed before, the Hymenoptera are more purely terrestrial than any other insects. None are known to be aquatic in the early stages, and only two genera have been found swimming in the adult state on the surface of pools, and they are the low, minute, degraded Proctotrupids, *Prestwichia natans* and *Polynema natans* described by Mr. Lubbock. The Hymenoptera do not imitate or mimic the forms of other insects, but, on the contrary, their forms are extensively copied in the Lepidoptera, and especially the Diptera. A partial exception to this law is seen in the antennæ of the Australian genus *Thaumatosoma*, where they are long and slender, and knobbed as in the butterfly, and also in *Tetralonia mirabilis* of Smith, from Brazil.

The Hymenoptera, also, show their superiority to all other insects in the form of their degraded wingless species, such as *Pezomachus*, the workers of *Formica* and the female of *Mutilla*. In these forms we have no striking resemblances to lower orders and suborders, but a strong adherence to their own Hymenopterous characters. Again; in the degradational winged forms, we rarely find the antennæ pectinated; a common occurrence in the lower suborders. In a low species of the *Apiariæ*, *Lamprocolletes cladocerus*, from Australia,—that land of anomalies,—the antennæ are pectinated. This, Mr. F. Smith, the best living authority on this suborder, says, "is certainly the most remarkable bee that I have seen, and the only instance, to my knowledge, of a bee having pectinated antennæ; such an occurrence, indeed, in the Aculeate Hymenoptera is only known in two or three instances, as in *Psammotherma flabellata* amongst the *Mutillidæ*, and again in *Ctenocerus Klugii* in the *Pompilidæ;* there is also a modification of it in one or two other species of *Pompilidæ*." Among the *Tenthredinidæ*, the male *Lophyrus* has well-pectinated antennæ, as also has *Cladomacra macropus* of Smith, from New Guinea and Celebes.

The wings of perhaps the most degraded Hymenoptera, the *Proctotrupidæ*, are rarely fissured; when this occurs, as in *Pteratomus Putnamii*, they somewhat resemble those of *Pterophorus*, the lowest moth. It is extremely rare that the compound eyes are replaced by stemmata, or simple eyes; in but one instance, the genus *Anthophorabia*, are the eyes in the male sex reduced to a simple ocellus. This species lives in the darkness of the cells of Anthophora.

By reason of the permanence of the type, due to the high rank of these insects, the generic and specific characters are founded on very slight differences, so that these insects, and particularly the two higher families, the Wasps (*Vespidæ*) and Bees (*Apiariæ*) are the most difficult insects to study. The easiest characters for the recognition of the genera, lie in the venation of the wings; though in the fossorial families the legs vary greatly. The best specific characters lie in the sculpturing and style of coloration, but the spots and markings are apt to vary greatly. The great differences between the sexes are liable to mislead the student, and hence large collections are indispensable for their proper study. Bees act as "marriage priests" in the fertilization of plants, conveying pollen from flower to flower, and thus insuring the formation of the fruit. It is said that most orchids could not be fertilized without the interposition of Bees.

Their interesting habits deserve long and patient study; it is for their observations on the insects of this suborder that the names of Réaumur, the two Hubers, and Latreille will be ever held in special remembrance.

Most Hymenoptera love the sun, and they may be caught while flying about flowers. The nests of bees, wasps, and ants should be sought for and the entire colony captured, together with the parasites. The hairy species should be pinned while in the net, and the naked ones can be put in the collecting-bottle. The larger species may be pinned, like other insects, through the thorax; but the minute Chalcids, etc., should be gummed, like small Coleoptera, upon cards.

The nests of bees and of wasps and ants and the young in various stages of growth should be collected, and in such numbers as to show their different stages of construction, to serve as illustrations of insect architecture.

APIARIÆ Latreille (*Apidæ* Leach). This and those families succeeding which are provided with a true sting, were called by Latreille *Hymenoptera Aculeata*. The male antennæ are mostly thirteen-jointed, while in the female they are twelve-jointed. The females (and the workers, when they exist) feed the larvæ, which mostly live in nests or cells.

In the social Bees, besides the normal male and female forms, there are asexual females, whose inner genital organs are partly aborted, though externally only differing in their smaller size from the true females. The male antennæ are longer, tapering more towards the tips, and the eyes of the male approach each other closer over the vertex than in the opposite sex, though these are characters which apply to other Hymenoptera. The mouth-parts are in the higher genera greatly elongated, the labium being long, with the lingua of great length, and the lobes of the maxillæ long and knife-shaped; but these parts, as well as the form of the jaws, are subject to great modifications in the different genera: the labial palpi are four-jointed, and the maxillary palpi are from one to six-jointed. The hind tibia and basal joint of the tarsi are, in the pollen-gathering species, very broad; the tibia is in Apis and Bombus hollowed on the outside, and stiff bristles project over the cavity from each side of the joint, forming the honey-basket (*corbiculum*), on which the "clodden masses of honey and pollen" are conveyed to their nests. In the parasitic genera, such as *Apathus*, the tibia is, on the contrary, convex, rather than concave, though of the usual width; while in *Nomada*, also parasitic, the legs are narrow, the tibia not being dilated.

In *Andrena* and its allies, *Halictus* and *Colletes*, the mouth-parts, especially the tongue, are much shortened, thus affording a passage into the *Vespidæ*. In these genera the tongue is folded back but once between the horny encasement of the maxillæ, but in the higher *Apiariæ* the part formed by the union of the lingua and maxilla is twice bent back, and thus protected by the horny lobes of the maxillæ. The fore-wings have two or three subcostal (cubital) cells.

There are two thousand species of this family. The differences between the larvæ of the various genera of this family are very slight, those of the parasitic species are, however, readily distinguished from their hosts.

The higher *Apiariæ*, comprising the subfamily *Apinæ*, have the ligula long, cylindrical, while the labial palpi have two very long, slender, compressed basal joints, and two short terminal joints.

The genus *Apis* has no terminal spurs on the hind tibiæ, while the fore-wings have three subcostal (cubital) cells, the middle of which is elongated and acutely wedge-shaped. The eyes in the male are united above; the mouth-parts are nearly aborted, and the hind legs are smooth. In the female there are two paraglossæ on the ligula, and the maxillary palpi are one-jointed. The worker only differs externally from the female in the shorter abdomen.

The larva of the Honey-bee closely resembles that of Bombus, but the body is shorter, broader, and more flattened, while the head is less prominent, and the lateral tubercles along the body are, perhaps, less prominent than in the young Humble-bee, otherwise the two genera are, in the larval state, much alike. In its natural position, the larva lies at the bottom of the cell doubled upon itself.

Though the larvæ are said usually to feed upon pollen, Mr. Desborough states that honey alone is the food of the grub, as he reared 729 larvæ with no other food than honey. But as with the wild bees they may extract honey from the pollen provided for them. He says the matured bees may be observed feeding at night on the bee-bread (pollen). Langstroth (The Hive and Honey-bee), however, states that "pollen is indispensable to the nourishment of the young. It is very rich in the nitrogenous substances which are not contained in the honey."

The Honey-bee, *Apis mellifica*, is now distributed over the civilized world. It was introduced into this country during the seventeenth century, and into South America in 1845 (Gerstæcker). The Italian, or Ligurian, bee is considered by F. Smith as being a climatic variety.

The cultivation of the Honey-bee is rapidly increasing in this country, but the German Bee-masters have made the most progress in theoretical and practical Bee-culture. Convenient hives are now constructed by which all the operations of the bees can be observed at leisure. Gerstæcker thus sums up the habits of the Honey-bee: A fertilized queen which, with a few workers, has wintered over, lays its eggs in the spring first in the worker, and afterwards, at a later period, in the drone-cells (both arranged in two perpendicular rows of cells). Early in summer, the workers construct the larger flask-shaped queen-cells, which are placed on the edge of the comb, and in these the queen-larvæ are fed with rich and choice nourishment. As soon as the first of the new brood of queens is excluded from its cell, which it indicates by a peculiar buzzing noise, it deserts the old queen, carrying away with it a part of the swarm, and thus forms a new colony. The recently excluded queen then takes its marriage flight high in the air with a drone, and on its return undertakes the management of the hive, and the duty of laying eggs. When another queen is disclosed, the same process of forming a new colony goes on. When the supply of young queens is exhausted, the workers fall upon the drones and destroy them without mercy. The first brood of workers live about six weeks in summer, and then give way to a new brood. Mr. J. G. Desborough states that the maximum period of the life of a worker is eight months. The queens are known to live five years, and during their whole life lay more than a million eggs (V. Berlepsch). Langstroth states that "during the height of the breeding season, she will often, under favorable circumstances, lay from 2,000 to 3,000 eggs a day." According to Von Siebold's discovery only the queens' and workers' eggs are fertilized by sperm-cells stored in the *receptaculum seminis*, and these she can fertilize at will, retaining the power for four or five years, as the muscles guarding the duct leading from this sperm-bag are subject to her will. Drone eggs are laid by unfertilized queen-bees, and in some cases even by worker-bees. This last fact has been confirmed by the more recent observations of Mr. Tegetmeier, of London.

Principal Leitch, according to Tegetmeier, has suggested the theory that a worker egg may develop a queen, if transferred into a queen-cell. "It is well known that bees, deprived of their queen, select several worker-eggs, or very young larvæ, for the purpose of rearing queens. The cells in which these eggs are situated are lengthened out and the end turned downward." He suggests that the development into a queen was caused by the increased temperature of the queen-cell, above that of the worker-cells.

But Messrs. F. Smith and Woodbury (Proceedings of the Entomological Society of London, January 2, 1862) support F.

Huber's theory, that the change is due to "the quality as well as quantity of food with which the royal larva is supplied," though Dr. Leitch objects, that it has been by no means conclusively proved "that the so-called royal jelly differs in any respect from the ordinary food supplied to the worker larva;" and Mr. Woodbury cites the experiments of Dzierzon, as quoted by Kleine, "that as Huber, by introducing some royal jelly in cells containing worker-brood, obtained queens, it may be possible to induce bees to construct royal cells, when the Apiarian prefers to have them, by inserting a small portion of royal jelly in cells containing worker-larvæ." Kleine takes "an unsealed royal cell—which usually contains an excess of royal jelly—and removes from it a portion of the jelly, on the point of a knife or pen, and by placing it on the inner margin of any worker cell, feels confident that the larvæ in them will be reared as queens."

Before these points are settled we must study the habits of the Wild Bees, and of the other social Hymenoptera and White Ants, together with the social Aphides more carefully. Mr. F. W. Putnam pertinently states, "at present I cannot believe that the peculiarity of food, or the structure of the cells, produces a difference of development in Humble-bees, for the larvæ, as has been previously stated, were seen to make their own cells from the pollen paste. Is it not more natural to believe, as has been suggested to me by Professor J. Wyman, that the difference in the development of the eggs is owing to their being laid at various times after impregnation? Thus, if I am right in supposing that the queens are impregnated by the males late in the summer, the eggs, laid soon after, produce the large queen larvæ;* the next set of eggs, laid in the spring, produce the workers, or undeveloped females, while from those deposited still later, male bees are principally developed." (Proceedings of the Essex Institute, Salem, vol. iv, 1864, p. 103.)

Referring to Mr. Putnam's statement that there are both small and large queens (besides the workers), Dr. Gerstæcker infers,

* Dr. Gerstæcker, on the other hand, states that "from the brood-cells of a nest of *Bombus muscorum*, found by him on the 18th of September, there were developed at the end of the same month only workers."

"from the examination of numerous individuals found flying in the spring after hibernation, that these could not be considered as true queens, since their ovaries were only moderately developed, though larger than those of the workers, while in the true queen, captured in the summer, the ovaries were perfectly developed. This corresponds almost entirely to what we find in the wasps, whose spring females have only moderately developed ovaries."

How the Honey-bee builds its cells, and whether they are exactly hexagonal, are questions that have interested the best observers from Maraldi who wrote in 1712, and Réaumur, whose *Memoires* appeared in 1740, down to the present date. Their solution involves not only the closest observation of the insect while at work, but also the shrewdest judgment to explain the facts observed and deduct a legitimate theory. Does the bee intelligently plan her work out beforehand, or does she follow the guidance of what is called *instinct?* Does she construct hexagonal cells which are mathematically exact, or does she vary the proportions of each cell, so that it is perfect only in its general ideal form? Again, in making the cell, is the bee actually capable of making such a cell alone, or is it due to the resultant action of several bees? Professor J. Wyman is of the latter opinion, as he thinks "that if left alone to build a single cell, this would most probably be round. In the cells of *Melipona*, as Hüber's plate shows, they are only hexagonal when in contact with the adjoining cells." (Proceedings of the Boston Society of Natural History, x, p. 278, 1866.)

A similar view is that proposed in 1862 by the Rev. Samuel Haughton, in a paper read before the Natural History Society of Dublin, where he says, according to Mr. F. Smith, that the hexagonal form of the cell "may be accounted for simply by the mechanical pressure of the insects against each other during the formation of the cell. In consequence of the instinct that compels them to work with reference to a plane, and of the cylindrical form of the insect's body, the cells must be hexagonal."

Mr. G. R. Waterhouse (Transactions of the Entomological Society of London. Third series, vol. ii, p. 129, 1864) has proposed what has been called the "circular theory," or what the author himself terms "the principle of working in segments of circles." He contends "that the hexagonal form of the cells of certain bees and wasps may, and does, arise out of this mode of action when under certain conditions; that those conditions are, that the cells are so commenced that their natural circumferences, as the work proceeds, are either simply brought into contact with each other, or that the cells are so placed that the (we will say theoretical) circumferences must intersect. Contact with adjoining cells, then, is an essential condition to bring about the hexagonal form as I have before pointed out (See Proceedings of the Entomological Society, 1858, p. 17); but for this result it is not necessary that a hexagonal cell should be completely surrounded by other cells."

Is not this theory, after all, too mechanical? Is not our bee more of a free agent? Does it not have a *mind* to design its work? Mr. F. Smith, who has devoted years to the study of Hymenoptera, especially the higher forms of this suborder, the Bees and Wasps, replies to both theories of Waterhouse and Haughton, by bringing in the case of the Wasps which also build hexagonal cells, showing that a solitary wasp will build its cells in very regular hexagons. Thus the nest of the solitary Wasp, *Icaria guttatipennis*, "consists of a double row, the number of cells being ten; I now direct your attention to the fact that all the cells are perfectly hexagonal, the exterior planes being as beautifully finished as those in contact with the inner planes of the opposing cells. I have placed a drawing of this nest (Plate 5, Fig. 7) in the box on the table, and I particularly wish you to observe, that the first cell is carried up in a perfectly hexagonal form above the adjoining cells; a proof that, if Wasps never build perfect isolated hexagonal cells, they certainly possess the capability of doing so. The exterior of all the cells, as I before observed, is hexagonal, not cylindrical, until fresh cells are added on the outer side, as was observed to be the case in combs of the Hive-bee, by Mr. Tegetmeier." (Proceedings of the Entomological Society of London. Third series, ii, 1864, p. 135.)

An examination of the cells of three species of *Polistes* (the female of which begins alone in the spring to build her nest, the cells of which are afterwards greatly increased in number after the first brood of females appear), convinced us that the Wasp begins with the circular cup-shaped form of cell, and when about depositing an egg in it, changes her mode of operating, builds up the edges into a hexagonal form, and carries up the rim of each cell independently to its required height. She thus apparently changes her plan at a certain stage of the work, and is so far a free agent.

Mr. Smith also exhibited a portion of the nest of another wasp, *Tatua Morio* (Plate 5, Fig. 9), that proved to his mind the primary intention of the wasp instinctively to build cells with exactly six sides. The figure represents part of one of the flat floors, on which the foundations of the cells are laid in regular hexagons, instead of beginning in hemispherical cups.

Mr. Smith (p. 141) concludes, "that all hexagonal cells are not constructed upon a circular principle, and that the primary idea of all social bees and wasps is not to produce cylindrical cells with hemispherical bases."

In this connection the following extract from Mr. Smith's remarks is of interest: "It may not be known that in order to expedite the building of honey-combs, it is a common practice with bee-keepers in Germany to furnish hives with artificial foundations for the cells; these consist of sheets of wax, upon which is impressed a series of pyramidal hollows; in fact, the counterpart of a comb built by the bees themselves, entirely deprived of the cell-walls; and it is from such a piece of comb that the casts for the artificial foundations are obtained. A piece of casting of this description I lay before you, and I particularly call your attention (addressing the members of the Entomological Society of London) to the commencement of the outer cells; you will see, in some instances, a single plane of the hexagonal cell commenced, in others two or three are in progress; here you have a ground-plan supplied, or, I may say, the foundations of the habitations ready prepared, upon which the laborers are to raise the walls, and you may see how admirably they have done it. Instinct enables the bee to construct hexagonal cells without teaching, and, we are told, in one undeviating manner. Surely the example before us exhibits an amount of intelligence on the part of the bees in availing themselves of such adventitious aid. Must we not henceforth, when speaking of the marvels of the hive or the vespiary, erase from our vocabulary such terms as blind instinct; and must we not cease to stigmatize the bee as a mere machine?"

At the meeting of the same society held Feb. 1, 1864, Mr. F. Smith exhibited a collection of Wasps' nests, — one of *Vespa rufa*, the rest of *V. vulgaris;* they were in various stages of formation, the earliest consisting of only a single cup containing the first egg, others consisting of three or four cups, whilst others again were more complete. The whole had been artificially obtained by Mr. Stone, who tempted the wasps to build by excavating holes in banks and furnishing them with footstalks; in fact, Mr. Stone appeared to possess the power of inducing wasps to build nests of almost any shape he pleased.

But to return to the cell of the Bee. It should first be proved that the cells are not exactly and mathematically perfect hexagons, though sufficiently so for the purpose for which they are used. In the Proceedings of the American Academy of Arts and Sciences, vol. vii, 1866, Professor Wyman has, by a most careful as well as novel and ingenious mode of investigation, proved that the cells are all more or less imperfect, and that a hexagonal cell mathematically exact, does not exist in nature, but only in theory.

The form of the cell is liable to marked variations, chief among which the following may be mentioned, in the author's own words:

"1. The diameters of workers' cells may so vary, that ten of them may have an aggregate deviation from the normal quantity equal to the diameter of a cell. The average variation is a little less than one half that amount, namely, nearly 0.10 inch, in the same number of cells.

"2. The width of the sides varies, and this generally involves a variation of the angles which adjoining sides make with each other, since the sides vary not only in length but in direction.

"3. The variation in the diameters does not depend upon accidental distortion, but upon the manner in which the cell was built.

"4. The relative size of the rhombic faces of the pyramidal base is liable to frequent variation, and this where the cells are not transitional from one kind to another.

"5. When a fourth side exists in the basal pyramid, it may be in consequence of irregularity in the size of the cells, or of incorrect alignment of them on the two sides of the comb."

Sometimes one of the faces is lost, and a new one formed, so that all the basal portion of the cell becomes reversed, as will be seen by reference to Figs. 73 and 74; the first representing the cells when the base is viewed, and the second when looked at perpendicularly to one of the sides. In both figures A indicates the ordinary form of the cell. The whole series of Fig. 74 shows the gradual introduction of the new face, which is seen on the lower border, and the elimination of one of the original faces, which is seen on the upper border. At B, which is intermediate between the two extremes, the four faces consist of two equal rhombs,—one of which is the outgoing and the other the incoming one, and two equal hexagons. B, Fig. 74, represents the sides of the same cell, which, instead of forming three trapeziums, as at A, *a*, *b*, *c*, now form two pentagons, *a'* and *c'*, and a parallelogram, *b'*. At C, Figs. 73 and 74, the forms are in all respects the reverse of those of A. A and C are symmetrical with each other, and B is symmetrical in itself. No precise number of cells is necessary for the purpose of making this transition, for it may take place in two or three, or extend through a long series, as in Fig. 73.

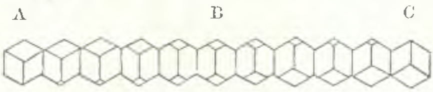


Fig. 73.

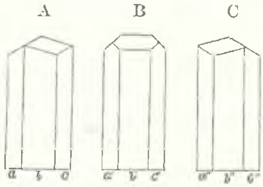


Fig. 74.

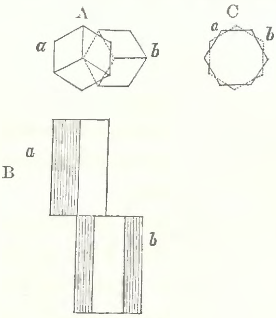


Fig. 75.

"6. Ordinarily, the error of alignment does not amount to more than one or two diameters of a cell. But occasionally the rows of cells on one side of the comb may deviate from their true direction with regard to those on the other, to the extent of 30°."

"Thus, if a piece of normal comb be held in the position in which it was built, two of the opposite angles of the hexagon, Fig. 75, A, *a*, will be in the same vertical line, and two of the sides will be parallel to this. The same is true of the opposite side of the comb; and thus all the corresponding parts of the cells on the two sides will be parallel. In the deviation we are now noticing, the change is like that represented in A, where the cell *a* is in its true position, while the cell *b*, which is from the opposite side, and is in contact with *a*, varies from it by about 30°. If we look at these two cells in the direction of their sides as at B, the prism *a* will have one of its angles towards the eye, and *b* one of its sides.

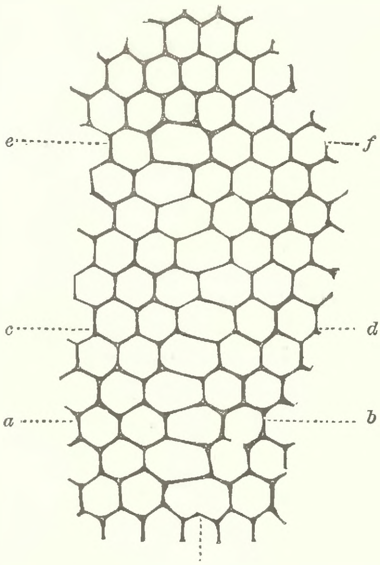


Fig. 76.

In consequence of this deviation and the continual crossing of the rows on opposite sides, the pyramidal base is not made, and the cell is shortened.

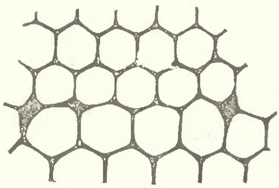


Fig. 77.

"7. In curved or bent combs the cells on the concave side tend to become narrower, while those on the other tend to become broader towards their mouths. In Fig. 76 (this and Figs. 77 and 78 are made from impressions obtained directly from the comb and transferred to wood; they represent the form of the cells exactly), as in the central line of cells, there are a variety of hexagons, each resulting from the union of two cells, the base being double while the mouth is single. That on the line *a*, *b*, has three sides at one end, united by two long sides with one at the other, and thus two of the opposite sides are not parallel; at *c*, *d*, two sides at

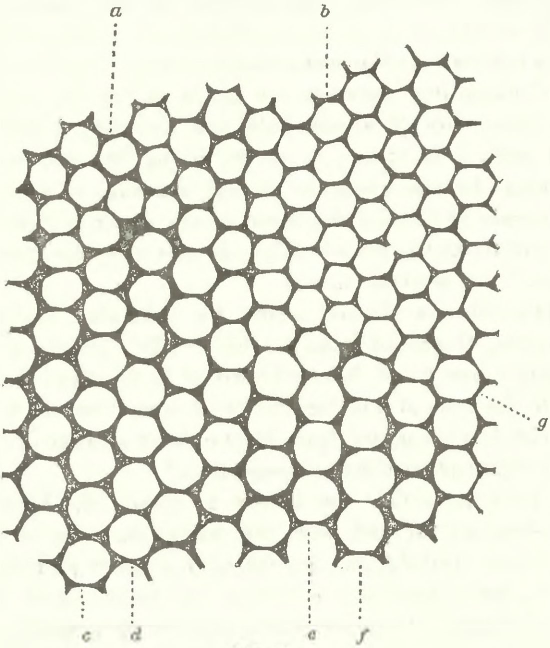


Fig. 78.

either end are united by two long sides, these last being parallel; and at *e*, *f*, the mouth of the compound cell has seven sides. Each has a partition at its base, separating the two originally distinct cells, and each was lined with a cocoon, showing that it had been used for rearing young. At *g*, not only has the partition between the combining cells disappeared, but also three of the sides of each cell."

The bees do not appear to have any systematic way of making a transition from worker to drone cells, which are one-fifth larger than the former. More commonly, they effect it by a gradual alteration of the diameters, thus enlarging a worker into a drone, or narrowing a drone into a worker cell. This alteration is usually made in from four to six rows. In one case

Professor Wyman noticed the transition made with only one cell, as in Fig. 78, but not without destroying the regularity of the two adjoining rows.

"In consequence of the gradual narrowing or widening of the transition cells, the comb tends to become more or less triangular and the cells to become disturbed. The bees counteract this tendency by the occasional intercalation of an additional row, of which two instances are given in Fig. 78, at *a* and *b*, where three rows of worker cells are continuous with two of drone cells, *c*, *d* and *e*, *f;* or, reversing the statement, and supposing the transition, as in the building of the comb, is from worker to drone-cells, a row of the latter is from time to time omitted as the rows *a* and *b;* in this way, the regularity of the comb is preserved."

Honey-cells are formed either by enlarging the ordinary brood-cells, or adding them to others often larger, or by constructing a new comb, devoted entirely to the storing of honey. "While the cells of this last are built unequivocally in accordance with the hexagonal type, they exhibit a range of variation from it which almost defies description."

No Ichneumon-flies are known to attack the larva of the Honey-bee, nor in fact, with few exceptions, any of the wild bees, owing, probably, to the difficulty of their gaining access to them, since *Anomalon vesparum* has been reared from the cells of wasps which are more exposed than those of bees. But the Honey, as well as the wild bees, are afflicted by a peculiar assemblage of insect-parasites, some of which have the most remarkable habits. The most formidable pest of the Hive-bee is the Bee Fly, *Phora incrassata*, which in Europe sometimes produces the well-known disease called "foul-brood." The Bee-louse, *Braula cæca*, is, in Europe, sometimes troublesome to the adult bee, while *Trichodes apiarius*, a beetle, devours the larvæ. The larvæ of *Meloë* and *Stylops* are known in Europe to infest the Honey-bee, and among the low intestinal worms Assmus enumerates *Gordius subbifurcus* which infests the drones of the Honey-bee as well as other insects. Professor Siebold has also described *Mermis albicans*, which is a similar kind of hair-worm, from two to five inches long, and whitish in color. This worm is also found, strangely enough, only in the drones, though it is the workers which frequent watery places (where the worm deposits its eggs) to appease their thirst. The Wax-moths, *Galleria cereana* and *Achroia alvearia*, do much harm by consuming the wax and thus breaking down the cells, and by filling the hive with their webs.*

The genus *Apis* is indigenous in South America, though the Honey-bee has been extensively introduced into the West Indies. Our Honey-bee is replaced in the tropics by the stingless, minute bees, which store up honey and live in far more numerous colonies. The cells of *Melipona* are hexagonal, nearly approaching in regularity those of the Hive-bee, while the honey-cells are irregular, much larger cavities, which hold about one-half as much honey as a cell of the Humble-bee. From a paper on the Brazilian Honey-bees, read by Mr. F. Smith before the Entomological Society of London, March, 1863, he states that the *Meliponas* are small insects, having *wings shorter than the abdomen*, the latter being very convex and oblong; their mandibles never being dentate; while the *Trigonas* have the wings more ample, and *longer than the abdomen*, which is short, somewhat triangular, while the mandibles are serrated, denticulate, or sometimes edentate. The *Meliponas* are restricted to the new world, while *Trigona* extends into Africa, India, and Australasia.

"All these bees are honey gatherers, but the honey collected by the different species varies greatly in quality: from the nests of some it is excellent; from others, worthless. The honey of the species '*Mombuca*' is said to be black and sour, the quality being dependent on species of flowers from which the honey is collected. This great difference in the honey of the various species is apparently confirmatory of the fact that each species confines itself to particular flowers, never visiting any other kind. The different relative length of the tongue in

* Explanation of Plate 2. Parasites of the Honey-bee. Fig. 1, *Phora incrassata*; Fig. 2, pupa; Fig. 3, larva. Fig. 4, *Braula cæca*; Fig. 5, larva. Fig. 6, *Trichodes apiarius*: *a*, larva; *b*, pupa. Fig. 7, *Meloë angusticollis*; Fig. 8, freshly hatched larva; Fig. 9, second stage of larva; Fig. 10, first stage of semi-pupa; Fig. 11, pupa. Fig. 12, *Stylops Childreni* in the body of a wild bee, Andrena; Fig. 13, top view of the same removed from its host; Fig. 14, male of the same; *a*, side view. Fig. 15, *Mucor mellitophorus*, a parasitic fungus. Fig. 16, unknown larva found in nest of Humble-bee. Descriptions of the insect parasites will be given beyond.

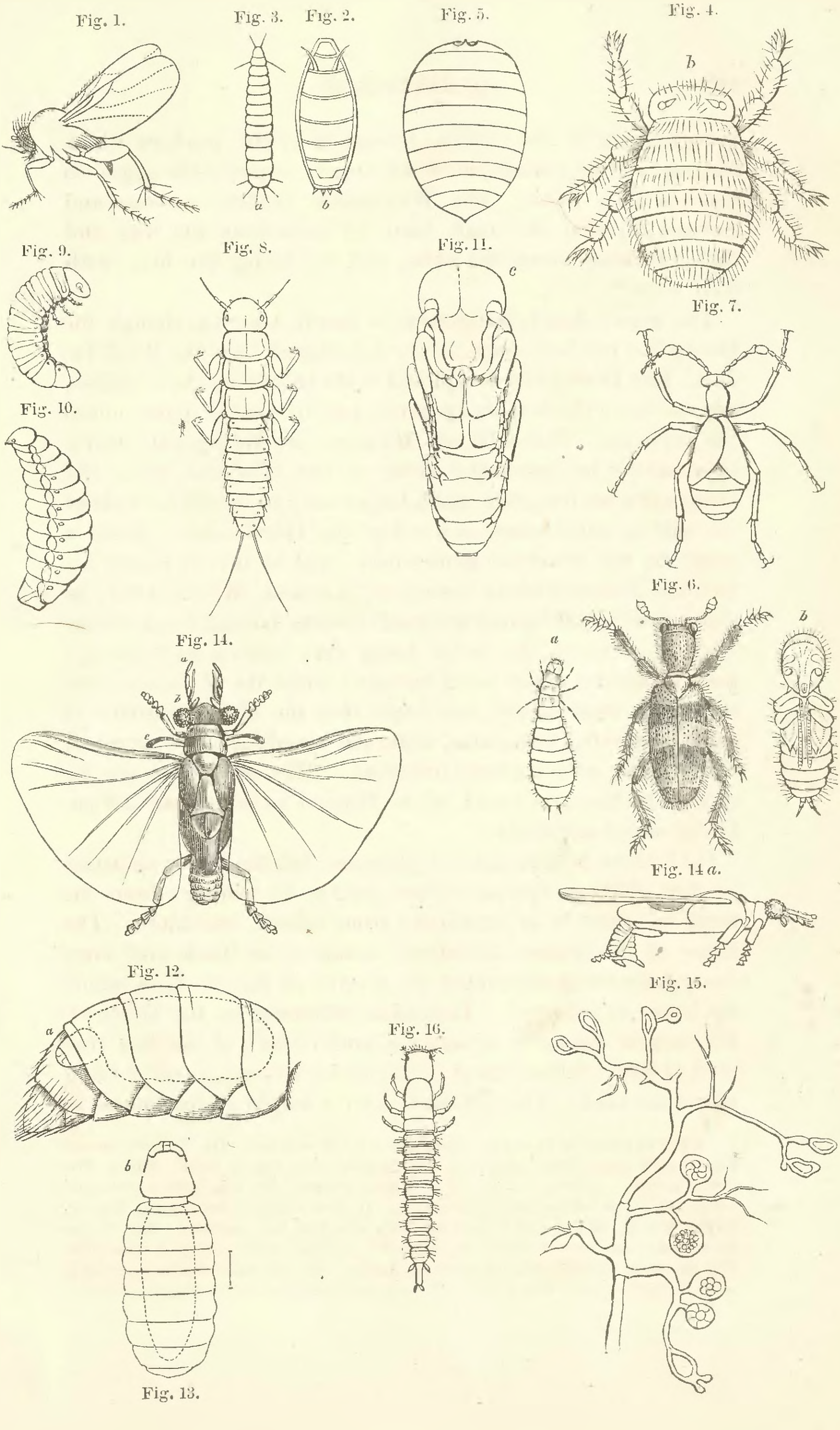


Fig. 1.
Fig. 3.
a
Fig. 2.
b
Fig. 5.
Fig. 4.
b
Fig. 9.
Fig. 8.
Fig. 11.
c
Fig. 7.
Fig. 10.
Fig. 6.
Fig. 14.
a
b
c
a
b
Fig. 14 a.
Fig. 12.
a
b
Fig. 15.
Fig. 16.
Fig. 13.

the species is also confirmatory of the same supposition; indeed, the great diversity in this respect observable in these bees, appears to me to be analogous to a similar diversity in the length of the bills of humming-birds, which, it is well known, are always adapted for reaching the nectaries of the particular flowers which they usually frequent."

In regard to the immense numbers of individuals in a colony, Mr. Stretch, who collected them at Panama, "found a nest several feet in length in the hollow of a tree, containing thousands of individuals, their numbers being, as he informs me, apparently countless.

"Gardner, in his travels, gives a list of such species (of Melipona) as he met in the provinces of Piauhy and Goyaz, where he found them numerous; in every house, he says, 'you find the honey of these bees;' many species, he tells us, build in the hollow trunks of trees, others in banks; some suspend their nests from branches of trees, whilst one species constructs its nest of clay, it being of large size; the honey of this species, he says, is very good." (Smith.)

In a nest of *Trigona carbonaria* from Eastern Australia, Smith, of the British Museum, found from 400 to 500 dead workers crammed in the spaces between the combs, but he did not find a female among them. The combs are arranged precisely similar to those of the common wasp. The number of honey-pots, which are placed at the foot of the nest, amounted to 250.

Smith inclines to the opinion that the hive of Trigona contains several prolific females; "the accounts given of the multitudes inhabiting some nests is too great, I think, to render it possible that one female could produce them all. Mr. Stretch described a hive that he saw, occupying the interior of a decaying tree, that measured six feet in length, and the multitude of bees he compared to a black cloud. M. Guerin found six females in a nest of *Melipona fulvipes*."

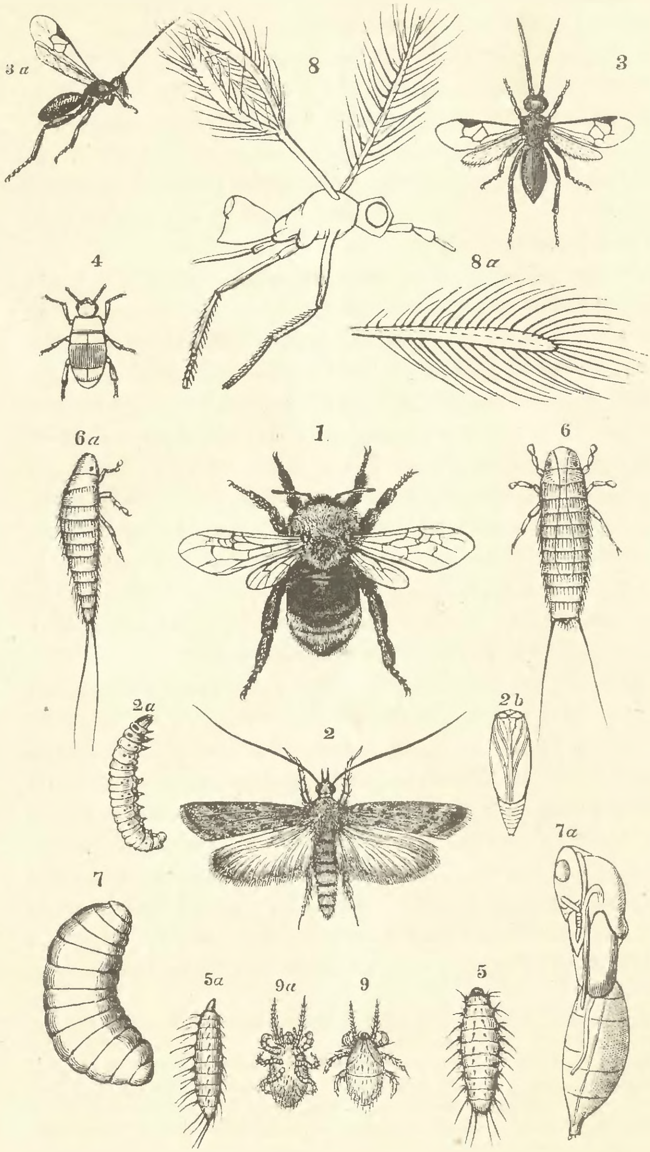
Hill states, in Gosse's Naturalist's Sojourn in Jamaica, "that the wax of these bees [Trigona] is very unctuous and dark colored, but susceptible of being whitened by bleaching. The honey is stored in clusters of cups, about the size of pigeon's eggs, at the bottom of the hive, and always from the brood-cells. The brood-cells are hexagonal; they are not deep, and the young ones, when ready to burst their casement, just fill the whole cavity. The mother bee is lighter in color than the other bees, and elongated at the abdomen to double their length." Smith also states that the female of this genus has the abdomen greatly distended, reminding one of the gravid female of the White Ant. (Smith, Proc. Ent. Soc., London, Dec. 7, 1863.)

In North America, our nearest ally, as regards its habits, of the true Honey-bee, is the Humble-bee (*Bombus*), of which over forty species are known to inhabit North America.

The economy of the Humble-bee is thus: the queen awakens in early spring from her winter's sleep beneath the leaves or moss, or in deserted nests, and selects a nesting-place generally in an abandoned nest of a field-mouse, or beneath a stump or sod, and "immediately," according to Mr. F. W. Putnam, "collects a small amount of pollen mixed with honey, and in this deposits from seven to fourteen eggs, gradually adding to the pollen mass until the first brood is hatched. She does not wait, however, for one brood to be hatched before laying the eggs of another; but, as soon as food enough has been collected, she lays the eggs for a second. The eggs [Plate 4, Fig. 2] are laid, in contact with each other, in one cavity of the mass of pollen, with a part of which they are slightly covered. They are very soon developed; in fact, the lines are nowhere distinctly drawn between the egg and the larva, the larva and pupa, and again between the latter and the imago; a perfect series, showing this gradual transformation of the young to the imago, can be found in almost every nest.

"As soon as the larvæ are capable of motion and commence feeding, they eat the pollen by which they are surrounded, and, gradually separating, push their way in various directions. Eating as they move, and increasing in size quite rapidly, they soon make large cavities in the pollen mass. When they have attained their full size, they spin a silken wall about them, which is strengthened by the old bees covering it with a thin layer of wax, which soon becomes hard and tough, thus forming a cell. [Plate 4, Figs. 1, 2.] The larvæ now gradually attain the pupa stage, and remain inactive until their full devel-

Pl. 3



opment. They then cut their way out, and are ready to assume their duties as workers, small females, males or queens.

"It is apparent that the irregular disposition of the cells is due to their being constructed so peculiarly by the larvæ. After the first brood, composed of workers, has come forth, the queen bee devotes her time principally to her duties at home, the workers supplying the colony with honey and pollen. As the queen continues prolific, more workers are added, and the nest is rapidly enlarged.

"About the middle of summer eggs are deposited which produce both small females and males." . . . "All eggs laid after the last of July produce the large females, or queens; and, the males being still in the nest, it is presumed that the queens are impregnated at this time, as, on the approach of cold weather, all except the queens, of which there are several in each nest, die." (Putnam, Com. Essex Inst., vol. iv, p. 98, 1864.)

Besides Apathus, the larvæ of various moths consume the honey and waxen cells; the two-winged flies, Volucella and Conops, and the larvæ of what is either an Anthomyia or Tachina-like fly; several species of Anthrax, the Coleopterous Anobium paniceum of Europe, Meloë, Stylops, and Antherophagus ochraceus are parasitic on Humble-bees.*

The habits of the genus *Apathus* are not clearly known, but they are supposed to prey, in the larva state, upon the larvæ of Bombus, being found in their nests; their habits, so far as known, ally them with Nomada. The species are distinguished by the tibiæ being convex, instead of concave, as in Bombus, while the mandibles of the females are acute, triangular, bidentate, being spatulate and three-toothed in Bombus, and they have no pollenigerous organs. There are males and females only, as in all the remaining genera of the family. *Apathus Ashtonii* (Plate 3, Fig. 1) is found in the Northern States.

* Explanation of Plate 3.—Parasites of the Humble and Leaf-cutter Bees. Fig. 1, *Apathus Ashtonii*. Fig. 2, *Nephopteryx Edmandsii*; *a*, larva; *b*, pupa. Fig. 3, 3*a*, *Microgaster nephoptericis*, an Ichneumon parasite of Nephopteryx. Fig. 4, *Antherophagus ochraceus*. Fig. 5, *Anthomyia*? larva; *a*, side view. Fig. 6, Recently hatched larva of *Stylops Childrenii*; *a*, side view. Fig. 7, larva; *a*, pupa of *Anthophorabia megachilis*, a Chalcid parasite on Megachile. Fig. 8, *Pteratomus Putnamii*, an exceedingly minute Proctotrupid fly, supposed to be parasitic on Anthorphorabia megachilis; *a*, a hind wing. Fig. 9, a Mite found in the nests of Humble-bees.

Xylocopa, the Carpenter-bee, is "the largest and most bulky of all known bees," but less hirsute than Bombus, while the basal joint of the labial palpi is almost four times as long as the second; and the maxillary palpi are six-jointed, the mouth-parts being very highly organized. The larva of *X. Virginica* (Plate 4, Fig. 3, adult; Fig. 4, larva; Fig. 5, nest) is slenderer than that of Bombus, the body tapering more rapidly towards each end.

The power of boring the most symmetrical tunnels in solid wood reaches its perfection in the large Virginian Carpenter-bee (*Xylocopa Virginica*). We have received from Mr. James Angus, of West Farms, N. Y., a piece of trellis for a grape-vine, made of pine wood, containing the cells and young in various stages of growth, together with the larvæ and chrysalids of *Anthrax sinuosa* (Plate 4, Fig. 6, larva; Fig. 7, pupa), a species of fly parasitic on the larva of the bee, and which buries its head in its soft body and feeds on its juices.

Mr. Angus thus writes us regarding its habits, under date of July 19: "I asked an intelligent and observing carpenter yesterday, if he knew how long it took the Xylocopa to bore her tunnel. He said he thought she bored about one-quarter of an inch a day. I don't think myself she bores more than one-half inch, if she does that. If I mistake not, it takes her about two days to make her own length at the first start; but this being across the grain of the wood may not be so easily done as the remainder, which runs parallel with it. She always follows the grain of the wood, with the exception of the entrance, which is about her own length. The tunnels run from one to one and a half feet in length. They generally run in opposite directions from the opening, and sometimes other galleries are run above the first, using the same opening. I think they only make new tunnels when old ones are not to be found, and that the same tunnels are used for many years. Some of the old tunnels are very wide. I have found parts of them about an inch in diameter. I think this is caused by rasping off the sides to procure the necessary material for constructing their cells. The partitions are composed of wood-raspings, and some sticky fluid, probably saliva, to make it adhere.

"The tunnels are sometimes taken possession of by other bees and wasps. I think when this is the case, the Xylocopa prefers making a new cell to cleaning out the mud and rubbish of the other species. I frequently find these bees remaining for a long time on the wing close to the opening, and bobbing their heads against the side, as if fanning air into the opening. I have seen them thus employed for twenty minutes. Whether one bee, or more, makes the tunnel, that is, whether they take turns in boring, I cannot say at present. In opening the cells, more than one are generally found, even at this season. About two weeks ago, I found as many as seven, I think, in one." *

The hole is divided by partitions into cells about seven-tenths of an inch long. These partitions are constructed of the dust or chippings made by the bee in eating out her cells, for our active little carpenter is provided with strong cutting jaws, moved by powerful muscles, and on her legs are stiff brushes of hair for cleaning out the tunnel as she descends into the heart of the solid wood. She must throw out the chips she bites off from the sides of the burrow with her hind legs, passing the load of chips backwards out of the cell with her fore-limbs, which she uses as hands.

The partitions are built most elaborately of a single flattened band of chips, which is rolled up into a coil four layers deep. One side, forming the bottom of the cell, is concave, being

* "Since writing the above I have opened one of the new holes of Xylocopa which was commenced between three and four weeks ago, in a pine slat used in the staging of the greenhouse. The dimensions were as follows: Opening fully 3-8 wide; depth 7-16; whole length of tunnel 6 and 5-16 inches. The tunnel branched both ways from the hole. One end, from opening, was 2 and 5-8, containing three cells, two with larva and pollen, the third empty. The other side of the opening, or the rest of the tunnel, was empty, with the exception of the old bee (only one) at work. I think this was the work of one bee, and, as near as I can judge, about twenty-five days' work. Width of tunnel inside at widest 9-16 inch.

For some days this bee has been discharging a great quantity of saw-dust and pollen, which I had collected by placing a vessel under it. It would seem that she had cells constructed also in the opposite side of the hole, and that she removed them to enlarge the tunnel. Among the stuff thrown out, I find a partition of a cell nearly entire.

I have just found a Xylocopa bobbing at one of the holes, and in order to ascertain the depth of the tunnel, and to see whether there were any others in them, I sounded with a pliable rod, and found others in one side, at a depth of five and one half inches; the other side was four inches deep, without bees. The morning was cool, so that the object in bobbing could not be to introduce fresh currents of air, but must have had some relation to those inside. The legs on such occasions are, as I have noticed, loaded with pollen."—American Naturalist, vol. 1, p. 370.

beaten down and smoothed off by the bee. The other side of the partition, forming the top of the cell, is flat and rough.

At the time of opening the burrow, July 8th, the cells contained nearly full-grown larvæ, with some half developed. They were feeding on the masses of pollen, which were as large as a thick kidney-bean, and occupied nearly half the cell. Sapyga repanda is parasitic in the cells of *Xylocopa violacea* of Southern Europe.

The habits and structure of the little *Ceratina* ally it closely with Xylocopa, as it hollows out the stems of plants, and builds in them its cylindrical cells. This bee is oblong in form, with tridentate mandibles, and a short labrum. The maxillary palpi are six-jointed, and the labial palpi are two-jointed. *Ceratina dupla* Say is a common small bright-green smooth-bodied species, which, in the middle of May, according to Dr. Harris' MS. notes, tunnels out the stems of the elder or blackberry, syringa, or any other pithy shrub, excavating them often to a depth of six or seven inches, and even, according to Mr. Haldeman (Harris MS.), bores in acorns. She makes the walls just wide enough to admit her body, and of a depth capable of holding three or four, often five or six cells (Plate 4, Fig. 11). The finely built cells, with their delicate silken walls, are cylindrical and nearly square at each end, though the free end of the last cell is rounded off. They are four and a half tenths of an inch long, and a little over one-third as broad. The bee places them at nearly equal distances apart, the slight interval between them being filled in with dirt.

Dr. T. W. Harris* states that, "May 15, 1832, one female laid its eggs in the hollow of an aster-stalk. Three perfect insects were disclosed from it July 28th." The observations of Mr. Angus, who saw some bees making their cells, May 18th, also confirms this account. The history of our little upholsterer is thus cleared up. Late in the spring she builds her cells, fills them with pollen, and lays one or more eggs upon each one. Thus in about two months the insect completes its transformations; within this period passing through the egg, the larval and chrysalid states, and then, as a bee, living through the winter. Its life thus spans one year.

*According to a note in MSS. deposited in the Library of the Boston Society of Natural History.

The larva (Plate 4, Fig. 10) is longer than that of Megachile, and compared with that of Xylocopa, the different segments are much more convex, giving a serrate outline to the back of the worm. The pupa, or chrysalis, we have found in the cells the last of July. It is white, and three-tenths of an inch long. It differs from that of the Leaf-cutter bee in having four spines on the end of the body, and in having a much longer tongue and maxillæ, both being almost twice as long.

In none of the wild bees are the cells constructed with more nicety than those of our little Ceratina. She bores out with her jaws a long deep well just the size of her body, and then stretches a thin delicate cloth of silk, drawn tight as a drumhead, across each end of her chambers, which she then fills with a mixture of pollen and honey.

Her young are not, in this supposed retreat, entirely free from danger. The most invidious foes enter and attack them. Three species of Ichneumon-flies, two of which belong to the Chalcid family, lay their eggs within the body of the larva, and emerge from the dried larva and pupa skins of the bee, often in great numbers. The smallest parasite, belonging to the genus Anthophorabia (so called from being first known as a parasite on another bee, Anthophora), is a minute species found also abundantly in the tight cells of the Leaf-cutter bee.

The species of *Anthidium*, according to Smith, are gaily marked with yellow bands and spots; the ligula is almost twice as long as the labial palpi, and acutely pointed; the paraglossæ are short, the maxillary palpi are two-jointed, and there are two subcostal cells. The males are longer than the females, with an elongated and stoutly toothed abdominal tip. The female lines her nest, situated in any hole convenient for its purpose, with down from woolly-stemmed plants. They pass the winter in the larva state, and the bees do not appear until mid-summer. The species mostly occur in the old world.

In *Anthophora*, which approaches nearer to Bombus in its plump and hairy body than the two preceding genera, the ligula is twice as long as the labial maxillæ, ending in a bristle-like point; the basal joint of the hind tarsus is thickly hirsute, while the middle tarsus of the males is generally elongated. The species are gregarious, their numerous cells, while independent, are crowded together in grassy banks. Species of Melecta are parasitic on them, ovipositing in their cells. The larvæ are infected by the Chalcid flies, Anthophorabia and Monodontomerus, and by a peculiar species of Mite, Heteropus ventricosus, described by Newport. Say has described *Anthophora abrupta* and *A. taurea* from Indiana.

In *Eucera* the antennæ are very long, while the body is still plump and hairy: our more common form in the Middle States is *Eucera maculata* St. Fargeau. The species are likewise gregarious, and, according to Smith, their habits are precisely the same as those of Anthophora.

In *Megachile*, the Leaf-cutter Bee, the head is broad, the body stout, oblong, the ligula is about one-half longer than the labial palpi, being quite stout, while the paraglossæ are short and pointed; the maxillæ are long and sabre-shaped, while their palpi are short and two-jointed. There are two subcostal cells in the fore wing. It is a thick-bodied bee, with a large square head, stout scissor-like jaws, and with a thick mass of dense hairs on the under side of the tail for the purpose of carrying pollen, since it is not provided with a pollen basket as in the Honey and Humble-bees. The larva is broader and flatter than that of Bombus, the raised pleural region is a little more prominent, and the raised, thickened tergal portion of each ring is more prominent than in Bombus.

The Megachile lays its eggs in burrows in the stems of the elder (Plate 4, Fig. 2), which we have received from Mr. James Angus; we have also found them in the hollows of the locust tree. Mr. F. W. Putnam thus speaks of the economy of *M. centuncularis*, our most common species. "My attention was first called, on the 26th of June, to a female busily engaged in bringing pieces of leaf to her cells, which she was building under a board, on the roof of the piazza, directly under my window. Nearly the whole morning was occupied by the bee in bringing pieces of leaf from a rose-bush growing about ten yards from her cells, returning at intervals of a half minute to a minute with the pieces which she carried in such a manner as not to impede her walking when she alighted near her hole. [We give a figure of the Leaf-cutter bee in the act of cutting out a circular piece of a rose-leaf (Plate 4, Fig. 8). She alights upon the leaf, and in a few seconds swiftly runs her scissors-like jaws around through the leaf, bearing off the piece in her hind legs.] About noon she had probably completed the cell, upon which she had been engaged, as, during the afternoon, she was occupied in bringing pollen, preparatory to laying her single egg in the cell. For about twenty days the bee continued at work, building new cells and supplying them with pollen. . . . On the 28th of July, upon removing the board, it was found that the bee had made thirty cells, arranged in nine rows of unequal length, some being slightly curved to adapt them to the space under the board. The longest row contained six cells, and was two and three-quarters inches in length; the whole leaf-structure being equal to a length of fifteen inches. Upon making an estimate of the pieces of leaf in this structure, it was ascertained that there must have been at least a thousand pieces used. In addition to the labor of making the cells, this bee, unassisted in all her duties, had to collect the requisite amount of pollen (and honey?) for each cell, and lay her eggs therein, when completed. Upon carefully cutting out a portion of one of the cells, a full-grown larva was seen engaged in spinning a slight silken cocoon about the walls of its prison, which were quite hard and smooth on the inside, probably owing to the movements of the larva, and the consequent pressing of the sticky particles to the walls. In a short time the opening made was closed over by a very thin silken web. The cells, measured on the inside of the hard walls, were .35 of an inch in length, and .15 in diameter. The natural attitude of the larva is somewhat curved in its cell, but if straightened, it just equals the inside length of the cell. On the 31st of July, two female bees came out, having cut their way through the sides of their cells." In three other cells "several hundred minute Ichneumons [Anthophorabia megachilis] were seen, which came forth as soon as the cells were opened." (Com. Essex Inst., vol. iv, p. 105, 1864.)

Megachile integer Say MS., according to Dr. Harris (MS. notes), forms its nest of leaves the first of August. This species is twice as large, but closely resembles *Megachile brevis* of Say. The front of the head is covered with dense ochreous hairs, becoming shorter and black on the vertex. The nest, preserved in the Harris collection, now in the Museum of the Boston Society of Natural History, is made of rose-leaves, and is scarcely distinguishable from that of *M. centuncularis.*

Osmia, the Mason Bee, is another genus of Carpenter or Upholsterer bees. The species are generally bluish, with greenish reflections, with smooth shiny bodies, and the species are of smaller size than in Megachile. The tongue in this genus is three times as long as the labium, tapering from the base to the acute apex, and clothed with short hair.

Mr. F. Smith states that the larva of the English species hatch in eight days after the eggs are laid, feeds ten to twelve days, when it becomes full-grown, then spins a thin silken covering, and remains in an inactive state until the following spring, when it completes its transformations.

The habits of the little Mason-bees are quite varied. They construct their cells in the stems of plants and in rotten posts and trees, or, like Andrena, they burrow in sunny banks. An European species selects snail-shells for its nest, wherein it builds its earthen cells, while other species nidificate under stones. Curtis found two hundred and thirty cocoons of a British species (*Osmia paretina*), placed on the under side of a flat stone, of which one-third were empty. Of the remainder, the most appeared between March and June, males appearing first; thirty-five more bees were developed the following spring. Thus there were three successive broods for three succeeding years, so that these bees lived three years before arriving at maturity.

Mr. G. R. Waterhouse, in the Transactions of the Entomological Society of London, for 1864 (3d series, vol. 2, p. 121), states that the cells of *Osmia leucomelana* "are formed of mud, and each cell is built separately. The female bee, having deposited a small pellet of mud in a sheltered spot between some tufts of grass, immediately commences to excavate a small cavity in its upper surface, scraping the mud away from the centre towards the margin by means of her jaws. A small shallow mud-cup is thus produced. It is rough and uneven on the outer surface, but beautifully smooth on the inner. On witnessing thus much of the work performed, I was struck with three points. First, the rapidity with which the insect worked; secondly, the tenacity with which she kept her original position whilst excavating; and thirdly, her constantly going over work which had apparently been completed. . . . The lid is excavated and rendered concave on its outer or upper surface, and is convex and rough on its inner surface; and, in fact, is a simple repetition of the first-formed portion of the cell, a part of a hollow sphere."

The largest species of Osmia known to us is a very dark-blue species which seems to be undescribed. We will call it the wood-boring Osmia (*Osmia lignivora*). It is larger than the *Osmia lignaria* of Say, being just half an inch long. The head is much shorter, and less square than in Say's species. The front of the head below the antennæ is clothed with dark hairs, but above and on the thorax with yellowish ochreous hairs. The body is deep blackish blue, with greenish reflections. We are indebted to a lady for specimens of the bees with their cells, which had been excavated in the interior of a maple tree several inches from the bark. The bee had industriously tunnelled out this elaborate burrow (Plate 4, Fig. 12), and, in this respect, resembles the habits of the Carpenter-bee (*Xylocopa*) more closely than any other species of its genus.

The tunnel was over three inches long, and about three-tenths of an inch wide. It contracted a little in width between the cell, showing that the bee worked intelligently, and wasted no more of her energies than was absolutely necessary. The burrow contained five cells, each half an inch long, being rather short and broad, with the hinder end rounded, while the opposite end, next to the one adjoining, is cut off squarely. The cell is somewhat jug-shaped, owing to a slight constriction just behind the mouth. The material of which the cell is composed is stout, silken, parchment-like, and very smooth within. The interstices between the cells are filled with rather coarse chippings made by the bee.

The bee cut its way out of the cells in March, and lived for a month afterwards on a diet of honey and water. It eagerly lapped up the drops of water supplied by its keeper, to whom it soon grew accustomed, and seemed to recognize.

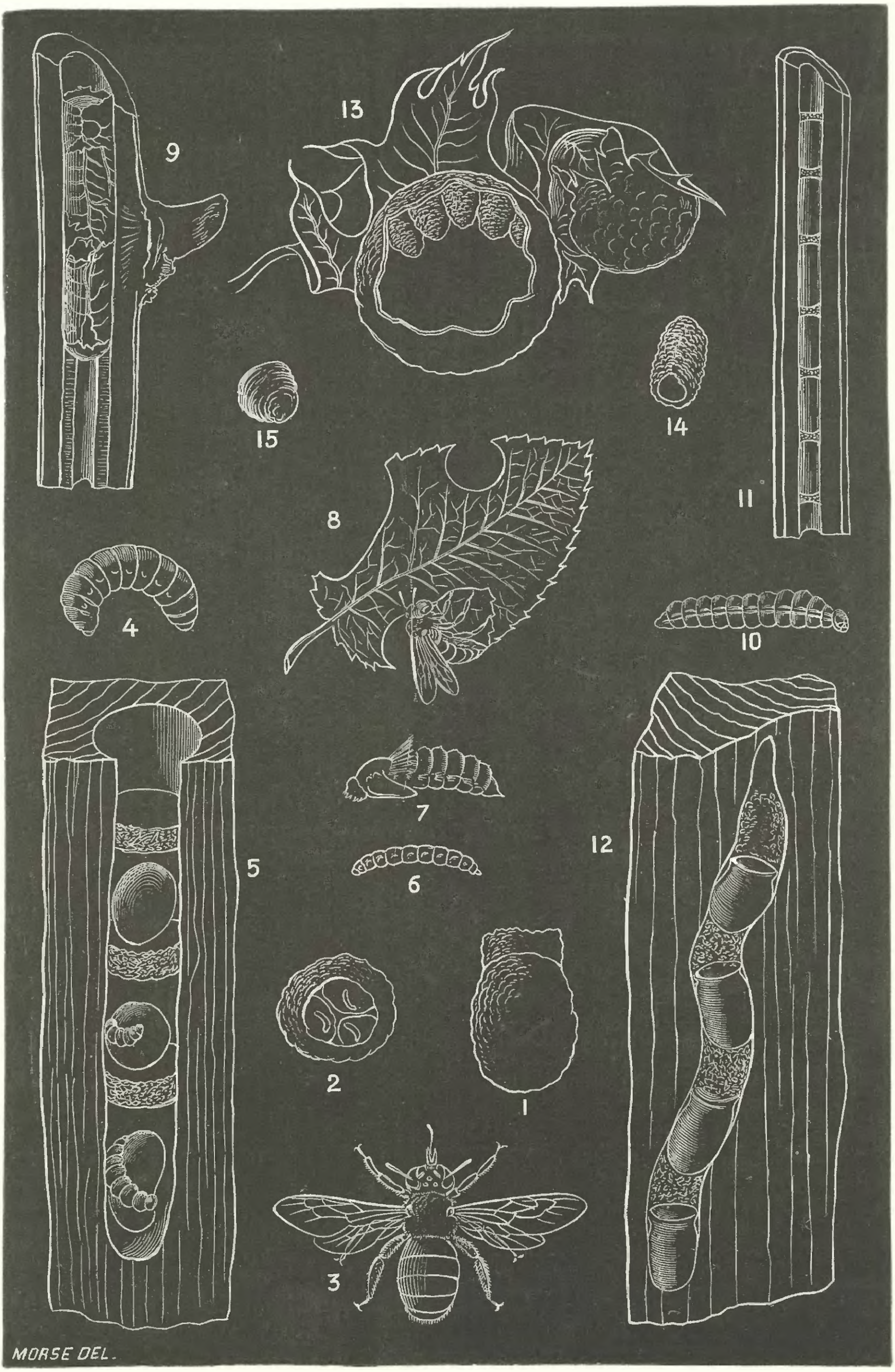
The female of *Osmia lignaria* Say MS., according to Dr.

Harris' MS. notes, was found in the perfect state in cocoons within earthen cells under stones, April 15th. The cell she constructs is half an inch long, oval, cylindrical, and contracted slightly into a sort of neck just before the opening for the exit of the bee. From Mr. James Angus I have received the pellets of pollen, about the size of a pea, in which it deposits its eggs; the larvæ were about one-third grown in August.

This species is larger than *Osmia simillima* of Smith, while the male antennæ are much paler, being fuscous. The front of the head is covered with long dense yellow ochreous hairs. The vertex is not of so dark a green as in *O. simillima*, and is covered with coarse punctures. The thorax is heavily clothed with yellow ochreous, thick hairs. The abdomen is yellowish, and much more hairy. The legs are stout, fuscous, with yellowish hairs. Length, thirty-five inches.

Our smallest and most abundant species is the little green *Osmia simillima* of Smith. It builds its little oval, somewhat urn-shaped cells, against the roof of the large deserted galls of the oak-gall fly (Diplolepis confluentus), placing them, in this instance, eleven in number, in two irregular rows, from which the mature bees issue through a hole in the gall (Plate 4,* Fig. 14. From specimens communicated by Mr. F. G. Sanborn). The earthen cells, containing the tough dense cocoons, were arranged irregularly so as to fit the concave vault of the larger gall, which was about two inches in diameter. On emerging from the cell the Osmia cuts out with its powerful jaws an ovate lid, nearly as large as one side of the cell. Both sexes may be found in April and May in the flowers of the willow

*EXPLANATION OF PLATE 4.—Fig. 1, a cell of the Humble-bee; natural size, with the pollen mass upon the top. Fig. 2, end view of the same mass, showing the three eggs laid in three divisions of the cavity. Fig. 3, *Xylocopa Virginica*, the Carpenter Bee. Fig. 4, the larva of *Xylocopa Virginica*; natural size. Fig. 5, the nest containing the cells of the same, with the partitions and pollen masses, on which the young larva is seen in the act of feeding; natural size. Fig. 6, young larva of *Anthrax sinuosa*; side view. Fig. 7, pupa of *Anthrax sinuosa*, side view; natural size. Fig. 8, the Leaf-cutter Bee (*Megachile*), on a rose leaf, in the act of cutting out a circular piece. Fig. 9, cells of Megachile, in the elder; natural size. Fig. 10, larva of *Ceratina dupla*, the little green Upholsterer Bee; enlarged. Fig. 11, cells of the same in the stem of the elder; natural size. Fig. 12, cells of *Osmia lignivora*, new species, the wood-devouring Mason-bee, excavated in the maple; natural size. Fig. 13, cells of *Osmia simillima*, the common green Mason-bee, built in the deserted gall of the Oak-gall Fly. Fig. 14, a single earthen cell of the same; natural size. Fig. 15, pollen mass, or bee-bread of *Osmia lignaria*; natural size. It is made up of distinct pellets of pollen, which are probably stuck together with saliva.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and fruit trees which blossom later. The antennæ are black, and the green body is covered with fine white hairs, becoming yellowish above.

In the Harris collection are the cells and specimens of *Osmia pacifica* Say, the peaceful Osmia, which, according to the manuscript notes of Dr. Harris, is found in the perfect state in earthen cells (Plate 5, Fig. 2) beneath stones. The cell is oval cylindrical, a little contracted as usual with those of all the species of the genus, thus forming an urn-shaped cell. It is half an inch long, and nearly three-tenths of an inch wide, while the cocoon, which is rather thin, is three-tenths of an inch long.

The following genera, called Cuckoo Bees, are parasitic on other bees, laying their eggs in the cells, or nests, of their host. In *Cœlioxys* the body is stout, and the bee closely mimics its host, Megachile. The ligula is very long, being almost three times the length of the labium, and the paraglossæ are wholly wanting; the maxillary palpi are short, three-jointed, and the abdominal tip of the male is variously toothed. *Cœlioxys octodentata* Say, is abundant late in the summer about flowers. An allied genus, *Melecta*, is parasitic on Anthophora, and *Epeolus* is parasitic on Colletes.

The species of *Nomada* are very numerous; in all, the tongue is long and acute, with paraglossæ about one-fourth as long as the tongue; the maxillary pair of palpi are six-jointed; and there are three subcostal cells. The species in their slender, smooth, gaily colored body resemble the wasps. These Cuckoo-bees lay their eggs in the nests of Andrena and Halictus, and, according to English authors, Panurgus and Eucera, where they may be found in all stages of development corresponding to those of their hosts. The females do not sting severely. The species emit sweet, balmy, or balsamical odors. Shuckard states that these bees should be killed with burning sulphur to preserve their bright colors.

The larvæ differ greatly from those of their hosts, Andrena, the head being much smaller, the body being smoother and rounder, and belonging to a more degraded, lower type. The whole body is more attenuated towards both extremities. The pupa differs from those of any other genus of this family known to us, except Andrena, by having three conspicuous spines on the upper and posterior edge of the orbit, which are also found in the pupa of Stigmus, a Crabronid genus, and which evidently aid in locomotion. Thus the same law of degradation obtains in these highly organized bee-parasites as in the lower parasitic species, though in a much less marked degree.

From specimens found in the nests of Andrena and Halictus, collected at Salem by Mr. J. H. Emerton, and now in the Museum of the Essex Institute, we have been enabled in great part to clear up the history of this bee. We have found in the nests of Andrena vicina both sexes of *Nomada imbricata* Smith, and several females of *Nomada pulchella* of Smith; and in the cells of Halictus parallelus Say, specimens of *Nomada imbricata.* Both full-grown larvæ and pupæ of different ages, up to the adult Nomada, ready to take leave of its host, were found in the cells of the Andrena vicina. It seems, therefore, that the newly hatched young of Nomada must feed on the pollen mass destined for the Andrena. But there seems to be enough for *both* genera to feed upon, as the young of both host and parasite were found living harmoniously together, and the hosts and their parasites are disclosed both at the same time. Does not this mild sort of parasitism in Nomada throw much light on the probable habits of Apathus, the Humble-bee parasite? It is more than probable that the Apathus larvæ simply eat the food of the Bombus larvæ, and do not attack the larvæ of their hosts. Both Nomada and Apathus in their adult stages live harmoniously with their hosts, and are seen gathering food from the same flowers, and flying about the same nest.

In the second subfamily, *Andrenetæ*, the ligula, or tongue, is for the most part short and broad, and the maxillary palpi have four joints of equal size.

In *Sphecodes* the body is smooth and wasp-like, and in its habit of running and flying in dry sandy places, it resembles Sphex, whence its generic name. The abdomen is generally light red, farther aiding in the resemblance to the *Sphegidæ*. The ligula is short, lancet-shaped, fringed with setæ; the paraglossæ are not so long as the tongue, while the labial palpi are shorter than the paraglossæ, and the maxillæ are broad, lanceolate, with six-jointed palpi. The antennæ of the males are short and sometimes moniliform. *Sphecodes dichroa* Harris is our most common species. Mr. F. Smith, from direct observation, states that this genus builds cells, though earlier authors have stated that it is parasitic on Halictus and Andrena.

Prosopis is generally yellow on the face, and is "less pubescent than any of the bees." The tongue is broad, subemarginate, the paraglossæ reach a little beyond the tongue; the labial palpi are as long as the tongue, while there are two subcostal cells in the fore wings. Smith states that the genus is not parasitical as formerly supposed, as he has "repeatedly bred them" from cells laid in a regular order in the hollow of bramble stems. Mr. S. Saunders has also raised them in Albania where "they construct their cells in bramble sticks (which they bore in the same manner as *Colletes*) with a thin transparent membrane, calculated for holding semi-liquid honey, which they store up for their young. The species are much attacked by Stylops." Like Sphecodes and Ceratina, this genus, according to Smith, is unprovided with pollenigerous organs. We have several species in this country of which *P. affinis* Smith, and *P. elliptica* Kirby, are found northward. The habits of our species are not known.

Augochlora comprises beautiful shining metallic green species, very commonly met with. The thorax is globose, and the anterior wings have one marginal and three submarginal cells; the first submarginal cell as long as the second and third united. *Augochlora purus* Smith is a small, green, rather common species. Mr. J. H. Emerton has found its nests in Salem, near those of Andrena. The mouth of the hole opened under a stone, and was built up so as to form a tube of sand (Plate 5, Fig. 1). The burrow on the 28th of June was four inches deep.

Andrena is a genus of great extent, and the species are often difficult to distinguish. The lanceolate tongue is moderately long, and the paraglossæ are half as long as the tongue itself, while the six-jointed maxillary palpi are longer than the maxillæ themselves. The wings have three subcostal cells, with the rudiments of a fourth one; the second is squarish, and the third receives a recurrent nervure near the middle. The posterior legs "have a long curled lock upon the trochanter beneath, and the anterior upper surface of the femora is clothed with long loose hair, which equally surrounds the whole of the tibiæ." (Shuckard.) The abdomen is banded more or less conspicuously with reddish.

The larva (Fig. 79) is stout and thick, with a head of moderate size, and the mouth-parts are a little shorter than usual, the maxillæ and labium especially. The segments of the body are much more convex (angularly so) than usual, giving a tuberculate outline to the body. It is stouter than that of Halictus, the wings are less convex than in that genus; while the maxillæ are much stouter and blunter. The pupa is distinguished from the other genera by much the same characters as the imago, except that there are two tubercles on the vertex near the ocelli. From a comparison of all its stages, this genus stands intermediate between those placed above, and Halictus, which, in all its characters, is a more degraded form. The males often differ widely from the other sex, in their broad heads and widely spreading bidentate mandibles.

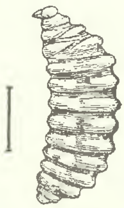


Fig. 79.

Mr. Emerton has observed the habits of our most common species, *Andrena vicina* Smith, which builds its nest in grassy fields. The burrow is sunken perpendicularly, with short passages leading to the cells, which are slightly inclined downwards and outwards from the main gallery. The walls of the gallery are rough, but the cells are lined with a mucus-like secretion, which, on hardening, looks like the glazing of earthen-ware. In Fig. 80 Mr. Emerton gives us a profile view of natural size of the nest showing the main burrow and the cells leading from it; the oldest cell, containing the pupa (*a*) is situated nearest the surface, while those containing larvæ (*b*) lie between the pupa and the cell (*e*) containing the pollen mass and egg resting upon it. The most recent cell (*f*) is the deepest down, and contains a freshly deposited pollen mass. At *c* is the beginning of a cell; *g* is the level of the ground. The bees were seen at work on the 4th of May, at Salem, Mass., digging their holes, one of which was already six inches deep; and by the 15th, hundreds of holes were observed. On the 28th of May, in unearthing six holes, eight cells were found to contain pollen, and two of them a small larva. On the 29th of June six full-grown larvæ were exhumed, and one about half-grown. About the first of August the larva transforms to a pupa, and during the last week of this month the mature bees appear.

In *Halictus*, which is a genus of great extent, the head is transverse, and flattish; the mouth-parts are of moderate length, the tongue being very acute, with acute paraglossæ half the length of the tongue, while the labial palpi are not quite so long as the paraglossæ. There are three subcostal cells in the wings, with the rudiments of a fourth often present, and the second cell is squarish. The abdomen is oblong ovate, with a longitudinal linear furrow on the tip in the female. In the males the body is longer and the antennæ more filiform and slender than usual in this family.

The larvæ are longer, and with more acutely convex segments than in Andrena. The pupæ differ much as the adult bees from Andrena, especially in the shorter mouth-parts.

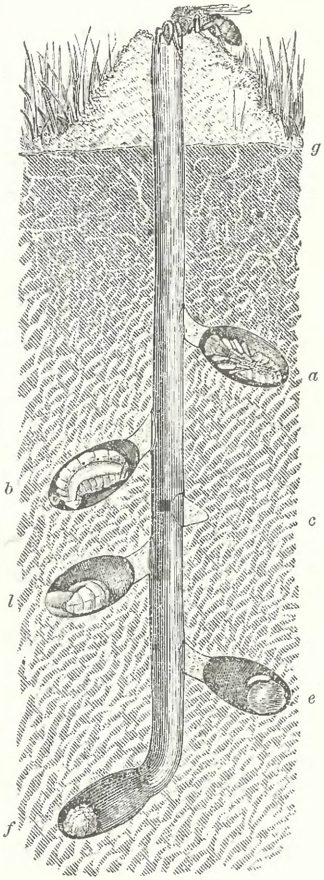


Fig. 80.

Halictus parallelus Say excavates cells almost exactly like those of Andrena; but since the bee is smaller, the holes are smaller, though as deep. Mr. Emerton found one nest, in a path, a foot in depth. Another nest, discovered September 9th, was about six inches deep. The cells are in form like those of Andrena, and like them are glazed within. The egg is rather slender and much curved; in form it is long, cylindrical, obtuse at one end, and much smaller at the other. The larva

(Fig. 81) is longer and slenderer, being quite different from the rather broad and flattened larva of Andrena. The body is rather thick behind, but in front tapers slowly towards the head, which is of moderate size. Its body is somewhat tuberculated, the tubercles aiding the grub in moving about its cell. Its length is .40 of an inch. On the pupa are four quite distinct conical tubercles forming a transverse line just in front of the ocelli; and there are also two larger, longer tubercles, on the outer side of each of which an ocellus is situated. Figure 82 represents the pupa seen from beneath.

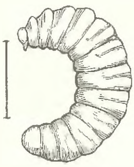


Fig. 81.

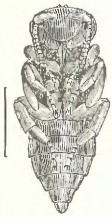


Fig. 82.

Search was made for the nests on July 16th, when the ground was very hard for six inches in depth, below which the soil was soft and fine, and over twenty cells were dug out. "The upper cells contained nearly mature pupæ, and the lower ones larvæ of various sizes, the smallest being hardly distinguishable by the naked eye. Each of these small larvæ was in a cell by itself, and situated upon a lump of pollen, which was of the size and shape of a pea, and was found to lessen in size as the larva grew larger. These young were probably the offspring of several females, as four mature bees were found in the hole." (Emerton.) The larva of an English species hatches in ten days after the eggs are laid.

Another brood of bees appeared the middle of September, as on the ninth of that month (1864) Mr. Emerton found several holes of the same species of bee made in a hard gravel road near the turnpike. When opened, they were found to contain several bees with their young. September 2, 1867, the same kind of bee was found in holes, and just ready to leave the cell.

Like Bombus, the females are supposed to hybernate, the males not appearing until late in the season. Like Andrena, these bees suffer from the attacks of Stylops, and according to Shuckard, an Ichneumon preys upon them, while certain species of Cerceris, Philanthus, and Crabro carry them off to store their nests with.

In *Colletes* the females, as Shuckard observes, resemble the workers of the Honey-bee, while there is considerable disparity between the sexes, the males being much smaller, the tongue and maxillæ very short; and the four-jointed labial palpi much shorter than the paraglossæ. There are three subcostal cells, with the rudiments of a fourth. These bees form large colonies, burrowing in the earth eight or ten inches deep, lining their cells "at the farther end with a very thin transparent membranaceous coating, resembling goldbeaters' skin." They thus furnish six or eight cartridge-like cells, covering each with a cap, "like the parchment on a drum-head." Smith, from whom we have been quoting, states that *Miltogramma punctata*, which is a Tachina-like fly, and the Cuckoo-bee, *Epeolus variegatus*, have, in Europe, been reared from their cocoons.

Vesparlæ Latreille, *Wasps*. In this family, which comprises about 900 species, the body is more attenuated, more cylindrical, with a harder and smoother tegument than in the *Apiariæ*. In the species with densely populated colonies, such as Vespa and Polistes, there are workers which are often very numerous, while in Eumenes and Odynerus, etc., there are only males and females. The antennæ are elbowed, the mandibles are large, stout; the maxillæ and labium of varying length; the maxillary palpi are six-jointed; while on the labial palpi, which are four-jointed, there are well-developed paraglossæ. The prothorax is prolonged on each side to the insertion of the wings which are long and narrow, and once folded longitudinally when at rest; the fore pair have two or three subcostal cells; the hind shanks and tibiæ are smooth. The eggs, when first laid, are globular, soon becoming oval.

The larvæ of this family are soft, fleshy, with larger heads in proportion to the rest of the body, than in the *Apiariæ;* the antennal tubercle, or rudimentary antennæ, are more distinct, and the mandibles are larger. The surface of the body is smoother in Vespa and Polistes, but more tuberculated in the solitary genera, Odynerus and allies, while the end of the body is more acute.

As in the *Apiariæ* the higher genera are social, building papery nests, while the lower are solitary and build cells of mud or sand in protected places.

In *Vespa*, the Paper Wasp, the ligula is squarish, with the paraglossæ nearly as long as the tongue, the outer maxillary lobes rounded oval, half as long as the palpi, and the labial maxillæ are scarcely longer than the tongue. The abdomen is broad at base, acutely conical. The nests are either with or without a papery covering, supported by a short pedicel.

Such females as have hybernated, begin to make their cells in the early part of summer. Smith states that the solitary female wasp "begins by making three saucer-shaped receptacles, in each of which she deposits an egg; she then proceeds to form other similar-shaped receptacles, until the eggs first deposited are hatched and the young grubs require a share of her attention. From the circular bases she now begins to raise her hexagonal cells, not building them up at once, but from time to time raising them as the young grubs grow. (Proc. Ent. Soc., London, 1858, p. 35.)

Waterhouse states that the cells formed by the solitary female early in the season appear "to be built entirely of glistening, whitish, silk-like threads which I have little doubt are a secretion from the insect, all the threads being firmly attached together as if they had originally been of a glutinous nature." The cells formed later in the season by the workers, differ in consisting of masticated rotten wood. "Almost simultaneously with the commencement of the cells, it appears that the nest-covering is commenced. At first it has the appearance of a miniature umbrella, serving to shelter the rudimentary cells." Plate 5, Fig. 3, shows a group of cells surrounded by one layer of paper, and the beginning of another. As the nest grows larger the cells are arranged in galleries, supported by pedicels, and the number of layers in the outside covering greatly increases in number.

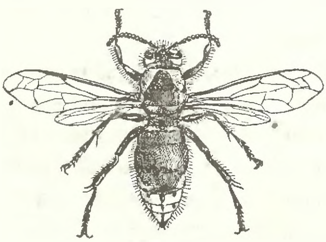


Fig. 83.

While our common and largest species, *Vespa maculata* Linn. (Fig. 83), and the yellow wasp, *V. arenaria* Fabr., build papery nests consisting of several galleries, with the mouth of the cells directed downwards, the East Indian species, *V. orientalis*, builds its cells of clay, and, according to Waterhouse, "the work is exceedingly beautiful and true." Another species, according to Smith, makes its nest of sandy loam, the exterior being so hard that a saw used in opening one of its sides was blunted.

The larva of *Vespa arenaria* is long and cylindrical, not so much curved as in Polistes. Its position in its cell corresponds to its form, as the cell is longer and narrower than that of Polistes. Each segment of the body is posteriorly somewhat thickened, as is the lateral (pleural) ridge of the body. The tip of the abdomen is rather blunt, the last sternite being large and transverse. The pupa is provided with a single tubercle on the vertex, where there are two in the *Crabronidæ* and *Sphegidæ*.

By the time the nest of V. arenaria is large enough to contain ten full-grown larvæ, and has about fourteen cells in all, being about an inch in diameter, the occupants of the two or three central cells will have changed to pupæ, and one wasp will have been excluded.

In a nest of the same species two inches in diameter, there were a second brood of larvæ. The outer row of cells were occupied by pupæ, while the central ones, emptied of the first brood, were filled with a second brood of larvæ. Evidently as soon as an imago leaves its cell, the female deposits an egg therein, as very minute larvæ were found occupying cells next to those containing large full-grown larvæ.

In comparing a number of pupæ from a large nest, they will be found to be in all stages of perfection, from the larva which has ceased feeding, and is preparing to transform, to the imago, still veiled by its thin subimago pellicle. It is difficult to draw lines between these stages. Also when compared closely side by side, it is difficult, if not impossible to find any two pupæ just alike, the development proceeding very unequally. Thus the limbs may be more perfect than the antennæ, or certain parts may be less perfect in some than in others, while the limbs may be more highly colored like the imago.

Like the bees, Vespa suffers from numerous parasites, including Rhipiphorous paradoxus, which is a beetle allied to Stylops, and Lebia (Dromius) linearis. The larva of Volucella is said to feed on the Vespa-larvæ, and Mr. Stone says that Anthomyia incana is also parasitic in Wasps' nests, while two species of Ichneumons, one of which is Anomalon vesparum, also infest the larvæ. No parasites have been as yet detected in this country.

The Hornet, *V. crabro* Linn., has, according to Mr. Angus, become domesticated about New York. This and the smaller wasps are sometimes injurious by eating into ripe fruit, but the injury is more than counterblanced by the number of flies and other insects they feed their young with.

Indeed, as Saussure states, the species of Vespa are more omnivorous in their tastes than any other wasps. They live by rapine and pillage, and have obtained a worse repute than other insects more injurious. In spring and early summer they feed on the sweets of flowers; but later in the season attack strawberries, plums, grapes, and other fruits, and often enter houses and there help themselves to the dishes on the table. They will eat raw meat, and then aid the butcher by devouring the flies that lay their eggs on his meats. They will sometimes destroy Honey-bees, attacking them on their return from the fields laden with pollen; they throw themselves upon their luckless victims, and tear the abdomen from the rest of the body, and suck their blood, devouring only the abdomen. They fall upon flies and butterflies, and, biting off their wings, feet, and head, devour the trunk. In attacking insects they use only their powerful jaws, and not the sting, differing in this respect from the fossorial wasps.

Saussure states that though wasps do not generally lay up food, yet at certain periods they do fill the cells with honey.

The females feed their young with food chewed up and reduced to a pulp. Saussure questions whether the larvæ of one sex are not fed on animal and the other on vegetable food, since Huber had shown "what a great influence the kind of food exerts on the sex of Bees." But it is now known that the sexes of some, and probably all insects are determined before the larvæ is hatched. I have seen the rudiments of the ovipositor in the half-grown larvæ of the Humble-bee, and it is most probable that those rudiments began to develop during embryonic life. It is far more probable that the sexual differences are determined at the time of conception.

Westwood states that the larvæ, which live head-downward from the reversed position of the comb, retain their position in the cell, while young, by a glutinous secretion, and afterwards "by the swollen front of the body which fills the open part of the cell." "The female cells are mostly placed apart from those of the males and neuters, those of the males being often mixed, but in a small number, in the neuter combs. The egg state lasts eight days, the larva state thirteen or fourteen, and that of the pupa about ten. After the imago has been produced, one of the old workers cleans out the cell, and fits it for the reception of a fresh inhabitant. The upper tier of cells, being first built, serves for the habitation of the workers; the females, being produced at the end of the summer, occupy the lowest tiers." When about to transform the larvæ spin a thin covering, thus closing over the cell.

In *Polistes* the paraglossæ are slender, and a little longer than the long, or as in one instance noticed by us in *P. Canadensis*, barrel-shaped ligula, which is split at the end; the palpi are stouter, while the whole body is much longer than in Vespa; the abdomen is subpedunculate, and the thorax is rather oblong than spherical, as in Vespa.

The larva differs from that of Vespa in its much larger head, and shorter, more ovoid form of the body, which is dilated in front so as to retain the insect in its cell, while the tip is more acute; the antennal tubercles are closer together; the clypeus is more regularly triangular and more distinct, while the labrum is much larger and excessively swollen, as are the mouth-parts generally. The mandibles are bidentate, where in Vespa they are tridentate. The pupa differs from that of Vespa, besides the usual generic characters, in having the tubercle on the head smaller.

The nests of Polistes (Plate 5, Fig. 4, nest of *P. annularis* Fabr., from Saussure) are not covered in by a papery wall as in Vespa, but may be found attached to bushes, with the mouth of the cells pointed downwards. While at Burksville Junction, Va., in the last week of April, I had an opportunity of watching three species beginning their cells on the same clump of bushes. They all worked in the same method, and the cells only differed slightly in size. The cells were formed mostly of crude silk, and the threads could be seen crossing each other, the same structure being observed at the top and bottom of each cell.

In the three-celled nest of Polistes (Plate 5, Fig. 5, 5*a*) first noticed April 29th, there were but two eggs deposited, the third cell being without an egg, and a little smaller, and the rim not so high as in the other two. The outer edge did not seem to be perfectly circular, though stated by Waterhouse to be so in the incipient cells, for in some cases we detected two slight angles, thus making three sides, which, however, would be easily overlooked on casual observation; as there are only two sides within, the cell, from being at its earliest inception hemispherical, or "saucer-shaped," becomes five, and subsequently six-sided, and thus from being circular, it is converted by the wasps into a hexagonal cell. In some cells, perhaps a majority, both in this and the other species, the newly made rim of the small cells is thinner than the parts below, and slightly bent inwards; thus being quite the reverse of the thickened rim of the cells of the Hive Bee. It would seem that the wasp plasters on more silk, especially on the angles, building them out, and making them more prominent, in order to complete, when other cells are added, their hexagonal form. The three cells are of much the same size and height when the third egg is laid, as we observed in another nest, that of *Polistes Canadensis* (Linn.), built at the Defences of Washington, near Munson's Hill, June 9th.

Again, when one or two more cells have been added to the nest, and there are four or five in all (Plate 5, Fig. 6; 6*a*, top view, in which there are four cells), two of them are nearly twice as large as the others, while the fifth has been just begun, and is eggless. The form of the two which run up much higher than the others is the same as that of the smaller and shorter ones, *i.e.* they are on one side nearly semicircular, and on the other, partly hexagonal, and the angular sides show a tendency to be even more circular than when the others are built around them, for the little architect seems to bring out the angles more prominently when carrying up the walls of the other cells. Thus she builds, as if by design, one and the same cell both by the "circular" and "hexagonal" methods, afterwards adopt-ing only the latter, and if she devotes her attentions specially to plastering the corners alone, with the design of making the cell six-sided, then we must allow, contrary to Mr. Waterhouse's views, that the wasp builds the hexagon by choice, and not as the mere result of her blindly "working in segments of circles;" for if our point be proved, and the most careful observation of the wasp while at work is needed to prove it, then it may be shown that the wasp is a free agent, and can abandon one method of working at a certain stage of her work, and adopt a different mode of operating.

The eggs are oval, pointed at the end, and glued to the inside of the cell. They are situated midway from the top and bottom of the incipient cell, and placed on the innermost sides, so that in a group of several cells the eggs are close together, only separated by the thin cellular walls. In a completed cell the egg is placed very near the bottom.

For several days a *Polistes Canadensis* was engaged in building its nest in my tent in camp near Washington. When first noticed on June 9th, there were three cells, two of which contained eggs; and it was not for two days, the 11th, that the third cell was completed, and a third egg deposited in it. The wasp paid especial attention to strengthening the pedicel, going over it repeatedly for an hour or two with its tongue, as if laying on more silken matter, and then proved the work by its swiftly vibrating antennæ. It would often fly out of the tent, and on its return anxiously examine each cell, thrusting its head deep down into each one. It gradually became accustomed to my presence, but eventually abandoned the nest, without adding more cells. The others, while at work on the bushes, absconded at my approach, and seemed very wary and distrustful, as if desirous of concealing their abodes. Mr. Smith has found *Trigonalys bipustulatus* to be a parasite on *Polistes lanio* Fabr. (*P. Canadensis* Linn.), from St. Salvador, S. A.

Saussure arranges the higher Vespidæ into two parallel series. Vespa is offset by Chartergus and Nectarina; lower down we find Tatua and Synœca, while Polistes is offset by Polybia. These five genera are tropical, and in their habits, the general appearance of their nests, and in the number of individuals represent Vespa and Polistes of the temperate zone. The genus *Nectarina* is a short plump wasp, somewhat like Odynerus in shape; its distinguishing mark is the concealment of the postscutellum by the scutellum. *Nectarina mellifica* Say, of Mexico, builds a large nest externally like that of a wasp, but it is more irregular, and the papery covering consists of but one layer. The interior of the nest is very different, the galleries of cells, instead of being parallel, being arranged in concentric spheres.

Chartergus has the tip of the clypeus slighted excavated, and an oval sessile abdomen. *C. chartarius* Olivier makes an exceedingly thick tough nest, attached by a broad base to the bough of a tree, about twice as long as thick, and ending in a cone, pierced in the centre by the entrance which passes through the middle to the basal gallery; the other galleries are formed by a continuation of the sides of the nest, and arrayed in a conical plane.

In *Tatua*, the abdomen is pedicelled, but the petiole is not enlarged, and the abdomen itself is very regularly conical. *T. morio* Cuvier, from Cayenne, forms a nest like that of Chartergus; but the galleries form a flat floor, and each gallery has an entrance from the outside of the nest, where in the latter there is one common entrance. Plate 5, Fig. 9, shows how the bases of the cells are laid out on the edge of a gallery. In *Synœca* the peculiarly shaped abdomen is cordate and compressed. The curious nest of *S. cyanea* Fabr. is formed of a single layer of cells fixed against the trunk of a tree, and covered in with a dense covering made from the bark of dead trees. Some nests of Synœca are three feet long. In the very extensive genus *Polybia*, which resembles Polistes in its general shape, the abdomen is pedicelled, and the mandibles are four-toothed. The nests are somewhat like those of Chartergus, but much smaller. Several species occur in Mexico, and in Brazil the number of species is very great. In *Apoïca* the abdomen is very long, and the third segment is as long as the second. Plate 5, Fig. 11, represents the nest of *Apoica pallida* Olivier, from Cayenne. It is unprotected, with a conical base, and with a single row of cells.

In *Icaria* we have an approach to Polistes in the slender series of cells composing the nest, forming two or three rows only. Plate 5, Fig. 7, represents the nest of *I. guttatipennis* Saussure, from Senegal; 8, ground plan of a similar nest. These wasps are mostly distinguished from Polybia by the petiole ending in a globular mass. Plate 5, Fig. 10, represents the elegant nest of *Mischocyttarus labiatus* Fabr., from Cayenne and Brazil, which consists of a few cells supported by a long pedicel. The wasp itself much resembles Polistes, but the petiole is very much longer.

The remaining genera noticed here are solitary, building separate cells, and with only males and females. There are three subcostal cells in the fore wings, and the maxillæ and labium are much elongated.

In Eumenes the abdomen has a long pedicel, being sessile in Odynerus. While authors place Eumenes higher than Odynerus, we would consider the latter as a higher, more cephalized form, since the abdomen is less elongated, and the head is larger.

In *Odynerus* the ligula is long, deeply forked at the slender extremity, while the slender paraglossæ are shorter, ending in a two-toothed claw-like tip; the maxillæ are slender, and the palpi have an elongated basal joint; the clypeus is nearly circular, toothed on the front edge. The larva differs from those of the higher *Vesparicæ*, in its more elongated head, the square clypeus, the unusually deep fissure of the bilobate labrum, and in the larger tubercles of the body, as the larva is more active, turning and twisting in its cell, while feeding on its living food; and in this respect it is more closely allied to the young *Crabronidæ*. In the pupa of *O. albophaleratus*, the tip is more incurved than in the pupa of Vespa, so that the hind legs (tarsi) reach to the tip, and the abdomen is rounded ovate, while in Vespa it is oblong.

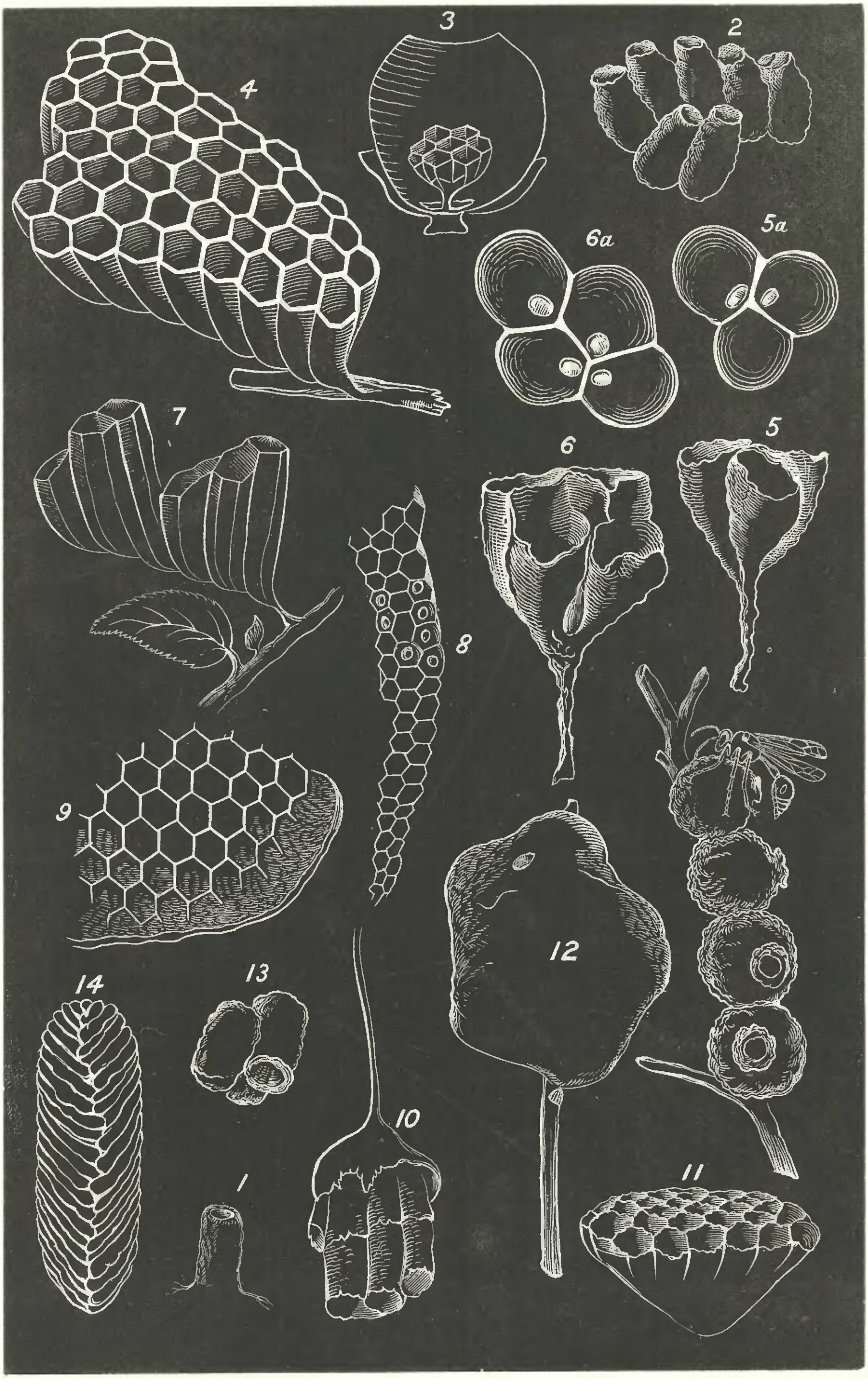
The cells (Plate 4, Figs. 13, 14) of *Odynerus albophaleratus* Sauss. have been detected like those of Osmia in a deserted gall of Diplolepis confluens, where several were found in a row, arranged around one side of the gall, side by side, with the holes pointing towards the centre of the gall. The cells are half an inch long, and one-half as wide, being formed of small pellets of mud, giving a corrugated, granulated appearance to the outside, while the inside is lined with silk.

We have received from Mr. Angus deserted cells of Ceratina in a syringa stem, in which we detected a pupa of an Odynerus, perhaps *O. leucomelas*; the cell was a little shorter than that of the Ceratina it had occupied. The cocoon of the Odynerus was of silk, and almost undistinguishable from the old cocoon of Ceratina. The wasp had dispensed with the necessity of making a mud cell. If future research shows that either this or any other species makes a mud cell or not at will, it shows the intelligence of these little "free-agents;" and that a blind adherence to fixed mechanical laws does not obtain in these insects.

The larvæ of Odynerus and Eumenes are carnivorous. I found several cells of *O. albophaleratus*, June 22d, in the deserted nest of a *Clisiocampa*, which were stored with micro-lepidopterous larvæ and pupæ, still alive, having been paralyzed by the sting of the wasp. The larvæ of the wasp was short and thick, being, when contracted, not more than twice as long as broad; the rings of the body are moderately convex, and the pleural region is faintly marked. Prof. A. E. Verrill has discovered the cells of an Odynerus at New Haven, forming a sandy mass (Plate 5, Fig. 12) attached to the stem of a plant.

In *Eumenes* the lingua is very long, being narrower and more deeply divided than in Odynerus; the second subcostal space of the wings is long and narrow, while in Odynerus it is triangular. The genus is easily recognized by the very long pedicel of the abdomen. *Eumenes fraterna* Say constructs a thin cell (Plate 5,* Fig. 15) of pellets of mud, and as large

* Explanation of Plate 5. Fig. 1. Mouth of the tunnel of *Augochlora purus*; from Emerton. Fig. 2. Cells of *Osmia pacifica*; communicated by Mr. Sanborn. Fig. 3. Vertical section of nest of *Vespa* with a group of primitive cells surrounded by one layer of paper, and part of another; from Saussure. Fig. 4. Nest of *Polistes annularis*; from Saussure. Fig. 5. Three primitive cells of Polistes; 5*a*, top view of the same, one being eggless. The sides adjoining are angular. Figs. 6 and 6*a*, a cell farther advanced, consisting of four cells, each containing an egg, and with the edges of the cells built up higher and more decidedly six-sided; original. Fig. 7. Cells of *Icaria guttatipennis*, showing that each cell is built up independently in regular hexagons. Fig. 8. Ground plan of a similar nest. Fig. 9. Ground plan of cells of *Tatua morio*; from Smith. Fig. 10. Nest of *Mischocyttarus labiatus*; from Saussure. Fig. 11. Nest of *Apoïca pallida*; from Saussure. Fig. 12. Nest of *Odynerus*; original. Fig. 13. Nest of *Odynerus albophaleratus*; original. Fig. 14. Mud cell of *Pelopæus flavipes*; original. Fig. 15. A row of spherical cells of *Eumenes fraterna*, with the female; original, from Harris.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as a cherry. It is attached by a short stout pedicel to bushes, and the cavity is filled with the larvæ of small moths.

Raphiglossa odyneroides, from Epirus, described by S. S. Saunders, makes elongated cells in galleries in briars, storing them with the larvæ of what he supposed to be weevils. The dark brown dense tough cocoon of a Chrysis was also found in the cells.

In *Masaris*, which connects the *Vesparicæ* with the succeeding family, the wings are not completely folded when at rest; there are but two subcostal cells; the maxillæ are rudimentary; and the antennæ are clavate and eight-jointed. *Masaris vespoides* Cresson, inhabits Colorado Territory.

CRABRONIDÆ Latreille. *Sand-wasps; Wood-wasps.* In the more typical genera the head is remarkably large, cuboidal, while the clypeus is very short, and covered for the most part with a dense silvery or golden pile. The antennæ are geniculate, the long second joint being received, when at rest, in a deep frontal vertical groove; the mandibles are large, and of even width throughout, and the mouth-parts are rather short, especially the lingua, which is often, however, well developed. There is only one subcostal cell, except in the *Philanthinæ*. The thorax is sub-spherical, and the abdomen is either short and stout, or more or less pedicellate. The forefeet are adapted for digging and tunnelling, the forelegs in the females being broad and flat, and in the males, which are supposed to do no work, they are sometimes, as in C.Thyreopus, armed with vexhillate expansions.

The larva is rather short and thick, a little flattened on the under side, but much rounded above; the segments are convex above, the thoracic segments differing from the abdominal segments in not being thickened posteriorly on each ring. They spin either a very slight cocoon, or a thin dense brown oval cylindrical case, generally reddish brown in color. The pupæ have much the same character as the imago, with prominent acute tubercles above the ocelli.

The members of this family afford, so far as we are acquainted with their habits, most interesting examples of the interdependence of structure and the habits of insects. Most of the species are wood-wasps, making their cells in cylindrical holes in rotten wood, or enlarging nail-holes in posts, as is the case with Crabro singularis, according to the observations of Mr. C. A. Shurtleff, thus adapting them to the requirements of their young. Other genera (Rhopalum pedicellatum, Stigmus fraternus, and Crabro stirpicola) avail themselves of those plants whose stem has a pith which they can readily excavate and refit for their habitations. The females provision their nests with caterpillars, aphidæ, spiders, and other insects.

This family is most difficult to classify; it consists rather of groups of genera, some higher and some lower, though as a general rule those genera with pedunculate abdomens are the lowest in the series. In illustration, we regard Stigmus, with its elongated decephalized body, as inferior to Blepharipus, which again is subordinate to the more cephalized Crabro, where the body is shorter, the abdomen sessile, the anterior part of the body more developed headwards, while its nests are constructed more elaborately. The genus Psen, for the same reason, is lower than Cerceris, of which it seems a degraded form.

Some of the most useful characters in separating the genera of this family are to be found in the form of the clypeus, its sculpturing and relative amount of pubescence or hirsuties; in the form and sculpturing of the *propodeum* (Newman), or thoracico-abdominal ring of Newport; while the tip of the abdomen presents excellent generic and also specific characters, depending on its grooved or flattened shape.

The species of this family are mostly found in the north temperate zone, being very abundant in North America and in Europe. The Pemphredoninæ occur far north in abundance, while Cerceris occurs farthest towards the tropics.

The subfamily *Philanthinæ* includes the three genera, *Philanthus*, *Eucerceris*, and *Cerceris*. In Philanthus (Fig. 84, wing), the head is short, transversely suboval, the clypeus longer than broad, with the first joint of the abdomen nearly as broad when seen from above as the succeeding one. Our more common form southward is *Philanthus vertilabris* Say (Fig. 85). In Europe *P. apivorus* provisions its nest with honey-bees.

Cresson remarks that *Eucerceris* (Fig. 86, fore wing of male; *a*, female) differs from Cerceris in the venation, which differs greatly in the two sexes. *E. zonatus* Say occurs in the west.

Fig. 84.

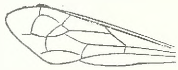


Fig. 86.

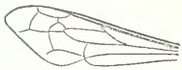


Fig. 86 *a*.

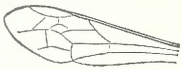


Fig. 87.

The species of *Cerceris* (Fig. 87, wing) have transversely oblong heads, the front of the head is flattened and destitute of hairs, and the rings of the abdomen are contracted, the middle part being unusually convex and coarsely punctured, while the basal ring is nearly one-half narrower than the succeeding ones. *Cerceris deserta* Say is our most common form. In Europe some species are known to store their nests with bees, and the larvæ of *Curculionidæ* and *Buprestidæ*. Dufour unearthed in a single field thirty nests of *C. bupresticida* which were filled with ten species of Buprestis, comprising four hundred individuals, and none of any other genus. *Cerceris tuberculata* provisions its nest with Leucosomus ophthalmicus; and *C. tricincta* with Clythra.

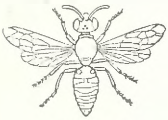


Fig. 85.

In the subfamily *Crabroninæ*, there is a great disparity in the sexes, the form of the females being the most persistent. In the male the head is smaller, narrow behind, with shorter mandibles, and a narrower clypeus; the body is also much slenderer, especially the abdomen, and the legs are simple in Crabro, but in Thyreopus variously modified by expansions of the joints, especially the tibia. The species of *Crabro* (Fig. 88) are readily distinguished by the large cubical head, and the sharp mucronate abdominal tip of the female. The more typical form of this very extensive genus is *Crabro sex-maculatus* Say, so-called from the six yellow spots on the subpedunculate abdomen. According to Dr. T. W. Harris (MS. notes), this wasp was seen by Rev. Mr. Leonard, of Dublin, N. H., burrowing in decayed wood, June 10th.

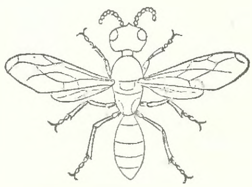


Fig. 88.

Crabro singularis Smith, was discovered by Mr. C. A. Shurtleff boring in a post.

In *Thyreopus*, the body is slender, and the forelegs are curiously dilated in the males, often forming a broad expansion, and so dotted as to present a sieve-like appearance, while the head is much shorter, being more transverse. *T. latipes* Smith is known by the broad, long, acute, mucronate, shield-like expansion of the fore tibia, which is striped with black at the base.

The species of *Rhopalum* are usually blackish, without the gay colors prevalent in the genera before mentioned; the legs are simple, and the abdomen is long and slender, with a long peduncle. The body of the larva is short and thick, tapering rapidly towards each extremity; the segments are convex, those of the thorax especially being smooth, broad, and regularly convex, while the abdominal rings are provided with prominent tubercles. The tip of the body is quite extensible, and when protruded is subacute, terminating in a small knob-like body, formed by the last ring. The larvæ of this genus differ from those of the *Vespariæ* and *Apiariæ* known to us by having a few hairs scattered over the body.

In the pupa the antennæ, in their natural position, do not quite reach to the second pair of trochanters, and reach only to the tip of the maxillary palpi. The tip of the abdomen is very acute and elongated unusually far beyond the ovipositor. On the head, between the ocelli and antennæ, are two very prominent, acute tubercles, and the abdominal segments are dentate on the hind edge. Thus both the larva and pupa would seem, by their anatomy, to be unusually active in their loose, illy-constructed cells, which do not confine their food so closely as in the other wasps, as the insects on which they probably feed have a greater range in their rather roomy cells. April 18th we opened several stems grown in the open air, and found both larvæ and pupæ; the latter in different stages of development. The cells were placed in the closely packed dust made by the larva of an Ægeria, or directly bored in the pith of the plants. There were six such cells, each with its inhabitant, within a space an inch in length, some laying crosswise, others along the middle. The larvæ spin but a very slight cocoon, not at all comparable with that of Crabro: the walls of the cell being simply lined with silken threads. Under other circumstances, *i. e.* where the cells are more exposed, it is not unlikely that a more elaborate cocoon may be spun.

Mr. James Angus has bred numerous specimens of *Rhopalum pedicellatum* Pack., from stems of the Rose, Corcorus, Japonica, and Spiræa, grown in hot-houses at West Farms, N. Y. The larva is a quarter of an inch long.

The following genera belong to the subfamily *Pemphredoninæ:*

The genus *Stigmus*, as its name indicates, may at once be known by the very large pterostigma, as well as the unusually small size of the species. The body of the larva is moderately long and slender, cylindrical, tapering slowly towards both extremities. The rings are short, very convex, subacutely so. and the larva is of a beautiful roseate color. *Stigmus fraternus* Say burrows in the stems of the Syringa, of which specimens have been received from Mr. Angus with the larvæ and pupæ.

In *Cemonus* the front narrows rapidly towards the insertion of the mandibles, and there is a short triangular enclosure on the propodeum, while the abdomen is shorter and thicker than in *Pemphredon*, a closely allied genus; the pedicel is also longer. The larvæ of *Cemonus inornatus* Harris live in irregular burrows in the elder, like those of Rhopalum from which they have been reared by Mr. Angus. They are known by the broad flattened head and body, serrate side and tergum of the body, and large, conspicuously bidentate mandibles, as well as by the peculiarly flattened abdominal tip.

In *Passalœcus* the labrum is very prominent, while the mandibles are very large, widening towards the tip, and in the common *P. mandibularis* Cresson they are white, and thus very conspicuous. This species burrows in company with the other wood-wasps mentioned above in the stems of the elder and syringa. The cells are lined with silk. The wasps appear early in June. Their nests are tenanted by Chalcids. The female stores her cells with Aphides, as we have found them abundantly in stems of plants received from Mr. Angus.

The genus *Psen* seems to be a degraded Cerceris, but the abdomen is pedicelled, and differs from *Mimesa*, a still more slender-bodied genus, in having the tip of the abdomen more or less grooved, while in Mimesa it is flat and not grooved at all.

Psen leucopus Say has a dense silvery pile on the front of the head, with black antennæ, and the pedicel is rather short.

NYSSONIDÆ Leach. In this family the head is transversely longer and less cubical than in the preceding group; the vertex is higher and more convex, while the front is narrow, the clypeus long and narrow, the eyes long and narrow, and the antennæ are more clavate than in the *Crabronidæ*, and the propodeum is sometimes armed with acute spines, while the enclosed space is smoothly polished or striated. The wings are long and narrow, and the abdomen is sessile in the typical genera, where it is obconic, but clavate when pedicellate.

In *Trypoxylon* the body is long, with a pedicellate clavate abdomen. In Europe "Mr. Johnson has detected it frequenting the holes of a post pre-occupied by a species of Odynerus, and into which it conveyed a small round ball, or pellet, containing about fifty individuals of a species of Aphis; this the Odynerus, upon her return, invariably turned out, flying out with it, held by her legs, to the distance of about a foot from the aperture of her cell, where she hovered a moment, and then let it fall; and this was constantly the case till the Trypoxylon had sufficient time to mortar up the orifice of the hole, and the Odynerus was then entirely excluded; for although she would return to the spot repeatedly, she never endeavored to force the entrance, but flew off to seek another hole elsewhere."

T. politum Say has purplish wings, and no enclosure on the propodeum.

T. frigidum Smith lives in the stems of Syringa, from which it has been reared by Mr. Angus. The thin, delicate cocoon is long and slender, enlarging slightly towards the anterior end.

The genus *Mellinus* (belonging to the third subfamily, *Mellininæ*,) is known by its broad front, and slender antennæ, and its pedunculate abdomen, while in *Alyson*, a slender-bodied genus, it is sessile. *Mellinus bimaculatus* Say has a black head, with pale tipped antennæ, and two ovate yellow spots on the abdomen. *Alyson oppositus* is black, with two yellow spots on the abdomen, which has the basal ring yellowish red in the female.

The fourth subfamily is the *Nyssoninæ*, so named from Nysson, a typical genus.

The genus *Gorytes* is truly a mimetic form, closely simulating the genus Odynerus, one of the *Vesparicæ*. The front of the head is narrow, while the clypeus is larger than usual. The species are numerous, occurring late in the summer on the flowers of Spiræa. *Gorites flavicornis* Harris is polished russet brown, with narrow yellow rings on the abdomen, the propodeum is smooth and polished, and the basal ring of the abdomen is black. A species has been observed in Europe protruding her sting into the frothy secretion of Tettigoniæ living on grass, and carrying off the insect to provision its nest with.

Oxybelus is a short, stout, black genus, with whitish abdominal spots, and stout spines on the thorax, while the sessile abdomen is distinctly conical. "Its prey consists of Diptera, which it has a peculiar mode of carrying by the hind legs the while it either opens the aperture of its burrow or else forms a new one with its anterior pair. Its flight is low, and in skips; it is very active." (Westwood.)

Oxybelus emarginatus Say has two oval membranous appendages to the metathorax, and is a common black species found abundantly on the flowers of the Virginia Creeper.

In *Nysson* the body is a little longer, narrow compared with that of Oxybelus, while the terminal joint of the antennæ is thickened, flattened, and excavated beneath. *Nysson lateralis* Say is dull black, with six light spots on the abdomen.

The species of *Stizus* are of large size and easily recognized by their hirsute body, stout legs, triangular silvery clypeus, and the high transverse vertex of the head. The propodeum has a faintly marked triangular enclosure. The species are very rapacious, paralyzing grasshoppers and other large insects with their formidable sting, and carrying them off to provision their nests. Professor S. Tenney has sent us a specimen of the Dog-day Cicada (C. canicularis) which *Stizus speciosus* had thus stung. Mr. Atkinson has observed the same fact, and has found the deep burrows of this species, the hole being three-fourths of an inch in diameter. He has observed it feeding on sap running from a tree.

The species of *Larra* are smaller, and differ from those of Stizus in the long, narrow, very prominent labrum, the shorter clypeus, broader front and longer abdomen, the tip of which is without the broad subtriangular area which is present in Stizus and the other genera of this family. *Larra unicincta* Say is blackish, with a single reddish band on the second abdominal ring.

Bembecidæ Latreille. We have but two genera, *Bembex* and *Monedula*, which have large heads and flattened bodies, bearing a strong resemblance to Syrphus flies from their similar coloration. The labrum is very large and long, triangular, like a beak. The species are very active, flying rapidly about flowers with a loud hum. "The female Bembex burrows in sand to a considerable depth, burying various species of Diptera (Syrphidæ, Muscidæ, etc.), and depositing her eggs at the same time in company with them, upon which the larvæ, when hatched, subsist. When a sufficient store has been collected, the parent closes the mouth of the cell with earth." "An anonymous correspondent in the Entomological Magazine, states that *B. rostrata* constructs its nests in the soft light sea-sands in the Ionian Islands, and appears to catch its prey (consisting of such flies as frequent the sand; amongst others, a bottle-green fly) whilst on the wing. He describes the mode in which the female, with astonishing swiftness, scratches its hole with its forelegs like a dog. *Bembex tarsata*, according to Latreille, provisions its nests with *Bombylii*." (Westwood.) Dufour states that two Diptera, Panopea carnea and Toxophora fasciata, the latter allied to Systrophus, are parasites on Bembex. Mr. F. G. Sanborn has noticed the exceedingly swift flight of our common *Bembex fasciata* Fabr. on sandy beaches where it is found most abundantly.

Monedula differs from Bembex in its slenderer body, more clavate antennæ, and its shorter, very obtuse labrum. The body is smoother, and most generally more highly colored and more gaily spotted than in Bembex.

Monedula Carolina Fabr. and *M. 4-fasciata* Say are common southwards of New England.

Larridæ Leach. Mr. F. Smith defines this family as having "mandibles notched exteriorly near the base; the labrum concealed, with a single spine at the apex of the intermediate tibiæ; the abdomen is ovoid-conical."

The genus *Astata* is a large hairy form, with long antennæ and palpi and an elongated prothorax. Its spiny legs show its near relationship to the *Sphegidæ*. *Astata unicolor* Say represents the genus in this country.

Tachytes is also of larger size than the following genus. It is covered with long dense golden short hairs, with a trapezoidal front. *Tachytes aurulentus* Fabr. is rare; it frequents the flowers of the Asclepias, as we have found pollen masses attached to the spines of its legs. We figure (89) a tarsus of a wasp belonging probably to this genus, received from Mr. V. T. Chambers, showing the pollen masses of Asclepias attached to the spines.


Fig. 89.

The genus *Larrada* "contains those species which have the marginal cell truncated at the apex and appendiculated, and three submarginal cells, the first as long as the two following; .... the metathorax [propodeum] truncated posteriorly, elongate, the sides being generally parallel; the mandibles are large and arcuate, with a tooth on their exterior towards the base; abdomen ovate-conical, acuminate at the apex." *Larrada argentata* Beauv. is covered with silvery pile. It is a slender form, with short, nearly unarmed legs.

A Brazilian species of *Larrada*, according to Mr. H. W. Bates, builds a nest composed apparently of the scrapings of the woolly texture of plants; it is attached to a leaf, having a close resemblance to a piece of German tinder, or a piece of sponge. The cocoons were dark brown, and of a brittle consistency. The reporter, Mr. F. Smith, adds: "I am not aware of any similar habit of building an external nest having been previously recorded; our British species of the closely allied genus Tachytes, are burrowers in the ground, particularly in sandy situations; their anterior tarsi are strongly ciliated, the claws bifid and admirably adapted for burrowing. On examining the insect which constructed the nest now exhibited, I find the legs differently armed; the anterior pair are not ciliated, and the claws are simple and slender, clearly indicative of a peculiar habit differing from its congeners, and how admirably is this illustrated in the nest before us?"

SPHEGIDÆ Latreille. Smith defines this family as having "the posterior margin of the prothorax not prolonged backwards to the insertion of the wings, and anteriorly produced into a neck, with the abdomen petiolated." The very fossorial legs are long and spiny, the posterior pair being of unusual length. The mandibles are large, curved, narrow, and acute, the base not being toothed externally, and the antennæ are long and filiform. The species are often gaily colored, being ornamented with black and red, brown and red, or are entirely black, or blue. They love the sunshine, are very active, restless in their movements, and have a powerful sting.

The sting of these and other wasps which store up insects for their young, penetrates the nervous centres and paralyzes the victim without depriving it of life, so that it lives many days. A store of living food is thus laid up for the young wasp. After being stung the caterpillars will transform into chrysalids, though too weak to change to moths. Mr. Gueinzius, who resides in South Africa, observes that "large spiders and caterpillars became immediately motionless on being stung, and I cannot help thinking that the poisonous acid of Hymenoptera has an antiseptic and preserving property; for caterpillars and locusts retain their colors weeks after being stung, and this, too, in a moist situation under a burning sun."

These insects either make their nests in the sand, or, like the succeeding family, are "mud-daubers," building their cells of mud and plastering them on walls, etc.

The tropical genus *Ampulex* is more closely allied to the preceding family than the other genera. The species are brassy green. Dr. G. A. Perkins has described in the American Naturalist, vol. 1, p. 293, the habits of a wasp, probably the *Ampulex Sibirica* Fabr., which inhabits Sierra Leone, and oviposits in the body of the cockroach. The dead bodies of the cockroaches are often found with the empty cocoon of the wasp occupying the cavity of the abdomen.

A species of this genus, abundant at Zanzibar at certain seasons, was frequently observed by Mr. C. Cooke to attack the cockroach. The cockroach, as if cowed at its presence, immediately yields without a struggle. The Ampulex stings and paralyses its victim. and then flies away with it.

Chlorion is closely allied, containing blue and metallic green species, often with golden yellow wings. *Chlorion cyaneum* Dahlb., a blue species, is found in the Southern States.

The genus *Prionony.x* "differs from the genus Sphex in having the claws quadridentate beneath at their base; the neuration of the wings and the form of the abdomen are the same as in *Harpactopus*," which is found only in the tropics and Australia. *Prionony.x Thomæ* is found from South Carolina to Brazil, including the West Indies.

The genus *Sphex* is quite an extensive one. The head is as wide as the thorax; the antennæ are filiform, mandibles large and acute, bidentate within, the teeth notched at their base, forming a rudimentary tooth, the apical tooth being acute. The thorax is elongate-ovate, truncated behind, with a transverse collar (prothorax). The fore wings have one marginal and three submarginal cells; the marginal cell elongate, rounded at its apex; the first submarginal cell as long as the two following. The abdomen is pedunculated, conically ovate, and the anterior tarsi are ciliated in the females.

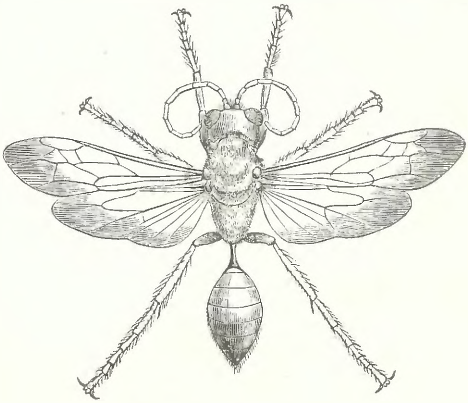


Fig. 90.

Sphex ichneumonea Linn. (Figure 90) is a large rust-red species, with a dense golden pubescence. It is common from Massachusetts southwards. In the last week of July, and during August and early in September, we noticed nearly a dozen of these wasps busily engaged in digging their holes in a gravelly walk. In previous seasons they were more numerous, burrowing into grassy banks near the walk. The holes were four to six inches deep. In beginning its hole the wasp dragged away with its teeth a stone one half as large as itself to a distance of eight inches from the hole, while it pushed away others with its head. In beginning its burrow it used its large and powerful jaws almost entirely, digging to the depth of an inch in five minutes, completing its hole in about half an hour. After having inserted its head into the hole, where it loosened the earth with its jaws and threw it out of the hole with its jaws and fore legs, it would retreat backwards and push the dirt still farther back from the mouth of the cell with its hind legs. In cases where the farther progress of the work was stopped by a stone too large for the wasp to remove or dig around, it would abandon it and begin a new hole. Just as soon as it reached the required depth the wasp flew a few feet to the adjoining bank and falling upon an Orchelimum vulgare or O. gracile, stung and paralyzed it instantly, bore it to its nest, and was out of sight for a moment, and while in the bottom of its hole must have deposited its egg in its victim. Reappearing it began to draw the sand back into the hole, scratching it in quite briskly by means of its spiny fore tarsi, while standing on its two hind pairs of legs. It thus threw in half an inch of dirt upon the grasshopper and then flew off. In this way one Sphex will make two or three such holes in an afternoon. The walk was hard and composed of a coarse sea-gravel, and the rapidity with which the wasp worked her way in with tooth and nail was marvellous.

Sphex tibialis St. Fargeau is a black, stout, thick insect. Mr. J. Angus has reared this species, sending me the larvæ in a cavity previously tunnelled by Xylocopa Virginica in a pine board. The hole was six inches long, and the oval cylindrical cocoons were packed loosely, either side by side, where there was room, or one a little in advance of the other. The interstices between them were filled with bits of rope, which had perhaps been bitten up into pieces by the wasp itself; while the end of the cell was filled for a distance of two inches with a coarse sedge arranged in layers, as if rammed in like gun-wadding. The cocoons are eighty to ninety hundredths of an inch long, oval lanceolate, somewhat like those of Pompilus. They consist of two layers, the outer very thin, the inner tough, parchment-like. The larvæ hybernate and turn to pupæ in the spring, appearing in the summer and also in the autumn.

The larva is cylindrical, with the pleural ridge prominent, and with no traces of feet; the head, which is small and not prominent, and rather narrow compared with that of Pelopæus, is bent inwards on the breast so that the mouth reaches to the sternum of the fourth abdominal ring. The posterior half of each ring is much thickened, giving a crenulated outline to the tergum. The abdominal tip is obtuse.

Sphex Lanierii Guerin, according to Smith (Proceedings of the Entomological Society of London, Feb. 7, 1859), constructs its nest of a cottony substance, filling a tunnel formed by a large curved leaf. The species of the genus are supposed to burrow in the ground, and the two cases above cited show an interesting divergence from this habit. Mr. Smith adds, that in "the Sphex which constructs the nest in the rolled leaf, the anterior tarsi are found to be very slightly ciliated, and the tibiæ almost destitute of spines, thus affording another instance proving that difference of structure is indicative of difference of habit."

The genus *Pelopæus* is of a slighter form than in Sphex, the body being longer and slenderer; the clypeus is as broad as long, triangular above, in front convex, or produced and ending in two teeth. The outer costal cell is lanceolate oval, the second subcostal cell subtrapezoidal, being widest above; it is also somewhat longer than broad. The first median cell is very long and narrow, much more so than usual. The pedicel of the abdomen is long, the first joint in the male being often as long as the remainder of the abdomen.

The larva of *P. cæruleus* Linn. is much like that of Sphex, having a cylindrical body with the rings thickened posteriorly. It differs from that of Pompilus in its longer and narrower head, the short broadly trapezoidal clypeus, and the distinctly marked exserted labrum. The mandibles are long and tridentate.

The pupa (of P. flavipes) differs from that of the *Vesparice* in having the head more raised from the breast; the palpi are not partially concealed, as they may be easily seen for their whole length. The long curved mandibles cover the base of the maxillæ and lingua, and the antennæ reach to the posterior coxæ. The maxillæ are slender, not reaching to the tip of the labium.

The female usually provisions her cells (Plate 5, Fig. 14) with spiders. The cells are constructed of layers of mud of unequal length, and formed of little pellets placed in two rows, and diverging from the middle. They are a little over an inch long, and from a half to three-quarters of an inch wide, and are somewhat three-sided, the inner side next the object, either stonewalls or rafters, to which it is attached, being flat. As the earthen cells sufficiently protect the delicate larvæ within, the cocoons are very thin, and brown in color.

The cells of *Pelopæus flavipes* from Brownville, Texas, collected by an United States officer and presented to the Boston Society of Natural History, contained both spiders and numerous pupæ of a fly, *Sarcophaga nudipennis* Loew (MS) which is somewhat allied to Tachina. These last hatched out in midsummer a few days before the specimens of Pelopæus. It is most probable that they were parasitic on the latter. These specimens of P. flavipes were more highly ornamented with yellow than in those found northwards in the Atlantic States, the metathorax being crossed by a broad yellow band.

The genus *Ammophila* is a long slender form, with a petiolate abdomen, the tip of which is often red. The petiole of the abdomen is two-jointed, and very long and slender, being longer than the fusiform part. In the males the petiole is in some species much shorter. The wings are small, with the apex more obtuse than usual; the second subcostal cell is pentagonal, and the third is broadly triangular.

Westwood states that "the species inhabit sandy districts, in which *A. sabulosa* forms its burrow, using its jaws in burrowing; and when they are loaded, it ascends backwards to the mouth, turns quickly around, flies to about a foot's distance, gives a sudden turn, throwing the sand in a complete shower to about six inches' distance, and again alights at the mouth of its burrow."

"Latreille states that this species provisions its cells with caterpillars, but Mr. Shuckard states that he has observed the female dragging a very large inflated spider up the nearly perpendicular side of a sand-bank, at least twenty feet high, and that whilst burrowing it makes a loud whirring buzz; and, in the Transactions of the Entomological Society of London, he states that he has detected both *A. sabulosa* and *A. hirsuta* dragging along large spiders. Mr. Curtis observed it bury the caterpillars of a Noctua and Geometra. St. Fargeau, however, states that *A. sabulosa* collects caterpillars of large size, especially those of Noctuæ, with a surprising perseverance, whereas *A. arenaria*, forming a distinct section in the genus, collects spiders." (Westwood.)

Ammophila cementaria Smith, and *A. urnaria* Klug, are the more common species in this country; they are red and white, while *A. luctuosa* Smith is a black, shorter, stouter, more hirsute species. They may all be seen flying about hot sandy places, and alighting near wells and standing water to drink.

Pompilidæ Leach. In this family the body is oblong, the sides often compressed, and the head shorter, when seen from above, being more transversely ovate than in the preceding family. The antennæ are long, not geniculate, and in the males are stouter and with shorter joints than in the females. The eyes are narrow oval, and the maxillary palpi are six, and the labial palpi four-jointed. The prothorax is extended on the sides back to the base of the wings, which latter are large and broad, the fore pair having three subcostal cells. The legs are very long and slender, with thick slender spines. The *Pompilidæ*, of which about seven hundred species are known, have a wide geographical range, from the temperate zone to the tropics. Like the *Sphegidæ*, they oviposit in the body of other insects, storing their nests, usually built in the sand, with spiders and caterpillars.

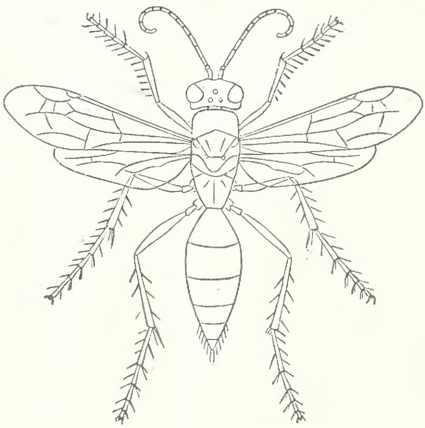


Fig. 91.

The head of *Pompilus* (Fig. 91) is a little longer, seen from above, than in the other genera; the front of the head is about a third longer than broad. The antennæ are long and filiform and sometimes crenulate, as in Figure 91 *a*, in the males; the mandibles are stout, broad, sabre-shaped, being much curved, with low flattened teeth, and the maxillary palpi are longer than the labial palpi. The wings are rather broad, with the three subcostal cells lying in a straight row. The abdomen is slightly compressed, and equals in length the remainder of the body. The sting is very large and formidable, and excessively painful, benumbing the parts it enters. They are exceedingly active, running and flying over sandy places like winged spiders.

Fig. 91 *a*.

There are about five hundred species of this genus described. They are usually shining black or deep bluish black, with

Fig. 92.

smoky or reddish wings, and sometimes a reddish abdominal band. This genus is interesting, as affording in its form a mean between the globular thorax and short body of the *Apiariæ* and the elongated body of the *Ichneumonidæ*.

The *Pompilus formosus* Say (Fig. 92), called in Texas the Tarantula-killer, attacks that immense spider the *Mygale Hentzii*, and, according to Dr. G. Linceeum (American Naturalist, May, 1867), paralyzes it with its formidable sting, and inserting an egg in its body, places it in its nest, dug to the depth of five inches. There is but a single brood, produced in June, which is killed off by the frosts of November. This species feeds in summer "upon the honey and pollen of the flowers of the Elder, and of *Vitis ampelopsis*, the Virginia Creeper; but its favorite nourishment is taken from the blossoms of *Asclepias quadrifolium*." (Lincecum.) *P. cylindricus* Cresson (Fig. 93, wing) is one of our smallest species, being from three to five lines long. It occurs in the South and West. *P. arctus* Cresson (Fig. 94, wing) inhabits Colorado Territory. *P. Mariæ* Cresson (Fig. 95, ♀ enlarged) is a beautiful and rare species found in Pennsylvania. The genus *Priocnemis* is characterized by the two hind pair of tibiæ being serrated (♀, Fig. 96, *a*, wing; *b*, posterior leg; *c*, anterior leg), and by the want of spines on the anterior legs. *P. unifasciatus* Say is a wide-spread species and readily recognized by the deep black color of the body, the yellow antennæ and the large yellow spot at the tip of each anterior wing.


Fig. 93.

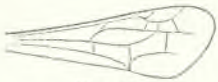


Fig. 94.

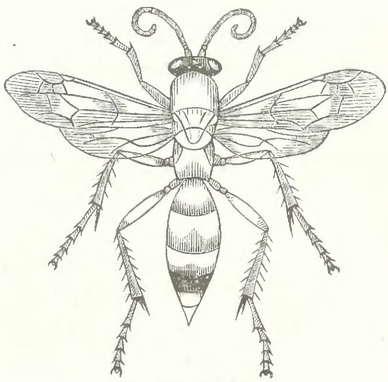


Fig. 95.

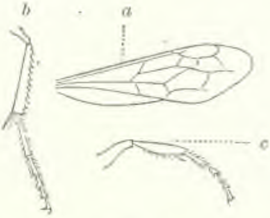


Fig. 96.

The genus *Agenia* (Fig. 97, *a*, wing; *b*, posterior leg) differs in having smooth legs. *A. brevis* Cresson (Fig. 98, wing) is a little species found in Georgia. *A. congruus* Cresson (Fig. 99, wing) was captured in West Virginia; and *A. acceptus* Cresson (Fig. 100, wing) in Georgia. The genus *Notocyphus* (Fig. 101, ♀, wing) is found in Brazil and Mexico. *Planiceps* (Fig. 102, wing) contains a few species, of which *P. niger* Cresson, an entirely black species, is found in Connecticut. *Aporus* (Fig. 103, wing) contains a single American species, *A. fasciatus* Smith, taken in North Carolina.

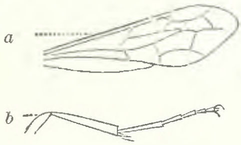


Fig. 97.

From Mr. F. G. Sanborn we have received the larva and cocoon of *Pompilus funereus* St. Farg., a small black species, which builds its nest in fields. The larva is short and broad, with the lateral region rather prominent, and the tip of the abdomen rather acute. It differs from Pelopæus in its stouter, rather flattened body, and thickened segments, though as our specimen is preserved in alcohol these characters may have become exaggerated. It more nearly resembles Pelopæus in its transverse clypeus, thin bilobate labrum, and the stout mandibles, which are, however, much stouter than in Pelopæus, while the whole head is shorter, broader, and rounder. It is probable that this peculiar form of the head (which as in Sphex is bent beneath the breast), together with the broad transverse clypeus, and broad, short, bilobate, thin, transparent labrum, and especially the unidentate short broad mandibles are family characters, separating the larvæ of this group from those of the *Sphegidæ*. The cocoon is ovate, long, and slender, much smaller at one end than the other, not being so regularly fusiform as in Sphex.

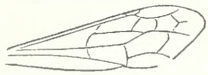


Fig. 99.

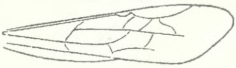


Fig. 101.

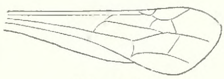


Fig. 102.

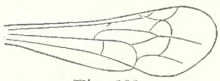


Fig. 103.

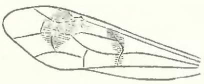


Fig. 98.

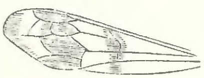


Fig. 100.

Ceropales differs from the foregoing genera in its broad head, its much shorter abdomen; and also in the eyes being a little excavated, in the depressed labium, the narrow front, which dilates above and below the middle, and in the greatly elongated hind legs, generally banded with red or whitish. *Ceropales bipunctata* Say is generally distributed throughout the United States. It is easily recognized by the black body and legs, and red posterior femora, and is six lines long. *C. Robinsonii* Cresson (Fig. 104, ♂) is an elegant species found in West Virginia. An allied genus is *Mygnimia* (Fig. 105, wing) containing *M. Mexicana* Cresson and *M. ustulata* Dahlb., two Mexican species.

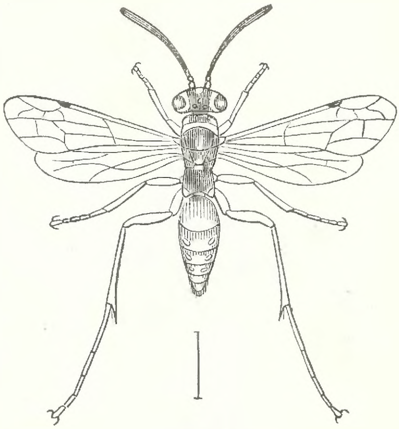


Fig. 104.

In the genus *Pepsis* (Fig. 106, wing) the maxillary and labial palpi are of equal length. The species are large, some of them being among the largest of Hymenoptera, and are generally indigo-blue in color. *Pepsis heros* Dahlbom is found in Cuba; it is two inches long. *P. cyanea* Linn., which is blackish-blue, with blue abdomen and wings, the latter reddish at the apex, has been described by Beauvois from the United States, while *P. elegans* St. Farg. also occurs in the Southern States.

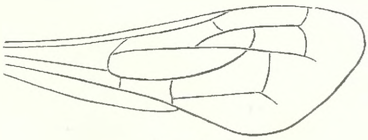


Fig. 105.

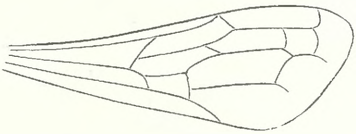


Fig. 106.

P. formosa Say affords another example of a species common to both sides of the Rocky Mountains, as it has been found both in Texas and California. It is black, with bluish or greenish reflections, with bright fiery red wings, and is thirteen to eighteen lines long.

Scoliadæ Leach. This family forms a group very easily distinguished from the *Bembecidæ* or *Chrysididæ*, as well as the *Pompilidæ*, by the broad front, the small indented eyes, and the great sexual differences in the antennæ, those of the male being long and slowly thickened towards the tip, while in the female they are short, thick, and elbowed on the second joint. The clypeus is large, irregularly quadrilateral, becoming shorter in the lower genera, and the labrum is small, scarcely exserted, while the mandibles are, in the female especially, large and broad. The prothorax is very square in front. In the fore-wings are three subcostal spaces. The abdomen in the typical genus (Scolia) is broad and flat, longer than the rest of the body. The abdomen of Mutilla approaches that of the *Chrysididæ* in having the second ring much enlarged over the others. The males usually have the anal stylets very prominent, while the sting of the female is very powerful. The body and legs are generally very hirsute, and the first tarsal joint is as long as the tibiæ.

The genus *Sapyga* is easily recognized by its smooth slender body, being ornamented with yellow, with transverse bands on the abdomen. The head is long, very convex in front, and the antennæ are clavate; the prothorax is very broad, giving an oblong appearance to the thorax. The legs are slender and smooth. It is said to be parasitic, laying its eggs in the cells of Osmia. *Sapyga Martinii* of Smith is found northward.

The species of *Scolia* are often of great size, being black and very hirsute, with the labium composed of three linear divisions; the abdomen alone being banded or spotted with yellow on the sides. They are found in the hottest places about strongly scented flowers. In Europe, *Scolia bicincta* "makes its burrows in sand-banks, to the depth of sixteen inches, with a very wide mouth;" and it is probable that the nest is stored with grasshoppers.

Scolia quadrimaculata Fabr. is found in the Middle and Southern States. The larva of *Scolia flavifrons* was found by Passerini to live in the body of the lamellicorn beetle, Oryctes nasicornis. In Madagascar, *Scolia oryctophaga* lives on Oryctes simia, according to Coquerel.

Professor Sumichrast states that at Tehuacan (Department of Puebla) the *Scolia Azteca* Sauss. is very common; and is particularly abundant in the leather tanneries, which leads him to think that the females of this species also deposit their eggs under the epidermis of the larva which abounds in the tan.

Tiphia is black throughout and rather hirsute. The antennæ are shorter than in Scolia or Myzine; the clypeus is also shorter, while the prothorax is longer. In the fore-wings the outer costal cell is short, broad, angulated, oval; and of the two subcostal cells, the outer one is broad and triangular, twice as long as broad, while the first median cell is regularly short rhomboidal, much more so than in the other genera.

The females, according to Westwood, "make perpendicular burrows in sandy situations, for the reception of their eggs; but the precise food stored up for the larvæ has not been observed." *Tiphia inornata* Say is a common species with us, and flies low over sandy places early in the season.

The short oval head, the large eyes, short meso-scutum, large meso-scutellum, and the flattened, rather smooth body, characterize the genus *Myzine*. The females are very different from the males, the two sexes being for a long time considered as separate genera. The female, especially, differs in the great length of the square prothorax, which is very broad and convex in front. In the male the eyes are lunate, while in the female they are small, entire, and remote. In its general form the females much resemble Scolia, while the males are long and narrow, with broad yellow bands, especially on the abdomen, and a large exserted sting-like organ. *Myzine sexcincta* Fabr. is seen from New England southwards, flying low over hot sandy places. The genus *Elis* is closely allied. Sumichrast (American Naturalist, vol. 2), surmises that *Elis costalis* St. Farg. lives on certain Scarabæides, which undergo their metamorphosis in the formicary of Œcodoma in Mexico.

MUTILLARIÆ Latreille. This interesting family is characterized by the females alone being wingless, though Morawitz says that wingless males occur in two species; and by the absence, generally, of the three ocelli. In Mutilla and Myrmosa the thorax is still high, compressed, and oblong cuboidal, and except in the closely united tergal pieces the females do not greatly recede from the type of the winged males. The species are very equal in size, are black, or black and red, and either smooth or hirsute.

The antennæ are inserted low down on the front, the clypeus being very short and broadly ovate (especially in Myrmosa), or it is indented, as in Mutilla. The tongue is shorter than usual. The sides of the thorax contract in width, both before and behind. The meso-scutum is squarer than usual, while the meso-scutellum is much narrower and longer, and the propodeum is squarely truncated behind, thus presenting a full convex surface. The abdomen is not much longer than the rest of the body, being shorter than usual. In all these characters this family shows its affinities to the Ants. The wings are very dissimilar in the different genera. In Myrmosa the neuration closely approaches that of Sapyga, while in the larger, more acute primaries of Mutilla, and especially in the short outer costal cell, and short open pterostigma, the latter genus differs from the others.

The male of *Scleroderma* closely mimics the *Proctotrypidæ*, the veins of the wings being absent, while the form of the head and abdomen also reminds us of some genera in that family. The wingless female is very different, having more of the form of Mutilla, with a large oblong head and long acutely conical abdomen. The species are minute and rarely met with. *S. contracta* Westwood is found in "Carolina."

In the female *Methoca* the eyes are very long, and the segments of the abdomen are widely separated, much as in the ants. *Methoca Canadensis* Smith is shining black, and slightly villose.

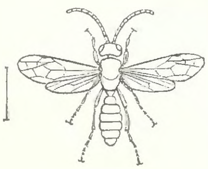


Fig. 107.

The species of *Myrmosa* may be known by the very short clypeus, the broad vertex, and the rings of the abdomen of the male being unusually contracted. The abdomen of the female is cylindrical, about twice as long as broad, and thickest on the second ring. The rings are densely hirsute on the hinder edge. *Myrmosa unicolor* Say (Figs. 107, male; 108, female) is widely distributed. We have taken this species in Maine, while sexually united, early in June. The wingless female is like an ant, and is pale reddish on the thorax and basal ring of the abdomen, and the antennæ and feet are concolorous, while the head and remaining abdominal rings are much darker. It is .20 inch long. The male is .28 inch long and entirely black.


Fig. 108.

The genus *Mutilla* is a very extensive one, and enjoys a wide geographical range. It is throughout stouter than *Myrmosa*, the head is more cubical, and the thorax and abdomen is shorter, the tip of the latter being somewhat truncated.

The wingless female closely resembles, both in its form and motions, a worker ant. The body is coarsely granulated and either naked or densely hirsute, and of a scarlet, black, or pale red, or brown-black color. The females are found running in hot sandy places, and hide themselves quickly when disturbed, while the males frequent flowers. *Mutilla occidentalis* is a large species. It is of a beautiful scarlet color and is armed with a very powerful sting. According to Professor A. E. Verrill this species was found by him, at New Haven, to construct deep holes in a hard beaten path, storing its nest with insects. This species is also said by Kirby to be very active, "taking flies by surprise." (Westwood.) Mr. Verrill noticed that this insect makes a slight creaking noise. The larvæ of *M. Europæa* are said to live parasitically in Humble-bees' nests. *Mutilla ferrugata* Fabr. (Fig. 109) is found frequently in New England.

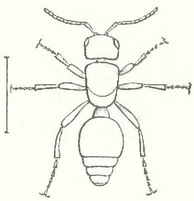


Fig. 109.

FORMICARIÆ Latreille. The family of ants would seem naturally to belong with the truly fossorial Hymenoptera, both from their habits and structure.

Both males and females are winged, but the males are much smaller than the females, while the wingless workers are smaller than the males. In these wingless forms the segments of the thorax become more or less separated, making the body much longer and slenderer, and less compact than in the winged normal sexual forms, the prothorax being more developed than in the males and females. The workers often consist of two forms: one with a large cubical head, or worker major, sometimes called a soldier, and the usual small-headed form, or worker minor.

The head is generally triangular. The eyes are large in the males, smaller in the workers, and in those of some genera (Ponera, Typhlopone, etc.) they are absent; while in the workers the ocelli are often wanting, though present in the winged individuals of both sexes. The antennæ are long, slender and elbowed. The mandibles are stout, and toothed, though in those species that do not themselves labor, but enslave the workers of other species, they are unarmed and slender. The maxillary palpi are from one to six-jointed, and the labial palpi two to four-jointed. The fore-wings usually have but a single complete subcostal (cubital) cell. The sting is often present, showing that in this respect as well as their fossorial habits the ants are truly aculeate Hymenoptera. The larva is short, cylindrical, with the end of the body obtuse. The rings of the body are moderately convex. The head is rather small and bent upon the breast. The larvæ are fed by the workers with food elaborated in their stomachs.

The larvæ of the stingless genera usually spin a delicate silken cocoon, while those of the aculeate genera do not. Both Latreille and Westwood, however, state that sometimes, as in *Formica fusca*, of Europe, the pupæ are naked, and at other times enclosed in a cocoon.

The colonies of the different species vary greatly in size. In the nests of *Formica sanguinea* the number of individuals is very great. The history of a formicarium, or ant's nest is as follows: The workers only (but sometimes the winged ants) hibernate, and are found early in spring, taking care of the eggs and larvæ produced by the autumnal brood of females. In the course of the summer the adult forms are developed, swarming on a hot sultry day. The little yellow ants, abundant in paths and about houses in New England, generally swarm on the afternoon of some hot day in the first week of September, when the air is filled towards sunset with myriads of them. The females, after their marriage flight in the air, may then be seen entering the ground to lay their eggs for new colonies, or, as Westwood states, they are often seized by the workers and retained in the old colonies. Having no more use for their wings they pluck them off, and may be seen running about wingless. According to Gould, an early English observer, the eggs destined to hatch the future females, males and workers, are deposited at three different periods.

The nests of some species of Formica are six feet in diameter and contain many thousand individuals. Ants also build nests of clay or mud, and inhabit hollow trees. They enjoy feeding upon the sweets of flowers and the honey of the Plant-lice, which they domesticate in their nests. Several species of beetles, including some of the *Staphylinidæ*, take up their abode in ants' nests. Ants are useful as scavengers, feeding on decaying animal matter. A good method of obtaining the skeletons of the smaller animals, is to place them on a densely populated ant-hill. The habits of the ants, their economy and slave-making habits, are described in the works of Huber, Latreille, and Kirby and Spence.

Upwards of a thousand species of ants have already been described; those of this country have still to be monographed.

The first group of this extensive family consists of Dorylus and its allies, and Formica and the neighboring genera, all of which are distinguished by having only the first abdominal segment contracted, while in the second group (*Myrmicariæ*), the two basal rings are contracted into knot-like segments.

The genus *Dorylus* was, by Latreille, Klug, and others, included in the *Mutillariæ*. The head is very short, the ocelli are large and globular. The thorax and abdomen are elongated, the last is cylindrical, with a small, round, basal joint. The legs are short, with broad compressed femora and feather-like tarsi. In the wings the outer subcostal cells are wanting. The females are not yet known. Mr. F. Smith says that Dorylus was found by Hon. W. Elliot to live in the manner of ants, under the stone foundation of a house in India. The society was very numerous. The difference in size of the male and worker is very remarkable. The males are of large size and are found in tropical Asia and Africa.

Typhlopone is an allied genus. *T. pallipes* Haldeman is found in Pennsylvania.

To the genus *Anomma* belong the Driver-ants of Western Africa. They march in vast armies, driving everything before them, so formidable are they from their numbers and bite, though they are of small size. They cross streams, bridging them by their interlocked bodies. Only the workers are known. Two species only, *A. Burmeisteri* Shuckard, and *A. arcens* Westwood, are described from near Cape Palmas, West Africa.

The genus *Ponera* is found distributed throughout the tropics. The females and workers are armed with spines; the abdomen is elongated, the segments more or less diminished in size, the first comparatively large and often cubical. The legs are slender. *P. ferruginea* Smith is a Mexican species.

The allied genus *Odontomachus* springs like some leaping spiders. It uses for this purpose its unusually long mandibles, which are bent at right angles. *O. clarus* Roger lives in Texas.

Formica includes the typical species of ants. Over two hundred species of this genus have been already described. The body is unarmed. The abdomen is short, oval or spherical, the scale-like first segment being lenticular in form, with a sharp upper edge. The subcostal cell of the fore-wings end in a point. *Formica sanguinea* Latr. is one of our most abundant species, making hillocks of sand or clay, according to the nature of the ground. From the formicary walks, and underground galleries, radiate in all directions. This species has been observed making forays upon each others colonies. We have found a variety of this species in Labrador, where it is common. It does not throw up hillocks, but tunnels the earth.

This species has been observed in Europe by P. Huber, to go on slave expeditions. They attack a "negro-colony" belonging to a smaller black species, pillaging the nest, and carrying off merely the larvæ and pupæ. The victors educate them in their own nests, and on arriving at maturity the negroes take the entire care of the colony. *Polyergus rufescens* is also a slave-making ant, and "Latreille very justly observes that it is physically impossible for the rufescent ants (*Polyergus rufescens*), on account of the form of their jaws, and the accessory parts of their mouth, either to prepare habitations for their family, to procure food, or to feed them." *Formica sanguinea* sallies forth in immensely long columns to attack the negro ant. Huber states that only five or six of these forays are made within a period of a month, at other seasons they remain at peace. Huber found that the slave-making *Polyergus rufescens* when left to themselves perish from pure laziness. They are waited upon and fed by their slaves, and when they are taken away, their masters perish miserably. Sometimes they are known to labor, and were once observed to carry their slaves to a spot chosen for a nest. The *F. sanguinea* is not so helpless, "they assist their negroes in the construction of their nests, they collect their sweet fluid from the Aphides; and one of their most usual occupations is to lie in wait for a small species of ant on which they feed; and when their nest is menaced by an enemy they show their value for these faithful servants, by carrying them down into the lowest apartments, as to a place of the greatest security." (Kirby.) Pupæ of both of the slave-making species were placed in the same formicary by Huber, where they were reared by the "negroes," and on arriving at maturity "lived together under the same roof in the most perfect amity," as we quote from Kirby. Darwin states that in England, *F. sanguinea* does not enslave other species.

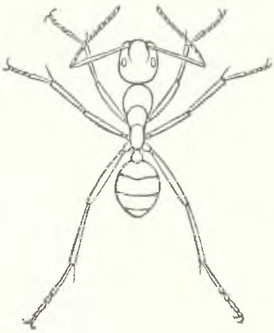


Fig. 110.

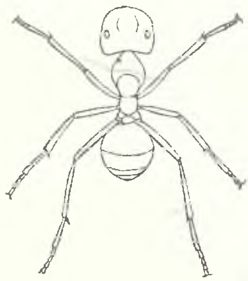


Fig. 111.

In this country Mr. J. A. Allen has described in the Proceedings of the Essex Institute, vol. 5, 1866, a foray of a colony of *F. sanguinea* upon a colony of a black species of Formica, for the purpose of making slaves of them.

Formica Pensylvanica, our largest species, is found in oaks and decaying trees, while *F. herculanea* Latr. burrows in the earth, its hole opening beneath stones and sticks.

Gould, who wrote in 1747, states that there are two sizes of workers of the common European *Formica rufa*, and *flava;* one set of individuals exceeding the other by about one-third. Kirby states that in his specimens "the large workers of *Formica rufa* are nearly three times, and of *F. flava*, twice the size of the small ones." Mr. E. Norton describes *F. fulvacea* (Fig. 110, worker minor), and also *Tapinoma tomentosa* (Fig. 111, worker major; antennæ broken off), from Mexico.

The tropical genus *Polyrhachis* includes, according to Smith, all those species that closely resemble *Formica*, but which have the thorax and node of the peduncle armed with spines or hooks. They construct small semicircular nests, of a kind of net-work, on the leaves of trees and shrubs. Their communities are small, seldom exceeding twenty individuals. Mr. Norton describes *P. arboricola* (Fig. 112, worker major) from Mexico. An allied genus is *Ectatomma* (Fig. 113, worker major of *E. ferruginea* Norton, from Mexico).

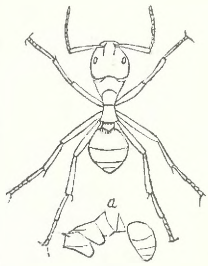


Fig. 112.

Mr. F. Smith has described a new genus, *Œcophylla*, which is allied to Formica. They are green ants, found building in trees in the tropics of the old world. The nest of *Œ. smaragdina* Smith is "formed by drawing together a number of green leaves, which they unite with a fine web. Some nests are a foot in diameter. They swarm, says Mr. Wallace, in hilly forests in New Guinea. Their sting is not very severe. This genus forms a link between Formica and Myrmica; it agrees with the former in having a single node to the peduncle, and with the latter in having the ocelli obsolete in the workers, and in being furnished with a sting."

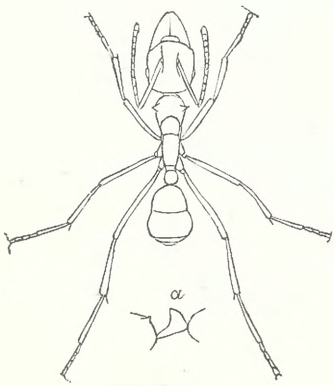


Fig. 113.

The curious Honey-ant of Texas and Mexico, *Myrmecocystus Mexicanus* Westwood, has two kinds of "workers of very distinct forms, one of the usual shape," according to Smith, "and performing the active duties of the formicarium; the other and larger worker is inactive and does not quit the nest, its sole purpose, apparently, being to elaborate a kind of honey, which they are said to discharge into prepared receptacles, which constitutes the food of the entire population of the community. In the honey-secreting workers the abdomen is distended into a large globose bladder-like form. From this honey an agreeable drink is made by the Mexicans."

The second subfamily, *Myrmicariæ*, includes those species in which the two first abdominal segments are contracted and lenticular. In *Myrmica* the females and workers are armed with spines, and the ocelli are absent in the workers. The species are very small, and mostly bright colored. *Myrmica molesta* Say is found in houses all over the world.

G. Lincecum describes the habits of the Agricultural Ant of Texas, *Myrmica molefaciens*. It lives in populous communities. "They build paved cities, construct roads, and sustain a large military force." In a year and a half from the time the colony begins, the ants previously living concealed beneath the surface, appear above and "clear away the grass, herbage, and other litter, to the distance of three or four feet around the entrance to their city, and construct a pavement, ... consisting of a pretty hard crust about half an inch thick," formed of coarse sand and grit. These pavements would be inundated in the rainy season, hence, "at least six months previous to the coming of the rain," they begin to build mounds rising a foot or more from the centre of the pavement. Within these mounds are neatly constructed cells into which the "eggs, young ones, and their stores of grain, are carried in time of rainy seasons." No green herb is allowed to grow on the pavement except a grain-bearing grass, Aristida stricta. This grain, when ripe, is harvested, and the chaff removed, while the clean grain is carefully stored away in dry cells. Lincecum avers that the ants even sow this grain. They also store up the "grain from several other species of grass, as well as seeds from many kinds of herbaceous plants."

Pheidole is distinguished by having workers with enormous heads. *P. notabilis* Smith, from the Island of Bachian, Indian Archipelago, is noted for the enormously enlarged, cubical head of the worker major, which is at least six times the size of the abdomen, while in the worker minor, the head is of the ordinary size. An Indian species, *P. providens* Westwood, according to Col. Sykes, "collects so large a store of grass seeds as to last from January and February, the time of their ripening, till October."

The genus *Atta* is also well-armed, while the workers have a very large, deeply incised and heart-shaped head, without ocelli, and the second abdominal knot-like ring is very transverse. *A. clypeata* Smith is a Mexican species.

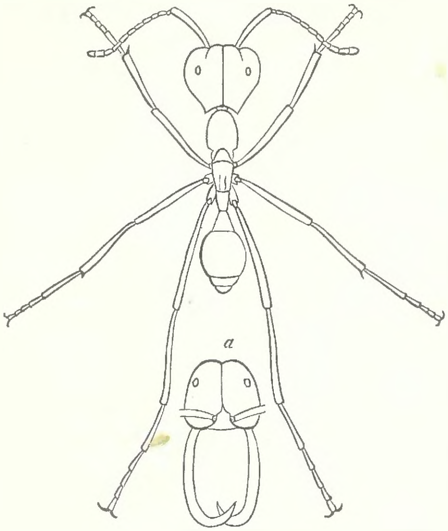


Fig. 114.

In *Eciton* the mandibles nearly equal the length of the insect itself. This genus is the most ferocious of all the ants, entering the nest of species of Formica and tearing them, limb from limb, and then carrying off the remains to their own houses.

Eciton Mexicana Roger (Fig. 114, worker major, *a*, front view of head, showing the immense sickle-like mandibles, and only the two basal joints of the antennæ; Fig. 115, worker minor, with a front view of the head, showing the mandibles of the usual size). This species, with *Eciton Sumichrasti* Norton, (Fig. 116, worker minor) has been found by Professor Sumichrast at Cordova and Orizaba, Mexico.

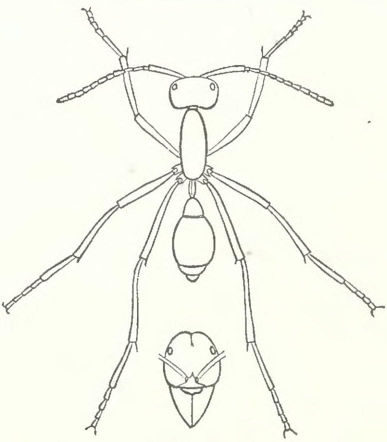


Fig. 115.

The males of Eciton are not yet known. Smith supposes that *Labidus* (a genus allied to Dorylus) is the male form, and Sumichrast thinks this conjecture is "sustained by the fact that it is in the season when the sorties of the Eciton are the more frequent that the Labidus also show themselves."

An allied genus is *Pseudomyrma*. *P. bicolor* Guérin (Fig. 117) is found in Central America. *P. flavidula* Smith, found in Central and South America, in Mexico lives, according to Sumichrast, within the spines which arm the stems of certain species of Mimosa. These spines, fixed in pairs upon the branches, are pierced near the end by a hole (Fig. 118 *a*), which serves for the entrance and exit of the ants.

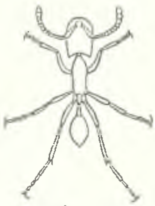


Fig. 116.

The genus *Œcodoma* differs from Atta in having the thorax armed with spines. *Œ. Mexicana* Smith (Figs. 119, female; 120, worker major) is abundant on the Gulf Coast of Mexico. In many places, according to Sumichrast, the natives eat the females after having detached the thorax. The intelligence of these ants is wonderful. They are seen in immense numbers transporting leaves. Sumichrast states that "the ground at the foot of the tree, where a troop of these '*arrieras*,' or workers, is assembled for despoiling it of its leaves, is ordinarily strewn with fragments cut off with the greatest precision. And if the tree is not too lofty, one can satisfy himself that a party of foragers, which have climbed the tree, occupies itself wholly in the labor of *cutting them off*, while at the foot of the tree are the *carriers* which make the journeys between the tree and the nest. This management, which indicates among these insects a rare degree of intelligence, is, perhaps, not a constant and invariable practice, but it is an incontestable fact, and one which can be constantly proved."


Fig. 117.

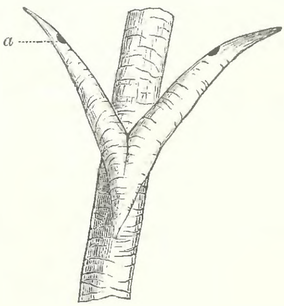


Fig. 118.

"It is specially in the argillaceous countries that the Œcodomas build their enormous formicaries, so that one perceives them from afar by the projection which they form above the level of the soil, as well as by the absence of vegetation in their immediate neighborhood. These nests occupy a surface of many square metres,* and their depth varies from one to two metres. Very many openings, of a diameter of about one to three inches, are contrived from the exterior, and conduct to the inner cavities which serve as storehouses for the eggs and larvæ. The central part of the nest forms a sort of funnel, designed for the drainage of water, from which, in a country where the periodical rains are often abundant, they could hardly escape without being entirely submerged, if they did not provide for it some outlet.

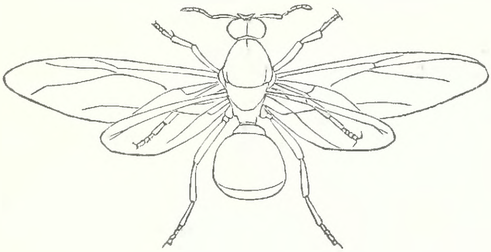


Fig. 119.

"The system which reigns in the interior of these formicaries is extreme. The collection of vegetable debris brought in by the workers is at times considerable; but it is deposited there in such a manner as not to cause any inconvenience to the inhabitants, nor impede their circulation. It is mostly leaves which are brought in from without, and it is the almost exclusive choice of this kind of vegetation which makes the *Œcodoma* a veritable scourge to agriculture. At each step, and in almost every place in the elevated woods, as on the plains; in desert places as well as in the neighborhood of habitations, one meets numerous columns of these insects, occupied with an admirable zeal in the transportation of leaves. It seems even that the great law of the *division of labor* is not ignored by these little creatures, judging from the observations which I have often had occasion to make." (Sumichrast.)

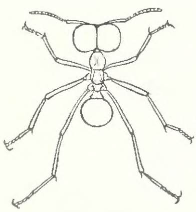


Fig. 120.

"The *Œ. cephalotes*," says H. W. Bates, "from its immense numbers, eternal industry, and its plundering propensities, becomes one of the most important animals of Brazil. Its immense hosts are unceasingly occupied in defoliating trees, and those most relished by them are precisely the useful kinds. They

* A metre is about thirty-nine (39.37) inches.

have regular divisions of laborers, numbers mounting the trees and cutting off the leaves in irregularly rounded pieces the size of a shilling, another relay carrying them off as they fall." "The heavily laden fellows, as they came trooping in, all deposited their load in a heap close to the mound. About the mound itself were a vast number of workers of a smaller size. The very large-headed ones were not engaged in leaf-cutting, nor seen in the processions, but were only to be seen on disturbing the nest." Bates also says, "I found, after removing a little of the surface, three burrows, each about an inch in diameter; half a foot downward, all three united in one tubular burrow about four inches in diameter. To the bottom of this I could not reach when I probed with a stick to the depth of four or five feet. This tube was perfectly smooth and covered with a vast number of workers of much smaller size than those occupied in conveying the leaves; they were unmixed with any of a larger size. Afterwards, on probing lower into the burrow, up came, one by one, several gigantic fellows, out of all proportion, larger than the largest of those outside, and which I could not have supposed to belong to the same species. Besides the greatly enlarged size of the head, etc., they have an ocellus in the middle of the forehead; this latter feature, added to their startling appearance from the cavernous depths of the formicarium, gave them quite a Cyclopean character."

Of another species, the *Œc. sexdentata*, Mr. Smith quotes from Rev. Hamlet Clark, that at Constancia, Brazil, the proprietor of a plantation used every means to exterminate it and failed. "Sometimes in a single night it will strip an orange or lemon tree of its leaves; a ditch of water around his garden, which quite keeps out all other ants, is of no use. This species carries a mine under its bed without any difficulty. Indeed, I have been assured again and again, by sensible men, that it has undermined, in its progress through the country, the great river Paraiba. At any rate, without anything like a natural or artificial bridge, it appears on the other side and continues its course." This testimony is confirmed by Mr. Lincecum (Proceedings of Academy of Natural Sciences, Philadelphia, 1867, p. 24) in an interesting account of the *Œc. Texana*, which he has observed for eighteen years. He states that they often carry their subterranean roads for several hundred yards in grassy districts, where the grass would prove an impediment to their progress. On one occasion, to secure access to a gentleman's garden, where they were cutting the vegetables to pieces, they tunnelled beneath a creek, which was at that place fifteen or twenty feet deep, and from bank to bank about thirty feet. He also observes that the smaller workers which remain around the nest do not seem to join in cutting or carrying the leaves, but are occupied with bringing out the sand, and generally work in a lazy way, very differently from the quick, active leaf-cutters. Also, that the pieces of leaves are usually dried outside before being carried in, and that if wet by a sudden shower are left to decay without. He also thinks that their lives are dependent upon access to water, and that they always choose places where it is accessible by digging wells. In one case, a well was dug by Mr. Pearson for his own use, and water found at the depth of thirty feet. The ant-well which he followed was twelve inches in diameter." (Norton, American Naturalist, vol. 2.)

Fig. 121.

The genus *Cryptocerus* is remarkable for its flattened head, with the sides expanded into flattened marginal plates, concealing, or partly hiding the eyes. *C. multispinosus* Norton (Fig. 121) is the most common species about Cordova, Mexico, where they live, according to Sumichrast, within the trunks of trees.

Chrysididæ Latreille. In this small group the thirteen-jointed antennæ are elbowed, the eyes are oval and the ocelli distinct. The maxillary palpi are five, and the labial palpi three-jointed. There are about four hundred species known.

These insects are very different from the ants in their oblong compact form, their nearly sessile, oblong abdomen, having only three to five rings visible, the remaining ones being drawn within, forming a long, large, jointed sting-like ovipositor, which can be thrust out like a telescope. The abdomen beneath is concave, and the insect can roll itself into a ball on being disturbed. They are green or black. The sting has no poison-bag, and in this respect, besides more fundamental characters, the Chrysis family approaches the Ichneumons. They best merit the name of "Cuckoo-flies," as they fly and run briskly in hot sunshine, on posts and trees, darting their ovipositor into holes in search of the nests of other Hymenoptera, in which to lay their eggs. Their larvæ are the first to hatch and devour the food stored up by other fossorial bees and wasps. "St. Fargeau, however, who has more carefully examined the economy of these insects, states that the eggs of the Chrysis does not hatch until the legitimate inhabitant has attained the greater part of its growth as a larva, when the larva of the Chrysis fastens on its back, sucks it, and in a very short time attains its full size, destroying its victim. It does not form a cocoon, but remains a long time in the pupa state." (Westwood.)

"In the Entomological Magazine has been noticed the discovery of Hedychrum bidentulum, which appears to be parasitic upon Psen caliginosus; the latter insect had formed its cells in the straws of a thatched arbor, as many as ten or twelve cells being placed in some of the straws. Some of the straws, perhaps about one in ten, contained one or rarely two, of the Hedychrum, placed indiscriminately amongst the others. Walkenaer, in his Memoirs upon Halictus, informs us that Hedychrum lucidulum waits at the mouth of the burrows of these bees, in order to deposit its eggs therein; and that when its design is perceived by the bees, they congregate together and drive it away. St. Fargeau states that the females of Hedychrum sometimes deposit their eggs in galls, while H. regium oviposits in the nest of Megachile muraria; and he mentions an instance in which the bee, returning to its nearly finished cell, laden with pollen paste, found the Hedychrum in its nest, which it attacked with its jaws; the parasite immediately, however, rolled itself into a ball, so that the Megachile was unable to hurt it; it, however, bit off its four wings which were exposed, rolled it to the ground and then deposited its load in the cell and flew away, whereupon the Hedychrum, now being wingless, had the persevering instinct to crawl up the wall to the nest, and there quietly deposit its egg, which it placed between the pollen paste and the wall of the cell, which prevented the Megachile from seeing it." (Westwood.)

In *Cleptes* the underside of the abdomen is not hollowed out;

it is acutely oval, and with five rings in the male. *Cleptes semiaurata* Latr. is found in Central Europe. We have no native species. In *Chrysis* and the other genera, Stilbum, Parnopes, and Hedychrum, the abdomen is hollowed beneath, and the tip is broad and square. *Chrysis hilaris* Dahlb. (Fig. 122) is a short, thick, bluish green species, .32 inch in length. It is not uncommon in New England.

In *Hedychrum* the maxillary palpi and ligula are rather short, the last cordate; the mandibles are three-toothed within. The abdomen is broad and short, almost spherical, the second segment being the largest. *H. dimidiatum* Say is found in the Middle States.

The European *Stilbum splendidum*, Fabr. according to Dufour, lives in the cells of Pelopæus spirifex. It makes oblong cocoons of a deep brown, with rounded ends; they are of great tenacity, being mixed with a gummy matter.

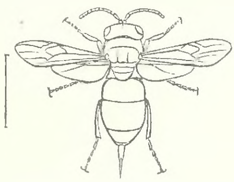


Fig. 122.

Mr. Guenzius states that in Port Natal "a species of *Stilbum* lays its eggs on the collected caterpillars stored up by Eumenes tinctor, which constructs a nest of mud and attaches it to reeds, etc., not in a single, but a large mass, in which cells are excavated, similar to the nest of Chalicodoma micraria?* First, it uses its ovipositor as a gimlet, and when its point has a little penetrated, then as a saw or rasp; it likewise feels with its ovipositor, and, finding an unfinished or an empty cell it withdraws it immediately, without laying an egg."

ICHNEUMONIDÆ Latreille. The Ichneumon-flies are readily recognized by the usually long and slender body, the long exserted ovipositor, which is often very long, and protected by a sheath formed of four stylets of the same length as the true ovipositor. The head is usually rather square, with long, slender, many-jointed antennæ which are not usually elbowed. The maxillary palpi are five to six-jointed, while the labial

* A query (?) after the name of a species indicates a doubt whether the insect really belongs to that species; so with a ? after the name of a genus. A ? before both the genus and species expresses a doubt whether that be the insect at all.

palpi are three to four-jointed. The abdomen is inserted immediately over the hind pair of trochanters, and usually consists of seven visible segments. The fore-wings have one to three subcostal (cubital) cells.

The larva is a soft, fleshy, cylindrical, footless grub, the rings of the body being moderately convex, and the head rather smaller than in the foregoing families. The eggs are laid by the parent either upon the outside or within the caterpillar, or other larva, on which its young is to feed. When hatched it devours the fatty portions of its victim which dies gradually of exhaustion. The ovipositor of some species is very long, and is fitted for boring through very dense substances; thus Mr. Bond, of England, observes that *Rhyssa persuasoria* actually bores through solid wood to deposit its eggs in the larvæ of Sirex; the ovipositor is worked into the wood like an awl. When about to enter the pupa state the larva spins a cocoon, consisting in the larger species of an inner dense case, and a looser, thinner, outer covering, and escapes as a fly through the skin of the caterpillar. The cocoons of the smaller genera, such as Cryptus and Microgaster, may be found packed closely in considerable numbers, side by side, or sometimes placed upright within the body of caterpillars.

The Ichneumon-flies are thus very serviceable to the agriculturist, as they must annually destroy immense numbers of caterpillars. In Europe over 2,000 species of this family have been described, and it is probable that we have an equal number of species in America; Gerstaecker estimates that there are 4,000 to 5,000 known species.

The Ichneumons also prey on certain Coleoptera and Hymenoptera, and even on larvæ of *Phryganidæ*, which live in the water. In Europe, Pimpla Fairmairii is parasitic on a spider, Clubione holosericea, according to Laboulbène. Boheman states that P. ovivora lives on a spider, and species of Pimpla and Hemiteles were also found in a nest of spiders, according to Gravenhorst. Bouché says that Pimpla rufata devours, during winter and spring, the eggs of Aranea diadema, and Ratzburg gives a list of fourteen species of Ichneumons parasitic on spiders, belonging to the genera Pimpla, Pezomachus, Pteromalus, Cryptus, Hemiteles, Microgaster, and Mesochorus. Mr.

Emerton informs me that he has reared a Pezomachus from the egg-sac of Attus, whose eggs it undoubtedly devours. They are not even free from attacks of members of their own family, as some smaller species are well known to prey on the larger.

Being cut off from communication with the external world, the Ichneumon larva breathes by means of the two principal tracheæ, which terminate in the end of the body, and are placed, according to Gerstaecker, in communication with a stigma of its host. From the complete assimilation of the liquid food, the intestine ends in a *cul de sac*, as we have seen it in the larvæ of Humble-bees and of Stylops, and as probably occurs in most other larvæ of similar habits, such as young gall-flies, weevils, etc., which live in cells and do not eat solid food.

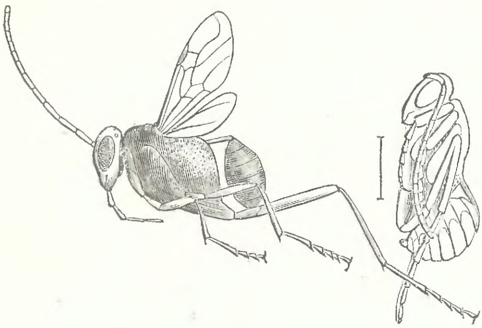


Fig. 123.

The first subfamily, the *Evaniidæ*, are insects of singular and very diverse form, in which the antennæ are either straight or elbowed, and thirteen to fourteen-jointed; the fore-wings have one to three subcostal (cubital) cells, and the hind wings are almost without veins.

In *Evania* and *Fœnus* the abdomen has a very slender pedicel, originating next the base of the metanotum. The former genus has a remarkably short triangular compressed abdomen in the female, but ovate in the male. The species are parasitic on Blatta and allies. *Evania lævigata* Olivier (Fig. 123, ♂ and pupa) is a black species, and is parasitic on the cockroach, Periplaneta, from the eggs of which we have taken the pupa and adult. The eggs of the cockroach are just large enough to accommodate a single Evania. This species

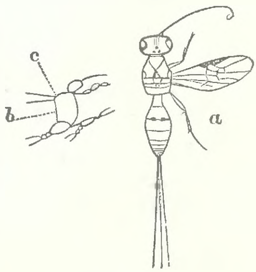


Fig. 124.

is widely distributed, and in Cuba, according to Cresson, it devours the eggs of Periplaneta Americana.

The genus *Aulacodes* of Cresson, "forms a very close connecting-link between the minute Ichneumons and the Evaniæ." *A. nigriventris* Cresson (Fig. 124, *a*; *b*, metathorax; *c*, insertion of the abdomen) lives in Cuba.

Fœnus is quite a different genus, as the abdomen is very long and slender. *Fœnus jaculator* Linn. is known in Europe to frequent the nests of *Crabronidæ*, ovipositing in the larvæ.

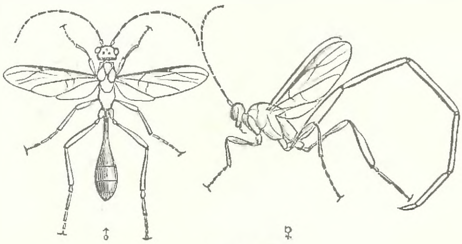


Fig. 125.

Pelecinus is a familiar insect, the immensely elongated, linear abdomen of the female easily distinguishing it. The male is extremely rare; its abdomen is short and clavate. It strikingly resembles Trypoxylon, though the abdomen is considerably larger. *Pelecinus polycerator* Drury (Fig. 125, ♂ and ♀) is widely distributed throughout this country.

The genuine *Ichneumonidæ* have long, straight, multiarticulate antennæ. The first subcostal (cubital) cell of the fore-wings is united with the median cell lying next to it, while the second is very small or wholly wanting. There are two recurrent veins. Mr. Cresson has described the genus *Eiphosoma* (Fig. 126), which he states may be known by the long, slender, compressed abdomen, and the long posterior legs, with their femora toothed beneath the tips. *E. annulatum* Cresson, a Cuban species, is, according to Poey, "parasitic upon a larva of Pyralis." (Cresson.)

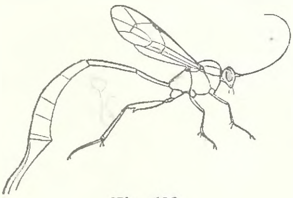


Fig. 126.

In *Ophion* the antennæ are as long as the body, the abdomen is compressed, and the species are honey-yellow in color. *O. macrurum* Linn. (Fig. 127) attacks the American Silkworm, Telea Polyphemus. *Anomalon* is a larger insect and usually black. *A. vesparum* is, in Europe, parasitic on Vespa.

The genus *Rhyssa* contains our largest species, and frequents the holes of boring insects in the trunks of trees, inserting its remarkably long ovipositor in the body of the larvæ deeply embedded in the trunk of the tree. Harris states that *Rhyssa* (Pimpla) *atrata* and *lunator* (Fig. 128, male) of Fabricius, "may frequently be seen thrusting their slender borers, measuring from three to four inches in length, into the trunks of trees inhabited by the grubs of the Tremex, and by other wood-eating insects; and, like the female Tremex, they sometimes become fastened to the trees, and die without being able to draw their borers out again." The abdomen of the male is very slender.

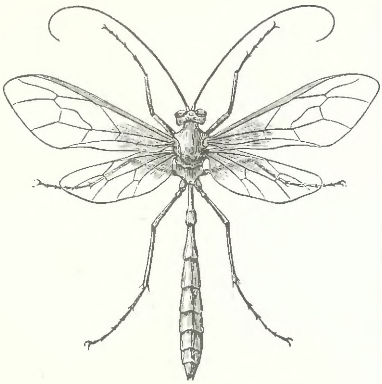


Fig. 127.

Pimpla has the ovipositor half as long as the abdomen. *P. pedalis* Cresson is a parasite on Clisiocampa.

The genus *Trogus* leads to Ichneumon. The antennæ are shorter than the body; the abdomen is slightly petiolate, fusiform, and the second subcostal cell is quadrangular. *Trogus excsorius* Brullé is tawny red, and is a parasite of Papilio Asterias.

The genus *Ichneumon* (Fig. 129) is one of great extent, probably containing over three hundred species. The abdomen is long and slender, lanceolate ovate, slightly petiolate. The second subcostal cell is five-sided, and the ovipositor is either concealed or slightly exserted.

Fig. 128.

Ichneumon suturalis Say is a very common form, and has been reared in abundance from the larva of the Army-worm, Leucania unipuncta. The body is pale rust-red, with black sutures on the thorax. Another common species, also parasitic on the

Army-worm, is the *Ichneumon paratus*, which is blackish, banded and spotted with yellow.

The singular genus *Grotea*, established by Mr. Cresson, has a long and narrow thorax (Fig. 130 *a*), and a very long and petiolated abdomen (*c*). We have taken *G. anguina* Cresson, the only species known, from the cells of Crabro in raspberry stems received from Mr. Angus.

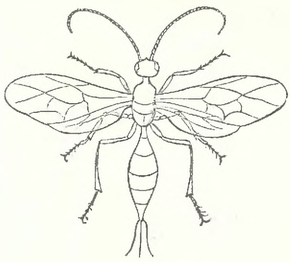


Fig. 129.

Cryptus is a genus of slender form, with a long, cylindrical abdomen, which is petiolate. In the female it is oval with an exserted ovipositor. Cresson figures a wing (Fig. 131) of *C.? ornatipennis*, a Cuban species, which has the wings differently veined from the other species. Westwood remarks that in Europe a species of this genus preys on the larvæ of the *Ptinidæ*.

Pezomachus is usually wingless, and might at first sight readily be mistaken for an ant. The body is small, the oval abdomen petiolate, and the wings, when present, are very small. The species are very numerous. Gerstæcker suggests that some may be wingless females, belonging to winged males of allied genera.


Fig. 131.

The third subfamily is the *Braconidæ*, containing those genera having long multiarticulate antennæ, and with the first subcostal cell separate from the first median, lying just behind it. The second subcostal cell is usually large, and there is only one recurrent vein.

The genus *Bracon* is distinguished by the deeply excavated clypeus. The first subcostal cell is completely formed behind, wanting the recurrent nerve; the second cell is long, and four-sided. More than five hundred species, mostly of bright, gay colors, are already known. The genus *Rhopalosoma* of Cresson connects Bracon and other minute genera (Braconidæ) with the true Ichneumons. *R. Poeyi* Cresson (Fig. 132) is a

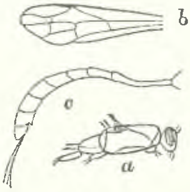


Fig. 130.

pale honey-yellow species, with a long club-shaped abdomen. It lives in Cuba.

Rogas is a genus differing from Bracon in having the three first abdominal rings long, forming a slender petiole.

In *Microgaster*, a genus containing numerous species, the antennæ are eighteen-jointed, and the abdomen is shorter than usual, and clavate. There are two or three subcostal cells, the second very small. *Microgaster nephoptericis* (Plate 3, figs. 3, 3 *a*) is parasitic on Nephopteryx Edmandsii, found in the cells of the Humble-bee.

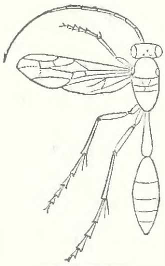


Fig. 132.

Aphidius, the parasite of the Plant-lice, is a most valuable ally of man. It is known by its small size, and by having the second and third segments of the abdomen moving free on each other. There are three cubital cells, though the wings are sometimes wanting. *Aphidius* (Praön) *avenaphis* of Fitch, the Oat-louse Aphidius, is black with honey-yellow legs, and is one-tenth of an inch long. *Aphidius* (Toxares) *triticaphis* Fitch, the Wheat-louse Aphidius, is black, shining, with thread-like antennæ composed of twenty-five joints. Its length is .08 inch. Frequently the large size of the parasite causes the body of the dead Aphis to swell out into a globular form.

Proctotrypidæ (*Proctotrupii*) Latreille. Egg-parasites. In this family are placed very minute species of parasitic Ichneumon-like Hymenopters which have rather long and slender bodies, with straight or elbowed antennæ of various lengths, often haired on the joints, usually ten to fifteen, sometimes only eight in number, while the wings are covered with minute hairs and most of the nervures are absent. The maxillary palpi are three to six, the labial palpi usually three-jointed. The abdomen has from five to seven joints, and the tarsi are mostly five-jointed, rarely four-jointed. These insects are often so minute that they can scarcely be distinguished by the naked eye unless it is specially trained; they are black or brown, and very active in their habits. They may be swept off grass and herbage, from aquatic plants, or from hot sand-banks. They prey on the wheat-flies by inserting their eggs in their larvæ, on gall-midges, and gall-flies, and on fungus-eating flies. In Europe, species of *Teleas* lay their eggs in those of other insects, especially butterflies and moths and hemipters, where they feed on the juices of the larvæ growing within the egg, coming out as perfect Ichneumons. We probably have many species of these insects in this country. They usually occur in great numbers where they are found at all. They are almost too small to pin, and if transfixed would be unfit for study, and should, therefore, be gummed on mica, or put into small vials with alcohol.

In *Proctotrupes* the antennæ are long, feathered, twelve-jointed. The fore-wings have the beginning of a cubital cell, and two longitudinal veins on the posterior half. The abdomen is spindle-shaped and very acutely pointed, the terminal joints being tubular in their arrangement, and thus, as Westwood states, approaching the *Chrysididæ*. An unknown species (Fig. 133) we have taken at the Glen, in the White Mountains.

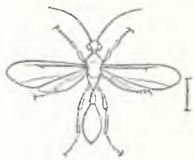


Fig. 133.

The head of *Diapria* is horizontal and longer than broad; the ocelli are moved forward on to the front edge; the long, filiform antennæ have a projection on the under side, with the basal joint much elongated; in the male they are thirteen or fourteen-jointed, with one joint less in the female. The wings are without stigma or veins. The abdomen is long, oval, pedicelled. In Europe, *D. cecidomyiarum* Bouché is parasitic on the larvæ of Cecidomyia artemisiæ. Esenbeck considers that this genus is also parasitic on the earth-inhabiting *Tipulidæ*.

Gonatopus is a wingless genus, with the head very broad, transverse, and the front deeply hollowed out, while the ten-jointed antennæ are long, slightly clavate, and the thorax is much elongated, deeply incised, forming two knot-like portions. *Gonatopus lunatus* Esenbeck, found in Europe, is one and a half lines long.

Ceraphron has the antennæ inserted near the mouth; they are elbowed, and eleven-jointed in the male, and ten-jointed in the female. The abdomen has a very short pedicel. The fore-wings have a very short, bent costal (radial) vein. *C. armatum* Say was described from Indiana.

The egg-parasite, *Teleas*, has the elbowed twelve-jointed antennæ inserted very near the front of the head, and slightly hairy and simple in the male, but in the female terminated in a six-jointed club. The thorax is short, the legs thickened and adapted for leaping, and the abdomen is pedicelled. Many species have been found in Europe. According to Westwood, "the type of this genus is the *Ichneumon ovulorum* of Linnæus (*Teleas Linnæi* Esenbeck), which Linnæus and De Geer obtained from the eggs of moths." It has been raised from the eggs of several *Bombycidæ*. "Bouché observed the female deposit an egg in each of the eggs of a brood of Bombyx neustria. He describes the larva as elliptical, white, shining, rugose, subincurved, and one-third of an inch long." (Westwood.)

Fig. 134.

Of the extensive genus *Platygaster* over a hundred European species are already known. The body, especially the abdomen, is generally flattened, the antennæ are ten-jointed, and in the female clavate. The wing veins are absent; the rather slender legs are not adapted for leaping, and the tarsi are five-jointed. A species of Platygaster (Fig. 134) not yet named, oviposits in the eggs of the Canker-worm moth, Anisopteryx vernata, and by its numbers does much to check the increase of this caterpillar. We have seen several of these minute insects engaged in inserting their eggs into those of the Canker-worm.

Dr. Harris, in speaking of the enemies of the Hessian-fly, states, that "two more parasites, which Mr. Herrick has not yet described, also destroy the Hessian-fly, while the latter is in the flax-seed or pupa state. Mr. Herrick says, that the egg-parasite of the Hessian-fly is a species of Platygaster, that it is very abundant in the autumn, when it lays its own eggs, four or five together, in a single egg of the Hessian-fly. This, it appears, does not prevent the latter from hatching, but the maggot of the Hessian-fly is unable to go through its transformations, and dies after taking on the flax-seed form. Meanwhile its intestine foes are hatched, come to their growth, spin themselves little brown cocoons within the skin of their victim, and in due time, are changed to winged insects, and eat their way out." *P. error* Fitch (Fig. 135) is closely allied to *P. tipulæ* Kirby, which, in Europe, destroys great numbers of the Wheat-midge. Whether this is a parasite of the midge, or not, Dr. Fitch has not yet determined.

The habits of the genus *Bethylus* remind us of the fossorial wasps. *Bethylus fuscicornis*, according to Haliday, "buries the larvæ of some species of Tinea, which feed upon the low tufts of Rosa spinosissima, dragging them to a considerable distance with great labor and solicitude, and employing, in the instance recorded by Mr. Haliday, the bore of a reed stuck in the ground instead of an artificial funnel, for the cells which should contain the progeny of the Bethylus, with its store of provision." (Westwood.)

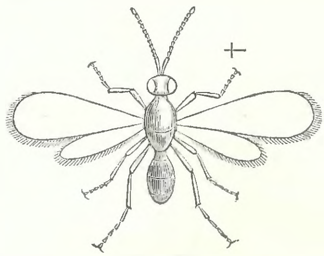


Fig. 135.

The genus *Inostemma* is remarkable for having the basal segment of the abdomen of the females furnished with a thick curved horn, which extends over the back of the thorax and head. Dr. Fitch states that *I. inserens* is supposed by Kirby to insert its eggs into those of the Wheat-midge. In the genus *Galesus* of Curtis, the mandibles are so enlarged and lengthened as to form a long beak, and Westwood farther states that in some specimens the anterior wings have a notch at the extremity. Say's genus *Coptera* has similar wings. *C. polita* Say was discovered in Indiana.

In the very minute species of *Mymar* and its allies, the head is transverse, with the antennæ inserted above the middle of the face; they are long and slender and elbowed in the male, but clavate in the female. There are no palpi, while the very narrow wings have a very short subcostal vein and on the edges are provided with long dense ciliæ. The antennæ of *Mymar* are thirteen-jointed in the male, and nine-jointed in the female; the club is not jointed. The tarsi are four-jointed, and the abdomen is pedunculated. *Mymar pulchellus* Curtis is a quarter of a line long. It is found in Europe. An allied form *Polynema ovulorum* Linn. lays numerous eggs in a single butterfly's egg.

In *Anaphes* the male antennæ are twelve-jointed, those of the female nine-jointed, and the abdomen is subsessile and ovoid. In *Anagrus* the male antennæ are thirteen-jointed, those of the female nine-jointed, while the tarsi are four-jointed, and the acutely conical abdomen is sessile. No native species are known.

The smallest Hymenopterous insect known, if not the most minute of all insects, is the *Pteratomus Putnamii* Pack. (Plate 3, figs. 8, 8*a*, hind wing), which we first discovered on the body of an Anthophorabia in the minute eggs of which it is undoubtedly parasitic. It differs from Anagrus in the obtusely conical abdomen, and the narrower, very linear wings, which are edged with a fringe of long, curved hairs, giving them a graceful, feathery appearance. The fore-wings are fissured, a very interesting fact, since it shows the tendency of the wings of a low Hymenopterous insect to be fissured like those of Pterophorus and Alucita, the two lowest Lepidopterous genera. It is one-ninetieth of an inch in length.

Chalcididæ Westwood. This is a group of great extent; the species are of small size; they are often of shiny colors, as the name of the principal genus implies, being either bronzen or metallic. They have also elbowed antennæ with from six to fourteen joints, and the wings are often deficient in veins. In some genera, including Chalcis, the hind thighs are thickened for leaping. The differences between the sexes, generally very marked in Hymenoptera, are here especially so. The abdomen is usually seven-jointed in the male and six-jointed in the female, the other rings being aborted. The male of several species has the joints of the antennæ swelled and furnished with long hairs above. Some of the species of Pteromalus are wingless, and closely resemble ants. They infest eggs and larvæ. Some species prey upon the Aphides, others lay their eggs in the nests of wasps and bees. One species is known in Europe to be a parasite of the common house-fly. Others consume the larvæ of the Hessian-fly, and those Cecidomyiæ that produce galls, and also the true gall-flies (Cynips). Some are parasites on other Ichneumon parasites, as there are species preying on the genus Aphidius, which is a parasite on the Aphis. Mr. Walsh has bred a species of Hockeria and of Glyphe, which are parasitic on a Microgaster, which in turn preys upon the Army-worm, Leucania unipuncta; and Chalcis albifrons Walsh, was bred from the cocoons of Pezomachus, an Ichneumon parasite of the same caterpillar.

The pupæ of some species are said to have the limbs and wings soldered together as in Lepidoptera, and the larvæ seldom spin a silken compact cocoon. We have probably in this country at least a thousand species of these small parasites, nearly twelve hundred having been named and described in Europe alone. They are generally large enough to be pinned or stuck upon cards or mica; some individuals should be preserved in this way, others, as wet specimens.

Fig. 136.

Chalcis is known by the abdomen having a long pedicel, its much thickened, oval thighs, and curved tibiæ. *Chalcis bracata* (Fig. 136), so named by Mr. Sanborn "in allusion to the ornamental and trousered appearance of the posterior feet" is about .32 inch in length. "Réaumur has described and figured a species of Chalcis, which is parasitic in the nest of the American wasp Epipone nitidulans and which he regarded as the female of that wasp." (Westwood.)

The genus *Leucospis* is of large size. It is known by having the large ovipositor laid upon the upper surface of the abdomen, and being spotted and banded with yellow, resembling wasps. One of our more common species is the *L. affinis* (Fig. 137) of Say. The Cuban *L. Poeyi* Guérin is parasitic on the Megachile Poeyi of Guérin.

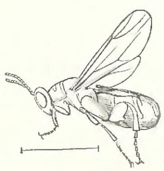


Fig. 137.

The well-known Joint-worm, *Eurytoma*, is thought by many to produce galls on wheat-stems. The antennæ are, in the male, slender and provided with verticils of hairs. The acutely oval abdomen has a short pedicel. The hind legs are scarcely thicker than the fore limbs. *E. hordei* Harris (Fig. 138) is found in gall-like swellings of wheat-stalks. It is still a matter of discussion, whether it directly produces the galls, or is parasitic, like many of the family, on other gall-insects. Dr. Harris, who has studied the habits of the Joint-worm, states that the body of the adult fly is jet black, and that the thighs, shanks (tibiæ), and claw-joints, are blackish, while the knees and other joints of the feet, are pale-yellow. The females are .13 inch long, while the males are smaller, have a club-shaped abdomen, and the joints of the antennæ surrounded with a verticil of hairs. The larva is described by Harris from specimens received from Virginia, as varying from one-tenth to nearly three-twentieths of an inch in length. It is of a pale yellowish white color, with an internal dusky streak, and is destitute of hairs. The head is round and partially retractile, with a distinct pair of jaws, and can be distinguished from the larvæ of the dipterous gall-flies by not having the v-shaped organs on the segment succeeding the head. During the summer, according to Mr. Gourgas's observations reported by Dr. Harris, and when the barley or wheat is about eight or ten inches high, the presence of the young Joint-worms is detected "by a sudden check in the growth of the plants, and the yellow color of their leaves," and several irregular gall-like swellings between the second and third joints, or, according to Dr. Fitch, "immediately above the lower joint in the sheathing base of the leaf;" or, as Harris states, in the joint itself. The ravages of this insect have been noticed in wheat and barley. During November, in New England, the worms transform into the pupa state, according to the observations of Dr. A. Nichols, and "live through the winter unchanged in the straw, many of them in the stubble in the field, while others are carried away when the grain is harvested." In Virginia, however, the larva does not transform until late in February, or early in March, according to Mr. Glover. From early in May, until the first week in July, the four-winged flies issue from the galls in the dry stubble, and are supposed to immediately lay their eggs in the stalks of the young wheat or barley plants. The losses by this insect has amounted, in Virginia, to over a third of the whole crop. The best remedy


Fig. 138.

against the attacks of this insidious foe, is to burn the stubble in the autumn or spring for several successive years. Ploughing in the stubble does not injure the insects, as they can work their way out of the earth.

It has been objected by Westwood, Ratzburg, and more recently by Mr. Walsh, in the Practical Entomologist, vol. i, that as all the species of this family, so far as known, are parasitic, the Eurytoma cannot be a gall-producer, and that the galls are made by a dipterous insect (Cecidomyia) on which the Eurytoma is a parasite; but, as they offer no new facts to support this opinion, we are inclined to believe from the statements of Harris, Fitch, Cabell, T. Glover (Patent Office Report for 1854), and others, that the larva of the Eurytoma produces the gall. We must remember that the habits of comparatively few species of this immense family have been studied; that the genus Eurytoma is not remotely allied to the Cynipidæ, or true gall-flies (which also comprise animal parasites), in which group it has actually been placed by Esenbeck, for the reason that in Europe "several species of Eurytoma have been observed to be attached to different kinds of galls." (Westwood.) Dr. Fitch also describes the Yellow-legged Barley-fly, *Eurytoma flavipes*, which produces similar galls in barley, and differs from the Wheat Joint-worm in having yellow legs, while the antennæ of the male are not surrounded with whorls of hair. The *Eurytoma secalis* Fitch infests rye. It differs from E. hordei in "having the hind pair of shanks dull pale-yellow, as well as the forward ones." We shall also see beyond that several species of Saw-flies produce true galls, while other species of the same genus are external feeders, which reconciles us more easily to the theory that the Eurytoma hordei, and the other species described by Dr. Fitch, differ in their habits from others of the family, and are not animal parasites. Indeed the Joint-worm is preyed upon by two Chalcid parasites, for Harris records finding the larvæ, probably of Torymus, feeding on the Eurytoma larvæ, and that a species of Torymus (named T. Harrisii, by Dr. Fitch, and perhaps the adult of the first-named Torymus) and a species of Pteromalus are parasites on Eurytoma.

In *Monodontomerus* (Torymus) the third joint of the antennæ is minute, and the hind femora are thick, but not serrated, and beneath armed with a tooth near the tip.

The wings are rudimentary so that it does not quit the cell. Newport states that the larva is flat, very hairy, and spins a silken cocoon when about to pupate. It is an "external feeding parasite" consuming the pupa as well as the larva of Anthophorabia. The imago appears about the last of June, perforating the cell of the bee. It also lives in the nests of Osmia, Anthophora, and Odynerus.

The genus *Anthophorabia* is so-called from being a parasite on Anthophora. The males differ remarkably from the females, especially in having simple instead of compound eyes, besides the usual three ocelli. *A. megachilis* Pack. (Plate 4; fig. 7, larva; 7 *a*, pupa) is a parasite on a species of Megachile. The larva is white, short and thick, cylindrical, with both extremities much alike; the segments are slightly convex, and the terminal ring is orbicular and rather large. Length, .04 inch, being one-third as broad as long. On opening the cells of Megachile, we found nearly a dozen containing these parasites, of which 150 larvæ were counted clustering on the outside of a dead and dry Megachile larva. In England they occur, according to Newport's observations, in much less numbers, as he found from thirty to fifty in a cell of Anthophora. A few females hatched out in the middle of October, and there were a few pupæ left, but the majority wintered over in the larva state, and a new and larger brood appeared in the spring.

Perilampus is a beautiful genus, with its shining, metallic tints. The eleven-jointed antennæ are short, lying when at rest in a deep frontal furrow. The head is large, while the abdomen is slightly pedicelled, being short, contracted, with the ovipositor concealed. *P. platygaster* Say and *P. triangularis* Say were described from Indiana.

The numerous species of *Pteromalus* often oviposit in the larvæ of butterflies. In this genus the antennæ are inserted in the middle of the front. The abdomen is nearly sessile, obtusely triangular, or acutely ovate in form, with the ovipositor concealed. The femora are slender. There are about three hundred species known to inhabit Europe. *Pteromalus vanessæ* Harris is a parasite on Vanessa Antiopa. *P. clisio-*

campæ Harris infests Clisiocampa. "*Pteromalus apum* is parasitic in the nests of the Mason-bee." (Westwood.) A species of this or an allied genus (Fig. 139) infests the eggs of the Clisiocampa Americana. Its eggs are probably laid within those of the Tent-caterpillar moth early in the summer, hatching out in the autumn, and late in the spring or early in June.

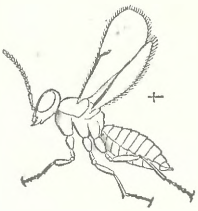


Fig. 139.

An allied genus, *Siphonura*, is a parasite on galls. It resembles a beetle, Mordella, from its very peculiar scutum.

The antennæ of Semiotellus are twelve-jointed. *S.* (Ceraphron) *destructor* Say (Fig. 140), according to that author, destroys the Hessian-fly, while lying in the "flax-seed" state. Fitch describes it as being a tenth of an inch long, black, with a brassy green reflection on the head and thorax, while the legs and base of the abdomen are yellowish.

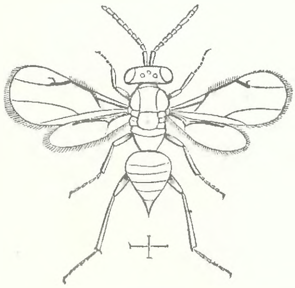


Fig. 140.

In *Encyrtus*, which comprises over a hundred species already known, usually rather small in size, the body is short and rounded. The eleven-jointed antennæ are inserted near the mouth. The thorax is square behind, and the sessile abdomen is short and broad at the base. *Encyrtus Bolus* and *E. Reate* are described from North America by Mr. F. Walker. *Encyrtus varicornis* is in Europe found as a parasite in the cells of Eumenes coarctata.

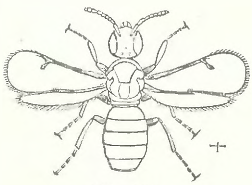


Fig. 141.

The antennæ of *Eulophus* are nine-jointed, with a long branch attached to the third, fourth, and fifth joints. The abdomen is flattened, sessile. *E. basalis* Say was described from Indiana. We figure a Chalcid (Fig. 141, ♂), allied to Eulopus, which preys upon the American Tent Caterpillar.

A species of *Blastophaga* (B. grossorum Grav.) is interesting as it is the means of assisting in the fertilization of the Fig blossoms, which act, as applied to this instance of the fertilization of flowering plants by insects, has been called by Mr. Westwood "caprification."

CYNIPIDÆ Westwood. (*Diplolepariæ* Latreille.) Gall-flies. In this most interesting family we have a singular combination of zoölogical and biological characters. The gall-flies are closely allied to the parasitic Chalcids, but in their habits are plant-parasites, as they live in a gall or tumor formed by the abnormal growth of the vegetable cells, due to the irritation first excited when the egg is laid in the bark, or substance of the leaf, as the case may be. The generation of the summer broods is also anomalous, but the parthenogenesis that occurs in these forms, by which immense numbers of females are produced, is necessary for the work they perform in the economy of nature. When we see a single oak hung with countless galls, the work of a single species, and learn how numerous are its natural

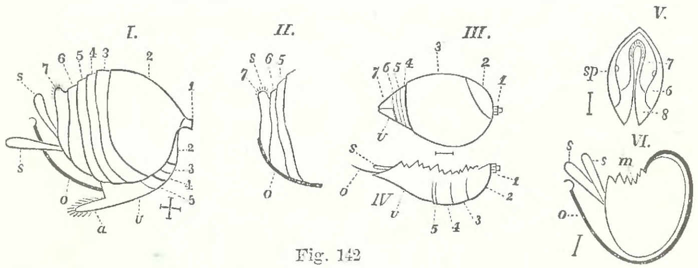


Fig. 142

enemies, it becomes evident that the demand for a great numerical increase must be met by extraordinary means, like the generation of the summer broods of the Plant-lice.

The gall-flies are readily recognized by their resemblance to certain Chalcids, but the abdomen is much compressed. and usually very short, while the second, or the second and third segments, are greatly developed, the remaining ones being imbricated or covered one by the other, leaving the hind edges exposed. Concealed within these, is the long, partially coiled, very slender ovipositor, which arises near the base of the abdomen.* Among other distinguishing characters, are the straight

* Fig. 142. I, abdomen of *Cynips quercus-aciculata* Osten Sacken, with the ovipositor exserted; II, the same with the ovipositor retracted; III, the abdomen of the female of *Figites* (Diplolepis) *5-lineatus* Say; IV, the same showing the ventral portion, in nature covered by the tergal portion of the abdomen; V, end view of the

(not being elbowed) thirteen to sixteen-jointed antennæ, the labial palpi being from two to four-jointed, and the maxillary palpi from four to six-jointed. The maxillary lobes are broad and membranous, while the ligula is fleshy, and either rounded or square at the end. There is a complete costal cell, while the subcostal cells are incomplete. The egg is of large size, and increases in size as the embryo becomes more developed. The larva is a short, thick, fleshy, footless grub, with the segments of the body rather convex. When hatched they immediately attack the interior of the gall, which has already formed around them. Many species transform within the gall, while others enter the earth and there become pupæ.

It is well known that of many gall-flies the males have never been discovered. "Hartig says that he examined at least 15,000 specimens of the genus *Cynips*, as limited by him, without ever discovering a male. To the same purpose he collected about 28,000 galls of *Cynips divisa*, and reared 9,000 to 10,000 Cynips from them; all were females. Of *C. folii*, likewise, he had thousands of specimens of the female sex without a single male." (Osten Sacken.) Siebold supposes in such cases that there is a true parthenogenesis, which accounts for the immense number of females.

Baron Osten Sacken, however, thinks that these females are impregnated by males of the same species which are produced from a different sort of gall, existing, however, on the same species of tree. He reports in the Proceedings of the Academy of Natural Sciences of Philadelphia, July 1861, "an observation, which, if confirmed, would solve the question of the sexes of Cynipidæ. From a singular, spindle-shaped gall on the red oak, I reared a male Cynips, which is similar to the gall-fly, *Cynips confluens* Harris, of the common oak-apple of the red oak, known by the female sex only, and looks exactly as one might suppose the male *Cynips confluens*, if known, ought to look. If it is proved that the Cynips of the spindle-

abdomen of Cynips, showing the relations of segments 7-8, the sternal portion of the eighth segment being obsolete; *sp*, the single pair of abdominal spiracles; VI, terminal ventral piece, from which the sheaths (*s s*) and the ovipositor (*o*) take their origin: it is strongly attached at *m* to the tergites of the sixth and seventh rings; *o*, ovipositor; *s*, *s* its sheaths; *a*, an appendage to *v*, the terminal sternite. — *From Walsh.*

shaped gall is the male of the Cynips of the oak-apple, and if it is shown, by further observation, that in the genera, supposed to be agamous, by Hartig, the males produced from galls are different from those of the females, then it will be plain how 28,000 galls of the same kind could give 10,000 females and not a single male.

"A strong proof in confirmation of my assertion is, that in those genera, the males of which are known, both sexes are obtained from galls in almost equal numbers; even the males, not unfrequently, predominate in number (see Hartig, l. c. iv, 399). Now the gall-flies, reared by me from the oak-apple, were all females. Dr. Fitch, also, had only females; and Mr. B. D. Walsh, at Rock Island, Illinois, reared (from oak-apples of a different kind) from thirty-five to forty females, without a single male. This leads to the conclusion that the Cynips of the oak-apples belongs to the genera hitherto supposed to be agamous."

For an account of the habits and many other interesting points in the biology of these interesting insects, we further quote Baron Osten Sacken. "Most of the gall-flies always attack the same kind of oak; thus, the gall of *C. seminator* Harris, is always found on the white oak; *C. tubicola* Osten Sacken on the post oak, etc. Still, some galls of the same form occur on different oaks; a gall closely resembling that of *C. quercus-globulus* Fitch, of the white oak, occurs also on the post oak, and the swamp chestnut oak; a gall very similar to the common oak-apple of the red oak occurs on the black-jack oak, etc. Are such galls identical, that is, are they produced by a gall-fly of the same kind? I have not been able to investigate this question sufficiently. Again, if the same gall-fly attacks different oaks, may it not, in some cases, produce a slightly different gall? It will be seen below, that *C. quercus-futilis*, from a leaf-gall on the white oak, is very like *C. quercus-papillata* from a leaf-gall on the swamp-chestnut oak. I could not perceive any difference, except a very slight one in the coloring of the feet. Both gall-flies may belong to the same species, and although the galls are somewhat different, they are in some respects analogous, and might be the produce of the same gall-fly on two different trees.

"Some gall-flies appear very early in the season; *Cynips quercus-palustris* for instance, emerges from its gall before the end of May; these galls are the earliest of the season; they grow out of the buds and appear full grown before the leaves are developed. May not this gall-fly have a second generation, and if it has, may not the gall of this second generation be different from the first produced, as it would be under different circumstances, in a more advanced season, perhaps on leaves instead of buds, etc?

"A remarkable fact is the extreme resemblance of some of the parasitical gall-flies with the true gall-fly of the same gall. Thus, *Cynips quercus-futilis*, O. Sacken, is strikingly like Aulax? futilis, the parasite of its gall. The common gall on the blackberry stems produces two gall-flies which can hardly be told apart at first glance, although they belong to different genera." (Proceedings of the Entomological Society of Philadelphia.)

Hartig has divided this family into three sections: First, Cynips and its allies, the *true gall-flies* (Psenides) in which the second (counting the slender pedicel as the first) segment of the abdomen is longer than half its length, and the subcostal area is narrow, the basal areolet (cell) being opposite the base of the former.

Cynips confluens Harris forms the oak-apple commonly met with on the scrub-oak. There is a spring and summer brood. These galls, sometimes two inches in diameter, are green and pulpy at first, but when ripe have a hard shell with a spongy interior, in the centre of which, lodged in a woody kernel, which serves as a cocoon, the larva transforms, escaping through a hole, which it gnaws through both the kernel and shell. We have found the fly ready to escape in June, and Dr. Harris has found it in October. Two galls are represented on Plate 4, fig. 13; the larger of which has been tenanted, after the gall-flies had escaped, by an Odynerus. *Cynips gallæ-tinctoriæ* Olivier produces the galls of commerce, brought from Asia Minor.

Biorhiza (Apophyllus Hartig) is a wingless genus, and lives beneath the earth in galls formed at the roots of oak trees. *Biorhiza nigra* Fitch is black throughout, including the antennæ and feet, and is but .08 inch long.

Galls are often found on the blackberry, tenanted by another genus, *Diastrophus*, which has usually fifteen-jointed antennæ in the male, and one joint less in the female. On opening a gall containing this fly, we often find an inquiline gall-fly, Aulax, "showing the most striking resemblance in size, coloring and sculpture, to the Diastrophus, their companion. The one is the very counterpart of the other, hardly showing any differences, except the strictly generic characters." (Osten Sacken.) These galls are also infested by Chalcid parasites, Callimome (two species), Ormyrus, and Eurytoma.

Osten Sacken enumerates "eight cynipidous galls on the different kinds of roses of this country." The flies all belong to the genus *Rhodites*, which is distinguished by the under side of the last abdominal segment being drawn out into a long point, while the antennæ are fourteen-jointed in both sexes. *R. rosæ* produces the *bedeguar* gall ("from the Hebrew *bedeguach*, said to mean rose-apple"). It was formerly used as a medicine. The galls form a moss-like mass, encircling the rose branch. *Rhodites dichlocerus* of Harris (Fig. 143), produces hard, woody, irregular swellings of the branches.


Fig. 143.

We now come to the second section, the *Guest gall-flies* (Inquilinæ), which are unable to produce galls themselves, as they do not secrete the gall-producing poison, though possessing a well developed ovipositor. Hence, like the Nomada, etc., among bees, they are Cuckoo-flies, laying their eggs in galls already formed.

This group may generally, according to Mr. Walsh, be distinguished from the preceding by the sheaths of the ovipositor always projecting, more or less, beyond the "dorsal valve," which is a small, hairy tubercle at the top of the seventh abdominal segment. This dorsal valve also projects greatly. In almost all the species, the ovipositor projects from between the tips of the sheaths.

Among the Inquiline genera are *Synophrus*, *Amblynotus*, *Synerges*, and *Aulax*, which are guests of various species of Cynipides.

In *Figites* and allies (Figitidæ), the third section of the family, the second segment is shorter than half the length of the abdomen, being much longer and less high and compressed than in the Cynipides, and the ovipositor is retracted within the abdomen. These insects are true internal parasites, resembling the Chalcids. *Ibalia* is a parasite on a wood-beetle. This genus has, by Walsh, been placed in the Cynipides. Figites has feather-like antennæ in the male; it is a parasite on the larvæ of Sarcophaga. The genus *Allotria* is a parasite on Aphis.

Walsh states that two genera, which he has identified as *Kleidotoma* and *Eucoila* are true *Figitidæ*, and "have the wings fringed like a *Mymar*, and the former has them emarginate at tip with the radial area in my species distinctly open, and the latter simple at tip with the radial area in my species marginally closed by a coarse brown vein." *Eucoila* is supposed to be parasitic on some insect attacking the turnip.

TENTHREDINIDÆ Leach. The Saw-flies connect the Hymenoptera with the Lepidoptera. In the perfect state they conform to the Hymenopterous type, but as larvæ they would often be mistaken for Lepidopterous larvæ, and in their habits closely resemble many caterpillars. The three divisions of the body, usually so trenchantly marked in the higher Hymenoptera, are here less distinct, since the abdomen is sessile, its basal ring being broad and applied closely to the thorax, while the succeeding rings are very equal in size. The head is broad and the thorax wide, closely resembling that of the Lepidoptera. The wings (Fig. 144, fore-wing) are larger in proportion to the rest of the body than usual; they are more net-veined, the cells being more numerous and extending to the outer margin.*

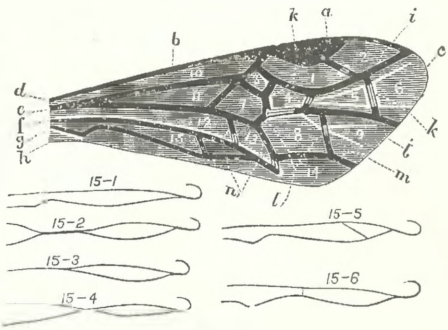


Fig. 144.

*In treating of this family we avail ourselves largely of the important work on the American species, publishing at the time of writing, by Mr. E. Norton, in the Transactions of the American Entomological Society, vols. 1, 2. We therefore

All these characters show that the saw-fly is a degraded Hymenopter.

The antennæ are not elbowed; are rather short and simple, clavate, but in rare instances fissured or feathered. The abdomen consists, usually, of eight external segments, the two last being aborted on the under side, owing to the great development of the ovipositor. The ovipositor or "saw" (compare Fig. 24) consists of two lamellæ, the lower edge of which is toothed and fits in a groove in the under side of the upper one, which is toothed above, both protected by the usual sheath-like stylets. On pressing, says Lacaze-Duthiers, the end of the abdomen, we see the saw depressed, leave the direction of the axis of the body, and become perpendicular. By this movement the saw, which both cuts and pierces, makes a gash in the soft part of the leaf where it deposits its eggs.

The eggs are laid more commonly near the ribs of the leaf, in a series of slits, each slit containing but a single egg. "Some species, on the other hand, introduce their eggs by means of their saws into the edges of leaves (*Nematus conjugatus* Dahlb.), and others beneath the longitudinal ribs of the leaves. A few, indeed, merely fasten their eggs upon the outer surface of the leaves (*Nematus grossulariæ*, etc.), attaching them together like a string of beads (Réaumur, vol. v, plate 10, fig. 8), whilst a few place them in a mass on the surface of the leaf (ibid, plate 11, figs. 8, 9)." (Westwood.) The irritation set up by the saws in the wounded leaf, causes a flow of sap which is stated by Westwood to be imbibed by the egg, so that it swells gradually to twice its original size. It is known that the egg of ants increase in size as the embryo develops, and we would

copy his diagram (Fig. 144), showing the venation of the wing (compare Fig. 29 and our nomenclature), with the explanation of parts given by him.

a, stigma; *b*, costa or costal margin; *c*, apical margin; *d*, costal and postcostal veins; *e*, externomedial; *f*, *g*, anal; *h*, posterior margin; *i*, marginal vein; *j*, submarginal vein; *k*, first, second, and third (transverse) submarginal nervures; *l*, recurrent nervures (discoidal); *m*, discoidal vein; *n*, first and second inner apical or submarginal nervures. Bullæ or clear spots, on the veins or nervures, with bullar or clear lines crossing them. 1, 2, marginal or radial cells; 3, 4, 5, 6, submarginal or cubital cells; 7, 8, 9, discoidal cells; 10, costal cell; 11, 12, brachial or medial cells; 13, 14, inner and outer apical cells. (Hinder cells, Hartig. Cellule du limbe, St. Farg.) No. 11 is sometimes the medial, and Nos. 12 and 13 the submedial cells; Nos. 9 and 14 the apical cells; Nos. 7 and 13 discoidal; Nos. 10, 11, 12, 15, the first, second, third and fourth brachial cells; 15, lanceolate cell. 1, open; 2, contracted; 3, petiolate; 4, subcontracted; 5, with oblique cross nervure; 6, with straight cross nervure.

question whether the increase in size of the eggs of the Saw-fly is not rather due to the same cause.

The punctures in the plant often lead, in some genera, to the production of galls, in which the larvæ live, thus showing the near relationship of this family to the gall-flies (Cynipidæ).

The larvæ strongly resemble caterpillars, but there are six to eight pairs of abdominal legs, whereas the caterpillar has but five pairs. Many species curl the hind body up spirally when feeding or at rest. They are usually green, with lines and markings of various colors. They usually moult four times, the last change being the most marked. Most of the larvæ secrete silk and spin a tough cocoon, in which they hibernate in the larva, and often in the pupa state. The pupa has free limbs, as in the other families. The eggs are usually deposited in the leaves of plants, but in a few cases, according to Norton, in slender or hollow stems. While some are slug-shaped, like the Pear-slug, others like *Lyda inanita*, mentioned by Westwood, live on rose bushes, and construct a "portable case, formed of bits of rose-leaves arranged in a spiral coil;" and other species are leaf-rollers, like the Tortricids. The larva of *Cephus* does injury to grain, in Europe, by boring within the stems of wheat. A remarkable instance of the care of the saw-fly for her young, is recorded by Mr. R. H. Lewis, who observed in Australia, the female of *Perga Lewisii* deposit its eggs in a slit next the midribs of an Eucalyptus leaf. They were placed transversely in a double series. "On this leaf the mother sits till the exclusion of the larvæ; and as soon as these are hatched, the parent follows them, sitting with out-stretched legs over her brood, protecting them from the attacks of parasites and other enemies with admirable perseverance." (Westwood.)

The species are mostly limited to the temperate zone, but few being found in the tropics. The perfect insects mostly occur in the early summer, and are found on the leaves of the trees they infest, or feeding on flowers, especially those of the umbelliferous plants.

The genus *Cimbex* contains our largest species, the antennæ ending in a knob. *C. Americana* Leach is widely distributed, and varies greatly in color. The large whitish larva, with a blackish dorsal stripe, may be found rolled up in a spiral on the leaves of the elm, birch, linden and willow trees. When disturbed it ejects a fluid from pores situated above the spiracles. It constructs a large tough parchment-like cocoon, and the fly appears in the early summer.

The genus *Trichiosoma* is recognized by its hairy body, and the antennæ have five joints preceding the three-jointed club. *T. triangulum* Kirby is found in British America and Colorado, and a variety, *T. bicolor* Harris, on Mount Washington; it is black, except the tip of the abdomen, with the fourth and fifth joints of the antennæ piceous, and the thorax is covered with ash-colored hair.

In *Abia* the antennæ are seven-jointed, with the club obtuse; the body is villose, the abdomen having a metallic silken hue. The *Abia caprifolium* Norton (Fig. 145, larva) is very destructive to the Tartarian Honeysuckle, sometimes stripping the bush of its leaves during successive seasons in Maine and Massachusetts. It hatches out and begins its ravages very soon after the leaves are out, eating circular holes in them. It lies curled up on the leaf and when disturbed emits drops of a watery fluid from the pores in the sides of the body, and then falls to the ground. During the early part of August it spins a pale yellowish silken cocoon, but does not change to a pupa, Mr. Riley states, until the following spring. He describes the larva as being common about Chicago; that it is "bluish green on the back, and yellow on the sides, which are pale near the spiracles, and covered with small black dots. Between every segment is a small, transverse, yellow band, with a black spot in the middle and at each end. Head free, of a brownish black above and color of the body beneath." The fly is described by Norton as being black, with faint greenish reflections on the abdomen; there are two white bands at the base of the metathorax, and the wings are banded. It is .36 inch long and the wings expand .70 inch. The larvæ can easily be destroyed from their

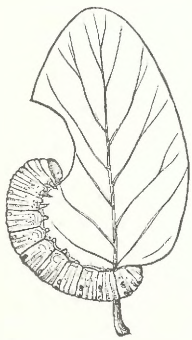


Fig. 145.

habit of falling to the ground when the bush is shaken, where they can be crushed by the foot. Dr. Fitch has reared *Abia cerasi* from one or two cocoons found on the wild cherry, the fly appearing in New York during March.

Hylotoma is a much smaller genus; the basal joint of the antenna is oval, while the second is small and round, and the terminal joint is very long. The larva is twenty-footed, and when eating curves the end of the body into the form of an S. The pupa is protected by a gauzy, doubly enveloping cocoon. *H. McLeayi* Leach is wholly black, sometimes with a tinge of blue. It is found throughout the Northern States.

The genus *Pristiphora*, closely allied to Nematus, is known by its nine-jointed antennæ, and the single costal cell; the first submarginal (subcostal) cell having two recurrent veinlets. *P. identidem* Norton has been discovered by Mr. W. C. Fish to be destructive to the cranberry on Cape Cod. He has reared the insect, and sent me the following notes on its habits, while the adult fly has been identified by Mr. Norton, to whom I submitted specimens. The larvæ were detected in the first week of June, eating the leaves; "they were light or pale yellowish green when first hatched." and grew darker with age. The head of the young was dark, but in the full-grown worm lighter. When full-grown they were about .30 of an inch in length, and had two lighter whitish green stripes running along the back from head to tail. They had spun their cocoons by the 20th of June in the rubbish at the bottom of the rearing bottles. On the 29th of June they came out in the perfect state. We would add to this description that the body, in two alcoholic specimens of the larvæ, was long, cylindrical, and smooth, with seven pairs of abdominal feet. The head is full, rounded and blackish, but after the last moult pale honey-yellow. The male is shining black, and Mr. Norton informs me that it is his *P. idiota*. *P. grossulariæ* Walsh is a widely diffused species in the Northern and Western States, and injures the currant and gooseberry. The female fly is shining black, while the head is dull yellow, and the legs are honey-yellow, with the tips of the six tarsi, and sometimes the extreme tips of the hinder tibiæ and of the tarsal joints pale dusky for a quarter of their length. The wings are partially hyaline, with black veins, a honey-yellow costa, and a dusky stigma, edged with honey-yellow. The male differs a little in having black coxæ. Mr. Walsh states that the larva is a pale grass-green worm, half an inch long, with a black head, which becomes green after the last moult, but with a lateral brown stripe meeting with the opposite one on the top of the head, where it is more or less confluent; and a central brown-black spot on its face. It appears the last of June and early in July, and a second brood in August. They spin their cocoons on the bushes on which they feed, and the fly appears in two or three weeks, the specimens reared by him flying on the 26th of August. *P. sycophanta* Walsh is an "inquiline," or guest gall-saw-fly, inhabiting a Cecidomyian gall on a willow.

The genus *Euura* comprises several gall-making species. It differs from the preceding genus in the second, instead of the first, submarginal cell having two recurrent venules. Mr. Walsh has raised *E. orbitalis* Norton (E. genuina Walsh) from galls found on Salix humilis. This gall is a bud which is found enlarged two or three times its natural size, before it unfolds in spring. The larva is twenty-footed, is from .13 to .19 of an inch long, of a greenish white color, and the head is dusky. It bores out of its gall in autumn, descending an inch into the ground, where it spins a thin, silken, whitish cocoon. The gall of *E. salicis-ovum* Walsh is found on Salix cordata. The female is shining yellow, while the ground color of the male is greenish white. The gall of this species is an oval roundish, sessile, one-chambered, green or brownish swelling, .30 to .50 of an inch long, placed lengthwise on the side of small twigs. The larva is pale yellowish, and the fly appears in April. The fly is, according to Walsh, "absolutely undistinguishable by any reliable character from the guest gall-saw-fly, *Euura perturbans* Walsh," which inhabits dipterous galls made by Cecidomyian flies on the willow and grape (Walsh). If these two "species" do not differ from each other, either in the larva or adult state, "by any reliable characters," then one must question whether the variation in habits is sufficient to separate them as species, and whether E. salicis-ovum does not, sometimes, instead of forming a new gall, lay its eggs in a gall ready-made by a dipterous gall-fly. We have seen that Odynerus albophaleratus, which usually makes a mud cell situated in the most diverse places, in one case at least, makes no cell at all, but uses the tunnel bored out by a Ceratina! and yet we should not split this species into two, on account of this difference in its habits. We had written this before meeting with Mr. Norton's remark that "it is difficult to give a hearty assent to Mr. Walsh's inquilines or guest-flies, without further investigation." (Transactions of the American Entomological Society, vol. i, p. 194.)

In *Nematus* the nine-jointed antennæ have the third joint longest. There is one costal and four subcostal cells, the second cell receiving two recurrent veinlets; the basal half of the lanceolate cell is closed; the hind wings have two middle cells, and the tibiæ are simple.

The larvæ are hairy with warts behind the abdominal feet. They have twenty feet, the fourth and eleventh segments (counting the head as one) being footless. They are either solitary, feeding upon the leaves of plants, or social and generally found on pine trees, while some species live in the galls of plants. The pupa, according to Hartig, is enclosed in an egg-shaped cocoon, like that of Lophyrus, but less firm, though with more outside silk. It is generally made in the earth, or in leaves which fall to the ground. *N. vertebratus* Say is green, with the antennæ and dorsal spots blackish, the thorax being trilineate. There are fifty species in this country, of which the most injurious one, the Gooseberry saw-fly, has been brought from Europe. This is the *N. ventricosus* Klug which was undoubtedly imported into this country about the year 1860, spreading mostly from Rochester, N. Y., where there are extensive nurseries. It does more injury to the currant and gooseberry than any other native insect, except the currant moth (Abraxas? tiliaria). Professor Winchell, who has studied this insect in Ann Arbor, Michigan, where it has been very destructive, observed the female on the 16th of June, while depositing her cylindrical, whitish and transparent eggs, in regular rows along the under side of the veins of the leaves, at the rate of about one in forty-five seconds. The embryo escapes from the egg in four days. It feeds, moults and burrows into the ground within a period of eight days. It remains thirteen days in the ground, being most of the time in the pupa state, while the fly lives nine days. The first brood of worms appeared May 21, the second brood June 25. Winchell describes the larva as being pale-green, with the head, tail and feet, black, with numerous black spots regularly arranged around the body, from which arise two or more hairs. Figure 146, 1, shows the eggs deposited along the under side of the midribs of the leaf; 2, the holes bored by the very young larvæ, and 3, those eaten by the larger worms.

In transporting gooseberry and currant bushes, Walsh recommends that the roots be carefully cleansed of dirt, so that the cocoons may not be carried about from one garden to another. The leaves of the bushes should be examined during the last week of May, and as only a few leaves are affected at first, these can be detected by the presence of the eggs and the little round holes in them, and should be plucked off and burnt. The female saw-fly is bright honey-yellow, with the head black, but yellow below the insertion of the antennæ. The male differs in its black thorax, and the antennæ are paler reddish than in the female.*

Fig. 146.

The genus *Emphytus* has nine-jointed antennæ; the third

* Mr. Norton has communicated the following description of the larva of another saw-fly of this genus which infests the weeping-willow.

"*Nematus trilineatus* Norton. The larvæ of this were first seen upon the weeping-willows about August 1st, in immense numbers, almost wholly stripping large trees of their leaves. They begin upon the edge of the leaf and eat all of it except the inner midrib. They are very sensitive to disturbances, very lively, and are generally found with the hinder part of their bodies bent up over the back. They are twenty-footed, of a bright green color, palest at head and tail, with five rows of black dots down the back, the outer row upon each side irregular and with intervals. On each side above the feet is another row of larger black dots, and the three anterior pair of feet are black at the base, middle and tip.

"A great number of the saw-flies were found flying about the trees, August 19th, in the proportion of about ten males to one female. The males being almost wholly black upon the thorax."

and fourth joints of equal length; the wings have two subcostal and three median cells, the first as long as the second, generally longer; the first receiving one recurrent vein, the second two. We have found the larva of *E. maculatus* Norton on the cultivated strawberry, to which, in the Western States, it sometimes does considerable damage, but it can be quite readily exterminated by hand-picking. Mr. Riley has carefully observed the habits of this insect, and we condense the following remarks from his account in the *Prairie Farmer*: — Early in May, in Northern Illinois, the female saw-fly deposits her eggs in the stem of the plant. They are white and .03 of an inch long, and may be readily perceived upon splitting the stalk; though the outside orifice, at which they were introduced, is scarcely perceptible, their presence causes a swelling in the stalk. By the middle of May the worms will have eaten innumerable small holes in the leaves. They are dirty yellow and

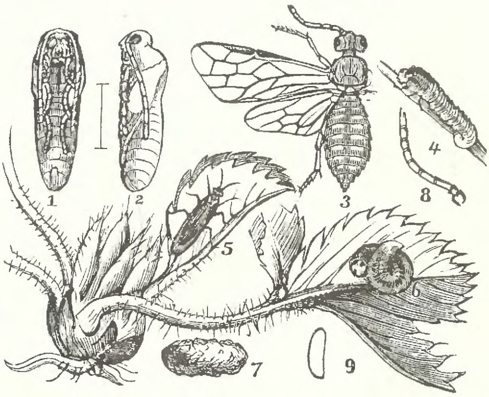


Fig. 147.

gray green, and at rest curl the abdomen up spirally. They moult four times, and are, when full-fed, about three-fourths of an inch in length. They make a loose, earthen cocoon in the ground, and change to perfect flies by the end of June and the beginning of July. A second brood of worms appear, and in the early part of August descend into the ground and remain in the larva state until the middle of the succeeding April, when they finish their transformations. The fly is pitchy black, with two rows of dull, dirty white, transverse spots upon the abdomen. The nine-jointed antennæ are black, and the legs are brown, and almost white at the joints. Fig. 147 represents the Strawberry Emphytus in all its stages of growth. 1, 2, ventral and side-view of the pupa; 3, the fly enlarged;

5, the same, natural size; 8, an antenna enlarged; 4, the larva while feeding; 6, the same, at rest; 7, the cocoon; 9, an egg enlarged.

Of the genus *Dolerus*, known by the second submarginal cell receiving two recurrents, *D. arvensis* Say, is a common blue-black species found in April and May on willows.

The genus *Selandria* is the most injurious genus of the family. It embraces the Pear and Rose-slugs, the Vine-slug and the Raspberry slug. The flies are small, black, with short and stout nine-jointed antennæ, and broad thin wings. "The larvæ are twenty and twenty-two-footed, presenting great differences in appearance and habit, being slimy, hairy or woolly, feeding in companies or alone, eating the whole leaf as they go, or, removing only the cuticle of the leaf, and forming sometimes one and sometimes two broods in a year. *Selandria vitis*, the Vine-slug, is twenty-footed; it has a smooth skin, and the body is somewhat thickened in the middle but slender towards the tail. "While growing, the color is green above, with black dots across each ring, and yellow beneath, with head and tail black. They live upon the vine and are very destructive, feeding early in August in companies, on the lower side of the leaf, and eating it all as they go from the edge inwards. There are two broods in a season. The fly is shining black, with red shoulders, and the front wings are clouded." (Norton.)

Fig. 148.

S. rubi Harris feeds on the raspberry, appearing in May. The larva is green, not slimy, and feeds in the night, or early in the morning. *S. tiliæ* feeds on the linden. The Pear-slug, *S. cerasi* Peck (Fig. 148, larvæ feeding on a leaf of the pear, and showing the surface eaten off in patches; *a*, enlarged; *b*, fly), is twenty-footed; it narrows rapidly behind the swollen thorax, and is covered with a sticky olive-colored slime. It feeds on the upper side of the leaves of both the wild and cultivated cherry and pear trees, and has been found on the plum and mountain-ash. It appears in June and September. The fly is shiny black, with the tips of the four anterior femora, and the tibiæ and tarsi, dull white. An egg-parasite, belonging to the genus Encyrtus, renders, according to Peck, a great number of its eggs abortive.

The Rose-slug, *Selandria rosæ* Harris, is longer than the Pear-slug, the body being scarcely thickened anteriorly, and not covered with slime. It is pale-green and yellowish beneath. It appears in July and August, and does great injury in disfiguring and killing the leaves of the rose, which remain dried and withered on the bush. When full-fed, the larva, like the Pear-slug, makes a cocoon beneath the surface of the ground. The flies are seen in abundance about the rose-bushes as soon as the leaves are expanded, when they may be caught with nets, or the hand on cloudy days. Hand-picking, and the application of a very weak solution of carbolic acid, coal oil, whale oil soap, or quassia, are useful in killing the larvæ.

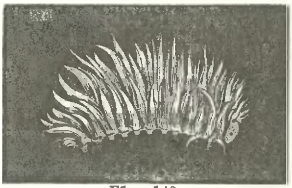


Fig. 149.

On the 25th of July a young friend brought me a large number of some remarkable larvæ (Fig. 149, natural size) of a saw-fly, which I surmised might belong to this genus. It presented the appearance of an animated, white, cottony mass, about an inch long and two-thirds as high. The head of the larva is rounded, pale whitish, and covered with a snow-white powdery secretion, with prominent black eyes. The body (Fig. 150, naked larva) is cylindrical, with eight pairs of abdominal legs, the segments transversely wrinkled, pale pea-green, with a powdery secretion low down on the sides, but above and on the back, arise long, flattened masses of flocculent matter (exactly resembling that produced by the woolly plant-lice and other Homopterous Hemiptera) forming an irregular dense cottony mass, reaching to a height equal to two-thirds the length of the worm, and concealing the head and tail. On the 27th and 28th of July the larvæ moulted, leaving the cast skins on the leaf. They were then naked, a little thicker than before, of a pale-green color,

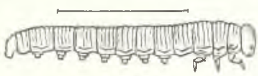


Fig. 150.

and were curled on the leaf. They eat out the edge of the leaf of the butternut tree. Sometime during August, two cocoons were spun between the leaves, but I did not succeed in raising the saw-fly. On describing the larva, in a letter to Mr. E. Norton, he kindly sent me alcoholic specimens of larvæ (without the woolly substance, which dissolves and disappears in alcohol) found feeding on the hickory, which are apparently, from the comparison of alcoholic specimens, identical with the Butternut Selandria. The adult fly (Fig. 151, ♂, *a*, cocoon), he has named *S. caryæ*, of which he has kindly furnished me with the subjoined description.*

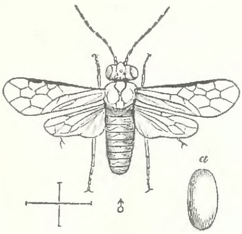


Fig. 151.

Allantus is closely related to Selandria, both in its structure and its habits, but differs in having the antennæ short and somewhat clavate. *A. basilaris* Say is a common species.

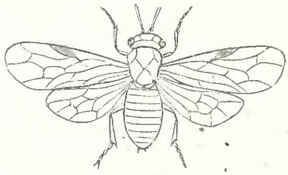


Fig. 152.

The Pine saw-fly, *Lophyrus*, may be known by the feathered antennæ of the male. *L. abietis* Harris (Fig. 152, female) infests the fir and pitch-pine. The male is black above and brown beneath, while the female is yellowish brown above,

* *Selandria caryæ* Norton, nov. sp. (Belonging to tribe 2. Under wings with one middle cell. Div. A. Antennæ filiform, short).

Female. Color shining black. The pro- and mesothorax and scutellum rufous, the apex of the latter black; the nasus and legs white, with their tarsi blackish: the base of coxæ and a line down the upper side of the legs black. Antennæ short, the second joint as long as the first; the four final joints together, not longer than the two preceding. Nasus slightly incurved. Claws of tarsi apparently bifid, Wings subviolaceous. Lanceolate cell petiolate, the first submedial cell above it, with a distinct cross vein. Under wings with one submarginal middle cell (all other species have this cell discoidal), the marginal cell with a cross nervure, and all the outer cells closed by an outer nervure, which does not touch the margin. The submedial cell extended nearly to margin. Length, .25 of an inch. Expanse of wings .40 of an inch.

"The male resembles the female, but the under wings are without middle cells. The larvæ feed upon the leaves of the hickory (Juglans squamosa.) They are found upon the lower side of the leaf, sometimes fifteen or twenty upon one leaf, which they eat from the outer extremity inward, often leaving nothing but the strong midribs. They cover themselves wholly with white flocculent tufts which are rubbed off on being touched, leaving a green twenty-two legged worm, about .75

with a short black stripe on each side of the thorax. The larvæ are about half an inch long, of a pale dirty green, yellowish beneath, striped with green, and when full-fed yellowish all over. They are social, and may often be found in considerable numbers on a single needle of the pitch-pine. The larvæ spin tough cocoons among the leaves, and the flies appear during August, but probably in greater numbers in the spring.

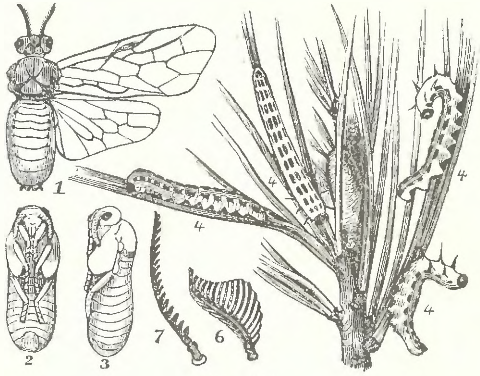


Fig. 153.

These slugs can be best destroyed by showering them with a solution of carbolic acid, petroleum, whale oil soap, or tobacco water. Mr. Fish has sent me the larvæ of a saw-fly, allied to L. abietis, which, in Eastham, Mass., ravaged the young pitch-pines planted in the sandy soil of that region.* The eggs are laid singly in the side of a needle of the pine; though sometimes an egg is inserted on each side of the leaf.

Mr. Riley has described the habits of the White-pine saw-fly,

of an inch in length when fully grown; darkest above, and with indistinct blackish spots upon the sides. The head is white with a small black dot upon each side.

"Specimens were taken upon the leaves July 4th. Went into the ground about the 20th of July. The cocoon is formed near the surface of the ground of a little earth or sand drawn together. Four specimens came forth about August 22d, all seeming very small for so large larvæ."

*On sending specimens of the male and female to Mr. Norton he writes that this is an undescribed species, of which he has prepared the following description:

"*Lophyrus pinus-rigida* Norton. New Species. Female. Length, 0.30; expanse of wings, 0.65 of an inch; antennæ seventeen-jointed, short, brown; color, luteous brown, with a black line joining the ocelli, a black stripe down each of the three lobes of the thorax above, and the sutures behind; body paler beneath; the trochanters and base of the tibiæ waxen; claws with an inner tooth near the middle; wings very slightly clouded; cross nervure of the lanceolate cell straight. Male. Length, 0.25; expanse of wings, 0.55 of an inch; antennæ fifteen-jointed, black, quite short, with twelve branches on each side, those at the base nearly as long as the sixth and seventh; apical joint simple, enlarged at base; color of insect black, with the abdomen at apex and beneath yellow-brown; legs the same color at base; below the knees whitish.

L. Abbotii Leach. The flies appear early in June, and there is but a single brood of larvæ, which remain on the trees, in Illinois, until November, and hibernate before changing to pupæ. The female is honey-yellow, with pale rufous legs, and the male is jet black. Fig. 153 represents, after Riley, the transformations of this species, whose habits closely resemble those of L. abietis. 1, is the fly somewhat magnified; 6, magnified antenna of the male; 7, female antenna; 2 and 3, pupæ; 4, larvæ in different positions, natural size; 5, cocoon. The *L. Lecontei* Fitch has been found feeding on the Scotch and Austrian pines in New Jersey, and has been described by Mr. Riley. The larva is an inch long, dirty or yellowish white, with dorsal black marks wider before than behind, and usually broken transversely in the full-grown individuals; they are farther apart than in L. Abbotii. "The lateral spots are somewhat square, with an additional row of smaller black marks below them, and the last segment is entirely black above. The antennæ of the male fly are twenty-one-jointed, and have on one side seventeen large, and on the other seventeen small branches, there being eighteen on one side and fifteen on the other in L. Abbotii. The female may at once be distinguished from L. Abbotii by her abdomen being jet-black above, with a small brown patch at the end, and a transverse line of the same color just below the thorax."

There are several allied genera, such as *Cladius* (*C. isomera* Harris), *Lyda* (*L. scripta* Say), and *Xyela* (*X. infuscata* Harris), which belong here. The last genus, *Cephus*, which by some

"The females of Lophyrus are all much alike and I have found the number and forms of the joints of the antennæ, so far, the only reliable guide. The male looks precisely like that of *L. abietis*, but the form of the antennæ differs in being much shorter. The female looks much like *L. abdominalis* Say, taken on the pine near New York. The following list will show how the species may be distinguished by counting the number of joints."

L. Fabricii Leach,	male,	not described,	female,	16 joints.	
L. compar Leach,	"	" "	"	16 "	
L. pinus-rigida Norton,	"	15 joints	"	17 "	Pine.
L. Abbotii Leach,	"	not described	"	17 "	"
L. abietis Harris,	"	21 joints,	"	18 "	
L. abdominalis Say,	"	not described,	"	18 "	Pine.
L. pinetum Norton,	"	19 joints,	"	18 "	"
L. Americanus Leach,	"	not described,	"	19 "	
L. insularis Cresson,	"	17 joints,	"	20 "	Pine.
L. Lecontei Fitch,	"	17 "	"	21 "	

authors is placed in the next family, is retained by Norton in the present group. The larva is, in Europe, injurious to rye and wheat, boring in the stems of the plant. *Cephus abbreviatus* Say is our more typical form, though rarely met with. *C. trimaculatus* Say is found in New York early in June, according to Dr. Fitch.

Uroceridæ Leach. The family of "Horntails" are so-called from the long prominent horn on the abdomen of the males, while the ovipositor or "saw," resembling that of the true saw-flies, is attached to the middle of the abdomen, and extends far beyond its tip. They are of large size, with a long cylindrical body and a large head, square next the thorax, but much rounded in front. The antennæ are long and filiform. The larvæ are "cylindrical fleshy grubs, of a whitish color, with a small rounded horny head, and a pointed horny tail. They have six very small legs under the fore-part of the body, and are provided with strong and powerful jaws, wherewith they bore long holes in the trunks of the trees they inhabit. Like other borers these grubs are wood-eaters, and often do great damage to pines and firs, wherein they are most commonly found." Harris farther states that, when about to transform, the larvæ make thin cocoons of silk in their burrows, interwoven with little chips made by the larva. "After the chrysalis skin is cast off, the winged insect breaks through its cocoon, creeps to the mouth of its burrow, and gnaws through the covering of bark over it, so as to come out of the tree into the open air."

Xiphidria is so-called from the sword-like ovipositor, which is much shorter than in the succeeding genera. The body is a little flattened, somewhat turned up behind, and the tip of the abdomen ends in an obtuse point, while the antennæ are short, curved and tapering at the end. *Xiphidria albicornis* Harris is black with yellowish legs and white antennæ, with the two lowest joints black. It is nearly three-fourths of an inch long.

The typical genus of the family is *Urocerus*, which has a large body, with a large ovipositor and long, sixteen to twenty-four-jointed antennæ, while the body of the male ends in a stout acute horn. *U. albicornis* Fabricius has white antennæ, and the female is of a deep blue-black color, while the male is black. It is found on pine trees in July. It is an inch in length.

The genus *Tremex* is known by the wings having two marginal and three submarginal cells. *Tremex Columba* Linn. infests the elm, pear and button-wood. The female is an inch and a half long, rust-red, varied with black, while the abdomen is black with seven ochre-yellow bands on the upper side, all but the two basal ones being interrupted in the middle. They fly during the last of summer.

"Dr. Harris thus describes the habits of this interesting insect. The female, when about to lay her eggs, draws her borer out of its sheath, till it stands perpendicularly under the middle of her body, when she plunges it, by repeated wiggling motions, through the bark into the wood. When the hole is made deep enough, she then drops an egg therein, conducting it to the place by means of the two furrowed pieces of the sheath. The borer often pierces the bark and wood to the depth of half an inch or more, and is sometimes driven in so tightly that the insect cannot draw it out again, but remains fastened to the tree till she dies. The eggs are oblong oval, pointed at each end, and rather less than one-twentieth of an inch in length.

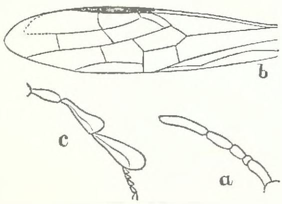


Fig. 154.

"The larva, or grub, is yellowish white, of a cylindrical shape, rounded behind, with a conical, horny point on the upper part of the hinder extremity, and it grows to the length of about an inch and a half. It is often destroyed by the maggots of two kinds of Ichneumon-flies (Rhyssa atrata and lunator of Fabricius). These flies may frequently be seen thrusting their slender borers, measuring from three to four inches in length, into the trunks of trees inhabited by the grubs of the Tremex, and by other wood-eating insects; and like the female of the Tremex they sometimes become fastened to the trees, and die without being able to draw their borers out again."

We have noticed the trunk of an elm, at Saratoga Springs, perforated by great numbers of holes, apparently made by these insects. *T. latitarsus* Cresson (Fig. 154; *a*, antenna; *b*, wing; *c*, hind leg) is remarkable for the expansions on the hind legs. It lives in Cuba.

LEPIDOPTERA.

Butterflies and Moths are readily recognized by their cylindrical, compact bodies; their small head, with its large clypeus; by the maxillæ being prolonged into a tubular

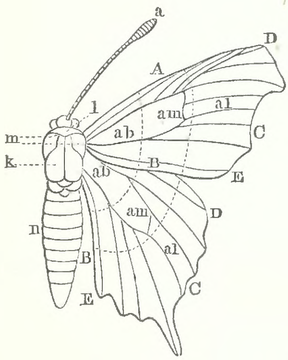


Fig. 155.*

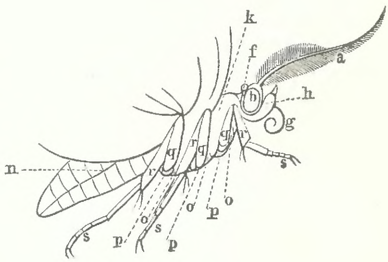


Fig. 156.

"tongue;" the obsolete mandibles; and the broad, regularly veined wings, which are covered with minute scales.

Their transformations are complete; the active larvæ assuming a cylindrical, worm-like form, being rarely footless, and

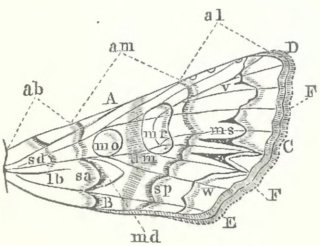


Fig. 157.

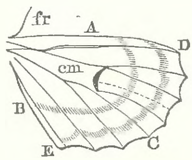


Fig. 158.

having from one to five pairs of fleshy abdominal legs, besides the three pairs of corneous jointed thoracic limbs. A large proportion (butterflies excepted) spin silken cocoons before

*For explanation of cuts, 155 to 171, see pages 233 and 234.

changing to pupæ (chrysalids, nymphs). In the pupa state the limbs and appendages of the head are soldered together, and the head and thorax tend to form one region, upon which the third region, or abdomen, is more or less movable. Three

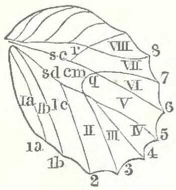


Fig. 159.

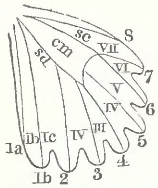


Fig. 160.

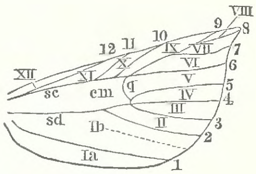


Fig. 161.

or four genera of the lower families are partially aquatic, while, as a whole, the suborder is purely terrestrial.

The three regions of the body are very distinct, but the head, though free, is smaller and with its parts less equally developed

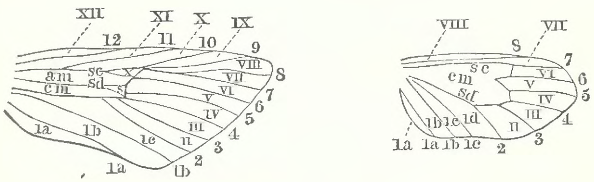


Fig. 162.

than in the Hymenoptera, and the "propodeum" has now become plainly the first abdominal ring. The abdomen is also longer, with the genital armor partially exserted, thus showing a tendency to decephalization. In fine, the whole body is

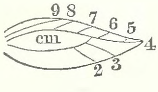


Fig. 163.

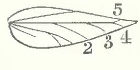


Fig. 164.

loosened and less compact than in the Hymenoptera. Their broad wings; obsolete mouth-parts, with the abnormally developed maxillæ; and active larvæ, with their worm-like shape, are also characters which show that they are more degraded than the Hymenoptera. There is also a greater disproportion in the relative size of the three thoracic rings. In the abdominal rings the pleurites are much larger than in Hymenoptera, where they are partially obsolete. They scarcely use the legs, the fore pair (so remarkably differentiated in the higher Hymenoptera) being partially obsolete in some butterflies (Vanessa, etc.). They are essentially fliers, not having the great variety in the mode of locomotion observable in the Hymenoptera. No parasites are known to occur in this suborder. They are only social while in the larval state, and then merely because their eggs, in such instances, are laid in bunches, and on distinct food-plants to which the larvæ are confined. The adults rarely take an active part in the economy of nature, and have but little opportunity for the manifestation of instinct and reason, though the larvæ in seeking for suitable places in which to undergo their transformations often exhibit wonderful instinct.

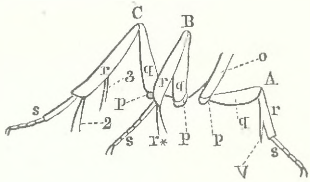


Fig. 165.

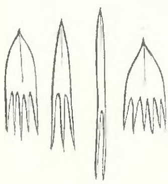


Fig. 166.

The readiest method of determining the natural position of groups is by a comparison of their degradational forms. Thus we find that in the degraded Hymenoptera the tripartite form of the body is preserved; while, on the contrary, in the wingless Lepidoptera (such as the female of Orgyia and Anisopteryx) the body is either oval, the head being less free and smaller than in the winged form, and the thorax and abdomen continuous, their respective rings being of much the same size and shape, while the legs are feeble: or, as in the female of Œketicus, the body is elongated, and worm-like. The wingless moths, then, are much lower than the worker ants, the female Scolia,

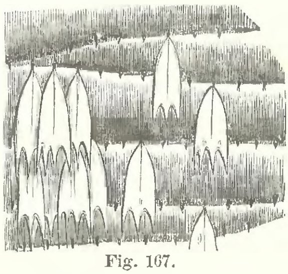


Fig. 167.

etc., giving us an unfailing test of the difference in rank of the two suborders. In their habits and transformations, and in their external anatomy, the Lepidoptera vary less than other insects.

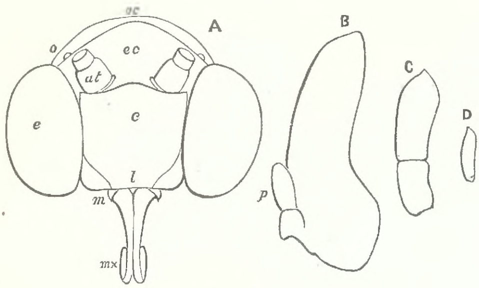


Fig. 168.

The Lepidoptera, while in the perfect state, can be scarcely said to walk much, compared with beetles and other walking insects, the legs being only used to support them while at rest, and not for locomotion. They move almost entirely by their broad wings, which with them are more highly specialized than in other insects. Their fore wings are usually triangular in form, while their hind wings are somewhat square or rounded. The anterior wings are the most typical in form and venation.

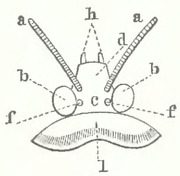


Fig. 169.

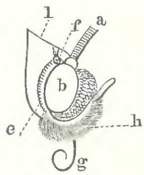


Fig. 170.

The surface, from the costa to the inner edge, may be

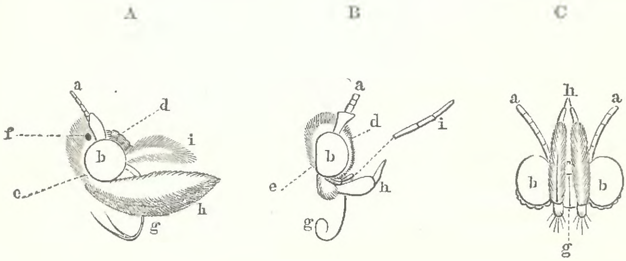


Fig. 171.

divided into three areas,—the costal, median, and internal. There are five principal veins: the costal and subcostal are grouped together, and form the *costa* or front edge of the wing; the median occupies the middle of the wing; and the submedian and internal, the hinder, or internal, area of the wing. The costal vein is usually simple, and joins the costa near its outer third. The subcostal, near the middle of the wing, is usually subdivided into five branches, which are called *venules*, while the median is usually subdivided into one venule less, and the submedian and internal are simple. The last, or fifth, subcostal venule, and the first median venule, generally each throw out a small venule, which meet to form the discal venule, thus enclosing a large central area called the discal area, or cell. There are rarely any cross venules present. Sometimes, as in Hepialus, there is a transverse costal venule, and an interno-submedian venule. They are usually found only in degraded Lepidoptera, and recall the net-veined style of venation of the Neuroptera.

The legs are slender, cylindrical, and weak. The coxæ are closely united with the thorax, the trochanters are spherical,

FIGS. 155, 156, give a general view of the body of a butterfly denuded of scales. FIG. 155. *a*, antenna; *l*, prothorax; *m*, patagia, or shoulder-tippets; *k*, mesoscutum; *n*, abdomen; A, costal edge of fore-wing; D, apex; C, outer edge excavated; E, outer angle; B, inner edge; *ab*, discal cell; *am*, discal venules, throwing off the independent vein, *al*. The dotted lines indicate the inner, middle and outer third of the wing. FIG. 157 illustrates the mode of ornamentation of the wings of moths; *ab*, *am* and *al*, the inner, the middle, and outer third of the wings. The capitals are the same as in FIG. 155; *sd*, the basal line; *sa*. the inner line; *sp*, the outer, and *ms*, the marginal line variously waved, scalloped and angulated. In most of the Noctuidæ are the dentiform spot, 1 *b*; *mo*, the orbicular, and *mr*, the reniform spots; between the two latter often runs the transverse shade, *um*. In FIG. 158, hind wing, *fr* indicates the "bristle" which fits into the "hook" on the fore-wing, uniting the two wings during flight; *cm*, situated in the discal cell, indicates the "lunule," and beyond are the outer and marginal dusky bands. FIG. 159, 1 *a*, internal vein; 1 *b*, submedian vein; 2, 3, 4, 5, the four branches (venules) of the median vein (in FIG. 160, 5 becomes the independent venule); 6 to 12, branches of the subcostal (in FIG. 161, xii, is the costo-subcostal recurrent venule). In FIG. 162, wings of the Hepialus, the venation is more irregular, and in the fore-wing the discal cell is divided into an anterior and posterior discal cellule, by the disco-longitudinal vein; *sd*, *x*, and *s*, accessory cells. In the Tineids the venation is very simple. In FIG. 163, the submedian and internal veins have disappeared; 9 is the costal vein; 2, 3, the two branches of the median vein; 4 to 8, branches of the subcostal vein. In FIG. 164, the internal vein is shortened, and the submedian forked, while the median and subcostal are merged together.—*From Heinemann, in Morris's Synopsis, Smithsonian Miscellaneous Collections.* Compare also FIG. 29 on page 23.

FIGS. 156 and 165. *a*, antenna, on one side wholly, and on the other partially, pectinate; *b*, eye; *f*, ocellus; *h*, labial palpus; *g*, maxillæ or "tongue;" *o*, coxa; *p*, trochanter; *q*, femur; *r*, tibia; V, single anterior spur; *r**, two middle tibial spurs; 2, 3, two pairs of posterior tibial spurs; *s*, tarsus.

and the femora, tibiæ and tarsi, slender and very equal in length. There are usually two tibial spurs. The tarsus is five-jointed, the terminal joint ending in two slender claws.

The scales covering the body of Lepidoptera are simply modified hairs. In studying the wing of the Cecropia moth, we find the hairs of the body and base of the wing gradually passing into the forms represented in Fig. 166. They are attached to the wings and laid partially over one another like the tiles on a roof (Fig. 167). They are inserted in somewhat regular lines, though, as seen in the figure, these lines are often irregular, as shown by the line of scars where the scales have been removed. The scales are beautifully ornamented with microscopic lines. We find, on removing the scales, that the head consists of three well-marked pieces,* *i. e.* the occiput or basal piece which lies behind the ocelli; the epicranium, lying behind the insertion of the antennæ, and carrying the eyes and ocelli, and the clypeus, which constitutes the front of the head. The latter piece is larger than in all other insects, its size being distinctive of the Lepidoptera. There is a general form of this piece for each family, and it affords excellent characters in the different genera, especially among the butterflies (as Mr. L. Trouvelot has shown us in a series of drawings made by him), and the *Zygænidæ* and *Bombycidæ*. It is largest, and most perfectly shield-shaped, in the Attaci. In the *Phalænidæ*, it is smaller, and square; and in the *Tineidæ* it is smaller still, while the occiput and epicranium are larger.

The labrum is remarkably small and often concealed by the overhanging clypeus. The labium is small, short, triangular, and the mentum is nearly obsolete. The lingua is obsolete, its place being supplied by the tongue-like maxillæ. The labial palpi are feebly developed, sometimes rudimentary, and consist

* FIG. 168. A, head of Ctenucha Virginica denuded; *oc*, occiput; *ec*, epicranium, with the two ocelli, *o*, and the base of the antennæ, *at*; *e*, eye; *c*, clypeus; *l*, labrum; *m*, mandible; *mx*, tongue, or maxillæ, with the end split apart; B, rudimentary maxilla of Actias Luna, with its single-jointed rudimentary palpus, showing the mode of attachment to the base of the maxilla; C, two-jointed, rudimentary labial palpus of A. Luna; D, the same, single jointed, of Platysamia Cecropia.

FIGS. 169, 170. Head of a moth in relation to the prothorax (1). FIG. 171, A, B, side view and (C) front view of the head of a moth; *a*, antenna; *b*, eye; *d*, the "front;" *e*, orbit of the eye; *f*, ocellus; *g*, maxilla situated between *h*, the three-jointed labial palpi; *i*, the maxillary palpus, sometimes very large and three-jointed.

of from one to three joints, the terminal one being small and pointed. They are recurved in front of the head, on each side of the spiral tongue, and are covered with hairs; their function, as *touchers* or feelers, seeming to be lost. The mandibles are rudimentary, consisting of a pair of horny tubercles, partly concealed by the front edge of the clypeus. The maxillæ, on the other hand, are remarkably developed. In their rudimentary state, as in Attacus, they form a pair of grooved blades, the hollowed sides being opposed and held

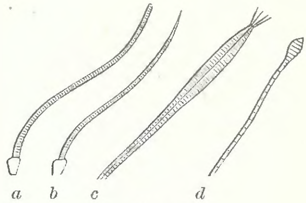


Fig. 172.

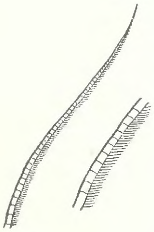


Fig. 173.

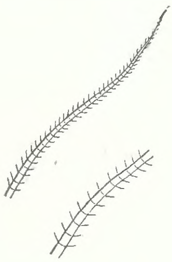


Fig. 174.

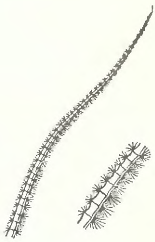


Fig. 175.

together by a row of minute teeth, thus forming a canal. The insect sucks through this long tube the sweets of flowers.

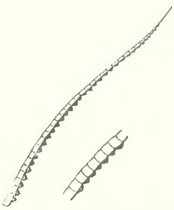


Fig. 176.

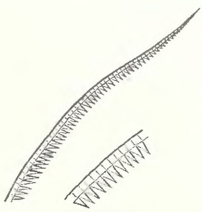


Fig. 177.

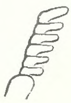


Fig. 178.

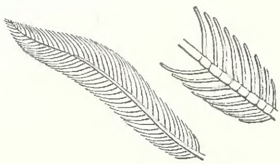


Fig. 179.

The "tongue" is often nearly as long as the body of the insect itself, and when at rest, is rolled up and held between the palpi. At its base are the minute rudimental maxillary palpi, which are generally concealed, but are apparent in the smaller and lower moths, Crambus and the Tineids. They are usually from two to three-jointed, and even five to six-jointed, as in Tinea granella, and longer than the maxillæ, thus resembling the *Phryganeidæ*, or Caddis flies.

In seeking for honey with their long maxillæ, the Lepidoptera play an important part in the fertilization of plants, especially the Orchids.

The ocelli are often present, though they do not form a triangle on the vertex, as there are only two, the third and most anterior one being absent. The eyes are large and globose, and vary in their distance apart in different families.

The antennæ vary greatly; they are either filiform (Fig. 172, *a*), or setiform (Fig. 172, *b*), or fusiform, as in the Sphinges (Fig. 172, *c*), or club-shaped, as in Papilio (Fig. 172, *d*). They are rarely entirely naked, but are finely ciliated (Fig. 173), or have a pair of bristles on each joint (Fig. 174), which are sometimes tufted (Fig. 175). The joints are sometimes toothed (Fig. 176), lamellate (Fig. 177), serrate (Fig. 178), or pectinate (Fig. 179).

The thorax in Lepidoptera is remarkable for the small size of the first, or prothoracic ring, the mesothorax being highly developed. In Telea (Figs. 11 and 12, on page 11) the characteristic form is well shown. The tergal arch of the prothorax is almost obsolete, the scutum alone being represented by a corneous piece, while the pleural parts are more developed as supports for the forelegs. In the mesothorax the præscutum is present, but is usually vertical, being bent down and concealed between the two rings, becoming visible, however, from above in Hepialus (Sthenopis), in which respect it strikingly resembles the position and development of the same piece in the neuropterous Polystœchotes. The scutum is large, with convex sides, broadest behind the middle, and deeply notched for the reception of the triangular scutellum, which is about one-fourth the size of the scutum. The postscutellum is transverse, and situated out of sight, unless the two hinder thoracic rings are separated, under the scutellum. The episterna and trochantines are large, and the whole mesothoracic flanks nearly twice as wide as those of the metathorax. The metathorax is much compressed antero-posteriorly. The scutum is thrown aside as it were by the scutellum into two lateral, nearly square halves, the remaining tergal pieces being usually obsolete and membranous, but in Sthenopis the præscutum and scutellum (Fig. 13, page 12) are large, and meet in the middle of the segment, much as in the neuropterous *Sialidæ* and *Hemerobiidæ*.

The abdomen is oval in Papilio, becoming long and linear in the Tineids. In the *Zygænidæ*, especially, the basal ring is membranous and is partly adherent to the thorax, and somewhat inflated on each side. The number of abdominal segments varies, being either eight or nine; the variation occurring, as stated by Lacaze-Duthiers, in closely allied genera; thus the genital and anal openings are placed more usually behind the eighth, but sometimes behind the ninth segment.

The genital armor is very simple, consisting of two valve-like pieces. The parts beyond (anal stylets, etc.) are aborted, so that the anus and external opening of the oviduct are brought closely together. In the male the parts are more complex, the anal forceps often, as in the Callosamia Promethea, forming long curved hooks for clasping the abdomen of the female.

The nervous system of Lepidoptera, and its changes during the transformations of the larva, have been studied most thoroughly by Herold (in Pieris) and Newport (in Sphinx ligustri and Vanessa urticæ). In the imago the ventral cord consists of seven ganglia, while in the larva there are eleven. This decrease in their number is due to the fusion, during the pupa state, of the first, second, third and fourth ganglia of the larva, exclusive of those situated in the front part of the head; these form the two thoracic ganglia which distribute nerves to the legs and the muscles of the wings. Meanwhile the fifth and sixth ganglia of the larva have either disappeared entirely, or been united with the others.

The digestive system (see Fig. 44, on page 35) of butterflies and moths is modified to suit their peculiar habits. They draw in the sweets of plants through the "tongue" by a sucking stomach which opens into the hinder end of the œsophagus. "The ileum is long, small, and nearly always forms several convolutions. The colon is constantly of a large size, and is often dilated into a cæcum at its anterior portion." (Siebold.) The salivary glands are composed of two simple tubes, which are very large in the larval state, extending into the abdomen.

The respiratory system is normal and well developed. In the larva the stigmata are wanting on the second and third thoracic and last abdominal segment. In those species of *Sphingidæ*, *Bombycidæ* and *Noctuidæ*, which have a long-sustained flight there are numerous vesicular dilatations of the tracheæ.

The urinary tubes are six in number; they are long, free, and open into the stomach by two excretory ducts.

The silk-glands consist of two long, flexuous, thick-walled sacs, situated on the sides of the body, and opening by a common orifice on the under lip (labium) usually at the extremity of a short tubular protuberance (Siebold). They are most developed when the larva approaches the pupa state. We once found a larva of Clisiocampa Americana that had just spun its cocoon, and to ascertain whether the silk had been exhausted, we removed the worm from its cocoon, when it spun another, but thinner one; and upon removing it a second time it spun a third very thin cocoon, before the supply of silk was entirely exhausted.

The ovary consists of four very long, spiral, multilocular tubes. The *receptaculum seminis* is pyriform, and often has a long, spiral *ductus seminalis*. At its base is situated a large, double sebaceous gland; and there are two small ramose glands, perhaps odoriferous, situated at the orifice of the vagina. The copulatory pouch is a remarkably large, pyriform reservoir, having for the reception of the male intromittent organ a canal, which opens by a special orifice, situated below and behind the external opening of the oviduct. (Siebold.)

The testes form two round or oval follicles, and the two short deferent canals unite with two simple and very flexuous accessory glands, to form the long *ductus ejaculatorius*.

Several interesting cases of hermaphroditism in butterflies and moths have been published by European entomologists. Mr. Edwards has noticed two remarkable instances in the Proceedings of the Philadelphia Entomological Society (vol. iv,

p. 380), the latter of which we have also seen. "A specimen of Papilio Asterias is in my collection, and was captured by Mr. J. Meyer of Brooklyn, L. I., two or three years since. It is a fine instance of a perfect hermaphrodite. The right wings are both male, the left wings both female, distinctly marked upon both surfaces with no suffusion of color. The size is that of the largest specimens of Asterias. The Saturnia Promethea is in the collection of Mrs. Bridgham of New York, and is a curious instance of an imperfect hermaphrodite. The left antenna and left primary are male; the right antenna and left secondary are female; the right primary is also female, but the right secondary is something between the two, neither male nor female. The color of the upper surface is nearly the same as the under surface of the male. On the under side the color and markings of the left primary are male, but the other three wings are female. The color and markings of the male Promethea are quite different from those of the female, and on this hermaphrodite the confusion of the sexes is conspicuous. It is a bred specimen. The body had been viscerated, so that it is impossible to determine its sex."

The larva of Ctenucha, which resembles that of Arctia, constructs its cocoon out of the hairs of its body, without spinning any silken threads, so far as we could ascertain by microscopical examination. The hairs of this, as of probably most hairy caterpillars, but more especially the Bombycid larvæ, are thickly armed with minute spinules, so that by being simply placed next to each other, they readily adhere together. The cocoon is finished in about twelve hours. We once noticed a Ctenucha larva just beginning its cocoon. Early in the morning it described an ellipse upon the side of the glass jar in which it was confined, out of hairs plucked from just behind its head. From this elliptical line as a base, it had by eight o'clock built up, rather unequally, the walls of its cocoon, in some places a third of the distance up, by simply piling upon each other the spinulated hairs, which adhered firmly together. At four o'clock in the afternoon, the arch was completed, and the larva walled in by a light partition, and soon afterwards the thin floor was made. No silk is spun throughout the whole operation, while in the cocoon of Pyrrharctia isabella there is a slight frame-work of silk upon which the hairs are placed.

Trouvelot states that the Polyphemus larva constructs its cocoon by drawing the leaves together as a support for the threads, forming the foundation of the cocoon. "This seems to be the most difficult feat for the worm to accomplish, as after this the work is simply mechanical, the cocoon being made of regular layers of silk united by a gummy substance. The silk is distributed in zig-zag lines of about one-eight of an inch long. When the cocoon is made, the worm will have moved his head to and fro, in order to distribute the silk, about two hundred and fifty-four thousand times. After about half a day's work, the cocoon is so far completed that the worm can hardly be distinguished through the fine texture of the wall; then a gummy, resinous substance, sometimes of a light brown color, is spread over all the inside of the cocoon. The larva continues to work for four or five days, hardly taking a few minutes of rest, and finally another coating is spun in the interior, when the cocoon is all finished and completely air-tight. The fibre diminishes in thickness as the completion of the cocoon advances, so that the last internal coating is not half so thick and so strong as the outside ones."

In those moths which spin a thick cocoon, the pupa, a few days previous to its exit, secretes an acid fluid from two glands opening into the mouth. This fluid, according to Mr. L. Trouvelot (American Naturalist, vol. i, p. 33), in his account of the Polyphemus silk-worm, dissolves the hard gummy substance uniting the silken threads, until after the expiration of half an hour, the moth is able to push the fibres aside, and work its way out, without breaking a thread.

Trouvelot says that the larvæ of the Polyphemus moth (and this remark will probably apply to all other Lepidopterous larvæ) seem entirely unable to discern objects with their simple eyes, but can distinguish light from darkness.

In their adult state butterflies and moths take but little food, consisting of honey, though Papilio Turnus, according to a Canadian observer, is attracted to heaps of decaying fish.

Caterpillars grow very rapidly, and consume a great quantity of food. Mr. Trouvelot gives us the following account of the gastronomical powers of the Polyphemus caterpillar. "It is astonishing how rapidly the larva grows, and one who has no experience in the matter could hardly believe what an amount of food is devoured by these little creatures. One experiment which I made can give some idea of it: when the young silk worm hatches out, it weighs one-twentieth of a grain; when

10 days old it weighs	1-2 a grain, or	10 times its original weight.							
20 " " " "	3 grains "	60 " " " "							
30 " " " "	31 " "	620 " " " "							
40 " " " "	90 " "	1800 " " " "							
56 " " " "	207 " "	4140 " " " "							

When a worm is thirty days old it will have consumed about ninety grains of food; but when fifty-six days old it is fully grown and has consumed not less than one hundred and twenty oak leaves weighing three-fourths of a pound; besides this it has drank not less than one-half an ounce of water. So the food taken by a single silk-worm in fifty-six days equals in weight eighty-six thousand times the primitive weight of the worm. Of this, about one-fourth of a pound becomes excrementitious matter; two hundred and seven grains are assimilated and over five ounces have evaporated. What a destruction of leaves this single species of insect could make if only a one hundredth part of the eggs laid came to maturity! A few years would be sufficient for the propagation of a number large enough to devour all the leaves of our forests." The Lepidoptera are almost without exception injurious to vegetation and are among the chief enemies of the agriculturist.

They are rarely found fossil owing to the delicacy of their bodies. Remains, doubtfully referred to the Lepidoptera, have been found in the Jura formation. A Sphinx-like moth has been discovered in the Tertiary formation of Europe, and a few minute forms have occurred in Amber.

Butterflies are easily distinguished from the other groups by their knobbed antennæ. In the Sphinges and their allies the feelers are thickened in the middle: in the Moths they are filiform and often pectinated like feathers. Lepidoptera have also been divided into three large groups, called Diurnal, Crepuscular and Nocturnal, since butterflies fly in the sunshine alone, most Sphinges in the twilight (some of them, however, fly in the hottest sunshine), while the moths are generally night-fliers, though many of them fly in the day time, thus showing that the distinctions are somewhat artificial.

The larger Lepidoptera (butterflies and the larger moths)

16

have been called *Macrolepidoptera*, while the smaller ones, including the smaller *Pyralidæ*, the *Tortricidæ*, and the *Tineidæ*, are called *Microlepidoptera*.

In studying these insects the best generic characters will be found in the antennæ, the shape of the head-parts, the venation and proportions of the wings: very slight changes in these parts separating genera and species. Size and coloration, which are usually very constant, afford good specific characters.

A good method of preserving larvæ dry, adopted at Dresden, is to squeeze out the intestines through a hole made near the anal extremity of the larva, then to insert a fine straw, after which it may be placed in a glass vase, itself placed in a tin vessel and held over a lamp; the larval skin is blown while suspended over the lamp, by which the skin dries faster. It may be done with a small tube or blow-pipe fixed at the end of a bladder, held under the arm or between the knees, so as to leave the hands at liberty; and the straw which is inserted into the body of the larva may be fastened by a cross-pin stuck through the skin, and thus retained in its proper position throughout the process of blowing. The small larvæ, such as those of the Tineæ, may be put alive into a hot bottle, baked until they swell to the proper extent and dry, when they can be pinned with all their contents inside. (Westwood, Proceedings of the Entomological Society of London, Sept. 7th, 1863.)

Dr. Knaggs has, in the Entomologist's Monthly Magazine, given some directions for managing caterpillars. Very young caterpillars, which will not eat the food provided, and become restless, should be reared in air-tight jam-pots, the tops of which are covered with green glass to darken the interior of the vessel. When small larvæ hide themselves by mining, entering buds and spinning together leaves, they should have as small a quantity of food as possible. In changing larvæ from one plant to a fresh one, a slight jar or puff of breath will dislodge them, and they can be transferred to the jam-pot, or the glass cylinder, covered at one end with muslin, can be turned muslin end downwards for them to crawl upon. The duplicate breeding cage, pot or tube, should be "sweetened" by free currents of fresh dry air and then stocked with fresh food.

Dr. Knaggs advises that "hiding places," or bits of chips, etc., be provided for such Noctuid larvæ as naturally lie concealed, such as *Orthosia*, *Xanthia*, *Noctua*, etc., "while for *Agrotis* and a few others a considerable depth of fine earth or sand is necessary."

"Larvæ, which in nature hibernate, must either be stimulated by warmth and fresh food to feed up unnaturally fast, or else through the winter must be exposed to out-door temperature." For such larvæ as begin to eat before the trees are leaved out, the leaves of evergreens must be provided, pine leaves, chickweed, grasses and mosses. Hibernating, living larvæ, must during the winter be kept dry, otherwise the damp seems to hang about their fur, and causes them to be attacked by a white fungus; while smooth larvæ require the natural dampness of the soil. Mr. Gibson strongly recommends that during the winter all cages containing larvæ be placed in front of a window facing the east or north-east, so that the inmates may be kept as cool as possible.

When the moth is fairly out of the pupa, as remarked by Mr. Sanborn, their wings often fail to properly expand, on account of the want of moisture, "the insect being unable to expand its wings in a heated, dry room. He has avoided this difficulty by placing the insect just emerged, or about to come forth, beneath a bell-glass, within which he had placed moistened pieces of bibulous paper."

Mr. Trouvelot has noticed that the difference in size of the wings of moths or butterflies is due to the fact that some of the fluid thrown into the wings during their development escapes from a break in the surface of the wing, so that this wing is smaller than the other. He has, by pinching a wing while thus developing, caused the fluid to "flow from the puncture, and immediately the wing so wounded ceased to grow, while the three others continued their development to its full extent." "I have sometimes advanced the development of the wings of Telea Polyphemus. I selected for this purpose, pupæ very far advanced in their transformation, as is shown by the looseness of the pupal skin, and by the color of the wings of the moth, which can be seen through it. I took carefully the pupal skin from around the moth and suspended the insect in the position that Lepidoptera take when emerging from the chrysalis. It is very rare that the wings of such an insect are developed, though I have obtained some perfect specimens in this way; and in one instance the development of the wings took place only three days after the pupal skin had been removed. Success is more certain if the insect is put under a glass jar with a moistened sponge, and something for the insect to hang from; the dampness of the air in the jar will prevent the soft wings from drying too fast, and when the time arrives for the insect to accomplish its transformation, the fluid will be active. Such an insect has much analogy with a vertebrate born prematurely; the insect, like the quadruped, remains almost motionless till the natural time for its birth arrives."

Papilionidæ Latreille. The Butterflies, or Diurnal Lepidoptera, are at once distinguished from the moths by their knobbed antennæ, though they are sometimes nearly filiform. The body is small, but there is a greater equality in the size of the three regions than in the moths, the abdomen being much shorter and smaller, as a general rule, than in the lower families. The ocelli are usually wanting; the spiral tongue or maxillæ, are long and well developed; and the wings are carried erect when in repose, and are not held together during flight by a bristle and socket as in the moths.

The larvæ vary greatly in shape and in their style of ornamentation, but they uniformly have, besides the thoracic legs, five pairs of abdominal legs. The pupa is called a "chrysalis" or "aurelian" from the bright golden hues which adorn those of many species. They disappear as the wet tissues beneath the pupa-skin harden just before the fly appears. The pupa is usually angulated on the sides of the thorax and along the upper side of the abdomen. A few species, such as those of Vanessa, hibernate, while several species, such as Vanessa Antiopa, are social as young larvæ. The most "perfect state of society is exhibited by a Mexican butterfly (Eucheira socialis Westwood), the caterpillars of which construct a very strong parchment-like bag, in which they not only reside, but undergo their change to the pupa state." Butterflies also occasionally swarm while in the perfect state, such as species of Colias, Cynthia and Danais, multitudes of which are sometimes seen passing over-head in long columns. They are truly tropical insects, since Gerstaecker mentions that three times as many species (600) occur at a single point (Para, Brazil) as in all Germany, where scarcely 200 species live. There are about 5,000 species known; 900 inhabit North America and probably the number will be increased to a thousand, while Mr. Scudder enumerates ninety-five species which have already been found in New England.

The noble genus *Ornithoptera* has very long, slightly knobbed antennæ, and a well developed prothorax; while the fore-wings are very large, elongated, triangular, and the hind wings are relatively smaller and rounded. *O. Priamus* Linn. is found in the Moluccas. There are twenty species known. The larvæ differ from those of Papilio in having an external forked sheath for the "tentacles." The pupa is sustained by a silken thread on each side, attached to a small lateral tubercle.

Of the extensive genus *Papilio*, or "Swallow-tail," over 300 species are known. The larva is rather short and stout, with a v-shaped scent-organ, or "tentacles." The pupa is supported by a filament passed entirely around it. The common *P. Asterias* Drury appears in New England in June, when it lays its eggs on the leaves of parsley and other umbelliferous plants. From this brood a new set of butterflies appear in August. The larva is yellow, striped and spotted with black, and when irritated, pushes out, from a slit in the prothoracic ring, a v-shaped, yellow, fleshy, scent-organ, used as a means of defence. The chrysalis is free, attached by the tip of the abdomen and supported by a loose silken thread, which is passed over the back. It lives in this state from nine to fifteen days. It has two ear-like projections on each side of the head and a prominence on the back of the thorax.

Mr. W. Saunders has received from St. John's, Newfoundland, several specimens of a butterfly, one of which I have before me, and which seems to be a very remarkable variety of P. Asterias, rather than a distinct and undescribed species, as supposed by my friend to whose collection it belongs. He writes me, after giving a detailed description, presented below,*

* "*Papilio brevicauda* Saunders. Female. Expands three and one-fifth inches; head, palpi and antennæ black; thorax black, fringed with yellow hairs on each side, for about half its length; body above black, with a row of seven or eight yellow spots along each side which are largest about the middle of the row; under

that "this species resembles P. Asterias, but differs from it in many points. In P. Asterias the palpi are edged within with yellow; in P. brevicauda they are black. P. Asterias has two yellow spots above at the base of the antennæ, which are either wanting, or exceedingly faint in the other species. P. Asterias has a spot of bright yellow on the anterior edge of each side of the thorax; P. brevicauda has a fringe of duller yellow, extending fully half the length of the thorax. On the primaries the discal bar in P. Asterias is much narrower, and the inner row of spots smaller and bright yellow, the upper one in the row being divided; in P. brevicauda the spots are fulvous, the upper

side of the body black, the abdomen being furnished with two rows of yellow spots corresponding with those above, with several additional spots within near the tip; feet black. Primaries above brownish black, with a bar of yellow across the end of the discal cell; just beyond this is a row of eight spots, extending across the wing nearly parallel with the outer margin; the upper one, which rests on the subcostal vein, is yellow, elongated and irregular, with a blackish dot beyond the middle: the lower ones are *fulvous;* the second and third smaller than the first and of an elongated, triangular form, with the apex pointing inwards; the fourth, fifth and sixth are similar in shape, but larger, the latter with its apex partially wanting; the seventh spot is wider and slightly concave on both the inner and outer edges, the inner edge is broken; the eighth is long, narrow and irregular, with its lower edge close to the hind margin of the wing. Behind the upper spot in this row is a second yellow spot nearly round. Between these and the outer margin is a second row of spots, eight in number, but much smaller in size. These are all yellow, the three upper ones nearly round, the lower ones more or less elongated, the lowest contracted in the middle as if composed of two spots joined together; the fringe of the wing is also spotted with yellow, the spots corresponding in number and position with those forming the second row.

"Secondaries above brownish black, with a row of seven large spots nearly confluent beyond the middle, in continuation of those on primaries, all more or less triangular in form, the middle ones somewhat elongated; these spots are yellow above and at the sides, fulvous from near the middle to the outer edge; the fulvous marking is less distinct on the second and third spots; within the margin is a second row, all yellow excepting the upper one which is tinged with fulvous; the upper spot is oblong, the second nearly round; third, fourth and fifth lunular, nearly equal in size; the sixth similar in form, but much smaller; while the inner one is irregularly concave above, holding in the cavity the eye-like spot at the anal angle. On the outer edge are six yellow spots, larger and more striking than those forming part of the fringe on the primaries. The space between the two inner rows of spots is sprinkled with metallic blue atoms. At the anal angle is a round, red spot, with a black dot in it below the middle, and a crescent of bluish atoms above; tails *very short*, scarcely one-eighth of an inch long,—not more than half the length of those of P. Asterias.

"Under surface of wings somewhat paler in color, with spots corresponding to those above. The upper spot of the inner row on the primaries is tinted with fulvous; the spots composing the inner row on the secondaries are more decidedly and uniformly fulvous; the four upper spots in the second row are also streaked with the same color; the bluish atoms between the rows are partially replaced by green ones." Taken at St. John's, Newfoundland.

one is undivided. The inner row of spots on the secondaries are also entirely yellow in P. Asterias, smaller and very different in form from those on P. brevicauda. The second row of spots is also smaller in P. Asterias, and the red spot at the anal angle paler, with a smaller black dot in it, and a wider crescent of bluish atoms above. The length of the tail, which is one of the most striking points of difference, has already been noticed."

We have compared some interesting varieties of P. Asterias in the Museum of the Boston Society of Natural History, collected about Boston by Mr. Shurtleff, which approach (in the reddish hue of the spots, usually yellow, especially on the under side, and the shortness of the tail) the Newfoundland specimen kindly sent us by Mr. Saunders, and strongly suggest the inference, with which Messrs. Scudder and Sanborn agree, that P. brevicauda is a very remarkable local variety of P. Asterias.

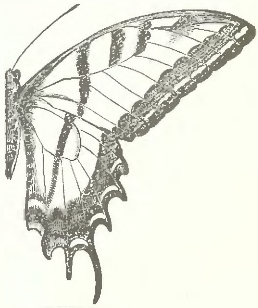


Fig. 180.

The yellow *Papilio Turnus* Linn. flies in June and July through woods and about lilacs. Its larva feeds on the apple and wild thorn; it is green with two eye-like spots on the thorax, and pupates in the middle of August. The black dimorphic ♀ form, P. Glaucus, is found in the Southern States. *P. Daunus* Boisd. (Fig. 180) originally found in Mexico, has been found in Kansas, near the Rocky Mountains, by Mr. James Ridings. He states that it strikingly resembles P. Turnus, but has longer antennæ, with longer, more curved fore-wings, besides differing in other characters. It expands nearly five inches. *P. Troilus* Linn. appears more commonly southward. The larva feeds on the sassafras and lilac trees, and was found by Mr. Saunders feeding, rolled up on a leaf, on the spice bush, August 3d. "Its length was about one and three-fourths inches, the body being thickest from the third to the fifth segments. The head is rather small, flat in front, slightly bilobed, dull flesh color, with a faint tinge of brown. The body is bright pea-green, with a yellow stripe across the anterior part of the second segment; edged behind with dull black. On the fourth segment are two prominent eye-like spots, of dull yellowish or yellowish buff, encircled by a fine ring of black, and a large black pupil filling most of the lower portion. The posterior portion of this black pupil is encircled by a shining bluish black ring, the anterior portion of which strikes a little beyond the middle of the pupil; there is also a line of black in front of the pupil extending nearly across the yellow portion, and a pale pinkish spot in the upper part of the yellow which is edged with a slightly darker shade. On the fifth segment are two large, irregular spots of the same color, pale buff, encircled by a faint ring of black, and having a faint pinkish spot on the anterior portion of each; these spots are nearer to each other than those on the fourth segment, a portion of the space between the fifth and sixth segments being deep black; each segment, from the sixth to the eleventh inclusive, has four blue dots, encircled with black, those on the seventh, eighth and ninth segments being largest. On each side, close to the under surface, is a wide yellow stripe, gradually softening into the green above, and edged below with blackish brown. Immediately below the spiracles is a row of blue dots edged with black, one on each segment from the sixth to the twelfth inclusive. The under surface is dull, pale greenish, or yellowish white, having a decided reddish tinge as it approaches the yellow stripe on the sides. The feet partake of the same general color." *P. Philenor* Fabr. is black, with a greenish reflection towards the outer border, with whitish spots on the margin, and on the hind wings six whitish lunules. The larva is brown, with two lateral rows of small, reddish tubercles, and two long tubercles on the prothoracic segment. The chrysalis (Fig. 181, side and dorsal view) is grayish violet, yellowish on the back, with the head ending in a truncated cone.

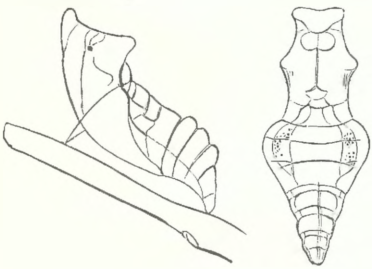


Fig. 181.

The genus *Parnassius* has short, thick antennæ, with a rounded club, and the fore-wings are much rounded at the apex; it inhabits mountains. *P. Smintheus* Doubleday, with three other species, is found in the Rocky Mountains.

The White Turnip, or Cabbage butterfly, *Pieris oleracea* Harris (Fig. 182 ; *a*, larva), is well known as being often destructive to cruciferous plants. In this genus, and its allies, the wings are rounded and entire on the edges, and are grooved on the inner edge to receive the abdomen. The greenish caterpillars are slender, "tapering a very little toward each end, and are sparingly clothed with a short down which is quite apparent, however, in Pieris oleracea." We have found the larvæ of this species on turnip leaves in the middle of August, at Chamberlain Farm in Northern Maine. They are of a dull green, and covered with dense hairs. They suspend themselves by the tail and a transverse loop ; and their chrysalids are angular at the sides, and pointed at both ends. (Harris.) *Pieris oleracea* is white, with the wings dusky next the body, the tips of the fore-wings are yellowish beneath, and the hind wings are straw-colored beneath. The yellowish, pear-shaped, longitudinally ribbed eggs, are laid three or four on a single leaf. In a week or ten days the larvæ are hatched. They live three weeks before becoming full-fed. The chrysalis state lasts ten to twelve days. There is an early summer (May) and a late summer (July) brood. *Pieris rapæ* Schrank has been introduced from Europe and is now found in the vicinity of Quebec and the northern parts of New England.

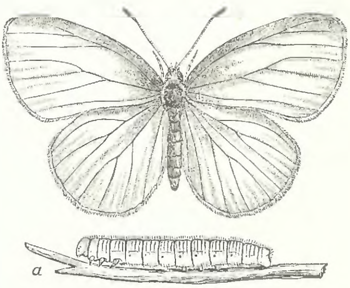


Fig. 182.

P. Protodice Boisd. and Lec. is found southward. The head of the chrysalis, kindly sent me by Mr. Saunders, is prolonged into a tubercle, which is equilaterally triangular, seen in outline, with two small tubercles near the base. On the thorax is a high, thin dorsal ridge, edged with red. On each side of the abdomen is a ridge, largest anteriorly, and rising into a thin tubercle on the second ring. There is a thin dorsal ridge on the posterior half of the abdomen. The tip is deeply excavated by a furrow extending the whole length of the terminal ring. There are seven rows of black dots on each ring.

It is pale whitish straw yellow throughout, with thick, black dots on the anterior half of the body. It is .70 of an inch in length. It also occurs in California.

The Sulphur-yellow butterflies, *Colias*, of which *C. Philodice* Godart, our most common butterfly, is a type, occur everywhere. There are two broods, one appearing in April and May, and the other in July. Mr. Saunders gives me the following history of this butterfly: "The female deposited her eggs on the 24th of July; they were very long, tapering at each end, with twelve or fourteen raised, longitudinal ribs, and smaller cross lines in the concave spaces between them. They hatched on the 31st. The freshly hatched larva is about a thirteenth of an inch long; the head is black, and the body dull yellowish brown. When five-eighths of an inch long, it is nearly the same as when mature; the head being dark green and slightly downy, with minute hairs, which also give a downy appearance to the whole body, which is also dotted minutely with paler points. There is a yellowish white stripe, on each side close to the under surface. Beneath, the body is slightly paler than above. The full grown larva is an inch long, and differs from the young in having an irregular streak of bright red running through the whitish lateral line. It feeds on the clover and lupine, and on the cultivated pea. It is not unlike a saw-fly larva in its appearance and movements, feeding on the upper surface of the leaves and twisting its body into a coil when disturbed. The chrysalis is about seven lines long, girt with a silken thread across the greatest diameter of the body, which is full and bulging on the sides. The head is pointed conically, with a purplish red line on each side, running to the tip and margined behind with yellow. The body is pale green, with a yellowish tinge, and a ventral line of a darker shade formed by a succession of minute, yellowish dots; a yellow stripe runs along the side on the five hinder segments. Beneath, on the seventh, eighth and ninth rings, is a blackish brown line on each side, deepening in color about the middle of each segment, and a dorsal line of dark green about the same length. It remains in the chrysalis state about ten days."

Mr. Scudder has described three species of this genus from the north. *C. Labradorensis* we have taken abundantly in

Labrador. It represents our C. Philodice. *C. interior* lives north of the Great Lakes, and *C. occidentalis* ranges from Fort Simpson to the Gulf of Georgia.

The species of a closely allied genus, *Terias* (*T. Lisa* and *T. Delia*), are much smaller and are more tropical.

The genus *Danais* has antennæ with a long and curved knob, the head and thorax are spotted with white, and the wings are round and entire. The caterpillars have projecting, thread-like horns, arranged in pairs on the top of the second and eleventh segments, and the body (D. Archippus) is banded with yellow, black and white. The oval chrysalids are short and thick and decked with golden spots. The larva of D. Archippus Harris feeds on the silk-weed, Asclepias, and matures in about two weeks, changing its skin three times, while the chrysalis state lasts for ten or twelve days. The butterfly appears from July to September.

A very beautiful and quite aberrant tropical genus is *Heliconia*, in which the wings are small, very narrow and often very transparent, while the antennæ are nearly as long as the body. The larvæ are either long, cylindrical and spinose (Acraea violæ), or furnished with several pairs of long fleshy appendages, and the chrysalids are often brilliantly spotted with golden and suspended by the tail.

According to H. W. Bates (Transactions of the Entomological Society, 1857), the venation of the wing in many species of *Mechanitis* and *Ithomia*, which are allied to Heliconia, varies in different individuals of the same species. The sexes have the closest resemblance in color and markings. They are very gregarious in their habits. The Brazilian "*H. Melpomone* varies in a curious manner. I have no doubt they are hybrids (*i. e.* the varieties), and I can almost point out the species with which it hybridates. Strange to say, the hybrids occur in one district and not in another, and one style of hybrids only occur in one district and not in the others, the species being equally abundant in all the districts."

Argynnis is readily recognized by the numerous round and triangular silver spots on the under side of the hind wings. The very spiny caterpillars have a round head, and the spines are branched, two of the prothoracic ones being the largest and reaching over the head. The angular arched chrysalids have the head either square, or slightly notched, with a smooth thorax, while on the back of the abdomen are two rows of usually gold colored tubercles. They usually feed on violets, and may be found from May to July. *Argynnis Idalia* Drury is found the last of summer. *A. Cybele* Fabr. is found in the Middle States, and *A. Atlantis* Edwards in the White Mountain valleys and the colder portions of New England.

Mr. C. A. Shurtleff discovered the larva and pupa of the latter, July 17th, at Eastport, Maine, and being with him at the time, we made the following description of them: The larva is uniformly cylindrical, tapering alike towards each end of the body. On each side of the vertex of the head is a small low spine, giving the head an oblong shape when seen sidewise. The front is broad, somewhat square, flattened, with scattered hairs. On the first and second thoracic rings are two large subdorsal spines and minute lateral warts bearing small bristles, and on the hind edge of these rings are two large spines. On the third thoracic ring are three large spines. On each abdominal ring are six stout spines of the same size and placed equidistant on the upper surface. The bristles on the spines are nearly one-half as long as the spines themselves. Small papillæ, giving rise to bristles, are scattered over the body, with a row of them above the abdominal feet. The triangular anal plate is small, papilliform and prominent. The larva is dark velvety purple, the base of the head being of a pale horn color; the body beneath is scarcely paler than above; the spines are pale livid on the basal half. They were full-fed and ready to pupate July 17th. The head of the pupa is square in front. On the prothorax are two subdorsal spines, and an elevated mesial ridge on the mesothoracic ring, rising highest behind. At the base of each wing is a sharp, conical, prominent papilla, immediately succeeded by a broad, thin-edged dilatation, constricted and appressed to the base of the abdomen; this is the internal angle of the wings. On the abdomen are two lines of subdorsal sharp papillæ, one on each side. The wings extend to the fifth abdominal ring, and from this point the abdomen rapidly tapers to the tip. The surface of the body is wrinkled with conspicuous black spiracles. Its general color is chestnut brown, mottled with black; the wings being black at the base. The sexes of the rare and superb *A. Diana* Cramer differ remarkably, the male being dark velvety brown, with a deep orange border, while the female is blue-black, with lighter blue spots and patches on the border of the wings. It has been taken in West Virginia, Georgia and Arkansas.

A. Aphrodite (Fig. 183*) abounds in the Northern States. According to Scudder, it is double-brooded, appearing about the middle of June, and fresh specimens late in August. *A. Montinus*, a more diminutive species, was discovered by Mr. Scudder on the lower half of the barren summits of the White Mountains. Allied to this last species by their size, are *A. Myrina* Cramer and *A. Bellona* Fabr. found in damp meadows late in summer. A. Myrina has tawny wings bordered with black above, and expands from one and three-fourths to one and eight-tenths of an inch. A. Bellona differs from the other species by not having any silvery spots on the under side of the wings. Mr. Saunders has reared A. Myrina from eggs deposited June 24th, by a specimen confined in a box. "The egg is pale green, elongated, shaped something like an acorn, with the base smooth, convex and the circumference striated longitudinally, with about fourteen raised striæ which are linear and smooth; the spaces between are about three times wider than the striæ, depressed, concave in the middle, and ribbed by a number of cross lines, fifteen to twenty between each striæ, and distinctly indented. The egg is contracted at the apex, the striæ protruding at the tip all around a little beyond the body of the egg. The larva hatched in six or seven days, and when fresh from the

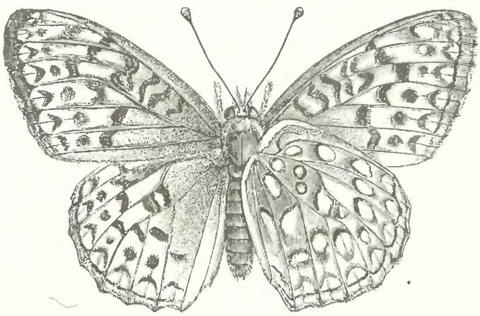


Fig. 183.

* The upper side of the wings are figured on the left side, and the under side on the right, in this and in FIGS. 184 and 188.

egg was about one-tenth of an inch long. The head is medium sized, black, and shining; the body above is dark brown, with transverse lines of a paler color, especially on the anterior segments; it is thickly covered with stout hairs of a pale brownish color; between the first and second moult it is one-fourth of an inch long. The head is bilobed, shining, black and hairy, and the body above is greenish black, the greenish tinge most apparent on the second and third segments, with a few small yellowish dots along each side, and transverse rows of strongly elevated, black tubercles, emitting numerous short, black hair-like spines.

"The under surface is similar to the upper; the feet are black and shining, and the prolegs are black, tipped with a paler hue. After the second moult there are two fleshy tubercles on the second segment much longer than the others, being three or four times their length, which are covered throughout with small hair-like spines. The yellowish spots along the sides of the body assume more of an orange tint, and there are one or two faint, longitudinal streaks of the same color along the sides close to the under surface, and between the rows of large, raised tubercles, are many smaller ones which are also black and appear but slightly raised. August 7th the larva was full-grown. The head is, at this period, slightly bilobed, black, shining, and covered with short, fine, black hairs.

"The body above is dark greyish brown, beautifully spotted and dotted with deep velvety black; the second segment, has two long, fleshy horns, yellowish white at base, black above, covered with minute, blackish, hair-like spines. The third and fourth segment, have each four whitish spines tipped with black, those on the sides placed on the anterior portion of the segment, those above about the middle. All the other segments have six whitish spines, excepting the terminal one, which has four. All the spines have fine branches of a black or brownish black color and are about one-third the length of the fleshy horns on the second segment. A pale line extends along each side from the fifth to the terminal segments close to the under surface. The under surface is brownish black, darker on the anterior segments; feet black and shining; prolegs brown, with a shining band of brownish black on the outside.

The duration of the pupa stage was ten or eleven days." The pupa, received from Mr. Saunders, has two large, conical tubercles in front of the insertion of the antennæ, and two acute tubercles on the prothorax. The thorax is acutely bituberculated on the sides, with an acute thin dorsal ridge, on each side of which are two small, sharp tubercles. Along the back of the abdomen are two rows of tubercles, those on the third abdominal ring being much larger. It is half an inch long, and pale ash, with black dots and irregular lines.

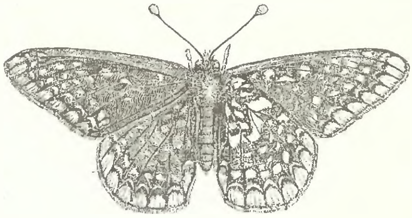


Fig. 184.

Melitæa differs in not having silver spots beneath, while the caterpillars are covered with blunt tubercles which give rise to short stiff bristles. They feed on different species of plantain. The chrysalids are like those of Argynnis, but spotted with black or brown, and not with golden.

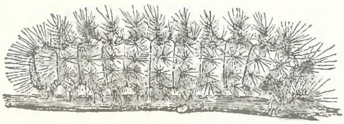


Fig. 185.

Melitæa Phaeton Drury (Fig. 184) is found in damp bogs. We have taken the young larva less than one-half of an inch long, early in spring under leaves, where it had doubtless hibernated. The mature larva (Fig. 185, enlarged, the specimen from which the drawing was made, is too contracted, the head being drawn in unnaturally; fig. 186, pupa) is cylindrical, and the head is slightly angulated. There are nine rows of black spines which are fleshy and surrounded at the tips with rather long, thickset spinules. The head and thoracic and last three abdominal rings are black; the rest of the body being deep orange, with black lines between the spines, and dots along the side. Towards the last of May and early in June it changes to a chrysalis, which is white with a slight bluish tinge, with yellow papillæ, and scattered black

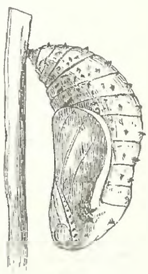


Fig. 186.

spots, giving it a gay and variegated appearance. The butterfly rises from cold, swampy places the last of June and early in July. Its wings are velvety black, with orange red crescents and spots. It expands from two to two and a quarter inches, being our largest species.

M. Tharos Boisd. and Leconte is a very abundant species in New England. There are two broods, one appearing in June and early in July, and the second one late in August and September. It has short, broad wings which are tawny orange above, with black, irregular lines and spots; it expands from one and three-tenths to one and a half inches.

Mr. Saunders has sent us a remarkable and undescribed butterfly, under the name of *Melitæa Packardii* Saunders, with the following description: "It resembles M. Tharos in size, and expands 1.42 of an inch. The palpi are pale brown above, yellowish below; antennæ black above, dotted with white and tipped with red; below white tipped with red. Head, thorax and abdomen, black above, clothed with brownish hairs; white underneath; feet brownish yellow; wings above brown, with a cupreous tinge, sprinkled with fulvous atoms, with a wide band of dark brown on the outer margin, faintly edged on each side with black. The primaries have a fulvous macular band a short distance from the base, extending nearly across the wings, and a patch of the same hue a little beyond and towards the front margin. Beyond the middle is a wide band of the same, divided by the veins into a series of seven spots; the upper one is very small, a mere dot with a whitish hue; the second is much larger; the third and fourth are nearly uniform in size, larger and more elongated than the second; the fifth and sixth are the largest and wider and longer than any of the upper ones; the seventh is nearly of the same width as the sixth, but not more than half the length; the fringe is dotted with white, especially about the tip.

"On the secondaries a wide fulvous patch covers the inner part of the wing, extending from near the base to near the middle of the wing, and bounded towards the inner margin by a brown edging; within this patch are three rounded blackish spots, one most distinct about the middle, the others near the inner margin and partly lost in the brown edging of the wing

Beyond this is an imperfect band of fulvous spots, in continuation of those on the primaries; the upper ones faint and indistinct, and two of the lower ones prominent and nearly round; the last small and linear. The inner margin is edged with fulvous, having a yellowish tinge which encroaches on the outer brown marginal band at the anal angle. The fringe of the secondaries is dotted with dull white. The primaries below are fulvous, with a single wavy, brown line across the wing a short distance within the outer margin; base yellowish, costal margin sprinkled with dark brown atoms, and a streak of the same along the middle of the wing near the hind margin. At the tip is a yellowish patch, occupying the space between the brown line and the margin, and within this, one of silvery white nearly equal in size. Below the white are three indistinct, yellowish patches, the lower one extending to the outer margin; a large patch of yellow at the lower corner where the outer and hinder margins meet. The secondaries below are yellowish from the base to near the middle, with streaks and spots of brown; the yellowish color extending down the inner to the hinder margin. Beyond the middle the wings are silvery white, sprinkled with yellow and brown scales, divided by the brown veins and partially crossed by an irregular streak of brown. There are also two brown patches on the hind margin, the smaller one nearly round and occupying the space between the first and second median venules; the larger being irregular and resting on the median vein, and extending across the third to the second subcostal venule. It was taken near Grimsby, Ontario County, Canada."

Melitæa Œnone Scudder is rarely found in Maine and Massachusetts; it is pale fulvous above, with blackish brown markings, and expands from one and three-fifths to one and four-fifths inches. *M. Harrisii* Scudder may be readily distinguished from *M. Œnone* by the under surface of the hind wings being cinnamon-red, with bands and spots of white margined with black. It expands one and three-fourths inches and is found in New England, though rather a rare species. The larva has been reared in Norway, Maine, by Mr. S. I. Smith. It feeds on Diplopappus umbellatus, pupating from the middle to the last of June, and remaining in the chrysalis state from ten to sixteen days; the butterfly appears from June 20th to Aug. 1st. The larva (Fig. 187) has also been discovered in Vermont by Mr. P. S. Sprague, and we describe it briefly from an alcoholic specimen, in the collection of Mr. Sanborn. It is cylindrical, with six acute, small tubercles on each side of each thoracic ring, while on the abdominal rings the four dorsal tubercles are larger and remarkably boot-shaped, the toe being formed by a lateral prolongation of the tubercle, and the heel is also well formed, from which arises a short bristle. The specimen is dark, with a lighter stripe along the back on each side of the median line of the body. Its length is .80 of an inch.

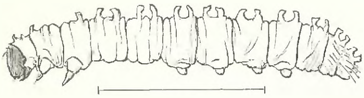


Fig. 187.

M. Chalcedon Doubleday is found in California and the Rocky Mountains, while *M. Anicia* Doubleday, the under side of which is much like that of Chalcedon, occurs not only in California and the Rocky Mountains but also in Kansas. *M. Texana* Edwards is a Texan species expanding one and one-half inches.

In *Vanessa* the wings are notched and angulated or tailed on the hind edges, while the palpi are long and beak-like. The larva is cylindrical and stoutly spined, the spines being long and branched. The caterpillars are gregarious during the early stages. "The head of the chrysalis is deeply notched, or furnished with two ear-like prominences; the sides are very angular; in the middle of the thorax there is a thin projection, in profile, somewhat like a Roman nose, and on the back are two rows of very sharp tubercles of a golden color." (Harris.) *Vanessa Antiopa* Linn. is one of our most abundant butterflies, being much more common in this country than in Europe, whence it has probably been imported. Its wings are purplish brown above, with a broad buff yellow border in which is a row of pale blue spots. The butterfly hibernates, appearing before the snow is off the ground. It is seen until June, and then not until the middle of August. The larva is black, spotted minutely with white, with a row of eight dark, brick-red spots on the back. The chrysalis is dark brown, with large tawny spots around the tubercles on the back. The caterpillar defoliates the willow, poplar and Balm of Gilead. *Vanessa Milbertii* Godart is much smaller and is rather rare. It occurs about roadsides in May, July and August. The larva feeds on nettles. Mr. Saunders informs me that "it was found feeding on the nettle, nearly full grown, July 26th. It was from one to one and one-eighth inches long. The head is black, thickly covered with fine, brownish white hairs, and sprinkled with many minute whitish dots. The body is black, thickly sprinkled with whitish dots and with small, fine, white hairs, each segment, excepting the second, with a transverse row of branching spines. A greenish yellow lateral line runs close to the under surface, with a second broken line of a brighter yellow color. All the spines and their branches are black, excepting the lower row on each side from the fifth to the twelfth segment, springing from the greenish yellow lines; these are of a greenish yellow color. Under surface dull greenish, minutely dotted with whitish dots. There is a wide, central, blackish stripe covering anteriorly, nearly the whole of the under surface." *V. Californica* Boisd. is bright fulvous, with three black bands on the anterior edge of the fore-wings, and there are no black crescents in the black border of the wings.

The genus *Grapta* differs from the preceding in its deeply incised wings, its smaller size, and red and brown colors. The under side of the hind wings has usually a silvery or golden dot and curved line, or both, imitating different punctuation marks. *Grapta interrogationis* Doubleday is one of the largest species, and has a golden semicolon beneath. It is found in May, August, and in autumn. The caterpillars injure the foliage of the elm and lime trees, and also the hop vine, sometimes defoliating the whole vine. The larva has been found, by Mr. Saunders, feeding on the hop, August 7th. "When full grown its length is one and one-fourth inches. The head is reddish black, flat in front and somewhat bilobed, each lobe tipped with a tubercle emitting five single, black, pointed spines; it is covered with many small, white, and several blackish tubercles. The body is cylindrical, black, thickly covered with streaks and dots of yellowish white; the second segment is without spines, but with a row of yellowish tubercles in their place; the third segment has four branching spines, all black, with a spot of dark yellow at their base; and on the fourth segment are four spines, as there are on all the others, excepting the terminal, which has two pairs, one posterior to the other. The spines are yellow, with blackish branches, excepting the terminal pair which is black; and there is a row of reddish ones on each side. The under surface is yellowish grey, darker on the anterior segments, with a central line of blackish and many small, black dots." The chrysalis state lasts from twelve to fourteen days. It is ash brown, with the head deeply notched, and eight silvery spots on the back. *Grapta c-argenteum* Kirby (Fig. 188, G. Progne Harris) is a small species with a silvery L in the middle of the under side of the hind wings. It is our most common species northward. It appears the last of summer. The larva lives on the hop and elm. *Grapta comma* Doubleday is more common southward. It is known by having a silvery comma in the middle of the hinder wings. The caterpillar lives on the hop and elm. Mr. W. H. Edwards has found the larvæ on the broad-leaved nettle. He says "my attention was first attracted by observing certain leaves drooping, and more or less eaten. On the under side of these I usually found the caterpillar inactive, and never more than one upon the same plant. The half-grown larvæ were black, with a yellowish stripe along the side from the third segment to the tail, and with yellow stripes across the back, and spots of the same color at the base of the dorsal spines, which were yellow, tipped with black. The mature larvæ were white, mottled or striped with grey or ashen, and with red spiracles."

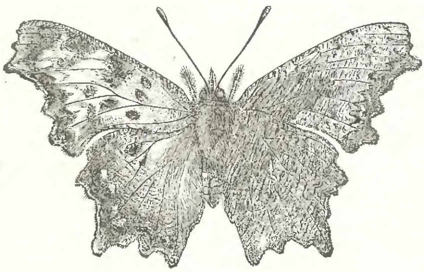


Fig. 188.

The chrysalis is brownish gray or white, variegated with pale brown, and ornamented with gold on the tubercles. The fly appears in May, July, August and September. In the colder and mountainous portions of New England and New York, these species are replaced by the *Grapta Faunus* of Edwards, who states that "comparing Faunus with c-album, the former is deeper colored by many degrees; it is one-fifth larger, the black spots and margins much heavier, and, owing to this and the depth of the ground-color, the general hue of the surface is much darker than either c-album or any of the American species." The under side of G. Faunus is beautifully marbled in several colors.

The genus *Pyrameis* differs from Vanessa in having the wings simply scalloped, not notched; beneath, they are not marked with metallic colors, and the long, tapering palpi curve upward. The larvæ are covered with branched spines, corresponding in size, and often wanting on the first and last segments; the head is heart-shaped. They are solitary, hiding under a rolled leaf or spinning a slight web, and hang by the hind feet alone when about to transform. The chrysalids are angular on the sides, with two or three lateral rows of sharp, golden tubercles, and a short, thick tubercle on the top of the thorax. *P. cardui* Linn. feeds on thistles and the sunflower, the hollyhock, burdock and other rough-leaved plants, in June and July. It remains in the pupa state twelve days, the butterfly appearing in Maine, about the 20th of July. *Pyrameis Huntera* Fabr. has much the same habits, while *P. Atalanta* Linn. feeds on the nettle. These species are all double-brooded, first appearing in May and then in July, August and September.

Junonia is closely allied to Vanessa. *J. cœnia* Boisd. and Lec. is found in the Southern States, the West Indies, Mexico and California.

In *Limenitis* the antennæ are very slender, and the hind wings are scalloped, while on both wings the discal area is open. The caterpillar and chrysalis are like those of Danais. *L. Misippus* Fabr. (Fig. 189) is tawny yellow above, and of a paler yellow beneath, with a broad, black border, spotted with white, and black veins. It expands from three to three and a half inches and flies from June to September. The larva is pale brown, variegated with white on the sides, and sometimes with green on the back; the prothoracic ring has two slender, blackish, spinulated horns, and on the tenth and eleventh rings are short tubercles. It feeds on the poplar and willow. The pupa is known by a thin, almost circular, projection standing out from its back. The young larvæ winter in cases "composed of the leaf of the willow, on which the larva feeds, neatly joined by its longest opposite margins, so as to form a cylindrical tube closed at one end and lined with silk." (Trouvelot.) *L. Ephestion* Stoll is blue black, with three black lines on the hind edges, and just within the outer border is a row of orange colored spots. It lives on the scrub-oak (Quercus ilicifolia) in June, and also on the whortleberry and the cherry. *Limenitis Arthemis* Drury is smaller and has an oblique, broad, white band, crossing both wings. It is common in the White and Adirondack Mountains, where it is double brooded, appearing late in June, and again late in August.

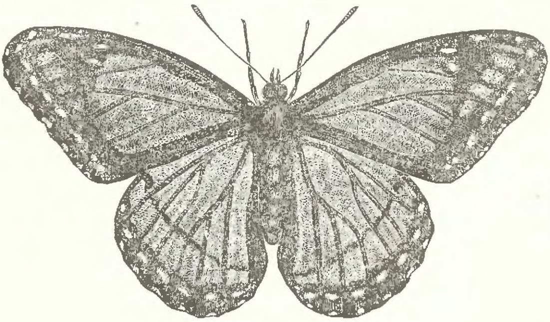


Fig. 189.*

The superb and regal genus *Morpho* is the Atlas among butterflies. The broad wings spread nearly six inches, and are usually of a brilliant blue above, and brown beneath, with eye-like spots. *Morpho Menelaus* Linn., from Brazil, expands five and a half inches. *M. Polyphemus* Chenu is a Mexican species. *M. Epistrophis* Hubner is of a delicate pale green, with two rows of lunate brown spots on the hind wings. The apex of the fore-wings is brown, and the discal spot is connected with the brown costa. It inhabits Brazil.

The genus *Satyrus*, and its allies, *Chionobas*, *Hipparchia* and *Neonympha*, are wood brown and ornamented, especially beneath, with eye-like spots, and have the wings entire, with the veins of the fore-wings swelled at their base, and the discal area open on the hind wings. They have a short, quick, jerky flight. The caterpillars are green and smooth, spindle-shaped, or cylindrical, tapering at both ends; the hind end is notched,

* FIGS. 189, 190 and 198, are from Tenney's Zoölogy.

and the head entire or notched. They live mostly on grasses. "The chrysalis is either oblong and somewhat angular on the sides, with the head notched, and two rows of pointed tubercles on the back, or short and rounded, with the head obtuse." (Harris). *Chionobas* is found on Alpine summits and in the Arctic regions and on subarctic mountains. *C. semidea* Say (Fig. 190; Fig. 191, hind wing) lives on the summit of Mount Washington. It feeds on lichens.

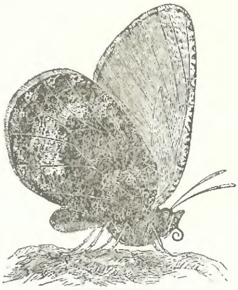


Fig. 190.

Mr. Scudder, has in the accompanying figures, closely exhibited the differences between the Alpine and Arctic species of Chionobas. *C. Jutta* Möschler (Fig. 192) we took in Northern Labrador; it extends as far south as Quebec, according to Edwards. *C. Chrixus* Doubleday, (Fig. 193) is found on Pike's Peak, Colorado Territory; *C. Calais* Scudder (Fig. 194) is found on Albany River, Hudson's Bay; *C. Bore* Schiödte (Fig. 195) we have collected in Hopedale, Labrador, as also *C. Œno* Boisd. (Fig. 196).

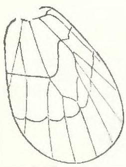


Fig. 191.

Fig. 192.

Satyrus Alope Fabr. is our largest species. It is dark brown, with a broad, ochre-yellow band beyond the middle. It is abundant in open fields in July and August. The pale green larva is striped with dark, the head is round, and the tail is forked. The chrysalis is rather long, rounded on the sides and with the head notched. *S. Nephele* Kirby is the more

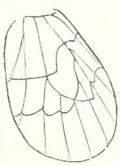


Fig. 193.

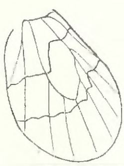


Fig. 194.

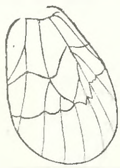


Fig. 195.

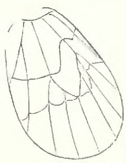


Fig. 196.

northern form, and in the upper Middle States, as about the Catskill mountains, occupies higher ground, according to Mr. Edwards, while S. Alope, which prevails southward, is found in the lowlands and valleys. S. Nephele is smaller, darker, and there is no yellow band on the fore-wings, though, sometimes, each eye-like spot is surrounded by a yellowish diffuse ring.

Neonympha Eurytris Fabr. flies low, with a jerky sort of motion, in thick woods, in June and July. The larva is like that of S. Alope, while the chrysalis is shorter with the head obtusely rounded. The adult is dark brown, with two black eye-spots, pupilled with a lead-colored dot, and surrounded with an ochre-yellow ring. On the hind wing is a smaller, similar spot. It expands one and seven-tenths of an inch.

The aberrant genus *Libythea*, with its long, snout-like palpi, reminds us of the Pyralids. It is small and the wings are irregularly notched. *L. Bachmanii* of Kirtland is not a common butterfly. It occurs southward, and in Central America and the West Indies.

The small, delicate Theclas and Lycænas are often of great beauty and interest. The palpi are elongated, the wings entire, and the hind pair are often once or double tailed. The larvæ are slug-like, as when moving on their short feet, sixteen in number, they seem rather to glide than walk. They are oval, flat below and rounded above, both extremities being much alike, with the small head retracted within the body. The short and thick chrysalids are flat beneath, but very convex above and rounded at each end. *Chrysophanus Americanus* Harris, our most abundant form, is coppery red above. Its green larva feeds on the sorrel, and there are three broods of butterflies in the year. The chrysalis is usually suspended under a stone. One sent by Mr. Saunders, is smooth, with no fine hairs. The head and thorax, including the wings, is dull reddish brown, dotted with black; the abdomen is much lighter cinereous, with very distinct, and irregular black dots, and a lateral row of twin black dots, one dot being a little behind its mate. On the middle of the back are three rows of smaller black dots. It is .45 of an inch in length. *Chrysophanus Thoe* Westwood is quite a rare species. Mr. Saunders describes the eggs as being "nearly round, a little flattened at the apex and flattened also at the base, where it is fastened to the box. They are greenish white, and thickly indented; at the apex is a considerable depression; immediately around this, the indentations are small, growing larger towards the base."

The genus *Lycæna* is azure blue throughout, with dark markings. *Lycæna neglecta* Edwards (Polyommatus pseudargiolus Harris) is very common about the Kalmia and Rhodora in May, and a new brood appears in June and July. It has been reared by Mr. Saunders, from whom I have received the pupa, which is a little hairy, being much smaller than in Thecla Acadica and paler ashy. It is spotted quite thickly with black blotches, and on each side of the abdomen is a subdorsal row of rather large, black, contiguous blotches, more distinct than in T. Acadica. It is .30 of an inch long.

L. comyntas Harris is quite common southward. It differs from the other species in having a little tail on the hind wings, at the base of which are two deep, orange-colored crescents. It flies in July and August. The caterpillar lives on the Lespedeza. It is green with three darker stripes. The brown chrysalis has three rows of black spots on the back.

Thecla differs from the two preceding genera, in its conspicuous tails and the longer clubs of the antennæ and its dusky brown hues. The larvæ are longer and flatter, and they usually live on trees. *Thecla humuli* Harris feeds on the hop-vine. It flies in July and August. *Thecla niphon* Godart, a dusky rust-red butterfly, feeds on the pine. The larva is green, with a dorsal yellow stripe, and a white one on each side. It changes to a short, thick, greyish pupa, with two rows of blackish dots, and beyond these a row of rust-red ones. Mr. Saunders has sent us the following description of the caterpillar and chrysalis of *Thecla Acadica* Edwards, found by him at London, Canada West, feeding on the willow, June 11th and 18th. "It was .63 of an inch in length, with a very small, pale brown head, withdrawn within the prothoracic segment, when at rest. The body is rather dark green, and is thickest from the mesothoracic to the sixth abdominal segment. There is a darker green, dorsal line, the dorsal region being flat, rather wide, and edged on each side with a raised, whitish yellow line, and the sides of the body are inclined at almost an acute angle, and striped with faint, oblique lines, of a greenish yellow. A whitish yellow line borders the under surface, beginning at the anterior edge of the second segment (the head is, for convenience, counted as a single ring, or segment) and extending entirely around the body. The chrysalis is .32 of an inch long, and .15 wide. It is fastened with a silken thread. The abdomen is thickened and somewhat raised. It is minutely hairy, pale brown, with many dots and patches of a darker color; the upper edge of the wings being quite dark, with a dark ventral stripe, and four or five short, dark lines on the side. It remains in the chrysalis state eight or nine days, the caterpillar turning dark July 3d, just before pupating." The body, especially the abdomen, is thicker and fuller than in Chrysophanus Americanus.

Thecla Mopsus Hübner is found in New England and Canada. Mr. Saunders sends me the following description of the larva taken June 9th, by beating bushes, at London, Canada. "It was .40 of an inch in length. The head is small, of a shining black color, with a pale stripe across the front just above the mandibles, and is drawn within the second ring when at rest. The body above is green along the middle rings, deep rose color at each extremity, and is thickly covered with short, brown hairs. The second segment is rosy above, greenish yellow at the sides, with an edging of the same color in front; the third segment is entirely rose colored; from the third to the tenth segments is a dorsal stripe of rose which is wide on the fourth, fifth, eight and ninth segments, but narrow and linear on the intermediate ones; on the tenth segment the green encroaches on the rose color on the sides of the body, extending more than half-way upon the segment behind the tenth. The body is rose colored with a dorsal streak of a darker shade. The rose color at each extremity is united by a rosy line along each side close to the under surface which grows fainter on the middle segments. The under surface is dull green, with a yellowish tint; the feet and prolegs (abdominal legs) are yellowish green. June 24th, the larva has now become quite large and will probably soon go into the chrysalis state. I found it would readily eat the plum and cherry.

"Its length is now .70; its width about .20 of an inch. The head is very small, bilobed, black and shining, with a streak of dull white across the front above the mandibles, which are reddish brown. The body above is dull green, with a yellowish tint, especially on the anterior segments, which are thickly covered with very short, brown hairs, scarcely visible without a magnifier; these hairs arise from small, pale, yellowish dots which appear slightly raised; there is a dorsal streak of dark green arising from the internal organs showing through the semitransparent skin. There is a patch of dull pink, or rosy color, on the anterior segments from the second to the fourth inclusive; it is faint on the second ring, and covering but a single portion of its upper surface, and nearly covering the dorsal crest on the third segment, and reduced again to a small, faint patch on the fourth. On the posterior segments is a much larger rosy patch, extending from the hinder part of the ninth segment to the end of the body. The hinder part of the ninth segment is merely tinged. On the tenth segment it becomes a rather large patch, widening posteriorly. Behind this the body is entirely covered with rosy red. The sides of the tenth segment, close to the under surface, have a streak of the same color, and there is a faint continuation of this on the ninth segment. The head is drawn within the second segment when at rest. The second segment is smaller than the third; there is a wide dorsal crest, or ridge, from the third to the tenth segments inclusive; behind this the body is suddenly flattened, the sides suddenly sloping. The under surface is yellowish green, with a few very fine brownish hairs; the feet and prolegs are greenish, semitransparent.

"On June 29th it fastened itself to the lid of the box, changing to a chrysalis July 1st, which was .45 of an inch in length, and its greatest width .20 of an inch. The body is pale brown and glossy, with many small, dark brown or blackish dots distributed over the whole surface; they are thicker along the middle above, with a faint, imperfect, ventral stripe from the seventh to the eleventh segments; the surface is thickly covered with very short, brown hairs, invisible without a magnifier. The imago appeared July 13th."

Mr. Saunders has found the larva of *Thecla strigosa* Harris, a rare species in Canada and New England, feeding on the thorn, Cratægus, July 13th. "The head is small, greenish, with a faint tint of brown, and a black stripe across the front below the middle, and a patch of white between this stripe and the mandibles, which are brownish black above. The body is of a rich velvety green, with a yellowish tinge, slightly paler between the segments, and a dorsal stripe of a darker shade, centred along the middle segments with a faint, yellowish line. The anterior edge of the second segment is yellowish brown, with a few dots of a darker color. The body is thickly covered with minute hairs which are brown above and white below, being scarcely visible to the naked eye. The body is flattened above (dorsal crest not bordered with yellow as in T. Acadica), steeply sloped at the sides, where it is striped with faint oblique lines of yellowish, two or three on each segment. The two last segments have a patch of yellowish on each side, making the dark dorsal line appear much more prominent. A faint yellowish line close to the under surface from the fifth to the terminal segments. The under surface is bluish green, with a darker patch on the last two segments.

"The chrysalis changed June 19th, and is nearly oval in form. The head-case is rounded, and the body is dark reddish brown, with black markings thickly covered with fine, short, whitish hairs, rather more numerous on the anterior and posterior segments. Anterior segments with many thickly set patches of blackish, and a dark ventral line from the sixth to the twelfth segments. It is bound by a few silken threads on the anterior portion of the first and second segments."

The accompanying cut (Fig. 197) represents the pupa of a Thecla, found in July by Mr. Sanborn, on the Glen road to Mount Washington. The body is smooth and tapers gradually from the mesothorax, and the venation of the wings is very apparent. Another pupa, probably of Thecla, found by Mr. Sanborn, is very different, being much stouter, and thicker through the abdomen, by a third of its diameter, than the chrysalis figured. It is rough and covered with short, fine, stiff hairs; the tegument is so thick, that there are no traces of the veins of the wing, while the sutures between the segments and the appendages are not nearly as distinct. The larva, according to Mr. Sanborn's notes, was found feeding upon the White Pine, July 13th. "It was .45 of an inch long; the head was retracted, yellowish, and the body pale, transparent green, with four longitudinal, white stripes, and one transverse, lozenge-shaped

Fig. 197.

patch, of the same color, on the eleventh segment. The rings were all somewhat elevated in the middle of their diameter and thinly covered with yellowish brown, short hairs." He did not succeed in rearing the butterfly, but this description will be useful to any entomologist who may be fortunate enough to rear it hereafter.

The Hesperians, or Skippers, are a large group of small, dark, dun-colored butterflies, whose antennæ have the knob curved like a hook, or ending in a little point bent to one side, reminding us of the antennæ of the Sphinges. They are moth-like in their motions, form, and larval characters. They are stout bodied, with large heads and prominent eyes, and thick palpi, almost square at the end. The larvæ are spindle-shaped, naked, and with a remarkably large head. They are solitary, and often hide in folded leaves like the *Tortricidæ*, transforming in a rude cocoon of dead leaves or stubble, held together by silken threads. The pupæ are somewhat conical, like those of moths, smooth and generally covered with a bluish white powder. They are fastened by the tail and a slight band of threads within their rude cocoons. We have many species in this country; the largest forms occurring southwards.


Fig. 198.

Eudamus Tityrus Cramer feeds on the locust and is our largest species northward. *E. Bathyllus* flies in June and July. It feeds on Glycine and Hedysarum in May and June. In *Hesperia* the knobs are shorter, and end in a point turned sidewise. The upper wings are raised, and the lower spread out flat when at rest. The chrysalis has a long tongue-case free at the end, in this respect showing a transition to the hawk-moths. They are snuff-brown, with dark spots.

Mr. W. Saunders has been very successful in raising the larvæ of *H. Hobomoc* Harris and other butterflies and moths, by watching for the fertile eggs in captured specimens, which are often deposited on the sides of the collecting box. The food-plant of the larvæ can usually be discovered after experimenting with those plants on which other species of this or allied genera are known to feed. "The egg, deposited June 17th, is nearly round, flattened on the lower side, and of a pale green color. Under the microscope it appears plainly reticulated, with fine, six-sided markings, strongly resembling the cornea of a fly's eye. The larva on finding its way out, June 27th, began to eat the egg-shell at the centre above. It feeds on grass, on the inside of the leaves near the joints, drawing portions of the leaves together with silken threads. When placed on a strongly ribbed blade of grass, it spins a few threads from rib to rib, and stations itself behind the threads. By the 14th of July the caterpillars were three-eighths of an inch long and resembled those of H. Mystic of the same age." Mr. Saunders did not succeed in raising the caterpillars to maturity as they were unfortunately lost.

The most abundant species in New England is *A. Wamsutta* Harris (Fig. 198) which frequents roadsides throughout the summer. According to Mr. Saunders' notes, from "eggs deposited July 10th, the young larva was hatched July 24th, the eggs growing darker about two or three days previous. The egg is pale greenish yellow, or yellowish green, strongly convex above, and flattened at the place of attachment. The flattened portion is slightly concave and very faintly reticulated under a power of forty-five diameters.

The young larva, when first hatched, is about the same as that of Mystic and Hobomoc, probably .10 of an inch, and is scarcely distinguishable from them, excepting that it is slightly darker in color. The head is large and prominent and of a shining black color. The second segment has a ring of brownish black, encircling it above. The body is dull brownish yellow, very faintly dotted with black, each dot emitting a single, rather long, brownish hair. The under surface is rather paler than the upper.

Mr. Saunders has also reared the larva of *H. Mystic* Edwards from the egg, which is "strongly convex above, flattened below and depressed in the centre of the flattened portion. Under a magnifying power of eighty diameters, the surface is seen to be faintly reticulated; it is pale yellowish green. The eggs were deposited about the 20th of June and hatched on the 28th and 29th of June. When hatched it was .10 of an inch long, with a large, black head, and was white, becoming yellowish brown, especially towards the end of the body. It feeds on grass, and at this stage can scarcely be distinguished from the young larva of H. Hobomoc. When an inch long the head is not large in proportion to the body, though it is prominent and wider than the second segment; it is dull reddish brown and black posteriorly. The body above is semitransparent, dull brownish green, with minute, whitish hairs, similar to those on the head, with a dorsal line and many darker dots over the surface. The second segment is pale whitish, with a line of brownish black across the upper surface, with a faint, pale, lateral line close to the under surface: the terminal segments are paler than the rest of the body. The feet are whitish, semitransparent. This species is found from Canada to Maryland.

SPHINGIDÆ Latreille. The Hawk-moths or Humming-bird moths are among the largest and stoutest of Lepidoptera. The body is very stout, spindle-shaped, with narrow, powerful wings. Their flight is, consequently, exceedingly swift and strong. The antennæ are prismatic in form and thickened in the middle. The tongue, or maxillæ, is remarkably long, so that the insect is able, while on the wing, to explore the interior of deep flowers. This habit of remaining for a considerable time poised in the air on their rapidly vibrating wings, causes them to be mistaken for humming-birds. At rest the wings are folded, roof-like, over the body. The larvæ have sixteen legs, and on the last segment is an acute horn, sometimes represented by a simple tubercle. At rest they stand with the forepart of the body elevated in a supposed Sphinx-like attitude. The larvæ descend into the earth and transform, often in rude, earthen cocoons, moulded into form by the pressure of the body. The tongue-case is usually free.

There are between 300 and 400 species known, a large part of which are tropical American. Most of the species fly in June and July. The larvæ transform in the latter part of August and in September.

In *Ellema* the body is small. The head is small, narrow and somewhat tufted, and with small eyes. It might be passed over on a hasty view for a Noctuid. The larva of *Ellema Harrisii* Clemens is green, has no caudal horn, and lives on the pine.

Mr. Saunders writes me that he has found it feeding on the pine, about the middle of September. "It is two inches long, the body being smooth and nearly cylindrical and thickest in the middle of the body. The head is large, pointed above, flat in front and green, with a yellow stripe on each side. The body is bright green, with a dorsal row of dark red spots on the fifth to the twelfth segments inclusive, with a bright yellow stripe on each side of the reddish spots and a lateral white stripe mixed with yellow." The moth is a very small, ash grey species, only expanding two inches. It frequents flowers at dusk in June.

The genus *Sphinx*, as now limited by systematists, is much larger bodied, with a long and narrow head, small eyes and long and narrow wings. The head of the larva is rather large, semi-oval and flattened in front. The body is cylindrical, smooth and obliquely banded on the side, with an arching, caudal horn. It transforms in a subterranean earthen cell. The tongue-case of the pupa is short and free, instead of being soldered to the body. *Sphinx gordius* Cramer is dark brown, with a roseate tinge, and the thorax is blackish brown above. The larva feeds on the apple.

Sphinx kalmiæ Smith is hoary and rust-red, and on the hind wings are a median and marginal black band. The caterpillar feeds on the lilac and laurel. It is pale green, with seven oblique, lateral, pale yellow bands, edged above with black, which is again bordered with pale blue. *Sphinx drupiferarum* Smith has the fore-wings blackish brown, with the discal dot and outer edge of the wing whitish fawn-color. The larva feeds on the different species of plum. The body is pale green, with lateral purple bands, edged beneath with white. *Sphinx chersis* Hübner (S. cinerea Harris) is the largest species we have, and is pale ashen, and reddish gray beneath. The larva feeds on the lilac.

The large "potato worm" belongs to the genus *Macrosila*, containing our largest species of the family; the head is proportionally large, and the wings are rather broad, with the interior angles dilated. *M. cingulata* Fabr. has pink hind wings and pink spots on the abdomen. It feeds on the sweet potato. *M. quinque-maculata* Haworth (Fig. 199, moth; *a*,

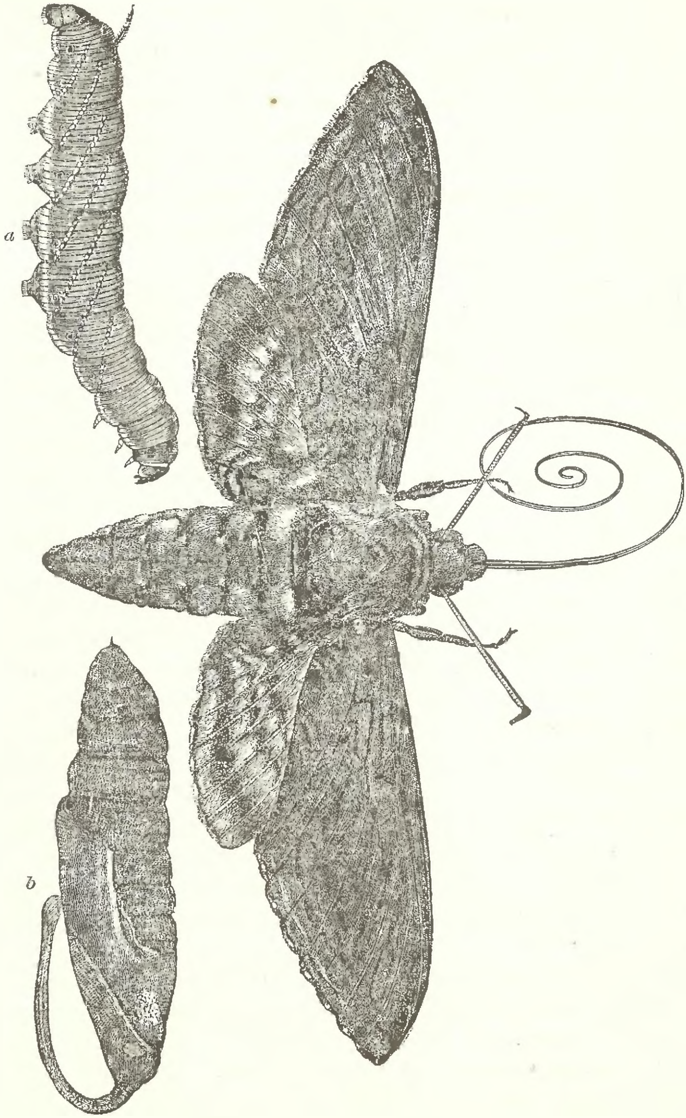


Fig. 199.

larva; *b*, pupa) is gray; the fore-wings are immaculate at the base, and on the hind wings are two distinct angulated bands. The larva feeds on the tomato and potato vines. It is dark green, with a series of greenish yellow angular bands on the side. The tongue-case is long and much arched. *M. Carolina* Linn. is cinereous, with a white spot at the base of the fore-wing, while the central band of the hind wings are indistinct. The larva (Fig. 200) feeds on the tobacco and tomato. It is dark green with lateral, oblique, white bands, edged above with bluish and short transverse black stripes.

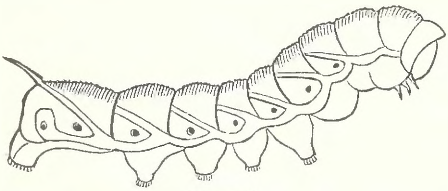


Fig. 200.

The tongue-case is shorter and less curved than in M. 5-maculata. The tongue of a Madagascar hawk-moth, *M. cluentius*, Wallace states, is nine and a quarter inches long, probably adapted for exploring the long nectaries of some Orchids.

In *Ceratomia* the body is thick, with the head and eyes small; the thorax is short and round, while the abdomen is rather long. The larva is easily known by the four thoracic horns, besides the usual caudal horn. The tongue-case is not free. *C. Amyntor* Hübner (quadricornis Harris) feeds on the elm.

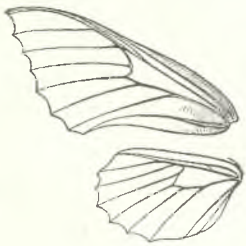


Fig. 201.

We now come to the more aberrant forms of the family. Under the name of *Cressonia* Mr. Grote has separated from the genus Smerinthus, a species in which the wings are more notched than in the latter genus, and the antennæ are slightly pectinated. *Cressonia juglandis* Smith (Fig. 201, venation) is of a pale fawn-color, and has no eye-like spots on the hind wings, as in Smerinthus. The larva is bluish green, with a row of subdorsal and stigmatal reddish brown spots, and six oblique, lateral, bright yellow bands. It lives on the wild cherry.

In *Smerinthus* the body is stout, the head sunken and the maxillæ are only as long as the palpi, being almost obsolete.

The species are said to fly heavily and only in the night. The head of the larva is semi-oval or pyramidal, acute above, and the thoracic rings are obliquely banded on each side. The pupa is smooth, cylindrical and somewhat conical in form. *S. modestus* Harris is a very large species, expanding nearly six inches. It feeds on the Lombardy poplar. *S. excœcatus* Smith has the hind wings rosy on the inner angle. The "ocellus" or eye-like spot is black, with two or three blue pupils. The larva is apple green, with seven oblique, yellowish white lines on the sides, and a bluish caudal horn. It feeds on the apple and the Rosa Carolina. *S. geminatus* Say (Fig. 202, venation of the hind wing) is so-called from the two or three blue pupils in the black ocellus. The hind wings are rosy. The pupa has been found at the roots of willows.

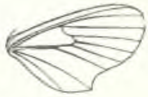


Fig. 202.

In the genus *Philampelus*, or lover of the vine, as its name indicates, the tongue is again as long as the body. The antennæ have a long hook tapering to the end, bearing ciliæ in the male. The abdomen is large and thick, and the wings are deeply concave on the inner border. The larva has a tubercle in place of a caudal horn. The tongue-case of the pupa is not free. *P. vitis* Harris is olive green, with pale green hind wings, which are rose-red towards the inner margin. The larva is flesh-colored mixed with yellow, and with short, transverse, black lines, and lateral, semi-oval, yellowish white bands, edged with black.

In *Deilephila* the abdomen tapers suddenly at the tip and the fusiform antennæ end in a minute hook. The gaily colored larva has a straight and rather short caudal horn. There are no oblique bands on the sides of the body, but a row of subdorsal spots on each side. Clemens states that the anterior segments are much attenuated, and are capable of being withdrawn or shortened, or much extended. "When disturbed they fall from their food-plants, shorten the anterior segments and bend the head inwards." They transform in a cell excavated from the surface. The tongue-case of the pupa is not free. *D. lineata* Fabr. is olive green, with six white lines on the thorax. The hind wings are black with a rose colored central band. The larva is yellowish green; the subdorsal spots consisting of two curved, short, black lines, with yellow above and beneath. It is double brooded in Texas. The larva feeds on the purslane and turnip, and will, in confinement, eat the apple. *D. chamænerii* Harris has a white line on each side of the head and thorax. The larva feeds on the willow-herb (Epilobium angustifolium). It is bronze green, dull red beneath, with nine round cream-colored spots, pupilled with black, and a dull red caudal horn.

The genus *Thyreus* has a lateral tuft on each side of the tip of the flattened, oval abdomen, and the head is broad and obtuse, while the fore-wings are excavated just below the tips. The body of the larva tapers gently from the first abdominal ring, and the last segment has a lenticular tubercle instead of a true horn. When at rest it throws its head from side to side thus producing a crepitating noise. It transforms in a cell on the surface. *T. Abbotii* Swainson (Fig. 203 and larva) is dull chocolate brown, with dull sulphureous hind wings, with a dark brown terminal band broken up into short lines on a roseate spot at the inner angle. The larva is reddish brown, with numerous patches of light green. The tubercle is black, encircled at base by a yellowish line and a blackish cordate patch. It feeds on the wild and cultivated grape-vines and on the Ampelopsis quinquefolia, or woodbine.

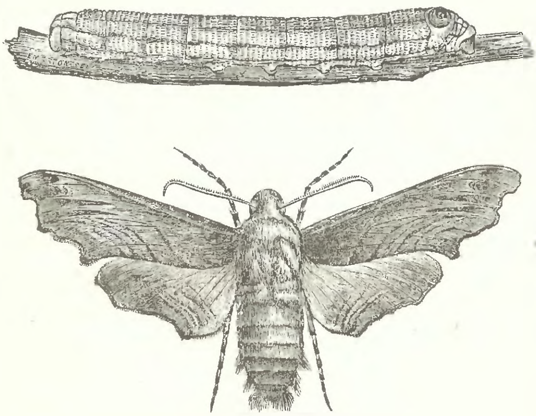


Fig. 203.

The Bee-moth or Clear-wing, *Sesia*, is smaller than the foregoing genera, and the body is flattened, oval and gaily colored with yellow, black and red, while the wings are transparent in the middle. The larva tapers in front, has a dorsal stripe just above the row of stigmata, and a short recurved horn. It transforms in an imperfect cocoon at the surface of the earth. *Sesia diffinis* Boisd. is pale greenish yellow, with the abdomen black beneath, and the legs black. The larva is pale green, reddish beneath. *Sesia Thysbe* Fabr. is a more common species northward. The thorax is deep olive green, with the abdomen reddish beneath, and with whitish legs. It is abundant, flying in June in the hot sun about the lilac and Rhodora Canadensis.

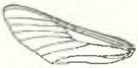


Fig. 204.

Under the name of *Lepisesia* Mr. Grote has separated *L. flavofasciata* Barnston (Fig. 204, venation of fore-wing) found in Canada, from the genus Macroglossa, represented in Europe by *M. stellatarum* Linn. Mr. Grote also separates from the latter genus, under the name of *Eupyrrhoglossum*, a Cuban moth, which has larger, fuller eyes, and larger hind wings than in Macroglossa. *E. Sagra* (Fig. 205, venation of fore-wing) is a handsome form described by Professor Poey.

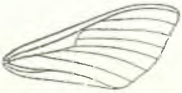


Fig 205.

ÆGERIADÆ Harris. These elegant and gaily colored moths, which by the arrangement of their colors and their clear wings, look like bees and wasps, are readily recognized by their small size, narrow wings, thickened antennæ, and by the tufts at the end of the body, which they can spread out fan-like. They fly very swiftly in the hottest sunshine. The larvæ are borers, living mostly in the hollowed stems of plants. They are whitish, cylindrical, with sparse, short, inconspicuous hairs, and they have no anal horns. They transform in a rude, oblong, oval cocoon, constructed of the chips they make in boring out their tunnels, cemented by a gummy secretion. The pupæ are chestnut-brown, with transverse rows of short teeth on the abdominal rings, by which they make their way out, partly through the hole previously made by the larva for the exit of the moth. The shell of the chrysalis is often left protruding from the hole. This family is, therefore, quite injurious to gardeners.

Ægeria exitiosa Say (Fig. 206, ♂) the Peach-tree borer, has caused the death of many peach trees and also, according to Fitch, occasionally attacks the plum. It is a slender, dark blue moth, expanding an inch and a half, or more. The male is much smaller than the female (Fig. 207), expanding one inch. She deposits her eggs near the root of the tree. The larvæ are hatched and bore in to feed upon the inner bark and sap wood. When one year old they make their cocoon under the bark or at the root of the tree. Borers of all sizes, Harris states, will be found in the trees throughout the year.

The trees should be protected by wrapping sheathing paper around the bottom of the trunk, and putting fresh mortar around the roots. The wounded part may be covered with clay. *Ægeria pyri* Harris infests the pear tree. It is purple black above and golden yellow beneath, with three yellow bands across the abdomen, the middle band being the larger.

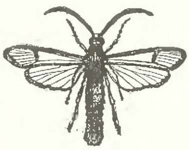


Fig. 206.

The habits of the Grape-root borer, *Æ. polistiformis* Harris, resemble those of the Peach-tree borer. It sometimes destroys grape-vines in the Middle and Western States, but does not attack the Scuppernong variety. The larva lives under ground, the female, according to Walsh, "depositing her egg on the collar of the grape-vine, close to the earth; the young larvæ, as soon as they hatch out, immediately descend into the roots." They attack the sap-wood and bark of the roots, eating irregular furrows. The cocoons are oval, and covered with bits of wood and dirt. They are found, through the summer, in the earth near the roots of the grape, and the moths fly from the middle of June until the middle of September, according to Dr. Kron. Harris describes the moth as being dark brown, tinged with tawny orange on the sides, and banded with bright yellow upon the edge of the second abdominal ring. The thorax and fourth abdominal ring are faintly tinged with yellow, or tawny orange, as are the palpi, under side of the antennæ, and the legs. The female has a little orange colored tuft on each side of the tail, and the males have two tufts on each side. The wings expand from one to one and a half inches. Another species, *Æ. caudata* Harris, inhabits the wild currant.

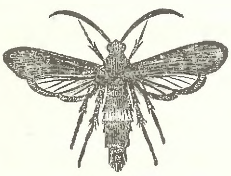


Fig. 207.

The currant borer, *Ægeria tipuliforme* Linn. (Fig. 208; *b*, larva; *a*, pupa, enlarged) has been introduced from Europe, and is a great pest in our gardens, injuring the currant bushes. It is a slender, agile, dark blue moth, found flying in July in the hot sun, about the currant leaves. The larva bores in the stems, and by splitting them open, in the fall and spring, we shall find the larva, which pupates towards the last of May.

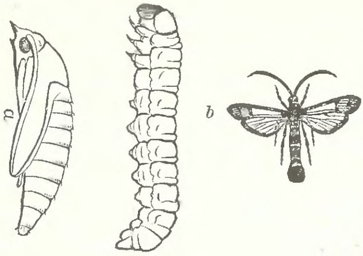


Fig. 208.

Mr. James Ridings describes from Virginia *Æ. quinque caudata* (Fig. 209) which has five filaments at the tip of the abdomen. Its body is blue black, with a transparent spot at the base of the hind wings, while the third abdominal segment is red above.

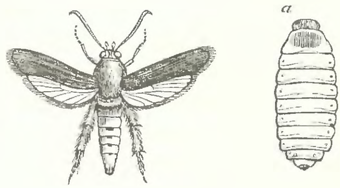


Fig. 210.

The Squash-vine borer, *Melittia cucurbitæ* Harris (Fig. 210; *a*, larva), often kills, very suddenly, the squash plant. The moth is orange colored, spotted with black, and its hind legs are fringed with long, orange and black hairs. She oviposits on the vine close to the roots, from the tenth of July to the middle of August. The larva eats out the interior of the vine, and usually transforms in a rude earthen cocoon near the roots, but as we have noticed, within the stem, beginning to spin its cocoon the first of October.

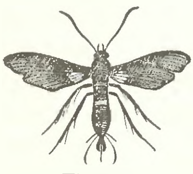


Fig. 209.

ZYGÆNIDÆ Latreille. This interesting group connects the diurnal with the nocturnal Lepidoptera. Some of the forms (Castnia) remind us strikingly of the butterflies. The group may be recognized by the rather large free head, and the simple antennæ which are slightly swollen in the middle, or partially clavate, as in Zygæna. The wings are long and narrow in the typical genera, becoming shorter and broader in the lower genera, such as *Euremia*, from India. The scales are fine, powdery and scattered thinly over the surface, often leaving naked spots on the wings. The species are usually green or deep blue, with scales of purplish black, or entirely black, alternating with gay colors, such as golden, bronze, or white and red. They fly in the hot sunshine.

The sixteen-footed, greenish larvæ are short, cylindrical, the body being obtuse at each end. The head is very small and when at rest is partially drawn into the prothoracic ring. The segments are short and convex, with transverse rows of unequal tubercles which give rise to thin fascicles of very short and evenly cut hairs, which are often nearly absent. The larvæ are either naked, as in Alypia, Eudryas and Castnia, or, as in the lower moth-like species, they are hairy, like those of the Lithosians and Arctians in the next family. Before transforming, the larvæ usually spin a dense, silken cocoon, though Eudryas and Castnia make none at all, and Ctenucha a slight one of hairs. The pupa of Zygæna, especially, is intermediate in form between that of Ægeria and Arctia, being much stouter than the first, and somewhat less so than the last. The head is prominent, and the tips of the abdomen sub-acute. Ctenucha is more like Arctia, while Castnia and Alypia are elongate, slender, with the head made especially prominent by a tubercle on the front of the clypeus.

In common with the *Sphingidæ* and *Ægeriadæ*, the Zygænidæ are confined to the temperate and tropical regions. The family type, *Zygæna*, has its metropolis about the Mediterranean Sea, and thence spreads to the north of Europe, and southward to the Cape of Good Hope. *Zygæna exulans* is found as far north as Lapland, and in vertical distribution rises 6,000 to 7,000 feet in the Alps of Styria.

Castnia is, however, a tropical American genus. Alypia is the most northern genus, extending into the Hudson Bay territories. Glaucopis and allies, which comprise a large number of species, are almost exclusively tropical American. In Australia, as Klug observes, Castnia is represented by Synemon. The American genus Eudryas is represented by very closely allied South African genera.

Castnia closely resembles the Hesperians, though much larger. The species are of large size and of brilliant hues, and fly in the day time, like the butterflies. The head is, however, much narrower in front, and the antennæ inserted higher up. The larva is a borer, living in the stems of Orchids; it is not known, but probably has the usual form of boring caterpillars, and the pupa is said by Klug to resemble that of Cossus.

Alypia comprises black moths, ornamented with white and yellow patches on the wings. The antennæ are long, and a little thickened in the middle. The wings are short and broad. The body of the pupa is not contracted at the base of the abdomen as in Eudryas. The larva feeds on the grape and constructs an earthen cocoon, like that of Ægeria, according to Harris. *A. octo-maculata* Fabr. is black, with eight spots, two on each wing, those on the fore wing being yellowish, those on the hind wing white.

The genus *Psychomorpha* is allied to Alypia, but differs in the broadly pectinated antennæ, and the shorter palpi, which do not pass beyond the front of the head. *P. epimenis* Drury (Fig. 211) is found from Connecticut southwards. It is black, with a broad, yellow, white, irregularly lunate patch crossing the outer third of the wing, and on the under side is larger, being triangular, with two square black spots connected with the costa; on the hind wings is a little larger, mostly regular crescent-shaped brick-red spot; it expands 1.10 inches. Doubleday (Harris Correspondence) states on the authority of Abbot, that the larva feeds on Bignonia radicans, in Georgia. "It is pale, with black lines, and though having the full complement of legs, seems to be a semi-looper in its walk, like Brephos."

Fig. 211.

Eudryas is a peculiar form, gaily colored, and easily known by the densely tufted forelegs, and the short tufts of metallic scales on the thorax and abdomen. The antennæ are filiform, and the abdomen is tipped with hairs. The larva of *E. grata* Fabr. is gaily colored with orange and blue, dotted with black. The body is long and widens towards the eighth ring, which is humped, from which the body rapidly narrows to the tip.

Across each segment is a row of tubercles which give rise to three fascicles of hairs. The pupa is rather long, with a prominent tubercle on the front of the head, and the abdominal tip ends in four tubercles. The larva feeds on the grape during midsummer and at the end of August creeps down, burying itself three or four inches, without making any cocoon. Mr. L. Mitchell of Norwich, Connecticut, has had the kindness to send me "a piece of wood burrowed by the E. grata with one of the pupæ in position." As E. unio is now known to burrow in the stems of plants, our opinion that Eudryas is allied to Castnia would seem to be confirmed by the habits of the larvæ which seem, at least occasionally, to bore into wood.

Eudryas unio Hubner according to Mr. Kirkpatrick, burrows in the stems of Hibiscus, thus resembling Castnia in its habits.

Mr. Grote establishes the genus *Euscirrhopterus* for a moth closely allied to Eudryas. *E. Poeyi* Grote (Fig. 212, fore wing; the venation of the hind wing being "almost identical with that of Eudryas") is a brown and yellow Cuban species.

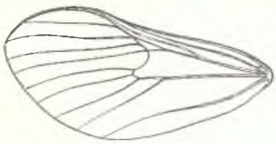


Fig. 212.

Zygæna is an European genus, and its characters have been indicated in describing those of the family. The antennæ are much thickened towards the end, the wings are long and narrow, and the species are usually entirely blue black, or green with red, or white and red bands and spots.

Acoloithus represents the Procris (P. vitis) of Europe, but the wings are longer and narrower, and the hind wings are very ovate. The gregarious larva of *A. Americana* is little over half an inch long, being short and thick. It is yellow with a transverse row of black spots on each ring. Before pupating it spins a dense cocoon in crevices. The moth is deep blue black, with a saffron collar. Riley states that the "eggs are deposited in clusters, and in twenty-five to thirty days from the time of hatching, the worms, which then measure rather more than half an inch, spin dirty white, flattened cocoons, mostly in clusters on the leaf. Three days afterwards they become chrysalids, also somewhat flattened, and of a shiny yellowish brown; while in ten days more the moths issue."

The genus *Pyromorpha* has thin, oblong wings, very broad at base, the hinder pair being as broad as the fore-pair; with a small, slender body. *P. dimidiata* Herrich-Schæffer (afterwards described by Clemens under the name of Malthaca perlucidula) is blackish brown, with the basal half of the costal region of both wings yellowish. It expands one inch, and is found sparingly in the Middle States, but has been detected near Boston by Mr. Sanborn.

The species of *Glaucopis* and its allies, abounding in tropical America, are represented in the Northern States by *Ctenucha*, which has pectinated antennæ, long, slender, acutely pointed palpi, and rather broad wings; the apex of the fore-pair being much rounded. The thick-bodied larva feeds on sedges and grass, and is very hairy, like an Arctian. The pupa is short and thick, and much like that of Arctia. *Ctenucha Virginica* Charpentier is of a deep indigo blue, with a smoky tinge on the fore wings, a lighter blue abdomen and a saffron collar. It flies in the hottest sunshine. The female lays her smooth, green, spherical eggs in a broad mass.

Fig. 213.

Lycomorpha has dentated antennæ, the body is unusually slender, and the wings long and narrow. *L. Pholus* Drury is deep blue, the wings being saffron at base. The larva feeds on lichens. From Mr. E. Bicknell I have received the eggs of this moth. The larvæ hatched August 10th, and closely resembled the larvæ of the Arctians when of the same age.

The genus *Callalucia*, according to Grote, differs from its better known ally, Ctenucha, by its antennæ not being so broadly pectinated, its shorter palpi, and by important differences in the venation of the wings. *C. vermiculata* Grote (Fig. 213, hind wing) occurs in Colorado Territory.

Bombycidæ Latreille. This large and handsome family comprises some of the largest and most regal of moths. Their thick heavy bodies, and small sunken heads, and often obsolete mouth-parts (the maxillæ or tongue being especially short compared with other moths), and the broadly pectinated antennæ, together with their broad, often falcate wings and sluggish habits, notwithstanding numerous exceptions, afford good characters for distinguishing them. The clypeus is large, the antennæ are inserted higher up than in other moths, so that when in doubt as to the position of some aberrant forms, a reference to these characters enables us to determine quite readily as to their affinities. The larvæ are thick, usually more hairy than other moths, or, as in the typical forms, Attacus, etc., are thick, fleshy and with seven longitudinal rows of long tubercles, crowned with spines. The hairs, especially of the Arctians, are thickly spinulated, so that the cocoons of the hairy species are very dense and made with but little silk, while the naked larvæ, of which the silk-worm is a type, spin very dense cocoons of the finest silk. It is probable that the caterpillars are usually developed in the egg soon after it is laid in autumn. Dr. Burnett has noticed that the embryos of the American Tent caterpillar are developed before winter sets in, and "Guérin-Méneville has found that the larvæ of the Japanese silk-worm (Samia Yama-maï) are developed in the egg within a few days of their deposition in autumn, although they are not hatched until the following spring." (Zoological Record, 1864.)

Several moths of this family (Arctia pudica, Setina aurita, Hypoprepia fucosa, etc.) have been known to produce a stridulating noise by rubbing their hind legs over a vesicular expansion situated on the sides of the thorax, and the Death's-head Sphinx has long been known to produce a creaking sound. The pupæ are very short and thick and easily recognized by their plump form. "Bar mentions the occurrence in Cayenne of an aquatic caterpillar, which produces a moth, resembling *Bombyx phædima* of Cramer. This larva lives at the bottom of the water, and feeds on the roots of an abundant weed." (Bulletin Société Entomologique de France, 1864.)

Lithosia and its allies (Lithosiinæ) have very narrow wings, the antennæ filiform, and the body slender. The larvæ are cylindrical and covered with short, spinulated hairs. Some of them do not spin cocoons, so far as we know, the pupa of Crocota being found under stones with the dried larva skin still adhering to the tip of the abdomen. *Lithosia argillacea* Pack. is slate-colored, with yellow palpi and prothorax. The base of the wings and the tip of the abdomen are yellowish.

Lithosia casta Sanborn (Fig. 214) is an undescribed species of great beauty, discovered by Mr. Sanborn at Berlin Falls, N. H., August 10th, and also at Ausable Chasm, N. Y. It is pure milk white, with a slight slate-colored tinge on the hind wings, and is slate-colored beneath, especially on the fore wings, and white on the inner edge of the hind wings. Just behind the middle of the white abdomen are tufts of tawny hairs, and the tip is white. It expands one and a quarter inches.

Fig. 214.

Crambidia has still narrower wings. *C. pallida* Pack. is of an uniform drab color and would be easily mistaken for a Crambus. *Nudaria* has broad wings like a geometrid moth, with hyaline spots. The larva is hirsute and makes a thin cocoon of interwoven hairs. *N. mundana* is a European moth. It is represented in this country by *Euphanessa mendica* Walk., which has broader wings and longer palpi. The wings have two rows of smoky transparent spots.

Hypoprepia has rather broader wings than Lithosia. *H. fucosa* Hübner is deep scarlet, with three leaden stripes on the fore wings, the middle stripe situated at the apex of the wing. The larva, Mr. Saunders informs me, is "spiny and black, sprinkled lightly with yellow dots and short lines; there is a dorsal row of yellow dots from the fifth to the twelfth segments. The head is black." Early in May, according to Harris, it makes its cocoon, which is thin and silky, and the moth appears twenty days afterwards.

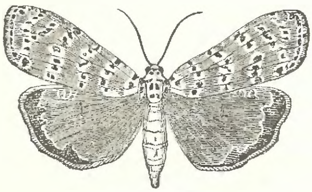


Fig. 215.

Crocota is red, or yellowish red, throughout, with black margins and dots on the wings. The antennæ are filiform and the wings are broad, being triangular in form. Our most common species is *Crocota ferruginosa* Walk., which is pale rust-red, with two dusky broad bands on the outer half of the wing. A much larger form is *Utetheisa bella* Linn. (Fig. 215), a beautiful moth, whose yellow fore wings are crossed by bands of white, encircling black dots, while its scarlet hind wings are edged irregularly with black.

The genus *Callimorpha* is still larger, with broad wings. *C. Lecontei* Boisduval is white, the fore wings being almost entirely bordered with brown. The caterpillars of this genus are usually dark colored, with longitudinal yellow stripes. By day they hide under leaves or stones and feed by night on various shrubby and herbaceous plants. *C. interrupto-marginata* Beauv. (Fig. 216, fore wing) has an anchor-shaped black spot when the wings are folded, one side of the anchor being seen in the figure.

Arctia and its allies are stout-bodied, with short, moderately broad wings, and simple or feathered antennæ. The hairy larvæ are covered with dense whorls of long, spinulose hairs. They make a loose cocoon of interwoven hairs under the shelter of some board or stone. The pupa is short and thick. *Arctia virgo* Linn. is an exceedingly beautiful insect. Its fore wings sometimes expand two inches and a half, and are flesh-red, streaked thickly with broad, black slashes, and on the vermilion-red hind wings are seven or eight large black spots. The caterpillar is brown. *A. Anna* Grote is allied, but differs in the wholly black abdomen and black hind wings. It was described first from Pennsylvania, and has been detected by Mr. B. P. Mann on the Alpine summit of Mount Washington, N. H.

Fig. 216.

The common black and reddish, very hairy caterpillar, found feeding on various garden weeds, is the young of *Pyrrharctia isabella* Smith, a stout-bodied, snuff colored moth. The caterpillar hibernates, as do most of the others of the group of Arctians, and we have kept it fasting for six weeks in the spring, previous to pupating in the middle of June; it remained twenty-seven days in the pupa state, the moth appearing early in June.

Leucarctia differs from Spilosoma in having narrower wings, and the outer edge much more oblique. *Leucarctia acræa* Smith is white and buff colored. Its caterpillar is the salt-marsh caterpillar, which at times has been very injurious by its great numbers. It is yellow, with long hairs growing from yellow warts, and it makes a coarse, hairy cocoon.

Hyphantria textor Harris is entirely white. The caterpillar, or "fall web worm," is slender, greenish yellow, dotted with black, with thin, silken hairs. It spins a thin and almost transparent cocoon, or almost none at all. *H. cunea* Drury is white, spotted with black dots. Mr. Saunders informs me that the larva "will feed on Chenopodium album. The head is small, black, shining, bilobate. The body is black, with a slight shade of brown, and sprinkled with very small, whitish dots. Each segment has a transverse row of shining black tubercles, each giving rise to a tuft of hairs of the same color; on each side of the body is a double row of orange-colored spots from the sixth to the twelfth segment inclusive."

The "yellow bear" is the caterpillar of *Spilosoma Virginica* Fabr. The moth is white, with a black discal dot on the fore wings and two black dots on the hind wings, one on the middle and another near the inner angle.

Halesidota has a more slender body, with longer antennæ and palpi, and longer wings than Arctia, being thin and yellowish, crossed by light brownish streaks. The larva is very short and thick, usually white, with dark pencils and tufts of hairs, arising from twelve black tubercles on each ring, placed as seen in the cut (Fig. 217). *H. tessellaris* Smith, the "checkered tussock moth," is ochre-yellow, with its partially transparent fore wings crossed by five rows of dusky spots. *H. caryæ* Harris is light ochreous, with three rows of white semitransparent spots parallel to the very oblique outer margin. "The chrysalis, according to Harris, is short, thick, and rather blunt, but not rounded at the end and not downy." Mr. Saunders writes me, that the larva of *H. maculata* Harris "feeds on the oak. It is 1.30 inches in length; the body is black, thickly covered with tufts of bright yellow and black hairs. From the fourth to the eleventh segments inclusive is a dorsal row of black tufts, the largest of which is on the fourth segments." The moth appears early in June; it is light ochre-yellow, with large, irregular, light, transverse, brown spots on the fore wings.

Fig. 217

These tufted larvæ lead to the tussock caterpillars, which, as in *Orgyia*, have long pencils of hair projecting over the head and tail. The pretty larvæ of this genus are variously tufted and colored, and feed on the apple tree and various garden vegetables. The males have very broad wings, with very broadly pectinated antennæ, and fly in the hot sunshine in September. The females are wingless and often lay their eggs on the outside of the cocoon, and then die, scarcely moving from their eggs. *O. antiqua* Och. is tawny brown, while *O. leucostigma* Smith is dark brown, with a lunate white spot near the outer angle.

The thick and woolly-bodied, pale yellowish, crinkled-haired *Lagoa* is an interesting genus. The tip of the abdomen is very broad, and the antennæ are curved and broadly pectinated, while the wings are short and broad. The larva is very densely pilose with short, thick, evenly cut hairs, those at the end being longer and more irregular. It is broadly oval, and might easily be mistaken for a hairy Limacodes larva, for, like it, the head is retracted and the legs are so rudimentary as to impart a gliding motion to the caterpillar when it walks. *Lagoa crispata* Pack. is so named from the crinkled woolly hairs on the fore wings. It is dusky orange and slate-colored on the thorax and low down on the sides. Previous to the last moult it is whitish throughout and the hairs are much thinner. The larva (Fig. 218) feeds on the blackberry, and, according to a correspondent in Maryland, it feeds on the apple. The cocoon is long, cylindrical and dense, being formed of the hairs of the larva, closely woven with silk. The pupa is very thin, and after the moth escapes, the thin skin is found sticking partially out of the cocoon, as in Limacodes and its allies (Cochlidiæ).

Fig. 218.

This last group of genera is as interesting as it is anomalous, when we consider the slug-like, footless larvæ, which are either nearly hemispherical, boat-shaped, or oblong, with large fleshy spines, and are painted often with the gayest colors. The pupæ are very thin skinned, and the cocoons are nearly spherical. The moths are often diminutive, the larger forms being stout, woolly-bodied and with short, thick antennæ, pectinated two-thirds their length, while the smaller genera with slender bodies have simple filiform antennæ, and closely resemble some of the Tortrices.

Euclea is a very stout and woolly genus; the antennæ are three-fourths as long as the fore wings and pectinated on their basal half. The fore wings are a little shorter than the body and the hind wings reach to the tip of the broadly tufted abdomen. *Euclea Monitor* Pack. is cinnamon brown, with a large irregular green patch in the middle of the fore wings. We named this species from the striking resemblance of the larva to the iron-clad "Monitor." It is very regularly elliptical, flattened above, and a broad conspicuous brown spot in the middle of the back reminds one of the "cheese-box" or turret. Long, fleshy, bristling spines arise from each end of the larva.

Empretia stimulea Clemens (Plate 8; Fig. 1; 1 *a*, larva) is our largest species of this group. The moth is rarely found by collectors, and is of a rich, deep velvety brown, with a reddish tinge. There is a dark streak along the basal half of the median vein, on which is situated a golden spot, while there are two twin golden spots near the apex of the wing. It expands an inch and a half. The larva is thick and elliptical, the body being rounded above, but flattened beneath, and a little fuller towards the head. There is a pair of densely spinulated tubercles on each side of the segments, the subdorsal pair on the metathoracic ring, and a pair on the seventh abdominal ring, being two-thirds as long as the body is wide. There are three pairs of small, but well developed thoracic legs, while there are none on the abdominal segments. The body is reddish, with the upper side green between the two largest pair of spines, centred with a broad elliptical reddish spot, edged with white, as is the green portion along the side of the body. According to Mr. S. I. Smith, of New Haven, from whom the specimen figured was received, the larva feeds on the raspberry. He states that the hairs sting, as its specific name indicates. The cocoon is rounded, almost spherical, and is surrounded with a loose web, the whole structure being over three-fourths of an inch in length. The moth appeared June 18th.

Phobetrum has narrow wings, and the male is very unlike the female, which has been raised by Mr. Trouvelot, and was confounded by us with the *Thyridopteryx ephemeræformis* of Haworth. Its antennæ are very broadly pectinated, and the remarkably long, narrow fore wings are partly transparent. *Thyridopteryx nigricans* Pack. must be considered as belonging to this genus. The cocoon of the latter species is tough, leathery, brown, and nearly spherical. The larva of *P. pithecium* Smith is broad, ovate, flattened, with six long, tongue-like, fleshy lateral appendages. It feeds on the plum, cherry and apple.

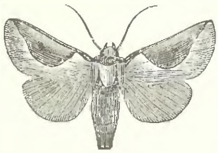


Fig. 219.

In *Limacodes* the fore wings are oblong, the costa being straight, while the hind wings scarcely reach to the tip of the abdomen. The fore wings are often crossed by straight lines forming a V. *L. scapha* Harris (Fig. 219) is light cinnamon brown, with a dark tan-colored triangular spot, lined externally with silver, which is continued along the costa to the base of the wing and terminates sharply on the apex. The larva, as its specific name indicates, is boat-shaped, being of the form of a castana nut, and is green, spotted above with brown, and pale beneath, while the sides of the body are raised, the dorsal surface being flattened. It constructs a dense, oval, spherical cocoon, surrounded by an outer thin envelope.

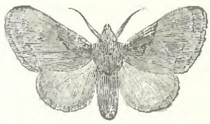


Fig. 220.

Callochlora chloris H-Sch. (Fig. 220) is a pale brown moth, allied to Euclea, and with a broad, pea-green band crossing the fore wings.

Lithacodes (*L. fasciola* Boisd. Fig. 221) and *Tortricodes*, strikingly resemble the genus Tortrix, from their narrow wings, slender bodies, and filiform antennæ.

The subfamily Psychinæ, embraces some remarkably divergent forms. The two genera, *Phryganidia* and *Thyridopteryx*, differing so much in the breadth of their wings and thickness of their bodies, are, however, connected by many intermediate forms occurring in Europe. *Psyche* is a hairy-bodied moth, with broad and thin wings, the female of which is wingless and closely resembles the larva, and inhabits a case, which is constructed of bits of its food-plant. The female of *Psyche helix* has been known to produce young from eggs not fertilized by the male. It lives in a case of grains of sand arranged in the form of a snail shell, thus resembling some Phryganeids in its habits, as it does structurally.

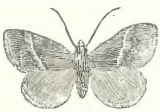


Fig. 221.

The male of *Thyridopteryx* (*T. ephemeræformis* Haworth), the "basket-worm," is stout-bodied, with broadly pectinated antennæ and a long abdomen; the anal forceps and the adjoining parts being capable of unusual extension in order to reach the oviduct of the female, which is wingless, cylindrical, and in its general form closely resembles its larva, and does not leave its case. On being hatched from the eggs, which are, so far as known by us, not extruded from its case by the parent, the young larvæ immediately build little, elongated, basket-like cones, of bits of twigs of the cedar, on which they feed, and may then be seen walking about, tail in the air, this tail or abdomen covered by the incipient case, and presenting a comical sight. The case (Fig. 222) of the full grown larva is elongated, oval, cylindrical, and the fleshy larva transforms within it, while it shelters the female through life. The genus *Œceticus* comprises large species, with much the same habits, growing in tropical America and in Australia.

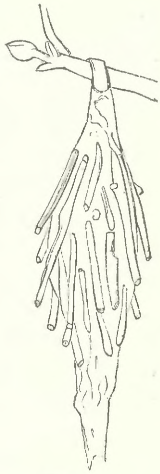


Fig. 222.

A basket-worm, allied to *Œceticus*, has been discovered in Florida, by Mr. Glover, feeding upon the orange, and we give the following account of it from the study of his admirable drawings. With much the same habits, it belongs to quite a different and undescribed genus. The body of the male resembles that of the broad winged Psyche, and indeed, this moth may be regarded as a connecting link between the latter genus and Œceticus. It may be called the *Platœceticus Gloverii* (Fig. 223). Its body is slender, with pectinated antennæ; the wings very broad, irregular, and the hind wings are broad and much rounded, reaching a third of their length beyond the tip of the abdomen. It is dark brown throughout, and expands three-fourths of an inch. The wingless, cylindrical, worm-like female (Fig. 223 *b*) is acutely oval in form, and whitish. The larva (Fig. 223 *c*) is rather flattened and resembles that of

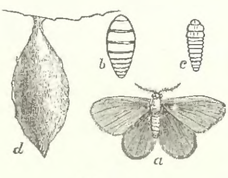


Fig. 223.

Thyridopteryx. It constructs an oval cocoon (Fig. 223 *d*) which hangs to the edge of the leaf.

The genus *Perophora*, another sack-bearer (P. Melsheimerii Harris), is a gigantic Psychid, being about the size of the silk-worm moth, which it closely resembles in the imago state. It also lives in a case during the larva state, formed of two oblong pieces of leaf, fastened together in the neatest manner by their edges, and lined with a thick and tough layer of brownish silk. The larva is cylindrical, as thick as a common pipe-stem and light reddish brown in color. The head has extensible, jointed feelers which, when extended, are kept in constant motion, while behind is a pair of antenna-like organs, broad and flattened at the end. The tail is widened and flattened, forming a circular horny plate, which like the operculum of a whelk, closes up the aperture of the case. Before transforming within its case, the larva closes each end with a circular silken lid. The pupa is blunt at the hinder end and with a row of teeth on each abdominal ring. Both sexes are winged. Our species, *P. Melsheimerii* Harris, is reddish ash grey, sprinkled with blackish points, and with a common oblique blackish line.

Fig. 224.

Notodonta and its allies (Ptilodontes Hübner) are mostly naked in the larva state, with large humps on the back, and the hind legs often greatly prolonged, as in Cerura, the "fork-tail." The pupa and moths are best described by stating that they bear a close resemblance to the Noctuids, for which they are often mistaken.

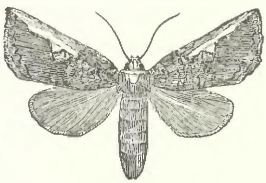


Fig. 225.

Cœlodasys (Notodonta) *unicornis* Smith derives its specific name from the horn on the back of the caterpillar, and its generic name from the large conical tuft of hairs on the under side of the prothorax. The moth is light brown, with irregular green patches on the fore wings. The cocoon is thin and parchment-like, and the caterpillars remain a long time in their cocoons before changing to pupæ. *Nerice bidentata* Walker (Fig. 224) is a closely allied moth. *Edema* *albifrons* Smith (Fig. 225) is known by the costa being white on the outer two-thirds. It feeds on the oak, to which it is occasionally destructive. Mr. Riley (American Entomologist, vol. i, p. 39) describes the larva as being of a "bluish white ground-color, marked longitudinally with yellow bands and fine black lines, with the head and a hump on the eleventh segment either of a light coral or dark flesh color." It generally elevates the end of the body. It pupates during the last of September, the moth appearing about the middle of April, in the vicinity of Chicago.

Platypteryx, a small geometra-like moth, with its broad falcate wings, seems a miniature Attacus. Its larva is slender, with fourteen legs, and naked, with several little prominences on the back, and the tail is forked like Cerura. The pupa is enclosed in a cocoon among leaves. *P. geniculata* Walker, and *Dryopteris rosea* Grote, represent this interesting group. We also give a rude sketch, traced from Abbot's drawings, from the advanced sheets of the Harris Correspondence, of an undescribed species of Dryopteris (Fig. 226, and its larva). Doubleday states that the moth is rose-colored, with a few red dots in the yellow portion of the hind wings.

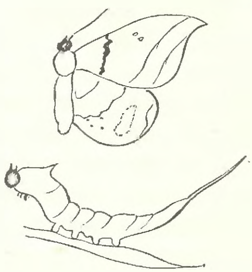


Fig. 226.

The Chinese silk-worm, *Bombyx mori* Linn., has white falcate fore wings, while the hind wings do not reach to the tip of the abdomen, and the antennæ are well pectinated. The larva is naked, rather slender compared with those of the next group, and cylindrical; the second thoracic ring is humped, and there is a long horn on the tail. It is three to three and a half inches long. It is of an ashy or cream color, but "in almost every batch of worms there will be seen after the first moult has occurred, some dark colored, which, at the first glance, appear to be a distinct species," but Captain Hutton, of India, shows that "so far, however, are they from being a mere passing variety that they are actually types of the original species, and merely require to be treated according to the established rules of breeding in order to render them permanent and healthy."

"He attributed the enormous loss of silk-worms by muscardine and other diseases, and the consequent diminution of the crop of silk, to the combined effects of bad and scanty food, want of sufficient light and ventilation, too high a temperature, and constant interbreeding for centuries of a debilitated stock. He asserted that there was no such thing now in existence as a perfectly healthy domesticated stock of silkworms; and moreover, that it was useless to seek for healthy seed, for whether in Europe, Persia, India or China, the worms were all equally degenerated, or, if there were a difference at all, it was in favor of the European race. He had for several years been experimenting on Bombyx mori, with a view, if possible, to reclaim the worms, to restore to them a healthy constitution and to induce them to *revert* from their present artificial and moribund condition to one of vigor and permanent health. The occasional occurrence in a brood of one or more dark grey or blackish-brindled worms — the 'vers tigrés' or 'vers zébrés' of the French — contrasting strongly with the pale sickly hue of the majority, must have been noticed by all who have had experience in rearing silk-worms; such occurrences have been always spoken of as indicating varieties arising from domestication. The author had endeavored, by a series of experiments, to ascertain the cause of this phenomenon, his conviction being, either that the species had at some time or other been crossed by another of different colors, and that Nature, as sooner or later she always would do, was making an effort to separate them, or that the original color of the worm had been dark, and an effort was being made to *revert* from a sickly condition to the original healthy starting point. He accordingly picked out all the dark colored worms and reared them separately, allowing the moths to couple only *inter se*, and the same with the white worms. In the following spring the one batch of eggs produced nearly all dark brindled worms, whilst the other batch produced white worms, sparingly interspersed with an occasional dark one; these latter were removed into a dark batch, which was also weeded of its pale worms. In the third year the worms were still darker than before, and were always larger and more vigorous than the pale ones, giving larger and better stuffed cocoons. He finally succeeded in getting an entire brood of dark worms, which he regarded as a sign of increased health and strength in the larvæ, thus proving that the dark worms were of the original race, which also agrees with the colors of the numerous species of the genus of which he has, with others, made known nearly twenty. The author also considers the white cocoons as a strong sign of degeneracy, arguing that the good quality of the silk produced, was no proof of the general health of the insect, as the maladies affected rather the quantity produced, and the present great fineness was due likewise to the disease." (Proceedings of the Entomological Society of London.) The silk-worm is an annual, though some species of this group yield two and three broods in the warmer parts of India. It moults four times, but occasionally only three times.

The cocoon of the silk-worm is white or whitish yellow and is over an inch long and nearly half as broad; 360 cocoons weigh a pound and a half. In France and Italy about thirty-six days elapse between the hatching of the larva and the formation of the cocoon, it taking four days for the spinning of the cocoon. In England and certain parts of India it requires forty-six days for its formation.

The above remarks apply to *Bombyx mori* Linn., the Chinese silk-worm, which feeds on the mulberry, originally derived from the mountainous provinces of China. It is the largest and strongest of the domesticated species. There are, however, as shown by Captain Hutton, twelve species of silk-worms, most of which have been confounded under the name of *B. mori*, and which belong to the genera *Bombyx* of Schrank, *Ocinara* of Walker, and *Trilocha* Moore. There are six domesticated species of Bombyx. There is not silk enough in the cocoon of *Ocinara* to make it worth cultivating (Hutton).

Captain Hutton, speaking of the larvæ of *B. Huttoni*, remarks that it "is curious to observe the instinctive knowledge which these worms appear to possess of the approach of a hail-storm. No sooner are the peals of thunder heard, than the whole brood seems to regard them as a warning trumpet-call, and all are instantly in motion, seeking shelter beneath the thicker branches, and even descending the trunk of the tree to some little distance, but never proceeding so low down as to lose the protecting shelter of the boughs. For rain they care nothing, but appear to be able to distinguish between the coming of a heavy shower, and the more pitiless pelting of the hail."

Attacus and its allies (Attaci) form the central and most typical group of the family. They are among the largest of insects. The genus *Attacus* is found in China, the East Indies and the South Sea Islands, and in Brazil. Its immense size, falcate wings, with the large triangular transparent spot in the centre, readily distinguish it. *A. Atlas* Linn., from China, expands from seven to nine inches. *Samia* is a smaller genus and with a partially transparent lunate spot in the middle of the wings. *Samia Cynthia* Linn. has been introduced from China and is a hardy worm, quite easily raised, and the silk is

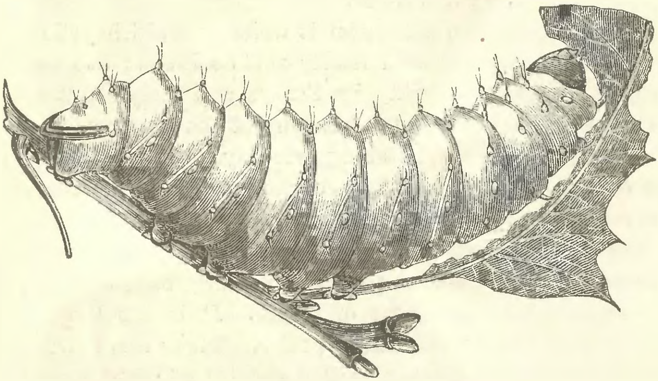
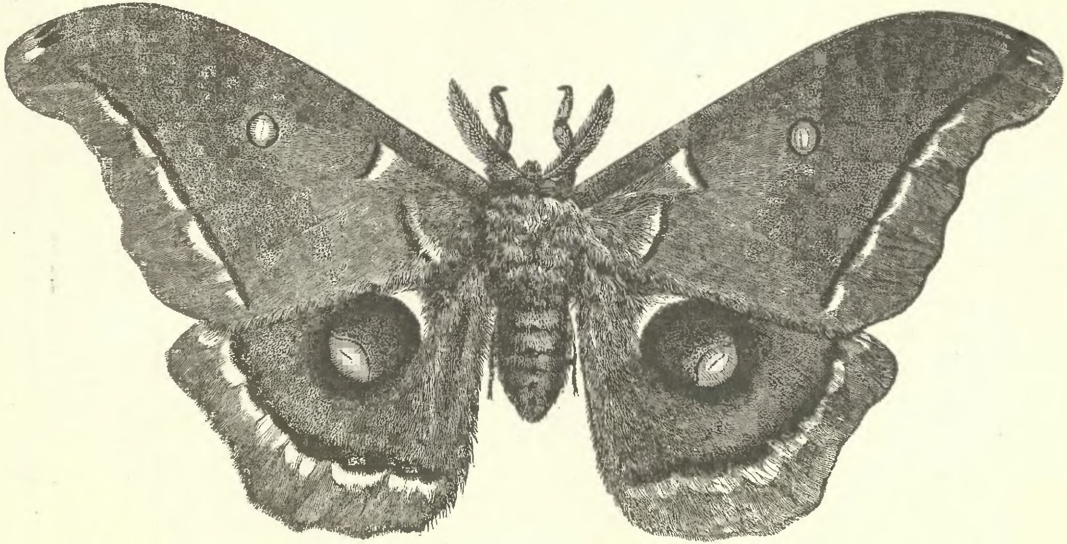


Fig. 227.

of a good quality. Mr. W. V. Andrews urges, in the American Naturalist (vol. ii, p. 311), the cultivation of the Cynthia silkworm in this country, as it is double-brooded, our native species bearing but a single crop of worms. It feeds on the ailanthus, and can be reared in the open air. Among many allied forms, generally referred to the genus Attacus but which still need revision, are the *A. Mylitta* (Tussah worm), from China and India; *A. Pernyi*, from Manchouria, which feeds on the oak, and which has been raised in France, and the Japanese *A. Yama-maï*, all of which produce silk, though less reared in Europe than the Cynthia worm. The silk of the Yama-maï moth approaches nearest that of B. mori, and as it feeds on

Plate 6.



the oak, and can be raised in the open air, its cultivation has gained much attention in Europe. *A. Aurota* Beauv. is common in Central and South America. In Brazil it could be raised with success for home use, but is too delicate for a northern climate.

Telea Polyphemus (Pl. 6, male; Pl. 7, female) is brown, with large transparent eye-like spots in the centre of the wings. The thread of which the cocoon is spun is continuous, and is readily unwound. It is coarser than that of the Bombyx mori, but has a rich gloss and can be used very extensively in commerce. Its larva (Fig. 227), which feeds on the oak, is thick, fleshy, striped obliquely with white on the sides, with angulated segments, on which are tubercles giving rise to a few short hairs. The pupa (Fig. 228) is very thick, and the cocoon (Fig. 229) is regularly oval cylindrical.

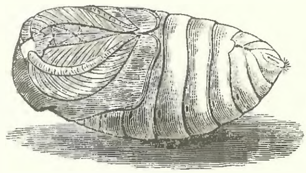


Fig. 228.

Mr. L. Trouvelot gives an account in the American Naturalist (vol. i) of this silk-worm, which is our most hardy native worm. So successful was he in rearing them that in a single season "not less than a million could be seen feeding in the open air upon bushes covered with a net." The moths leave the cocoons late in May, appearing until the middle of June. They then lay their eggs, generally singly, on the under side of the leaves. In ten or twelve days the caterpillars hatch; the operation usually takes place early in the day. The worm moults five times, the first four moultings occurring at intervals of ten days, while about twenty days elapse between the fourth and fifth moults, this process usually occurring late in the afternoon. It makes its cocoon late in September, and in six or eight days after beginning its cocoon assumes the pupa state, and in this condition passes the winter.

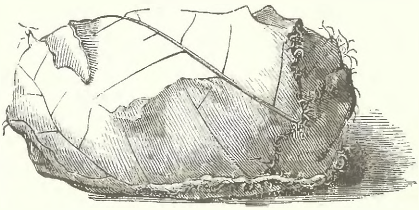


Fig. 229.

The genus *Actias* is at once known by the hind wings being prolonged into a long tail which reaches far behind the tip of the abdomen. *Actias Luna* Linn. is green and the larva closely resembles that of Telea; it is, however, banded obliquely with yellow instead of white, and spins a cocoon that is of much the same shape. It is not so hardy a worm as the Polyphemus caterpillar. It lives on the walnut, hickory and maple. In the Museum of the Peabody Academy is a closely allied and undescribed species from the west coast of Guatemala, which we would call *Actias Azteca*. It differs from A. Luna in its much smaller size, expanding only three and a half inches, and in the shorter fore wings, the apex being much rounded and with shorter veins, while the "tails" on the hind wings are only half as long as those of A. Luna. It also differs in having the origin of the first subcostal venule much nearer the discal spot than in A. Luna, being very near that of the second subcostal venule. It is whitish green, with markings not essentially differing from those of A. Luna.

Callosamia is a genus with broader wings and no transparent eye-like spots. The larva has large tubercles and is very plump. Its characters are intermediate between those of *Samia* and *Platysamia*. *C. Promethea* Drury is a smaller species than the others. Its larva is pale bluish green, with the head, tail and feet yellow, with eight warts on each ring, those on the two first thoracic rings being the largest, much longer than the rest and coral red. The cocoon is hung by a stout silken cord to the stem of the leaf which is then wrapped around it. It may be found attached to the twigs of the wild cherry, Azalea and Cephalanthus, or button bush, in winter after the leaves have fallen.

Our most common species of this group is the Cecropia moth, belonging to the genus *Platysamia*, which has a broader head and wings than the foregoing genera. The caterpillar of *P. Cecropia* Linn. is longer, with long spinulated tubercles, especially marked on the thoracic rings; the large, very dense cocoon is open at one end and thus the silk cannot be unwound so well as that of the Polyphemus worm, but it is still useful, and *Platysamia Euryale* Boisduval is cultivated in California for its silk, though the cultivation of the Chinese silkworm (B. mori) is carried on there very largely.

The next group, the Ceratocampadæ of Harris, is composed of large moths, in which the hind wings scarcely extend beyond the tip of the abdomen, and the wings are often ocellated. The larvæ are longer than in the *Attaci* and more hairy.

Eucronia Maia Drury has a narrow, lunate, curved white line in the centre of each wing; it expands from two and a half to three inches, and is black with a common, broad, yellowish white band. The caterpillar is elongated, with six long branched prickles on each ring. It feeds on the oak.

Hyperchiria varia Walker (Saturnia Io of Harris) is a little larger than the preceding. The male is yellow and the female reddish brown, with a faint eye-like spot on the fore wing, and on the hind wings a large round blue spot, margined with black and pupilled with white. The caterpillar is green, with spreading tufts of spines, very sharp, stinging severely when the insect is handled, and arising from a tubercle, of which there are six on each ring; the fascicles on the side are as represented in Fig. 230. The pupa is thick, pointed at the tip of the abdomen, and the cocoon is thin, being made under leaves on the ground. It feeds on the corn and cotton, to which it is very harmful southwards, and also on the maple, elm, etc.

Fig. 230.

Citheronia regalis Hübner expands from five to six inches, and its fore wings are olive colored, spotted with yellow and veined with broad red lines, while the hind wings are orange red, spotted with olive, green and yellow. The caterpillar is spiny, having four large acute spinulated spines on the anterior thoracic segments. It feeds on the walnut, hickory and the persimmon tree, and spins no cocoon. A second species, *C. Mexicana* Grote and Robinson, has been described, as its name indicates, from Mexico: it is more orange and less red, with duller yellow patches. Fig. 231 is a rude sketch (from the Harris Correspondence) of the young larva, with two of the peculiar long hairs next the head magnified. A much smaller species, which expands only 3.10 inches, is the *C. sepulcralis* G. and R., which was discovered at Andover, Mass., by Mr. J. O. Treat. It is purplish brown, without any yellow spots, and with a diffuse discal spot, centred

Fig. 231.

with reddish scales. Mr. Treat has raised this fine moth from the larva found on the common pitch pine; it resembles that of C. regalis. It also occurs in Georgia, as it has been figured in the unpublished drawings of Abbot, now in the possession of the Boston Society of Natural History.

Eacles imperialis Hübner has broader wings, expanding from four and a half to over five inches. The wings are yellow with purple brown spots. The larva is but slightly tuberculated, with long, fine hairs. Its chrysalis is like that of Anisota.

The genus *Anisota* is much smaller than the foregoing, with variously striped larvæ, which are naked, with two long, slender spines on the prothoracic ring, and six much shorter spines on each of the succeeding segments. They make no cocoons, but bury themselves several inches deep in the soil just before transforming, and the chrysalids end in a long spine, with the abdominal rings very convex and armed with a row of small spines. The species have much smaller, narrower wings, with less broadly pectinated antennæ than in the foregoing moths. *A. rubicunda* Fabr. is rose colored, with a broad, pale yellow band on the fore wings. *Anisota senatoria* Smith is pale tawny brown, with a large, white, round dot in the centre of each fore wing.

The next group of this extensive family embraces the Lachneides of Hübner, in which the moths have very woolly stout bodies, small wings, with stoutly pectinated antennæ, while the larvæ are long, cylindrical and hairy, scarcely tuberculated, and spin a very dense cocoon. The pupæ are longer than in the two preceding subfamilies. *Gastropacha* (Fig. 159, hind wing) has scalloped wings, and a singular grayish larva whose body is expanded laterally, being rather flattened. *G. Americana* Harris is rusty brown, slightly frosted, and with ashen bands on the wings.

In *Tolype* the wings are entire. *T. Velleda* Stoll is a curious moth, being white, clouded with blue gray, with two broad, dark gray bands on the fore wings. The larva is hairy and is liable to be mistaken for an excrescence on the bark of the apple tree, on which it feeds.

The American Tent Caterpillar is the larva of *Clisiocampa*, well known by its handsome caterpillars, and its large, conspicuous webs placed in neglected apple trees and on the wild cherry. The eggs are laid on the twigs, in bunches of from 300 to 400, placed side by side and covered with a tough gummy matter; they are sometimes infested by chalcid parasites.

The larvæ of *C. Americana* Harris hatch out just as the leaves are unfolding and soon form a web, under which the colony lives. They may be destroyed by previously searching for the bunches of eggs on the twigs before the tree is leaved out, and the caterpillars may be killed with a brush or mop dipped into strong soap-suds, or a weak solution of petroleum.

The larvæ become full grown about the middle of June, then spin their dense white cocoons, under the bark of trees, etc., and the moths appear about the first of July. The larva of *C. Americana* is about two inches long, hairy, with a dorsal white stripe, with numerous fine crinkled black lines on a yellow ground, united below into a common black band, with a blue spot on the side of each ring. The moth (Fig. 232, and larva)

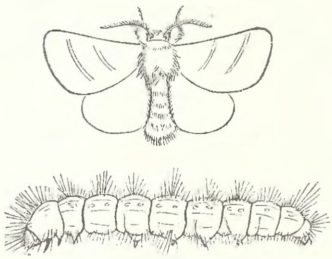


Fig. 232.

is reddish brown, with two oblique, dirty white lines on the fore wings. It expands from an inch and a quarter to an inch and a half. The Forest Tent caterpillar, *C. disstria* Hübner (C. sylvatica Harris) differs in the apex of the fore wings being much longer, with two transverse rust brown, nearly straight, parallel lines. It is sometimes destructive to the apple and oak trees.

The *Hepiali* are a group of boring moths, the larvæ boring in the stems of plants or in trees. The wings are narrow, both pairs being very equal in size, and show a tendency to recur to the net-veined style of venation of the Neuroptera. *Xyleutes* is a large moth, with a stout vein passing through the middle of the discal space, and the short antennæ have two rows of short teeth on the under side. *X. robiniæ* Peck is gray, with irregular black lines and dots on the wings, and a black line on the inside of the shoulder tippets. The hind wings of the male

(X. crepera Harris) are distinctly triangular and yellow on the outer half. The larva is nearly three inches long, is reddish above and covered with sparse long hairs. It bores in various directions through the red oak and locust, and spins a dense cocoon. The pupa is much elongated, with the suture between the segments well marked, and the head and thorax rather small.

Sthenopis is a gigantic moth, with more falcate wings than in Hepialus. *S. argenteomaculata* Harris expands nearly three inches, and is ashy gray, variegated with dusky clouds and bands, with a small, triangular, silvery spot and round dot near the base of the fore wings. Hepialus is smaller, with a larger head and straighter wings. *H. humuli* Linn. is injurious to the hop vine in Europe. Our most common species, *H. mustelinus* Pack., is sable brown, with slight silvery lines on the fore wings. It expands a little over an inch and a quarter.

NOCTUÆLITÆ Latreille (*Noctuidæ*). Owlet moths. There is a great uniformity in the genera of this family, which are characterized by their thick bodies, the thorax being often crested, by the stout and well developed palpi, and the simple and sometimes slightly pectinated antennæ. The fore wings are small and narrow, and the rather large hind wings are when at rest folded under them, so that the moth looks much smaller than when flying. They fly swiftly at night, and are attracted by light. The fore wings have almost invariably a dot and reniform spot in the middle of the wing, and the moths are generally dark and dull colored. The larvæ taper towards each end, and are striped and barred in different ways. They have sixteen feet, except those of the lower genera, such as Catocala and other broad-winged genera, which have fourteen, and look when they walk like the Geometers. They make thin earthen cocoons, and the pupæ generally live under ground. In these and other more essential characters, this family is intermediate between the Bombycidæ and the Phalænidæ. There are about 2,500 species known.

These moths can be taken at dusk flying about flowers, while they enter open windows in the evening, and during the night are attracted by the light within. When alighted on the table under a lamp a slight tap with a ruler will kill them without injuring the specimens. In warm, foggy evenings, they enter in great numbers. The moths fly in July and August, but many species occur only in autumn, while others hibernate and are taken early in the spring. An English writer says, "moths are extremely susceptible of any keenness in the air; a north or east wind is very likely to keep them from venturing abroad. Different species have different hours of flight."

An English entomologist states, that "after dusk the flowers of the willow are the resort of several species of moths (Noctuidæ), some of which have hibernated, and others have just left their pupa state. It is now some fifteen years since the collectors first took moths in this way, that were likely long to have remained deficient in the collections but for the discovery, by Mr. H. Doubleday, of the attractive powers of the sallow blossoms. I believe it was the same gentleman who found out about the same time that a mixture of sugar and beer [or rum and sugar or molasses, etc.], mixed to a consistence somewhat thinner than treacle, is a most attractive bait to all the *Noctuidæ*. The revolution wrought in our collections, and our knowledge of species since its use, is wonderful."

"The mixture is taken to the woods, and put upon the trunks of trees in patches or stripes, just at dusk. Before it is dark some moths arrive, and a succession of comers continue all through the night, until the first dawn of day warns the revellers to depart. The collector goes, soon after dark, with a bull's-eye lantern, a ring net, and a lot of large pill boxes. He turns his light full on the wetted place, at the same time placing his net underneath it, in order to catch any moth that may fall. The sugar bait may be used from March to October with success, not only in woods, but in lanes, gardens, and wherever a tree or post can be found to put it upon. The best nights will be those that are warm, dark and wet; cold, moonlight, or bright, clear and dry nights are always found to be unproductive. It is also of no avail to use sugar in the vicinity of attractive flowers, such as those of the willow, lime or ivy. Sometimes one of the *Geometridæ* or *Tineidæ* comes, and occasionlly a good beetle." The virgins' bower, when in blossom, is a favorite resort of Noctuæ. Many can be taken by carrying a kerosene lamp into the woods and watching for whatever is attracted by its light.

Thyatira and *Cymatophora* are allied by their small, hairy heads, to the Notodontæ in the preceding family. In Thyratira the palpi are long and depressed, and the fore wings are dark, with five or six large light spots, and the larva is like that of the Notodontæ, the segments being humped, and the anal legs raised while at rest, while *Cymatophora* is pale ashen, the fore wings being crossed by four or five waved lines. The larva is smooth, rather flattened beneath, with a large head. It feeds on trees, between two leaves united by silk. *C. caniplaga* Walker describes from Canada. *Gramatophora trisignata* Doubleday (Fig. 233, fore wing) is a gaily colored species, greenish, marbled with black, with three large, round, brown spots on the fore wings. The larva (Fig. 234) is humped, giving it a zig-zag outline, and is brown with the third to the sixth abdominal rings much paler. It has the unusual power of boring very smooth, cylindrical holes in solid pine wood. We have received specimens of its tunnels from Mrs. J. Brigham. We have found the larvæ just moulting on the leaves of the lilac, September 12th.

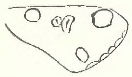


Fig. 233.

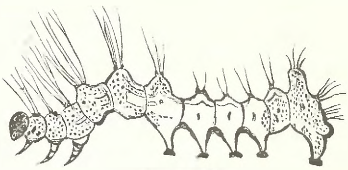


Fig. 234.

In *Acronycta* the head becomes large and broad, the fore wings are broad and short, with dark streaks and a dark mark, like the Greek letter Psi on the inner margin. The larvæ vary in being humped or cylindrical, downy, slightly hairy, or very hairy, and feed exposed on shrubs. The pupa lies in a cocoon made in moss or in crevices of bark. *A. oblinita* Smith (Fig. 235, larva) is whitish gray, with darker streaks on the fore wings.

Fig. 235.

Apatela Americana Harris is a large, pale gray moth, without black streaks, whose woolly, yellowish caterpillar, with long, slender pencils of black hairs, feeds on the maple.

We have received from Mr. Sanborn a singular caterpiller allied to this genus (Fig. 236), which is figured in the Harris Correspondence as *Acronycta acris?* var. Americana. "It is greenish brown," according to Harris, "each segment above with a transverse oval greenish yellow spot; the body is beset with a few long black bristles, dilated at the end, which do not grow, as usual, from small warts; there are no long bristles on the second and third thoracic, or on the tenth abdominal rings. It moves very quickly, and rests with the fore part of the body bent sideways. The chrysalis was found under a log fastened to another with a few threads. The moth appeared June 28th."

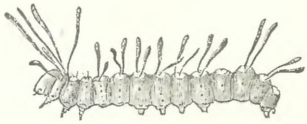


Fig. 236.

In *Leucania* the fore-wings are short, the outer margin nearly straight, while the hind wings are usually white. *Leucania unipuncta* Haworth (Plate 8, fig. 2; *a*, larva) is the "Army-worm" of the Northern States. Its larva is smooth, cylindrical, tapering rapidly towards each end, and striped with fine, dark, longitudinal lines. It feeds on grasses, and in certain years has greatly ravaged wheat fields. It hides by day among tufts of grass. The moth is rusty, grayish brown, peppered with black scales, and with an oblique row of about ten black dots running towards the apex, and a white discal spot. It expands a little over one and a half inches. It constructs, in the middle of August, a rude earthen cocoon, or cell of dry grass. The moth appears the last of August northwards. Six species of Ichneumon, and one of Tachina, prey upon this species. To prevent the too great accumulation of this very destructive caterpillar, the grass land should be burnt over in autumn. When on the march their armies may be kept out by ditching, and hogs and fowl should be turned into fields during the middle of August, while they are transforming, to prevent their attacks the succeeding year.

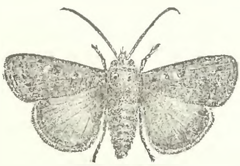


Fig. 237.

Agrotis, the Dart-moth, is known by its crested thorax; the palpi are broad and truncated, level with the front, and the antennæ are either somewhat pectinated or distinctly ciliated. The dot and reniform spot are very distinct, being situated on a black ground, and there is a basal, median, black streak on the fore wing. The apex of the hind wings is much produced. The larvæ, called "cut worms," are thick, with a distinct, horny, prothoracic plate, like that in the Tortrices, or leaf-rollers; they are marked with shining and warty, or smooth and concolorous spots, and often longitudinal dark lines, and live by day hidden under sticks and the roots of low plants; feeding by night. The pupa is found living under ground. *Agrotis tessellata* of Harris (Fig. 237) is dark ash colored; the two ordinary spots on the fore wings are large and pale, and alternate with a triangular and a square, deep, black spot. It expands an inch and a quarter. *Agrotis devastator* Harris is the moth of the cabbage cut-worm. Another very abundant species, often seen flying over the blossoms of the Golden-rod in autumn is the *Agrotis subgothica* (Fig. 238). Mr. Riley states that this moth is the "parent of a cut-worm which very closely resembles that of A. Cochrani, but which has the dark side divided into two stripes. The chrysalis remains somewhat longer in the ground, and the moth makes its appearance from four to six weeks later than A. Cochrani."

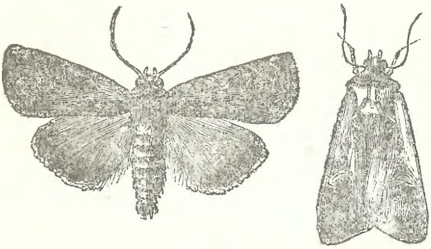


Fig. 238.

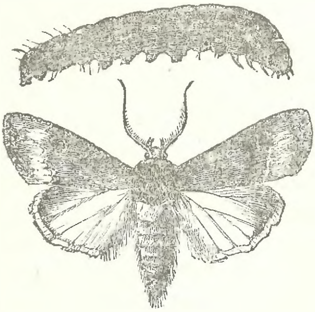


Fig. 239.

A. suffusa Den. and Schief. (A. telifera of Harris, fig. 239) is so named from the lance-like streaks on the fore wings. It appears late in July, and probably attacks corn, as Mr. Uhler has found the chrysalids at the roots of corn in Maryland. Riley describes the larva under the name of the Large Black Cut-worm. It is an inch and a half in length when crawling.

"Its general color above is dull, dark, leaden brown, with a faint trace of a dirty yellow white line along the back. The subdorsal line is more distinct, and between it and the stigmata are two other indistinct pale lines. There are eight black, shiny, piliferous spots on each segment; two near the subdorsal line, the smaller a little above anteriorly; the larger just below it, and a little back of the middle of the segment, with the line appearing especially light above it. The other two are placed each side of the stigmata, the one anteriorly a little above, the other just behind, in the same line with them, and having a white shade above it."

While cut-worms have usually been supposed to feed upon the roots of grasses and to cut off the leaves of succulent vegetables, Mr. Cochran, of Calumet, Ill., has discovered that one species ascends the apple, pear and grape, eating off the fruit buds, thus doing immense damage to the orchard. Mr. Cochran, in a letter published in the "Prairie Farmer," states that "they destroy low branched fruit trees of all kinds except the peach, feeding on the fruit buds first, the wood buds as a second choice, and preferring them to all things, tender grape buds and shoots (to which they are also partial) not excepted; the miller always preferring to lay her eggs near the hill or mound over the roots of the trees in the orchard, and if, as is many times the case, the trees have a spring dressing of lime or ashes with the view of preventing the operations of the May beetles, this will be selected with unerring instinct by the miller, thus giving her larvæ a fine warm bed to cover themselves with during the day from the observation of their enemies. They will leave potatoes, peas and all other young, green things, for the buds of the apple and the pear. The long, naked, young trees of the orchard are almost exempt from their voracious attacks, but I found them about midnight, of a dark and damp night, well up in the limbs of these. The habit of the dwarf apple and pear tree, however, just suits their nature, and much of the complaint of those people who cannot make these trees thrive on a sandy soil, has its source and foundation here, though apparently, utterly unknown to the orchardist. There is no known remedy; salt has no properties repulsive to them; they burrow in it equally as quick as in lime or ashes. Tobacco, soap and other diluted washes do not even provoke them; but a tin tube, six inches in length, opened on one side and closed around the base of the tree, fitting close and entering at the lower end an inch into the earth, is what the lawyers would term an effectual estoppel to further proceedings.

"If the dwarf tree branches so low from the ground as not to leave six inches clear of trunk between the limbs and ground, the limbs must be sacrificed to save the tree, as in two nights four or five of these pests will fully and effectually strip a four or five year old dwarf of every fruit and wood bud, and often when the tree is green utterly denude it of its foliage. I look upon them as an enemy to the orchard more fatal than the canker worm when left to themselves, but fortunately for mankind, more surely headed off."

Mr. Riley has named this cut-worm *Agrotis Cochrani* (Fig. 240, and larva) and describes the larva which, according to the observations of J. Townley of Marquette, Wis., also ascends standard trees, not confining its injuries to dwarf trees. The cut-worm is 1.07 inches in length. "It is slightly shagreened and the general color is of a dingy ash gray, with lighter or darker shadings. The back is light, inclining to flesh color with a darker dingy line along the dorsum. The sides, particularly along the subdorsal line, are of a darker shade. On each segment there are eight small, black, shiny, slightly elevated points, having the appearance of black sealing-wax, from each of which originates a small black bristle. The stigmata are of the same black color and one of the black spots is placed quite close to them anteriorly. The head is shiny and of the same dingy color, with two darker marks; thick and almost joining at the upper surface, becoming thinner below and diverging towards the palpi. The upper surface of the first segment is also shiny like the head. The ventral region is of the same dingy color, but lighter, having a greenish tinge

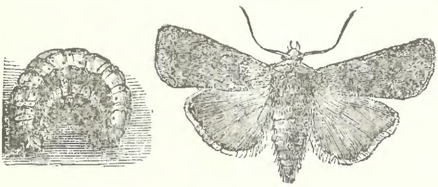


Fig. 240.

anteriorly and inclining to yellow under the anal segment. Prolegs and feet of the same color. It has a few short bristles on the anterior and lateral segments.

"The head is light brown, with a dark brown spot on each side and dark brown above, leaving the inverted Y mark in the middle light brown, and having much the appearance of a goblet, as one looks from tail to head. The cervical shield is dark brown, except a stripe above and on each side. There are sparse, short, white bristles laterally and posteriorly. The venter and legs are of a glaucous glassy color, and the feet are light brown."

"The moth in its general appearance bears a great resemblance to *Hadena chenopodii*, but the two are found to differ essentially when compared. From specimens of H. chenopodii, kindly furnished me by Mr. Walsh, and named by Grote, I am enabled to give the essential differences, which are: 1. In *A. Cochrani*, as already stated, the middle area exceeds somewhat in width either of the other two, while in H. chenopodii it is but half as wide as either; 2. In the Agrotis the space between the spots and between the reniform and transverse posterior is dark, relieving the spots and giving them a light appearance, whilst in the Hadena this space is of the same color as the wing, and the reniform spot is dark. The claviform spot in the Hadena is also quite prominent, and one of its distinctive features; while in the Agrotis it is just about obsolete.

Another larva is called by Mr. Riley the W-marked cutworm. "It measures one and an eighth inches, and its general color is ash gray, inclining on the back and upper sides to dirty yellow: it is finely speckled all over with black and brown spots. Along the back there is a fine line of a lighter color shaded on each side at the ring joints with a darker color. Subdorsal line light sulphur yellow, with a band of dirty brownish yellow underneath. Along the stigmatal region is a wavy line of a dark shade with flesh colored markings underneath it; but the distinguishing feature is a row of black velvety marks along each side of the back, on all but the thoracic segments, and bearing a general resemblance (looking from tail to head), to the letter W. The ventral region is greenish gray; prolegs of the same color; thoracic feet brown black. Head black with white lines in front, resembling an inverted Y, and white at the sides. The thoracic segments frequently have a greenish hue."

Still another, of which the moth is unknown, is described by Mr. Riley under the name of the Pale Cut-worm. "It is of the same length as Cochran's cut-worm, and the general color is pale gray, with a lilac colored hue, caused by innumerable light purplish markings on an almost white ground. There is no particular shading on the back, and it is very slight along the subdorsal line. The stigmatal line, however, being destitute of the above mentioned markings, is almost white. Above this line there is a band of a darker shade than the rest of the body. At first sight this worm appears quite smooth and uniform in color, the most striking feature being the second segment, which is shiny black, with three white lines. One of these lines is on the top, and continues to some extent on the head; the others are placed on each side of this and do not run down as far. The anal segment has also two black shiny marks on its surface. The stigmata are black and the head is gray, below light shiny, and brown above. Legs and feet of the same color as the under side of the body which is nearly white with a glaucous tinge. There are a few scattering hairs near the tail. This worm is smoother than the others."

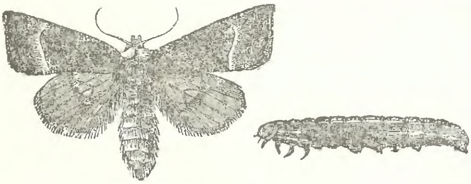


Fig. 241. *a*

In *Gortyna* the antennæ are crenulated in the male, and the fore wings are yellow with darker markings. The larva is dull colored with warty spots. That of *G. flavago*, an European species, feeds in the stems of thistles and the burdock, changing to a pupa inside the stem. *G. leucostigma* attacks the columbine (Harris). The habits of the Dahlia and Aster stalk borer (Gortyna nitela Guenée) have been described by Mr. Riley, who states that the fore wings of the moth (Fig. 241; *a*, larva) are lilac gray, speckled with minute yellow dots, with a distinct white band running across them. The caterpillar is generally of a livid or purplish brown, though varying much as to depth of shading and is darker before than behind. "The young worm hatches about the first of July and immediately commences its work of destruction. It works in such a surreptitious manner as to be too often unnoticed till the vine is destroyed. The plant does not generally show any signs of decay until the cocoon is about fully grown, when it wilts and is past recovery. This occurs about a month after the worm is hatched, and it then crawls just under the surface of the ground, fastens a little earth together around itself by a slight web and changes to a chrysalis of a very light mahogany brown color, and three-fourths of an inch long. The moth comes forth the fore part of September. The careful culturist need fear nothing from this troublesome insect, as an occasional close inspection of the plants about the first of July will reveal the hole where the borer has entered, which is generally quite a distance from the ground, and by splitting downwards one side of the stalk with a penknife it may be found and killed. If this inspection be made at the proper time the worm will be found but a short distance from the hole and the split in the stalk will heal by being kept closed with a piece of thread." (Prairie Farmer.)

Achatodes differs from Gortyna in not having the fore wings falcate. *A. zeæ*, described by Harris, is rust-red with gray clouds and bands on the fore wings and yellowish gray hind wings; it expands an inch and a half. The larva feeds inside the stalks of corn, within which it transforms; it is a little over an inch long, smooth and naked, with the head and the top of the first and last rings of the body black, and with a double row of small, smooth, black dots across each of the other rings. It also infests the dahlia and elder.

The genus *Mamestra* comprises rather large moths in which the antennæ are rather long and simple in the male; the front of the head is smooth and convex, and the reniform dot is very distinct, while the outer margin of the fore wings is rather oblique. The larva is longer than usual and feeds on the leaves of low plants, remaining concealed by day. The pupa is subterranean, the cocoon being made of earth.

Mamestra arctica Boisd. (Hadena amica) is common northward, and is found in the colder subarctic regions of America and Europe. It cuts off the leaves of roses and other shrubs. Fitch states that the larva, late in May in New York, cuts off the young shoots of the currant. It is an inch and a half long, of a shining livid color, with faint dots, from which arise a very short, fine hair. It remains in the pupa state about a month beneath the ground, the moth appearing in July. It is found also in Labrador and in Europe. The moth expands an inch and three quarters and is of a deep Spanish brown, variegated with gray, with a very conspicuous reniform dot; the outer edge is bordered with blue gray. Harris also describes *M. picta*, a reddish brown species, with a conspicuous white Z on the outer edge of the fore wing. The larva is yellow, gaily variegated with three longitudinal stripes. It feeds on garden vegetables, and Mr. Fish informs me that it feeds on the cranberry.

The genus *Plusia* is quite unlike the foregoing genera, as the palpi are long and slender, and the fore wings are acute, with silver marks and lines, usually a dot and dash, like a semicolon; the inner angle is tufted, and the hind wings are triangular.

Our most common species is *Plusia precationis* Guenée, the larva of which, according to Mr. Saunders, feeds on the hollyhock in August. "It is one and a half inches long, the body tapering anteriorly and thickening in the middle and towards the end. The head is small, smooth, shining green, with a black stripe on each side. The body is green with dull whitish, longitudinal lines above and a whitish stripe somewhat more distinct on each side near the spiracles. It changed to a chrysalis August 9th." A species of *Plusia*, like P. præcationis, is figured by Mr. Glover in his unpublished plates of insects injurious to the cotton plant. It has a much curved, semicircular discal spot, with a distinct dot just beyond, the two spots arranged thus . The caterpillar is pale green, the body increasing in size from the head to the tail and with a lateral row of brown dots. "It was found eating the cotton flower in Georgia the last of October." It forms a loose, thin cocoon among the leaves, and the pupa is pale green, spotted above with irregular brown spots. Mr. Glover also figures quite a different species of Plusia, which has the same habits as the species just mentioned. It belongs, however, to a different section of the genus, and on the discal area is an oblique, golden, irregular oval patch, containing two unequal dots. The larva is pale green and has a broad, lateral, white stripe. The chrysalis is brown and protected by a thin, loose cocoon. *P. divergens* Fabr. lives on the Alps, in Finmark, and in Labrador. Mr. F. G. Sanborn found, July 6th, a closely allied species on the summit of Mount Washington, N. H., which differs from P. divergens in the forked, golden, discal spot being a third smaller, while the two branches of the spot go off at right angles to each other. On the fore wings the second line from the base is acutely dentate on the submedian vein, where in P. divergens it is straight, and the outer line is also dentate, not being so in P. divergens. The hind wings are yellowish at base, with a wide black margin. It may be called *Plusia montana.* Mr. Grote has described *P. ignea* (P. alticola of Walker) from Pike's Peak, which is closely allied to *P. divergens.* *Plusia ærea* Hübner (Fig. 242, side view) is a reddish brown moth, with obscure markings, and without the usual metallic spots. It expands a little over an inch, and is not uncommon in the Northern States.


Fig. 242.

Anomis is a slender-bodied genus, with triangular fore wings. *A. xylina* Say feeds upon the cotton. It is a brown moth with a dark discal oval spot centred by two pale dots. She deposits, according to Mr. Glover, a low, much flattened, vertically ribbed egg upon the surface of the leaf. The larva is a looper, whence it can be readily distinguished from the army and boll worms, and its body is thickest in the middle, very hairy, green, dotted with black along a subdorsal yellowish line, and with black dots beneath. It matures early in the season, and a second brood becomes fully grown in September and October. When about to transform it gathers a leaf together by a web, thus forming a rude cocoon. (Glover.)

Like our northern army worm (Leucania unipuncta) the Army worm of the South (Fig. 243, and larva, from Glover), makes its appearance in great numbers in a single day, committing the greatest havoc in a few hours. Professor J. Darby, of Auburn, Ala., writes me that "Saturday, September 19th, I was in the field examining the forms (buds before flowering) and the young bolls (fruit after the floral organs have fallen off). I examined all carefully, with no signs of eggs or worms. On Sunday I did not see it. On Monday I passed it as usual and observed nothing unusual. On Tuesday morning I passed it and noticed nothing unusual. On Tuesday noon every plant in the field was stripped of all its upper leaves; not one remaining as far as could be seen, and the plants were covered with millions of worms. I counted on one plant forty-six worms. They commence at the top of the plant, eating every leaf. When the leaves were gone they attacked the young bolls, eating through the perianth and consuming the young cotton. In the course of four days the work was done. They did not touch the grape or any other plant in the field, so far as I have been able to see. Many left the field and thousands were in the road and on the fences, but not one in a thousand thus escaped. To-day, September 23d, there is scarcely one to be seen. Their disappearance is as mysterious as their coming. They have left no signs that I can see, either on the stalks or in the ground. They have extended over hundreds of miles, and nothing has proved a barrier to them, having been as destructive on islands in the river, as elsewhere. One-third of the cotton crop has been destroyed. Nothing of the kind has occurred in thirty years past to my knowledge." The larva is reddish brown, with distinct black spots, the dorsal line being streaked with yellow and black. It hibernates as a moth. The presence of this caterpillar in the West Indies caused the cultivation of cotton to be abandoned. The same, or another species, also appears often in Guiana and other parts of South America. A good remedy against the worm is a mixture of two parts of carbolic acid with 100 of water, to be sprinkled on the leaves of the plant. *Heliothis* has pubescent antennæ, the thorax and abdomen are smooth, and the fore wings slightly acute at tip. The larva is elongated, but not attenuate, with a large head and distinct lines along the body.

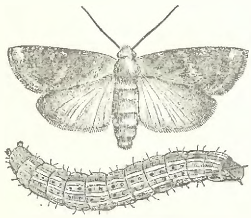


Fig. 243.

It feeds exposed on low plants, preferring the flowers. The pupa is conical and subterranean. *H. armigera* Linn. (Fig. 244; *a*, larva) is the "boll worm" of the Southern States, so destructive to cotton crops. Riley states that it also feeds on the fruit of the tomato, and in Southern Illinois on the silk and green kernels of corn and also the phlox, tomato and corn-stalks, and, according to Mr. T. Glover, it bores into the pumpkin. Mr. Riley, in the "Prairie Farmer," describes apparently the same insect under the name of the "Phlox worm" (Fig. 245, and larva). He states that there are two broods in a year, the first appearing in July, and becoming moths by the middle of August, the second passing the winter in the chrysalis state. The eggs are deposited singly on all portions of the plant, and the caterpillar, when about to become a chrysalis, enters the ground, and interweaves grains of sand with a few silken theads, forming a very slight elastic cocoon." The genus *Heliocheilus* differs from Heliothis in its broader and shorter wings and its venation. *H. paradoxus* Grote (Fig. 246, venation of fore wing) is a pale testaceous moth, with the fore wings darker. It inhabits Colorado Territory.

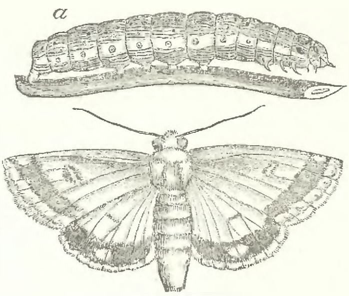


Fig. 244.

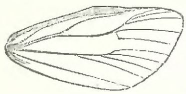


Fig. 246.

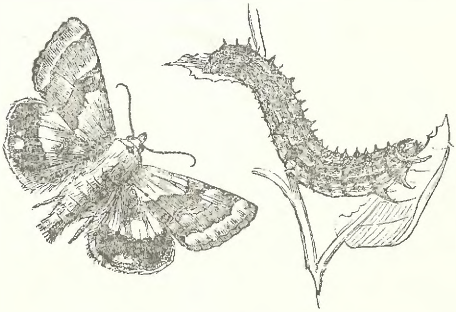


Fig. 245.

Anarta is rather a small moth, with a hairy body and small head; the fore wings are thick and velvety, with confused markings, and the hind wings are yellow or white, often bordered with black. The larva is short and smooth in repose, with the anterior portion of the body bent under the breast. The pupa is enclosed in a cocoon of silk mixed with earth. The genus is arctic or subarctic, and inhabits Alpine summits. *A. algida* Lefebvre inhabits Labrador and Lapland. A closely allied and undescribed species, seems to be peculiar to the summit of Mount Washington, N. H., where it has been detected by Mr. Sanborn.

Xanthoptera semicrocea Guenée (Plate 8, fig. 3; *a*, larva) is brown, with the base of the wings saffron yellow; it expands a little less than one inch. Dr. A. W. Chapman, of Appalachicola, Fla., states in a letter to Mr. Sanborn, that the larva feeds on the leaves of the Pitcher plant, Sarracenia. It is red and cylindrical, with short black tubercles on the top of each segment, and a black cylindrical spine on each side of the four basal rings of the abdomen, surmounted by fine hairs. It does not spin a cocoon but hangs loosely by a few silken threads within the pitcher-like leaf, and the moth is the only insect that can get out of the bristly and narrow opening of the "pitcher."

The little slender-bodied genus *Erastria* has filiform antennæ and a slender crested abdomen, with the usual lines and dots quite distinct. The larva is smooth and slender, with only three pairs of abdominal legs. The pupa is enclosed in a cocoon among leaves or moss. *E. carneola* Guenée is a common species, with the outer edge of the fore wings flesh colored.

In *Brephos* the hind wings are bright orange, the body is hairy and the antennæ are ciliated; the abdomen is slender, and the wings are broader than usual. The larva is smooth, elongate, with sixteen legs, though the first two abdominal pairs are useless for walking, hence the larva has a semi-looping gait. It feeds on trees and makes a slight cocoon in moss or under bark. *B. infans* Moschler inhabits Labrador and New England. It flies early in April before the snow has left the ground.

Catocala is a beautiful genus, the species being numerous in this country and of very large size, often expanding three inches or more; the wings are broad, and in repose form a very flat roof. The larva is elongate, slender, flattened beneath and spotted with black, attenuated at each end, with fleshy filaments on the sides above the legs, while the head is flattened and rather forked above. It feeds on trees and rests attached to the trunks. The pupa is covered with a bluish efflorescence, enclosed in a slight cocoon of silk, spun amongst leaves or bark. *C. piatrix* Grote is brown on the anterior wings and varied with black, while the hind wings are yellow with a broad median and marginal band. It is common in the Middle and Eastern States.

C. ultronia Hubner (Plate 8, fig. 4; *a*, larva) expands two and a half inches and is of a rich umber color, with a broad ash stripe along the middle of the wings, not extending towards the apex, which is brown. The hind wings are deep red, dusky at base, with a median black band, and beyond is a red band a little broader than the dark one, while a little less than the outer third of the wing is blackish. The larva feeds on the Canada plum. It is gray with black punctures, and the head is edged with black. The segments are transversely wrinkled, and on each one are two whitish and two brownish papillæ; the two brown ones on the eleventh ring are much enlarged, and on the ninth ring is a small brownish horn. On the sides of the body, before the spiracles is a line of light pink filaments fringing the scalloped sides. On July 15th the larva changed to a chrysalis in an earthen cocoon, and the moth appeared on the 2d of August.

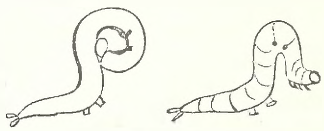


Fig. 247.

Drasteria is a small, grayish moth, with two geminate black dots near the apex, and a broad diffuse line on the fore wing. The larva is a looper, and the body is attenuated at each end. *D. erechtea* Cramer flies very abundantly in grass lands in May and early summer. Mr. Saunders informs me that the larva (Fig. 247) is "one and a quarter inches long and walks like a geometer; the body is thickest in the middle, being somewhat smaller towards the head, but tapering much more posteriorly, while the head is not large and is rather flattened in front and is pale brown, with darker longitudinal lines. The body above is reddish brown, with many longitudinal darker lines and stripes; there is a double whitish dorsal line, with a stripe on each side of the darker shade, another stripe of the same hue on each side close to the stigmata, and between these stripes are faint longitudinal lines. It fed on clover and went into the chrysalis state Sept. 21st."

The two remaining genera have broad wings, and are blackish, with numerous transverse waved lines. The edges of the wings are scalloped, the palpi are very long, and the head narrow between the eyes, thus showing their affinities to the *Phalænidæ*. The species of *Homoptera* are of a dark ash color. *H. lunata* Drury has a lunate discal spot.

Erebus is a gigantic moth, with the outer margin very oblique and a large, incised, discal spot and sublunate marginal spots. Our large, blackish species, dark as night, is *Erebus odora* Drury; it expands about five inches. The magnificent, pale gray *Erebus Agrippina* Cramer (E. strix of Fabricius) inhabits Brazil; it expands nearly ten inches.

Phalænidæ Latreille (*Geometridæ*). The Geometrids are easily known by their slender, finely scaled bodies and broad thin wings, which in repose are not folded roof-like over the body, but are spread horizontally and scarcely overlap each other. The antennæ are usually pectinated. They are delicate, pale, often greenish or yellowish moths, and fly more by day than the Noctuids. The palpi are short and slender, and the tongue, or maxillæ, is weak and short.

The larvæ rarely have more than ten legs, some having fourteen, and a few (Metrocampa and Ellopia) twelve. Thus from the absence of legs on the basal rings of the abdomen, the larvæ are loopers, or geometers, as grasping the object on which they are walking with their fore legs, they bring the hind legs close up to the fore legs, thus making a loop like the Greek letter Omega. They usually let themselves down by spinning a silken thread, hence they are sometimes called "Drop-worms." When about to pupate, the larva either spins a slight, loose, silken cocoon, or conceals itself under a covering of leaves fastened together with silk, or buries itself in the ground without any cocoon, while Harris states that a very few fasten themselves to the stems of plants and are changed to chrysalids, which hang naked and suspended by the tail. The pupa is long, slender, conical, generally smooth, sometimes with lateral protuberances on the head, and usually dark brown, but often variegated. The species, of which there are about 1,800 described, are widely distributed, and more are found in the arctic regions than of the preceding family.

We place at the head of this family the genus *Urania* and its allies. From their large size, splendid colors, swallow-tailed wings, the fore pair of which are elongated towards the tips, while the outer edge is very oblique, as in Papilio; their habit of flying by day and other resemblances to the butterflies Latreille placed them among the butterflies immediately after the Hesperians. They have also been supposed to belong to the same group as Castnia, but the shape of the head, the long geometriform antennæ, the palpi and the conical pupa and other characters ally them with the Urapteryx and the higher Phalænidæ. *Urania Leilus* is velvet black, the fore wings crossed by emerald green striæ, and the hind edge of the hind wings are banded with light blue and golden, while the fringe and long tail are white. It is found in Surinam and Brazil.

Urapteryx is a true Geometrid, with very square hind wings extending beyond the abdomen, with their outer margin prolonged into a short tail. *U. politia* Cramer is a yellow species found in Mexico and the West Indies. The larva of the European *U. sambucaria* feeds on the oak, elder, bramble, etc., and is elongate, with projections from the eighth and twelfth segments. The pupa is elongate and enclosed in a net-like cocoon suspended by threads.

In *Chœrodes* the hind wings are still angulated, the angle reaching beyond the tips of the abdomen; the falcate apex of the fore wings is acute, and the outer margin is entire and angulated just above the middle. The species are usually pale ochreous, with short transverse strigæ and two darker lines, the outer one of which is obtusely angulated just before the apex. *C. transversata* Drury is a pale ochreous species, which we have found resting on red maple leaves.

The genus *Angerona* comprises the single species *A. crocataria* Fabr., the larva of which (Plate 8, fig. 5 *a*) we have found feeding on the cultivated strawberry during the last of June. It is an inch and a half long and when at rest extends itself straight out. The body gradually increases in size to the first pair of abdominal legs. The head is flattened so as to be square above, and whitish green, with three longitudinal brown lines. The prothoracic ring is concolorous with the head, from which two brown lines extend, forming an inverted V on the hinder edge. The body is pale grass green above, with the sides bulging. There are four minute black dots on each ring, a whitish, indistinct subdorsal line, and a lateral white line extending to the sides of the anal legs. The body is greenish white. The moth (Plate 8, fig. 5, male) is of a rich yellow, with brown patches on the wings, and appears in July.

In *Endropia*, which is closely allied to Chœrodes, the outer edge of the wings is deeply notched. *E. tigrinaria* Guenée is dirty ochreous, the wings being sprinkled with black; the outer line is nearly straight, ferruginous, paler within, with some submarginal spots, and the basal line on the fore wings is angulated, while the apex is pale and margined externally with blackish.

Metrocampa is pearly white, with the wings a little bent in the middle. *M. perlata* Guen. is pure white, with two darker oblique lines not angulated; it is found not uncommonly northward. The larva of the English *M. margaritata* has twelve legs, and like Catocala has fleshy filaments on the sides just above the legs. The pupa lives on the surface of the earth.

Ellopia has pectinated antennæ and exceedingly thin transparent wings, which are angulated in the middle of the outer edge, and with an inner and outer line, the latter bent nearly at right angles. The larva has twelve legs, but is smooth. The English *E. fasciaria* feeds on firs. *Ellopia flagitiaria* Guenée is pale ashen ochreous, with the speckles and two bands pale brown. It expands from six to eighteen lines.

In *Caberodes* the antennæ are broadly pectinated, and the apex of the fore wings are nearly rectangular. The species are pale ochreous with thick wings, and the outer line terminates near the apex. *C. metrocamparia* Guenée is common northwards; with a blackish discal dot and outer dusky line arcuated and margined with white.

The genus *Nematocampa* is characterized by the four filaments on the back of the larva. *N. filamentaria* Guen. (Plate 8, fig. 7; 7 *a*, larva) is a small moth of a pale ochreous color, with reddish brown lines and dots, a ring in the discal space,

Plate 7.

Plate 8.


8
7
7a
13
15
6
21
5a
15b
15a
10
16b
5
18
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10a
17
18a
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4
12a
12
20
4a
1
19
15c
2
1a
19a
23b
2a
14
23
3a
23a
3
9
9b
9a
11

and just beyond a dark lead-colored band which becomes a broad squarish patch on the inner angle, and which is continuous with a broad band of the same color on the hind wings. It expands three quarters of an inch. Its singular larva we have found feeding, late in June, on the strawberry. It is .70 of an inch long, cylindrical and with two pairs of long curled filaments, situated on the third and fifth abdominal rings respectively; its general color is wood gray, and the pupa is pale reddish gray. The moth appeared on the 27th of July.

The genus *Abraxas*, to which our currant worm belongs, may be known by the whitish or ochreous wings being covered with dark, often partially transparent blotches, and the larva being gaily speckled with black and golden spots. *A. ribearia* Fitch is ochre-yellow, with two rows of dark spots, the inner row being incomplete and the outer row with a large blotch in the middle of the wings. As soon as the leaves of the currant and gooseberry are fairly expanded, late in May or early in June, the young caterpillar may be found busily eating them. In about three weeks after hatching it becomes fully grown, being about an inch long, and bright yellow with black dots. The chrysalis may be found under the bushes, either upon the ground or just under the surface. In two weeks after pupating the yellowish moth may be seen flying about the garden. Riley states that by sprinkling powdered hellebore upon the leaves, or applying a solution of eight or twelve ounces to a bucket of water, the larvæ will be killed, while hand-picking and shaking the bushes will also reduce their numbers.

The genus *Ennomos* is stouter and much more hairy than any of the preceding genera; the antennæ are well pectinated in the male, the wings are not so broad as usual and are dentate. The larva is rather long and twig-like, either smooth or humped, and spins a cocoon consisting of leaves drawn together by silk. *E. magnaria* Guen. is yellow, punctured with black, with two dusky lines, and the fringe is partly blackish. *E. subsignaria* Hubner (Fig. 248, moth; Plate 8, fig. 6, larva) is a delicate, white, widely distributed species, and in the city of New York, where it is free from the attacks of its natural enemies, it is very destructive to the elm trees.

A writer in the "Practical Entomologist" (vol. i, p. 57) states that the caterpillars are hatched as soon as the leaves unfold, and live unobserved for a week or so in the young shoots in the tree-tops, and when half grown are seen crawling about the tree. Towards the end of June they pupate, and in about a week after the moth appears. The importation of the English sparrow is said to have very effectually checked the ravages of this caterpillar, which may be recognized by its resemblance to the twigs of the tree on which it feeds, while its rather large head and the terminal ring of the body are bright red.

In *Amphidasys* the body is very stout and the triangular wings are inclined to be small (in Nyssia, an European genus, the female has minute rudimentary wings) and narrow, while the antennæ are broadly pectinated. The larva is stout, twig-like, being dark brown and warted; it is swollen at each end, and the head is often bifid. The pupa is subterranean. Such are the habits of *A. cognataria* Guen. which is white and very thickly sprinkled with ashy black. We have found the larva feeding on the "Missouri currant," the gooseberry, and the red Spiræa. It went into the pupa state on the 22d of September.

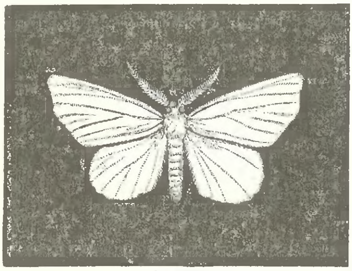


Fig. 248.

Boarmia has pectinated antennæ, the tip being generally simple, while the abdomen is rather slender and the wings are dusky gray and crossed by dentate lines. The larva is twig-like, elongate, with small humps and lateral projections, and lives on trees. The pupa is subterranean. *B. gnopharia* Guen. is ashen, the wings clouded with fuscous, and dusted with black scales, with four black dentate lines. A species of *Boarmia*, figured by Mr. Glover, "eats the flowers of the cotton, being found early in October." The larva is of the same thickness throughout, with a rather large head angulated above, and two tubercles near the tip. It is brown, with a double lateral pale stripe. The chrysalis is brown and enclosed in an underground cocoon. The moth expands nearly an inch and a half, and is ash colored, sprinkled densely with brown speckles, with three angulated, transverse, black stripes.

Geometra and its allies (Nemoria, Iodis, and Racheospila), have smooth, round or angular, entire wings, which are green, often with whitish lines. *Geometra* is the largest genus; "it has pectinated antennæ, and the larva is rather short, downy, with several dorsal humps. The pupa is enclosed in a transparent cocoon amongst moss." (Stainton.) *G. iridaria* Guen. is pea green, with two broad bands, and the costa of the fore wings is white sprinkled with rust red.

A great many species, often difficult to identify from the sameness in their markings, are comprised in the genus *Acidalia*, which is known by its rather thin wings, with the edges usually entire, and with stripes and bands and other markings common to both. The hind wings are often slightly angulated. The larva is smooth, slender, and feeds concealed under low plants. The pupa is subterranean, or lives in a cocoon among leaves. *A. nivosaria* Guen. is pure white. *A. enucleata* Guen. is whitish yellow; its wings are speckled with brown, and with pale lines and submarginal spots.

Macaria is easily recognized by its falcate wings, which have a rounded excavation below the hooked tip, and there is a rather prominent angle on the hind wings. There are usually two large blotches, one in the middle of the wing, and the other on the outer third of the costa. The larva is rather short and smooth, and feeds on trees and shrubs. The pupa is protected by a cocoon. *M. granitata* Guen. is gray, with indistinct darker bands and minute black speckles, with a rust red costal spot in front of a black discal spot.

Fig. 249.

Zerene is a beautiful genus, with feathery antennæ and broad, thin, white wings. *Z. catenaria* Drury is white with black discal dots, and two black scalloped lines. The larva is a general feeder, eating sedges, the goldenrod, blueberry, waxwork, and according to Mr. Fish, is injurious to the cranberry. It is a pretty caterpillar (Fig. 249) and is straw colored, the segments being wrinkled and thickened, with two subdorsal darker threads; the head is yellow with six black dots; the spiracles are black, situated in a white field, and with a black dot on each side. In Maine it pupates about the middle of August, making a thin gauzy cocoon, consisting of yellowish green silken threads. The pupa is white, with scattered black dots and black stripes; it remains thirty-two days in the pupa state, the moth appearing during the middle of September.

In *Anisopteryx* the male antennæ are simply pubescent, the wings are ample, and rounded at the tip, while the hind wings are rounded. The female is wingless, the head small and the body is oval. The male of *A. vernata* Peck (Plate 8, fig. 9; 9*a*, female; 9*b*, larva), the moth of the Canker worm, is ash colored, with a whitish costal spot near the tip of the fore wings which are crossed by two jagged whitish bands dotted with black on the outside; they expand about one inch and a quarter. In the early spring and late in autumn the male flies about and couples with the wingless female, which lays a patch of short, cylindrical eggs, from sixty to one hundred or more, arranged in rows, and glued to the surface of the bark. The larvæ hatch from the first to the middle of May, or as Harris states, about the time of the flowering of the red currant, and the leaving out of the apple tree. Almost before the presence of the larvæ is known they often nearly strip an orchard of its leaves. They also attack the cherry, plum, elm, and other trees and shrubs. The canker worm (Plate 8, fig. 9*b*) when mature is about an inch long, ash colored on the back, black on the sides, and beneath yellowish. It varies greatly in the intensity of its markings. It ceases eating when four weeks old, and late in June creeps down, or lets itself down by a thread, and burrowing from two to six inches in the loose earth, there forms a rude earthen cocoon, fastening the grains of earth together with silk. Twenty-four hours after the cocoon is finished the worm becomes a chrysalid, which, in the male, is slender, rather pointed in front and light brown in color. Coming forth in the autumn and following spring, its progress up the tree can be arrested by the application of coal oil or printer's ink, by the well known methods, around the trunk, while the bunches of eggs should be picked off and burnt. The *A. pometaria* Harris is as abundant as A. vernata; it has thinner wings, wanting the whitish bands and spot, and having an oblique, dusky, apical line. We are inclined to think that it is simply a variety of A. vernata. Harris has detected an ichneumon parasite which preys upon the canker worm, and a species of Tachina also attacks the caterpillars, and we have noticed a minute species of Platygaster (Fig. 134), first discovered by Herrick, ovipositing in its eggs. The Calosomas also devour them, and probably other ground beetles; and certain wasps (Eumenes) store their nests with them. (Harris.)

Allied to the canker worm is the *Hybernia tiliaria* Harris, the male of which is much larger and has feathered antennæ. The female is larger and slenderer than that of the canker worm, and along the back are two rows of black dots on a pale grayish ground. The moth flies late in the autumn. The larva is bright yellow, with ten crinkled black lines along the top of the back, and is an inch and a quarter in length. It feeds on the lime, apple and elm, and is sometimes very destructive.

Eupithecia is a diminutive form, with very small rounded hind wings, while the fore wings are much elongated towards the apex, and at rest both pairs are spread out and pressed closely to the surface on which the moth rests. The larva is rather short, stiff, often marked with dorsal lozenges, and the head is small and rounded. It feeds on trees or low plants; sometimes on seeds of plants. The pupa is slender, conical and pointed. *E. miserulata* Grote is clear silky grayish, with a black interrupted outer line and a grayish fringe, interrupted with black.

Cidaria numbers many species in which the antennæ of the male is simple or slightly pubescent, and the fore wings are rather pointed at the tip, while the hind wings are rounded. The larva is elongate and slender, with the head often notched. It feeds on trees or shrubs, and the pupa is of variegated colors. *Cidaria diversilineata* Hübn. (Plate 8, fig. 10, 10*a*, larva) is yellowish ochreous, with brownish angular lines, and at rest the abdomen is curved over the back. Mr. Saunders has found the larva feeding on the woodbine. According to his notes "the body above is dark brown, with a slightly reddish tint, and patches of a darker shade along the dorsal region, being the color of the twigs of its food plant. It remains in the pupa state about a week." We have also found both brown and green specimens feeding on the grape vine in midsummer. The worms can be removed by hand-picking as they are rather conspicuous objects. A larva, probably of Cidaria, has been found by Mr. W. C. Fish, stripping the cranberry plants in Harwich, Mass., late in August. Mr. Fish writes, "I have never met them that I am aware of before, but on one bog in this place they destroyed nearly two acres of cranberry vines, eating off all the green leaves, the bog being as black in spots as though a fire had been over it." They were not numerous elsewhere in that town, but may prove at times to be a great pest to cranberry growers. We failed to rear the larvæ sent by Mr. Fish. They are about the size of the canker worm. The head, which is no wider than the rest of the body, is deeply indented, on each side rising into a tubercle; the anal plate is long, acute, and beneath it are two minute acute tubercles, tinged with reddish. It is dull reddish brown, simulating the color of the twigs of the cranberry, and is finely lineated with still darker lines. The head is speckled with brown, with a conspicuous transverse band across the vertex, and two rows of pale spots across the front. Just above the spiracles is a broad dusky band. Beneath, the body is paler, with a mesial clear line edged with brown. It is .80 of an inch in length. Mr. Fish states that the owner of the bog flowed it with water so that it was completely covered and the worms were killed. This is a rapid and the most effectual way to exterminate insects ravaging cranberry lots.

Pyralidæ Latreille. The Snout-moths, so called from their very long and slender compressed palpi, are very easily recognized by this character alone. The more typical forms have triangular fore wings, and a slender abdomen and long slender legs, the front pair of which are often tufted. They are usually dull ash gray, with a marked silken lustre. The larger genera, Hypena and Herminia, etc., are called *Deltoids*, as when at rest the wings form a triangle of the form of the Greek letter Delta. Their antennæ are sometimes pectinated in the male. They are usually gregarious in their habits, and often extremely local. They haunt moist grassy places, are readily disturbed by day, and fly before dusk, while some are true day-fliers. The larvæ are generally known by their remarkably glassy appearance, and the few hairs on them have an unusually bristly look. Many spin a cocoon. The pupa is long, slender, and conical.

The largest form is *Hypena*, in which the male antennæ are hairy, and the palpi are long, ascending, and the fore legs are not tufted, and there are often slight tufts of raised scales on the fore wings. The larva is elongate, cylindrical, with fourteen legs, and feeds on low or climbing plants, making a slight cocoon among leaves.

The Hop vine moth, *H. humuli* Harris (Fig. 250; *a*, larva and pupa) is very destructive to the hop. It is marbled with gray beyond the middle of the fore wings, with a distinct oblique gray spot on the tip; they are crossed by two wavy blackish lines formed of elevated black tufts, and there are two similar tufts in the middle of the wings; it expands one inch and a quarter. The larva is glassy pea-green. The body is long and slender, with rather convex rings, and with long sparse hairs. The head is rather large and deeply divided into two lobes by the median suture; it is a little more yellowish green than the body, which tapers gradually towards the tail, while the anal legs are long and slender, there being but two pairs of abdominal legs, so that the caterpillar walks with a looping gait. The body is striped with a narrow whitish line, edged broadly below with dusky, and with two white lines on the sides of the body, though specimens vary in the number of lines, some having no lateral whitish stripes. It is .45 of an inch in length. When half grown the larva is pale livid flesh color, not greenish, with a broad dark dorsal line, bounded on each side by a whitish line. It is double-brooded, the first lot of caterpillars appearing in May and June, the moths coming out late in June and early in July; while the second brood of larvæ appear in July and August, the moth flying in September. It is very active, leaping off the leaf to the ground when disturbed. When fully grown it forms a loose silken cocoon

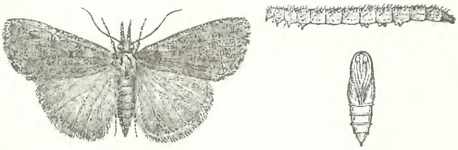


Fig. 250. *a*

within a folded leaf or any crevice, the moth appearing in three weeks. We have raised a species of Tachina from the pupa. The vine should be showered with a solution of whale oil, and soapsuds, and the plants shaken to rid them of these pests.

Herminia differs from Hypena in its tufted fore legs; the larva is short, slender towards each end, covered with small spots; it has sixteen legs, and feeds concealed among dry leaves, making a narrow cocoon among them. *H. jucchusialis* Guenée is one of our most common species.

Pyralis has narrow wings, the fore wings being oblong, with distinct lines, and the palpi are short, ascending. The Meal moth, *P. farinalis* Harris, is reddish gray at the base and hind edge of the fore wings, becoming more reddish towards the tip, with two whitish cross lines, the space between being ochreous. The larva is dull whitish, with a reddish brown head, and having reddish prothoracic and anal plates. It feeds on straw and corn, and Mr. Riley has found it feeding on clover.

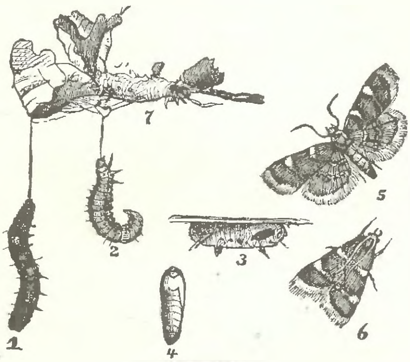


Fig. 251.

The Clover worm, or *Asopia costalis* Fabr. (Fig. 251; 1, 2, larva in different positions; 3, 7, cocoon; 4, pupa; 5, 6, moth), according to Riley, "attacks and spoils clover for feeding purposes, both in the stack and mow, by interweaving and covering it with abundant white silken webs and black excrement that much resembles coarse gunpowder. The parent of these clover worms is a pretty little lilac-colored moth, with wide golden fringes," and has been introduced from Europe. The moths fly late in June and in July, and they creep into all parts of the stack, as the larvæ have been found eight feet from the ground, though they are mostly found at the bottom. The larva is three-fourths of an inch long and is dull dark brown, with an olivaceous hue. Mr. Riley thinks there are several broods through the year, and suggests as a preventative to stack the clover on a good log or rail foundation so as to allow the air to pass up through from beneath.

In *Aglossa pinguinalis* Harris, the Grease moth, the palpi are rather long, the fore wings are grayish brown clouded with a darker hue, and are crossed by two indented lines. The larva is of an uniform dark brown, with a darker head and prothoracic plate, and feeds on greasy horse clothes, etc.

Another species of Aglossa (perhaps A. cuprealis) has been sent me by Prof. A. E. Verrill, who writes me that the larva does great damage to the old leather bound volumes in the library of Yale College, by eating out great patches and galleries in the leather covers, and also, in some cases, some of the glue and pasteboard. It spins a silken cocoon. The moth (Plate 8, fig. 20) differs from A. pinguinalis by the hind wings being pale whitish gray, instead of grayish brown. The palpi have the third joint one-third as long as the second. It is pale brown, with a slight reddish tinge, and the wings are crossed by two pale bands, with several pale costal spots. The outer band is heaviest on the costa and inner angle, and faint in the middle of the wing. The hind wings are pale, shining whitish, with no bands. It expands .90 of an inch.

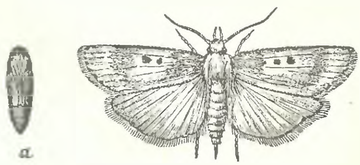


Fig. 252.

In Europe, Mr. Curtis states, the *Aphomia colonella* Linn. (Fig. 252) which also occurs with us, is a formidable foe of the humble bee, feeding upon its honey. When fully fed it spins a tough web of a close woolly texture, in which the caterpillar turns to a chrysalis (*a*). "The female moth creeps into the nest in June to deposit her eggs, and the caterpillars live in families sometimes of five hundred, to the total destruction of the progeny of the poor humble bees. The moths are of a dirty white, the upper wings have a greenish and rosy tinge, with a line of black dots round the margin, a whitish space near the base, and two black lines near the costa in the male. The female has two distinct, indented, transverse bars, and two black spots on the disc."

Hydrocampa and its allies are exceedingly interesting from the aquatic habits of the larvæ, which remind us of the Caddis worms. *Cataclysta* is at once known by its slender body and narrow wings, the hinder pair of which have a row of eye-like spots along the hind margin. The larva is elongate, with a pale head, and is aquatic, feeding beneath the leaves of the Duck weed, living in a cylindrical silken case covered with leaves. The pupa has a long ventral projection, and is enclosed in the case of the larva. *C. fulicalis* Clemens has, on the outer margin of the hind wings, a row of five black lunules connected by intermediate metallic violet blue spots, and behind them a row of orange yellow dots.

The larva of *Paraponyx* is provided with branchiæ and spiracles; the pupa residing in a cocoon among leaves under water.

Hydrocampa has large white spots on the outer edge of the fore wings. The larva is rather thick, attenuated at each end, with a black head. It is aquatic, living in a flat case under the leaves of water lilies. The pupa resembles that of Cataclysta.

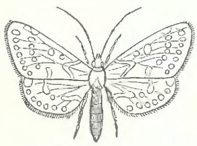


Fig. 253.

The genus *Botys* (Fig. 253) includes many species, in which the conical abdomen is longer than the wings, and the tip of the front pair is often prolonged. The larva is said by Stainton to be lively, attenuated at each end and semitransparent, with warty spots. It feeds in rolled up leaves. The pupa is elongate, smooth, enclosed in a slight cocoon among leaves. *B. verticalis* Albin is whitish, with the outer edge of the fore wings dark grayish. The larva feeds on the nettle. *B. citrina* G. and R. is a bright yellow species.

The genus *Desmia* is at once known by its resemblance to Botys, and by its black body and wings, spotted with broad white patches, while the male antennæ are swollen in the middle. *D. maculalis* Westwood, the Grape leaf folder, is shiny black, with a white fringe on its wings, which are spotted in the middle with white patches, and with two white bands on the abdomen of the female. It is found chiefly in the Southern States, where it attacks the grape. The larva, according to Riley, who observed the moth in Southern Illinois, is "glass-green, and folds a leaf, or attaches two, that may be close together, by aid of a few silken threads. It is very active, jumping and jerking at the least touch. It acquires a flesh-colored hue prior to changing to a chrysalis, which it usually does just within the leaf. Many which thus changed with me on the 21st of July, became moths on the 29th of the same month."

To the genus *Phycita* belongs the Apple leaf crumpler, or *P. nebulo* of Walsh, which in the West is known to strip the trees of their early leaves. It draws the leaves together by a web, and about the middle of June becomes fully grown, when it closes up its horn-like case, and at the end of the same month and early in July appears as a long, narrow-winged moth, somewhat like Nephopteryx, but with broader fore wings.

Nephopteryx is a genus with very narrow wings, with the male antennæ sinuous at the base. It feeds on various trees, while the larva of *N. Edmandsii* Pack. (Plate 3, fig. 2; 2*a*, larva; 2*b*, pupa), feeds on the cells of the humble bee.

The genus *Pempelia* closely resembles Nephopteryx. Our most injurious species is the Gooseberry worm, which is undescribed. It may be called the *P. grossulariæ* (Fig. 254; *a*, cocoon) and is allied to the European *P. semirubella*. Though familiar with the insect, and having raised the moth, our specimens were too much rubbed for identification, and we are indebted to Mr. Saunders of London, Canada, for very perfect specimens of the moth, and notes regarding its habits, confirmatory of our own observations. The moth is pale gray, with a dark, transverse, diffuse band on the inner third of the wing, enclosing a zig-zag white line not reaching the costa. There is a discal discoloration, and beyond, a white zig-zag line with a long, very acute angle on the internal margin, and a row of marginal black dots, while the apex is white, and the veins and their branches white; it expands nearly an inch. As soon as gooseberries and currants are well formed, many turn prematurely red and dull whitish, which is due to the presence of a pale green, smooth worm, which, after eating out the inside of one berry, leaving a hole for the passage of the excrement, enters another berry making a passage-way of silk until it draws together a bunch of currants, or two or three gooseberries. During the last of June it pupates, while the moth does

a Fig. 254.

not appear until the spring of the following year, Mr. Saunders' specimens having left the chrysalis May 8th.

Crambus, so abundant throughout the summer in grass, is at once known by the long narrow wings being rolled around the body in a tubular form. The larva has sixteen legs, is whitish or dull colored, with large shining spots, and feeds on moss in silken galleries. Mr. Saunders has hatched the larvæ from the eggs. "They feed readily on grass, the blades of which they fasten together with silken threads, under which they live concealed; they will also feed on clover." *Crambus mutabilis* Clemens is grayish fuscous, the palpi a little darker, while the fore wings have a grayish median stripe, not extending beyond the disk, and the discal dot is dark brown. It is a variable and a common species. Other kinds are variously streaked with silvery white.

The Bee moth, *Galleria*, has rather broad wings, which are indented on the outer edge. *G. cereana* Fabr. (Plate 8, fig. 11) is dusky gray, streaked with purple brown on the outer edge, with a few dark brown spots on the inner margin. The larva is yellowish white, with brownish dots. It constructs silken galleries running through the comb, in which it feeds. It spins a thick white cocoon. Two broods of moths appear, one in April and May, the other in August. They lay their eggs at evening while the bees are resting. The caterpillars mature in about three weeks.

TORTRICIDÆ Leach. The "Leaf-rollers" are best characterized by the shortness of the palpi, which project beak-like, and are rarely long enough to be curved in front of the head; and by the oblong fore wings. They are of small size, rarely expanding over an inch, and are folded roof-like (Fig. 255) over the body. The fore wings are broad, compared with those of the *Tineidæ*, and are much rounded on the costa. They are variegated with bands and spots, often of brilliant metallic hues, while the hind wings are dull colored like the body, the inner edge being folded fan-like against the body. The antennæ are filiform and the legs are much shorter than in the Pyralids. They fly mostly by night, resting during the day upon the plant on which the larva

Fig. 255.

feeds. They most abound in summer, though a few species are found in the spring and autumn.

The larvæ are cylindrical, usually transversely wrinkled, and nearly naked. The pupa is slender, and the rings of the abdomen armed with transverse rows of teeth. Many of the larger species roll up the leaves of trees, or gather them into a rude tent, with silken threads; others devour the interior of fruit buds and seeds, or live in the tender shoots, or under the bark, or in the roots, while some live exposed on the leaves of plants.

In *Antithesia* the palpi are longer than the head, and the thorax is tufted behind; the fore wings are more than twice as long as broad, the costa being regularly arched, while the apex is obtuse, and the apical third of the costa is white or ochreous. *A. bipartitana* Clem. has white fore wings, with a dark brown basal patch, and a central concolorous band, with two or three dark brown spots on the outer third of the costa. The tip of the wing is spotted with brown, and there is a pale brownish spot in the middle of the white apical third of the wing. It is not uncommon northwards.

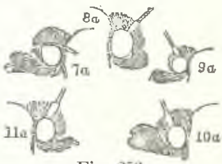


Fig. 256.

Another species has been detected on the rose by Mr. F. W. Putnam. The larva is yellowish green with a jet black head and prothoracic shield, and pupates late in June, the moth appearing during July. It is identical with the *Antithesia pruniana* of Hubner (Plate 8, fig. 13, natural size) a destructive moth in Europe, where it devours the plum, as its specific name indicates. The inner two thirds of the fore wings are marbled with black and lilac colored scales; the apical third being white, with three costo-apical dark spots, and the extreme apex black.

The genus *Siderea* has rather long fore wings, the costa being regularly arched, and the tip rather pointed, the outer edge being concave below the tip. Clemens, doubtfully, refers his *S.? nubilana* (Fig. 256, 7*a*, head) to this genus. The fore wings are brown, with dark brown markings, and there is a dark brown basal line and a central irregular dark brown band, which becomes ochreous brown in the middle of the wing, and seems to be separated from a conspicuous dark brown triangular patch, which is edged narrowly with ochreous. Near the inner angle are two dark brown oblique stripes.

The typical genus *Tortrix* has the palpi much longer than the head, with the fore wings about twice as long as broad, and the costa arched abruptly at the base, while the outer edge is truncate and sometimes hollowed out below the tip. *T. gelidana* Möschler is a common arctic form, and occurs commonly in northern Labrador, and has been detected on the Alpine summit of Mount Washington by Mr. F. G. Sanborn. He has also detected a new species which feeds on the cranberry, for which we suggest the name *Tortrix oxycoccana*. Its body is dark brown, with lighter hairs on each side of the abdominal segments, and fuscous at the tip. The fore wings are of a peculiar glistening gray, mottled with reddish brown scales, especially towards the outer edge. There are no well defined spots or bands. The hind wings and body, and under surface of the wings are slate colored. The wings expand 1.15 inches.

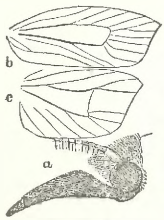


Fig. 257.

The *Leptoris breviornatana* of Clemens (Fig. 257; *a*, side view of the head and labial palpi; *b*, fore wing; *c*, hind wing), which is referred to the genus Tortrix by Mr. C. T. Robinson, has tawny yellow fore wings, with the veins brown. An oblique brown band arises on the basal third of the costa, and runs to the middle of the inner margin, but does not reach it. On the costa is a brown patch. It lives in Virginia. Mr. Robinson also informs me that in a forthcoming paper on this family he refers the *Ptycholoma? semifuscana* of Clemens (Fig. 258; *a*, head; *b*, fore wing; *c*, hind wing) to the present genus. "The fore wings are white along the costa and hinder margin, marked with pale brown, ochreous and tarnished silvery stripes and spots." It ranges from Maine to Virginia.

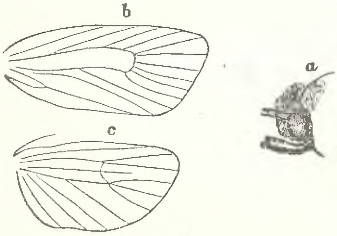


Fig. 258.

The genus *Lozotænia* has palpi rather longer than the head.

It differs from Tortrix in the male having a fold or flap of scales extending nearly to the tip of the fore wing, while the outer edge is indented below the tip, which is rather produced upwards. The larvæ of this genus feed in leaves, the edges of which are drawn together by silken threads, or in the stems and seeds of plants. *L. rosaceana* Harris (Plate 8, fig. 12; 12*a*, larva) is pale brown, with two oblique, darker reddish brown bands, and a triangular spot of the same color on the costa near the tip. The hind wings are ochreous yellow, and blackish within. The larva, early in June, binds together the leaves of the rose, apple and strawberry. It is plump and rather large, and of a pale yellowish green. We found, on the 23d of June, the fully grown larva on the leaves of the strawberry, doubling them up and binding them together by a few silken threads. The worm is pale livid, greenish above and paler beneath, with a conspicuous black dot on each side of the hinder edge of the prothorax. The head is very pale honey yellow, with two black spots: one near the insertion of the mandibles, and the other on the side near the base of the head. The posterior half of each segment is transversely wrinkled a few times. The body is scattered over with a few minute tubercles, each giving rise to a fine hair. It is .80 of an inch long. One specimen spun its slight cocoon on June 26th, the pupa appearing June 30th. It is sometimes attacked by Ichneumons. The pupa is pointed on the vertex of the head, and on the back of each abdominal ring are two rows of spines. The moth usually appears the last of June.

We have reared another species from the wild strawberry. It may be called the *Lozotænia fragariana*. It is a very pretty moth expanding .80 of an inch, with red fore wings, darker on the outer half and with a large triangular white spot near the middle of the costa; the outer edge of the spot is hollowed out. The outer edge of the wing is pale, especially in the middle, and concolorous with the head and palpi, and thorax. The hind wings and abdomen are whitish buff. The hind wings are whitish beneath. The larva may be found in Maine, early in June, folding the leaves, and the moth appears in the middle of the same month.

The *Lozotænia gossypiana*, or Cotton Leaf-roller, we describe from the very characteristic drawings of Mr. Glover. The larva closely resembles that of L. rosaceana and is about the same size. It rolls up the leaf of the cotton into a loose circular fold, and when fully grown spins a thin, loose, transparent cocoon between the leaves. On the abdominal tip of the brown cocoon are three pairs of minute hooks, the two outer pairs supported on a pedicel, by which the chrysalis is retained in place in the cocoon. The moth is the size of the L. rosaceana, being pale reddish brown, and with three darker bars, the inner one crossing the costal two-thirds of the wing, the middle and broadest crossing the wing obliquely, and terminating near the outer angle, while the third bar cuts off the apex of the wing. The hind wings are paler, but dusky along the inner side.

The species of *Penthina* may be recognized by the oblong fore wings, the apex being obtuse, sometimes a little falcate. An interesting species, according to information received from Mr. M. C. Reed of Hudson, Ohio, rolls up the leaves of the grape, and when the fruit becomes formed, eats the pulp and seeds, thus doing a two-fold injury to the vine. It may be called the *Penthina vitivorana* (Plate 8, fig. 22, enlarged). The head, thorax and palpi, and basal half of the antennæ are fulvous. The fore wings are dark slate brown. From the middle of the costa proceeds a blackish band which curves to the middle of the outer third of the wing; beyond is a linear curved costal band succeeded by another broader but quite short costal line; the costa is tawny beyond, sending a tawny patch obliquely inwards. Near the margin is an irregular blackish patch and two dark spots on the costa, and a larger one at the apex. The hind wings and body are dark slate color. It expands .40 of an inch. The first brood of caterpillars feeds on the leaves, appearing in May (in Ohio), or as soon as the leaves are grown. The second brood appears when the grapes are nearly filled out, and then they feed on the pulp and seeds. Mr. Reed writes me that "in every instance where a grape was opened containing a fully grown larva, the seeds were mere shells. They continue their work until the grapes are fully ripe, and at that time on removing to a new berry, seem to make their home in the old one, which is attached by a web." The larva turns over the edge of a leaf to form a rude cocoon for the chrysalis. Mr. Read suggests destroying the leaves thus affected before they fall in autumn, as the larvæ do not descend to the earth to undergo their transformations.

Halonota differs from Tortrix in having the apex of the fore wings rather obtuse, and there is a pale blotch usually present on the middle of the inner margin. *H. simulana* Clemens is brownish ochreous, with dull ochreous palpi, reddish at the tip; the fore wings are brown, with a slight brassy hue, and with an ochreous dorsal blotch; the costa is streaked with ochreous, and there are two violet streaks, one running beneath the tip and the other to a faint eye-like patch, behind which, on the hinder margin, are three black spots.

The genus *Grapholitha* is characterized by Stainton as having the palpi longer than the head, with the fore wings more than twice as long as wide, the costa being slightly arched, and the apex rather pointed, while the outer edge is a little hollowed out below the apex, and rounded at the inner angle. The larvæ live in the folded leaves of shrubs, or in the tops of herbaceous plants, or in their roots. Mr. Robinson refers the *Steganoptycha? ochreana* of Clemens, to Grapholitha (Fig. 259; *a*, head; *b*, fore wing; *c*, hind wing.*) The fore wings are pale yellowish, and the outer half of the costa is streaked with ochreous brown, and there is an eye-like patch which is white, and contains two ochreous brown streaks and two black dots. It was discovered in Virginia. Robinson also refers Clemens' *Euryptychia saligneana* (Fig. 256; 8 *a*) to this genus. It was bred by Mr. B. D. Walsh, in Illinois, from a willow gall. The fore wings are white, tinted with yellowish, with a dark brown basal patch, the wing beyond being nearly white varied with lead colored speckles, and striped over the venules with dull, leaden gray, transverse stripes, two of which near the anal angle, form a white eye-like patch. (Clemens.)

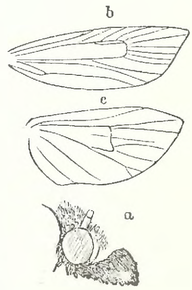
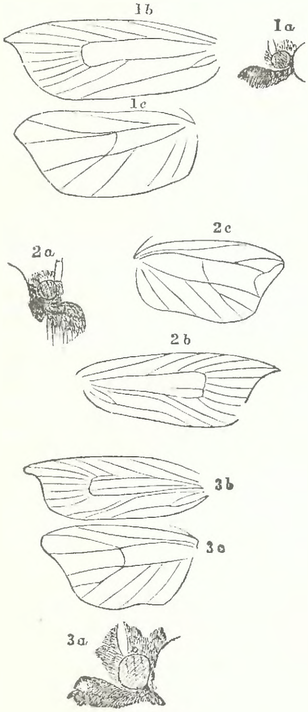


Fig. 259.

Under the name of *Callimosema scintillana* (Fig. 256; 9 *a*),

*The artist has represented the last branch of the median vein forked at the tip. It should have been the middle branch. (*Clemens.*)

Clemens describes a moth with narrow fore wings, and a large eye-like spot across the inner angle, the venation being the same as in *Ioplocama*. In this latter genus (Fig. 256; 10 *a*, I. formosana Clemens) the wings are broader and have the costa of the fore wings dilated at the base, while the labial palpi are broad, and reach far beyond the front of the head.



* Fig. 230.

In *Anchylopera* the palpi are shorter than the head, with the fore wings broader than usual, and the costa somewhat obtusely arched towards the base, while the tip is often hook-like and the outer edge concave. The larva feeds between the united leaves of plants. *A. spireæfoliana* Clemens is white on the fore wings, with a large, reddish brown dorsal patch extending from the base to the middle of the wing, and an oblique band from the middle of the costa to about the centre of the wing; the costa beyond is streaked alternately with white and reddish brown to the apex. The larva feeds on the leaves of Spiræa opulifolia, or Nine-bark. It is pale green with a yellowish tinge. (Clemens.)*

Mr. Fish has discovered an undescribed species which feeds on the cranberry, and which we may call the Cranberry Anchylopera, *A. vacciniana* (Plate 8, fig. 21, enlarged). The moth is dark ash, the fore wings being whitish, dusted with brown and reddish scales, with white narrow bands on the costa, alternating with broader yellowish

*Fig. 230; 1 *a*, represents the head of *A. nubeculana*, described by Clemens in the Proceedings of the Entomological Society of Philadelphia; 1 *b*, the venation of the fore wing; and 1 *c*, the hind wing; 2 *a*, the head of *A. ocellana* Clemens; 2 *b*, the fore wing; 2 *c*, the hind wing; 3 *a*, the head of *A. mediofasciana* Clemens; 3 *b* the fore wing; and 3 *c*, the hind wing.

brown bands, five of which are several times larger than the others, and from four of them irregular indistinct lines cross the wing. The first line is situated just beyond the inner third of the wing, and is often obsolete. The second line is the largest and is slightly bent once in the middle of the wing. There is a large brown spot parallel to the costa, being situated on the angle. The third line is oblique and stops before reaching the inner angle and is forked on the costa, while the fourth line is a short apical diffuse irregular line. The apex of the wing is dark brown, and is a little more acute than usual in the genus. The length of a fore wing is .20 of an inch. It lays its eggs on the leaves during the month of August and a new brood of larvæ appear in September, though they hatch mostly in the following spring, or early in June, and become fully grown in July.

The larva seen from above is much like that of Lozotænia rosaceana, but the head is a little larger in proportion to the rest of the body, being as wide as the body in its thickest part. The body is more hairy, while the prothorax is not dark. The chrysalis is rather slender, the body being contracted at the base of the abdomen, on the rings of which there are dorsal rows of fine spines.

Mr. Fish writes me that "these larvæ, called the Cranberry-vine worms, hatch about the first of June from eggs that have remained upon the leaves of the plant all winter. They commence to feed upon the tender growing shoots of the plant, drawing the leaves together with their web for shelter, concealing themselves and feeding within. Before reaching their full size they, if very numerous, almost wholly destroy the leaves and tender shoots, giving the whole bog a dark dry appearance as though a fire had been over it. This is why they are in some places known as 'fire-worms.' Having reached their full size they spin up among the leaves or among the dead leaves upon the ground. After remaining in the pupa state about ten or thirteen days the moths come out and deposit their eggs upon the leaves.

"This year the moths were out the last of June and first of July. In five or six days the eggs hatched and this second brood, which is usually the most destructive, mostly changed to pupæ on the 20th of July. On the 26th of July the first moth came out and most were out before the 4th of August. I saw the moth at Sandwich as late as the 20th of August. Most of the eggs laid in August do not hatch until the following spring. I did succeed in finding two or three larvæ in September, but they were rare at that time. The only sure means known of destroying them, is to let water upon the bog for twenty-four hours."

Another Tortricid larva, which seems to differ generically from the vine worm, in being thicker and having a larger, squarer prothoracic ring, and a less hairy body is called the "Fruit-worm." According to Mr. Fish, these worms appear the first of August and work all through the month. The first signs of their presence are seen in the berries that are attacked turning prematurely red. Most of them reach their full size before the first of September. In some places where the vines have been retarded by being kept under water until the first of June previous (it is common to cover the bogs with water when convenient), they do not reach their full size until a few weeks later. When fully grown they enter the ground and spin their cocoons within a few inches of the surface. The cocoons are covered with grains of sand and are hardly distinguishable from small lumps of earth. They remain in the ground all winter. I do not know positively the perfect insect, as I have never been able to rear it in-doors. In the spring of 1867 I bred two species of Ichneumons from these cocoons that had remained in the house over winter."

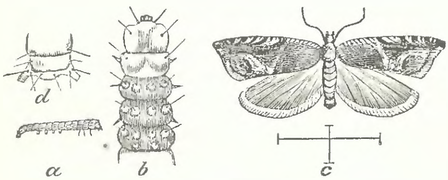


Fig. 261.

The Strawberry leaf-roller (A. fragariæ Riley, Fig. 261; *c*, lines showing the dimensions of the moth; *a*, larva, natural size; *b*, the head and four succeeding rings of the body; *d*, the terminal ring of the abdomen, showing the anal legs) has, according to Riley, recently been doing much injury to strawberry plants in Illinois and Canada. "It crumples and folds the leaves, feeding on their pulpy substance, and causing them to appear dry and seared, and most usually lines the inside of the fold with silk. There are two broods during the year, and the worms of the first brood, which appear during the month of June, change to the pupa state within the rolled up leaf, and become minute reddish brown moths during the fore part of July. After pairing in the usual manner, the females deposit their eggs on the plants, from which eggs in due time hatches a second brood of worms. These last come to their growth towards the end of September, and changing to pupæ, pass the winter in that state. The moth expands from .40 to .45 of an inch. The head and thorax are reddish brown, with pale palpi and legs, and dusky antennæ, while the tarsal joints are dusky at the tips. The fore wings are reddish brown and streaked and spotted with black and white, as in the figure, while the hind wings and abdomen are dusky." (American Entomologist, vol. i, p. 89.)

The Coddling moth, *Carpocapsa*, has palpi longer than the head; the apex of the fore wings is rather obtuse, and the outer edge is suddenly hollowed out below the tip. The larvæ feed in the interior of fruits. *C. pomonella* Linn. (Fig. 256, 11 *a*) is gray, with numerous darker, transverse lines, and with a curved black line before the ocellated patch on the inner angle, which line is edged with a coppery tint. The moth lays its eggs on apple and pear trees early in summer in the blossom-end of the fruit, and the larva hatches in a few days, burrowing into the core. It matures in three weeks, when the apple drops to the ground and the larva transforms in a thin cocoon in crevices in bark, etc., and in a few days another brood of moths appear, though most of them remain in their cocoons through the winter as larvæ, where we have found them under the loosened bark early in May.

This formidable pest may be partially destroyed by gathering "wind-falls," though the larva often deserts the worm-eaten apple before it falls. The best remedy is that suggested by Dr. Trimble, who binds bands of hay about the trees from July until the middle of September. The larvæ crawl under these bands and there spin their silken cocoons, when every few days the bands can be removed and the worms destroyed.

TINEIDÆ Leach. The Tineids are a family of great extent, and the species are very destructive to vegetation, having innumerable modes of attack. They may be distinguished from the *Tortricidæ* by their smaller size, while the narrow wings which lie on the top of, or are rolled around the body when at rest, are often falcate, or pointed acutely, and edged with a long fringe of exceeding delicacy. The maxillary palpi are greatly developed, while the labial palpi are of the usual size, and usually recurved in front of the head. The antennæ are long and filiform. The larvæ are cylindrical, variously wrinkled transversely, and with from fourteen to sixteen feet. They often construct cases in which they live, and usually spin a slight silken cocoon. About 1,200 species are already known in Europe alone. Those of this country have been mostly described by Dr. Clemens.

In studying this interesting family, Stainton remarks that "the elongated wings, the slender body and the long or very long fringes to the wings, are characters by which the Tineidæ may generally be recognized at once; and the development of the palpi and their variety in form and structure, offer most tangible grounds for separating the greater number of the genera. Indeed, if the student will look at the head of a species to see whether it is hairy or smooth, if he will then notice the palpi, whether the maxillary palpi are developed and to what extent, and whether the labial palpi are slender, ascending or drooping, whether the second joint is densely clothed with scales, or bears a long protruding tuft, and if he will farther notice the form of the hind wings, which are either well rounded or very pointed, or indented towards the tip, he will be perfectly surprised to see how easily he will arrange these insects into genera by their structure."

The larvæ vary excessively in the number of legs, sixteen being the usual number, but in several genera (Gracilaria, Lithocolletis, etc.), we only find fourteen; in Nepticula, though the legs are but poorly developed, they number eighteen; on the other hand the larvæ of a few of the smaller genera (Antispila, Tinagma, etc.) are absolutely footless.

For collecting and preserving these minute and delicate moths, which are called by collectors, *micro-lepidoptera*, especial instructions are necessary. When the moth is taken in the net, it can be blown by the breath into the bottom. "Then by elevating the hand through the ring, or on a level with it, a common cupping glass of about two inches in diameter, or a wine glass carried in the pocket, is placed on top of the left hand over the constricted portion, the grasp relaxed, and the insect permitted to escape through the opening into its interior. The glass is then closed below by the left hand on the outside of the net, and may be transferred to the top of the collecting box, when it can be quieted by chloroform" (Clemens); or the moths may be collected in pill boxes, and then carried home and opened into a larger box filled with fumes of ether or benzine or cyanide of potassium. In pinching any moths on the thorax, as is sometimes done, the form of that region is invariably distorted, and many of the scales removed. In searching for "Micros" we must look carefully on the *lee side* of trees, fences, hedges, and undulations in the ground, for they avoid the wind. Indeed, we can take advantage of this habit of many Micros, and by blowing vigorously on the trunks of trees start the moth off into the net so placed as to intercept it. This method is most productive, C. G. Barrett states, in the "Entomologist's Monthly Magazine," while a steady wind is blowing.

In seeking for the larvæ we must remember that most of them are leaf miners, and their burrows are detected by the waved brown withered lines on the surface of leaves, and their "*frass*," or excrement, thrown out at one end. Some are found between united leaves, of which the upper is crumpled. Others construct portable cases which they draw about the trunks of trees, fences, etc. Others burrow in the stems of grass, or in fungi, toadstools, and in the pith of currant or raspberry bushes. Most are solitary, a few gregarious. A bush stripped of its leaves and covered with webs, if not done by Clisiocampa (the American Tent Caterpillar), will witness the work of a Tineid. Buds of unfolded herbs suffer from their attacks, such as the heads of composite flowers which are drawn together and consumed by the larvæ.

After some practice in rearing larvæ it will be found easier and more profitable to search for the leaf miners, and rear the perfect, fresh, and uninjured moths from them. In this way many species never found in the perfect state can be secured.*

In raising "*micro*" larvæ it is essential that the leaf in which they mine be preserved fresh for a long time. Thus a glass jar, tumbler or jam-pot, the top of which has been ground to receive an air-tight glass cover, and the bottom covered with moist white sand, will keep a leaf fresh for a week, and thus a larva in the summer will have to be fed but two or three times before it changes; and the moth can be seen through the glass without taking off the cover; or a glass cylinder can be placed over a plant inserted in wet sand, having the top covered with gauze. Dr. H. G. Knaggs in treating of the management of caterpillars in breeding boxes, enumerates the diseases, beside muscardine and cholerine, to which they are subject. Among direct injuries are wounds and bruises, which may be productive of deformities in the future imago; the stings of ichneumon flies, whose eggs laid either upon or in the body may be crushed with finely pointed scissors or pliers; frost bites, and suffocation chiefly from drowning. If the caterpillar has not been more than ten or twelve hours in the water it may be recovered by being dried on a piece of blotting paper and exposed to the sun. Larvæ may also starve to death even when food is abundant, from loss of appetite, or improper ventilation, light, etc.; or they may eat too much, become dropsical, and die. Caterpillars undoubtedly suffer from a contagious disease analogous to low fever. Many die while moulting, especially the larvæ of Butterflies, Sphinges, and Bombycids; others are carried off by diarrhœa, which is generally caused by improper feeding on too juicy or relaxing food, when oak leaves or dry stunted foliage should be given them. To relieve constipation they should be fed with lettuce and other natural purgatives, and lastly, they may be attacked by fungi, especially, besides those previously men-

*"In general, it may be said, the mines of the leaf miners are characteristic of the genus to which the larva may belong. A single mine once identified, enables the collector to pronounce on the genus of all the species he may find thereafter. This added to the ease with which the larvæ are collected, and the little subsequent care required to bring them to maturity, except to keep the leaves in a fresh and healthy state, makes the study of this group, in every respect, pleasant and satisfactory to the entomologist." (Clemens.)

tioned, a species of Oidium. Such patients should be put in direct sunlight or dry currents of air. (Entomologist's Monthly Magazine, June, 1868.) The pupæ easily dry up; they should be kept moist, in tubes of glass closed at either end, through which the moth can be seen when disclosed.

In setting *micro-lepidoptera:* "If the insect is *very small* I hold it by its legs between the thumb and finger of the left hand, whilst I pierce it with the pin held between the thumb and finger of the right hand; if the insect is not very small I use a rough surface, as a piece of blotting-paper, or piece of cloth, for it to lie upon and prevent its slipping about, and then cautiously insert the point of the pin in the middle of the thorax, as nearly as possible in a vertical direction. As soon as the pin is fairly through the insect, remove it to a piece of soft cork, and by pressing it in, push the insect as far up the pin as is required.

"For setting the insects I find nothing answers as well as a piece of soft cork, papered with smooth paper, and with grooves cut to admit the bodies. The wings are placed in the required position by the setting needle, and are then retained in their places by a wedge-shaped thin paper brace, placed over them till a square brace of smooth card-board is placed over the ends of the wings." (Stainton.) A small square of glass can also be laid on the wings to keep them expanded, and thus serve the same purpose as the paper braces. Linnæus first set the example of having the specific names of the Tortricids end in *ana* and of the Tineids in *ella*, and at the present day the rule is generally followed by entomologists, who have also given the same terminations to the names of the smaller species of Pyralids, such as Pempelia, Crambus and allied genera.

In the group of Tineids proper, the head is roughly scaled, with short and thick labial palpi, while the maxillary palpi are generally extremely well developed, and the antennæ sometimes (Adela) extremely long. The larvæ live in a portable case and feed on wool, hair, etc., and fungi, or decayed wood.

Solenobia has very short labial palpi, which are almost concealed in the hairs of the mouth, and the case of the larva is shorter than usual. The unimpregnated females of this genus lay fertile eggs, so that one may breed a species for years without ever seeing a male. (Stainton.) *Solenobia? Walshella* Clemens is gray, varied with fuscous. The silken case is granulated with fine sand; the larva is probably lichenivorous.

In *Tinea* the head is rough, the maxillary palpi are usually folded and five jointed, while the labial palpi are cylindrical,

Fig. 262.

hairy and sometimes bristly. The fore wings are oblong ovate, and the hind wings ovate and clothed with scales.

The common Clothes moth, *Tinea flavifrontella* Linn. (Fig. 262; fig. 263, *a*, larva, with its case, *b*; *c*, chrysalis, enlarged) is of a light buff color, with a silky iridescent lustre, the hind wings and abdomen being a little paler. The head is thickly tufted with hairs and is a little tawny. The wings are long and narrow, pointed acutely, with the most beautiful and delicate long silken fringe, which increases in length towards the base of the wing. The moth begins to fly about our apartments in May, individuals remaining through the summer. They lay their eggs in woollens, though we have reared numerous specimens which had attacked a mass of cotton. Early in June we found numbers of the caterpillars in their flattened

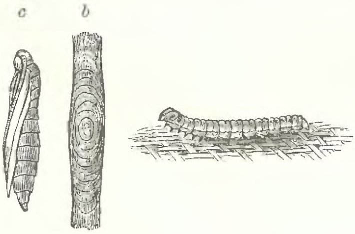


Fig. 263.

cylindrical cases which in this instance were white, the color of the substance they fed upon. The larva is whitish with a tolerably plump body, which tapers slightly towards the end of the body, while the head is honey yellow. The segments of the body are thickened above by two transverse folds. The body of the chrysalis is considerably curved, with the head smooth and rounded. The antennæ, together with the hind legs, which are laid on the breast, reach to the tip of the abdomen. On the upper surface of each ring is a short transverse row of minute spines, which aid the chrysalis in moving towards the mouth of its case, just before changing to a moth. When about to transform, the skin splits open on the back, and the perfect insect glides out. The skin is moulted with great rapidity. To avoid the ravages of this destructive moth, woollens and furs should be carefully shaken and examined early in June. Dr. Harris states that "powdered black pepper strewed under the edge of carpets is said to repel moths. Sheets of paper sprinkled with spirits of turpentine, camphor in coarse powder, leaves of tobacco, or shavings of Russian leather, should be placed among the clothes when they are laid aside for the summer; and furs and other small articles can be kept by being sewed in bags with bits of camphor wood, red cedar, or of Spanish cedar, while the cloth lining of carriages can be secured forever from the attacks of moths by being washed or sponged on both sides with a solution of the corrosive sublimate of mercury in alcohol, made just strong enough not to leave a white stain on a black feather." The moths can be most readily killed by pouring benzine among them, though its use must be much restricted from the disagreeable odor which remains, and its inflammable nature. The use of a weak solution of carbolic acid is also recommended. *Tinea tapetzella* Linn., the Carpet moth, is blackish at the base of the fore wings, the remainder being yellowish white, while the hind wings are dark gray, and the head white. The larva feeds on carpets, etc.

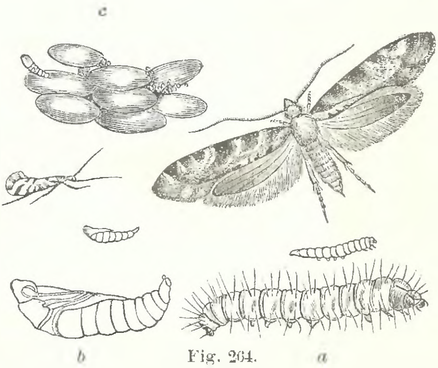


Fig. 264.

Tinea granella Linn. (Fig. 264 natural size, and enlarged, with the wings spread; *a*, larva, natural size and enlarged; *b*, pupa, natural size and enlarged; *c*, grains of wheat held together with a firm web) the Grain moth, is found flying in granaries during the summer. The female lays thirty or more minute eggs, one or two on each grain of wheat. The white worm hatches in a few days, eats its way into the grain, closing the entrance with its castings, and after it has devoured the interior of one grain, unites others in succession to it, until it binds together by a fine web a number of them. When nearly full grown they cover the grains with a very thick web. According to Curtis the larvæ retire to cracks and crevices in the floor and walls of the granary, and construct their cocoons by gnawing the wood and working it up with their web until it has the form and size of a grain of wheat, wherein it remains through the winter, changing to a chrysalis early in the spring; while two or three weeks after the moth appears. It is creamy white, with six brown spots on the costa, and with a long brown fringe. To prevent its attacks empty granaries should be thoroughly cleansed and whitewashed, or washed with coal oil, and when the moths are flying numbers may be attracted to the flames of a bright light; also when the larvæ are at work, the grain should be shovelled over frequently to disturb them.

The beautiful genus *Adela* is at once known by its excessively long antennæ. The larva makes a flat case, and feeds on the leaves of various low plants, such as the wood Anemone and Veronica. The *A. Ridingsella* of Clemens has coppery brown fore wings, with a pale grayish brown mesial patch dusted with black, and four or five black spots at the inner angle, while the hind wings are fuscous.

Hyponomeuta has a smooth head, with rather short, slender, reflexed, subacute labial palpi; the fore wings are white, dotted in rows with black, and on the base of the hind wings is a transparent patch. The larvæ are gregarious, and the pupa is enclosed in a cocoon. *H. millepunctatella* Clemens is white, with the base of the costa blackish, and with longitudinal rows of distinct black dots, two of which, one along the inner margin, and one along the fold, are plain. The hind wings are blackish gray.

In *Depressaria* the fore wings are unusually oblong, being rounded at the apex; and the hind wings are broader than usual, with the inner edge emarginate opposite the submedian vein, and rounded opposite the internal vein. The abdomen is flattened above, with projecting scales at the sides. The larvæ of this genus are extremely active, and feed on a variety of substances; some in rolled up leaves of composite plants, some in the leaves and others in the umbels of the umbelliferous plants. Many of the worms descend from the plant on the slightest agitation, so that considerable caution is necessary in attempts to collect them. The full-fed larvæ descend to the ground and change to pupæ among the fallen leaves. The perfect insects have the peculiarity of sliding about when laid on their backs. *D. atrodorsella* Clem. is yellow ochreous, with six or eight black costal dots, with a reddish patch extending from the disc towards the tip of the wing. The head is rufous above, with the face blackish brown above and yellowish beneath.

During the last summer we observed a locust tree which had some of the branches well nigh defoliated by an undescribed species of this genus which we may call the *Depressaria robiniella* (Plate 8, fig. 14, natural size). The head, palpi and fore wings are light brick red, spotted irregularly with yellow, and the antennæ are slate brown. The fore wings are a little darker in the middle, especially towards the inner edge. There is a submarginal darker brown band near the outer edge, which does not reach the costa, and on the outer edge is a row of minute black dots. The hind wings and abdomen are of a pale slate gray, and of the same color beneath, while the legs are of a very pale straw yellow. It differs from most of the species of the genus in having the apex of the fore wing less rounded than usual, and in this and other respects it is allied to the European *D. laterella*. The larva is thick-bodied, with a black head, and is green, the cervical shield being green. It devours the leaves, drawing them together by threads, and also eats the flower buds. It was most abundant in the last week of June. It turned to a chrysalis July 8th, and in about two weeks the moth appeared.

In *Gelechia* the fore wings are rather long and pointed, and the hind wings are trapezoidal and more or less excavated below the tip. The terminal joint of the labial palpi is slender, almost needle-like, smooth and pointed. This genus is of great extent and comprises a considerable diversity of species. The moth is extremely active. Clemens states that "the habits of the larvæ are extremely varied, feeding upon leaves, flower-buds, young shoots, and in the interior of grain and seeds. The species that feed in buds and shoots are mostly in the larva state in spring and the beginning of summer; those that feed in and upon leaves are met with in summer and autumn, and those that feed on seeds do so in the autumn and winter." The Angoumois Grain moth, *G. cerealella* Linn. (Fig. 265), is ochreous, with a fuscous streak towards the base, and a few fuscous dots towards the tip of the wing, while the hind wings are grayish ochreous. The wings are sometimes unspotted. It feeds in wheat granaries, where it secretes itself within the grain, devouring the mealy substance. Réaumur, according to Mr. Stainton, thus speaks of the economy of material in the food of the larva of Gelechia cerealella. "A grain of wheat or of barley contains the precise quantity of food necessary to nourish the larva from its birth till it is full fed. For if we open a grain inhabited by a younger and smaller larva, we find that there is more or less of the substance of the grain still to be consumed, according to the size of the larva. But what is remarkable is, that in the latter case, we find at least as much and probably more excrement, and in larger pellets, than we find in a grain tenanted by an older larva." It is thus driven to eat its excrement over once and perhaps more than once! We have received from Mr. F. G. Sanborn the larva (Fig. 266, much enlarged) of this moth, which had eaten out the kernel of grains of parching corn, leaving but a thin shell. The body is unusually short, thick and white, the tegument being very thin and transparent. *Gelechia fungivorella* Clem. has roseate white fore wings, dusted and banded with brown. Walsh states that "the larva mines a cabbage-like gall (C. salicis-brassicoides), peculiar to Salix longifolia, and a pine-cone-like gall on Salix cordata, named C. salicis-strobiloides by Osten Sacken." The larva of a similar species, *G. roseosuffusella*, inhabits the fruit panicles of the sumach.

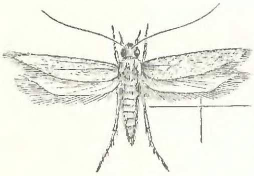


Fig. 265.

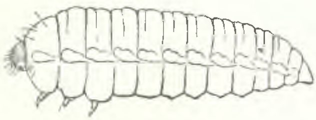


Fig 266.

Coleophora is a beautiful form, with long fringes to the wings, which are long and lanceolate, especially the hinder pair. The head is smooth above and in front, and the slender, simple antennæ are sometimes thickened with scales as far as their middle. The labial palpi are slender, rather porrected, with a slender prolonged tuft from the second joint, and the third joint is pointed. The larva is a case-bearer, changing to a pupa within the case. While these moths abound in the larva state, the adult insects are rarely met with. The leaf-feeding larvæ are very easily found, as their presence may be detected by the pale blotches they form on the leaf they feed upon, while the seed-feeding larvæ are much better concealed.

"Coleophora larvæ do not well bear confinement in the humid air of the breeding jar. To be successful in rearing the larvæ, one must use a pot of moistened sand, in which the food plant is placed, covered with a glass cylinder, with fine gauze tied over the top; or the plant may be kept in water and covered with a cylinder of glass. For this purpose old chimney tops to lamps answer very well. The larvæ of this genus, taken in the fall of the year, hibernate in their cases until the following spring, and feed upon the first leaves that put forth. They must not, therefore, be kept in a warm room during the winter. The pupæ of the fall brood of larvæ thrive much better, likewise, if not kept in a warm room during the cold months. The spring, or early summer brood of larvæ, produce imagos in a few weeks after entering the pupa state, and hence it is much more satisfactory to collect early in the year than during the latter part." (Clemens.)

In *C. rosæfoliella* Clem. the head and thorax are white, while the fore wings are pale grayish towards the base, clouded with dark brown from the middle to the tip, and the hind wings are dark brown. The case is silken, covered with granulations, cylindrical, slightly compressed, the mouth slightly deflexed and the opposite hook-like end turned down slightly. Its color is brown, varied with gray and reddish-brown granulations. The larva feeds in the spring on the common garden rose, and the case was found in winter attached to a thorn on one of the stems. *C. rosacella* Clem. also feeds in the spring on the rose and sweet briar. The case is made of the cuticle of the rose-leaf on which the larva feeds. It is a compressed cylinder, and dilated slightly in the middle of the under edge. Color dark ochreous. (Clemens.) *Coleophora coruscipennella* Clemens is a beautiful bronzed green species, with the terminal half of the antennæ white, ringed with brown. The fore wings are reddish violet on the apex, and the hind wings are dark brown. An unknown species is represented on Plate 8, fig. 17. It was found feeding on the pear the 5th of September, carrying about a flattened case of the form indicated in the figure, which is enlarged about five times. We have also found another Coleophora larva, with a long, flattened, cylindrical case, alike at each end, constructed of the outer skin of the leaf. It was found late in September feeding on the apple.

In the genus *Batrachedra* the wings are narrow, especially the hind ones which are sharply pointed, with a tuft near the base of the costa. *B. salicipomonella* Clemens (Fig. 267, venation and side view of the head, enlarged), in its larval state, according to Mr. Walsh, inhabits the gall made by a saw-fly on the willow.

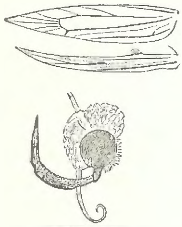


Fig. 267.

Elachista is a very extensive genus characterized by the long and slender, slightly recurved palpi. The fore wings are smooth, elongate and rarely oblong, and the hind wings are narrow and pointed. The larva mines the leaves of grasses and allied plants. Over fifty species have been described in Europe. Clemens refers doubtfully to this genus, a Virginian species, *Elachista? orichalcella*, which is of a beautiful metallic coppery color, while the hind wings and fringe are rather pale ochreous.

The genus *Lithocolletis* comprises very minute but most richly colored moths. The head is rough, the labial palpi filiform and drooping, while the fore wings are elongate, and the hind wings are linear lanceolate, with long fringes. They are often excessively abundant, are rather sluggish, but fly readily in the early morning. In Europe they are double-brooded, and hibernate in the pupa state (Clemens states that some hibernate as moths), appearing in the perfect state in spring, while a second brood of moths appear in August. The larvæ have fourteen feet, and mine the leaves of trees, shrubs or low plants, separating either the upper or lower cuticle and feeding on the inner substance of the leaf. When the mine is on the upper surface, or at least most frequently when it is in this position, the leaf becomes folded and curved at the place mined, and the separated cuticle is gathered into folds, or covers the curved portion so as to make a capacious habitation. Some of the miners of the upper surface of leaves make large blotches, or tracts, and when the mines are fresh the separated cuticle is whitish and very noticeable. The miners of the under surface, cause the upper cuticle to become discolored in patches, and this with the fold of the side of the leaf is often sufficient to indicate the presence of a mine. Usually the species are confined to a single plant; some, however, feed on several allied plants. The larva seldom quits the mine and changes in it to a pupa. Some species either make no cocoon or only a very slight one, and others make one of grains of excrement woven together with silk. *L. Fitchella* Clemens (Argyromiges quercifoliella Fitch) is silvery white, with pale reddish saffron fore wings, slightly tinged with a brassy hue. It feeds on the oak, according to Dr. Fitch.

L. salicifoliella Clemens during the latter part of June or early in July mines the under surface of the leaves of the yellow willow (Salix vitellina var. alba). *L. juglandiella* makes an elongated, rather wide tract on the upper surface of the leaves of the black walnut.

During the last summer the larva of an undescribed species, which we may call *Lithocolletis geminatella* (Plate 8, fig. 15; *a*, larva; *b*, pupa; *c*, its mine, the first three figures enlarged six diameters) was abundant on the apple and pear trees. The moth is of a dark slate gray, without any prominent markings, with ochreous hairs on the top of the head. There is a black round spot on the middle of the inner edge of the wing (omitted in the figure, which is drawn from a slightly rubbed specimen). On the outer edge is an eye-like spot, pupilled with black, like the "eye" in a peacock's tail. The antennæ are dark, ringed with a pale slate color. It expands .30 of an inch. The larva is pale livid reddish with a black head and cervical shield, and .14 of an inch in length. It was first discovered about the middle of August, hanging from a branch suspended by a thread. From this time it became abundant, until the leaves began to fall in the first week of October; nearly every leaf on some of the pear and apple trees having a mine like that represented in Plate 8, fig. 15*c*. Usually the larva draws two leaves together, or folds one up, and as it eats its way along the surface of the leaf, leaves its excrement filling up the space behind, thus making blotches and otherwise disfiguring the leaves. In this mine it transforms into a long slender pupa, which may be found surrounded with the castings of the larva. The moths first appeared August 19th, and flew in-doors at night attracted by the light.

Lithocolletis curvilineatella (Plate 8, fig. 16, enlarged) is a pale whitish species with yellowish scales, with a black line, which beginning on the middle of the costa, curves around towards the apex, ending in the usual eye-like spot on the outer edge, beyond which is a dark marginal line; in the middle of the wing near the inner side is a longitudinal black oval spot, paler within. The hind wings are pale gray, and the body and legs pale whitish yellow. The wings expand .30 of an inch. We never met with the larva, but the cocoon is long and slender, a little blunt at each end and white, with slight longitudinal ridges. It may be found attached to the bark on the branches of the apple tree in May and also in the autumn and winter. Besides differing from L. geminatella in making a regular cocoon, the pupa is a little stouter and the top of the head is blunter.

Another species, which appears to be undescribed, we would call the *Lithocolletis nidificansella* (Plate 8, fig. 19, moth; 19*a*, cocoon) from the singular way the cocoon is suspended in a leaf like a hanging nest, by silken cords. The single specimen figured was found early in September, the moth appearing on the 11th. The larva feeds on the pear, and when about to transform had evidently drawn the edges of the leaf together by a few threads, and then suspended its thin cocoon in the manner indicated in the figure, the position of the chrysalis being represented by the black line in the centre of the cocoon. The moth is silvery white, with gray hind wings. The fore wings are white, with golden bronze streaks and spots. The costa is white, with three oblique golden lines running outwards from the edge of the wing towards the outer margin, the inner one being minute, and the outer one broad and less oblique than the others. Beyond, are three apical straight thread-like lines next the eye-like black dot, near which arises a slender pencil of long hairs. Below the costa the wing is spotted with gold, and there is a broad oblique golden dark band directed outwards and reaching to the middle of the wing. The costa is golden on the outer third of its length. The wings expand .36 of an inch.

Lyonetia is closely allied to the preceding genus, and may be distinguished from it by the head being smooth, the scales being broad and flattened down. Mr. F. G. Sanborn first drew our attention to this moth, having reared it from cocoons found on the apple. From the singular habit of the larva in making a case instead of living in a mine in leaves, we would call it the *Lyonetia saccatella* (Plate 8, fig. 18; 18*a*, the larva; 18*b*, the larva with its case, all a little enlarged). The moth is a perfect gem; its head and short antennæ are pale gray and its fore wings are light slate gray on the basal half, and beyond bright orange, enclosing two white bands, one costal and the other arising from the inner edge, both nearly meeting in the middle of the wing, and edged externally with black. There is a square, black, very conspicuous spot near the fringe, in which is a long pencil of black hairs, not shown in the figure. The outer angle of the wing is dusky. It expands .20 of an inch. The larva is a little flattened green worm, and constructs a flattened oval case of the skin of the leaf which it draws about. The case is open at each end, and is roomy enough for the larva to turn around in. It becomes fully grown by the last of August, and in October we have found the cocoons attached to the bark of the tree, where they may also be seen through the winter and in the spring.

The last important genus, *Nepticula*, contains the smallest known lepidopterous insects. "Many of them are excessively beautiful, resplendent with burnished copper, gold and silver scales. They may be observed in May and June, sitting on the trunks of trees or palings; but to see these atoms requires an experienced eye. Most of the species appear to be double-brooded, and are easily collected in plenty in the larva state. A nut-leaf, containing from twenty to thirty larvæ of *Nepticula microtheriella*, is no unusual sight. In *Nepticula* the antennæ are not half as long as the fore wings, which are rather broad while the hind pair are lanceolate.

"The larvæ mine very narrow serpentine paths in the interior of leaves, the mine being always on the upper surface. They vary much in form, being sometimes a slender gallery or line, either simple, or enlarged towards the end into a blotch. When the larva is full-fed it quits the mine, cutting for this purpose the separated cuticle, in order to weave a minute cocoon." (Clemens.) *N. corylifoliella* Clemens mines the hazel. *N. platanella* Clemens mines the button-wood tree, or sycamore, and *N. amelanchierella* Clemens mines the leaves of the June berry in June and July.

PTEROPHORIDÆ Latreille. The small group of *Plume-moths* may be at once known by their fissured and plumed wings. The body is long and slender, with long antennæ and legs. They are the lowest moths, the long slender abdomen and fissured wings being marks of degradation. The larvæ have sixteen legs and are rather hairy. They form no cocoon, but, fastening themselves by the tail to a leaf or stem, shed their larva-skins and appear in the pupa state. Some of the pupæ are nearly as hairy as the larvæ, others are quite naked. Most of the larvæ feed in the early summer months, and the perfect insects appear rather later, though some may be seen in spring. (Stainton, Manual of British Butterflies and Moths.)

In *Pterophorus* the hind margin of the fore wing is more or less deeply cleft, while the hind wings are almost divided into three separate slender lobes or plumes. The larvæ live in the flowers and stems as well as on the leaves of plants. *P. periscelidactylus* Fitch (Plate 8, fig. 23 ; *a*, larva ; *b*, pupa, enlarged) is tawny yellow, the fore wings having three large white spots and two bands beyond ; the outer line is thread-like, the inner line being much broader on the costal division of the wing, reappearing at the base of the split in the wing, and below extending out to the lower half of the outer line. The hind wings are darker brown than the rest of the moth, while the third and shortest division of the wing is white, but brown at the end, with the fringe on the outer fourth of the wing still darker brown. The legs are white with tufts of brown scales surrounding the hind legs. It expands .65 of an inch. The larvæ, received from Mr. M. C. Reed, of Hudson, Ohio, were pale green, with a greenish yellow head. Along the body is a double dorsal paler line, and whitish tubercles, from which proceed very long uneven hairs, and the body is also covered with very short white hairs, giving a frosted appearance to the worm. They are about half an inch long. About the middle of June it changes to the singular chrysalis represented on the plate, and in about a fortnight appears as one of the most delicate and graceful of moths. It may be seen flying about our graperies in midsummer, and is attracted to our apartments after nightfall by the lights within. It feeds upon the young leaves of the grape, hiding itself in a hollow ball made of leaves drawn together by threads. The pupa is slender, conical, obliquely truncated at the head, with two long compressed horns placed side by side, and jutting upwards from the middle of its back, and numerous smaller projecting points and ridges. It reminds one of the chrysalids of the butterflies, in its habit of remaining attached by its tail to the plant on which it feeds.

In *Alucita* the wings are still farther subdivided, each wing being divided from the base into six distinct feathers. The larva of the European *A. polydactyla* feeds in the unopened buds of the honey-suckle. It is not hairy, and spins a cocoon.

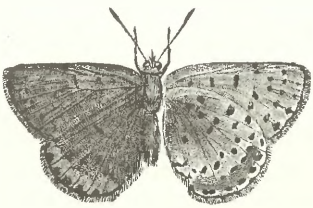


Fig. 269.
Chrysophanus Thoe Westwood.

DIPTERA.

FLIES may be easily recognized by their having but a single pair of wings, the hinder pair being aborted, and existing in a rudimentary state under the name of "*halter*." The more essential character of the Diptera, however, consists in the greatly centralized, more or less globular thorax. Both the prothorax and metathorax are greatly aborted, and the legs are somewhat weak. As the second pair of wings are obsolete, the muscles adapted for flying are not developed.

When the wings are entirely wanting, as in Chionea, the Spider fly, and the Spider-like Bat-tick (Nycteribia), the thorax becomes still more globular, and the head of Nycteribia shows a tendency to become immersed in the thorax, as in the spiders.

The abdomen is either short, conical and broad at the base, being rarely pedicellate; or long and cylindrical, or flattened either horizontally or laterally. The conical form of the abdomen accords with the quick jerky flight of the House fly, as compared with the steady slow flight of Tipula, whose abdomen is very long. The abdomen is composed of from five to nine distinct segments. As Lacaze-Duthiers states, the Diptera as a rule have no true ovipositor like that of bees, etc., though the three terminal rings are retracted within the abdominal cavity, and are capable of being thrust out like the joints of a telescope. When about to lay their eggs they simply place them in cracks or upon the substances that are to form the future food of the larva, having no organs for boring, though the female Tipulids are able to work the hard tip of the abdomen into the ground where they deposit their eggs. The terminal ring of the abdomen in the males is provided with clasping organs.

The head is very free from the thorax in the true flies, and is spherical, hemispherical or conical. The eyes are large, with very numerous facets, and often approach each other closely on the front of the head, especially in the males. The ocelli, when present, are placed on the vertex, and the antennæ are inserted below, in the middle (antero-posteriorly) of the front.

They are either long and evenly jointed, as in the *Tipulidæ*, often with long cilia, and sometimes verticillate, as in Cecidomyia; or, as in the House fly, the typical form is a short and stout, two to three-jointed antenna, ending in a bristle.

In the Hymenoptera and Lepidoptera only a portion of the mouth parts are used for sucking in food, but in the present group, the labrum, with the two pairs of appendages, *i. e.*, the maxillæ and mandibles, are (when all are well developed, as in the Mosquito) ensheathed partially within the labium, and with the last form a channel for the passage of the fluid food into the mouth.

The labium forms the under side of the sheath, while the mandibles and maxillæ are represented by simple setæ, though the one, two, or three-jointed maxillary palpi are present, and in this last character the rostrum of the flies differs from the beak of the Hemiptera. As in the Hymenoptera, the lingua is well, though differently developed, terminating in a large fleshy knob which is divided into two fleshy flaps called the *labellæ*.

The wings are naked, as in the Hymenoptera, though fine hairs may be detected by the microscope on the veins, becoming most apparent in the Psychodæ, where the wings are very hairy. In form they are long and narrow, the costal edge being straight, the apex of the wing obtusely rounded, while the oblique outer edge is very long and nearly parallel with the costa, where in the Lepidoptera it is nearly at right angles to it. The veins are six in number, and in their direction and branches (Fig. 270–271) correspond more closely with the venation of the Lepidoptera than any other suborder. The veins are straight, and with fewer branches than in the Lepidoptera, but with more cross venules, which in the wing of the *Tipulidæ*, remind us of the net-veined Neuroptera. When, as in the Cecidomyiæ, the veins become in part obsolete, only three veins remain, the costal, subcostal and median. The form and size of the cells, especially the submarginal ones, are of much use in distinguishing the species, while the changes in the costal and basal portion of the wing are the most important in classifying the genera and families.

The function of the halteres, or "poisers," is still problematical. Hicks and Leydig consider them as organs of hearing, while Goureau and Loew think they are concerned in the act of respiration.

Besides the well known wingless genus Chionea, and the Flea, Sheep-tick, and Braula, Loew, the eminent German entomologist, enumerates several European species of Tipula, the females of which have the wings rudimentary; and also a species of Limnobia (Idioptera). Epidapus is wingless in both sexes. "Psyllomyia, Apterina and Elachiptera, and species of Tachista, Chersodromia and Geomyza have rudimentary wings in both sexes; in other forms the wings are only abbreviated in both sexes (Sciomyza), or in those of the male or female are smaller than in the other sex (species of Empis, Rhamphomyia, Idioptera and Tipula)."

FIG. 270. *Diagram of a wing with two submarginal and five posterior cells (Cladura indivisa). Cells:*—1, costal; 2, subcostal; 3, marginal; 3*, inner marginal; 4, submarginal; 5, second submarginal; 6–10, first to fifth posterior; 11, discal; 12, first basal; 13, second basal; 14, anal; 15, axillary; 16, spurious. *Veins:*—*b l*, auxiliary; *c m*, first longitudinal; *h*, *n*, *o*, second longitudinal; *h i*, præfurca; *k n*, anterior branch of the second longitudinal vein; *k o*, posterior branch of the second longitudinal vein; *i k*, petiole of the first submarginal cell; *i p*, third longitudinal; *d q r s t*, fourth longitudinal; *q r*, fork of its anterior branch; the posterior branch of this fork, ending in *r*, is Mr. Loew's *anterior intercalary vein*; *s t*, fork of the posterior branch of the fourth vein; the branch of this fork, ending in *t*, is Mr. Loew's posterior intercalary vein; *e u*, fifth longitudinal; *f v*, sixth longitudinal; *g w*, seventh longitudinal. *Cross-veins:*—*x*, humeral; *x x*, subcostal; *xxx*, marginal; *x**, small, or anterior cross-vein; *x***, great cross-vein.—*From Osten Sacken.*

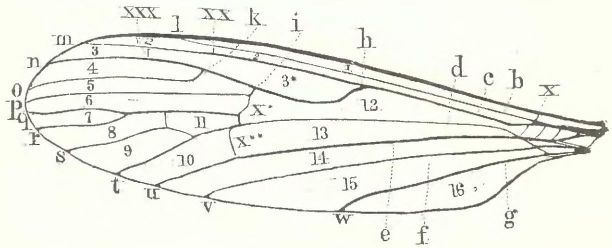


Fig. 270.

FIG. 271 (1). *Wing of Ortalis.*—*a*, transverse shoulder-vein; *b*, auxiliary vein; *c*, *d*, *e*, *f*, *g* and *h*, first, second, third, fourth, fifth and sixth longitudinal veins; *i*, small or middle transverse vein; *k*, hinder transverse vein; *l*, *m*, *n*, *o*, costal vein; *p*, anterior basal transverse vein; *q*, posterior basal transverse vein; *r*, rudiment of the fourth trunk; *s*, axillary incision; *A*, *B*, and *C*, first, second and third costal cells; *D*, marginal cell; *E*, submarginal cell; *F*, *G* and *H*, first, second and third posterior cells; *I*, discal cell; *K*. first or large basal cell; *L*, second basal cell, or

M. Marey has determined that a common fly when held captive moves its wings 330 times a second; a honey bee 190 times, and a cabbage butterfly (Pieris) nine times. The wings describe a figure 8 in the air. (Cosmos.) Landois, calculating the rapidity of the vibrations by the sound produced

anterior of the small basal cells; *M*, third basal cell, or posterior of the small basal cells; *N*, anal or axillary corner of the wing; *O*, alar appendage, (alula).

FIG. 271 (2). *Wing of Empis.*—*t*, anterior branch of the third longitudinal vein; *u*, anterior intercalary.

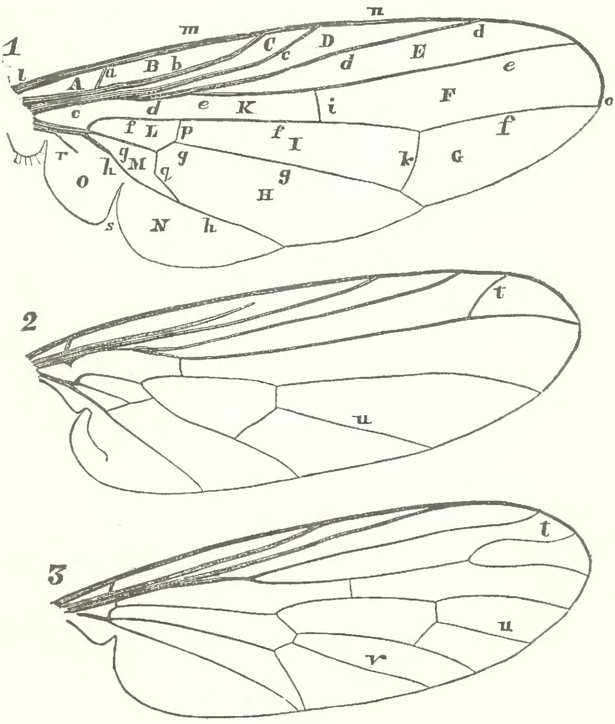


Fig. 271.

FIG. 271 (3). *Wing of Dasypogon.*—*t*, anterior branch of the third longitudinal vein; *u*, anterior intercalary vein; *v*, posterior intercalary vein.—*From Loew.*

Comparing the wing of Ortalis with that of the bee and butterfly figured on page 23, we should prefer to use the same terminology and call *l*, *m*, *n*, the marginal vein; *A*, *b*, the costal; *c*, *d* and *e* the three branches of the subcostal vein; *f*, the median vein; *h*, the submedian; and *r*, the internal vein. In Macquart's system, modified slightly by Sacken (fig. 270), *b*, *l*, is the costal; *cm*, the subcostal; *d* and *e*, the median; *f*, the submedian, and *g* the internal vein.

thereby, states that the fly, which produces the sound of F, vibrates its wings 352 times a second, and the bee, which makes the sound of A′, 440 times a second. "On the contrary a tired bee hums on E′, and therefore vibrates its wings only 330 times in a second. This difference is probably involuntary, but the change of 'tone' is evidently under the command of the will, and thus offers another point of similarity to a true 'voice.' A bee in the pursuit of honey hums continually and contentedly on A′, but if it is excited or angry it produces a very different note. Thus, then, the sounds of insects do not merely serve to bring the sexes together; they are not merely 'love songs,' but also serve, like any true language, to express the feelings. (Sir John Lubbock's Address before the London Entomological Society, 1868.)

Landois describes the sound-producing organs in several genera of flies. "He distinguishes three different tones as emitted by these insects: during flight, a relatively low tone, a higher one when the wings are held so as to prevent their vibrating, and a higher still when the fly is held so that all motion of the external parts is prevented. The last mentioned is the true voice of the insect; it is produced by the stigmata of the thorax, and may be heard when every other part of the body is cut away. The first sound is caused by the rapid vibration of the wings in the air; the second is caused, or at all events accompanied, by the vibration and friction of the abdominal segments, and by a violent movement of the head against the anterior wall of the thorax." The halteres also assist in producing the sound. The vibration of the head in the Diptera during the emission of sound is regarded by this author as due to the transmission of movement from the thorax. (Zoölogical Record, 1867.) Landois also states that there are small species which give a deeper note than larger ones, on account of the wing-vibrations not being of the same number in a given time. (Lubbock.)

The legs are slender, unarmed, except with stout bristles, as in Asilus; the joints are simple, cylindrical; the tarsi are five-jointed, the terminal joint ending in two claws (ungues), between which is the cushion, or *pulvillus*, consisting of two or three fleshy vesicles, often armed with hairs, which are tubular, and secrete an adhesive fluid, which is said to aid the fly in walking up-side-down on polished surfaces.

The nervous system in the Diptera is characterized by a grouping of the thoracic ganglia into a single mass, from which proceed nerves to the abdomen; the abdominal ganglia being for the most part aborted. Thus in some *Muscidæ*, Œstrus, and Hippobosca, the nervous cord behind the cephalic portion, consists of a single thoracic ganglion, which gives out nerves in different directions. The higher Muscids, such as Syrphus and Conops have in addition one or two ganglia situated at the base of the abdomen. The higher groups, such as the *Tabanidæ*, *Asilidæ* and *Bombylidæ* have six ganglia, and the *Empidæ*, *Tipulidæ* and *Culicidæ* have more. The larvæ usually have one more pair than the adult, having ten and sometimes eleven ganglia, with long commissures, which are often double.

The digestive system is less complex than usual. As in the two preceding suborders, on one side of the œsophagus is a pedicellate sucking stomach which extends into the abdomen near the true chyle-making stomach. The latter is of the usual intestinoid form, enlarging a little anteriorly, with two cœcal appendages beneath on each side, near the cardiac extremity.

The four, rarely five, Malpighian vessels which correspond to the kidneys of vertebrates, are united before they open into the single or double common outlet.

There are two main tracheæ, and two large air-sacs, one on each side, at the base of the abdomen. The system of tracheæ is simplest in the aquatic Tipulid larvæ, resembling in this respect the Phryganeæ, where the tracheæ are subcutaneous and designed to extract the air from the water.

The testes are generally colored, being provided with a pigment layer. They are oval, curved or tortuous glands, with a short efferent vessel (vas differens). The ovaries consist of three to four chambered tubes, and a short oviduct. The *receptaculum seminis* is generally triple. A true *bursa copulatrix* is wanting in the Diptera, but in "many *Muscidæ* the vagina has, as a seminal receptacle or uterus, a spacious and sometimes two-lobed reservoir in which the fecundated eggs are accumulated in great numbers, and remain until the larvæ are sufficiently developed to be hatched, so that these animals are viviparous. In the pupiparous Hipposboscæ, the female organs are formed on an entirely special type, corresponding with the remarkable mode of reproduction in these animals." (Siebold.) Near the external opening of the oviduct is a pair of glands designed to secrete the gummy matter coating the eggs.

The eggs of the Diptera are usually cylindrical, elongated and slightly curved, and the surface is smooth, not being ornamented as in the Lepidoptera. In the *Tipulidæ* the eggs become mature as soon as the pupa skin is thrown off, when they are immediately laid.

The larvæ are footless, white, fleshy, thin skinned, cylindrical and worm-like, spindled or linear in shape. They have, in the higher families, as in the *Tipulidæ*, a distinct head; but they are often headless, as in the *Muscidæ*, and are then called maggots. They live in mould, decaying organic substances, or in the water. Many maggots are provided with two corneous hooks, probably the mandibles, with which they seize their food.

The pupa is either naked (Pupa obtecta, Fig. 276), like the chrysalids of moths, with the limbs exposed, as in the *Tipulidæ*; or they are coarctate (pupa coarctata, Fig. 272) as in the flies generally, the skin of the larva serving to protect the soft pupa within, as during the growth of the pupa the old larval skin separates from the newly formed pupa skin, which contracts slightly. It is then called the puparium, and is usually cylindrical and regularly rounded at each end like the cocoon of moths. Those which have the pupæ obtected, when aquatic and active, are provided with gill-like filaments permeated with tracheæ.


Fig. 272.

The semipupa stage of Diptera, corresponds generally with that of the Hymenoptera and Lepidoptera. By an ingenious device Dr. Fitch succeeded in observing in the living insect the processes by which the larva of the willow Cecidomyia (*C. salicis*) turns to a pupa, and which is usually accomplished during the night. He states that "as the first step of this change, at the anterior end of the larva the *cutis* or opake inner skin becomes wholly broken up and dissolved into a watery fluid, whereby the thin transparent outer skin or cuticle is elevated like a vesicle or blister, which occupies about a fourth of the length of the worm on its under side, but is much shorter on its back. The insect is now in its embryo-pupa state, having lost its larva form and having not yet assumed its pupa form. In the fluid contained in this vesicle, the wings, legs and antennæ of the future fly now begin to be developed, whereby the sheaths of the wings at length come to be discerned immediately under the skin. This skin is exceedingly thin, delicate and transparent, like the *tunica arachnoides* of the human brain, a mere film, as thin as a spider's web. Eventually the insect, by gently writhing, ruptures this film at its anterior end, and gradually crowds it off downwards to the lower end of the vesicle, carrying the minute black jaws of the larva with it. It there remains, becoming dry and torn into shreds which flake and fall off by the continued motions of the insect. At the same time from the remainder of the surface not occupied by this vesicle, a still more slight and delicate film, appearing as though the worm had been wet in milk which had dried upon it, forming an exceedingly thin pellicle or scurf, becomes separated by the same motions of the insect and drops off in minute scales scarcely to be perceived with a magnifying glass. And now the insect has acquired its perfect pupa form."

Frederic Brauer has proposed in his "Monographie der Œstriden," a division of the Diptera into two large groups. This division is much more natural than the old one into those with coarctate and obtected pupæ. The first group is the *Diptera orthorapha*, comprising the Nemocera, or flies with long antennæ, together with the *Stratiomyidæ*, *Xylophagidæ*, *Tabanidæ*, *Acroceridæ* (?), *Bombylidæ*, *Asilidæ*, *Leptidæ*, *Therevidæ*, *Empidæ* and *Dolichopidæ* (passing over some small families whose metamorphoses are not known). In these families the larva skin at the last moult splits down along the middle of the back of the three thoracic rings, while a transverse split on the first thoracic ring makes a T-shaped fissure. Through this the mummy-like pupa with free limbs escapes; or it remains within the loose envelope formed by the old larval skin, when this author calls it a "false puparium."

In the second group, the *Diptera cyclorapha*, the true coarctate, cylindrical, smooth puparium is formed by the contraction of the larva skin, but is very different in shape from the mature larva; while this puparium remains in vital connection by means of tracheæ, with the enclosed pupa, which escapes from the puparium through a curved seam or lid in the anterior end, and not by a slit in the back. This group includes the *Pipunculidæ*, *Syrphidæ*, *Conopidæ*, *Œstridæ*, *Muscidæ* and *Pupipara*.

Certain Diptera are injurious to crops, as gall producers, but indirectly the *Tachinidæ* are beneficial since they prey on caterpillars; while the greater number act as scavengers in the water and on land, and thus as sanitary agents. Diptera enjoy a wider geographical range than other insects. None of the larger families are exclusively tropical; the *Muscidæ* and mosquitoes are found in the circumpolar regions in abundance, as well as in the tropics. They are the earliest to appear in spring and the latest to disappear in autumn. They are active at all times, in rain or sunshine, day or night, though the greater number prefer the sunshine.

From their habit of living in vegetables, flowers, and other substances sometimes eaten by persons, physicians occasionally are called to treat cases where dipterous larvæ have been swallowed and produced sickness. Among those most frequently vomited are larvæ of various Muscids, especially Anthomyia. "C. Gerhardt records a case in which a patient, after four days illness, vomited about fifty larvæ of some dipterous insect, probably a large species of Muscidæ. A. Laboulbène describes and figures in the Annals of the Entomological Society of France, a larva of Teichomyza fusca Macquart, which is exceedingly abundant in the public urinals in France, and which lives in human urine. He identifies it with the larvæ described and figured by Davaine in 1857, as having been evacuated from the intestines of a woman after she had suffered much pain. (Zoölogical Record for 1867.) Four other cases are on record of larvæ having been voided by the urinary passages, or found living in urine, though, as suggested to us by Dr. Hagen, it is possible that in such cases, the worms were not voided, but lived in the urine previous to the time they were detected by the reporters of such cases.

Dr. J. Leidy reports in the Proceedings of the Academy of Natural Sciences of Philadelphia, for 1859, a case where a number of specimens which "appeared to be the larvæ of the Bluebottle fly," were given him by a physician, having been vomited from the stomach by a child. Also, a second case where numerous larvæ of a species of Anthomyia, "were given to him for examination by a physician who had obtained them from his own person. He had been seized with all the symptoms of cholera morbus, and in the discharges he had detected numerous specimens of this, to him, unknown parasite. It was in the latter part of summer, and the larvæ, it is suspected, had been swallowed with some cold boiled vegetables. Dr. Leidy had observed the same kind of larva in another case, accompanied with the ordinary phenomena of cholera morbus."

Isidore Geoffroy Saint Hilaire records a case of a larva of the common fly found living in the skin of an infant; while Dr. Livingston, according to Cobbold, detected a "solitary larva of a species which had taken up its residence in his leg. Dr. Kirk removed this parasite by incision; and on a second occasion he obtained a similar specimen from the shoulder of a negro."

There are about 2,500 species of North American flies described, and it is probable that the number of living North American species amounts to 10,000. In Europe there are also about 10,000 known species, belonging to about 680 genera.

The flies of this country, compared with the other groups, have been but little studied, though the habits of many are so interesting and the species very numerous. The different parts of the body vary much more than in the Hymenoptera and Lepidoptera, and in such a degree as to often afford comparatively easy characters for discriminating the genera.

Their habits are very variable. Fresh water aquaria are necessary for the maintenance of aquatic larvæ. If quantities of swamp mud and moss with decaying matter are kept in boxes and jars, multitudes of small flies will be hatched out. Leaf-mining and seed-inhabiting species can be treated as micro-lepidoptera, and earth-inhabiting larvæ like ordinary caterpillars. Dung, mould in hollow trees, stems of plants and toadstools contain numerous larvæ or *maggots*, as the young of flies are called, which must be kept in damp boxes.

Flies can be pinned alive, without killing them by pressure, which destroys their form; and numbers may be killed at once by moistening the bottom of the collecting box with creosote, benzine or ether, or putting them into a bottle with a wide mouth, containing cyanide of potassium. Minute species can be pinned with very slender pins, or pieces of fine silver wire, and stuck into pieces of pith, which can be placed high up on a large pin. In pinning long-legged, slender species, it is advisable to run a piece of card or paper up under their bodies upon which their legs may rest, and thus prevent their loss by breakage. Of these insects, as with all others, duplicates in all stages of growth should be preserved in alcohol, while the minute species dry up unless put in spirits.

In the genuine flies the thorax is highly centralized; the maxillæ are covered by the labrum, and the labium is not provided with palpi. The females lay eggs from which the larvæ are hatched. They are also divided into the *Nemocera*, comprising those flies having long, thread-like, many-jointed antennæ, and embracing the higher families, *i. e.* the *Culicidæ*, *Tipulidæ*, *Bibionidæ* and *Rhyphidæ*; while the remaining families of this division are included in the *Brachycera*, or flies with short antennæ, such as the *Muscidæ*, etc. But the fossil genera, Electra and Chryothemis, discovered by Professor Loew in the amber of the Tertiary formation, and a North American genus of *Xylophagidæ*, and the genus Rachicerus, have intermediate characters combining these distinctions, which are thus shown to be somewhat arbitrary.

CULICIDÆ Latreille. The family of Mosquitoes or Gnats have the mouth-parts very long and slender; the maxillæ and mandibles are free and lancet-like. Figure 274 (A, larva; c, its respiratory tube; B, pupa; *d*, the respiratory tubes; *a*, the end of the abdomen, with the two oar-like swimming leaves, seen in profile at B, from drawings made by Mr. E. Burgess,) illustrates the transformations of a species inhabiting brackish water in the vicinity of Boston. The larvæ remain most of the time at the bottom feeding upon decaying matter, thus acting as scavengers and doing great benefit in clearing swamps of miasms. Occasionally they rise to the surface for air by a jerking movement, inhaling it through the star-like respiratory tube which connects with the tracheæ.

The pupæ have club-shaped bodies owing to the greatly enlarged thorax, with two respiratory tubes like those of Corethra, situated on the thorax. They remain near the surface of the water wriggling towards the bottom when disturbed, aided by the two broad swimming caudal leaves. Though active in their habits they do not eat. The eggs are laid in a boat-shaped mass, which floats on the surface of the water. About four weeks after hatching the imago appears, so that there are several broods during the summer. The females alone bite, the males not coming into our apartments but spending their lives in the retirement of the swamps and woods.

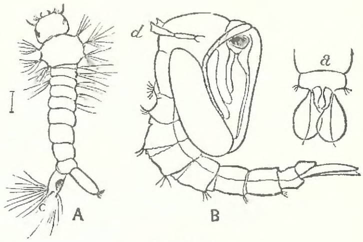


Fig. 273.

This genus abounds in the high Arctic regions as well as in the tropics. *Culex pipiens* Linn. inhabits Europe, and there are over thirty North American species described in various works.

Figure 274 represents a vertical and side view of the head (greatly magnified) of a common species of Culex found in Labrador. The antennæ (*a*) do not reach as far as the tip of the beak, and are supplied at each joint with a thin verticil of hairs (by an oversight partly omitted in the upper figure). The beak consists of a stout bristle-like labrum (not shown in the figure), the bristle-like maxillæ (*mx*, with their rather large three-jointed palpi *mp*) with the mandibles (*m*)

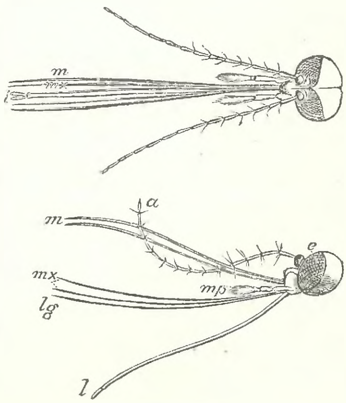


Fig. 274.

which are thicker than the maxillæ and barbed at the tip, and the single hair-like lingua, or tongue (*lg*). These six bristle-like organs are folded together within the hollowed labium (*l*), which is a little enlarged at the tip, and forms a gutter-like case for the rest of the mouth-parts. The mosquito, without any apparent effort, thrusts them, thus massed into a single awl-like beak, into the flesh, and draws in the blood through the channel formed by the fine bristles, Westwood stating that the labium does not penetrate the flesh, but becomes bent upon the breast of the fly. He adds "it is supposed that, at the same time it instils into the wound a venomous liquid, which, while it enables the blood to flow faster, is the chief cause of the subsequent irritation." So far as we are aware no poison glands have been demonstrated to exist in the head of flies, or other six-footed insects, and we are disposed to doubt whether any poison is poured into the wound, and to question whether the barbed mandibles are not sufficient to produce the irritation ordinarily accompanying the punctured wound made by the mosquito as well as other flies.

A large mosquito, with two light spots on each wing (*Anopheles quadrimaculatus* Say), bites fiercely. It is abundant very early in the spring before other mosquitoes appear. It seems to hibernate in houses. The genus *Corethra* has the male antennæ very long and densely hairy. The wings are finely ciliated as in Culex, and the inner edge has a short fringe. The beautifully transparent and delicate whitish larvæ may be seen in early spring in quiet pools. Early in April the pupa state is assumed, disclosing the flies late in the month.

Chironomidæ Westwood. Of this small family the genus *Chironomus* includes some small species which are mosquito-like, with feathered antennæ, and abound in swarms in early spring before the snow disappears. The larvæ are long, slender, worm-like; sometimes of a blood-red color, and aquatic in their habits. While most of the larvæ of this genus live in fresh water, we have observed multitudes of the young of *C. oceanicus* Pack. living on floating eel-grass and in green sea-weeds at low water mark in Salem harbor. There are two broods of the larvæ, the first becoming fully grown the last of April, the other the last of September, the flies appearing about the middle of October. The larva (Fig. 275, *a*, enlarged about three times, with the head greatly magnified; *b*, the labrum; *c*, the mandibles; *d*, the labium) is cylindrical, whitish and about a quarter of an inch long. The single pair of fore legs (Fig. 276*a*) are provided with about twenty-five longitudinal rows of hooks, while the anal legs (Fig. 277; *a*, a portion of the dorsal vessel) terminate in a single crown of hooks which can be drawn in out of sight. The worms were found either creeping over the surface of the weeds, or if about to pupate, concealed in a rude thin case or tube, formed of the debris collected on the weeds. It feeds on sea-weeds and small worms. It remains in the pupa state (Fig. 276) about two weeks, transforming into a fly (Fig. 278 male, and head of the female) which differs from the true Chironomi in having shorter antennæ and smaller palpi, and also in the venation, and the longer thorax. *Tanypus* resembles Culex in its larva and pupa state, being of similar form. Lyonnet figures a larva which spins a movable case of silk and moss. The eggs of *T. varius* are laid on the leaves of aquatic plants, and fastened together with gluten. Some species of *Ceratopogon*, like the mosquito, are blood suckers. The larvæ are, however, terrestrial, living in mushrooms, or under the bark of decaying trees.

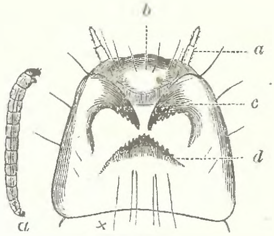


Fig. 275.

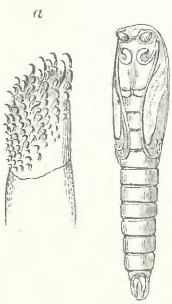


Fig. 276.

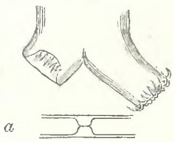


Fig. 277.

CECIDOMYIDÆ Westwood. The group of Gall-flies comprises minute, delicate, slender-bodied species, whose bodies are clothed with long hairs. The wings have usually three or four longitudinal veins, and are folded over the back. They are gall-flies, the female laying her eggs in the stalk of cereals, and in the stems, leaves and buds of various plants which produce gall-like excrescences inhabited by the larvæ. The Wheat-midge or Hessian-fly does not, however, produce such an enlargement, while other larvæ only produce a folding of the leaf, swelling of a leaf-rib, or arrest the growth of a bud or stalk.

Before giving a special account of the Wheat-midge, so destructive to wheat crops, let us, with the aid of Baron Osten Sacken's résumé in the Smithsonian Monographs of North American Diptera, Part 1, take a glance at the habits of the family. As a rule the species prefer living plants, though several species of Epidosis and Diplosis live in decaying wood, and C. fuscicollis Meigen (?) has been reared by Bouché from decaying bulbs of tulips and hyacinths. Others live under the bark of trees, in the cones of pines, or in fungi. Each species is, as a rule, confined to a peculiar species of plant. Some of the larvæ live as guests or parasites in galls formed by other Cecidomyiæ. Thus C. acrophila and C. pavida live socially in the deformed buds of Fraxinus; and Diplosis socialis inhabits the gall of Lasioptera rubi. The larvæ of some species of Diplosis are parasitic among the plant-lice (Aphis). Some of the larvæ live on the surface of leaves, C. glutinosa having been found by Osten Sacken living on the surface of hickory leaves.

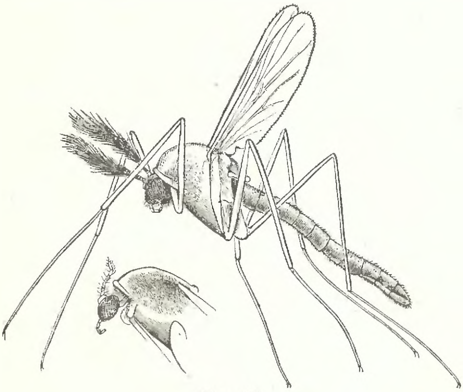


Fig. 278.

The rather long, cylindrical eggs laid on the surface of leaves, etc., are generally hatched in a few days, though this period may be hastened or retarded by heat or cold. The young larvæ are colorless and transparent, with age becoming reddish or yellow, or white. They are fourteen-jointed, a supposed supernumerary joint being placed between the head and the first thoracic segment. The last abdominal ring is sometimes provided with bristles or horny spinules, frequently curved, which aid the larvæ in leaping, as they have been observed by Dufour to do. The head and mouth-parts are exceedingly rudimentary, consisting of a ring with two processes extending backwards; the soft fleshy labium protrudes through this ring; and from the upper part of the ring arise a pair of two-jointed organs, supposed to be rudimental antennæ. On the under side of the body at the juncture of the first or prothoracic segment with the supernumerary segment, is a horny piece called, provisionally, the *breast-bone* (Fig. 284, *a*), and which is present in most of the larvæ of this group. The larvæ having no jaws, must suck in the sap and moisture through the mouth, or absorb it through the skin. They make no excrement, like the larvæ of the Hive bee and Humble bee. Though their motions are ordinarily slow, just before pupation they are very active. The larvæ are not known to moult, though probably the larva skin is shed by gradually peeling off in shreds, in this respect resembling the thin-skinned larvæ of bees.

Some larvæ of Cecidomyia before becoming pupæ, leave their galls and descend to the ground, while others remain in them, where they spin a slight silken cocoon. Dr. Harris has described the mode of pupation of the larva of *C. salicis* Fitch, stating that "the approaching change is marked by an alteration of the color of the anterior segments of the larva, which from orange become red and shining, as if distended by blood. Soon afterwards, rudimentary legs, wings and antennæ begin, as it were, to bud and put forth, and rapidly grow to their full pupal dimensions, and thus the transformation to the pupa is completed." This process is undergone beneath the larva skin, out of which the pupa does not draw its body, as in the obtected diptera generally. The larva skin, dried and cylindrical in shape, thus serves as a cocoon to preserve the soft pupa from harm. The semipupa of C. destructor thus "takes the form and color of a flax-seed. While this change is going on externally, the body of the insect gradually cleaves from its outer dry and brownish skin. When this is carefully opened, the included insect will be seen to be still in the larva state.*

*This "larva" is probably the semipupa, or "beginning of the pupa state" (Harris), and may be compared with the semipupa of the Bee. (Fig. 27.)

It does not change its condition and become a true pupa until a few days before it discloses the winged insect."

The pupa resembles that of the fungus-eating Tipulids, such as Sciara. The bases of the antennæ are often produced into horn-like points, which aid the pupa in working its way out from the gall before assuming the fly state, and for the same purpose the back of the abdomen is spinose, and often there are a few bristles at the tip.

According to Dr. Harris, the *Cecidomyia destructor* Say, or Hessian-fly (Fig. 280), has two broods, as the flies appear in the spring and autumn. At each of these periods the fly lays twenty or thirty eggs in a crease in the leaf of the young plant. In about four days, in warm weather, they hatch and the pale red larvæ (*a*) "crawl down the leaf, working their way in between it and the main stalk, passing downwards till they come to a joint, just above which they remain, a little below the surface of the ground, with the head towards the root of the plant" (*c*). Here they imbibe the sap by suction alone, and by the simple pressure of their bodies they become embedded in the side of the stem. Two or three larvæ thus embedded serve to weaken the plant, and cause it to wither and die. The larvæ become full grown in five or six weeks, then measuring about three-twentieths of an inch in length. About the first of December their skin hardens, becomes brown and then turns to a bright chestnut color. This is the so-called flax-seed state, or puparium. In two or three weeks the "larva" (or more truly speaking, the semipupa) becomes detached from the old case. In this puparium the larva remains through the winter. Towards the end of April or the beginning of May the pupa (Fig. 280, *b*) becomes fully formed, and in the middle of May, in New England, the pupa comes forth from the brown puparium, "wrapped in a thin white skin," according to Herrick, "which it soon breaks and is then at liberty." The flies appear just as

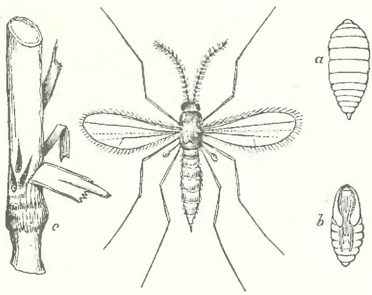


Fig. 280.

the wheat is coming up; they lay their eggs for a period of three weeks, and then entirely disappear. The maggots hatched from these eggs take the flax-seed form in June and July, and are thus found in the harvest time, most of them remaining on the stubble. Most of the flies appear in the autumn, but others remain in the puparium until the following spring. By burning the stubble in the fall, their attacks may best be prevented. Among the parasites on this species, are the egg-parasites, Platygaster, and Semiotellus (Ceraphron) destructor Say (Fig. 140), the latter of which pierces the larva through the sheath of the leaf. Two other Ichneumon parasites, according to Herrick, destroy the fly while in the flax-seed or semipupa state. The ravages of the Hessian-fly have been greatly checked by these minute insects, so that it is in many localities not so destructive as it was formerly. Dr. Fitch has suggested that the European parasites of this insect and the C. tritici, could be imported and bred in large quantities, so as to stop their ravages. With proper pecuniary aid from the State this seems feasible, while our native parasites might perhaps also be bred and multiplied so as to effectually exterminate these pests.

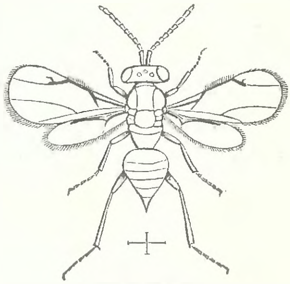


Fig. 140.

The Wheat-midge, *C. tritici* Kirby, attacks the wheat in the ear. When the wheat is in blossom the females lay their eggs in the evening by means of the long retractile tube-like extremity of the body, within the chaffy scales of the flowers, in clusters of from two to fifteen or more. In eight or ten days the eggs disclose the transparent maggots, which with age become orange colored, and when fully grown are one-eighth of an inch long. They crowd around the germ of the wheat, which by pressure becomes shrivelled and aborted. At the end of July and in the beginning of August the maggots become full fed, and in a few days moult their skins, leaving the old larva skin entire, except a little rent in one end of it. "Great numbers of these skins are found in the wheat ears immediately after the moulting process is completed." Sometimes the larva descends to the ground and moults there. Harris states that "it is shorter, somewhat flattened, and more obtuse than before, and is of a deeper yellow color, with an oblong greenish spot in the middle of the body. In this state, which is intermediate between the larva and pupa states, which has by Dr. Fitch been termed the "embryo-pupa," and by us "semipupa," the insect spins a minute earthen cocoon, which, according to Dr. Fitch, is smaller than a mustard seed and remains in the ground through the winter, burrowing to the depth of an inch beneath the surface. In the next June they are transformed to pupæ, with the limbs free. When about to assume the adult state the pupa works its way to the surface in June and July. Its chief parasite, the Platygaster error Fitch (Fig. 135), is allied to P. tipulæ, which in Europe destroys great numbers of the midge.

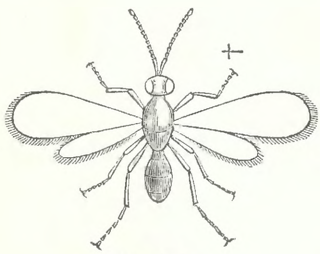


Fig. 135.

It is evident that deep ploughing in the fall or spring will destroy many of the insects, and grain sown after the 15th or 20th of May, in New England, will generally escape their attacks.

The wings of the Hessian-fly are blackish; those of the *C. tritici* are transparent. This last species is orange colored, with long, slender, pale yellow legs, and the joints of the antennæ are twenty-four in number in the male, and twelve in the female.

The *Cecidomyia rigidæ* Osten Sacken (C. salicis Fitch) forms a gall surrounded by the dry and brittle terminal bud at the end of the twigs of the willow. The single larva discloses the fly early in the spring. The bright yellow larva of *C. grossulariæ* Fitch, causes the gooseberry to turn red prematurely and become putrid. The pupa of *C. pini-inopis* is supposed by Osten Sacken to be coarctate, the larva fastening itself to a pine leaf and remaining motionless until the resinous exudation resulting from its attacks hardens, forming a cocoon-like pupa case or puparium.

Mr. Walsh describes in the "American Entomologist," vol. i,

p. 105, the gall formed by *C. strobiloides* O. Sacken (Fig. 281; *a*, natural size; *b*, antenna; *c*, gall) which is simply an enlarged and deformed bud of Salix cordata. The fly appears in April, or early in May, oviposits in a terminal bud, and the gall attains its full size by the middle of July. The larva hibernates in a thin cocoon, changing to a pupa in the spring. (Walsh.) Another willow gall made by C. *salicis-brassicoides* Walsh occurs

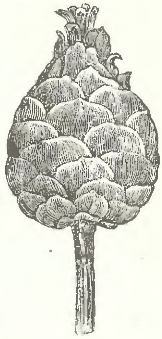


Fig. 281, *c*.

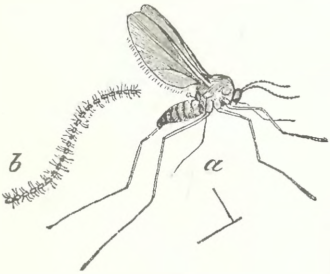


Fig. 281.

on the Salix longifolia, the galls forming a mass (Fig. 282) like the sprouts on a cabbage stalk. Mr. Walsh also describes the Grape-vine Apple Gall (Fig. 283, gall of C.? vitis pomum; *a*, natural size; *b*, a section), the fly of which is unknown. The gall is divided into numerous cells, each containing a larva. It occurs on the wild Frost grape. The Grape-vine filbert gall (C.? vitis-coryloides Walsh, fig. 284; *a*, head of larva, showing the clove-shaped breast bone; *b*, a bunch of galls, natural size; *c*, section of a gall, showing the cell the larva inhabits) is found on the wild Frost grape in Illinois.

Fig. 282.

Walsh has described fourteen additional species of Cecidomyiæ inhabiting eight different species of willow. The specific character of the insects themselves, are in all their stages of the slightest possible character, but the different galls can be readily distinguished. These galls, according to Walsh and other authors, also afford a shelter to so-called "inquiline," or guest species, such as the larvæ of other species of Cecidomyia and species of Scatopse and Drosophila, *Curculionidæ* and minute Lepidoptera, together with Aphides and species of Thrips, which last are thought by Mr. Walsh to prey upon the cecidomyious larvæ.

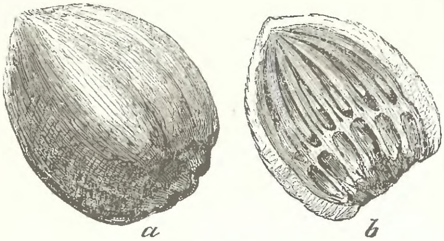


Fig. 283.

The subdivisions of the large genus Cecidomyia are noticed by Osten Sacken in Part 1 of the Smithsonian Monographs of Diptera. As the student can refer to that work, we simply introduce the cuts showing the venation of the wing of each genus, without farther characterizing them. (Fig. 285, Cecidomyia; 286, Diplosis; 287, Colpodia; 288, Epidosis; 289, Asynapta; 290, Spaniocera; 291, Lasioptera). Another group of this family are *Anarete* and its allies (Fig. 292, Zygoneura; 293, Anarete; 294, Catocha; 295, Campylomyza; 296, Lestremia) which are also related to the Mycetophilids.

Fig. 284.

We have already referred, on page 51, to certain cecidomyians, which in the larval condition produce young. We figure (297) a species whose metamorphosis has been traced by Nicholas Wagner. The larva is cylindrical in form, like most cecidomyian larvæ, with the division between the segments indicated by rows of minute spines. From the germ-balls (*a*, nearest the posterior end of the body) the embryo is gradually formed (as at *a* in the eighth and ninth rings of the body), when they assume a cylindrical form like the eggs of the adult fly of this family. These eggs may be compared with the

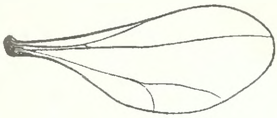


Fig. 285.

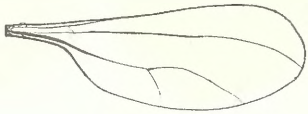


Fig. 286.

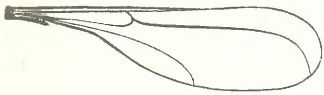


Fig. 287.

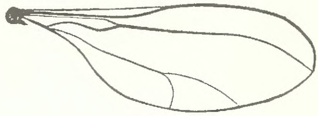


Fig. 288.

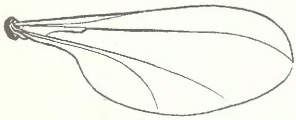


Fig. 289.

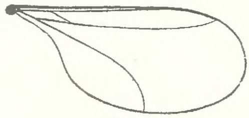


Fig. 290.

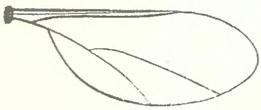


Fig. 291.

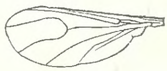


Fig. 292.

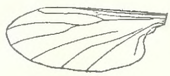


Fig. 293.

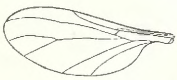


Fig. 294.

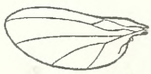


Fig. 295.

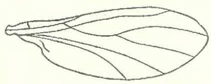


Fig. 296.

"pseudova" of the Aphis, and are developed from the two large fatty bodies (corpora adiposa) which are situated one on each side of the body. These "false eggs" increase in number and develop until the entire cavity of the mother larva becomes distended with young worms like itself, and which are finally born and may be compared with the wingless broods of Plant-lice.*

*Baron Osten Sacken afterwards abandoned the hypothesis (stated on p. 209) that the females of Cynipidæ are impregnated by males inhabiting a different sort of gall. See the Proceedings of the Entomological Society of Philadelphia, 1862, p. 249, § 3, Sexes of the Cynipidæ.

Several species have been found in Europe under the bark of apple trees, etc. Loew states "that the species on which Wagner made his observations is nearly allied to the genus Heteropeza, but still more closely to the genus Monodicrana, from the amber of the Tertiary formation on the shores of the Baltic. (Zoölogical Record, 1865.) Meinert describes a similar species of worm and its imago, under the name of *Miastor metroloas*, and characterizes the fly as having very short two-jointed palpi, and moniliform eleven-jointed antennæ. The wings have three veins, the middle one of which does not reach the apex of the wing.

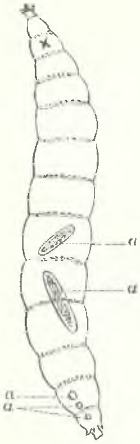


Fig. 297.

PSYCHODIDÆ Zetterstedt. The principal genus in this small family is *Psychoda*, comprising small flies with broad, very short, oval whitish wings, which, like the body, are very hairy. They may be seen flying and leaping on the banks of, or on the surface of pools, and on windows. The larvæ live in dung. The larva of the European *P. phalænoides* (so named from its resemblance to a moth) is "long, subfusiform and depressed, with a slender, straight cylindrical tail, longer than the preceding segment. The pupa has two short appendages, thickened at the tips behind the head. The abdomen is tapering." (Westwood.)

TIPULIDÆ Latreille. The Daddy-long-legs or Crane-flies are well known by their large size and long legs, and from their close resemblance in form have probably given rise to the humorous stories of giant mosquitoes, which sometimes appear in newspapers. They are characterized by their slender antennæ and palpi, and their remarkably long legs, while the abdomen is very slender and cylindrical in shape; the group chiefly differs, however, from other flies, according to Baron Osten Sacken (Monograph of the Diptera of North America, Part iv), in the presence of a transverse V-shaped suture across the mesonotum; by the completeness of the venation, and the presence of a well developed ovipositor, "with its two pairs of long, horny, pointed valves." The larvæ (Fig. 298, natural size, a larva of this family found living under stones in a running brook at Burkesville Junction, Va. In the American Naturalist, vol. ii, it was referred to Tabanus) differ from those of the neighboring families in having but a single pair of spiracles at the anal end of the body. The head is rather large, and "embedded nearly up to the mouth in the first thoracic segment; the mandibles are horny and strong, and forked at the end." The body is grub-like, of a uniform grayish, brownish, or whitish color, and consists of twelve segments.

Fig. 298.

"The larvæ of Ctenophora, living in wood, have a soft, white, smooth skin, similar to that of the larvæ of longicorn beetles, or of the *Asilidæ*, living in similar conditions. The larva of Tipula living in the soil, or the larvæ of those species of Ctenophora which are found in wood so far decomposed as to be like soil or vegetable mould, have a much tougher skin, and are covered with a microscopic, appressed pubescence. This toughness, as well as some stiff bristles, scattered over the surface of the skin, is probably useful in burrowing. Thus the larva of Trichocera, digging in vegetable mould or in fungi, is covered, according to Perris, with microscopic erect bristles. The larva of Ula, living in fungi, has, according to the same author, still longer bristles. Those larvæ living in water (as some Limnobina) are soft and slimy, of a dirty greenish color, and with a peculiar clothing of appressed microscopic hairs, not unlike those of the larvæ of Stratiomys. The most anomalous of all the Tipulideous larvæ are those of the Cylindrotomina. That of Cylindrotoma distinctissima lives upon the leaves of plants, as Anemone, Viola, Stellaria, almost like a caterpillar. It is green, with a crest along the back, consisting of a row of fleshy processes. The larva of Cylindrotoma (Phalacrocera) replicata, according to Degeer, lives in the water, on water plants, and is distinguished by numerous filaments, which, although resembling spines, are flexible and hollow on the inside. Degeer took them for organs of respiration." (Osten Sacken.)

The larvæ move by means of minute stiff bristles arising from transverse swellings on the under side of the body. "The end of the body is truncated, and the two spiracles are placed upon the truncature," from the edge of which part arise usually four retractile processes.

In the aquatic larva of Ptychoptera there is a long respiratory tube at the end of the body. The pupæ (Fig. 299, under side, enlarged twice, represents a pupa of this family) have usually on the thorax two horn-like processes, representing the thoracic spiracles, and in Ptychoptera one of these processes acquires a great length, in order to allow the pupa to breath under water.

Fig. 299.

The Tipulids, like other flies with soft bodies which contract in drying, should, as Osten Sacken suggests, be studied from fresh specimens, especially when the thorax and abdomen, with the ovipositor, are to be examined. The Tipulids of the United States, east of the Mississippi river, closely represent those of Europe, while Osten Sacken states that a few species are found to be common to both countries; and he farther states, with regard to the *Tipulidæ*, that "whenever the North American fauna differs from the European in the occurrence of a peculiar generic form, or in a marked prevalence of another, this difference is due, either to an admixture of South American forms, or of forms peculiar to the amber fauna."

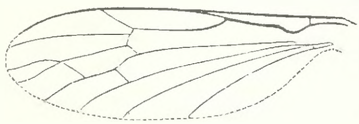


Fig. 300.

The genus *Tipula* comprises the largest individuals of the family, and the species may be seen early in May flying over grassy fields. The larvæ live in garden mould and under moss in fields and woods. *T. trivittata* Say is one of our most common species.

In the genus *Limnobia* the body is very slender and delicate, though stouter than in *Dicranomyia*, a closely allied genus, the larvæ of which are probably aquatic. "The larvæ live in decaying vegetable matter, especially in wood and fungi." "Van Roser discovered the larvæ of the European *L. annulus* (closely allied to L. cinctipes Say) in decayed wood. They are like an earth-worm in size, as well as in color, and line their burrows with a kind of silken web." (Osten Sacken.)

The genus *Styringomyia* (Fig. 300, wing) is an anomalous genus found in gum copal brought from Zanzibar. Of three other anomalous genera belonging here Osten Sacken describes *Rhamphidia*, of which the rostrum is long, but shorter than the thorax, with species common to Europe and America, and also found in amber; *Toxorrhina* which is found both in North and South America, and *Elephantomyia* which occurs only in North America, and has a very slender filiform rostrum, almost as long as the body. *E. Westwoodii* O. Sacken is found in the Northern States and Canada.

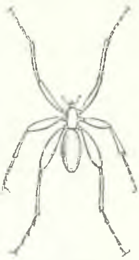


Fig. 301.

Erioptera and its allies have two submarginal cells and the tibiæ are without spurs at the tip. In *Erioptera* the wings are pubescent along the veins only, giving the whole wing a hairy appearance. *E. venusta* O. Sacken has yellowish wings, with two brown bands, and is a common species in the Atlantic States. According to Osten Sacken *Chionea* is closely allied to Erioptera. It is wingless, with six-jointed antennæ of anomalous structure, and stout, hairy feet, and a short abdomen, which, according to Harris is provided with a "sword-shaped borer, resembling that of a grasshopper." "These insects occur on snow in winter, the larvæ live underground, apparently upon vegetable matter, and have been described in detail by Brauer in the Transactions of the Zoölogical and Botanical Society of Vienna for 1854." *C. valga* Harris (Fig. 301, enlarged; fig. 302, larva of the European C. araneoides Dalman) is reddish brown, with paler legs.

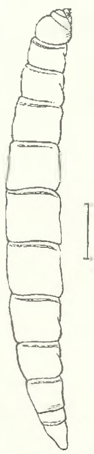


Fig. 302.

Another section of this large family is represented by the genus *Limnophila*, in which there are two submarginal cells, usually five posterior cells, and the wings and eyes are smooth, and the antennæ sixteen-jointed. The larvæ live in decayed wood. The larva of the European *L. dispar* digs longitudinal burrows in the dry stems of Anglica sylvestris. "It is cylindrical, glabrous, of a livid gray, with a horny black head." (Osten Sacken.)

The anomalous genus *Trichocera* has pubescent eyes and distinct ocelli on the sides of the frontal tubercle. The species appear in swarms, flying up and down in their mazy dances, especially at twilight early in spring, though they may be seen late in autumn and on warm days in winter. They live in decaying vegetable matter. *Pedicia* is a gigantic crane-fly, embracing the largest flies of the family, and with Trichocera is the only genus of this family having ocelli.

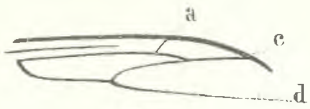


Fig. 303.

P. albivitta has hyaline wings, with the costa, the fifth longitudinal vein and the central cross veins margined with brown. The body is 1.4 of an inch in length. The larva of an European species lives in well water.

The genus *Cylindrotoma* and its allies, resemble Tipula in the course of the veins lying in the vicinity of the stigma, and Osten Sacken illustrates the resemblances by the accompanying drawings, of which Fig. 303 represents the venation near the stigma of Cylindrotoma; Fig. 304 that of the European *Phalacrocera replicata*, closely allied to the preceding genus, and Fig. 305 that of a genuine Tipula.

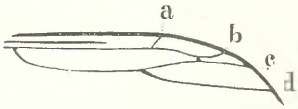


Fig. 304.

Ptychoptera is rather stout-bodied and has a singular membranous spatulate organ, ciliated on the margin, which is inserted at the base of the halteres. (Osten Sacken.) *P. rufocincta* O. S. is black with reddish bands on the feet.

The larva of the European *P. paludosa* has a long respiratory tube at the end of the body, which it raises to the surface of the water, and in the pupa "one of the horny processes which distinguishes the thorax of all the pupæ of the *Tipulidæ*, is enormously prolonged, likewise, for the purpose of breathing under water. (Osten Sacken.) The very singular genus *Bittacomorpha* is an aberrant form, resembling the neuropterous Bittacus. The antennæ consist of twenty joints, and the first joint of the tarsi is very much thickened, while the abdomen is very long and slender. *B. clavipes* Fabr. is

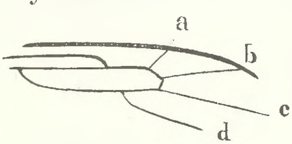


Fig. 305.

black with a white stripe on the mesonotum, the metanotum and flanks being white, and the legs banded with white. It is a widely diffused species, and presents a most singular appearance when flying, as it moves slowly, with its feet variegated with snow-white, and extending like the radii of a circle. (Osten Sacken.) In the genus *Protoplasma* (Fig. 306, wing) there are six posterior cells in the wing. *P. Fitchii* O. Sacken is brownish gray, with brown bands on the wings.

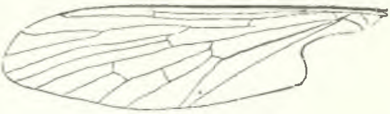


Fig. 306.

MYCETOPHILIDÆ Macquart. This family comprises small flies, capable of leaping to a considerable height, and provided with two or three ocelli, but not having a proboscis. While the antennæ are usually simple, as in all other Diptera, those of *Platyroptilon Miersii* Westwood are forked, having a branch one-half as long as the antenna itself. The thorax does not have a transverse suture, and the wings are without a discal cell, while the coxæ are greatly elongated, and the tibiæ are all armed with spurs. The larvæ are subcylindrical and smooth, with locomotive bristles beneath, and eight pairs of stigmata; they are in color white or yellowish. They are gregarious, living in decaying vegetable matter, fungi, or in dung, one species forming a gall. They shed their skin several times before becoming fully grown. Osten Sacken states that the larva of *Sciophila* which covers the surface of the fungus it feeds in with a web, is long and almost serpentiform, while those of *Bolitophila* and *Mycetophila* are shorter and stouter, and that of *Sciara* is intermediate. The pupæ of this family are smooth, with rounded angles and edges, whereas those of Tipula are sharp and pointed. They are enclosed in a silken cocoon. Some species of Sciara do not, however, spin cocoons. The larva of *Mycetophila scatophora* Perris "carries on its back a sheath formed of its own excrements and moulded by means of a peculiar undulatory motion of the skin. The pupæ remain within the sheath, but before assuming this state the larva extends the sheath anteriorly in a short neck, and tapestries it on the inside with a pellicle, which renders it more tough and resisting." The larvæ of one genus sometimes live gregariously with those of other genera. Thus Osten Sacken found that the "larvæ of Sciophila appeared in a decaying fungus only after the transformations of Mycetophila were entirely completed. For two or three weeks the eggs of the former remained apparently dormant among the bustle of so many larvæ of the other species." (Osten Sacken.) *Leja* resembles Sciophila in its habits. The larvæ of *Sciara* have no bristles on the tubercles of the under side of the body, usually present in the family. They are more gregarious than the other genera, and have the singular propensity of sticking together in dense patches, generally under the bark of trees. When fully grown they sometimes march in processions in a dense mass, sometimes several feet long, and two to three inches broad, and half an inch in thickness, whence the Germans call them "Army-worms." To the same genus belongs the *S.* (Molobrus) *mali* of Fitch, the apple midge, whose larva is glassy white and devours the interior of apples.

Professor E. D. Cope describes in the Proceedings of the Philadelphia Academy, 1867, page 222, a procession of a species of *Sciara* observed in September by William Kite, in Chester County, Penn., where he had observed this army-worm for three consecutive years. "This company (consisting by rough estimation of about 2,400) extended over a length of about twenty-two inches, with a breadth of from three-fourths of an inch in the thickest part, to about one-eighth of an inch at the head, and one-tenth at tail; five or six worms deep in thicker parts. They advanced at the rate of four inches in five minutes, the hinder ones working their way over the top of the rest." These larvæ were about one-half an inch long, semitransparent, with black heads. Mr. Kite observed another procession July 8th, which was six feet six inches long. These trains were attacked by larvæ of Staphylinids, ants, dipterous larvæ and other predaceous insects. Seven other persons in this country have witnessed similar trains, one of which was observed in Lee, Mass.

The larva of *Mycetobia*, which agrees closely with that of Rhyphus, is found living in putrescent sap under the bark of the elm tree. We have found, through the summer, great numbers of an undescribed species (Fig. 307; *a*, larva; *b*, pupa, magnified three times. Fig. 308, head of the larva greatly enlarged; *a*, antenna; *l*, labrum; *m*, mandible; *mx*, maxillæ? *mp*, maxillary palpi? *g*, gena?) which seems to differ from Dufour's figure of the European *M. pallipes* in the form of the wings and their venation, as well as in the form of the pupa. The larvæ were first seen in abundance on the 26th of June in the crevices of the bark of the elm from which flowed a sour sap mingled with dust, and in this putrescent mass the slender white worms glided swiftly about. The body is long and slender, scarcely tapering towards either end, and consists of twelve segments besides the head. Like the larva of Scenopinus and Thereva, each abdominal ring is subdivided by a well defined false suture; but the hinder division in this larva is about one-fourth shorter than the rest of the ring. It is .36 of an inch long. The head is pale honey yellow, and the body pure white. The three thoracic rings are marked posteriorly with honey yellow, with a pair of large round pale spots low down on the side of each ring. It moves with great activity, keeping its mouth-parts constantly moving, pushing them into the dirt. The pupæ were found sticking straight out from the bark, being attached by the spines on the tail. They were straight, long, cylindrical, the thorax being but little larger than the base of the abdomen. The head is square in front, ending in two lateral horns, and the abdomen is covered with stout spines, especially at the tip. It is .20 of an inch long, and is pale honey yellow and covered with dirt. The flies appeared June 27th, and for six weeks after flew about the trees. The head is black, the thorax and abdomen brown, with a leaden hue; the abdomen is a little paler, being whitish beneath, but darker towards the tip. The legs are pale, a little darker externally, especially

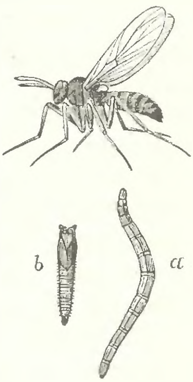


Fig. 307.

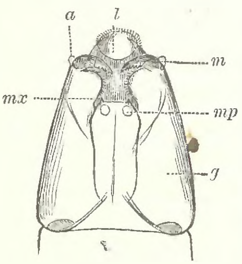


Fig. 308.

towards the tips of the joint, and the hind tarsi are a little dusky. Its length is .10 of an inch, not including the antennæ. It may be called the *Mycetobia sordida*.

PULICIDÆ Westwood. While this group has been considered by many writers as forming a distinct "order," or suborder of insects, equivalent to the Diptera, under the name of Aphaniptera, we prefer, with Straus Durckheim, to consider them as wingless flies, and perhaps scarcely more abnormal than Nycteribia or Braula. Instead of placing them at the foot of the suborder, we prefer, in accordance with a suggestion made by Haliday (Westwood, Class. Insects, vol. ii, p. 495, note), who places them near the Mycetophilids, or "fungivorous Tipulids," to consider them as allied to that group. The body is much compressed; there are two simple eyes which take the place of the compound eyes, the epicranial portion of the head being greatly prolonged, while the labrum is wanting, and the labium is small and membranous; the three-jointed labial palpi, always absent in other diptera, are long and slender. The form of the larva, including the shape of the head and its habit of living in dirt, and its way of moving about, as also its transformations, certainly ally the flea with the Mycetophilids.

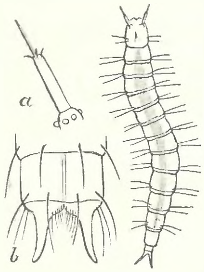


Fig 309

We have received from Dr. G. A. Perkins of Salem, the eggs and larvæ of the species infesting the cat, from which we have also hatched the young larvæ. The eggs (of which, according to Westwood, eight or ten are laid by one female) were shaken from the cat's fur, whence they are said to fall upon the floor and there hatch, the larvæ living in the dust and dirt on the floor, and feeding on decaying vegetable substances. The egg is oval cylindrical, and one forty-fifth of an inch long. The larva when hatched is .06 of an inch long (Fig. 309, the larva four days old; *a*, antenna; *b*, end of the body) white, cylindrical, the sides of the body being a little expanded, giving it a slightly flattened appearance when seen from above. The segments are rather convex, the sutures being deeply impressed. There are four long hairs on the side of each ring, becoming longer towards the end of the abdomen, where they are longer than the body is thick. The terminal segment of the body is considerably smaller than the one preceding it, and has two long spines arising from the tergal part of the ring; these spines seem to assist the larva in moving through the hairs and dust in which it lives. The well developed head is rounded, conical, narrower than the prothoracic ring, pale honey yellow, and with long three-jointed antennæ.

Mr. Emerton, who made the drawings here given, informs me that the larvæ, when fifteen days old, did not differ from those freshly hatched. I have been unable to discover that it moults. Westwood states that "when fully grown, which occurs in summer in about twelve days, the larvæ enclose themselves in a small cocoon of silk. Rösel, however, observed that some of the larvæ underwent their transformations without forming any cocoon." "The pupa is quite inactive, with the legs

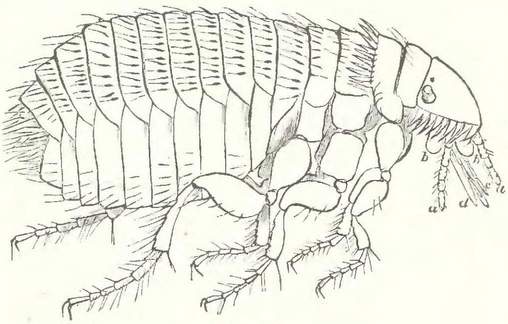


Fig. 310.

enclosed in separate cases. The period of the duration of the pupa state varies from eleven to sixteen days." Our specimens were hatched early in October, and they probably pass the winter before changing, as Westwood states that they pass the winter in the larva state. The species here represented (Fig. 310, *b*, maxillæ, and their palpi, *a*; *d*, the mandibles, which are minutely serrated; *c*, labial palpi, the labium not being shown in the figure) was found on the person of a man, though it seems to differ specifically from Westwood's figure of *P. irritans* Linn., the human flea; other species live on the dog, cat, squirrel, and other quadrupeds and various birds. The antennæ are concealed in a small cavity situated behind the simple eyes and are four-jointed; in *P. musculi*

Duges, they are external. Kirby describes a gigantic species two lines long, from British America. As a preventive measure in ridding dogs of fleas we would suggest the frequent sweeping and cleansing of the floors of their kennels, and renewing of the straw or chips composing their beds—chips being the best material for them to sleep upon. Flea-afflicted dogs should be washed every few days in strong soapsuds, or weak tobacco, or petroleum water. A writer in the "Science-Gossip" recommends the use of Persian Insect Powder, one package of which suffices for a good sized dog. The powder should be well rubbed in all over the skin; or the dog, if small, can be put into a bag previously dusted with the powder; in either case the dog should be washed soon after."

One of the most serious insect torments of the tropics of America is the *Sarcopsylla* (Rynchoprion of Oken) *penetrans* Linn., called by the natives, the Jigger, Chigoe, Bicho, Chique, or Pique. (Fig. 311 much enlarged; *a*, the gravid female, natural size). The female during the dry season, bores into the feet of the natives (though it also lives in dogs and mice, which accounts for its presence in houses), the operation requiring but a quarter of an hour, usually penetrating under the nails, and lives there until her body becomes distended with eggs; the abdomen swelling out to the size of a pea. The presence of the insect often causes distressing sores. The Chigoe lays about sixty eggs, according to Karsten, depositing them in a sort of sac on each side of the external opening of the oviduct. The larvæ do not live in the body of the parent, or of its host, but, like those of Pulex, live free on the ground. The best preventatives against its attacks are cleanliness and the constant wearing of shoes or slippers when in the house, and of boots when out of doors.

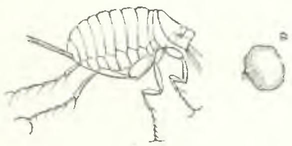


Fig. 311.

Simulidæ Loew. *Simulium molestum* (Fig. 312; *a*, larva of this or an allied species, magnified), the Black-fly, represents this family. Its antennæ are eleven-jointed; the palpi are four-jointed, with long, fine terminal joints, and the ocelli are wanting, while the posterior tibiæ, and first joint of the hind tarsi are dilated. The body is short and thick. The labrum is free, sharp as a dagger, and the proboscis is well developed and draws blood profusely. The species are numerous. The Black-fly, so well known as the torment of travellers in the North, is black, with a broad silvery ring on the legs. We have received a large species from Mr. E. T. Cox, called in the West the Buffalo fly. On the prairies of Illinois it has been known to plague horses to death by its bite. The *S.* (Rhagio) *Columbaschense* Fabr. in Hungary abounds in immense numbers, often killing cattle. Other species abound in the American tropics where they are a great scourge. The cylindrical larva of the European species is furnished with short antennæ and two flabelliform appendages. On the under side of the prothorax is a thick conical and retractile tubercle, and there are several curved filaments at the end of the body. The pupa has eight very long lateral filaments on the front of the thorax, and the posterior end of the body is enclosed in a semioval membranous cocoon, open in front, and posteriorly attached to some plant. The fly leaves the pupa beneath the water.

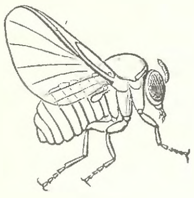


Fig. 312.

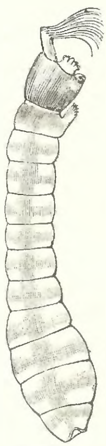


Fig. 312, *a*.

Bibionidæ Macquart. This group is characterized by having three ocelli and the prothorax much developed; the wings have no discal cell. The coxæ are not prolonged and the empodium (supplementary cushion) is proportionally long, while the pulvilli are sometimes wanting. The typical genus, *Bibio* of Geoffroy, has short, nine-jointed antennæ, five-jointed palpi, and the eyes of the male are large and contiguous, while those of the females are small. The larvæ are cylindrical, footless, with ten spiracles, and furnished with transverse rows of short hairs, being found in dung, but they mostly feed on the roots of grass, whole patches of larvæ appearing as if winter-killed. Robins destroy immense numbers of them. Westwood has found the pupæ enclosed in smooth oval cells; they are naked, the thorax gibbous, with the rudimental wings and legs very short. *Bibio albipennis* Say, a white-winged species, is double-brooded, and flies in swarms in June and October, alighting slowly on the passer-by.

Rhyphidæ Loew. This family is known by the wings having a perfect discal cell, while the empodium resembles a pulvillus; the pulvilli being wanting. The single genus Rhyphus has short fourteen-jointed antennæ, the second joint of the palpi swollen, and the legs are not spiny. *Rhyphus alternatus* Say, is common on windows.

The succeeding families belong to the *Brachycera*, or short-horned flies.

Xylophagidæ (Macquart). This family is known by the three basal cells of the wings being very prolonged, the annulated third joint of the antennæ always without a style or terminal bristle, and by the spurred tibiæ. *Xylophagus* has ten-jointed antennæ, with the ovipositor very long. The larva is cylindrical, with an oblique scaly plate on the tail, while the head ends in an acute horny point. Loew doubtfully refers the genus *Bolbomyia*, found fossil in the Prussian Amber, to this group.

Stratiomyidæ Latreille. The wings in this group have the three basal cells much prolonged, and the costal vein reaching only to the middle of the wing. The third joint of the antennæ is sometimes subdivided into several portions. The tibiæ are spurless and the pulvilliform empodium is much developed. The coarctate pupa retains the larva skin nearly in its original form. The genus *Beris* is easily distinguished by having seven, instead of five (the usual number) abdominal segments visible. In *Sargus* the eyes of the males approximate much closer than in the females. They are showy insects, with bright metallic colors, and are widely distributed over the earth. The larva lives in the earth, is oval oblong, narrowing before; the head is scaly, with two ocelli, and armed with two hooks, while the body is hairy. Fig. 313 represents a pupa belonging probably to this family. *Stratiomys* has a broad flattened abdomen, and the scutellum spined. The larvæ are aquatic, being apodal and flattened, and slender especially at the end of the body, which is elongated and has a simple terminal spiracle "surrounded by a great number of bearded hairs, which form a coronet, and which are capable of being closed up so as to retain a bubble of air, and by the assistance of which the insect suspends itself at the surface of the water for respiration. On assuming the pupa state, the insect floats at liberty in the water, the enclosed pupa occupying only the anterior portion of its larva skin."

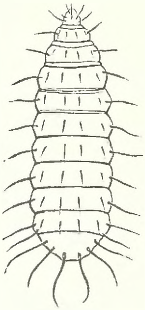


Fig. 313.

TABANIDÆ Latreille. In this important family the three basal cells of the wings are much prolonged; the third longitudinal vein is furcate, and the tegulæ are rather large. The proboscis of the male has four, that of the female six bristles. The third joint of the antennæ is annulate and always without style or bristle. The eyes are large, and the thorax oblong and flattened above. The female Horse-flies are troublesome from their formidable bite. The pupæ are obtected, resembling the adult flies. *Pangonia* has a proboscis often longer than the body itself. *Chrysops*, the Golden-eyed fly, is very troublesome, unceasingly flying about one's head, striving to alight and draw blood. The two basal joints of the antennæ are prolonged, hairy, the third spindle-shaped. *Chrysops niger* Macquart and *C. vittatus* Wiedemann are the two most abundant species.

Tabanus, the Horse-fly, is known by its large size and powerful biting and sucking apparatus. Like the mosquito, the male horse-fly does not bite, but lives on the sweets of flowers. The accompanying sketch shows the structure of the proboscis of the female of the Green-head fly, *Tabanus lineola* Fabr. (Fig. 314; *a*, five terminal joints of the antennæ; *lb*, labrum; *m*, mandibles; *mx*, maxillæ; *mp*, the two-jointed, large, stout, maxillary palpi; *l*, the tongue). Its bite is most painful and poisonous to many. Mr. Walsh has shown, however, that in its larval state the horse-fly is useful to man, as it feeds on snails and probably the larvæ of other root-eating insects. The larvæ of other species are aquatic, living under submerged objects. Walsh describes a greenish transparent larva which is cylindrical, twelve-jointed, the body being most slender towards the head, which is small, truncate, conical, the anterior part capable of extension, with short, fleshy, exarticulate antennæ and without ocelli. There are six pairs of dorsal fleshy tubercles. On the under side of the abdominal segments are six retractile false legs, and a single anal retractile proleg. It is, when disturbed, vigorous and restless, swimming quickly, often elevating the anal slit, in which the stigmata are probable placed, out of the water to take in the air. The pupa is cylindrical, obtuse at the head, tapering a little posteriorly, and is of a pale yellowish brown. There are six tubercles at the mouth, above which are the trigonate three or four-jointed antennæ. The abdominal segments are furnished with a ring of appressed bristles directed backwards, and the anal spine is large, truncated, and terminates in six small, stout spines. *T. atratus* Fabr. is a common species; it is black, covered with a whitish bloom, and expands nearly two inches, while the *Tabanus cinctus* Fabr., or Orange-belted horse-fly, is smaller and less abundant. Of the smaller species the *Tabanus lineola* Fabr. (Fig. 315) is so named from the whitish line along the abdomen. This fly is our most common species, thousands of them appearing during the hotter parts of the summer, when the sun is shining on our marshes and Western prairies; horses and cattle are sometimes worried to death by their harassing bites. In cloudy weather they do not fly and they perish on the cool frosty nights of September.

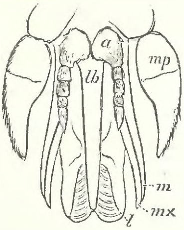


Fig. 314.

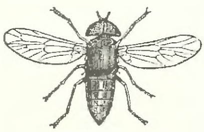


Fig. 315.

LEPTIDÆ Meigen. This family is easily distinguished from the preceding by the simple third joint of the antennæ, which are provided with a simple or thickened styliform bristle.

The tibiæ are spurred; the larvæ slender, cylindrical; the body widening posteriorly, terminates in two points, while the pupa is naked, incomplete, with transverse rows of spines on the abdomen, becoming largest at the tip. The larva of *Leptis vermileo* Fabr. lives at the bottom of holes which it makes in sand, and thus, like the ant-lion, entraps other insects.

CYRTIDÆ Loew. Known by the greatly inflated thorax and abdomen this family is of but small extent, comprising species which have the proboscis rather obsolete, or long and bent beneath the body. Such are the genera *Cyrtus*, *Acrocera* and *Oncodes*. The genus *Hirmoneura* represents the family HIRMONEURIDÆ of Loew.

MYDASIDÆ Leach. This family, represented in this country by the single genus Midas, is easily known by the large size of the species, and by the long clavate antennæ, the fleshy labium, and the minute empodium. The larva and pupa are said by Harris to almost exactly resemble those of the rapacious Asilidæ. The larva of *Midas clavatus* Drury is cylindrical, whitish, tapering before and almost rounded behind, with two spiracles in the last segment but one of the abdomen, and is two inches long. It lives and undergoes its transformations in decaying logs. (Harris.) The pupa (Fig. 316, drawn from a specimen in the Harris collection) is about an inch and a quarter long, brown, nearly cylindrical, with a forked tail; there are eight spines on the forepart of the body. *Midas fulvipes* Walsh has similar habits and its transformations are similar; the larva is insectivorous.


Fig. 316.

ASILIDÆ (Asilici) Latreille. These large, stout, Robber-flies, as the Germans style them, are covered with stiff hairs, and have long abdomens. The third joint of the antennæ is simple; the labium forms a horny sheath, and the empodium is like a horny bristle. They are rapacious, seizing other insects and flying off with them, like the fossorial hymenoptera. *Dasypogon* (Fig. 271, 3, wing) has the second longitudinal vein running into the border of the wing, while the anterior tibiæ end in a hooked spine.

The genus *Laphria* is large, stout-bodied, very hirsute, the second longitudinal vein runs into the first, and the style of the antennæ is either thick and stout, and generally wanting, or entirely obsolete. In their loud buzz, swift, peculiar flight and general appearance, the species strikingly resemble humble bees. *Laphria thoracica* Fabr. is nearly an inch long, and is black with yellow hairs on the thorax. *Asilus* is much longer, with an acutely pointed prolonged abdomen, and the species are often nearly naked, while the more essential characters lie in the union of the second longitudinal vein with the first, and the termination of the antennæ in a distinct bristle. The larvæ of *Asilus sericeus* Say, which feed on roots of the rhubarb plant, according to Dr. Harris, are yellowish white, about three-quarters of an inch long, a little flattened and tapering at each end, with a small brown, retractile head, which is provided with two little horny brown hooks. The brown pupa is naked, with a pair of tubercles on the front of the head, three spines on the side, a forked tail, and a transverse row of fine teeth across each abdominal segment, by which they are enabled to work their way to the surface. The *Trupanea apivora* Fitch, or Bee-killer, captures the honey bee on the wing, one having been known to kill 141 bees in a day. (Riley.)

THEREVIDÆ Westwood. This small group is characterized by the wings having the three basal cells much prolonged ; the third longitudinal vein is furcate, and the antennæ have a terminal style of variable form, sometimes wanting. There is no empodium, and the labium is fleshy. The larva is very long and slender, the abdominal rings having a double segmented appearance, with two respiratory tubes at the end of the body. They are found in garden mould and rotten wood. The pupa is oblong, with two spines on the front of the head, and three on the side of the thorax. Westwood states that the larva of a species of *Thereva*, which is like a wire-worm in shape, feeds on the pupæ of some moths.

BOMBYLIIDÆ Latreille. These pretty flies are very hirsute, with an oval body and long proboscis; the wings have the three basal cells much prolonged, with the anterior intercalary vein present almost without exception, the posterior always wanting. The third joint of the antennæ is simple, and the empodium quite rudimentary. They are exceedingly swift on the wing and are found in sunny paths and glades early in the spring and throughout the summer. They can only be captured when alighted on the ground. The eggs are laid in the nests of bees, and the half cylindrical, long, fleshy, smooth, unarmed larvæ devour the bee larvæ, while the pupa is spiny, armed on the head with horny lamellæ. In the genus *Bombylius* the body is ovate, with long dense hairs and a small head. The eyes of the male are grown together, and the legs are very slender. A species is known in England to lay its eggs at the opening of the holes of Andrena, whose larvæ and pupæ are devoured by the larvæ of the fly. *Systropus* is very long and slender, and wasp-like, as in Conops, with the proboscis equalling the thorax in length. The genus *Anthrax* is more flattened and oblong in shape than Bombylius, with a short proboscis; the eyes are not connected in the males. The species are gaily colored, the wings often partially black; they fly in paths in the hottest days of summer. The larvæ are parasitic on bees, and in their transformations closely resemble those of Bombylius. Audouin has found *Anthrax morio* in the nest of Anthophora, and Westwood has found the pupa-skin in the nest of Megachile, while the larva has, in England, more recently been found to be parasitic in the nests of certain Andrenidæ. We have received from Mr. J. Angus the larva and pupa (Plate 4, figs. 6, 7) of *Anthrax sinuosa* Wiedemann, which is parasitic in the nest of Xylocopa Virginica.

SYRPHIDÆ Leach. These gaily colored flies, so useful to agriculturists from their habit of feeding upon Plant-lice, closely resemble the wasps in form and coloration, having hemispherical heads, large broad eyes, and rather flattened bodies ornamented with yellow bands and spots. The wings have the three basal cells much prolonged, the third longitudinal vein simple, a spurious longitudinal vein between the third and fourth longitudinal veins; while the fourth longitudinal vein is united at its end with the third, and there is no intercalary vein. The genital armor of the male is unsymmetrical, and there is no empodium. They hover in the hot sun over and about flowers, resting upon them to feed on their sweets. The larvæ either live in the water, when the body ends in a long extensile breathing tube; or are terrestrial, living in decaying wood, or parasitically in nests of bees, or, as in Syrphus, live among plant-lice. The singular spherical larva of *Microdon globosus* (Fig. 317; *a*, puparium; *s*, spiracular tubercles; *v*, vent; *b*, anterior view of the same; *c*, larva just before pupation) is found, according to Mr. Sanborn, under sticks in company with shells.

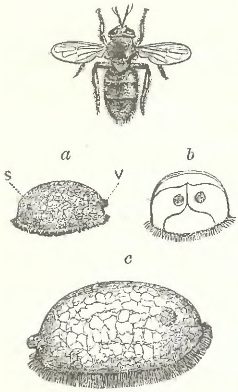


Fig. 317.

Milesia strikingly resembles, in its style of coloration and form, the common large yellow wasp. The antennæ are short, drooping, with a stout oval terminal joint, and a subterminal bristle. *M. excentrica* Harris, with its yellow spots and bands resembles a wasp.

Eristalis is well known by its aquatic "rat-tailed" larvæ, the abdomen terminating in a long respiratory tube equalling the body in length, with two stigmata at the end, which they protrude out of the water. There are seven pairs of prolegs, more distinct than in any other genus in the entire suborder. The pupa is found buried in the earth. The body of the larva shortens and hardens, forming the puparium, which is provided with four horns, serving as organs of respiration.

The species of *Eristalis** are seen flying abundantly about

*Jules Kunckel has recently detected a true peritrachial circulation in Eristalis, thus confirming the discoveries of Blanchard and Agassiz. He saw the blood imprisoned between the inner air tube and the envelope of the trachea, and penetrating into the capillary termination of those tracheæ, and saw the flow of the blood globules in the peritracheal space. This peritracheal circulation thus seems to correspond with the arterial circulation of the vertebrate animals, and the minute branches of the tracheæ are capillaries, and the blood is arterial. "*En résumé*, the tracheæ of insects, air tubes in their central portion, blood vessels in their peripheral portion [*i. e.*, the space surrounding the air tube] become at their extremities true arterial capillaries." "The blood in the peritracheal space remains through all its course in contact with the oxygen; it arrives at the capillaflowers in the spring, and are common throughout the spring. They scoop up the pollen of the flowers with their maxillæ. We have received from Mr. E. T. Cox the puparium (Fig. 318) of a species which inhabits the salt vats of the Equality Salt Works of Gallatin County, Ill. The puparium of a species of *Helophilus* closely resembling that figured by Westwood (Class. Insects, Fig. 131, 8), has been found living in the salt water canal of the Naumkeag Factory leading into Salem Harbor, and is in the Museum of the Peabody Academy.

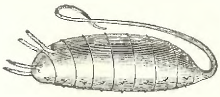


Fig. 318.

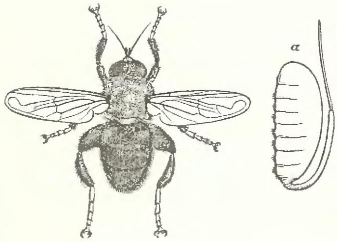


Fig. 319.

Closely allied to Eristalis is the genus Merodon, of which *M. bardus* Say (Fig. 319; *a*, puparium, natural size) is frequently met with. Its thorax, the first abdominal ring and the side of the second are covered with short yellow hairs; it is .70 of an inch in length. The puparium is of the same length, and is cylindrical, ending suddenly in a respiratory filament a little longer than the body; it is quite stout, contracting beyond its middle into a slender filament. On each abdominal ring is a pair of small, low, flattened tubercles crowned by a number of radiating spinules. Its larva is undoubtedly aquatic, like that of Eristalis. Mr. Sanborn has also reared from the pupa state *M. Narcissi*, which probably lives in the soil about decaying bulbs, as the puparium has no respiratory tube, but instead a very short sessile truncated projection, scarcely as long as it is thick, with a pair of stigmata in the end; the body is cylindrical and rounded alike at each end, with a slight con-

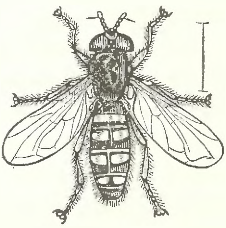


Fig. 320.

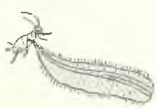


Fig. 321.

ries perfectly vivified; it is a true arterial blood. These capillaries are not in communication with the venous capillaries; the blood is taken up by the tissues, it nourishes them and flows into the venous lacunæ, and the lacunar currents carry it to the dorsal vessel." *Annales des Sciences Naturelles*, 1868.

traction behind the middle of the head; its surface is roughened with transverse wrinkles, but no regularly marked sutures, indicating the divisions between the segments, are apparent. It has been introduced from Europe, according to Mr. Sanborn, by the importers of Dutch bulbs.

The well known genus *Syrphus* (Fig 320, S. politus Say) so useful in reducing the immense numbers of plant-lice, lays a single egg in a group of plant-lice, which hatches out a footless, eyeless, flattened, transversely wrinkled, gaily colored green and purple maggot (Fig. 321) having a very extensile body, which enables it to reach up and grasp the Aphis by the peculiar sucking mouth-parts. When fully grown the larva adheres by means of a glutinous secretion to a leaf, its body contracts and hardens, forming a half cylindrical puparium.

The species of *Volucella* are parasitic in their habits, the larvæ feeding on those of Bombus. They are long, "narrowed in front, transversely wrinkled, with fine lateral points, and the tail is armed with six radiating points; the mouth is armed with two bifid mandibles, and three pairs of tentacula." (Westwood.) The pupæ are not known. The fly would be easily mistaken for a bee, nearly attaining the size of the worker Humble-bee, being remarkably plump and hirsute. J. Künckel states that in Europe two species are known to live in the nests of Vespa.

Conopidæ Leach. The species of this family bear some resemblance to the wasp, Eumenes, from their long, slender, pedicelled abdomen. The three basal cells of the wings are large, the third closed, more or less remote from the posterior border, and all the longitudinal veins are simple. The eyes in both sexes are smaller than in the preceding family, being separated. The proboscis is, with a few exceptions, much prolonged, and the third joint of the antennæ has either an apical style or a thick dorsal bristle. The male genital armor is symmetrical and turned beneath the abdomen. The flask-shaped larva of Conops is "soft, whitish, eleven-jointed, with a long neck and a mouth armed with lips and hooks (mandibles), and two lateral elevated plates supporting the two spiracles." It was found by Lachat and Audouin living in the abdomen of Bombus. It is also said by St. Fargeau to live in the nest of Vespa, and *Conops flavipes* was bred, according to Curtis, from the body of Osmia.

Mr. S. S. Saunders has observed in Epirus the habits of a species which lives in the abdomen of Pompilus audax Smith. The fly lays its eggs in June in the adult Pompilus, probably ovipositing between the abdominal segments. During August the larvæ become fully grown, probably in ten or fifteen days. The puparium is oval, of an uniform, deep, piceous hue, and the fly works its way through the first and second abdominal rings of the wasp, whose abdomen then breaks in two. Saunders also found a similar Conops larva in Sphex flavipennis, captured at the same time and place as the Pompilus; also a smaller species of Conops was bred from the abdomen of Odynerus. We have also bred a species from one of two species of Bombus, either B. vagans or B. fervidus.

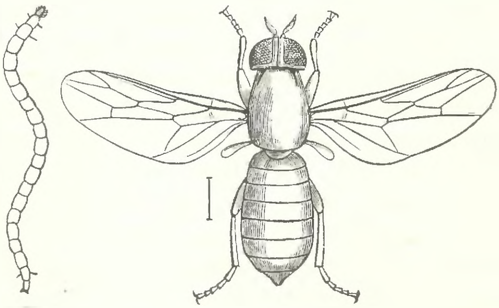

a

Fig. 322.

In *Myopa* the antennal bristle is subterminal, and the proboscis is twice elbowed. Westwood has observed *Myopa atra* flying about sand-banks in which were the burrows of various bees, and by other authors the genus is said to be parasitic on bees.

The genus *Pipunculus* represents a small group in which the head is almost entirely occupied by the eyes, the front and face being exceedingly narrow, while the antennæ have a basal bristle.

Loew considers the genus *Scenopinus* as the type of a distinct family, hinting at its relationship with the Bombyliidæ. The genus is known by the short antennæ, without style or bristle; and by the short proboscis with its broad fleshy end. The larvæ are long, very slender, much like those of Thereva, and the pupa is much like that of Leptis. Mr. Sanborn has reared *S. pallipes* Say (Fig. 322; *a*, larva). The larva is found under carpets, and is remarkable for the double segmented appearance of all the abdominal segments, except the last one, so that the body, exclusive of the head, seems as if twenty-jointed instead of having but twelve joints. The head is conical, one-third longer than broad, and of a reddish brown color, while the body is white. It is .65 of an inch in length. The larva is also said to live in rotten wood, and is too scarce to be destructive to carpets. The fly is black, with a metallic hue, and with pale feet.

The genus *Platypeza* also represents the *Platypezidæ* of Meigen, the antennæ of which have an apical bristle, with the male genital armor (hypopygium) turned symmetrically under the abdomen. The middle tibiæ are provided with spurs, and the empodium is wanting. The larva is flat, with rigid curved bristles along the side. It lives in rotten mushrooms.

Empidæ Leach. The species of this family closely resemble the Asilidæ in their long body, incumbent wings, and rapacious, carnivorous habits. The first joint of the antennæ is not much shortened, and the third joint has an apical or dorsal bristle, while the empodium is usually membranaceous and of a linear form. The head is small, spherical, the eyes united in the male; the proboscis is horny, without a distinct tongue, and bent upon the breast. The slender larvæ, whose segments are much constricted, are found in garden mould. The species hover in swarms over standing water, flying backwards and forwards as if by a common impulse. They appear very early in the spring, or in autumn. The genera *Hybos* and *Tachydromia* represent small groups which are closely allied to Empis.

Dolichopodidæ Latreille. Loew has characterized this well marked family as generally comprising metallic green, brisk and restless Diptera of small or medium size, predatory on other insects, and living principally in damp situations; the larvæ living under ground or in decaying wood. The head is hemispherical, the eyes large and hairy, the antennæ are stretched straight out, with a two-jointed bristle. The proboscis is short and stout, concealed above by the single jointed, usually scale-shaped palpi, with a wide opening which can be shut by the protruding suctorial flaps. The wings do not have the auxiliary vein running towards the anterior margin; the anterior basal cell is very short; and the discoidal cell coalescent with the second basal cell, while the posterior basal cell is very small. They are mostly "found on the leaves of aquatic plants, on stones partly overflown with water, on dams and near waterfalls; some of them are able to run rapidly over the water, even when it is rippled by the wind (*Hydophorus*); others are fond of salt or brackish waters (*Aphrosylus*, *Thinophilus* and some *Hydrophorus*); the species of *Medeterus* prefer dry situations, and are found on stumps of trees, fences, etc., even in very dry and hot weather."

Œstridæ Leach. Bot-flies, Breeze-flies. In these flies, so interesting in their habits, the body is stout, hairy, like the Humble bees, and they are easily recognized by having the opening of the mouth very small, with rudimentary oral organs. The middle part of the face is exceedingly narrow, and the minute antennæ are inserted in rounded pits. The eggs hatch very soon after laying, and Riley (First Annual Report on the Noxious Insects of Missouri, p. 164) thinks, from the testimony of three independent witnesses, that the sheep botfly is viviparous, the larvæ hatching within the body of the parent, who deposits in the nostrils of the sheep the "perfectly formed and living grub."

The larvæ are, in general, thick, fleshy, footless grubs, consisting of eleven segments exclusive of the head, which are spined and tuberculated, the former in rows, which enable them to move about readily when living under the skin or in the frontal sinus and thus greatly irritate the animals on which they live. The stigmata are placed in a scaly plate on the thickened posterior end of the body. The mouth of the cutaneous larvæ consists simply of fleshy tubercles, while in those species that live in the stomach and frontal sinuses of their hosts, it is provided with horny hooks. While in this state they moult twice, and then attain their full size. They feed on the purulent matter originating from the irritation produced by the movements of their bodies. Just before assuming the pupa state, the larva leaves its peculiar habitat, descends into the ground, and there becomes a coarctate pupa, enclosed within the old larva skin, and remaining in connection with it by means of four tracheæ.

Fig. 323.

The genus *Gastrophilus* has very small mouth-parts, the deep lying palpi being somewhat spherical, and the proboscis nearly obsolete, while the abdomen is sessile. The species are of medium size, short and thick, and very hairy. The female lays her eggs on the horse's hips, or forelegs, by which the larvæ are introduced into the stomach. The body of the larva widens posteriorly; the mandibles are not visible, and the maxillæ constitute the so-called mouth-hooks, by which the larva grapples and adheres to the walls of the horse's stomach. The rudimentary antennæ are indicated by an ocellus-like point. The Horse Bot-fly, *Gastrophilus equi* Fabr. (Fig. 323; fig. 324, larva), in its perfect state is pale yellowish, spotted with red, with a grayish yellow hirsuties; the thorax is banded with black, or sometimes,

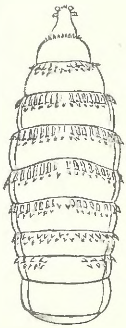


Fig. 324.

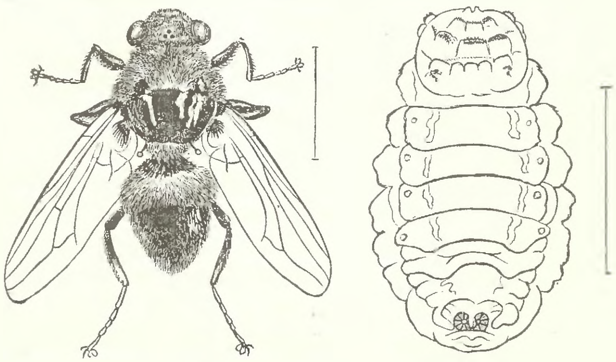


Fig. 325. *a*

though rarely, reddish hairs. The hinder trochanters are hooked in the males, and tuberculated in the females, and the wings are banded with reddish, with two spots at the apex. The larvæ live from May till October, and when fully grown, hang by their mouth-hooks on the edge of the rectum, whence they are carried out in the excrement. The pupa state lasts from thirty to forty days, and the perfect fly appears the next season from June to October.

In *Hypoderma* the palpi are entirely wanting. The species are either very large, or of medium size, and often quite small, covered with fine dense hairs. The legs are long and slender. The *Hypoderma bovis* Degeer (Fig. 325, *a*, larva) or Bot-fly of the ox, is black, densely pilose; the front of the head is dirty ashen, with whitish yellow hairs. The naked black thorax is twice broadly banded with yellow and white; the scutellum has slight tubercles; the abdomen is black, with a basal white or yellowish band, a mesial black band, and at the end is a reddish orange band of hairs. The larvæ are found during the month of May and in the summer in the tumors on the backs of cattle, and when fully grown, which is generally in July, work their way out and fall to the ground. They exist in the puparium twenty-six to thirty days, and the fly appears from June to September. This species is found over all the civilized portions of the world. *Hypoderma tarandi* Linn. infests, in like manner, the Reindeer. The genus *Œstromyia* is thought to inhabit the Hare. *Œstrus ovis* Linn., the Sheep Bot-fly, is of a dirty ash color, with a fuscous ashen, banded, and obscurely spotted thorax. The abdomen is marbled with yellowish and white flecks, and is hairy at the end. The larva lives, during April, May and June, in the frontal sinus of the sheep, and also in the nasal cavity, whence it falls to the ground. It changes to a pupa in twenty-four hours, and the fly appears during the summer. *Cuterebra* has the third joint of the antennæ oval or elliptical and the bristle is dorsal and feathered; the species are short, very plump and hairy flies, with a proboscis elbowed at the base, and with a metallic shining rounded abdomen. The larvæ live in subcutaneous bots beneath the skin of various animals. One species (the C. emasculator of Fitch) lives in the scrotum of the squirrel, which it is known to emasculate.

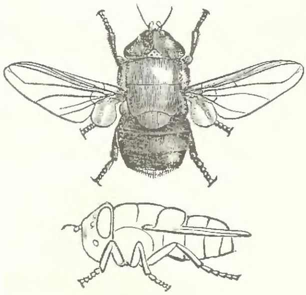


Fig. 326.

Mr. S. S. Rathvon has reared *C. buccata* Fabr. (Fig. 326, and side view) from the body of a striped squirrel, the larvæ having emerged from the region of the kidneys." (American Entomologist, p. 116.) Other species live in the Opossum and different species of field-mice. *Cuterebra horripilum* Clark is found throughout the United States, and *C. cuniculi* Clark lives in the hare and rabbit, in the Southern States, and is found, according to Coquerel, in the bots of horses.

The genus *Dermatobia* includes the *Ver macaque*, of Cayenne and Mexico, found beneath the skin of man in tropical America, and it is disputed whether it be a true indigenous "Œstrus hominis," or originally attacks the monkey, dog, or other mammal. In Cayenne the species attacking man is called the Ver Macaque; in Brazil (Para) Ura; in Costa Rica, Torcel; in New Grenada, *Gusano peludo*, or Muche. The *D. noxialis* Goudot? (Fig. 327) *Ver moyocuil*, lives on the dog, and is found in Mexico and New Grenada. The larvæ are long, cylindrical, S-shaped, differing greatly in form from others of this family. The flies are closely allied to those of the preceding genus.

Fig. 327.

Dr. Leidy states in the Proceedings of the Philadelphia Academy (1859), that several specimens of the larva of a bot-fly were obtained by Dr. J. L. Leconte in Honduras, from his travelling companions. They were "usually found beneath the skin of the shoulders, breasts, arms, buttocks and thighs, and were suspected to have been introduced when the persons were bathing." "Dr. Leconte informs us that his companions were not aware of the time when the eggs of the larvæ, obtained by him, were deposited in their bodies. He also states that the presence of the larva gave rise to comparatively little uneasiness."

According to Krefft a species of *Batrachomyia* is parasitic upon four species of Australian frogs. The larvæ are found between the skin and the flesh behind the tympanum; they are of a yellow color and may be squeezed through a small opening that exists over them. When they quit the frog the latter dies. The change to the pupa state is usually effected on the lower surface of a piece of rock in some damp locality. The perfect insect emerges in thirty-two days. (Günther's Zoölogical Record, 1864.)

MUSCIDÆ Latreille. The common House-fly, the Blue-bottle fly, and the Flesh-fly, at once recall the appearance of this family, which is one of great extent, and much subdivided by entomologists. The antennæ are three-jointed, the terminal joint being flattened and with a plumose bristle in the typical species. The proboscis ends in a fleshy lobe, with porrect single-jointed maxillary palpi. The four longitudinal veins of the wing are simple; the first of the two veins on the hinder edge often approaching that on the apex of the wing; the tarsi have two pulvilli, and the abdomen is five-jointed. The larvæ are footless, cylindrico-conic, narrowing in front, with a head variable in form, and with hook-like maxillæ. There are often two pairs of spiracles, one on the terminal ring of the body, and the other pair on the prothoracic segment. The pupa is enclosed in the puparium, generally cylindrical, but sometimes preserving the original shape of the larva. The celebrated "Tsetze" fly (Glossina morsitans Westwood) is a member of this family. It kills cattle by its painful bite, though its injurious nature is said to have been overrated. It is allied to *Stomoxys*, the species of which bite very sharply. *S. caltricans* has a well developed proboscis, enabling it to bite severely. It is often found in houses.

The species of the genus *Tachina*, like the Ichneumonidæ, are parasitic in caterpillars, and others are found in the nests of bees. They are stout flies, covered with bristles, with the eyes much larger in the males than in the other sex. The bristle of the antennæ is bare or with a very short pubescence. The thorax is short, and the first posterior cell is closed, or but slightly opened, and the legs are short. The abdomen is oval or cylindrical, and the first segment is much shortened. The larvæ are oval, with the segments much constricted; they have no head; the last segment bears two spiracles. *T.* (Senometopia) *militaris* Walsh lays its eggs, from one to six in number, on the Army worm (Leucania unipuncta), "fastening them by an insoluble cement on the upper surface of the two or three first rings of the body. The eggs hatch often after the caterpillar has gone under ground to transform, and in fifteen to nineteen days, or the last of September, the flies appear. *T.* (Lydella) *doryphoræ* Riley (Fig. 328) preys on the larvæ of the Colorado potato beetle. Other species of genera allied to Tachina, according to Dufour, are parasitic on beetles, etc; thus, *Cassidomyia* preys on Cassida, *Hyalomyia* on Brachyderes, and *Ocyptera* attacks Pentatoma; and he thinks that *Chartophila floralis* feeds either on the food or the young itself of Andrena.

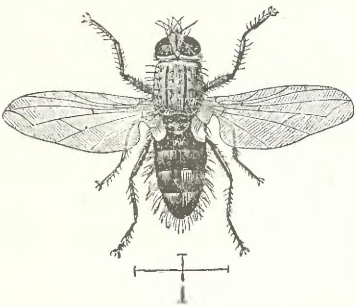


Fig. 328.

Sarcophaga, the Flesh-fly, has a small head, with the antennal bristle plumose or hairy, naked at the tip; the first posterior cell only slightly opened, or closed, with large tegulæ and stout legs. The flesh-fly, *Sarcophaga carnaria* Linn., is black, the thorax streaked with gray, and the abdomen checkered with whitish. The female is viviparous, that is, the larvæ hatch and live within the oviduct. The ovaries are large, arranged in a spiral manner and contain sometimes 20,000 eggs. We have reared *Sarcophaga nudipennis* Loew from the cells of Pelopæus flavipes, the Mud-dauber, which had been stored with spiders, the flies making their appearance on the first of July, a few days before the wasps issued from the cells. The parent flies had probably laid their eggs in the spiders before the cells were closed by the wasps. The nests were brought from Texas.

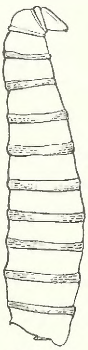


Fig. 329.

Musca has plumose antennæ, while in *Stomoxys* they are pectinated. Dufour states that the allied genera, *Echinomyia*, *Gonia*, *Dexia* and *Siphonia* are also viviparous. *Musca* (Lucilia) *Cæsar* Linn. the Blue-bottle fly, and *Musca* (Calliphora) *vomitoria* Linn. the Meat-fly, deposit their eggs (fly-blows) upon meat and decaying animal substances, and during the late war were grievously tormenting to our soldiers, laying their eggs in the wounds, especially of those left on the field over night. The larva of M. Cæsar (Fig. 329) is of very rapid growth. It is of an "elongated conical form, pointed towards the head, which is furnished with two fleshy horns," and horny mouth-parts, and a pair of rudiments of branchiæ on the prothoracic ring. The body is suddenly truncated, the end being furnished with a pair of stigmata. The pupa transforms in the ground, within a puparium of the usual long, cylindrical form.

Dr. Chapman of Appalachicola, writes to Mr. Sanborn that this fly, "attracted by the stench of a mass of decaying insects which have perished in the leaf of Sarracenia, ventures in and deposits its eggs, and the larvæ devour the festering heap. These in turn, on becoming flies, are unable to get out of their prison, perish, and are added to the putrefying mass that had nourished them."

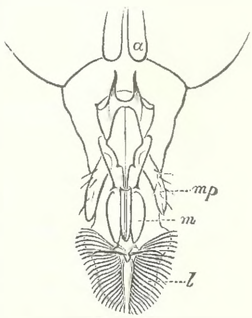


Fig. 330.

F. Smith notices in the Transactions of the Entomological Society of London, 1868, the "Warega" fly of Brazil, which is said to be the "pest of both man and animals; it is a species of Musca, and is said to lay its eggs in the skin; large and terrible swellings are formed. The mode of extracting the maggot is to cut an opening, and to press it out—a most painful operation. These wounds are very difficult to cure."

The House-fly, *Musca domestica* Linn., is common in the warmer parts of the year, and hibernates through the winter. A study of the proboscis of the fly reveals a wonderful adaptability of the mouth-parts of this insect to their uses. We have already noticed the most perfect condition of these parts as seen in the horse-fly. In the proboscis of the house-fly the hard parts are obsolete, and instead we have a fleshy tongue-like organ (Fig. 330), bent up underneath the head when at rest. The maxillæ are minute, and the palpi (*mp*) are single-jointed, and the mandibles (*m*) are comparatively useless, being very short and small compared with the lancet-like jaws of the mosquito or horse-fly. But the structure of the tongue itself (labium, *l*) is most curious. When the fly settles upon a lump of sugar or other sweet object, it unbends its tongue, extends it, and the broad knob-like end divides into two flat, muscular leaves (*l*), which thus present a sucker-like surface, with which the fly laps up liquid sweets. These two leaves are supported upon a framework of tracheal tubes, which act as a set of springs to open and shut the muscular leaves. In the preceding figure, Mr. Emerton has faithfully represented these modified tracheæ, which end in hairs projecting externally. Thus the inside of this broad fleshy expansion is rough like a rasp, and as Newport states, "is easily employed by the insect in scraping or tearing delicate surfaces. It is by means of this curious structure that the busy house-fly occasions much mischief to the covers of our books, by scraping off the albuminous polish, and leaving tracings of its depredations in the soiled and spotted appearance which it occasions on them. It is by means of these also that it teases us in the heat of summer, when it alights on the hand or face to sip the perspiration as it exudes from, and is condensed upon, the skin."

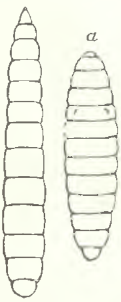


Fig. 331.

Every one notices that house-flies are most abundant around barns in August and September, and it is in the ordure of stables that the early stages of this insect are passed. No one has traced the transformations of this fly in this country, but we copy from Bouché's work on the transformations of insects, the rather rude figures of the larva (Fig. 331), and puparium (*a*) of the *Musca domestica* of Europe, which is supposed to be our species. Bouché states that the larva is cylindrical, rounded posteriorly, smooth and shining, fleshy, and yellowish white, and is four lines long. The puparium is dark reddish brown, and three lines in length. It remains in the pupa state from eight to fourteen days. In Europe it is preyed upon by minute ichneumon flies (*Chalcids*). *Idia Bigoti*, according to Coquerel and Mondiere, produces a disease in the natives of Senegal, probably by ovipositing on the skin, thus giving rise to hard red fluctuating tumors, in which the larva of this fly resides.

The species of the genus *Anthomyia*, seen about flowers, in the larva state live in decaying vegetable matter and in privies. They are smaller flies than the foregoing genera, with smaller alulae, and the fourth longitudinal vein of the wing is straight, thus leaving the first posterior cell fully open. The larvæ are generally much like those of the meat-fly, but are thicker, while others, described as belonging to this genus, are said to be flattened and hairy.

The Radish-fly, *Anthomyia raphani* Harris, abounds in the roots of the radish, the fly appearing towards the end of June. Another species, the Onion-fly, *Anthomyia ceparum* (Fig. 332), causes the leaves of the onion to turn yellow and die from the attacks of the larvæ in the roots. The larvæ mature in two weeks, transform in the root, and two weeks later disclose the flies. Mr. Walsh suggests that the larvæ may be destroyed by pouring boiling hot water over the young plants, which, without injuring the onions, destroys the maggots. The

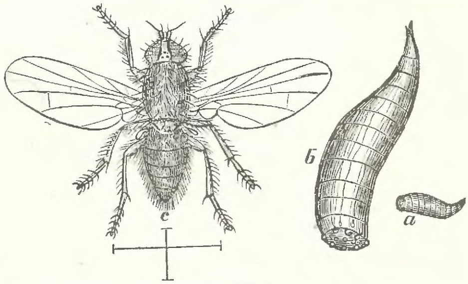
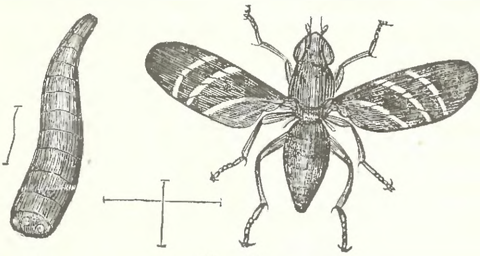


Fig. 332.

Seed-corn Maggot, the larva of *Anthomyia zeæ* Riley (Fig. 344, p. 419, *a*, larva; *b*, puparium; *c*, kernels eaten), destroys, in New Jersey, the kernels of sprouted corn before it comes up. The Cabbage maggot, the larva of *A. brassicæ* Bouché, a common fly in Europe, has been found in Michigan to be injurious to the cabbage. (Riley.) The hairy maggots of *A. canicularis* or an allied species, live in rotten turnips. (Harris.) The puparium (Plate 3, fig. 5, 5*a*) of another species has been found by Mr. F. W. Putnam in the nests of the humble bee.

In *Ortalis* the front is quite prominent, the clypeus is greatly developed, the opening of the mouth wide, and the proboscis much thickened. This genus comprises variously banded and spotted flies, which may be seen walking along leaves vibrating their wings. They feed on the leaves, and afterwards the pulpy fruit of the cherry, olive and orange. Another Onion-fly, discovered by Dr. Shimer in Illinois, is the *Ortalis flexa* of Wiedemann (Fig. 333; *a*, larva). The fly differs from the Anthomyia ceparum, besides more important respects, in having black wings with three broad curved bands. The maggot feeds in the root thus killing the top of the plant.

A species of *Trypeta*, according to F. Smith, which in Brazil is called the "Berna" fly, deposits its eggs in wounds, both on man and beast. "It is remarkable from having the apical segment of the abdomen elongated into a long ovipositor. Mr. Peckolt says the negroes suffer much from the attacks of this fly, which frequently deposits its eggs in their nostrils whilst they are sleeping, and such are the effects of its attacks, that, in some cases, death ensues." (Transactions of the Entomological Society, London, 1868, p. 135.)



a Fig. 333.

To the genus *Lonchæa*, Osten Sacken refers, with considerable doubt, a fly, which I have found in abundance, raising blister-like swellings on the twigs of the willow. They were fully grown in April. The larva (Fig. 334, fly; *a*, the larva; *b*, the pupa) is curved, cylindrical, tapering nearly alike towards each extremity, though the thoracic region is the thickest. The rings are thickened upon their posterior edges, so that they appear contracted in the middle. It is glassy green, with two little elongated tubercles placed near each other at a little distance from the end, where in the pupa they are terminal. It is .15 of an inch long when fully extended. The pupa-case, found late in May, is oval, long, cylindrical and obtuse at both ends; the anterior end is more blunt; the first segment of the body is minute and forms the

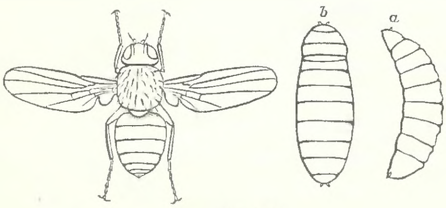


Fig. 334.

lid, which opens when the fly makes its exit, and bears two small slender tubercles which project upwards. The posterior end bears two terminal spine-like tubercles similar to those on the head, but projecting horizontally. The puparium is glassy green, and the limbs of the enclosed pupa can be partially seen through the skin. The rings are (especially on the thorax) spinose, being the remnants of the rows of spines around the hind edge of the larval segments. It is .15 of an inch long. The pupa lies a short distance from the opening of its burrow, which is about half an inch long, and is situated between the wood and the bark. The larva before pupating eats away the bark, leaving a thin outer scale, or roundish black space which can be folded back like a lid, which the fly pushes open when it emerges. Several swellings occur on the twig in the space of six inches. The fly appeared the 25th of June. Dufour states that in Europe *Lonchæa nigra* lives in the outer bark of the oak, and another under the bark of the poplar, while still another species makes a sort of gall in the dogsgrass.

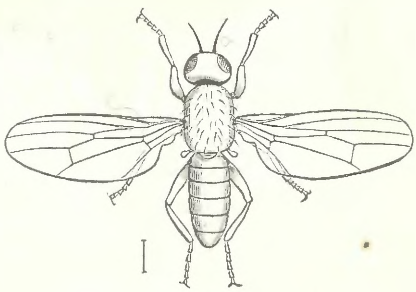


Fig. 335.

The genus *Sphyracephala* is remarkable for its stalked eyes, which are placed on long stems going out from the sides of the head. Some species are found fossil in the Prussian amber. *S. brevicornis* Say is rather rare.

The Cheese maggot is the larva of *Piophila casei* (Fig. 335) a shining black fly, three-twentieths of an inch long, with the four posterior legs yellowish, and with transparent wings. The whitish larva is cylindrical, and .22 of an inch in length, and is acutely pointed towards the head and truncated behind, with two long horny stigmata in the middle of the truncature, and two longer fleshy filaments on the lower edge. When moving it extends its mouth-hooks, and pulls itself along by them. Mr. F. W. Putnam has called my attention to the power of leaping possessed by the maggot. When about to leap the larva brings the under side of the abdomen towards the head, while laying on its side, and reaching forward with its head, and at the same time extending its mouth-hooks, grapples by means of them with the hinder edge of the truncature and pulling hard, suddenly withdraws them, jerking itself to a distance of four or five inches. The Wine-fly (Fig. 336, puparium) also belongs to the same genus, and with its puparium may be found floating in old wine and cider.

Fig. 336.

Several species of the genus *Ephydra* have been found living in salt water. Mr. E. T. Cox has sent us specimens of *Ephydra halophila* Pack. (Fig. 337; *a*, wing; *b*, puparium), which in the pupa state lives in great numbers in the first graduation house of the Equality Salt Works of Gallatin County, Illinois. The larva itself we have not seen, but the puparium is cylindrical, half an inch long, the body ending in a long respiratory tube forked at the end. The fly itself is coppery green, with pale honey yellow legs, and is .15 of an inch in length. Another species has been found by Professor B. Silliman living in great abundance in Mono Lake, Cal., and in the Museum of the Peabody Academy are puparia of this genus from Labrador, and from under sea-weed on Narragansett Bay, and a pool of brackish water at Marblehead; they are noticed by the author in the "Proceedings of the Essex Institute," vol. vi.

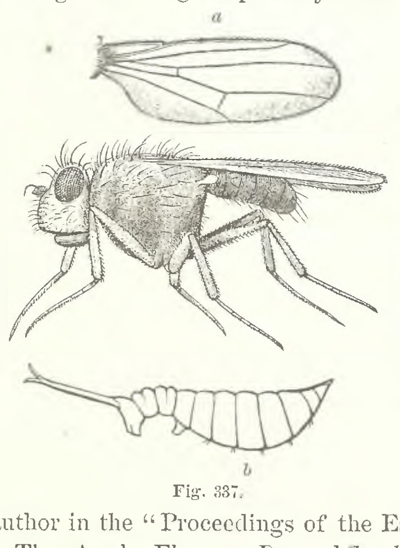


Fig. 337.

The Apple Fly, or *Drosophila*, has habits like the apple midge. Mr. W. C. Fish has described in the "American Naturalist," the habits of an unknown species (Fig. 338; *a*, larva), which he writes me has been very common this year in Barnstable County, Mass. He says that "it attacks mostly the earlier varieties, seeming to have a particular fondness for the old fashioned Summer, or High-top Sweet. The larvæ enter the apple usually where it has been bored by the Apple-worm (Carpocapsa), not uncommonly through the crescent-like puncture of the curculio, and sometimes through the calyx, when it has not been troubled by other insects. Many of them arrive at maturity in August, and the fly soon appears, and successive generations of the maggots follow until cold weather. I have frequently found the pupæ in the bottom of barrels in a cellar in the winter, and the flies appear in the spring. In the early apples, the larvæ work about in every direction. If there are several in an apple, they make it unfit for use. Apples that appear perfectly sound when taken from the tree, will sometimes, if kept, be all alive with them in a few weeks." Other species are known to inhabit putrescent vegetable matter, especially fruits. Mr. B. D. Walsh also describes in his "First Annual Report on the Noxious Insects of Illinois," another apple fly, *Trypeta pomonella* Walsh, which destroys stored apples, and has been found troublesome in various parts of the country.

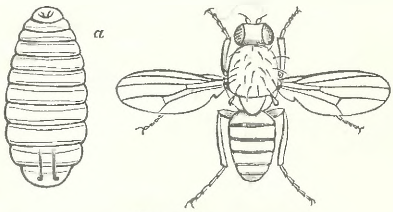


Fig. 336.

In England *Oscinis granarius* Curtis lives in the stems of wheat. The *Oscinis vastator* Curtis does serious damage to wheat and barley crops in England, by eating the base of the stalk. The larvæ are fully grown late in June, and a month later, the fly appears. Their attacks are restrained by numerous Pteromali, and a minute Proctotrupid (Sigalphus caudatus) oviposits in the egg of the Oscinis. Other allied species in the larva state cause the stems of wheat and barley to swell twice their usual size, which disease is termed in England the *gout.*

The larvæ of *Chlorops lineata* Fabr. in Europe, destroy the central leaves and plant itself, the female laying her eggs on the stems when the wheat begins to show the ear. In a fortnight the eggs hatch, and the fly appears in September. Curtis also states that *Chlorops Herpinii* Guérin, attacks the ears of barley, from six to ten larvæ being found in each, and by destroying the flowers render the ear sterile. *Oscinis frit* Linn. in Europe inhabits the husks of the barley, and destroys one-tenth of the grain. Linnæus calculated the annual loss from the attacks of this single species at half a million dollars. Ploughing and harrowing are of no use in guarding against these insects, as they do not transform in the earth; the best remedy lies in the rotation of crops. Many of these small flies, like the micro-lepidoptera, are leaf-miners, and are not readily distinguished from them when in the larva state.

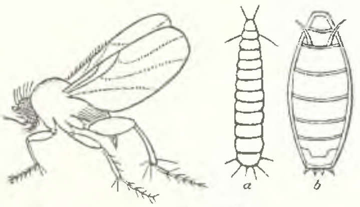


Fig. 339.

Of the genus *Phora*, a European species (P. incrassata Fig. 339; *a*, larva; *b*, puparium) frequents bee hives, and is thought by some to produce the disease which is known among apiarians as "foulbrood."

In the pupiparous Diptera, namely, those flies which are born as pupæ from the body of the parent, the larva state having been passed within the oviduct, the thorax is more closely agglutinated than before; the head is small and sunken in the thorax, and in the wingless species this consolidation of the head and thorax is so marked as to cause them to bear a remarkable resemblance to the spiders. Spider-like in their looks, they are spider-like in their habits, as the names Spider-flies, Bat-ticks and Bird-ticks, imply a likeness to the lower spiders or ticks. The antennæ are very deeply inserted and partially obsolete; the labrum is ensheathed by the maxillæ, and the thoracic nervous ganglia are, as in the Arachnida, concentrated into a single mass.

HIPPOBOSCIDÆ Westwood. The Forest-flies and Sheep Ticks are characterized by the horny and flattened body, the horizontal flattened head received into the front edge of the thorax, the large eyes, the rudimentary papilla-like antennæ placed very near together, and the proboscis is formed by the labrum and maxillæ, whose palpi are wanting; the labium is very short; wings with the veins present only on the costal edge, the others either aborted or only partially developed. They resemble the lice in their parasitic habits, living beneath the hairs of vertebrates, especially of bats, and are abundant beneath the feathers of birds.

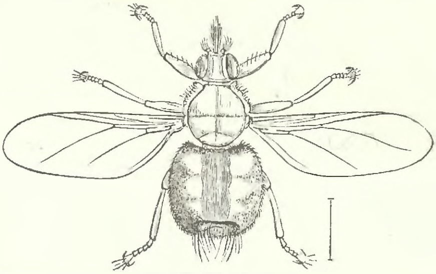


Fig. 340.

These flies differ from all other insects in their peculiar mode of development, which reminds us of the intra-uterine life of the vertebrate fœtus. According to Dufour and Leuckart they have an irregular uterus-like enlargement of the oviduct, which furnishes a milk-like secretion for the nourishment of the larvæ. The body of the larvæ, for each female produces but one or two young, when first hatched is not divided into rings, but is smooth, ovate, egg-like, forming a puparium-like case in which the larvæ transform to pupæ immediately after birth.

The Forest-fly or Horse-tick, *Hippobosca* Latreille, has no ocelli, with five stout veins on the costal edge of the wing; thorax broad, and the proboscis short and thick. We figure a species* of this genus (Fig. 340) which was found on the Great Horned Owl. Its body is much flattened, adapted for its life under the feathers, where it gorges itself with the blood of its host. The genus *Lipoptena*, which has ocelli, with only three costal veins, a long slender proboscis, and a small thorax, is remarkable for living in its wingless state on the Deer, but when the wings are developed it is found on the Grouse (Tetrao). The Bird-tick, *Ornithomyia*, has ocelli, a short proboscis and six costal veins, and there are numerous species, all bird parasites.

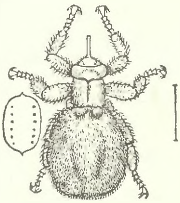


Fig. 341.

* *Hippobosca bubonis* n. sp. female. Uniform horn color, with a reddish tinge, and blackish hairs; legs paler, with dark tarsi, body beneath paler: tip of abdomen black, with long bristles. Length of body .30 inch; of a wing .34 inch. Differs from *H. equinæ* in being larger, and in its uniform reddish color. Taken Oct. 5; Museum of the Peabody Academy of Science.

In the wingless Sheep-tick, *Melophagus ovinus* Linn. which is often very troublesome (Fig. 341, and puparium), the head is wider than the thorax, the proboscis is as long as the head itself, the limbs are short and thick, and the bristly abdomen is broad and not divided into joints.

The genus *Carnus*, which was placed in the *Conopidæ* by Nitzsch, seems rather to belong here. *C. hemapterus* Nitzsch, is "of the size of a flea, with minute rudiments of wings, and is parasitic on birds of the genus Sturnus."

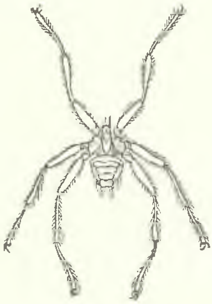


Fig. 342.

Nycteribidæ Leach. The Bat-ticks are remarkably spider-like, with a beaker-like head, without eyes, having four ocelli, or else entirely blind. The finger-like, two-jointed antennæ are situated on the under side of the head. The proboscis is feather-like, the palpi very large and porrect; the legs are of great size, with the basal joint of the tarsi of remarkable length, and the hairy abdomen is composed of six segments. They are very small parasites, one or two lines in length. Westwood has extracted the puparium from the body, showing the close relationship of these strange forms to Hippobosca. *Nycteribia Westwoodii* Guérin (Fig. 342) is an East Indian species.

Braulina Gerstaecker. The Bee-lice are wingless, minute, blind insects, with large heads; the thorax is transverse, ring-shaped, half as long as the head; the abdomen is round, five-jointed, and the legs are thick, with long claws enabling them to cling to the hairs of bees.

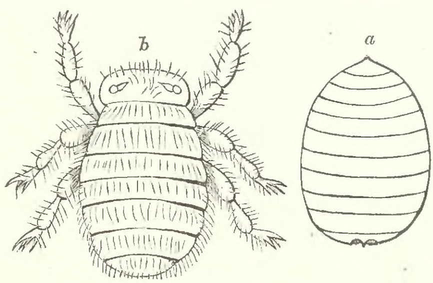
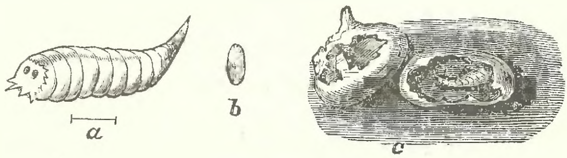


Fig. 343.

The genus *Braula* may be compared with the flea, its body being flattened vertically, while that of the flea is flattened laterally. While the transformations of Braula show it to be undoubtedly a degraded Muscid, with a true puparium; those of the flea, with its worm-like, more highly organized larva, and the free obtected pupa show that, though wingless, it occupies a much higher grade in the dipterous series. *Braula cœca* Nitzsch (Fig. 343, and larva) is found living parasitically on the honey bee in Europe, and has not been detected in this country.

The antennæ are short, two-jointed and sunken in deep pits. It is from one-half to two-thirds of a line long. The larva is headless, oval, eleven-jointed and white in color. On the day it hatches from the egg it sheds its skin and changes to an oval puparium of a dark brown color. It is a body parasite, one or two of them occurring on the body of the bee, though sometimes they greatly multiply and are very troublesome to the bee.

Fig. 344.



Anthomyia zeæ Riley.

We now take up the second series of suborders of the hexapodous insects, in which the different segments of the body show a strong tendency to remain equal in size, as in the larva state; in other words there is less concentration of the parts towards the head. In all these groups the prothorax is greatly developed, generally free, while the wings tend to conceal the two posterior thoracic segments, and the body generally is elongated, flattened or angulated, not cylindrical as is usually the case in the preceding and higher series. The degraded wingless forms resemble the worm-like Myriapods, while, as we have seen above, the wingless flies resemble the Arachnida. The imago (especially in the Hemiptera, Orthoptera and certain Neuroptera) resembles the larva; that is, the metamorphosis is less complete than in the preceding groups.

COLEOPTERA.

In the highest suborder of this series, the Coleoptera, we find the most complete metamorphosis and the greatest specialization of parts, with a more complete concentration of them towards the head than in the lower suborders. They are at once recognized by the elytra, or thickened horny fore wings, which are not actively used in flight (the hind wings being especially adapted for that purpose), while they cover and encase the two posterior segments of the thorax and the abdomen. The prothoracic ring is greatly enlarged, often excavated in front to receive the head. These characters are very persistent; there are few aberrant forms and the suborder is remarkably homogeneous and easily limited.

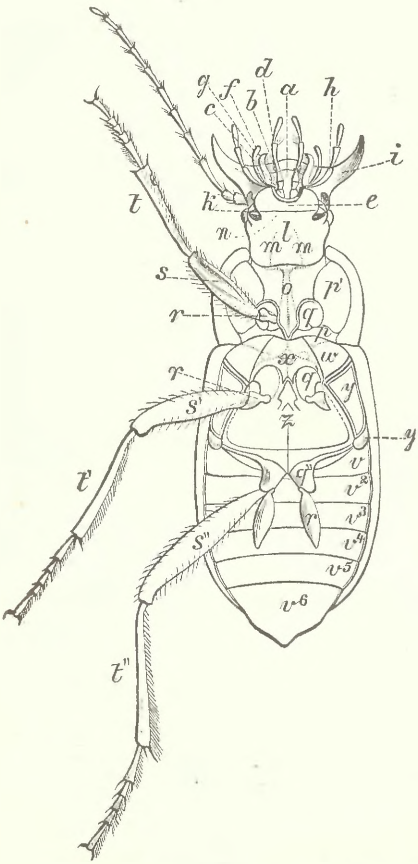


Fig. 345.

The head is free from the thorax, but less so than in the preceding suborders; it is scarcely narrowed behind, and its position is usually horizontal. The eyes are usually

Fig. 345, under surface of Harpalus caliginosus. (After Leconte.) *a*, ligula; *b*, paraglossæ; *c*, supports of labial palpi; *d*, labial palpus; *e*, mentum; *f*, inner lobe of maxilla; *g*, outer lobe of maxilla; *h*, maxillary palpus; *i*, mandible; *k*, quite large, and there is but a pair of ocelli, when present, or there may be but a single ocellus. The antennæ are generally inserted just in front of the eyes, and rarely between them as

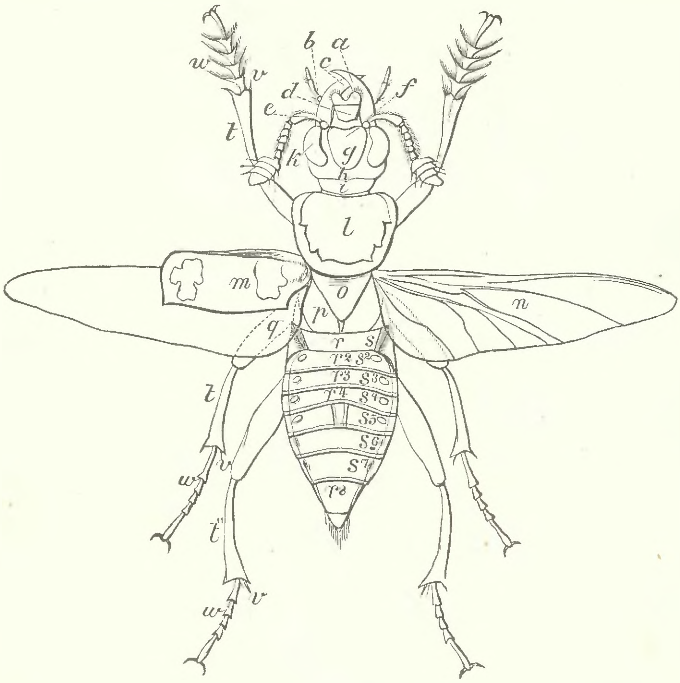


Fig. 346.

in the previous suborders. They are either filiform where the joints are cylindrical, as in the *Carabidæ*, not enlarging towards the end, or serrate, as in the *Elateridæ*, where the

buccal opening; *l*, gula or throat; *m*, *m*, buccal sutures; *n*, gular suture; *o*, prosternum: *p*, episternum of prothorax; *p'*, epimeron of prothorax; *q*, *q'*, *q''*, coxæ; *r*, *r'*, *r''*, trochanters; *s*, *s'*, *s''*, femora or thighs; *t*, *t'*, *t''*, tibiæ; *v*, *v''*, *v*^{3}, etc., ventral abdominal segments; *w*, episterna of mesothorax (the epimeron is just behind it); *x*, mesoternum; *y*, episterna of metathorax; *y'*, epimeron of metathorax; *z*, metasternum.

FIG. 346, upper surface of Necrophorus Americanus. (After Leconte.) *a*, mandible; *b*, maxillary palpus; *c*, labrum; *d*, epistoma; *e*, antennæ; *f*, front; *g*, vertex; *h*, occiput; *i*, neck; *k*, eye; *l*, pronotum (usually called prothorax); *m*, elytron; *n*, hind wing; *o*, scutellum (of mesothorax); *p*, metanotum (or dorsal surface of metathorax); *q*, femur or thigh; *r*, *r*, *r*, tergites of the abdomen; *s*, s^2, s^3, spiracles or stigmata; *t*, *t'*, *t''*, tibiæ; *v*, tibial spurs; *w*, tarsi.

joints are triangular and compressed, giving thereby a serrate outline to the inner edge; or clavate, as in the *Silphidæ*,

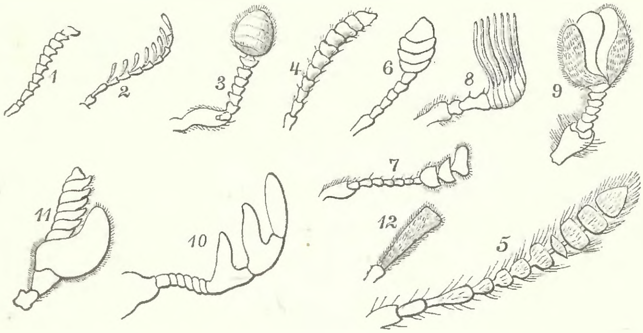


Fig. 347.

where the enlarged terminal joints give a rounded club-shaped termination; lamellate, when the terminal joints are prolonged

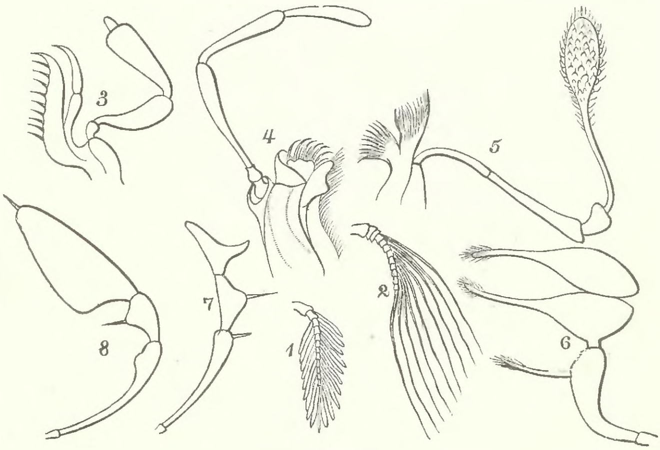


Fig. 348.

internally, forming broad leaf-like expansions, as in the *Scarabeidæ*, while the geniculate antenna is produced when

FIG. 347. Different forms of antennæ: 1, serrate; 2, pectinate; 3, capitate (and also geniculate); 4, 5, 6, 7, clavate; 8, 9, lamellate; 10, serrate (Dorcatoma); 11, irregular (Gyrinus); 12, two-jointed antenna of Adranes cæcus.

FIG. 348. 1, bipectinate; 2, flabellate antennæ; 3, maxillæ of Bembidium; 4, of Hydrophilus; 5, of Pselaphus; 6, maxillary palpus of Ctenistes; 7, of Tmesiphorus; 8, of Tychus.—*From Leconte.*

the second and succeeding joints make an angle with the first. The mandibles are always well developed as chewing organs, becoming abnormally enlarged in Lucanus, while in certain Scarabeidæ they are small and membranous.

The maxillæ (Fig. 348) are supposed to prepare the food to be crushed by the mandibles. The body of the maxilla consists of the *cardo;* a second joint, *stipes*, to which last are attached two lobes and a palpus. In certain *Cicindelidæ* and *Carabidæ*, the outer lobe is slender and two-jointed like a palpus. The maxillary palpi are usually four-jointed, sometimes with one joint less, and in but a single instance is there any additional joint, as in Aleochara.

The mentum is generally square or trapezoidal, varying in size. The labium bears the ligula, and supports the labial palpi, and varying much in form, is thus important in classification. The labial palpi are usually three-jointed, sometimes two-jointed, or with no joints apparent, as in certain *Staphylinidæ*, according to Leconte.

The greatly enlarged prothorax is free and very movable, the pronotum or dorsal piece, considered to be formed originally of four pieces, is usually very distinct from the pieces composing the flanks, though sometime they are continuous. The two hinder rings of the thorax are covered up by the wings and do not vary in form so as to be of much use in classification. They are respectively composed of a præscutum, scutum and scutellum, and postscutellum, the first and fourth pieces being more or less aborted. The pieces composing the flanks are partly concealed by the great enlargement of the dorsal parts of the segment, much more so than in the preceding suborders, the side pieces being much smaller and more difficult to trace; and these flank-pieces (pleurites) help form the under surface of the body, where in the Hymenoptera, Lepidoptera and Diptera, they are greatly enlarged, forming the bulging sides of the body.

The epimera and episterna of both the meso- and metathorax, Leconte states, are of much value in classification, especially those of the mesothorax, "according as they reach the middle coxæ, or are cut off from them by the junction of the episterna with the metasternum." The thickened horny anterior pair of wings (elytra), often retain traces of the original veins, consisting of three or four longitudinal lines. Their office in flight seems to be to assist the hind wings in sustaining the body, as but rarely when the insect is on the wing do the elytra remain quiet on the back. The membranous hind wings are provided with the usual number of principal veins, but these are not subdivided into veinlets. The wing is long, narrow and pointed, with the costal edge strong, being evidently adapted for a swift and powerful flight.

In the running species, such as many *Carabidæ*, the hind wings being useless, are aborted, and very rarely in some tropical *Lampyridæ* and *Scarabæidæ* are both pairs of wings wanting in both sexes, though, as in the Glow-worm and some of its allies the females are apterous. The legs are well developed, as the beetles are among the most powerful running insects. The coxæ are large and of much use in distinguishing the families. The trochantine is usually present in the forelegs, but often absent in the middle pair; the trochanters, or second joint of the leg, is small, circular, obliquely cut off, and the femur and tibia lying next beyond are of varying form, correlated with the habits of the insect, the hinder pair becoming oar-like in the swimming *Dytiscidæ* and some *Hydrophilidæ*, while in the *Gyrinidæ* both pairs of hind legs become broad and flat. The number of tarsal joints varies from the normal number, five, to four and three joints, the terminal joint as usual being two-clawed. These claws are only known to be wanting in Phanæus, a Scarabæid, and the aberrant family *Stylopidæ*. According to the number of the tarsal joints the families of Coleoptera have been grouped into the *Pentamera* (five-jointed), the *Tetramera* (four-jointed), the *Trimera* (three-jointed), and *Heteromera*, which are four-jointed in the hind pair, while the first and second pairs are five-jointed.

The abdomen, usually partly concealed by the wings, is sessile, its base broad; in form it is usually somewhat flattened. The tergal and sternal portion of each ring is connected usually by the membranous pleural piece, which represents the epimera and episterna of the thorax, and on which the stigmata are situated. While in the other suborders the typical number of abdominal segments is ten, no more than nine have been traced in the Coleoptera.

A few genera are capable of producing sounds by rubbing the limbs or elytra over finely wrinkled surfaces, which in Trox are situated on the side of the basal segments of the abdomen, and in Strategus on the tergum of the penultimate segment of the abdomen, while such a surface is found in Ligyrus on the surface of the elytra.

The nervous system is subject to great variation in the Coleoptera. The ganglia may be fused into three principal masses, as in the Lamellicorns, *Curculionidæ* and *Scolytidæ*, where the first mass corresponds to the prothoracic ganglia, the second and larger to the second and third thoracic ganglia, usually separated in the other suborders, while the third oblong mass represents the whole number of abdominal ganglia, from which radiate the nerves which are distributed to the muscles of the abdomen and the reproductive system. In the *Cistelidæ*, *Œdemeridæ* and *Cerambycidæ*, the abdominal portion of the nervous cord occupies the whole body, and there are five ganglia in the abdomen. These two types of the nervous cord sometimes run into each, but are always distinct in the larva state.

The alimentary canal is very simple in the flesh-eating species, going directly, without many convolutions to the anus, but in the vegetable feeders it is very long and greatly convoluted. The gizzard is oval in shape, its internal folds being armed with hooks. There are two salivary glands. The urinary tubes are either four or six in number.

"The phosphorescent organs of the *Lampyridæ* and certain *Elateridæ* consist of a mass of spherical cells, filled with a finely granular substance and surrounded by numerous trachean branches. This substance which, by daylight, appears of a yellow, sulphur-like aspect, fills in the *Lampyridæ*, a portion of the abdominal cavity, and shines on the ventral surface through the last abdominal segments, which are covered with a very thin skin; while with the *Elateridæ*, the illumination occurs through two transparent spots, situated on the dorsal surface of the prothorax. The light produced by these organs, so remarkably rich in tracheæ, is undoubtedly the result of a combustion kept up by the air of these vessels. This combustion explains the remission of this phosphorescence observed with the brilliant fire-flies, and which coincides, not with the movements of the heart, but with those of inspiration and expiration." (Siebold.)

The tracheæ of the Coleoptera are always highly developed. In the larva state they arise from two principal trunks. In the adult, however, they branch out directly near each stigma and distribute branches which communicate with other main trunks. In those species which fly most, both the fine and larger tracheæ end in vesicles, which are distributed in great abundance all over the body. In the *Lucanidæ* they are especially numerous, thus lightening the bulk of the enormously developed head.

The ovaries are arranged in the form of branches of few or numerous tri- or multilocular tubes; the *receptaculum seminis* is wedge-shaped and often arcuate, communicating with the copulatory pouch by a long flexuous spiral seminal duct, and there is a *bursa copulatrix* usually present. The *testes* vary in consisting of two long cœca, or two round or oblong follicles, or pyriform and placed like a bunch of grapes on the extremity of the *vasa deferentia*, or as in the Lamellicorns, *Cerambycidæ*, *Curculionidæ* and *Crioceridæ*, they are round, flattened, disc-like, and are situated, two to twelve in number, on each side of the body. The organ of intromission is very extensible, composed of the terminal segments of the body, which form a broad flattened, hairy canaliculated piece.

The larvæ when active and not permanently enclosed (like the Curculio) in the substances that form their food, are elongated, flattened, wormlike, myriapodous-looking, with a large head, well developed mouth-parts, and with three pairs of thoracic feet, either horny, or fleshy and retractile, while there is often a single terminal prop-leg on the terminal segment of the body and a lateral horny spine. The larvæ of the *Cerambycidæ* are white, soft and more or less cylindrical, while those of the *Curculionidæ* are footless or nearly so, and resemble those of the Gall-flies, both hymenopterous and dipterous.

The pupæ have free limbs, and are either enclosed in cocoons of earth, or if wood-borers in rude cocoons of fine chips and dust, united by threads, or a viscid matter supplied by the insect. None are known to be coarctate, though some Coccinellæ transform within the old larva skin, not rejecting it, as usual in the group, while other pupæ are enclosed in the cases in which the larvæ lived. In some *Staphylinidæ* the pupa shows a tendency to become obtected, the limbs being soldered to the body as if it were enclosed in a common sheath. Generally, however, the antennæ are folded on each side of the clypeus, and the mandibles, maxillæ and labial palpi appear as elongated papillæ. The wing-pads being small, are shaped like those of the adult Melöe, and are laid upon the posterior femora, thus exposing the meso- and metathorax to view. The tarsal joints lie parallel on each side of the middle line of the body, the hinder pair not reaching to the tips of the abdomen, which ends in a pair of acute prolonged forked incurved horny hooks, which must aid the pupa in working its way to the surface when about to transform into the beetle.

The number of living species is between 60,000 and 80,000, and over 8,000 species are known to inhabit the United States. There are about 1,000 fossil species known. They are found as low down as the Coal Formation, though more abundant in the Tertiary deposits and especially the Amber of Prussia.

Coleoptera have always been the favorites of entomologists. They have been studied, when in their perfect state, more than any other insects, but owing to the difficulty of finding their larvæ, and carrying them through their successive stages of growth, the early stages of comparatively few species are known.

The most productive places for the occurrence of beetles are alluvial loams covered with woods, or with rank vegetation, where at the roots of plants or upon their flowers, under leaves, logs and stones, under the bark of decaying trees, and in ditches and by the banks of streams, the species occur in the greatest numbers. Grass lands, mosses and fungi, the surfaces of trees and dead animals, bones, chips, pieces of board and excrement, should be searched diligently. Many are thrown ashore in sea-wrack, or occur under the debris of freshets on river banks. Many *Carabidæ* run on sandy shores. Very early in spring stones can be upturned, ants' nests searched, and the muddy waters sifted for species not met with at other times of the year.

For beating bushes a large strong ring-net should be made, with a stout bag of cotton cloth fifteen inches deep. This is a very serviceable net for many purposes. Vials of alcohol, a few quills stopped with cork, and close tin boxes for larvæ and the fungi, etc., in which they live, should be provided; indeed, the collector should never be without a vial and box. Beetles should be collected largely in alcohol, and the colors do not change if pinned soon after being taken. Coleoptera should be placed *high up* on the pin, as indeed all insects should. The pin should be stuck through the right elytron (Fig. 349) so that it shall come out beneath or between the middle and hind pair of legs. Small species should be pinned with minute pins, which can be afterwards mounted on higher ones.

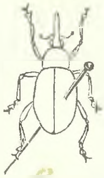


Fig. 349.

CICINDELIDÆ Leach. The Tiger Beetles have very large heads, much broader than the prothorax, very long curved jaws and long, slender legs. The outer lobe of the maxillæ is biarticulate, the inner usually terminated by an articulated hook. The eleven-jointed antennæ are inserted on the front above the base of the mandibles. They are brownish or greenish with metallic and purplish reflections, marked with light dots and stripes. They abound in sunny paths and sandy shores of rivers, ponds and the ocean, flying and running swiftly, and are thus very difficult to capture. The larvæ (Fig. 350) are hideous in aspect; the head is very large with long jaws; the thoracic rings large and broad, and the ninth ring has a large tubercle which ends in a hook, by which the hunch-backed grub can climb up its hole, near the entrance of which it lies in wait for weaker insects. These holes may always be found in sandy banks frequented by the beetles.


Fig. 350.

While all the species living in the United States are ground beetles, in the tropics there are some which live on trees. H. W. Bates states that *Ctenostoma* and its allies have a greater resemblance to ants than to the Cicindelæ proper, so much so that when the insects are seen prowling in search of prey along

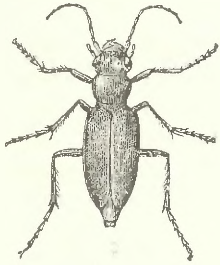


Fig. 351.

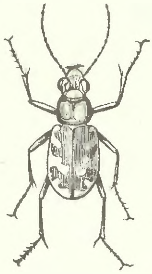


Fig. 352.

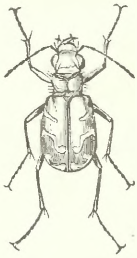


Fig. 353.

the slender branches of trees, they can scarcely be distinguished from large ants of the Ponera group.

The genus *Amblychila* has the third joint of the maxillary

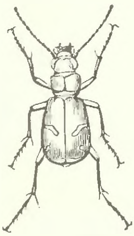


Fig. 354.

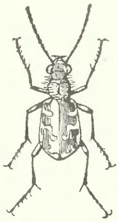


Fig. 355.

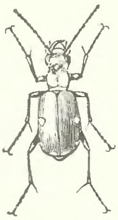


Fig. 356.

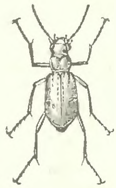


Fig. 357.

palpi longer than the fourth, and the first joint of the labial palpi very short, while the epipleuræ are wide. *Omus* differs in the wider epipleuræ; both genera inhabit the Pacific States,

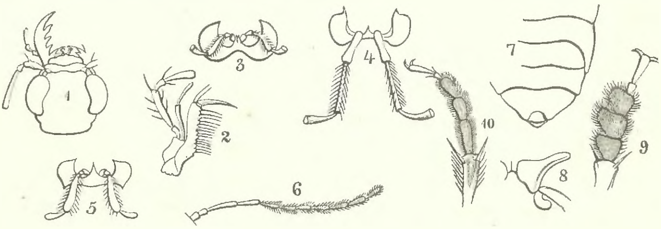


Fig. 358.

and the former is found as far east as Kansas. *Tetracha* (Fig. 351, T. Virginica Hope) has the first joint of the labial palpi elongated. In *Cicindela* and allies, the third joint of the maxillary palpi is shorter than the fourth. This country is very rich in species, among the most common of which are *C. generosa* Dejean (Fig. 352); *C. vulgaris* Say (Fig. 353); *C. purpurea* Olivier (Fig. 354); *C. hirticollis* Say (Fig. 355); *C. sexguttata* Fabr. (Fig. 356), a bright green active species with six golden dots; and *C. punctulata* Olivier* (Fig. 357).

Carabidæ Leach. This is a family of very great extent, and one very difficult to limit. In form the species vary greatly; the antennæ are inserted behind the base of the mandibles under a frontal ridge; maxillæ with the outer lobe palpiform, usually biarticulate, while the inner lobe is usually

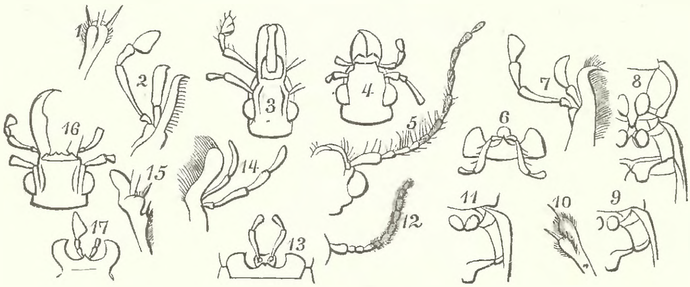


Fig. 359.

curved, acute and ciliate, with spines. The epimera and episterna of the prothorax are usually distinct; the three anterior segments of the abdomen, usually six, rarely seven or eight in number, are connate. The legs are slender, formed for running; anterior and middle coxæ globular, posterior ones dilated internally, and the tarsi are five-jointed.†

* Fig. 358 illustrates the external anatomy of this family:—1, head of Cicindela; 2, maxillæ of Cicindela; 3, mentum of Omus; 4, mentum of Tetracha; 5, mentum of Cicindela; 6, antennæ of the same; 7, abdomen of the male of the same; 8, posterior coxa of the same; 9, anterior tarsus of Omus (male); 10, anterior tarsus of Cicindela.—*From Leconte.*

† Fig. 359 illustrates the external anatomy of the *Carabidæ*:—1, extremity of the anterior tibia of Carabus, inner face; 2, maxillæ of Cychrus; 3, head of Cychrus; 4, head of Carabus; 5, antenna and part of head of Loricera; 6, mentum of Carabus; 7, maxilla of Carabus; 8, under surface of Pasimachus; 9, under surface of meso- and metathorax of Metrius; 10, anterior tibia of Metrius; 11, under surface of meso- and metathorax of Physea; 12, antennæ of Pasimachus; 13, mentum of Pasimachus; 14, maxilla of Pasimachus; 15, anterior tibia of Pasimachus; 16, head of Promecognathus; 17, mentum of Pseudomorphus, showing the indistinct gular suture.—*From Leconte.*

They are, with few exceptions, predaceous beetles; they are runners, the hind wings being often absent. Their colors are dull metallic or black. They run in grass, or lurk under stones and sticks, or under the bark of trees, whence they go out to hunt in the night-time. They may be found also in great numbers under the debris of freshets and under stones in the spring.

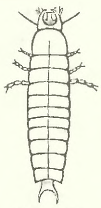


Fig. 361.

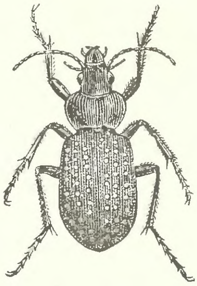


Fig. 360.

The larvæ are found in much the same situations as the beetles, and are generally oblong, broad, with the terminal ring armed with two horny hooks or longer filaments, and with a single false leg beneath.

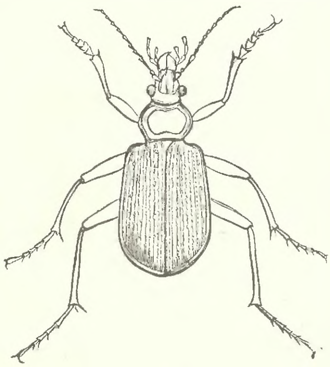
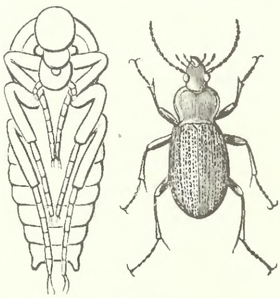


Fig. 362.

The genus *Omophron*, remarkable for its rounded convex form, and wanting the scutellum, is found on the wet sands by rivers and pools, where also *Elaphrus* occurs, which somewhat resembles Cicindela. It has slightly emarginate anterior tibiæ, with large prominent eyes, and rows of large shallow ocellate holes on the elytra. The genus *Calosoma* is well known, being common in fields, where it lies in little holes in the sod, in wait for its prey. I have seen *C. calidum* Fabr. (Fig. 360) attacking the June bug (Lachnosterna fusca) tearing open its sides. Its larva (Fig. 361) is black. *C. scrutator* Fabr. (Fig. 362) is a still larger species with bright green elytra. It is known, according to Harris, to ascend trees in search of canker-worms.



a Fig. 363.

Carabus has similar habits, but differs in having the third joint of the antennæ cylindrical, while that of Calosoma is greatly compressed. *C. serratus* Say (Fig. 363; *a*, pupa of the European C. auronitens) is black bordered with purple. The closely allied species of *Cychrus*, of rich purple and blue tints, differ in the longer head, the deeply bilobate labrum, and in having four of the antennal joints smooth, with thickly striated elytra. (We figure some unknown larvæ of this family which are allied to Carabus; Fig. 364, natural size; Fig. 365, a little enlarged; *a*, mouth parts; *b*, end of the body, and Fig. 366, a larva apparently of the same genus.) *Pasimachus elongatus* Lec. (Fig. 367) has been found, according to Walsh, to prey on the Doryphora, or Potato beetle.

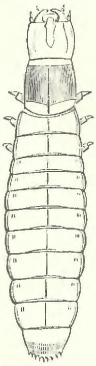
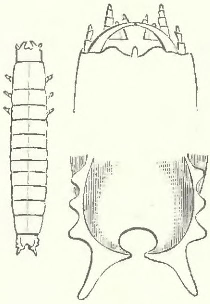


Fig. 364.



a

b

Fig. 365.

The genus Scarites and its allies have the anterior toothed palmate tibiæ more or less produced at the apex, with a pedunculate abdomen. In *Scarites* and *Pasimachus* the basal joint of the antenna is very long; the former having the maxillæ rounded at the tip, and the thorax rounded behind, while in Pasimachus, the thorax is distinctly angulated, and the maxillæ are hooked. In *Clivina* the basal joint of the antennæ is short, the mandibles flat and acute, and the clypeus is not emarginate.

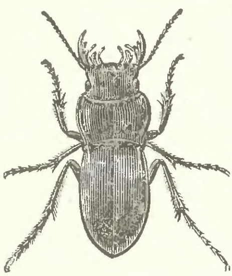


Fig. 367.

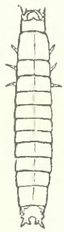


Fig. 366.

In Harpalus and allies the epimera of the mesothorax do not extend to the coxæ, and the mesosternum is large, widely separating the middle coxæ. Of this group *Brachinus* (B. fumans Fabr. Fig. 368), the Bombardier beetle, with its narrow head and cordate prothorax, is remarkable for discharging with quite an explosion from its anal glands a pungent fluid, probably

Fig. 368.

of use as a protection against its enemies. They are yellowish red, with bluish and greenish elytra. *Helluomorpha* (H. præusta Lap. Fig. 369; *a*, mentum) has a large mentum and much compressed antennæ. *Galerita* is similar but much larger, with a red thorax, and blue or black elytra. Fig. 370 represents the larva; Fig. 371 the pupa of *G. Lecontei* Dejean, a Southern species.

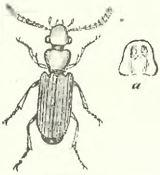


Fig. 369.

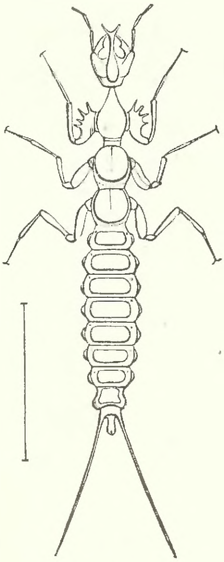


Fig. 370.

Casnonia has a rhomboidal head, with a long narrow neck and a cylindrical thorax. *C. Pensylvanica* Dejean (Fig. 372) is not uncommon, being found under stones. The species of *Lebia* are found upon flowers, especially the golden rod, in August and September. They are gaily colored, with the head constricted behind and the thorax pedunculate. The species of *Platynus* (P. cupripenne Say, Fig. 373) are often of brilliant metallic green and red colors. In *Cymindis*, which is hairy, the head is not constricted behind, and the last joint of the labial palpi is dilated. In *Pterostichus*, which is a genus of great extent, the three basal joints of the antennæ are smooth, the anterior tibiæ are thickened at the extremity, and the dilated tarsal joints are triangular or cordate. The species are black and of common occurrence. *Amara* differs in the head not being narrowed behind, the slightly emarginate labrum and the elytra being without the usual punctures. Zimmerman states that the species are annual, or double brooded annually; the eggs, which are laid beneath the surface of the soil, do not mature for several days after coupling; the larvæ moult once, live six to eight

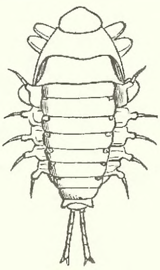


Fig. 371.


Fig. 372.


Fig. 373.

weeks, and the pupa lives half that time; the beetles often hibernate. The larva has the general form of that of Poecilus.

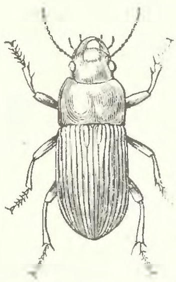


Fig. 374.


Fig. 375.

The species of *Harpalus* are large, with a very square prothorax. *H. caliginosus* Say (Fig. 374) is beneficial in eating cut-worms and other injurious larvæ. Fig. 375 represents a larva supposed to belong to this or an allied genus. The blind *Anophthalmus Tellkampfii* Erichs. from the Mammoth Cave, has no eyes, while the legs are very long, especially the narrow fore tibiæ; but in *Trechus*, which is closely allied to the blind Cave Beetle, the eyes are as large as usual, and the legs stouter.

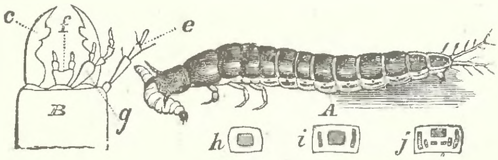


Fig. 376.

Bembidium comprises species of very small size and variable in form, in which the anterior tibiæ are not dilated at the base. They are found abundantly under the refuse of freshets and tides, preying upon dead animal matter and other insects, and a species of *Cillenum*, closely allied to Bembidium, is known to seize the beach-flea, Gammarus, and devour it. Fig. 376 (A, a little enlarged; B, head; *c*, mandible; *e*, antenna; *f*, labium and its two-jointed palpi; *g*, maxillæ; *h*, *i*, *j*, under side of different abdominal rings) represents the larva of a Ground beetle, which, according to Walsh, preys upon the larva of the Plum curculio while under ground. Fig. 377 represents the supposed larva of a European species of *Chlænius*, and Fig. 378 what we suppose is the larva of a beetle allied to Cillenum.


Fig. 377.

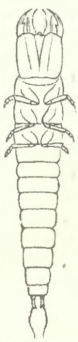


Fig. 378.

Amphizoidæ Leconte. The genus *Amphizoa* (Fig. 379, A. insolens; *a*, antenna; *b*, labrum; *c*, mandibles; *d*, maxillæ; *e*, ligula; *f*, mentum; *g*, prosternum, front, and *h*, side view; *i*, under side of the rest of the body, showing the six ventral segments of the abdomen; *j*, anterior tarsus: from Horn) found in Northern California, is the sole representative of this family and differs from the preceding family in the metasternum be-

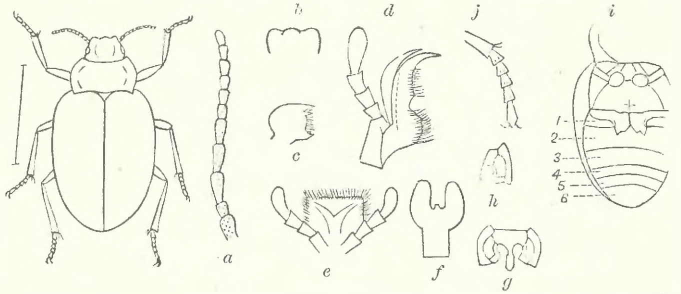


Fig. 379.

ing truncate behind, and not reaching the abdomen. *A. insolens* Lec. is an anomalous form, being subaquatic, and in its structure and habits connecting the *Carabidæ* with the succeeding family.

DYTISCIDÆ McLeay. The Diving Beetles, or Water Tigers, are oval flattened elliptical beetles, which differ from the *Carabidæ* in the form of the hinder coxæ, which are very large, touching each other on the inner edge, and externally reaching the side of the body, entirely cutting off the abdominal segments from the metathorax, while the oar-like swimming legs are covered with long hairs, and the hinder pair are much flattened. The larvæ are called "water tigers," being long, cylindrical, with large flattened heads, armed with scissor-like jaws with which they seize other insects, or snip off the tails of tadpoles, while they are even known to attack young fishes, sucking their blood. They are known to moult several times, four or five days intervening between the first two periods of moulting, and ten days between the latter. The body ends in a pair of long respiratory tubes, which they protrude into the air, though eight pairs of rudimentary spiracles exist. When about to transform the larva creeps on to the land, constructs a round cell, and in about five days assumes the pupa state, and in two or three weeks the beetle appears, if in summer, or if in autumn hibernates as a pupa, to transform to a beetle in the spring.

In *Haliplus* the antennæ are ten-jointed, bristle-shaped, and the legs are scarcely adapted for swimming, being narrow. The body is very convex, spotted with black or gray, while the elytra are covered with rows of punctures. In the remaining genera, the types of the family, the antennæ are eleven-jointed and the hind legs oar-like. "The larvæ differ not only by their dorsal segments being armed with spines, which gives them a very grotesque appearance, but by their possessing only one claw, and by their anal segment (which is rudimentary in all other Dytiscidæ) being enormously elongated and forked, so that the anus is placed on the under side of this peculiar tail, and the spiracles of the eighth pair, which are terminal and tube-like in other *Dytiscidæ* here become lateral and quite plain." (Schiödte.) In *Colymbetes* and *Agabus* the anterior tarsi of the males are broad, oblong, and covered beneath with cups of equal, or nearly equal, size. Agabus differs in having the thorax as wide at the base as at the middle, or still wider. In *Dytiscus* the ovate, not very convex body is usually broader behind the middle, and the last joint of the palpi is not elongated, while in *Acilius* which is usually banded, the intermediate tarsi of the male are not dilated. The males of these two genera often have the elytra deeply furrowed, while those of the females are smooth. *Dytiscus fasciventris* Say and *Acilius mediatus* Say are common in all our ponds northward.

GYRINIDÆ Latreille. Whirligigs. These oval bluish black beetles are easily distinguished by their peculiar form and habits. They are always seen in groups, gyrating and circling about on the surface of pools, and when caught, give out a disagreeable milky fluid. Like the previous family, upon being disturbed, they suddenly dive to the bottom, holding on by their claws to submerged objects. They carry down a bubble of air on the tip of the abdomen, and when the supply is exhausted rise for more.

The cylindrical eggs are placed by the female, end to end, in parallel rows on the leaves of aquatic plants, and the larvæ are hatched in about eight days. They are myriapodous in form, with a pair of large, long, lateral respiratory filaments on each segment, much as in the larva of Corydalus. They become fully grown in August, crawl out of the water and spin an oval cocoon, within which the pupa remains a month, and then appears as a beetle. In *Gyrinus* (Fig. 380, *G. borealis* Aubé; Fig. 381, larva of a European species) the scutellum is distinct; the species of *Dineutus*, of which *D. Americanus* is a type, are larger, and lack the scutellum.

Fig. 380.

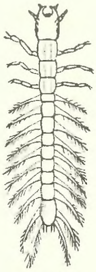


Fig. 381.

Schiödte states that the larvæ of *Carabidæ*, *Dytiscidæ* and *Gyrinidæ* differ from those of other Coleoptera in having double claws, while in the others the tarsus is undivided and claw-like.

Hydrophilidæ Leach. Carnivorous as larvæ, but when beetles, vegetable eaters, and living on refuse and decaying matter, this family unites the habits of the foregoing families with those of the scavenger Silphids. They are aquatic, small, convex, oval, or hemispherical beetles, in which the middle and posterior feet are sometimes adapted for swimming; the antennæ are short, and the palpi very long and slender. The females spin a silken, turnip-shaped nidus for their eggs, fifty to sixty in number, which ends in a horny projection, serving as a respiratory tube to supply the young larvæ with air as they are hatched. Others carry the cocoon about with them on the under side of the body. To spin this large amount of silk, they are provided with two large silk glands, with external spinnerets. The larvæ hatch in from two to six weeks, and moult three times; when mature they are long, cylindrical, tapering rapidly towards the posterior end, with short legs, while the head is flattened above and very convex beneath, with the mandibles elevated much as in the larva of Cicindela, enabling them to

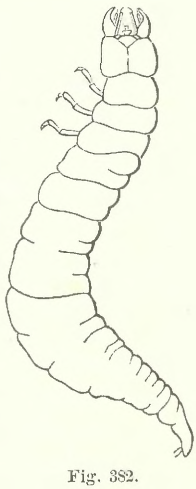


Fig. 382.

seize their food by throwing their heads back and extending the jaws. When handled "it becomes placid, and emits a blackish fetid fluid from the mouth accompanied by a slight noise." The larva of the European *H. piceus* Linn. (Fig. 382) becomes mature in two months, then ascends to the bank, forms an oval cocoon, and transforms to a beetle in about forty days.

In the genus *Spercheus* (S. tessellatus Melsheimer) the middle and hind tarsal joints are equal in length. The females of the European species carry the eggs in a silken nidus beneath their abdomens, and as the eggs are hatched every eight or ten days, others are laid to keep up the supply.

Hydrophilus is large, oval, olive black, with smooth elytra, and the prosternum is small, with a long spine on the metasternum. In the larvæ the lateral appendages of the abdomen are soft, flexible, ciliated, and assist in buoying up the heavy fleshy body (for which purpose the antennæ are ciliated) but they do not serve for respiration, as in *Berosus*, another European genus of this family. (Schiödte.) *H. triangularis* Say is a large pitchy black species. In *Hydrobius* the last joint of the maxillary palpi is longer than the preceding. *Sphæridium* and its allies are characterized by an ovate, convex or hemispherical form, being black, with the elytra often spotted or margined with yellow, and with ten rows of punctures or striæ, though in *Cyclonotum* there are no striæ. In *Cercyon* the mesosternum is not produced, and the prosternum is keeled over. "In the larvæ of *Cercyon* and *Sphæridium*, which represent the Hydrophiline type modified for life on dry land (though in humid places) we find neither lateral abdominal appendages nor even true feet, the animal wriggling its way through the debris amongst which it lives, whilst the last abdominal segment is the largest of all and is often armed with hooks." (Schiödte.)

SILPHIDÆ Leach. The Carrion or Sexton beetles are useful in burying decaying bodies, in which they lay their eggs. By living in the vicinity of carrion, and by their very clavate antennæ and flattened head and body, and the black nauseous fluid they give out, the common species are readily recognized.

The larvæ are crustaceous, flattened, with the sides of the body often serrated, black, and of a fetid odor. They undergo their transformations in an oval cocoon. In *Necrophorus* (Fig. 346, N. Americanus Oliv.) the antennæ have ten apparent joints, and the rounded club is four-jointed. The genus *Silpha*, of which *S. Lapponica* Herbst (Fig. 383, larva fully grown; 384, young, from Labrador) is a common species, differs in the third joint of the antenna being no longer than the second, but shorter than the first. In *Necrophilus* the third joint is as long as the first. *N. Surinamensis* Fabr. has a yellow thorax with a central irregular black spot. *Catops* and its allies live in fungi, carrion and ants' nests, and are small, black, oval insects. The eyeless *Adelops hirtus* Tellk. is blind, wanting the eyes, and is found in Mammoth Cave. *Anisotoma* and allies, with eleven-jointed antennæ, are oval and sometimes hemispherical, and capable of being rolled up into a ball. They are of small size and found in fungi, or under the bark of dead trees. *Agathidium* (Fig. 385, larva of the European A. seminulum) has the club of the antennæ three-jointed. *Clambus* and allies comprise exceedingly minute species, found in decaying vegetable matter.

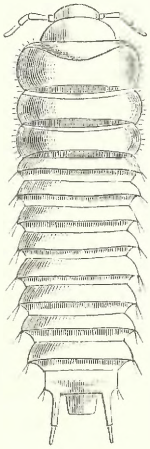


Fig. 384.

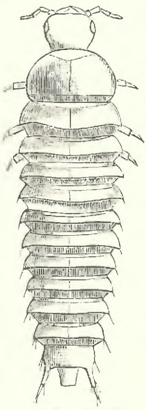


Fig. 383.

An aberrant form is *Brathinus*, two species of which, *B. nitidus* Lec. and *B. varicornis* Lec., have been found from Lake Superior to Nova Scotia, about the roots of grass in damp places. According to Leconte, they are small shiny insects of graceful form, and distinguished by the prominent middle coxæ.

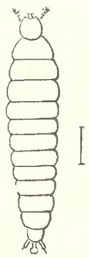


Fig. 385.

Scydmænidæ Leach. The species of this small group differ from the *Pselaphidæ* to which they are closely allied by their long elytra and distant conical posterior coxæ. They are minute, oval, brown, shiny insects found under stones near water, under bark and in ants' nests. *Scydmænus* is the typical genus.

PSELAPHIDÆ MacLeay. In this group the labial palpi are very small, while the four-jointed maxillary palpi are of remarkable length; the eyes are composed of large lenses, and are sometimes wanting; the elytra are short, truncated, beneath which the wings, when present, are folded and the legs are long and the femora are stout, while beyond the leg is usually slender. "The species are very small, not exceeding one-eighth of an inch in length, and are of a chestnut-brown color, usually slightly pubescent; the head and thorax are most frequently narrower than the elytra and abdomen, which is convex and usually obtuse at tip. Many are found flying in twilight; their habits at other times are various, some being found in ants' nests, while others occur under stones and bark. North America seems to be rich in this family; more than fifty species are known to me, and several of the genera have not occurred in other countries. This family closely approaches the *Staphylinidæ*, but the ventral segments are fewer in number, and not freely moving, and the eyes are composed of large lenses." (Leconte.) The genus *Claviger* and its allies *Adranes cæcus* Leconte, which is found in ants' nests in Northern Georgia, have antennæ with less than six joints; it is blind, and the antennæ have only two joints. *Pselaphus* and its allies have eleven-jointed, rarely ten-jointed antennæ.

STAPHYLINIDÆ Leach. The Rove-beetles are easily recognized by their long linear black bodies, with remarkably short elytra, and seven to eight visible horny abdominal segments. The maxillæ are bilobate, usually ciliated, with four-jointed palpi, except in Aleochara, when there is an additional joint; the antennæ, variable in form and insertion, are usually eleven-jointed, and while the legs are variable in length and form, the anterior coxæ are usually large, conical, prominent and contiguous. Though sometimes an inch in length, they are more commonly minute, inhabiting wet places under stones, manure heaps, fungi, moss, under the bark or leaves of trees. Many species inhabit ants' nests, and should be carefully sought for on dewy mornings under stones and pieces of wood, which should be taken up and shaken over a white cloth or paper; or the whole nest should be sifted through a rather coarse sieve, when the small beetles will fall through the meshes. The eggs are very large. The larvæ (Fig. 386, under side of a larva probably belonging to this family, from Maine, enlarged twice) closely resemble the beetles, being narrow, the segments of very equal size, the terminal ring forming a long prop-leg, on each side of which there is a long ciliate seta. In the pupæ the hind wings are not folded beneath the elytra, but extend below, meeting upon the breast.

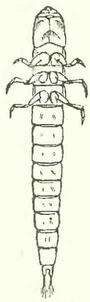


Fig. 386.

In the true Staphylini the anterior coxæ are prominent and their coxal cavities are open behind. Aleochara and its allies are difficult to distinguish, as the characters separating them are but slightly marked; they have the maxillary palpi moderate in length, with the second and third joints also of moderate length, the fourth small, subulate, distinct, and in *Aleochara* itself there is an additional very small fifth joint. In *Homolota*, numerous in species, the ligula is short and bifid, and the first to the fourth joints of the hind tarsi decrease in length. In *Tachyporus* and allies the prothoracic spiracles are visible; the anterior coxæ are large, conical and prominent, with the trochanters very distinct, while the antennæ are inserted under the lateral margin of the front. The species are usually convex above, with the thorax always ample, arched and highly polished, and the abdomen conical, sometimes very short. They are found partly in fungi, partly under bark. Dr. Leconte, whom we have been quoting, states that the species of *Bolitobius* usually have the head much elongated; when, however, the head is oval, they approach closely to the genus *Quedius* of the next tribe, but are recognized by the antennæ being inserted at the lateral margin of the front, near the eyes, and not at the anterior angle of the frontal margin, as in Quedius.

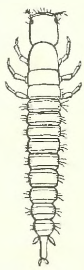


Fig. 387.

In *Staphylinus* the antennæ are inserted on the anterior margin of the front, inside of the base of the mandibles, but distant from each other; the thorax is punctured and pubescent, the middle coxæ slightly separate, while the abdomen is narrowed at the tips. Fig. 387 represents the larva of this or a closely allied genus found in a humble bee's nest. *Philonthus* differs in having the femora unarmed. The species live in decaying matters and excrement. The species of *Pæderus* (Fig. 388, the larva of the European P. tempestivus Erichs.) are found under stones, etc., near water.

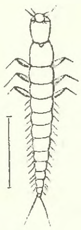


Fig. 388.

In *Stenus*, of which *S. stygicus* Say and *S. Juno* Fabr. are types, the eyes are large and prominent, so that the head resembles that of Cicindela and the antennæ are inserted upon the front between the eyes; the labrum is entire and rounded anteriorly, the paraglossæ are dilated, rounded, and the body is coarsely punctured, while that of its nearest ally *Dianous* is finely punctured and the paraglossæ are connate and indistinct. Another small group of genera is represented by *Oxyporus*, which is found in fungi, and which has a large head, with large long mandibles crossing each other, and five-jointed tarsi; and *Oxytelus* which is found in wet places and in dung, and has three-jointed tarsi, with a row of spines on the front tibiæ, and the middle coxæ separated.

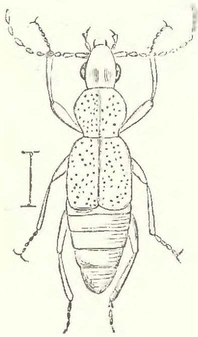
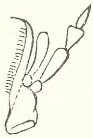


Fig. 389.



a

Anthophagus cæsus?, Harris Correspondence (Fig. 389; *a*, maxilla), is found in wet ground where spearmint grows, of which it diffuses a strong odor.

In *Omalium* the antennæ are inserted under the lateral margin of the front, the elytra are long, and the tibiæ finely spinous. *Micralymna* is closely allied, but differs in the elytra being very short. The genus *Micropeplus* is squarish in form and connects the present family with the one following.

HISTERIDÆ Leach. As stated by Leconte, "this is a very well defined family of insects, moderately numerous, nearly all of a shining black color, with the elytra variously sculptured with striæ; some few species of Hister and Saprinus have the elytra marked with red, and a few of the latter genus are metallic in color. The form of the body is variable; those of the first group are oblong and flat, with prominent mandibles; the others are round, oblong oval, globose, some depressed and some convex. The species live under the bark of trees, in excrement and in carcasses. When disturbed the insects retract the antennæ and feet, appearing as if dead. The antennæ are geniculate, the eighth and following joints forming a compact annulated, rounded or (rarely) triangular club. The elytra are truncate behind, leaving two segments of the abdomen uncovered. The linear flattened larvæ have the terminal ring ending in two biarticulated appendages, and a single anal prop-leg. The larva of the European *Hister merdarius* (Fig. 390) lives in cow dung, forming a cell in which it transforms, and like Andrenus, the pale brown pupa retains the larva-skin about it. In Hister the head is retracted and bent downwards, and the club of the antenna is round and annulated. *Hister interruptus* Beauv. and *H. marginicollis* Lec. are common northward.

Fig. 390

The genus *Hetærius* differs in the antennal club being obconical, truncate and solid. The species are found only in ants' nests early in the spring. In *Saprinus* the antennæ are inserted under the margin of the front; the antennal cavities being at the sides of the prosternum proper. The species are mostly found in carrion.

Scaphidiidæ MacLeay. "This family," according to Dr. Leconte, "contains small oval or rounded oval, convex, very shining insects, living in fungi. The sides of the thorax are oblique, and the head small, so as to make the body somewhat pointed in front; the thorax is very closely applied to the front, and the elytra are broadly truncate, permitting the tip of the conical abdomen to appear." In *Scaphidium* the antennæ are clavate, the eyes emarginate, the posterior tibiæ are not spinous, and the first joint of the posterior tarsi longest.

Trichopterygidæ (Trichopterygia Erichson). This inconsiderable family comprises the smallest beetles known. The eleven-jointed antennæ, which are verticillate, with long hairs, are inserted at the margin of the front, and the club is long and loosely articulated. The beetles live under the bark of trees and in ants' nests. The larvæ are carnivorous, being very active, without ocelli, and with cylindrical bodies, with four-jointed antennæ and long four-jointed legs. *Trichopteryx* is known by its pubescent body, and laminate posterior coxæ. One species is one-third of a line long; others are still smaller. The larva of the European *T. intermedia* Gillmeister (Fig. 391, enlarged) feeds on Poduræ.


Fig. 391

PHALACRIDÆ Erichson. "A small number of oval or rounded oval, convex, shining insects, constitute this family. They are found on flowers, and sometimes under bark. The elytra have sometimes approximate rows of small punctures, but more usually only a sutural stria. The scutellum is larger than usual, triangular. One of the four genera (Tolyphus) of this family is wanting in our fauna. The other three are separated by the form of the posterior tarsi." (Leconte.) In *Phalacrus* the anterior and posterior tarsi are of the same length. The larvæ are vegetable feeders, living in the flowers of composite plants.

NITIDULARIÆ Latreille. This family includes small oval or elliptical, flattened beetles, which are sometimes almost globular. The head is suddenly narrowed before the insertion of the antennæ, thus forming a short beak, and the antennæ may be partially retracted into a groove under the eyes. The larvæ are both carnivorous and vegetable-feeders; they are elongated, with two to four-jointed antennæ, three ocelli on each side, with a flattened hairy body, ending in four small, horny, recurved tubercles. The pupæ may be found under the surface of the ground in earth and sawdust. *Carpophilus* has the second and third abdominal segments short, while the first, fourth and fifth are longer, and the claws are simple. *Carpophilus antiquus* Mels. is a well known spe-

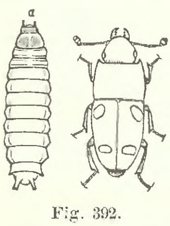


Fig. 392.

cies. *Nitidula* and its allies are elliptical depressed, often with a broad margin; the elytra covers the whole abdomen, or leaves merely the tips exposed. In *Nitidula* the last joint of the labial palpi is not thicker than the preceding, and the species often have two red spots on the elytra, as in *Nitidula bipustulata* Fabr. In *Epuræa*, which is found under stones and bark, the last joint of the palpi is large and thick. *Omosita colon* Fabr. is also spotted twice with red; the genus may be recognized by the antennal grooves diverging behind, following the outline of the eyes, while in the males the sixth abdominal segment is wanting. *Ips* is much longer and larger, with truncate elytra, and the head is immersed in the thorax to the eyes. *Ips sanguinolentus* Say has a broad red band on the elytra, with two large round dots. *Ips fasciatus* Say (Fig. 391, and larva; found in the roots of the squash by Mr. M. C. Read) has two broad interrupted yellow bands on the elytra; both species occur about flowing sap in spring. *Ips ferruginea* of Europe lives on the young of Hylesinus ligniperda. *Rhizophagus depressus* is known in Europe to attack the larvæ of Hylurgus piniperda, according to Dufour.

Monotomidæ Chaudoir. The species of this inconsiderable group are much like the preceding family in form, but as Leconte states, differ from them in the anterior coxæ being small, rounded and separated. They occur under the bark of trees.

Trogositidæ Kirby. This group, usually united with the preceding family, is distinguished by the bilobate maxillæ, with the short, four-jointed maxillæ and the short undilated tarsi. They generally live under bark, but some have been transported over the whole world in grain. In *Trogosita*, which comprises long insects, with the thorax narrowed behind, the ligula is entire, the tibiæ are not spinous, and the thorax is prominently angulated in front.

Colydiidæ Erichson. The small globular anterior and middle coxæ, and the four-jointed simple tarsi will enable them, Leconte states, to be readily distinguished from any of the neighboring families. The species are of small size, usually rather long and cylindrical, and occur in fungi, in the earth, or under the bark of trees. *Colydium* is slender, with finely striate elytra, and the anterior tibiæ have one spur enlarged and hooked; while the first joint of the tarsi is elongated. *C. elongatum* is stated by European authors to attack the larvæ of Platypus, a genus allied to Scolytus.

Rhyssodidæ Erichson. This group, by some authors united with the preceding family, simulates the form of the Carabids. The antennæ are, however, composed of equal globular joints, and the head is strongly constricted behind into a neck. They are found under bark. In *Rhyssodes* the eyes are placed upon the side, and in the other genus, *Clinidium*, upon the upper surface of the head.

Cucujidæ Latreille. The species of this family are very much flattened long insects, with flat, strongly emarginated elytra, and the abdomen has five full segments, equal in length. They are found under bark. The larvæ are quite transparent, with the terminal joint ending in two horny curved hooks. The antennæ are four-jointed, the limbs provided with a single claw, and there are five ocelli on each side of the head. In *Sylvanus*, which is of small size, the nine to eleven-jointed antennæ do not have the first joint elongated as usual, while the terminal ones are enlarged. *Sylvanus Surinamensis* Linn. is one-fourth of a line long, of a rusty brown color, and covered with short yellowish hairs. The larva is a flattened yellowish white grub, with the terminal joint somewhat conical. It breeds in bran, rice and wheat. *Cucujus* is a bright scarlet flattened insect, with punctured elytra, and three faintly marked smooth lines. The larvæ differ from those of Sylvanus by having two horny tubercles at the end of the abdomen; they are often found in granaries.

Cryptophagidæ Kirby. This family differs from the preceding group in the greater length of the first abdominal ring, the thickened body, and in the thorax being as wide as the elytra. *Antherophagus* is readily known by its resemblance to Epuræa among the *Nitidulidæ*, as its head and body is flat, the front not prolonged, and in the male is deeply excised at the tip. The antennæ of the female are clubbed as usual, and the mandibles are prominent and suddenly incurved at the tips. It is often found on flowers in the perfect state. We have found the larvæ (Fig. 393; *a*, end of abdomen) of *Antherophagus ochraceus* Say (Plate 3, fig. 4) in the nests of humble bees during July and August. They are whitish, and .32 of an inch in length. The beetles are of a pale honey yellow, with little darker antennæ, legs and elytra, while the ends of the antennal joints, the base of the coxæ and tibiæ, and tip of the terminal joint of the tarsi are black. The larva of the European *Cryptophagus hirtus* Gyll. (Fig. 394) is found in cellars.

Fig. 393.

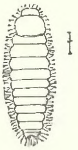


Fig. 394.

DERODONTIDÆ Leconte. In these insects the transverse form of the anterior and posterior coxæ (which latter are slightly separated), dilated internally, forming a small plate to protect the insertion of the thigh, distinguishes this group from all the preceding families, and approximates it somewhat to the families following the *Elateridæ*.

LATHRIDIIDÆ Redtenbacher. Leconte states that the insects of this small family are of very small size, found flying in twilight, and also under bark and stones; they are of graceful form, the elytra being usually wider than the thorax; the species of *Bonvouloiria* and most of the species of *Lathridius* (Fig. 395, larva of L. minutus Linn., enlarged) are very remarkably sculptured, with elevated lines on the thorax.

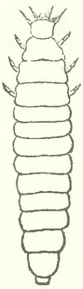


Fig. 395.

OTHNIIDÆ Leconte. *Othnius umbrosus* Lec. is the type of this family. It occurred in Nebraska, near the Rocky Mountains.

MYCETOPHAGIDÆ Leach. The genus *Mycetophagus* is finely punctured with closely appressed hairs; the anterior coxal cavities are open; the tarsi are four-jointed and filiform, the anterior pair in the males having but three joints; the frontal suture is always distinct and usually deep; the eyes are transverse and the antennæ gradually enlarged externally.

Dermestidæ Leach. These well known insects have the head small and deflexed, with short mandibles, rounded eyes, with a single ocellus; the prothorax is short, sometimes excavated for the reception of the antennæ, which are inserted in front of the eyes and are usually eleven-jointed, and the legs are short, somewhat contractile, the tarsi being five-jointed. In Byturus the mandibles have several teeth, and the claws are armed with a large basal tooth. They are small oval brown beetles found eating flowers. Mr. J. L. Russell of Salem, has called my attention to the ravages committed by *B. unicolor* Say on the raspberry; it eats the flowers and makes long holes in the leaves, and for two or three summers has been very abundant. Hand picking was found to be the best remedy. Every entomologist dreads the presence of *Dermestes* and *Anthrenus* in his cabinet. The ugly, bristly, insidious larva, which so skilfully hides in the body whose interior it consumes, leaving only the shell ready to fall to pieces at the slightest jar, can be kept out only with the greatest precautions. *Dermestes lardarius* Linn., the larger of the two, is oblong oval, with short legs, black, with the base of the elytra gray buff, covered by two broad lines. It is timid and slow in its movements, and when disturbed seeks a shelter, or mimics death. We have found the larva (Fig. 396) of probably another species of Dermestes, crawling up the side of an out-house. It was nearly twice the size of D. lardarius. *Attagenus pellio* Stephens is another insect which infests museums. It is shorter than Dermestes, black, with two dots on the wing covers. The larva (Fig. 397, enlarged three times) is long and slender, cylindrical, with reddish brown hairs closely appressed to the body, giving it a silky, shining appearance. The abdomen ends in a long pencil of hairs.

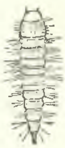


Fig. 396.


Fig. 397.

Anthrenus varius Fabr. (Fig. 398; *a*, larva; *b*, pupa) is rounded oval, with transverse waved lines. Its larva is thick, with long bristles, which are largest on the end of the body. They are generally destructive in museums, and prey on stuffed specimens of all sorts. The beetles fly about early in spring and then lay their eggs. The insect is found in all its stages through the year. They may be killed like the Clothes-moth, also found in museums, by saturating the specimen infested by them with benzine. To prevent their attacks, they should be kept out of collections by keeping benzine in constant evaporation in open vessels. Camphor and turpentine and creosote are also very useful. Insects recently prepared should be placed in quarantine, so we may be sure none of the museum pests will be introduced into the drawers or cases of the cabinet while either in the egg or larva state. Their presence in cabinets may be detected by the dust they make falling on the white surface beneath. Specimens thoroughly impregnated with carbolic acid, or arsenic, or corrosive sublimate, will not be attacked by them.

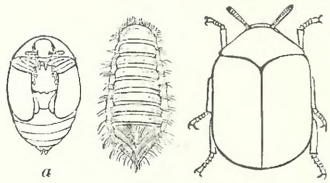


Fig. 398.

BYRRHIDÆ Leach. Pill Beetles. This group has the head retracted under the thorax, with the parts of the mouth more or less protected by the prosternum; the legs are short, stout and retractile, and the antennæ are clavate. The typical species are "oval or rounded, very convex, dull black or bronzed insects, covered with a fine, easily removed pubescence, forming varied patterns." In *Byrrhus* all the tarsi are retractile. We have taken *Byrrhus Americanus* Lec. in Labrador, on the stems of the "Labrador tea." They are found in cold mountainous districts. The larvæ (Fig. 399, larva of *B. pillula* Illiger, a European species found in moss) are fleshy, cylindrical, with the last two rings of the body larger than the others.


Fig. 399.

GEORYSSIDÆ Heer. This family consists of but a single genus, characterized by Leconte as comprising small, rounded, convex, roughly sculptured, black insects, found at the margins of streams, on wet sand; they cover themselves with a mass of mud, so that no part of the insect is visible. *Georyssus pusillus* Lec. is our only species.

PARNIDÆ MacLeay. These are aquatic beetles, having a retractile head, and are often found clinging to submerged stones, both in the larval and pupal states. The body of the beetle is "clothed with a fine pubescence, enabling a film of air to be preserved beneath the water." The larvæ are hemispherical like a basin. "The larva of *Psephenus Lecontei* Hald. (Fig. 400, under side, enlarged three times) is an elliptical object, with the margins widely extended beyond the body, and is seen on stones under the water of rapid streams; it is especially abundant in the rapids of Niagara, and differs in no important particular from the larva of *Helichus* of the next subfamily. It respires by branchial filaments." (Leconte.) *Elmis* (Fig. 401, larva of a European species) is known by the narrow, elongate scutellum.

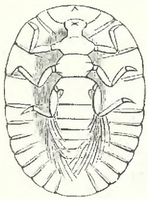


Fig. 400.

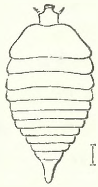


Fig. 401.

HETEROCERIDÆ MacLeay. "This family consists of but a single genus, *Heterocerus;* it is represented in every portion of our territory. The species are numerous, but very similar in form and color, so that care is necessary in distinguishing them. They are oblong or subelongate, oval, densely clothed with short, silky pubescence, very finely punctuate, and of a brown color, with the elytra usually variegated with undulating bands or spots of a yellow color. They live in galleries which they excavate in sand or mud at the margin of bodies of water, and, when disturbed, run from their galleries and take flight, after the manner of certain species of Bembidium." (Leconte.)

LUCANIDÆ Latreille. This family is closely allied to the next, and is often united with it, as it differs chiefly from the outer lamellate joints of the antennæ not being so closely united into a compact club, as in the *Scarabeidæ*, and the mentum is usually large. The genus *Lucanus*, called the Stag-horn beetle, is of large size, with enormously developed jaws in the male, as in *Lucanus dama* Fabr. (Fig. 402, ♂). The larva of *Lucanus dama* (Fig. 403, and cocoon, natural size) is long, thick, nearly cylindrical, and the corneous rust-colored head is armed with two large jaws. Living in rotten wood, like the *Cerambycidæ*, it constructs a cocoon of the chips it makes. The larva of the European *L. cervus* is stated by Roesel to live six years. Harris states that they lay their eggs in crevices of the bark of trees, especially near the roots. The larvæ resemble the grubs of the Scarabæans in color and form, but are smoother, being less wrinkled. *Dorcas brevis* Say (Fig. 404) is an exceedingly rare insect whose habits are unknown. In *Passalus cornutus* Fabr., belonging to a more aberrant genus, the body is long and flattened with a short bent hook on the head, and the elytra deeply striate. Madam Merian describes the larva of Passalus as being a thick fleshy worm, with a small scaly head, six legs, and slender posteriorly; it lives in decaying wood.

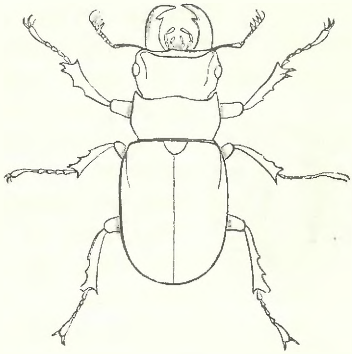


Fig. 402.

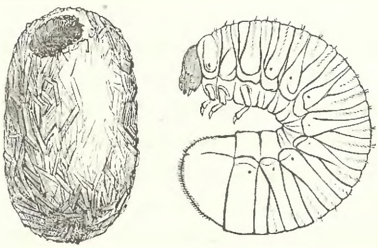


Fig. 403.

SCARABÆIDÆ Erichson. This family, the *Lamellicornia* of Latreille, is one of immense extent, being divided into more than 700 genera, comprising some 6,000 species, or three-fourths as many Coleoptera as are known to live in this country. They comprise the mammoths among insects, and it is in the tropics that we meet with the most numerous and bizarre, as well as gigantic forms. Always readily recognized by their clubbed lamellate antennæ, the terminal joints being expanded into broad flat leaves, which, at the will of the insect, can be closely shut into a compact club, or loosely expanded fan-like, and laid under the projecting clypeus, so overhanging the mouth-parts as to give rise to the terms beetle-horned, and "beetling;" these insects, by their robust, thick, often square body, short fossorial legs, with large hooked claws for seizing leaves and stems, have been well known to all observing persons, however slight their entomological knowledge. The larvæ are thick and fleshy cylindrical grubs, with a corneous head, and rather long four-jointed antennæ; the ocelli are generally wanting; the legs are stout and long, without claws, and the last abdominal segment is soft and baggy. The body is often very transparent, the tracheæ appearing through. Fig. 405 represents a singular larva (magnified twice) of this family from Mr. Sanborn's collection.

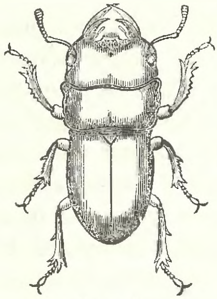


Fig. 404.

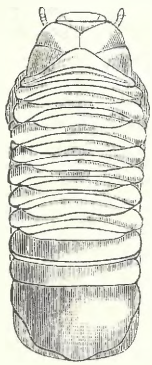


Fig. 405.

The genus Copris and allies are known by their rounded form, and the broadly expanded clypeus, which covers in the mouth-parts. In some species (those of Deltochilum) the anterior tarsi are wanting either in the females or both sexes; and in some species a stridulating apparatus is found on the upper surface of the abdomen. In *Copris* the labial palpi are dilated, the first joint of the antennal club does not receive the others, and the claws are distinct. The larva of *C. Carolina* Fabr., while, according to Osten Sacken, having the general appearance of the larvæ of the Lamellicorns, is much thicker and curved up, the back being much swollen and "distended into a hump-like expansion. It is about two inches long and of a dirty yellowish white. Each larva was found enclosed in a globular case of dung or earthy matter, about an inch and a quarter in diameter." (Proceedings of the Entomological Society of Philadelphia, vol. i, pl. 1, fig. 1.)

The closely allied *Phaneus carnifex* MacLeay is common southward, and easily known by its brilliant copper colored thorax and bright green elytra, and by the large horn on the head of the male. These insects are called "Tumble-bugs," as they enclose their eggs in pellets of manure, holding them between their hind legs, and rolling them away to a place of safety. The species of *Aphodius* live also in manure; they are quite small, nearly cylindrical, with the mouth-parts concealed by the clypeus; the antennæ are nine-jointed, the club consisting of three joints, and the lobes of the maxillæ are membranaceous, unarmed, while the upper parts of the eyes are visible in repose. *Aphodius fimetarius* Linn., which is black with bright red elytra, has been introduced from Europe, and is abundant in woods, flying over dung; it is now common in the carriage road of Mount Washington. Fig. 406 represents the larva of the European *A. fossor* Linn. Chapuis and Candèze found it in manure in spring. *Geotrupes* has eleven-jointed antennæ, with the club three-jointed, the middle coxæ are contiguous, and while the club of its nearest ally, *Bolboceras*, a shorter insect, is large and lenticular in form, that of the present genus is lamellate, as usual. *Geotrupes splendidus* Fabr. is a common beetle, with a bright shining green body, flying in paths and wood roads late in the summer. The species of *Trox* differ in having slightly fossorial legs; they are oblong convex, the surface being very rough and covered with dirt which is scraped off with difficulty. They live in dried decaying animal matter, and, according to Leconte, "possess a distinct stridulating organ; it is an elliptical plate, with pearly reflections, occupying the upper part of the external face of the ascending portion of the first ventral segment, and is covered by the elytra; on the inner surface of the elytra, near the margin, about opposite the thorax, is an oval, smooth, polished space, which has, probably, some connection with the stridulating organ." The larva of "*Trox Carolina* Dej." (T. scabro-

Fig. 406.

sus Beauv. Fig. 407), is described by Chapuis and Candèze as coming from New Orleans.

Melolontha and its allies come next in the series. They feed exclusively on living plants. The genus *Acratus* was estab-

Fig. 407.

lished by Dr. Horn for *A. flavipennis* Horn (Fig. 408; *a*, antenna; *b*, maxilla; *c*, mentum; *d*, mandible; *e*, anterior leg and tarsal claw) found in Arizona. The genus *Dichelonycha* is distinguished by the front margin of the thorax being narrow and membranous, with equal claws, cleft at the tip. *Dichelonycha elongatula* Schönh. is a long green beetle, with long legs, and of a metallic green color; it is found in June on the leaves of the birch.

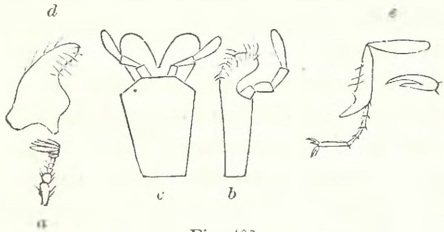


Fig. 408.

Macrodactylus subspinosus Fabricius, the well known Rose-bug or Rose-chafer, is brown, covered with ochreous scales; the legs, tarsi and claws are very long and slender. It overruns garden plants, especially injuring the rose leaves. Dr. Harris has observed the transformations of this insect. The nearly globular whitish eggs, about thirty in number, are deposited by the female from one to four inches beneath the surface of the soil, and are hatched in about twenty days. The whitish larva becomes fully grown in the autumn, and is then three-quarters of an inch long and an eighth of an inch wide. In October it descends below the reach of frost, and in the next May is transformed to a pupa in an oval earthen cell. The pupa is yellowish white,

Fig. 409.

somewhat of the form of the beetle, with short wings; its antennæ and legs folded on its breast, with its white body surrounded by a thin film. The beetles may be often seen in clusters on low bushes in partially cleared fields having just appeared from their cocoons. Dr. Horn has described the genus *Plectrodes* for a Californian species, *P. pubescens* Horn (Fig. 409; *a*, maxilla and palpus; *b*, tarsal claw). The well known June-bug or Dor-bug, *Lachnosterna fusca* Frohl (Fig. 410, 411, larva; 412, side view of pupa), lives as a larva on the roots of grass and is often turned up by the spade or plough. It is then a large fleshy grub, very commonly met with, and is injurious to growing corn and wheat. The pupa is found in its rude earthen cocoon in May. The beetles are very injurious to the leaves of fruit trees. They are chestnut brown, with yellowish hairs beneath, and nearly an inch in length. There are several smaller, closely allied species. *Melolontha* (Polyphylla) *variolosa* Harris differs in its enormously developed six-jointed lamellate antennal club, that of the female being much smaller.

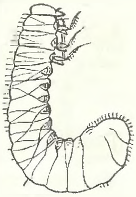


Fig. 410.

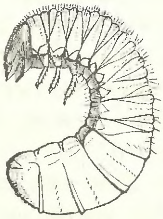


Fig. 411.

In *Anomala* the body is small, the antennæ nine-jointed, and the mandibles when at rest do not project beyond the clypeus. Such is *Anomala varians* Fabr., which is very injurious to the vine in June and July. *Pelidnota punctata* Linn. has similar habits. It is oblong oval, very convex above, with dull brownish yellow elytra, with three large black dots on each side. It is often abundant on grape-vines in July and August, and proves very injurious.

The *Cotalpa lanigera* Linn. (Fig. 413; *a*, larva) or the Goldsmith beetle, is nearly an inch long, bright yellow, with long white, woolly hairs beneath, where it is metallic green. It often injures fruit and shade trees, and Mr. S. Lockwood states that in the larva state it destroys the roots of the strawberry plant. He remarks that on the 16th of June a pair of Cotalpas coupled, and in the evening the female burrowed beneath the dirt, reappearing the next morning, having meanwhile laid at different depths, and singly, fourteen white, long, oval eggs; on the 13th of July the larvæ hatched, being five-sixteenths of an inch long. (American Naturalist, vol. ii, p. 441.)

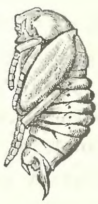


Fig. 412.

In *Dynastes* the labial palpi are inserted on the sides of the mentum, which is acuminate in front; the head and thorax are armed with large horns in the males; the first joint of the posterior tarsi is not elevated, and there are no stridulating organs. Our only species is *Dynastes Tityrus* Linn., found in the Southern States. It is over two inches long, of a greenish gray color, with black spots scattered irregularly over the elytra. *Dynastes Hercules* Linn., one of the giants of the family, is about six inches long.

The genus *Cetonia* and its allies are flower beetles; their mandibles are feebly developed and in part membranous and concealed with the other oral organs beneath the clypeus; and in flying they "do not raise or expand the elytra, as most Coleoptera do, but pass the wings from the side, under the elytra, which do not at all embrace the sides of the body." (Leconte.)

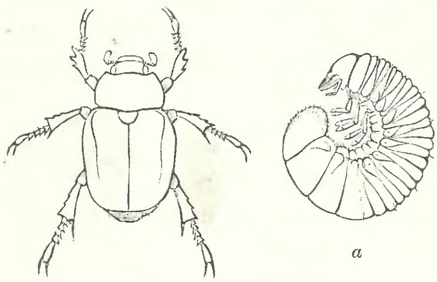


Fig. 413.

The immense Goliath beetles of the western coast of Africa belong to the genus *Goliathus*, in which the clypeus of the males is generally forked or armed with horns. Dr. Harris has proposed the name of *Hegemon* "for the subgenus, including the princely *Scarabæus Goliathus* of Linnæus, together with the still more magnificent *Goliathus Drurii* of Westwood, and the *G. Cacicus* of Gory and Percheron." Of Hope's subgenus *Mecynorhina*, the Scarabæus Polyphemus of Fabricius is the type; it is velvet green above, with a pale buff head and markings, and is two and a half inches long, exclusive of the horns. Dr. Harris has also described as new to science *M. Savagii* which has a velvet green thorax, and velvet black elytra, with tawny bands and spots; it is about two inches long. The *G. Goliathus* is perhaps the largest of all the Coleoptera; specimens measuring nearly four inches. Dr. G. A. Perkins of Salem, Mass., who collected a large part of the fine series of specimens of these Goliath beetles in the Museum of the Peabody Academy of

Science, informs me that they are found in the tops of trees where they feed on flowers and on sap exuding from wounds in the bark, like the Cetoniæ, and that the natives obtain them by jarring the trees. Harris states that "it appears, from the observations of Dr. Savage, that the food of the Goliath beetles is fluid, like that of the Trichii and Cetoniæ, insects belonging to the same natural family, but the latter live chiefly on the nectar of flowers, and the former on the sap of plants. The long bushes on their jaws, and the diverging rows of hairs that line their lower lips, are admirably fitted for absorbing liquid food; while their horny teeth afford these beetles additional means for obtaining it from the leaves and juicy stems of plants, when the blossoms have disappeared."

From *Cetonia*, Lacordaire has separated the genus *Euryomia*, distinguished by the untoothed maxillæ, by the clypeus being usually parabolic, sometimes parallel and rarely emarginate in front. *Euryomia Inda* Linn. attacks ripe peaches, spoiling them for the market. They are found about running sap in April and flying in fields in May, and a new brood appears in September. In *Osmoderma* the elytra are not sinuate on the sides, the prothorax is narrower than the elytra and usually rounded on the sides. *Osmoderma scabra* Dej. is a large long-legged beetle of a coppery purplish black color. The larva lives in decaying cherry and apple trees. According to Harris it is a whitish fleshy grub, with a reddish corneous head, and closely resembles the grub of the common dor-beetle. In autumn it forms an oval cocoon by gluing together the chips it makes, and the beetle appears in July.

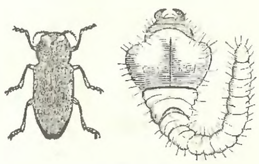


Fig. 414. *a*

Buprestidæ Leach. This very extensive family is known by the serrated antennæ, the outer joints of which are usually furnished with pores, which are either diffused on the sides, or concentrated in a cavity (fovea) on the under side or at the tip. The head is deeply sunken up to the elliptical eyes, and the labrum is small and prominent, while the mandibles are short and stout. The legs are short, the tibiæ are usually slender, and the species are generally long, flattened beetles of very tough thick consistence, and are found on flowers, or sunning themselves on the bark of trees in midsummer. The larvæ are flattened footless grubs, with the prothoracic ring greatly enlarged.

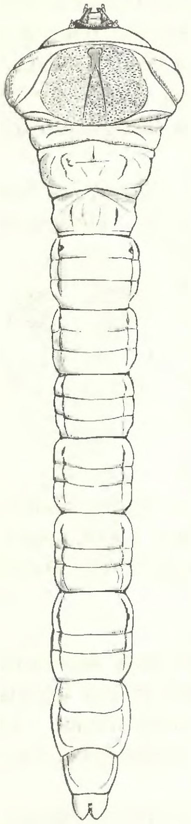


Fig. 416.

In *Chalcophora* the antennal pores are diffused on the sides of the joints, or only on the lower margin; the mesosternal suture is indistinct; the antennæ are inserted in small foveæ, and the posterior tarsi have the first joint elongated. *C. Virginiensis* Drury is one of our most common species, and may be seen flying about pine trees in hot days in May and June. Its larva bores into pines, often proving very injurious.

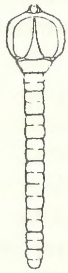


Fig. 415.

Dicerca is noted for having the tips of the elytra lengthened out and diverging from each other. *Dicerca divaricata* Say is frequently met with; it is smoother than usual and highly polished with a bronzed hue. The elytra are marked with numerous fine irregular impressed lines and small oblong square elevated black spots. The larvæ attack the wild cherry and the garden cherry and peach. *Dicerca lurida* Fabr. is found on the trunks and limbs of the hickory.

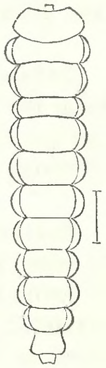


Fig. 417.

The genus *Chrysobothris* differs in having the antennæ inserted at the inner extremity of two short oblique grooves, by which the front is narrowed; the anterior femora are strongly toothed, the third joint of the tarsi is truncate, while in the hind tarsi the first joint is elongated. The species are rather broad and flattened, with impressed bands and spots on the elytra. *Chrysobothris femorata* Fabr. (Fig. 414; *a*, larva; Fig. 415, larva of the same genus, found under bark of oaks) is greenish black above, with a brassy polish; it infests the apple and oak, in which it lives one year. *C. Harrisii* Hentz inhabits the small limbs of the white pine. It is also very injurious to apple trees and red maples. To prevent its attacks Fitch recommends placing a piece of soap in a fork in the tree so that it will be washed down by the rains over the bark, while young trees may be rubbed with soap; this is an excellent remedy against the attacks of all kinds of borers.

The genuine species of Buprestis occur in Europe. The largest species of this family known to us is the *Euchroma Columbica* Mann. which occurs in Central and South America. It is two and a half inches long and metallic green. Mr. McNiel has sent to the Museum of the Peabody Academy several immense white larvæ (Fig. 416, natural size), from Nicaragua, which are, without much doubt, the young of this gigantic beetle.

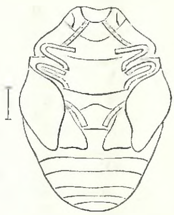


Fig. 418.

The small, flattened, ovate, angular *Brachys* is probably a leaf miner, as such are the habits of the closely allied genus *Trachys* (T. pygmæa, Fig. 417, larva; 418, pupa), as observed in Europe where it mines the leaves of the Malva and Alcæa, according to M. Leprieur.

Throscidæ Laporte. This small group has been separated from the succeeding family; the species differ in not having the power of leaping, owing to the immovable thorax. In *Throscus* the antennæ are terminated by a three-jointed club.

Elateridæ Leach. A very large and easily limited family, in which the serrate, eleven-jointed antennæ, are inserted upon or under the margin of the front, in grooves, while the head is retracted, though sometimes free as usual from the prothorax, between which and the mesothorax is a loose articulation, enabling the species to leap in the air by a sudden jerking movement, which Dr. Leconte thus describes: "a few of the species of the first subfamily (Eucnemidæ) and a majority of those of the third (Elateridæ), possess the singular power of springing in the air when placed on the back. This is effected by extending the prothorax so as to bring the prosternal spine to the anterior part of the mesosternal cavity, then suddenly relaxing the muscles so that the spine descends violently into the cavity, the force given by this sudden movement causes the base of the elytra to strike the supporting surface, and by their elasticity the whole body is propelled upward."

The larvæ, known by the name of Wire-worms, are vegetable feeders, living on the roots of grass, wheat, corn, potatoes, turnips and other garden vegetables. Fig. 419 (enlarged four times) represents a larva of this family found by Mr. Sanborn in the roots of the squash vine. The eggs are laid probably in pastures and fallen ground where the surface is undisturbed, or in the vicinity of rotten wood. The larvæ moult three times, and some species are known to live in this state five years. When fully grown they transform in an earthen cocoon, and may be seen rising out of the ground during the summer, especially in June. The larvæ are very long cylindrical (whence their name wire-worm), hard-bodied and difficult to kill, and are generally pale testaceous, or yellowish red in color. They have only six thoracic legs, and a slight anal prop-leg; the body is flattened towards the head and tail.

Fig. 419.

Eucnemis differs from the true Elaters in the serrate antennæ being inserted in approximate grooves at the margin of the thorax beneath, which makes the clypeus narrow. The species do not leap so vigorously as those of other leaping genera. *Fornax* differs from *Eucnemis* in the antennæ being filiform. In *Adelocera* (Fig. 420, A. obtecta Say) the third joint of the antennæ is equal to, or larger than the fourth. In *Elater* and its allies, the antennæ are widely separated, being inserted in small cavities (foveæ) under the margin of the front, and before the eyes. *Alaus oculatus* Esch. is the largest Elater we have, the scutellum is oval, and the elytra have a broad margin. The genus *Elater* has the front of the head convex and margined quite broadly, and the thorax is always

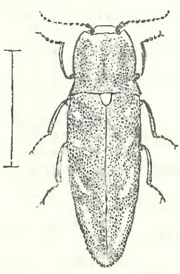


Fig. 420.

narrowed in front, with the tarsi ciliate beneath, and entirely simple. *Elater obliquus* Say is a small species about a quarter of an inch long, of a leathery brown color, and yellowish red on the prothorax and base of the elytra. In *Agriotes* and allies the front is very convex, the edge of which is higher than the labrum; the antennæ are slender, scarcely serrate, the first joint being a little longer than usual.

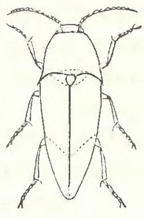


Fig. 421.

In *Ludius* the front is convex, but not margined behind the labrum, the angle of the hind coxæ are acute and prominent, while the mesosternum is not prominent. Mr. Walsh has found the larva of *L. attenuatus* Say (Fig. 421; fig. 422, larva) which lived in decaying wood for two years in his breeding jar. The genus *Agriotes* has the margin of the prothorax bent down in front, while in *Dolopius* it is straight. *Agriotes mancus* Say is a pale reddish brown species, while *A. stabilis*, much more abundant northward, is slenderer, of a darker hue, with a dark shade along the inner edge of each elytron. *D. pauper* Lec. is a small species found northward.

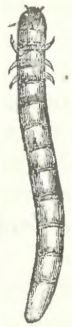


Fig. 422.

Melanotus includes some of our most common species, such as *M. communis* Gyll., which is of the usual dull brown color. The genus may be known by the front being moderately convex, margined anteriorly, and the antennæ are serrate, with the first joint of the usual size, while the prothorax is lobed in front, and the claws are strongly pectinate. Fig. 423 represents a larva probably of this genus.

Fig. 423.

In *Limonius* and *Athous* the front is margined, the mouth placed farther forward from the prosternum, the coxal plates are narrow, gradually dilated inwards, and the first joint is only moderate in length. In *Limonius* the first tarsal joint is scarcely longer than the second, while in *Athous* the first tarsal joint is elongated, and the prosternal lobe is long. *Limonius plebeius* Lec. and *L. ectypus* Say are obscure reddish brown insects, with a slight fine pubescence.

In *Corymbites* the front is more or less flattened, and the coxal plates are narrow externally. *C. æripennis* Lec. is a shiny dark greenish species and is found northward. *C. viridis* Say is dull mahogany brown, mottled with a fine grayish bloom. *C. cylindriformis* Germ. is more common, and of the usual dull reddish brown. *C. triundulatus* Lec. is frequently found in New England, and has three transverse waved bands on the pale elytra; it is found on the blossoms of the rhubarb plant. *C. hieroglyphicus* Harris (Fig. 424, elytra) is a similar form.

Fig. 424.

To the genus *Pyrophorus* belong the different species of Fireflies of Central and South America. *P. noctilucus* (Fig. 425, natural size) is dark rusty brown, and has two large eye-like luminous spots on the sides of the thorax, and another at the base of the abdomen. Dr. G. A. Perkins in the "American Naturalist," vol. ii, p. 428, states that "by placing the luminous parts of one insect quite near the paper, very fine print can be easily read by its aid, though I cannot imagine the light, even of a large number, to be sufficient for any practical illuminating purposes as has been affirmed by some writers. The Cuban ladies make a singular use of these living gems, sewing them in lace bags, which are disposed as ornaments upon their dresses, or arranged as a fillet for their hair."

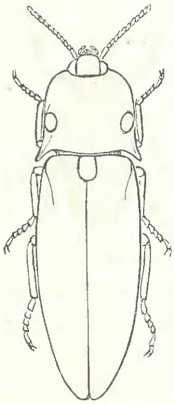


Fig. 425.

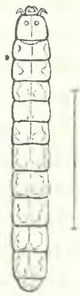


Fig. 426.

The species of *Melanactes* are large shining black insects found under stones, and are known by having the coxal plates gradually dilated inwards. The larvæ (Fig. 426, a luminous larva of this genus discovered by Mr. Sanborn in Roxbury, Mass.) are luminous and differ from others of this family, according to Osten Sacken, by their small sunken head, and the presence of a pair of ocelli. The abdomen ends in a prop-leg.

CEBRIONIDÆ Westwood. This family differs from the preceding group in the greater number (six) of abdominal segments, the well developed tibial spurs, the expansion of the anterior tibiæ at the apex, and in the close connection between the front and the labrum. The females are found at the entrance of holes which they excavate in the ground. (Leconte.) In *Cebrio* the labrum is separated by suture from the front, and the anterior tibiæ are entire. *Cebrio bicolor* Fabr. is found in the Southern States.

RHIPICERIDÆ Latreille. In this small group the head is prominent and the maxillæ have usually but a single lobe; the eleven-jointed antennæ are inserted before and in front of the eyes, under ridges, and are serrate in the females and frequently flabellate in the males. The larvæ, in their general appearance, resemble those of the *Elateridæ* or *Tenebrionidæ*, being cylindrical, the head almost of the same breadth as the body, which is hard and horny, more or less dark brown, and in *Zenoa picea* Beauv. is a little more than an inch in length. "The eighth segment is punctate all around, and more densely than the others. The posterior part of this segment is obliquely truncate, and is closed posteriorly by a round, flat, horny piece, punctate on the outside and which can, to a certain extent, be opened and closed like a lid, being connected by a hinge superiorly, and an expanding membrane inferiorly. This lid is to be considered as the ninth segment of the abdomen." (Osten Sacken.) The larva, with the adult Zenoa picea, was found under bark in Southern Illinois by Mr. Walsh. *Sandalus* (S. petrophya Knoch, and tarsus, Fig. 427), with short antennæ, flabellate in the males, is found in various species of cedars.

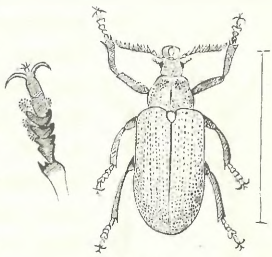


Fig. 427.

SCHIZOPODIDÆ Leconte. This small group is represented by only a single species, *Schizopodus lætus* Leconte. It resembles in form a Galleruca; it is of a metallic green color, coarsely punctured, with red elytra, and is nearly six-tenths of an inch long. The head is bent down, closely affixed to the prothorax, and the eleven-jointed antennæ are inserted immediately in front of the eyes, under a slight prominence.

Dascyllidæ Guérin. This group embraces genera differing much from each other; the head is usually bent down, sometimes prominent; the antennæ are eleven-jointed, distant at their insertion immediately in front of the eyes, being placed under a slight ridge, and the mandibles are not prominent. They all live on aquatic plants, and the larvæ are either like those of the *Scarabæidæ*, being provided with short four-jointed antennæ, and without ocelli, as in *Atopa;* or they are long, ovate, with distinct ocelli, long bristle-like antennæ and very well developed limbs, as in *Cyphon*. The genus *Prionocyphon* has the first joint of the antennæ much dilated, and the joint of the labial palpi is inserted on the side of the second; in *Cyphon* the palpi are normal. Baron Osten Sacken describes the larva of *Prionocyphon discoideus* Say as being long, flattened ovate, like a sow-bug (Oniscus) with sharp lateral edges, the body slightly attenuated before and behind, of a leathery consistence, dull pale yellowish, and four-tenths of an inch in length. It was found by Mr. Walsh in the hollow of an oak stump filled with water, in which it "vibrated vigorously up and down a pencil of hairs proceeding from a horizontal slit in the tail; this pencil is composed of three pairs of filaments, each beautifully bipectinate. When at the surface this larva generally, but not always, swims on its back, keeping its body slightly below the surface, and striking with its feet, so as to jerk from point to point, in a curved line. The pencil of hairs touches the surface all the time. "Occasionally, says Mr. Walsh, "a bubble of air is discharged from the tail. Generally, when it is beneath the surface, the anal pencil is retracted entirely. It has the power of jerking its body suddenly round, and darting up and down with great vigor. Its remarkably long antennæ are constantly vibrating, like those of terrestrial insects. The pupa is white, with large black eyes which are very conspicuous beneath, and two short black setæ on the occiput. The body is covered with a short, white, erect down or pubescence. The antennæ are about two-thirds the length of the body, placed lengthwise beneath, side by side. The body is scarcely two-tenths of an inch long.

LAMPYRIDÆ Leach. The species of the family of Fire-flies resemble the Elaters, but they are shorter and broader, and of softer consistence. The head is usually immersed in the thorax; the usually eleven-jointed, serrate, rarely pectinate or flabellate antennæ are inserted on the front rather closely together in the typical genera. The elytra never strongly embrace the sides of the abdomen, are sometimes short, and in some foreign genera entirely wanting in the females. The anterior coxæ are contiguous, conical, with a large trochantine; the middle coxæ are oblique, and the hinder ones transverse; while the legs are slender or compressed and of moderate length. The larvæ are rather long, flattened, blackish, with pale spots on the angles of each segment.

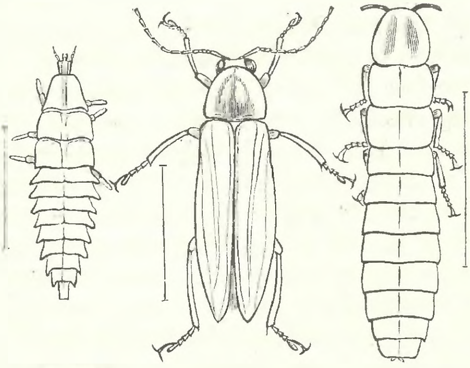


Fig. 432. Fig. 430. Fig. 428.

In *Lycus* the antennæ are inserted in front of the eyes, at the base of the long beak into which the head is prolonged, and the sides of the thorax are somewhat foliaceous. The female of the Glow-worm, *Lampyris*, of Europe is wingless. She lays her eggs, which are of large size, in the earth or upon moss and plants; the larva (Fig. 428, female of a species of this genus from Zanzibar), which feeds on snails, is said to become fully grown in April, and in fifteen days assumes the imago state. An anonymous French author states, according to Westwood, that when the larva is ready to assume the pupa state, instead of slitting the skin in a line down the back, a slit on each side of the three thoracic segments is made, separating the upper from the lower surfaces." While the female is large and larva-like, the much smaller male has broad elytra and a rather narrow slender body.

In the genus *Photinus*, of which there are numerous species in this country, the antennæ are compressed, or nearly filiform, and the species differ from those of Lampyris, by the females having wings. Nearly all have phosphorescent glands in the last abdominal segments.

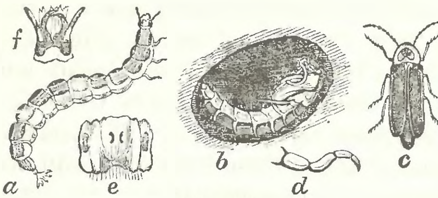


Fig. 429.

The editors of the "American Entomologist," p. 19, give the history of *P. pyralis* Linn. (Fig. 429; *a*, larva; *e*, underside of a segment; *f*, head; *d*, a leg; *b*, pupa in its cocoon of earth; *c*, the adult). The larva lives in the ground, feeding on earthworms and soft bodied insects. When fully grown, or during the latter part of June, it forms an oval cavity in the earth and pupates, and in ten days becomes a beetle.

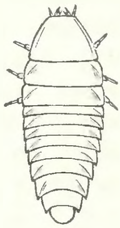


Fig. 431.

In *Photuris* the wings and elytra are complete in both sexes, while the head is narrowed behind, and the labrum is distinct. *P. Pensylvanica* DeGeer (Fig. 430, and 431, larva) is our most common species, and the larva figured I regard as belonging to this species. It is not uncommonly met with in the evening shining brightly as it crawls along, and is blackish and crustaceous like a pill bug. Another Photuris larva (Fig. 432) I have found under a stone in May. It is represented as in the act of walking, the feet on one side of the body moving alternately with those on the other. This is the mode in which insects usually walk.

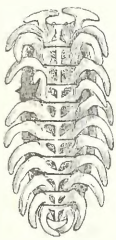


Fig. 433.

Fig. 433 (enlarged three times) represents a very singular larva, evidently belonging to this family, and related to the genus *Drilus*. It was found by Rev. E. C. Bolles, at Westbrooke, Maine, under leaves, and it probably, like other larvæ of this family, is carnivorous. Its body is very flat, with the sides of the head and each ring of the body produced into a remarkably long, soft, fleshy tubercle, while there are two rows of black spots along the back.

In the genus *Phengodes*, the females of which are not yet known in this country, the third and following joints of the antennæ emit two very long, slender and flexible pubescent branches from near the base; the second and third joints are very short. The elytra are one-third the length of the abdomen, and are strongly divergent and subulate. Dr. Leconte describes *Phengodes plumosa* Oliv. as being testaceous, with the antennæ, excepting the base, and the narrow tips of the elytra fuscous, and the sides of the thorax broadly depressed; it occurs from New York to Texas. In *Chauliognathus* the antennæ are filiform; the elytra are as long or nearly as long as the abdomen and rounded at tip, while the anterior margin of the thorax is rounded. *C. Pensylvanicus* DeGeer (Fig. 434; *a*, larva; *b*, head enlarged; *c*, labium; *d*, labrum; *e*, a leg: *f*, maxilla; *g*, antenna; *h*, mandible), in the larva state devours the grubs of the plum curculio. (American Entomologist, i, p. 35.) In *Telephorus* the head is never concealed by the thorax, and the latter is rounded from the sides along the front margin, the front of the head is emarginate at tip; the claws are toothed, being rarely cleft. The species are found on the leaves of trees in June. Walsh states that the larva of *T. Carolina* Fabr. preys on wood-feeding larvæ. Mr. P. S. Sprague has reared the larva of *T. bilineatus* Say. He found it near Boston under stones in spring, when it pupates, and early in May becomes a beetle. It is found on the leaves of the birch as soon as they are expanded.

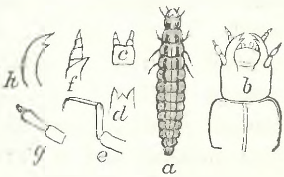


Fig. 434.

Malachidæ Redtenbacher. This small group, often united with the preceding family, is chiefly distinguished by the antennæ being inserted on the sides of the front, and by the body in some genera being furnished with soft extensible vesicles, while the abdominal segments are in part membranous. *Malachius* and its allies are of small size. Some of them resemble at first sight some Staphylinidæ; they frequent flowers and the banks of ponds and streams. The females of *Microlipus* are apterous.

Cleridæ Kirby. These beautiful flower beetles are known by the prominent head, the usually emarginate eyes, and the usually eleven-jointed antennæ inserted at the sides of the front, and either serrate or pectinate, with the outer joints enlarged, forming a serrate, or rarely a compact club. Their bodies are slender, with slender legs. They are rapid in their movements, and run like ants (which they much resemble when in motion) over flowers and trees to feed on the sweets and sap. The larvæ are carnivorous and infest the nests of bees. They are flattened, hairy grubs, the tip of the abdomen ending in two horny points. Those of the genera *Corynetes* and *Necrobia* live on dead animal matter.

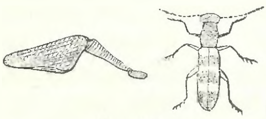


Fig. 435.

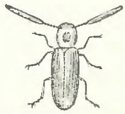


Fig. 436.

In *Priocera* (Fig. 435, P. undulata Say) the eyes are coarsely granulated; the antennæ are serrate, and the maxillary palpi are cylindrical. In *Elasmocerus* (E. terminatus Say, ♂, Fig. 436) the antennæ are ten-jointed, the last joint being very long and flat.

The genus *Trichodes* is known by the maxillary palpi being somewhat dilated, otherwise it agrees with the succeeding genus. *T. Nuttallii* Kirby is abundant in August on the flowers of Spiræa alba; its larva is to be looked for in the nests of bees. In Europe *T. apiarius* Linn. (Fig. 437; *a*, larva; *b*, pupa) has long been known to devour the young bees. In its perfect state it is found on flowers.

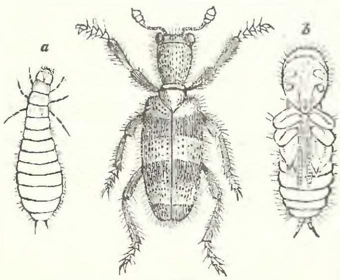


Fig. 437.

In *Clerus* the head is large, the eyes not very prominent, finely granulated, the antennal club is somewhat triangular; the maxillary palpi are not dilated, and the posterior tarsi are moderate in length and broadly dilated. *Thanasimus* differs in the body being hairy, while the posterior tarsi are longer and scarcely dilated. The long narrow slender pink larvæ can be found under the bark of dead pine trees where they probably prey upon the larvæ of Hylurgus and Hylobius. The larvæ of Clerus are of a beautiful red color. The European *Clerus alvearius* infests the nests of the Mason-bees, Osmia and Megachile. "The larva when hatched, first devours the grub of the bee in the cell in which it is born and then proceeds from cell to cell, preying upon the inhabitant of each until arrived at maturity. It is in this situation, also, that it undergoes its changes in a small cocoon, which it has previously constructed, making its escape from the nest in the beetle state, where the hardness of its covering sufficiently defends it from the stings of the bees." (Westwood.)

LYMEXYLIDÆ Leach. This small group, chiefly interesting as containing a genus which has proved of great mischief to the ship timber of Europe, from its boring habits, is distinguished by the head being bent down and narrowed behind; by the usually very large eyes, the two ciliate lobes of the maxillæ, the palpi of which are stout, four-jointed, and in the male very large and flabellate, while the mandibles are short and obtusely bidentate. The body is long and narrow, with slender legs. The genus *Lymexylon* has five abdominal segments. The larva is very long and slender, with the first thoracic segment dilated into a large hood, while the terminal ring is produced into a large obtuse lobe. In Europe it greatly injures oak trees and ship timber, but our species (Lymexylon sericeum Harris, Fig. 438, and antennæ, legs and palpi) is too rare to be of any harm at present.

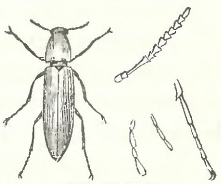


Fig. 438.

CUPESIDÆ Lacordaire. Leconte states that "the affinities of this family are very obscure; in the form and insertion of the antennæ it is similar to the first genera of the next family, but other characters, such as the form of the coxæ and the retractility of the legs, are at variance. The body is covered with small scales as in the genera alluded to." *Cupes capitata* Fabr. is black with the head red; while *Cupes cinerea* Say is pale gray, with darker lines. They are found under the bark of decaying trees, and also occasionally in houses. (Leconte.)

PTINIDÆ Leach. These are small beetles, often of an obscure brown color, somewhat oval in shape, and truncated behind; the nine-jointed filiform antennæ are inserted on the front, or sides of the front; the head is retractile, frequently protected by the prothorax; the labrum is distinct; the maxillæ have two ciliate lobes, and the maxillary palpi are short and four-jointed. The legs are slender, contractile, and the insect when disturbed draws them up and feigns death. In *Ptinus* the antennæ are inserted on the front very close together, the legs are long, not contractile, with large trochanters; the teeth of the mentum are acute, and the labrum is rounded. The males differ from the short and thickened females in being long and narrow. The beetles are found about out-houses, the wood of which they perforate in various directions. *Ptinus fur* Linn. (Fig. 438; *a*, larva), the most commonly diffused species, is known to attack museums and collections of insects. It is .15 of an inch in length, and uniformly chestnut brown in color. The larva here figured was found eating the dried contents of a shell in the Museum of the Peabody Academy of Science.

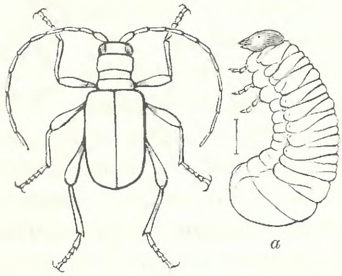


Fig. 439.

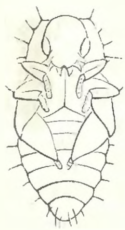


Fig. 440.

Sitodrepa panicea Fabr. (Fig. 440, pupa) is a small insect like Anobium, of a pale reddish brown color, with much paler dense hairs. It is .13 of an inch long. The larva resembles in its form that of Ptinus, but the body is much thicker, not growing smaller towards the head as in that genus; the end of the body is smooth, obtusely rounded, with fine hairs; it is .08 of an inch long and undoubtedly grows larger. It occurred in all its stages and in great abundance in several nests of Vespa in the Museum of the Peabody Academy, where it undoubtedly eat the dried remains of the wasps; it was extensively preyed upon by a Pteromalus-like Chalcid.

The genus *Anobium* is cylindrical, the eleven-jointed antennæ are distant from each other at base and inserted immediately in front of the eyes, the mesosternum is flat, and the anterior coxæ are nearly contiguous. The larva is thick and fleshy, resembling some Scarabæid larvæ in the fleshy baggy tip of the abdomen, except that they do not lay on their side when walking. They construct a silken cocoon interweaving the particles of dust they make. *A. notatum* Say is blackish above, varied with ashen, and the posterior angles of the prothorax are rather acute. In Europe they are called Death-ticks, as the ticking made by them in the walls of houses, a familiar sound in this country, was supposed by the superstitious to announce the death of persons, though it is but a sexual call. Doubt having been thrown on the statement that Anobium causes the ticking noise, Mr. H. Doubleday states in the "Entomologist," vol. iii, p. 66, "I can speak positively with regard to the Anobium, and I assure you that this little beetle produces the loud ticking sound by raising itself upon its legs as high as it can, and then striking the head and under part of the thorax against the substance upon which it is standing, generally five or six times in succession, and it always chooses a substance which produces the most sound. It is evidently a call note from one individual to another, as you very rarely hear one rap without its being immediately answered by another." Mr. Sanborn has reared the larva (Fig. 441, enlarged) of *Ernobius mollis* Fabr., which is a near ally of Anobium.

Fig. 441

Fig. 442.

Bostrichus and its allies are distinguished by their long bodies, the head being usually bent down and covered by the hood-like thorax; the antennæ are distant and the anterior coxæ are contiguous. They are found in fungi or under bark. In *Bostrichus* the front is margined on the sides. In *Amphicerus* the front is not so margined. The apple twig borer, *A.*

bicaudatus Say (Fig. 442) in the valley of the Mississippi, is very injurious to apple trees, boring under the bark of small twigs "just above one of the buds, and on cutting into them it will be noticed that a cylindrical hole, about the size of a common knitting needle, extends downwards from the perforation above the bud, through the very heart of the twig, for the length of an inch and a half." (Walsh.) The larva which I have received from Dr. Shimer, has much the same form as that of Lyctus, but the head is more prominent and also the sides of the body. The anterior half of the body is considerably thicker than behind and the legs are provided with long hairs; the end of the body is smooth and much rounded. It is .30 of an inch long.

Specimens of *Rhizopertha pusilla* have been introduced, Leconte states, into wheat distributed from the Patent Office. In this last genus the eighth and ninth joints of the antennæ are triangular.

In the genus *Lyctus* the head is prominent, the body long and narrow, and the club of the antenna is two-jointed, while the outer apical angle of the anterior tibiæ is prolonged. We have received from Dr. H. Shimer, *L. opaculus* Lec., in all its stages (Fig. 443; *a*, larva; *b*, pupa). The beetle is chestnut brown, with short yellowish hairs and puncto-striate elytra; it is .20 of an inch in length. The larva is white, its body is cylindrical, thick and fleshy, with a small head and strong black mandibles; the thoracic rings are thickest. It is .17 of inch long. According to Dr. Shimer it eats the wood of dead grape vines.

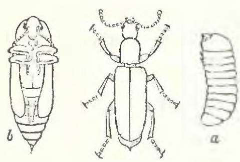


Fig. 443.

CIOIDÆ Leach. This small group is known by the maxillæ being exposed at the base, the two ciliate lobes of which are flattened, and the eight to ten-jointed clavate antennæ are inserted at the anterior margin of the eyes; the head is protected by the prothorax, which is cylindrical, rounded in front, with the lateral margin distinct. The species of the genus *Cis*, which have ten-jointed antennæ, are very small, cylindrical, dark colored, gregarious beetles, which live under the bark of trees, and in dry, woody species of fungi. Some males have the head and anterior margin of the thorax horned.

TENEBRIONIDÆ Latreille. This is not a very easily limited family; the most trenchant characters, however, are stated by Leconte to be these: the two-lobed maxillæ have the smaller lobe sometimes armed with a terminal corneous hook; the palpi four-jointed; the mandibles are usually short, robust and furnished with a basal tooth; the eyes are usually transverse, and the antennæ are generally inserted under the sides of the head, or at least under a small frontal ridge, and are usually eleven-jointed, clavate, subserrate or very rarely pectinate, as in *Rhipidandrus*. The elytra are rounded at tip, covering the abdomen, and frequently embracing its sides very far down, while the hind wings are frequently wanting. The legs vary in length; the anterior coxæ are globose, without any trochantine; the hind tarsi are four-jointed, and the abdomen has five free segments, the first three appearing more closely united than the others. The larvæ are slender, flattened, horny, resembling the wire-worms; from two to five ocelli on each side, or wanting entirely, and the last ring of the body often has two spines. The larvæ (Fig. 444, larva of an unknown species) moult several times, and when about to transform make no cocoon, the beetles appearing in about six weeks. Dr. Leconte says that the distribution of the genera of this family is very remarkable. Of those without wings scarcely any are common to the two continents. With the exception of three, they are not represented in North America, east of the longitude of the mouth of the Platte or Nebraska River; from that point they increase in number of genera, species and individuals, until in California they form the characteristic feature of the insect fauna."


Fig. 444

We can only notice a few genera, interesting to the general reader, and refer the special student, as heretofore, to Dr. Leconte's able treatment of the Coleoptera previously cited.

The genus *Blaps*, in which the hind wings are obsolete, does not occur in this country, being represented by numerous species of *Elodes* and *Promus*. The European *Blaps mortisaga* is the Church-yard beetle. Dr. Pickells states, according to Westwood, that "one of these beetles was immersed repeatedly in spirits of wine, but revived after remaining therein all night, and afterwards lived three years." The larvæ are eaten by the women in Egypt, after being roasted.

In *Upis* the legs are long, with small tibial spurs, while the tarsi are clothed beneath with a silky, golden pubescence, the hind tarsi being long, and the epipleuræ are gradually narrowed towards the base of the elytra. *Upis ceramboides* Linn. is a fine large, deep purple black beetle, with roughly shagreened elytra, and is found under the bark of trees. In *Tenebrio* the body is long ovate and winged, the legs are slender, the femora swollen less than usual, with larger tibial spurs; the tarsi are clothed with a rigid pubescence, and the epipleuræ extend to the tip of the elytra. *Tenebrio molitor* Linn., the Meal worm, is found in all its stages about corn and rye meal; it is frequently swallowed with food. "It is also very destructive to ship-biscuits packed in casks, which when opened are found eaten through in holes by these insects and their larvæ." (Westwood.) The larva is about an inch long, cylindrical, smooth and glossy, with the terminal segment semicircular, slightly serrated on the edges, and terminated in a single point. An allied beetle in Brazil is known to eject a caustic fluid, and in Europe some are known to cover themselves with this fluid. In *Boletophagus* the antennæ are eleven-jointed and the eyes are entirely divided. *B. cornutus* Panzer (Fig. 445, ♀, *a*, larva; *b*, pupa, ♂), as its name implies, lives in those fungi, which, according to Dr. Leconte, either grow upon trees or under bark, and may be known by the front of the head being prolonged and margined anteriorly and on the sides, covering the mouth above, often thus dividing the eyes, while the dull black body is covered with stout tubercles. It is found in all its stages in fungi, in August. The

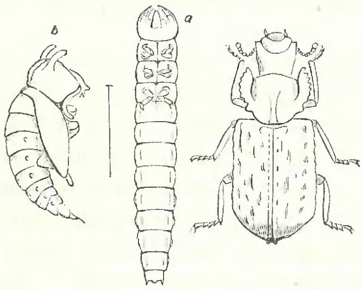


Fig. 445.

larva is long and narrow, cylindrical, the head free from the body, rounded, with stout, broad, triangular mandibles; the tip of the abdomen is square, with a sharp spine on each side. It is .80 of an inch in length, and of a dark chestnut brown color.

ÆGIALITIDÆ Leconte. This family is represented by a single species, *Ægialites debilis* Lec., from Russian America.

CISTELIDÆ Latreille. This group, as Leconte states, "approaches very nearly to the more degraded forms of the *Tenebrionidæ*, and the degradation of structure is carried still farther by the anterior coxæ becoming conical, prominent, and contiguous in certain genera. The only characters to be relied on for isolation in this family are, first, the pectinate claws; and second, the anterior coxal cavities being closed behind. They are found on leaves and flowers, or under bark." *Allecula* at first sight somewhat resembles an Elater. *Cistela* differs from its allies in having the last joint of the maxillary palpi longer than wide.

LAGRIIDÆ Westwood. This inconsiderable family differs from the *Tenebrionidæ*, in the greater prominence of the anterior coxæ, and the dilated penultimate joint of the tarsi, though the larvæ differ in being rather long, almost as wide as long, convex above, and with the exception of the large head are thickly covered with hairs. There are two genera, *Arthromacra* and *Statyra*, which are found on leaves and under bark.

MONOMMIDÆ Lacordaire. This little group is a very distinct one, composed of small, black, oval, flattened beetles. *Monomma* is confined to the Eastern Continent, and a species of *Hyporhagus* is found, one on the eastern, the other on the Pacific side of this country.

MELANDRYIDÆ Leach. This group comprises a few species of elongate form, with two basal impressions on the prothorax, and the first joint of the hind tarsi is always much elongated. They are found under bark and in fungi. In *Melandrya* the head is bent forward, the base of the prothorax is sinuous, but not distinctly lobed, and the elytra are striate. *M. striata* Say is found in the Atlantic States.

PYTHIDÆ Lacordaire. This is a small group of mostly northern species found living under bark and stones. *Pytho* and its allies resemble some *Tenebrionidæ*.

ŒDEMERIDÆ Latreille. This group comprises insects of moderate size, and, according to Leconte, generally found on plants, though some species of *Asclera* live on the ground near water, and *Microtonus sericans* is a very small brown sericeous insect, found on leaves in the Atlantic States.

CEPHALOIDÆ. Leconte places in a distinct family, the single species, *Cephaloon lepturides* Newman, which is found on plants northward.

MORDELLIDÆ Leach. These are curious small, wedge-shaped, glistening, pubescent, black beetles, which occur in abundance on the flowers of Golden-rods and asters, and when disturbed leap off like fleas, or slip suddenly to the ground. *Anaspis* has the fourth joint of the anterior and middle tarsi very small, and the body is fusiform, with oval eyes. In *Mordella* the body is wedge-shaped, the eyes are finely granulated, the scutellum is triangular, and the last joint of the maxillary palpi triangular or securiform. The larvæ are said to live in the pith of plants during autumn, and are long, subcylindrical, and the sides of the rings are furnished with fleshy tubercles. *Mordellistena* differs in the hind tibiæ having subapical and oblique ridges.

ANTHICIDÆ Latreille. Of this small group, *Notoxus anchora* Hentz is noted for having the head prolonged over the mouth into a horn; it is found in marshy places. Leconte states that *Tanarthrus salinus* Lec. flies and runs on salt mud like a Cicindela; it occurs in the Colorado desert. The numerous species of *Anthicus* live in sandy places near water. *Formicomus* is ant-like, being wingless.

Pyrochroidæ Latreille. A small group of beetles which are found under the bark of trees; they generally have a reddish thorax contrasting with the black head and elytra. "The branches of the pectinate male antennæ are rigid in *Pyrochroa*, and very slender and flexible in *Dendroides;* in *Schizotus* they are of an intermediate form, and somewhat flexible." (Leconte.) The larva of *Dendroides* is a very flat whitish grub, with two large curved spines on the tail; it lives under the bark of pines and other trees. Two species of this genus, *D. concolor* Newman and *D. Canadensis* Latr., are equally common in New England. Fig. 446, enlarged, represents the larva of a species of *Pyrochroa*, of which *P. flabellata* Fabr. is a type.

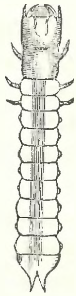


Fig. 446.

Meloidæ Gyllenhal. This is a family of great interest from the parasitic habits of the larvæ, which differ remarkably from the adult forms. The head is much bent forwards, and is suddenly constricted far behind the eyes into a small neck; the eleven-jointed antennæ are inserted at the sides of the front, before the eyes; the elytra are variable in form, but when abnormally shortened, are ovate, rather than square at the tip, and the hind wings are often absent. The legs are long, the hind tarsi are four-jointed, the penultimate joint usually cylindrical. They are soft-bodied, cylindrical, slender beetles, and are always found on flowers. The larvæ are ovate, flattened, often very minute and then somewhat resembling the Pediculi in habits. *Meloë* is a large dark blue beetle found about buttercups and crawling on grass in May and again late in August. The elytra are small and short, overlapping each other on the large ovate full abdomen; the claws are cleft, the male antennæ are twisted and knotted. The eggs are laid in the ground, probably near the nests of bees, for in the early spring, the young larvæ recently hatched are found on the bodies of various bees, such as Bombus, Halictus and Andrena, and also various Syrphi and Muscæ frequenting the flowers of the willow in April, whence they are conveyed by the agency of the bees. On these flowers we have found them in abundance. They are very active in their habits, and difficult to rear in confinement, which can only be done by confining the bees on which they are found, and supplying them with flowers. When the bee becomes exhausted by the loss of fluids drawn out by its parasite, it is quickly deserted by these minute torments for a newly introduced and more lively bee. The length of the larva at this period (Fig. 447) is .06 of an inch. It differs very remarkably from those of the neighboring families, which are generally oval, being long and linear-oblong, flattened. The three thoracic rings are of equal size, transversely oblong, the head being of nearly the same size with one of the thoracic segments, and provided with short antennæ. The legs have long claws with an intermediate long pad. From the tip of the abdomen proceed two pair of setæ, the inner one much longer than the other pair.

Fig. 447.

It is shorter than that of *M. violaceus*, figured by Newport, who has, with great sagacity, cleared up the remarkable history of this genus. It is undoubtedly the young of our common *Meloë angusticollis* Say (Fig. 448). The larvæ are conveyed by the bees themselves into their nests where they prey on the larvæ and bee bread. When full-fed and ready to pass through their transformations, instead of at once assuming the pupa state, they pass through what has been called by Fabre a "hypermetamorphosis." In other words the changes in form preparatory to assuming the pupa state are here more marked than usual, and are almost coequal with the larva and pupa states, so that the Meloë instead of passing through only three states (the egg, larva and pupa) in reality passes through these and two others in addition which are intermediate. Fabre states that the larva, soon after entering the nest of its host, changes its skin and assumes a second larval form (Fig. 449) resembling a lamellicorn larva. Newport, however, who with Siebold has carefully described the metamorphosis of Meloë, does not men-

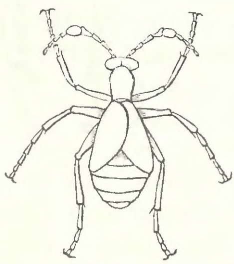


Fig. 448.

tion this stage in its development. In this stage the larva is said to be motionless; the head is mask-like, without movable appendages, and the feet are represented by six tubercles. This is, properly speaking, the "semipupa." This form, however, according to Fabre, changes its skin and turns into a third larval form (Fig. 450). After some time it assumes its true pupa form (Fig. 451) and finally moults this skin to appear as a beetle.

Fig. 449.

In *Horia* and allies the head is large, square behind, and the front is not prolonged beyond the base of the antennæ. *Horia sanguinipennis* Say is now placed by Leconte in the genus *Tricrania*, which differs in the last joint of the maxillary palpi being longer than the third, and by the triangular head. It is found in the nest of the humble bee, and in the West Indies a species of Horia is found in the nests of Xylocopa teredo, a species of carpenter bee.

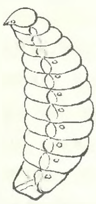


Fig. 450.

Sitaris, an European genus, has much the same habits as *Meloë*. Its eggs are laid near the entrance of bees' nests, and at the very moment, according to Fabre, that the bee lays her egg in the honey-cell, the flattened, oval, Sitaris larva drops from the body of the bee upon the egg and feasts upon its contents. It then feeds on the honey in the cell of the bee and changes into a white, cylindrical, nearly footless grub, and after it becomes full-fed, and has assumed the supposed "pupa" state, the skin, without bursting, encloses a kind of hard "pupa" skin which is very similar in outline to the former larva, and within this skin is found a whitish larva, which directly changes into the true pupa. These changes M. Fabre calls a "hypermetamorphosis," but it will probably be found that the two so-called "pupa" states, immediately preceding the final genuine pupa state he describes, are but changes of the semipupa, and can be paralleled in some degree by the remarkable changes of the bee and moth noted by us previously.

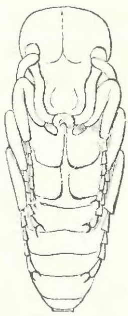


Fig. 451.

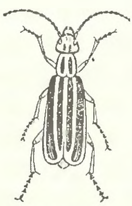


Fig. 452.

The Blister beetles, of which *Lytta* (Cantharis) affords many species, secrete the substance known as "Cantharadine." The Spanish-fly is used in commerce, and is a bright shining green species. Our native forms, which as well as Meloë, when dried, can be used for producing blisters, are dark colored. Their larvæ have the same form as that of Meloë; it remains yet to ascertain their true habits, though Latreille states that they live beneath the ground feeding on the roots of vegetables. Among the species of Blister beetles which are especially injurious to the potato are *Lytta vittata* Fabr. (Fig. 452), *L. cinerea* Fabr. (Fig. 453, *a*), *L. murina* Lec. (Fig. 453, *b*), and *L. marginata* Fabr. (Fig. 454).

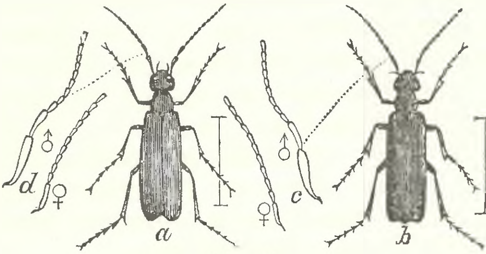


Fig. 453.


Fig. 454.

Phodaga alticeps Lec. (Fig. 455; 1, front of male; 2, profile of male; 3, anterior tibia and tarsus; 4, middle tibia; 5, claw; from Horn) is a Californian species, remarkable for the great differences between the sexes, in the form of the legs and tarsi.

Rhipiphoridæ Gerstaecker. This family is characterized by Leconte as having a vertical head, with perfect mouth-parts, affixed to the prothorax by a very slender neck, which is entirely contained within the prothorax, while the vertex is usually elevated. The eleven-jointed antennæ (ten-jointed in the female of certain species) are pectinate or flabellate in the males, and frequently serrate in the females. The prothorax is as large as the elytra at base, much narrowed in front, and the elytra, rarely covering the abdomen, are usually narrowed behind, diverging on the back. The legs are long and slender, with filiform tarsi, and the claws are pectinate or toothed, being rarely simple. They are found on flowers. The larval

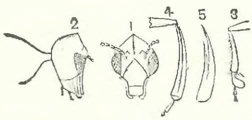


Fig. 455.

forms are not yet known. *Rhipiphorus* is a wedge-shaped genus, not found in America. *R. Finnicus* Paykull is said to be a parasite on Chrysis, the cuckoo wasp. It is here represented by two genera, *Macrosiagon* and *Emmenadia* which are wedge-shaped, with coarsely punctured and sparsely pubescent bodies, with the vertex of the head much elevated. In *Myodites* the elytra are very small. The species are found on Solidago or Golden-rod in August. The genus *Metoecus* is allied to Myodites. *Metoecus paradoxus* Linn. is in Europe a parasite in the nests of wasps (Vespa) eating the larvæ.

In the genus *Rhipidius* the males have short pointed dehiscent elytra, while the females are entirely wingless and worm-like. It is a parasite on *Blatta Germanica.* They are to be looked for in this country, where they have not yet occurred.

STYLOPIDÆ Kirby. This most anomalous family, both as regards the structure and the habits of the few species composing it, were for a long time excluded from the Coleoptera by systematists generally, and by Gerstaecker they are even now placed in the old "order" Strepsiptera. They are minute forms, and have been characterized thus by Dr. Leconte. "Oral organs atrophied except the mandibles and one pair of palpi. Head large, transverse, vertical, prolonged at the sides, forming a stout peduncle, at the end of which are situated the eyes, which are convex and very coarsely granulated. Antennæ inserted on the front, at the base of the lateral processes of the head; forked in one genus. Prothorax exceedingly short. Mesothorax short, bearing at each side a slender, coriaceous club-shaped appendage, with the inner margin membranous: this appendage represents the elytra. Metathorax very large, greater in bulk than the rest of the body, with the sutures of the dorsal pieces all distinct. The postscutellum is conical and prolonged far over the base of the abdomen; wings very large, fan-shaped, with a few diverging nervures; the epimera are very large, and project behind almost as far as the postscutellum. Abdomen small, with from seven to nine segments. Legs short; anterior and middle coxæ cylindrical, prominent; hind coxæ very small, contiguous, quadrate; tibiæ without spurs; tarsi without claws, joints each with a membranous lobe beneath." The females are sac-like. They live enclosed in the body of the bee.

In *Stylops* the antennæ are six-jointed, and in Xenos they are four-jointed. From the middle of May until late in June both sexes of Stylops may be found in "stylopized" individuals of Andrena and Polistes. The flattened triangular head of the female may be seen projecting from between the abdominal segments of the bee, and sometimes there are two or three of them. On carefully drawing out the whole body of a female *Stylops Childreni* (Fig. 456; *a*, abdomen of bee enclosing the female Stylops; *b*, top view), which is very extensible, baggy and full of a thin fluid, and examining it under a high power we found multitudes, at least three hundred, of very minute Stylops larvæ, like particles of dust issuing in every direction from the body of the parent. Most of them escaped from near the head, over which they ran, as they must do, when the parent is in its natural position, in order to get out upon the surface of the bee. It thus appears that the young (Plate 3, fig. 6, 6*a*) are hatched within the body of the parent, and are therefore viviparous. The head of the female is flattened, triangular, nearly equilaterally so, with the apex or region of the mouth obtuse, and the two hinder angles each containing a minute simple eye; the larger part of the head above consists of the epicranium, which is narrow in front, with the edge convex; the mandibles are obsolete, being two flattened portions lying in front of the gena and separated from that region by a very distinct suture; no clypeus or labrum can be distinguished. The mouth is transverse and opens on the upper side of the head, while in front, owing to the position of the mouth, lies the rather large labium and the rounded papilliform maxillæ.

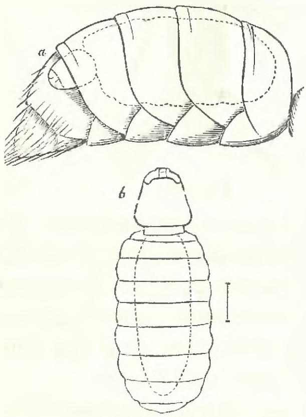


Fig. 456.

The larva is elliptical in form, the head semioval, while the tip of the abdomen is truncate; the sides of the body are straight, there being no well defined sutures between the segments; seen laterally the larva is thickest at the metathoracic ring. Two simple eyes are situated near the base of the head. The body is so transparent that the intestine can be traced easily to just before the tip, where it ends in a *cul de sac*. The two anterior pairs of legs are much alike; coxæ short; femora and tibiæ small, cylindrical; a slender tibial spur; the tarsi consisting of a single clavate joint equalling the tibia in length, being much swollen at the tip, and without claws. The hind tarsi are longer, very slender, two-jointed, the terminal one being bulbous. The terminal styles, inserted in the tenth abdominal ring, are a little more than one-half the length of the body, which is covered with long setose scales. In their movements these infinitesimal larvæ were very active, as they scrambled over the body of the parent, holding their caudal setæ nearly erect.

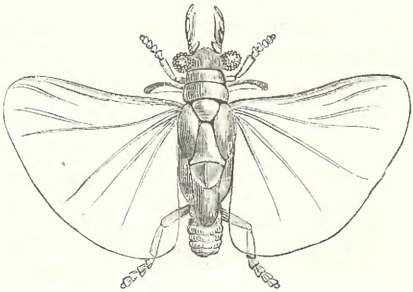


Fig. 457.

On the last of April we caught a male *Stylops Childreni* Westwood (Fig. 457, and 458) in the same net with a stylopized Andrena placida, and as the abdomen of the male was long and very extensile, its tip being provided with a capacious forceps for seizing the body of the female, it is most probable that the female described belonged to the same species, and that at this time the short-lived male, for this one lived but for a day in confinement after capture, unites sexually with the female. It appears then that the larvæ are hatched during the middle or last of June, from the eggs fertilized in April, and which are retained within the body of the parent. The larvæ then crawl on to the body of bees and penetrate within the abdomen of those that are to hibernate, and live there through the winter. The entire body of the male is, with the

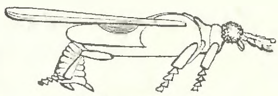


Fig. 458.

head and antennæ, of a velvety black, the abdomen slightly brownish, while the legs and anal forceps are pale resinous brown, and the tips of the tibiæ and the tarsal joints pale testaceous. It is about one-fourth of an inch in length.

The succeeding families comprise the divisions *Tetramera* and *Trimera* of early authors, in which the penultimate joint of the tarsi is but slightly developed, forming an enlargement at the base of the last joint, with which it is closely united.

BRUCHIDÆ Leach. This small family comprises Curculio-like beetles of short rounded form which are noted for their activity and readiness to take flight when disturbed. They differ from the *Curculionidæ* in the proboscis being folded on the chest, the antennæ being short and straight and inserted in a cavity next to the eyes. There are 300 species of Bruchus known. *Bruchus pisi* Linn., the Pea weevil, is found in peas in the spring at sowing time. It appears soon after the pea is in flower, laying its eggs on the flowers. The young larva feeds in the growing pod, on the pulp of the pea. Peas infested with them should be soaked in boiling hot water before sowing. *Bruchus fabi* Linn. in like manner infests the bean.

CURCULIONIDÆ Latreille. The weevil family may be at once recognized by the head being lengthened into a long snout or proboscis (used for boring into objects when about to oviposit), near the middle of which are situated the long, slender, elbowed antennæ. At the extremity of the snout are situated the mouth-parts, which are much reduced in size, the palpi having small rounded joints. Their bodies are hard and generally round and often very minute. They are very timid and quickly feign death. The larvæ are white, thick, fleshy, footless grubs, with fleshy tubercles instead of legs, and are armed with thick curved jaws. They feed on nuts, seeds, the roots, pith and bark of plants, leaves or flowers, and especially the fruits, while some are leaf-miners and others are said to make galls. Preparatory to transforming they spin silken cocoons. The number of species already known is immense, being not less than from 8,000 to 10,000, and upwards of 630 genera have been already described by Schönherr and others, of which we can notice but a few of the most important.

Brenthus and its allies differ from the following genera in their remarkably long and slender bodies, the snout being stretched straight out, not bent down as usual; while the slightly clavate antennæ are not elbowed. Dr. Harris gives the history of *B. septemtrionalis* Herbst (Fig. 459). The female in midsummer punctures with her long snout the bark of the white oak. The grub, when hatched, bores into the solid wood; it is nearly cylindrical, whitish, except the last segment, which is dark brown and horny, and is obliquely hollowed at the end, which is dentate, forming a scoop by which the larva clears its gallery of chips. There are three pairs of legs and an anal prop-leg. The pupa is described as being white, with the head bent on the chest between the wings and legs. On the back are rows of sharp teeth, with two larger thorns at the anal tip.

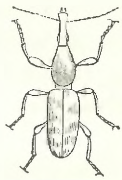


Fig. 459.

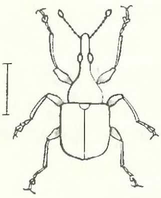


Fig. 460.

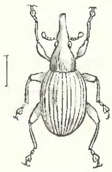


Fig. 461.

Harris states that "the different kinds of *Attelabus* are said to roll up the edges of leaves, thereby forming little nests of the shape and size of thimbles to contain their eggs and to shelter their young, which afterwards devour the leaves." *A. analis* Illiger (Fig. 460) is dull red, with dark blue antennæ and legs. In *Rhynchites* the head is not contracted behind into a neck. *R. bicolor* Fabr. injures various roses, wild and cultivated. It is red above, with the antennæ, legs and sides of the body black.

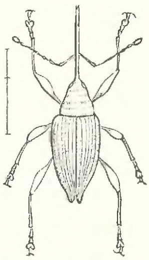


Fig. 462.

The little seed weevils, *Apion*, are pear-shaped and generally black. *Apion Sayi* Schönh. (Fig. 461) lives in the pods of the wild Indigo. It is black and one-tenth of an inch in length. *Balaninus*, the nut-weevil, is oval in shape, with a very slender snout, nearly as long as the body. *B. nasicus* Say (Fig. 462) is found on hazel bushes, and probably infests the nuts. Harris describes it as being dark brown, and clothed with very short, rust-yellow, flattened hairs, which are disposed in spots on its wing covers. It is nearly three-tenths of an inch long, exclusive of the snout.

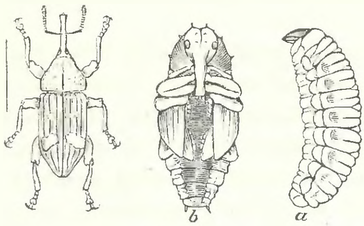


Fig. 463.

The genus *Hylobius* has the antennæ inserted before the middle of the snout, not far from the sides of the mouth. The Pine weevil, *Hylobius pales* Herbst, is very destructive to pines, the pitch-pine especially. This deep chestnut colored weevil is very abundant in May and June. It has a line on the thorax, and yellowish white dots scattered over the body, while the thighs are toothed beneath, and the slender cylindrical snout is nearly as long as the thorax. The larvæ are found under the bark. In old trees it burrows under the bark, its galleries extending irregularly over the inner surface of the bark and in the sap wood.

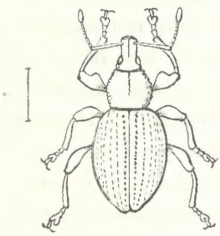


Fig. 464.

The White-pine weevil, *Pissodes strobi* Peck (Fig. 463; *a*, larva; *b*, pupa), equally destructive with the former, is a smaller beetle, more slender, and oblong oval in form. It is rust-colored brown, with two white dots on the thorax, a white scutellum, and behind the middle of the elytra, which are punctured in rows, is a transverse white line. Harris states that its eggs are deposited on the leading shoots of the pine, probably on the outer bark, and the larva when hatched bores into the shoot, and thus distorts the tree for life. The pupa is found just under the bark, the beetles appearing in the autumn, though in much greater numbers in May.

We have found this insect, in all its stages of growth, under the bark of the white pine the last of April, the larvæ being the most numerous. The larva is white, footless, cylindrical, with a pale reddish head. It is .32 of an inch long, and transforms in a cell. The pupa is white, the tip of the abdomen being square, with a sharp spine on each side. It is .30 of an inch long. An insect that would be readily mistaken for the *Hylobius pales* is the *Otiorhynchus sulcatus* of Fabricius (Fig. 464), which is of much the same color, but with a thicker body.

The Plum Gouger, *Anthonomus prunicida* Walsh, resembles the Plum curculio in its habits, and, according to Walsh, is equally as common in Northern and Central Illinois. It makes a round puncture in the plum, sometimes five or six, from which the gum copiously exudes. Instead of living, however, in the pulp, it devours the kernel and usually transforms inside the stone of the fruit. "The thorax of the plum gouger is ochre-yellow; the head and hinder parts slate-color, the latter with irregular white and black spots. In common with the other species of the genus to which it belongs its snout usually projects forward, whereas that of the Curculio usually hangs perpendicularly downwards." (Walsh.) *A. sycophanta* Walsh is brown-black and was bred by Mr. Walsh from the galls of various saw-flies found on the willow, and he supposes that this species, "while in the larva state, must destroy the egg or the very young larva of the gall-making Nematus, just as *A. cratægi* Walsh evidently does; which was found in an undescribed Cecidomyian gall on the thorn bush, and just as the larva of *A. scutellatus* Schönh. gradually destroys the young plant-lice among which it lives; otherwise the two larvæ would exist in the same gall." Walsh has also bred *A. tessellatus* Walsh from the Cecidomyian gall, C. s. brassicoides. It is "a very constant species and easily recognizable by the tessellate appearance of the elytra." *A. quadrigibbus* Say punctures the apple, making from one to twenty holes in the fruit.

The Cranberry weevil, as we may call it, or the *Anthonomus suturalis* Lec., is a minute reddish brown beetle, with the beak one-half as long as the body, just beyond the middle of which the antennæ are inserted. The head is darker than the rest of the body, being brown black. The thorax is a little darker than the elytra and covered very sparsely with short whitish hairs; the scutellum is whitish, and the elytra are shining reddish brown, with the striæ deeply punctured, the interstices being smooth. It is .13 of an inch long including the beak. Mr. W. C. Fish writes me that in the middle of July he detected this little weevil laying its eggs in the buds of the cranberry. "It selects a bud not quite ready to open, and clinging to it, works its snout deep into the centre of the bud. An egg is then deposited in the hole made, when the beetle climbs to the stem and cuts it off near where it joins the bud, which drops to the ground and there decays; the egg hatching and the grub going through its transformations within." The larva is long and rather slender, cylindrical, the body being of uniform thickness and curved; the head is pale honey yellow; the jaws tipped with black; the rings are very convex, especially the prothoracic one; it is white, with a few fine pale hairs, and is .08 of an inch in length.

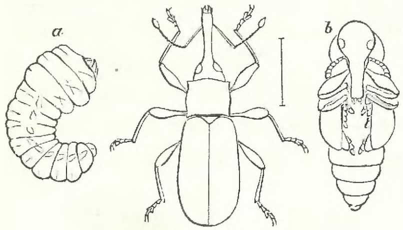


Fig. 465.

The *Magdalinus olyra* Herbst (Fig. 465; *a*, larva; *b*, pupa; the thorax of the larva is enlarged by the pupa growing beneath; the pupa from which the drawing was made is not fully developed, since the tip of the fully grown pupa ends in two spines) may be found in all its stages early in May under the bark of the oak. The larva is white, with the head freer from the body than in Pissodes strobi (though it is not so represented in the figure). The body of the beetle is black, punctured, and the thorax has a lateral tubercle on the front edge, while the tarsi are brown with whitish hairs. It is a quarter of an inch long.

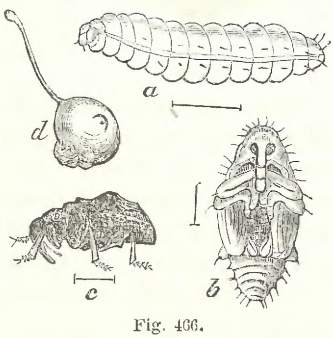


Fig. 466.

Conotrachelus nenuphar Herbst, the Plum-weevil (Fig. 466; *a*, larva; *b*, pupa; *c*, beetle; *d*, plum stung by the weevil) is a short, stout, thick weevil, and the snout is curved, rather longer than the thorax, and bent on the chest when at rest. It is dark brown, spotted with white, ochre-yellow and black, and the surface is rough, from which the beetle, as Harris says, looks like a dried bud when shaken from the trees. When the fruit is set, the beetles sting the plums, and sometimes apples and peaches, with their snouts, making a curved incision, in which a single egg is deposited. Mr. F. C. Hill shows that the curculio makes the crescent-shaped cut after the egg is pushed in "so as to undermine the egg, and leave it in a kind of flap formed by the little piece of the flesh of the fruit which she has undermined. Can her object be to wilt the piece around the egg and prevent the growing fruit from crushing it?" (Practical Entomologist, ii, p. 115.) The grub hatched therefrom is a little footless, fleshy white grub, with a distinct round light brown head. The irritation set up by these larvæ causes the fruit to drop before it is of full size, with the larva still within. Now full-fed, it burrows directly into the ground and there transforms during the last of the summer. In three weeks it becomes a beetle It also attacks many other garden fruits, such as the cherry, peach and quince. Drs. Harris, Burnett and others, think the larva is but a temporary occupant of the wart on plumb and cherry trees, and not a cause of the disease. The best remedy is jarring the trees, and catching the larvæ in sheets and burning them. Dr. Hull's "curculio catcher" is an excellent invention for destroying these insects; it consists of a large inverted white umbrella, fixed upon a large wheelbarrow split in front to receive the trunk of the tree, against which it is driven with force sufficient to jar the curculios from the tree into the umbrella.

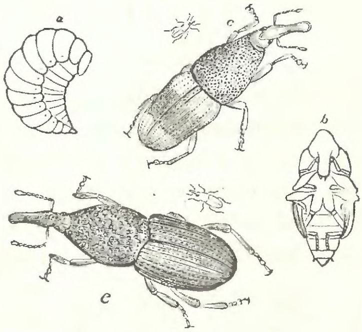


Fig. 467.

The genus *Ceutorhynchus* is a small, short, thick curculio, which attacks the seeds of the radish and allied plants. We have noticed a pale gray species on the radish, which probably inhabits the seeds.

The genus *Calandra* has a slender snout slightly bent downwards, a coarsely punctured thorax nearly half as long as the whole body, while the elytra are furrowed and do not quite cover the tip of the abdomen. The Grain Weevil, *Sitophilus granarius* Linn. (Fig. 467; *e*, and natural size; *b*, pupa, enlarged), is pitchy red in color and about an eighth of an inch long, and is immensely prolific. This great pest, both as a larva and beetle, consumes wheat after it is stored up, being very abundant in granaries. The larva devours the inside of a hull, leaving the shell whole, so that its presence is not readily detected. To prevent its attacks Harris recommends that the wheat be kept cool, well ventilated and frequently stirred.

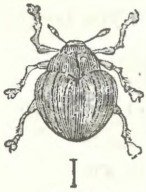


Fig. 468.

A similar weevil, *Sitophilus oryzæ* Linn. (Fig. 467; *e*, and natural size), attacks the grains of rice and also of wheat; it differs in having two large red spots on each elytron, and it is abundant in the South, where it is called the "black weevil."

The Grape Curculio, *Cœliodes inæqualis* Say (Fig. 468; 469; *a*, grape disfigured by the larva; *b*, larva), has lately, according to Walsh, been very destructive to grapes, stinging the fruit and thus destroying whole bunches of them. The presence of the larva in the grape may be known by a discoloration on one side of the berry as if prematurely ripening, though it be the last of June or early in July. Late in July or early in August the grub may be found fully grown, when it drops to the ground and descending a little beneath the surface transforms, and the beetle appears early in September. It is grayish black, the elytra black freckled with gray spots, and striated, with large punctures. The legs are dull brick red; the femora are unarmed, while the four anterior tibiæ have a large rectangular tooth near the base. It is from .09 to .11 of an inch in length. As a preventative against their attacks, the vines should be thoroughly shaken each day in June.

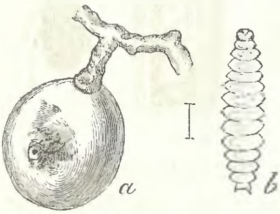


Fig. 469.

Another larva (Fig. 470), probably of this family, has been discovered by Mr. W. Saunders of London, Canada, in the seeds of the grape, causing the berries to shrivel.

The Potato-stalk Weevil, *Baridius trinotatus* Say (Fig. 471; *a*, larva; *b*, pupa; *c*, adult), is a common species in the Middle and Western States, where it causes the stalk to wilt and die, hence all stalks so affected should be burnt. "The beetle is of a bluish or ash gray color, distinguished as its name implies, by having three shiny black impressed spots at the lower edge of the thorax. The female deposits a single egg in an oblong slit about one-eighth of an inch long, which she has previously formed with her beak in the stalk of the potato. The larva subsequently hatches out and bores into the heart of the stalk, always proceeding downward towards the root. When fully grown it is a little over one-fourth of an inch long, and is a soft, whitish, legless grub, with a scaly head." (Riley.) Fig. 472 represents the larva of *B. vestitus* Schönherr, which bores into the stems of the tobacco plant in Mexico.

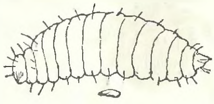


Fig. 470.

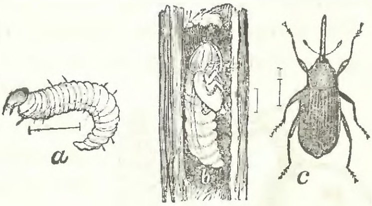


Fig. 471.

Mr. Huntington has observed the Grape Cane gall curculio, *Baridius Sesostris* Lec. (Fig. 473) in the larval state in large bunches near the joints of the Clinton grape on Kelly's Island, near Sandusky, Ohio, and has also found the beetle in considerable numbers. The larva closely resembles that of the Potato Baridius. Riley states that the gall is formed during the previous autumn while the tender cane is growing. "It has almost invariably a longitudinal slit or depression on one side, dividing that side into two cheeks, which generally have a rosy tint." It pupates late in June, and early in July the adult appears. It may be known by its polished elytra and punctured thorax. It is pale reddish, with a stout beak, equalling the body in length, and each elytron has a swelling on the outer edge near the base, and another near the tip. It is a tenth of an inch long. It is the *Madarus vitis* of Riley.

Fig. 472.

SCOLYTIDÆ Westwood. These cylindrical bark borers are rounded beetles of an elongate cylindrical form, truncated before and behind. They mine under the bark of trees, running their winding galleries in every direction. They rarely attack

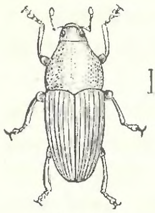


Fig. 473.

living healthy trees. They are usually brown or black in color. The rounded head does not end in a snout and is deeply sunken in the thorax; the clavate antennæ are somewhat elbowed, while the palpi are very short; the elytra are often hollowed at the end, and the short stout legs are toothed on the under side of the femora, and the tarsi are slender and narrow. The eggs are laid in the bark, whence the larvæ on being hatched bore straight into the sap wood, or mine between the bark and sap wood. They are like those of the preceding family, fleshy, cylindrical, footless larvæ, wrinkled on the back. When fully grown in the autumn they gnaw an exit for the beetle, taking care to leave a little space closed in front of their burrow to conceal the pupa. The bark of trees infested by them should be scraped and whitewashed. *Hylurgus terebrans* Oliv. (Fig. 474) is a rather large red species, very abundant in spring.

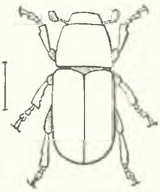


Fig. 474.

It is found under the bark of pines associated with Pissodes, though the larva is smaller and more cylindrical. It mines the inner surface of the bark, slightly grooving the sap wood, and pupates in April, appearing as a beetle in great numbers on warm days early in May. *Hylurgus dentatus* Say infests the cedar.

Fig. 475.

The *Scolytus destructor* of Olivier often does much injury to old and decaying elm trees in Europe. Capt. Cox exhibited to the Entomological Society of London a piece of elm three feet long, which was scored by the lateral tubes of this insect, which he estimated must have given birth to 280,000 larvæ. The various species of *Scolytus*, *Tomicus* and *Xyloterus* give rise to the disease called fireblight, by their ravages beneath the twigs of fruit trees, causing the bark to shrivel and peal off as if a fire had run through the orchard. The best method of restraining their attacks is to peal off the affected bark, exposing the eggs and larvæ to the air, when the birds will soon destroy them. *T. monographus* does great damage by drilling holes in malt-liquor casks in India. It was calculated that sometimes 134,000 holes were drilled in the staves forming a single cask. Immersion in boiling water has been found an effectual remedy. (Morse.)

Also associated with Pissodes, we have found in April the galleries of *Tomicus pini* Say branching out from a common centre. They are filled up with fine chips, and, according to Fitch, are notched in the sides "in which the eggs have been placed, where they would remain undisturbed by the beetle as it crawled backwards and forth through the gallery." These little beetles have not the long snout of the weevils, hence they cannot bore through the outer bark, but enter into the burrows made the preceding year, and distribute their eggs along the sides. (Fitch.) *T. xylographus* Say (Fig. 475) is often a most formidable enemy to the white pine in the North, and the yellow pine in the South. The genus *Cryphalus* is a slenderer form. A species, probably the *C. materarius* of Fitch (Fig. 476), has been found by Mr. Huntington of Kelly's Island, to bore into empty wine casks and spoil them for use.


Fig. 475.

Cerambycidæ Leach. (Longicornia Latreille). This immense family, numbering already nearly 4,000 known species, comprises some of the largest, most showy, as well as the most destructive insects of the suborder. They are readily recognized by their oblong, often cylindrical bodies, the remarkably long, filiform, recurved antennæ, and the powerful incurved mandibles. Their eggs are introduced into the cracks in the bark of plants by the long fleshy extensile tip of the abdomen. The larvæ are long, flattened, cylindrical, fleshy, often footless whitish grubs, with very convex rings, the prothoracic segment being much larger and broader than the succeeding, while the head is small and armed with strong sharp mandibles adapted for boring like an auger in the hardest woods.

These borers live from one to three years before transforming, at the end of which time they construct a cocoon of chips at the end of their burrows, the head of the pupa lying next to the thin portion of bark left to conceal the hole. As quoted by Baron Osten Sacken in an interesting article on the larval forms of some of our native beetles, Erichson states that "notwithstanding the great similitude between the larvæ of Longicorns, some important differences in the structure of those belonging to the four subdivisions of this family may be noticed. The larvæ of the Lamiidæ differ more than the others, on account of the total absence of feet, and the position of the first pair of stigmata which is placed in the fold between the pro- and mesothoracic segments, less abruptly separated than the others. The other larvæ have this first pair on the sides of the mesothorax, and have feet, which, however, are sometimes so small as to be perceptible only when magnified, even in large sized larvæ. The Cerambycidæ (Cerambyx, Callidium and allies) have, on the posterior side of the prothorax, above and below, a fleshy, transverse fold, separated by a furrow from the horny disc of this segment. In the Prionidæ and Lepturidæ, the same fold is visible only on the under side. The *Lepturæ* have a large flattened head, as broad as the prothorax, whereas in the other Longicorn larvæ the head is small and much narrower than the thorax. The larvæ of the Prionidæ show the least differences from those of the Lepturidæ; and that of Spondylis is remarkably allied to the latter." "The pupa is at first soft and whitish, and it exhibits all the parts of the future beetle under a filmy veil which inwraps every limb. The wings and legs are folded upon the breast; the long antennæ are turned back against the sides of the body, and then bent forwards between the legs." (Harris.) The beetles mostly hide by day and fly by night.

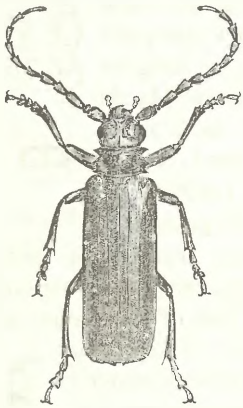


Fig. 477.

Parandra brunnea Fabr. is much unlike the remaining genera, being Tenebrio-like in form, with a broad head and short antennæ, and shining red in color. The larva is described by Osten Sacken as having a yellowish cordate head, with a large prothorax and fleshy tubercles on the upper and under side of the segments, with the first pair of stigmata placed on the sides of the mesothorax. It is found in dead beach trees.

The *Orthosoma unicolor* Drury (Fig. 477) is a light bay colored beetle found flying from the middle of July until September. We have found the larva (Fig. 478) in the rotten stumps of the pine, and in the Western States Riley states that a larva (Fig. 479, head and thorax seen from beneath), probably of this species, eats the roots of the grape-vine, hollowing out and sometimes severing the root and killing the vine.

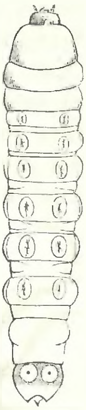


Fig. 478.

Prionus brevicornis Fabr. is a very large, not uncommon beetle, of an ovate shape and pitchy black color, with short, thick jaws, and antennæ about half as long as the body. The larvæ, Harris states, are as thick as a man's thumb, and are found in the trunks and roots of the Balm of Gilead and Lombardy poplar.

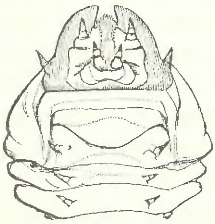


Fig. 479.

Crossidius pulchrior Bland (Fig. 480), from Nebraska, is a pale reddish beetle, with the antennæ, head, base and the large mark on the disk of the elytra and legs black. An allied form is *Eburia? Ulkei* Bland (Fig. 481, showing the sculpturing of the head) which is described as coming from Cape St. Lucas, Lower California.

Fig. 480.

The larva of *Stenocorus putator* Peck (Fig. 482; *a*, larva, just about transforming; *b*, pupa) nearly amputates the branches of the black and white oaks. After becoming mature in the trunk, and just before undergoing its transformations, it gnaws off a branch which falls to the ground, containing the larva, which changes to a beetle in midsummer, and lays its egg near the axilla of a leaf stalk or small stem. The beetle is a very slender one, with antennæ longer than the body in the males, the third and fourth joints of which are tipped with a small spine or thorn. It is dull brown, with gray spots. The Banded hickory borer, *Chion* (Cerasphorus) *cinctus* Drury, makes long galleries in the

Fig. 481.

trunks of hickory trees, the worm often working its way out of the wood after it has been made into articles of furniture or carriages. The *Asemum mœstum* Haldeman (Fig. 483; *a*, *a*, larva; *b*, pupa), we have found in all its stages under the bark of oaks, early in May. The larva is footless, white; the head is rather large, white, with strong black jaws convex on the outer side; the body is uniform, gradually diminishing in width posteriorly; it is .60 of an inch long. The pupa is .44 of an inch long. The beetle is about half an inch long and is dark brown, with very thick femora. It flies the last of May. I have received a larva of this species from Dr. Shimer, which was found by him boring in the grape-vine. The genus *Callidium* has antennæ of moderate length, a broad rounded prothorax, and a flattened body behind. The larvæ are unusually flattened, with a broad horny head, small stout mandibles, and six small legs, and they are said to live in this state two years. *Callidium antennatum* Newman is entirely blue; it bores in pine wood and in red cedar, mining under the bark. *C. semicircularis* Bland (Fig. 484) is reddish brown, with a white band on each elytron, enclosing a rather large, semicircular, black spot. It was discovered in Pennsylvania.

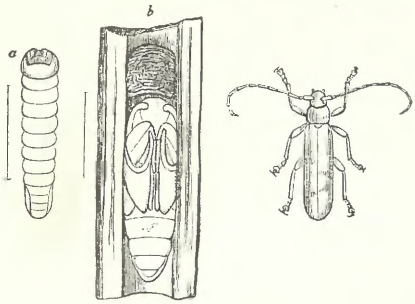


Fig. 482.

Fig. 484

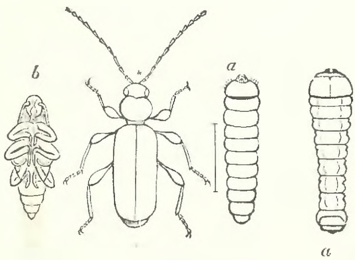


Fig. 483.

Clytus has a more cylindrical body, and spherical prothorax, besides being beautifully banded with golden, on a dark ground. *Clytus speciosus* Say injures the maple. We have taken the beetle on the summit of Mount Katahdin in Maine. The beetle lays its eggs in July and August, and the larvæ bore in all directions through the tree. Osten Sacken describes the larva of *C. pictus* Drury, the Hickory-tree borer (Fig. 485; *a*, larva; *b*, pupa), as being "six to seven-tenths of an inch in length, being rather long, somewhat flattened club-shaped, the thoracic segments being considerably broader than the abdominal ones, but at the same time distinctly flattened above and below." The pupa has numerous pointed granulations on the prothorax, and similar sharp spines on the abdominal segments. "On the penultimate

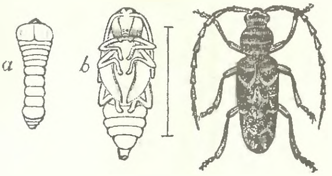


Fig. 485.

segments, these projections are larger and recurved anteriorly at the tip; there are six in a row near the posterior margin, and two others more anteriorly. The last segment has four similar projections in a row." The male of the Locust tree borer, *C. robiniæ* Forster (Fig. 486, ♂), according to Walsh, differs from that of *C. pictus* "in having much longer and stouter antennæ and in having its body tapered behind to a blunt point," while the females "are not distinguishable at all." It does great injury to the Locust tree, and appears in the beetle state in September, while *C. pictus*, the Hickory tree borer, appears in June. *C. araneiformis* Oliv. (Fig. 487) has been detected on a wharf in Philadelphia; it was first described as coming from St. Domingo.

Fig. 486.

The Long-handed *Acrocinus*, *A. longimanus* Fabr. (Fig. 488, larva, natural size), is a gigantic insect, allied to Prionus, but with enormously developed fore legs, the whole body, including the fore legs, when outstretched measuring ten inches; it is brown, beautifully banded with red and buff. M. Sallé has found the larva at Cordova, Mexico, under the bark of a Ficus. It grows larger in Brazil. *Leiopus* is a diminutive ally of Lamia. Dr. Shimer has detected the larva of *L. xanthoxyli* Shimer, undermining the bark of the prickly-ash, when the wood has recently died. It is a footless borer, "of whitish and pink orange colors, about one-fourth of an inch long." In the burrows

Fig. 487.

formed by the larvæ he found May 25th, several pink-orange pupæ, "invariably lying with their heads outwards; their long antennæ folded over the wing-cases obliquely down on the sides, passing beneath the posterior pair of legs, a little beyond them and then curving up over the breast, reach the head." The beetle is related to *L. alpha* Say, and is gray, with bands and spots of blackish pubescence; it is .25 of an inch long. Two species of ichneumons were found by Shimer to prey upon the beetle.

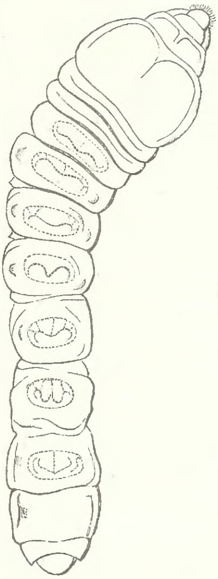


Fig. 488.

In *Monohammus* the antennæ are of great length. *M. titillator* Fabr. is brown mottled with gray; while a slenderer species, *M. scutellatus* Say, of a peculiar dark olive green, with a whitish scutellum, bores in the white pine.

The singular habits of the Girdler, *Oncideres cingulatus* Say (Fig. 489), have thus been described by Professor Haldeman in the Pennsylvania Farm Journal, vol. i, p. 34. "This insect was first described by Say in the Journal of the Academy of Natural Sciences, vol. v, p. 272, 1825, and its habits were discovered by us and published in our 'Materials towards a History of the Coleoptera longicornia of the United States;' Am. Phil. Trans., vol. x. p. 52, 1837.

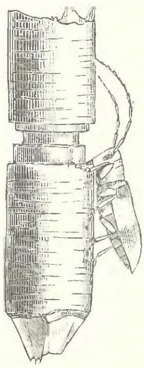


Fig. 489.

"In our walks through the forest our attention was frequently drawn to the branches and main shoots of young hickory trees (Carya alba), which were girdled with a deep notch in such a manner as to induce an observer to believe that the object in view was to kill the branch beyond the notch, and extraordinary as it may appear, this is actually the fact, and the operator is an insect whose instinct was implanted by the Almighty power who created it, and under such circumstances that it could never have been acquired as a habit. The effect of girdling is unknown to the insect, whose life is too short to foresee the necessities of its progeny during the succeeding season.

"This insect may be seen in Pennsylvania during the two last weeks in August and the first week in September feeding upon the bark of the tender branches of the young hickories. Both sexes are rather rare, particularly the male, which is rather smaller than the female, but with longer antennæ. The female makes perforations in the branches of the tree upon which she lives (which are from half an inch to less than a quarter of an inch thick), in which she deposits her eggs; she then proceeds to gnaw a groove of about a tenth of an inch wide and deep around the branch, and below the place where the eggs are deposited, so that the exterior portion dies and the larva feeds upon the dead wood and food which is essential to many insects, although but few have the means of providing it for themselves or their progeny by an instinct so remarkable.

"Where this insect is abundant, it must cause much damage to young forests of hop-poles by the destruction of the principal shoot. We have known insects which, from their rarity, could hardly be regarded as 'noxious,' increase to such an extent as to be very destructive, and the locust trees (Robinia pseudacacia) have had their foliage withered during the few last summers from such a cause (Cecidomyia robiniæ Hald.) which has caused these trees to wither since that period, particularly in August, 1868." The Tridentate Compsidea, *C. tridentata* Oliv. (Fig. 490, larva, enlarged three times), is a dark brown beetle, with a rusty red curved line behind the eyes, two stripes on the thorax, and a three-toothed stripe on the outer edge of each wing-cover, and is about half an inch long. It lives under the bark of elms, occasionally doing much damage. (Harris.)


Fig. 490.

The larva of *Psenocerus pini* Oliv. (supernotatus Say) which burrows in the stem of a climbing plant, supposed to be the grape, Osten Sacken describes as being three-tenths of an inch long, subcylindrical or prismatical, the pro- and mesothorax being a little broader than the other segments, and the whole body sparsely beset with fine golden hairs.

This insect, according to Fitch, also does much injury to the currant, eating the pith "through the whole length of the stalk and leaving it filled with a fine powder. It is about the first of June that the parent insect deposits her eggs upon the currant stalks, and the worms get their growth by the close of the season. They repose in their cells through the winter, changing to pupæ with the warmth of the following spring, and begin to appear abroad in their perfect state as early as the middle of May, the sexes pairing immediately after they come out." (Fitch.) In August, 1868, I received from Dr. P. A. Chadbourne, President of Madison University, several branches of the apple containing larvæ, which in the next spring changed to this beetle. They were very injurious to orchards in his vicinity, and this seems to be the first instance of its occurrence in the apple. The larva (Fig. 491, enlarged thrice) is nearly half an inch long; it is footless, white, with the head scarcely half as wide as the body and considerably flattened; the segments are rather convex, each having two rows of minute warts, and the tip is rather blunt, with a few fine golden hairs. It devoured the sap wood and under side of the bark and also the pith, thus locally killing the terminal twigs, and causing the bark to shrivel and peel off, leaving a distinct line of demarcation between the dead and living portions of the twig. Each larva seemed to live in a space one and one-half inches long, there being five holes through the bark within the space of as many inches. On the 16th of August the grubs seemed to have accomplished their work of destruction, as they were fully grown. The beetle is from .13 to .20 of an inch long, and may be known by its dark, reddish brown, cylindrical body, with a high tubercle at the base of the elytron, an oblique yellowish white line on the basal third, and a broad curved white line on the outer third of the elytron, or wing-cover.

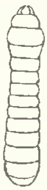


Fig. 491.

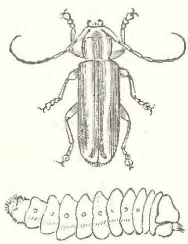


Fig. 492.

Saperda candida Fabr. (bivittata Say, Fig. 492) the well known Apple tree borer, flies about orchards in July in New

England, in May and June in the Western States, usually at night, but we once observed it flying in the hottest part of the day. At this time the female lays her eggs in the bark near the roots. The nearly cylindrical larvæ are whitish fleshy grubs, with a small horny head, while the prothoracic ring, as usual, is much larger than the others, the two preceding ones being very short, and from thence the body narrows to the tip. It bores upward into the wood, where it lives two or three years, finally making a cocoon eight or ten inches from its starting point, in a burrow next to the bark, whence it leaves the pupa state (which begins early in June) in midsummer. It also infests the wild apple, quince, pear, June-berry, mountain-ash and hawthorn. Riley advises soaping the trunk of the tree to prevent the beetle from laying its eggs, and when the tree is infested with them to cut through the bark at the upper end of their borings and pour in hot water, while in the autumn the bark should be examined and the young worms that had been hatched through the summer may be dug out and destroyed.

We have found what we supposed to be the young larvæ of *Desmocerus cyaneus* Fabr. in the stems of the elder; the beetle is a handsome purple and white Longicorn. We have found *Rhagium lineatum* Olivier living in old trunks of pine trees. The antennæ are no longer than the breadth of the body. It makes a cocoon of chips, and the beetle appears in the autumn, not, however, leaving the tree until the spring.

CHRYSOMELIDÆ Latreille. The Leaf-beetles are oval or oblong, often very thick and convex above, with short antennæ, round prominent eyes, with a narrow cylindrical thorax, and the hinder thighs often much thickened in the middle, while the abdomen has five free segments. The larvæ are short, rounded, cylindrical or flattened, generally of soft consistence, usually gaily colored, and beset with thick flattened tubercles or branching spines, and well developed thoracic feet. There are estimated to be from 8.000 to 10.000 species. They are found feeding, both in the larva and adult stages, on leaves, either on the surface, or, as in Hispa and several species of Haltica, their larvæ are leaf-miners.

The genus *Donacia* connects this family with the preceding. It has a rather long body and unusually long antennæ. *D. proxima* Kirby is dark blue, and *Donacia Kirbyi* Lacordaire is of a shining coppery hue. The larvæ live in the stems of water plants, and make a leathery cocoon in the earth before transforming.

The Grape-vine *Fidia* (F. viticida Walsh, Fig. 493) is very injurious to the grape in the Western States, from its habit of "cutting straight elongated holes of about an eighth of an inch in diameter in the leaves, and when numerous so riddling the leaves as to reduce them to mere shreds." It is chestnut brown, and covered with short whitish hairs, giving it a hoary appearance. Riley states that it is very abundant in the vineyards in Missouri, where it prefers Concord and Norton's Virginia grapes, while it occurs on the wild grape-vine and on the leaves of the Cercis Canadensis. "It makes its appearance during the month of June, and by the end of July has generally disappeared, from which fact we may infer that there is but one brood each year." The vines should be often shaken and chickens turned in to feed upon them when it is possible.

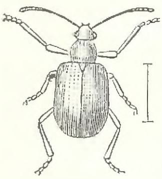


Fig. 493.

Crioceris is known by its rather long body, and the prothorax being narrower than the elytra. The antennæ are rather long, the fore coxæ are swollen, pressed together, and the claws are either free or united at the base. We have no native species, but *Crioceris asparagi* Linn. has been introduced into gardens about New York, doing much injury to the asparagus. Fitch describes it as being about a quarter of an inch long, with a tawny red prothorax and three bright lemon yellow spots on each elytron. The larva is soft-bodied, twice

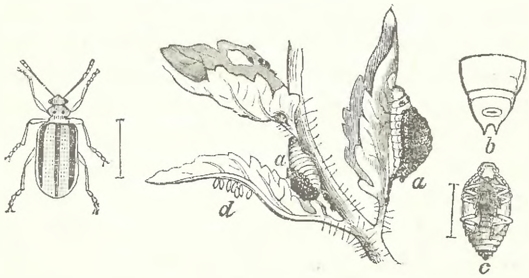


Fig. 494.

as long as thick, the body thickening posteriorly, and of a dull ash gray or obscure olive, with a black head and legs.

Lema trilineata Olivier (Fig. 494 ; *a*, larva ; *b*, terminal joints of abdomen ; *c*, pupa ; *d*, eggs) occurs in great abundance on the leaves of the potato. The dirty yellowish larvæ are found on it abundantly, and hide themselves by covering their bodies with their own excrement. They mature in about two weeks, transform in earthen cells cemented with a gummy exudation discharged from the mouth, and in a fortnight, being about the first of August, the beautiful yellow and black striped beetle, with a reddish head and prothorax, appears.

Hispa is also a miner in the larva state. *Hispa* (Uroplata) *rosea* Harris (Fig. 495) is supposed by Harris to mine the leaves of the apple tree. Harris describes it as being "of a deep or a tawny reddish yellow color above, marked with little deep red lines and spots. There are three smooth, longitudinal ribs on each elytron, spotted with blood-red, and the space between these lines are deeply punctured in double rows ; the under side of the body is black, and the legs are short and reddish. They measure about one-fifth of an inch in length." "The larvæ burrow under the skin of the leaves of plants, and eat the pulpy substance within, so that the skin over and under the place of their operations, turns brown and dies, having somewhat of a blistered appearance, and within these blistered spots the larvæ or grubs, the pupæ or the beetles, may often be found. The eggs of these insects are little rough, blackish grains, and are glued to the surface of the leaves, sometimes singly, and sometimes in clusters of four or five together. The grubs of our common species are about one-fifth of an inch in length, when fully grown. The body is oblong, flattened, rather broader before than behind, soft, and of a whitish color, except the head and the top of the first ring, which are brown, or blackish, and of a horny consistence. It has a pair of legs to each of the first three rings ; the other rings are provided with small fleshy warts at the sides, and transverse rows of little rasp-like points above and beneath. The pupa state lasts only about one week, soon after which the beetles come out of

Fig. 495.

their burrows." *Hispa* (Uroplata) *suturalis* Fabr. mines the Locust tree, and often proves very destructive in the Middle and Western States. They are flat, the body behind being broad and square, and the elytra are generally ridged and furrowed.

Cassida aurichalcea Fabr., the yellow Helmet beetle, is hemispherical, flattened, so that the edges of the wings are very thin; and the larva is broad, oval, flattened, and by means of two spines terminating its upturned abdomen, holds its old cast larva skin over its body as a means of protection. During the last week in July we have found the larvæ in all stages of growth very abundant on the Morning-glory in our garden, eating holes in the leaves. In the young the head and legs are more prominent than in the old. It pupates the last of July and early in August.

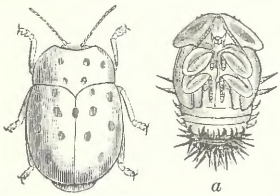


Fig. 496.

The *Chelymorpha cribraria* Fabr. (Fig. 496; *a*, pupa) we have found in all its stages on the leaves of the silk-weed late in July and early in August, and in one instance in Salem it occurred in abundance on the leaves of the raspberry. The larva differs from that of Cassida aurichalcea, not only in its greater size, but the body is thicker and narrower; the head is freer from the thorax, and the spines are simple, not spinulated. The body is yellow and less protected by the cast skin. When about to transform, the larva attaches itself to the leaf by a silken thread, a few segments from the end where the end of the body of the future pupa is situated. It is .45 of an inch long. The pupa is broad and rather flattened, dark and spotted with yellow and covered with a whitish powder, causing the yellow portions to appear more prominently; along each side of the abdomen is a row of five spines, and there are four spines on the anterior edge of the prothorax; it is .40 of an inch in length.

Fig. 497.

Fig. 497 represents, according to Harris, "the larva, nearly full size, of *Galeruca gelatinariæ* Fabr. or an allied species, found abundantly on Ambrosia elatior, July 30th. They live on the upper surface of the leaves and devour the cuticle and parenchyma above, leaving the lower cuticle untouched. It is of a dirty yellowish white color, with black tubercles bearing white bristles. Length one-fourth of an inch." (Harris Correspondence, p. 267.)

We have found *Galeruca marginella* Kirby (Fig. 498; *a*, larva; *b*, pupa) in all its stages of growth on Myrica gale, during the middle of August, in Northern Maine. The larva is shining black, coriaceous above, and the body is elongated, flattened, with a small orbicular black head. The upper side of the body is hard, from the close proximity of the black flattened tubercles. Beneath, whitish; on the side is a row of small black brown tubercles, and along the middle of the body is a row of transversely linear brown tubercles, on each side of which is a minute dot-like tubercle. It is not hairy, and measures .25 of an inch in length. When about to transform it fastens itself by its tail to the surface of a leaf. The pupa is brown-black. The beetle is umber brown, testaceous on the edges of the elytra, the legs being also testaceous, while the prothorax is pale, with three dark brown spots, of which the central one is T-shaped.

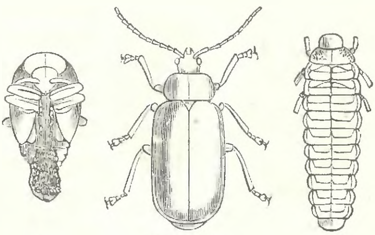


Fig. 498.

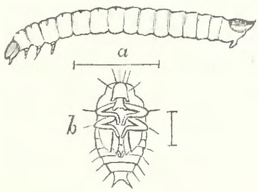


Fig. 499.

The Striped Squash beetle, *Diabrothica vittata* Fabr. (Fig. 499, *a*, larva; *b*, pupa seen from underneath; Fig. 500, adult) appears on squash vines as soon as they are up, and at once devours them unless their attacks are prevented. Covering the vines with cotton or a box covered with muslin or millinet is the only sure remedy, while on a large scale powdered charcoal, or lime is used, to be sprinkled on the leaves. Mr. Gregory, says the "American Agriculturist," relies upon plaster, or oyster-shell lime, which may be shaken

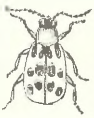


Fig. 501.


Fig. 500.

from a small sieve while the leaves are wet with dew or rain; to be applied as soon as the plants are up. He objects to the use of air-slacked stove lime, as it is apt to be too caustic and injure the plant. Dr. H. Shimer has given an account of the habits of this insect in the "Prairie Farmer," and has sent me specimens of the insect in its different stages. He states that the grub in June and July "eats the bark and often perforates and hollows out the lower part of the stem which is beneath the ground, and the upper portion of the root, and occasionally when the supply below fails, we find them in the vine just above the ground." It hibernates in the pupa state. "The larva arrives at maturity in about a month after the egg is laid; it remains in the pupa state about two weeks, and the beetle probably lives several days before depositing her eggs, so that one generation is in existence about two months, and we can only have two, never more than three broods in one season." He has found them boring in the squash and muskmelon vines as late as October 1st. The larva is a long, slender, white, cylindrical grub, with a small brownish head. The prothorax is a little corneous. The thoracic legs are very slender, pale brown; the end of the body is suddenly truncated, with a small prop-leg beneath. Above is an orbicular brown space, growing black posteriorly and ending in a pair of upcurved, vertical, slender black spines. It is .40 of an inch long. It will be seen that both in its boring habits and its corresponding, remarkable, elongated, cylindrical, soft white body, that this larva varies widely from that of Galleruca, to which the beetle is closely allied. The pupa is .17 of an inch long, white, with the tip of the abdomen ending in two long acute spines arising from a common base. The Twelve-spotted Diabrothica (Fig. 501, D. duodecim-punctata Fabr.) is injurious to the leaves of the Dahlia.

Fig. 502.

The genus *Haltica*, to which the little blackish Flea-beetles belong, is well known. The larvæ mine the leaves of the plants on which they afterwards feed. *Haltica* (Crepidodera) *cucumeris* Harris (Fig. 502) infests the cucumber. Harris describes it as being "only one-sixteenth of an inch long, of a black color, with clay-yellow antennæ and legs, except the hindmost thighs, which are brown. The upper side of the body is covered with punctures, which are arranged in rows on the wing-cases, and there is a deep transverse furrow across the hinder part of the thorax." It not only kills young cucumber-vines, eating the seed leaves, but is found all through the summer eating holes in the leaves of various garden vegetables.

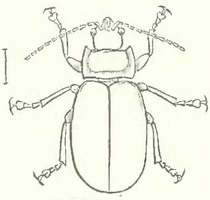


Fig. 503.

The Grape-leaf Flea Beetle, *H.* (Graptodera) *chalybea* Illiger, eats the buds and leaves of the grape. It is a steel blue insect, often varying in its shades of coloring, sometimes becoming greenish. It is a little over three-twentieths of an inch in length. In Ohio, Mr. M. C. Reed noticed the sexes of this species, which Dr. Leconte considers as probably the *Graptodera exapta* of Say (Fig. 503), pairing May 6th. The larvæ appeared the last of the month, and by the first week in June, and on the 30th of the same month, the beetles appeared. I have received specimens of the larva from Mr. Read. It is a yellowish white, cylindrical worm, with a jet black head and black tubercles, from each of which proceed several fine hairs. The prothorax is brown black above; on each succeeding ring of the body are ten tergal black tubercles, the two inner ones being long and narrow, and transverse, the others forming round dots. On each ring is a single black dot just between the two lower larger tubercles. On the sides are two rows of black tubercles, and along the middle of the under side a row of transverse tubercles, on each side of which is a row of dot-like tubercles. It is .35 of an inch in length.

a *b* Fig. 504.

The Striped Turnip Flea beetle, *H.* (Phyllotreta) *striolata* Fabr. (Fig. 504; *a*, larva; *b*, pupa), is black, with a waved yellowish stripe on each wing-cover, and is less than a tenth of an inch long. Dr. Shimer describes the larva as being white; the head is of a pale brown color, and near the end of the body is a brown spot equal to the head in size; besides the thoracic legs there is a single anal prop-leg. It is .35 of an inch long. It feeds upon roots beneath the ground. The pupa is naked, white, and transforms in an earthen cocoon. In seventeen days from the time the larva ceases eating the beetle appeared. It then feeds on the seed leaves of cabbages and turnips and other garden vegetables, when it proves very injurious, while afterwards in June, when the plants have attained their growth, they sicken and die from the attacks of the larva in their roots. (American Naturalist, vol. ii, p. 514.)


Fig. 505.

The Silk-weed Labidomera, *L. trimaculata* Fabr. (Fig. 505, larva) is found in its larval stage on the Silk-weed about the first of August. It is a thick hemispherical beetle, with a dark blue head and prothorax, and orange elytra, with three large blue spots on each wing-cover. It is one-half of an inch long.

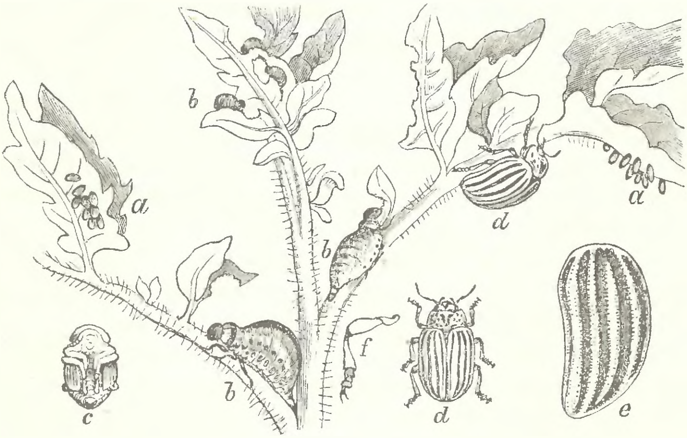


Fig. 506.

The Colorado potato beetle, *Doryphora decem-lineata* Say (Fig. 506 ; *a*, eggs ; *b*, the larvæ in different stages of growth ; *c*, the pupa ; *d*, beetle ; *e*, elytron, magnified ; *f*, leg, magnified) has gradually spread eastward as far as Indiana, from its original habitat in Colorado, having become very destructive to the potato-vine. It becomes a beetle within a month after hatching from the yellowish eggs ; the larva is pale yellow with a reddish tinge and a lateral row of black dots. Messrs. Walsh and Riley state that "there are three broods of larvæ every year in North Illinois and Central Missouri, each of which goes under ground to pass into the pupa state, the first two broods coming out of the ground in the beetle state about ten or twelve days afterwards, while the last one stays under ground all winter, and only emerges in the beetle state in the following spring, just in time to lay its eggs upon the young potato leaves," which it devours to such an extent as to sometimes almost cut off the entire crop in certain localities. The Editors of the "American Entomologist," from whom we have quoted, enumerate and figure various beetles, hemiptera, and a species of Tachina fly (Lydella doryphoræ Riley) which mostly prey upon the larvæ. Dr. H. Shimer shows, in the "American Naturalist," vol. iii, p. 91, that a dry and hot summer is very unfavorable to the development of this insect, the pupæ dying for want of sufficient moisture in the soil. The best remedy against its attacks is hand picking.

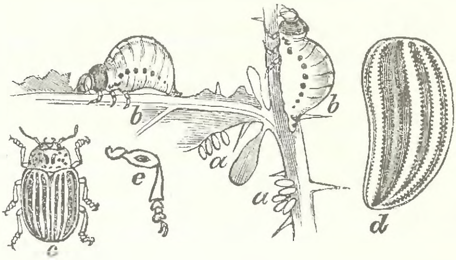


Fig. 505.

A very closely allied species or variety, the *D. juncta* Germar (Fig. 505), may be easily confounded with the other species, but differs, according to Walsh, in the head of the larva being paler, while in the beetle the third and fourth stripe from the outside are united, where they are distinct in the D. 10-lineata, and the legs are entirely pale yellow, with a dark spot on the femora. It feeds on the wild potato, not eating the cultivated species, and has always been an inhabitant of the Western and Southern States.


Fig. 506.

Chrysomela is an oval oblong genus, and its ally, *Calligrapha*, is very convex, hemispherical; the species are gaily spotted and banded; *Calligrapha scalaris* Lec. is abundant on the alder. The larvæ (Fig. 506, larva of C. Philadelphica Linn.) are thick and fleshy, with a row of black spiracles along the side of the body, and a dark prothoracic shield.

Eumolpus auratus Fabr. is a shining, rich golden green beetle, found on the dog's-bane.

Chlamys is a little oblong, cubical, roughly shagreened, metallic greenish beetle, found in abundance on leaves southward. The larva of *Chlamys plicata* Olivier, according to Mr. S. H. Scudder, who has reared it from the sweet-fern, is a sac bearer, drawing after it a rounded, flask-shaped, blackish sac, within which it withdraws when disturbed. Larvæ apparently belonging to this species were found by Mr. Emerton on grass in pastures in July. They are interesting as being true sac-bearers, recalling Psyche helix and other sac-bearing moths, and the Phryganeids. Fig. 507 represents the larva in the act of walking, the head and thoracic segments protruding from the case. The case is a quarter of an inch long and one-half as thick, being oval cylindrical. It is black and appears to be formed of little pellets of vegetable matter chewed by the larva and applied to the edge, with a seam along the middle of the under side, which readily spreads open when the sac is pressed. The case is a little contracted before the mouth, where the pellets are a little larger than elsewhere. The larva is of the form of those of others of the family, but the body is slenderer in front of the abdomen, and the legs are longer than usual. The abdomen is suddenly thickened and curved at right angles, the tip being rather pointed. The body is white, with a brown-black head and dark brown legs, and a prothoracic corneous piece, with a corneous piece at the insertion of each leg. It is, in its natural curved posture, .25 of an inch long. In the Museum of the Peabody Academy are several minute chalcid parasites reared from *C. plicata*.

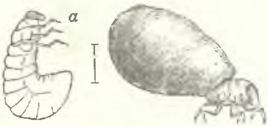


Fig. 507.

Cryptocephalus is a short, cylindrical genus, numbering nearly 800 species.

Erotylidæ Westwood. This family is very largely developed in tropical America, and is known by the large, flattened antennal club, which consists of three joints. Most of them are supposed to be leaf insects, while the more northern species live in fungi.

Endomychidæ Leach. In this small group are genera whose bodies are oval, with antennæ longer than the head, which with the trapeziform prothorax, distinguish them from the allied families. An interesting form from New Hampshire, the *Phymaphora pulchella* of Newman (Fig. 508), is described by Harris (Correspondence, p. 256) as being rust-red, with paler feet and antennæ, the head being black; there is a broad black band across the middle of the elytra, and the tips are black.


Fig. 508.

Coccinellidæ Latreille. The characteristic form of the "Lady-birds" is well known. They are hemispherical, generally red or yellow, with round or lunate black spots. The species are difficult to discriminate, and number upwards of 1,000. Some individuals belonging to different species have been known to unite sexually, but producing sterile eggs. The yellow long oval eggs are laid in patches, often in a group of plant-lice, which the larvæ greedily devour. They are rather long, oval, soft-bodied, pointed behind, with the prothorax larger than the other rings, often gaily colored and beset with tubercles or spines, and when about to turn to a pupa, the larva attaches itself by the end of the body to a leaf, and either throws off the larva skin, which remains around its tail, or the old dried skin is retained, loosely folded about the pupa as a protection, thus simulating the coarctate pupa of the flies. The Spotted Hippodamia, *H. maculata* DeGeer (Fig. 509) is pale red, with thirteen black spots on the body, and is quite common, while the *H. convergens* Guérin (Fig. 510, with larva and pupa) is common southwards. In *Coccinella* the body is smooth, hemispherical, with the hind angle of the prothorax acute.


Fig. 509.

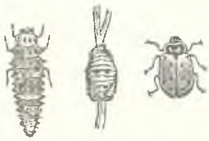


Fig. 510.

The eggs of the common Two-spotted Coccinella, *C. bipunctata* Linn., are laid in May on the bark of trees, and those of another brood are laid in June and hatched July 1st. They are oval, cylindrical, orange yellow, and are attached in a bunch of about twenty-five, by one end to the bark. They hatch out when the leaves and their natural article of diet, the Aphis, appear, and may be found running about over the leaves of various garden shrubs and trees. The body is black with flattened tubercles spinulated above; on each side of the first abdominal segment is a yellowish spot, and there is a broad yellowish spot in the middle of the fourth segment, and one on each side. On June 28th we found several fully grown larvæ a quarter of an inch long, transforming into pupæ, with a freshly transformed beetle. The larva begins the operation by attaching very firmly, with a sort of silky gum, its tail to the leaf, the point of attachment not being the extreme tip, but just before it, where the tip of the abdomen of the pupa is situated. Meanwhile the body contracts in length and widens, the head is bent upon the breast, and in about twenty-four hours the skin splits open and discloses the pupa. The body

Fig. 511.

of the pupa is black; the head is also black, and the prothorax is black and yellowish pink, with a black dot on each side, and a smaller black dot on each edge; the mesothorax, wing-covers, scutellum and legs, are shining black. The abdominal rings are pale flesh-colored, with two rows of large black spots on each side, the spots being transverse; the terga of the fourth to the seventh segments are separated, the body being arched and leaving a deep furrow between. The beetle is orange yellow, with a black head and prothorax; the side of the prothorax is whitish, with a central diamond-shaped white spot, and behind it a much longer whitish spot. The beetle derives its specific name from the two black dots on the elytra. It hibernates, and might be used to clear house-plants of plant-lice. The Nine-spotted Coccinella, *C. novemnotata* Herbst (Fig. 511, and pupa), and the Three-banded Coccinella, *C. trifasciata* Linn. (Fig. 512), are also not uncommon species.

Fig. 512.

The Fifteen-spotted Lady-bird, *Mysia 15-punctata* Olivier, is black on the head and prothorax, with seven black spots on the brownish red elytra, and a black spot on the scutellum; it is seven-twentieths of an inch in length. The larva closely resembles that of Coccinella, but along the body are six rows of stout spinulated spines; the upper surface of the body is black, with a pale spot on the hinder edge of the prothoracic ring; the body is pale beneath. It is half an inch long. The pupa is pale, not black like that of the Coccinellæ known to us, and is sixteen-spotted, with three additional rows of dark spots on the abdomen. The body is broad and flat, with a row of three spines on each side of the abdomen, and is .40 of an inch long.

In *Chilocorus* the margin of the elytra is dilated, and the lunate prothorax is rounded behind. *C. bivulnerulus* Mulsant (Fig. 513) is black, with two yellow spots.


Fig. 513.

The genus *Scymnus* is hemispherical, pubescent, with short, abruptly clavate antennæ. I have received from Dr. H. Shimer the larva and adult of *Scymnus cervicalis* Muls. which he found in the holes of insects boring in the Prickly-ash. The body is subcylindrical, pale whitish, much longer and slenderer and narrower than in Coccinella, with a small black round head; the legs are long and slender, more so than in Coccinella. The rings are rather convex, not tuberculated above, though provided with a few hairs. It is .12 of an inch long. The beetle is reddish brown, with very dark Prussian blue elytra, and is .10 of an inch long.


Fig. 514.

Epilachna borealis Thunberg (Fig. 514) is yellowish, with seven large black patches on each elytron. "The larvæ, according to Osten Sacken, are common on the leaves of the pumpkin. It is yellow, with long, brown, branched spines, arranged in rows of six on each segment, except the first thoracic segment, which has only four. The pupa instead of spines has short bristles, especially on the thorax."

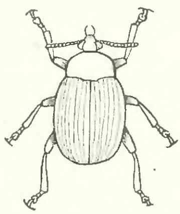


Fig. 515.
The Pea Weevil.

In the remaining suborders, the metamorphosis is, with the exception of most of the Neuroptera, generally "incomplete," the active larva and pupa closely resembling the adult, and often scarcely distinguishable from it except in being wingless. This similarity of the adult condition to the larval and pupal forms, as well as the equality in size of the different segments of the body, the aquatic habits of many of the species, and the numerous genuine parasites found among them, are indicative of their low rank.

HEMIPTERA.

This suborder, including the true "bugs," plant-lice, bed-bug and body-lice, may be briefly characterized by the beak-like sucking mouth-parts, composed of the mandibles and maxillæ, which are ensheathed by the large expanded labium, while the labrum is small and short; by the free, large prothorax, the usually angular short body, and the irregularly veined wings, the veins being but few in number, while the fore wings are often half coriaceous and opake. The metamorphosis is incomplete. There are many wingless parasitic forms, and many aquatic species.

The triangular head is nearly always sunken into the prothorax, and is small in proportion to the rest of the body; the eyes are small, nearly globular and very prominent, and the three ocelli are set far back, while the short, bristle-like, or filiform antennæ, composed of from five to nine joints, are inserted below and far in advance of the eyes, so that the front is broad and flat. The mouth-parts are greatly produced into a solid hard beak. The mandibles and maxillæ are long and style-like, the latter without palpi; they are ensheathed at their base by the canaliculate labium, which has obsolete palpi, while the lingua is short, but slightly developed, its function of tasting the food, owing to the peculiar habits of the suborder, being thrown into disuse. The labrum is well developed, being generally acutely triangular. The thorax is constructed on the coleopterous type, the prothorax being broad above, and the wings, when folded, concealing the rest of the body, while the side pieces (the epimera and episterna) are large and of much the same form as in the Coleoptera, and the legs are situated close together, with coxæ and trochanters very similar to those of the Coleoptera. The body is usually very flat above, or, in the more or less cylindrical species, somewhat broad and flat. The body is less concentrated headwards than in the Coleoptera, though much more so than in the Orthoptera, and in this respect, as well as in other essential characters, the group is intermediate between these two suborders. Both pairs of wings are very equal in size and alike in shape, except in the higher families where they are very unequal, the hinder pair being very small. They are generally very regularly ovate in shape, the costal edge being much curved and rounded towards the obtusely rounded apex; the outer edge is long and very oblique, and the inner edge short, though often longer than the outer edge in the lower families. The type of venation is rather peculiar in this suborder, as the costal veins are large and stout, while, as seen in the wings of Aphis, the median veins are sent out from the costa; indeed there is no central powerful vein in the middle of the wing; in other words the wing is scarcely differentiated into its three special regions, so well seen in the Hymenoptera and Lepidoptera, and especially the Orthoptera. The surface is net-veined rather than parallel-veined, but there are few veinlets, and the interspaces are large and few in number, and in this respect most Hemiptera show their superiority to the Orthoptera and Neuroptera. In the lower section of the suborder, the Heteropterous Hemiptera, the thickening of the basal half of the wing tends to obliterate all traces of the veins, and especially the veinlets.

The legs are slender, and often very long, owing to the great length of the femora and tibiæ, while the tarsi, like those of the lowest Coleoptera, are two or three-jointed.

The abdomen has six to nine segments apparent, though the typical number is eleven, according to Lacaze-Duthiers. The stigmata are very distinct, being often raised on a tubercle. On the basal ring of the abdomen are two cavities in which are sometimes seated vocal organs, as in the male Cicada, and in the metathorax of some species are glands for secreting a foul odorous fluid. Lacaze-Duthiers has given a sectional view of Ranatra (Fig. 516; V, dorsal vessel; I, intestine; N, nervous cord) which shows the relation of the elements of an abdominal segment. T, is the tergum; EM, the epimerum; ES, the episternum, and S, the sternum.

The ovipositor and the genital armature are generally concealed within the tip of the abdomen, being rarely exserted so as to form a prominent part of the body. It differs greatly in its development, and is difficult to reduce to a common type. Lacaze-Duthiers states that we may consider the abdomen of the Hemiptera as consisting of ten or eleven segments, according as we consider the horny ring, lying between the abdomen and thorax as the basal ring of the abdomen, or not. He regards the former view as the true one. This author contends that in *Ploa* the tergum of the first and second abdominal segments (proto and deutotergites) are coalesced, and that the original sutures are marked by simple striæ, while at the opposite end of the abdomen the genital and anal outlets are separated by three rings, *i.e.*, the eighth, ninth and tenth.

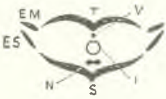


Fig. 516.

In the *Cicadidæ* and Phytocoris the ovipositor is perfect and much as described in the Hymenoptera. In the *Fulgoridæ*, Nautocoris, Ploa and Notonecta, the eighth segment is complete, while the ovipositor is more or less incomplete, and it often happens that a reunion of secondary pieces represents a principal piece, and that the elements of the two postgenital rings are articulated together by overlapping each other.

In Ranatra, Nepa and Gerris is a third modification of the ovipositor, where the postgenital segment is incomplete, and the sternal appendages and sternum of the segment bearing the ovipositor only remain, the other parts being aborted. In the Pentatomids and Cimex there is no ovipositor, but the aborted elements are more or less developed, so as to be identifiable.

The nervous system consists, besides those of the head, of two thoracic ganglia, of which the anterior is the smaller, which send off two main trunks to the abdomen.

The œsophagus is usually small and short, while the much convoluted stomach is very long and subdivided, first into a large, straight, glandular portion; second, into the convoluted smaller part, and third, in some Pentatomids and *Coreidæ* there is a third stomach "consisting of a very narrow, slightly flexuous canal, on which are inserted two or four rows of closely aggregated glandular tubes." (Siebold.) The *Cicadidæ*, and most Heteropterous Hemiptera, have very large lobulated salivary glands, divided into two unequal portions, and often with long digitiform processes.

In the aquatic species of the *Naucoridæ* and *Nepidæ* there are only two stigmata at the end of the abdomen. In Nepa and Ranatra the stigmata are situated at the base of a long tube. There are four long urinary tubes. The ovaries are formed of from four to eight tubes arranged in a verticillate manner about the end of the short oviduct. In the *Psyllidæ* and *Cicadidæ*, however, they are composed, in the first family, of from ten to thirty unilocular tubes, and in the second, of from twenty to seventy bilocular tubes. The *receptaculum seminis* consists of one or two small caeca, and the *Cicadidæ* are the only Hemiptera which have a copulatory pouch, this consisting of a pyriform vesicle. "The viviparous *Aphidæ* differ from those which are oviparous, in that their eight ovarian tubes are multilocular and their oviducts entirely without appendages, while with the second, or oviparous, these eight tubes are unilocular, and there is a seminal receptacle and two sebaceous glands." (Siebold.) The testes vary greatly in number and form, consisting of from one to five tubuliform or rounded glands.

The active larvæ of the Hemiptera, like those of the Orthoptera, resemble closely the imago, differing mainly in possessing the rudiments of wings, which are acquired after the first moulting. After two or more changes of skin they pass into the pupa state, which differs mainly from that of the larva in having larger wing-pads. While the development of the imago ordinarily occupies the summer months, in the Aphides it takes but a comparatively few days, but in the Seventeen-year Locust as many years as its name indicates. An exception to this mode of development is seen in the larva of the male

Coccus, which, as in the higher suborders, spins a silken cocoon, and changes into an inactive pupa.

Apterous individuals, especially females, sometimes occur, especially in the aquatic Hydrometra, Velia and Limnobates, and in many other genera the hind pair of wings are often absent.

The embryological development of such Hemiptera as have been observed (*i.e.*, Corixa, according to Dr. Brandt's researches), corresponds very closely with that of the Neuroptera (Calopteryx and Diplax).

There are about 12,000 species living and fossil. Some species are of great size, especially the Hydrocores, a division containing the aquatic genera, Velia, Nepa, Belostoma and Notonecta, and which first appeared in the Jurassic formation.

Latreille divided the Hemiptera into the Heteroptera and Homoptera. The latter are the higher in rank, as the body is more cephalized, the parts of the body more specialized, and in the *Aphidæ*, which top the series, we have a greater sexual differentiation, the females being both sexual and asexual, the latter by a budding process, and without the interposition of the male producing immense numbers of young, which feed in colonies. The species are smaller than in the Heteroptera, and are all terrestrial. The Heteropterous Hemiptera, on the other hand, are larger, the body is less compactly put together, the abdomen and thorax are elongated, the head is small compared with the rest of the body, and the species are large, some of great size (a sign of degradation among insects), and several families are aquatic, indicating a lower grade of development, while representatives of these were the first of the suborder to appear in geological times. Their affinities are with the Orthoptera and Neuroptera, while the *Aphidæ* and Homoptera generally, on the other hand, whose bodies are more cylindrical, ally themselves with the first and higher series of suborders.

In the Homopterous Hemiptera the fore pair of wings are generally transparent and usually net-veined, lying with the hind pair, which are considerably smaller, roof-like upon the body, and the head is held vertically, where in most Heteroptera it is horizontal and flattened.

Aphidæ Latreille. The Plant-lice have antennæ with from five to seven joints, and generally longer than the body. The ocelli are wanting, and the beak is three-jointed and developed in both sexes. The legs are long and slender, with two-jointed tarsi. The males and females are winged, and also the last brood of asexual individuals, but the early summer broods are wingless. Their bodies are flask-shaped, being cylindrical, the abdomen thick and rounded, and in Aphis and Lachnus is provided with two tubes on the sixth segment for the passage of a sweet fluid secreted from the stomach. The wings are not net-veined, having few veins, which pass outwards from the costa. They are usually green in color, with a soft powdery bloom which exudes from their bodies.

Bonnet first discovered that the summer brood of wingless individuals were born of virgin parents, hatched from eggs laid in the autumn, and that the true winged sexes composed the last generation, which united sexually, and that the female laid eggs in the autumn which produced the spring brood of asexual wingless individuals.

Dr. W. I. Burnett gives the following brief summary of the mode of development in this group. In the early autumn the colonies of plant-lice are composed of both male and female individuals; these pair, the males then die, and the females begin to deposit their eggs, after which they die also. Early in the spring, as soon as the sap begins to flow, these eggs are hatched, and the young lice immediately begin to pump up sap from the tender leaves and shoots, increase rapidly in size, and in a short time come to maturity. In this state it is found that the whole brood, without a single exception, consists solely of females, or rather, and more properly, of individuals which are capable of reproducing their kind. This reproduction takes place by a viviparous generation, there being found in the individuals in question, young lice, which, when capable of entering upon individual life, escape from their progenitors, and form a new and greatly increased colony. This second generation pursues the same course as the first, the individuals of which it is composed being, like those of the first, sexless, or at least without any trace of the male sex throughout. These same conditions are then repeated, and so on almost indefinitely, experiments having shown that the power of reproduction under such circumstances may be exercised, according to Bonnet, at least through nine generations, while Duval obtained thus eleven generations in seven months, his generations being curtailed at this stage not by a failure of the reproductive power but by the approach of winter, which killed his specimens; and Kyber even observed that a colony of *Aphis dianthi*, which had been brought into a constantly heated room, continued to propagate for four years in this manner, without the intervention of males, and even in this instance it remains to be proved how much longer these phenomena might have been continued." Dr. Burnett, from whom we quote, considers this anomalous mode of increase of individuals as a process of *budding*, and that the whole series, like the leaves of a tree, constitutes but a single generation, which results from the union of the sexes in the previous fall. It has always been supposed that the final autumnal set of individuals were males and females alone. But Dr. Burnett states: "The terminal brood has hitherto been considered, as far as I am aware, to be composed exclusively of males and females, or, in other words, of perfect insects of both sexes. I was surprised, therefore, on examining the internal organs of the non-winged individuals, to find that many of these last were not females proper, but simply the ordinary gemmiparous form. Moreover so great was the similarity of appearance between these two forms—true females and gemmiparous individuals—that they could be distinguished only by an examination of their internal genitalia."

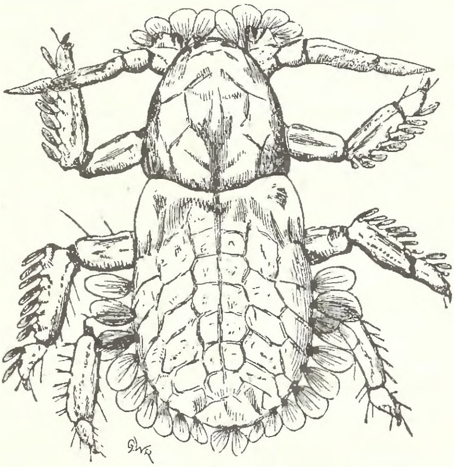


Fig. 517.

MM. Balbiani and Signoret have discovered that the common European *Aphis aceris* produces, besides young of the normal form, a singular dimorphous form (Fig. 517), first described in 1852 by Mr. J. Thornton, under the name of *Phyllophorus testudinatus*, and afterwards called *Periphyllus testudo* by M. Van der Hoeven. The chief characteristic of this remarkable form, which is flattened, scale-like, is the series of leaf-like scales surrounding the body and bordering the appendages, while the upper side of the abdomen is covered with hexagonal figures. The generative apparatus is also very rudimentary. It does not produce young, and the insects themselves do not increase in size after birth, being scarcely one millimetre in length. "They undergo no change of skin, never acquire wings like the reproductive individuals, and their antennæ always retain the five joints which they present in all young Aphides before the first moult." (Science Gossip, 1867, p. 204.)

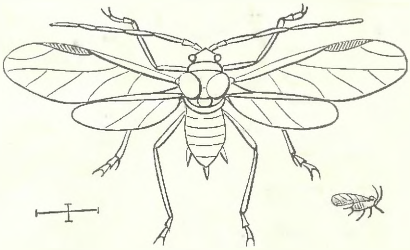


Fig. 518.

Aphides are found upon every part of plants. Some species which are wingless, are found on the roots of plants, others on the stems of twigs, others roll up leaves, or form gall-like swellings on leaves; the grain Aphis sucks the sap of the kernel. Ants are fond of the sweet excretions from the abdominal tubes, and often keep them captive in their nests like herds of cattle. Syrphus flies, Coccinellæ, etc., keep them within proper limits in nature. Various species of Aphidius kill larger numbers than we imagine. "When an Aphis has received an egg from one of these parasites it quits its companions and fastens itself by its ungues to the under side of a leaf, when it swells into a globular form, its skin stretched out and dried up, and in a short time the perfect parasite escapes by a circular hole, the mouth of which sometimes remains like a trap door." In the Museum of the Peabody Academy is an apple twig almost covered with dead Aphides, each perforated by a hole from which an Aphidius had escaped.

In *Aphis* the seven-jointed antennæ are longer than the body, the two basal joints short and thick, the seventh the longest, and near the end of the abdomen there are two long honey tubes. *Aphis avenæ* Fabr. is abundant and very injurious to the ears of wheat, sucking out the sap and greatly reducing the bulk of the corn. In certain years it has spread over the country in immense numbers. *Aphis mali* Fabr. (Fig. 518, winged female; Fig. 519, asexual female), and *A. malifoliæ* Fitch are found on the apple; *A. cerasi* Fabr. on the cherry; *A. persicæ* Sulzer on the peach, and *A. brassicæ* Linn. on the cabbage. There are about thirty species known in this country.

In *Lachnus* the sixth joint of the antennæ is shorter than the seventh, and the honey tubes are very short. *Lachnus strobi* is found on the white pine bushes often in great numbers.

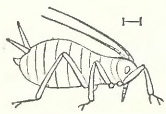
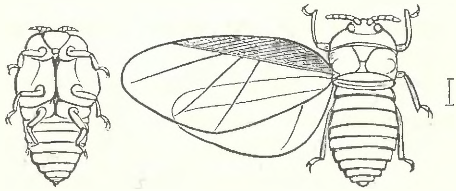


Fig. 519.

Lachnus caryæ Harris is a very large species which lives on the Hickory. Mr. Walsh states that he has "noticed in the autumn, numerous apterous females on the same tree, which lived many days and laid their eggs in confinement, but died without assuming wings." The genus *Eriosoma* differs in having no honey tubes, and in having only two median (discoidal) cells. The species are covered with a woolly flocculent substance, secreted from the abdomen, though no special glands for this purpose have yet been discovered, while but little "honey" is exuded from the orifices of the aborted honey-tubes. *Eriosoma lanigera* Hausmann, the Apple-blight, is black, with the abdomen honey yellow. The eggs are laid in the axils of the branches, especially near the roots of the tree, if there are any suckers present, and are enveloped in the powdery substance of the abdomen of the female. By their stings in the bark numerous warts and excresences are produced, the leaves turn yellow and drop off, and the tree often dies. Professor Verrill has found, about the middle of October, among the wingless individuals, "a large number of both males and females having well formed and rather large wings, but in other respects closely resembling the rest."

The genus *Adelges* was proposed by Vallot for certain broad, flattened plant-lice, which attack coniferous trees, often raising swellings on twigs like pine and spruce cones. The antennæ are short, five-jointed and slender; there are three straight veinlets arising from the main subcostal vein and directed outwards, and there are no honey tubes; otherwise these insects closely resemble the Aphides. A species (Fig. 520; *a*, pupa seen from beneath) closely related to the European *Adelges* (Chermes) *coccineus* of Ratzburg, and the *A. strobilobius* of Kaltenbach, which have similar habits, we have found in abundance on the spruce in Maine, where it produces swellings at the end of the twigs, resembling in size and form the cones of the same tree.


a Fig. 520.

Under the name of *Hamamelistes* Dr. Shimer describes a species, *H. cornu* (Fig. 521, wings), which inhabits "obliquely conical or horn-like galls on the upper side of the leaf of Hamamelis Virginica, the Witch Hazel, opening on the under side of the leaf." In this genus the "wings are laid flat on the back in repose, extending much beyond the body," while the honey tubes are either small or obsolete, and the antennæ are short, being from three to five-jointed.

The genus *Thelaxes* differs in the wings being folded flat on the back, and there are but two veins in the hind wings, one subcostal, the other median. *Thelaxes ulmicola* Walsh inhabits galls on the leaves of the elm. Mr. Walsh states that the winged females are black and more or less pruinose. In *Byrsocrypta* the wings are steeply roofed, according to Walsh, and in the six-jointed antennæ "the sixth joint is nearly as long as the fourth and fifth together." This genus also consists of several gall-inhabiting species. In the species of *Pemphigus*, which produce gall-like excresences on plants, the fourth to the sixth antennal joints are nearly equal in length, and, as in Byrsocrypta, there are two median veins, the third vein of the wing being simple, while in Eriosoma it is forked. Mr. Walsh has "ascertained from repeated observa-


Fig. 521.

tions the very curious fact, that the ants fetch the larvæ of *Pemphigus formicetorum* Walsh home to their nests from the roots on which they feed, and place them in little clusters of fifty or sixty individuals, where they soon elaborate such a dense mass of white cottony matter as to entirely conceal them." (Proceedings of the Entomological Society of Philadelphia, i, p. 307.)

Pemphigus formicarius is attended by Formica aphidicola. Mr. Walsh, who describes it, states that "two kinds of larvæ occurred in company; the first, when recent, scarcely twice as long as wide and whitish; the second, when recent, three times as long as wide and cinereous. From the latter I bred five *winged* individuals."

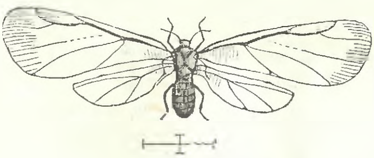


Fig. 522.

Another species, the Vagabond Pemphigus, *P. vagabondus* Walsh (Fig. 522), so-called from its habit of wandering to very great distances in its native forests, raises large galls (Fig. 523) on the tops of the cotton-wood and balsam poplars; and the "old blackened galls hang on to the twigs for several seasons, giving the tree a singular appearance when the leaves are off in the winter time." A single female begins the gall, whose young soon multiply, leaving the gall in September. Mr. Walsh has also described the Sumac gall (Fig. 524) caused by a smaller species, the *Pemphigus rhois* of Fitch, and also the Cockscomb-elm gall (Fig. 525) made by the *P. ulmicola* of Fitch, which infests young white elm trees, often densely covering the leaves. "By the end of June or the beginning of July, the gall becomes full of winged plant-

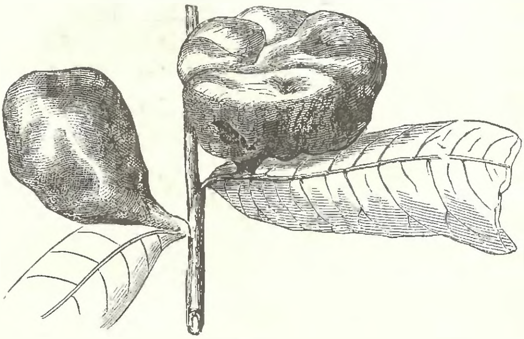


Fig. 523.

lice, when the slit on the under side of the leaf, through which the mother plant-louse built up the gall early in the spring, gapes open and allows the insects to escape into the open air." (American Entomologist, p. 108.)

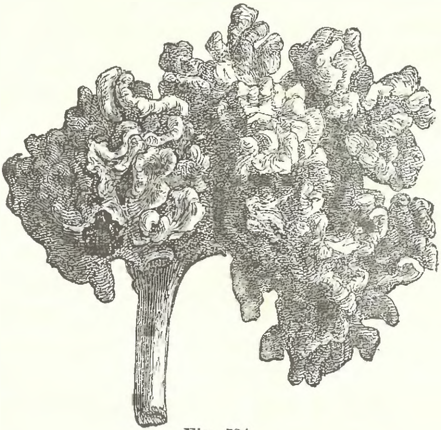


Fig. 524.

The Editors of the "American Entomologist" describe and figure the Apple root plant-louse, *Eriosoma* (Pemphigus) *pyri* of Fitch (Fig. 526; *a*, the gall; *b*, larva; *c*, female; *d*, leg; *e*, beak; *f*, antenna of female; *g*, of larva), which occurs sometimes in great abundance, forming, in October, galls like potatoes, and two to three inches in diameter, on the roots of apple trees, just beneath the surface of the ground.

The European *Chermes* (Pemphigus) *abietis* has two sorts of females, and is parthenogenous, according to Leuckart.

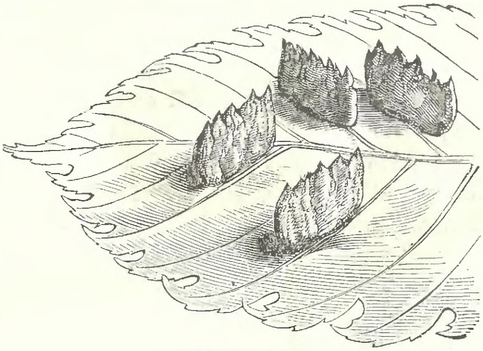


Fig. 525.

Coccidæ Fallen. The Bark-lice have six or more joints to the antennæ; the tarsi are two-jointed, the beak wanting in the males, in which the hind wings are usually wanting, while the scales made by the females are usually flattened, scale-like, or rounded hemispherical. The wingless, scale-like, adult females, by a retrograde development, in which the legs and rings of the body become aborted, remind us of the Barnacles and allies among

Crustacea, and like them, they can scarcely be referred to the type of Articulates at all, while other forms, such as C. cacti in its larval state, resemble Glomeris, or the Isopods, among Crustacea. On the other hand the males have been mistaken for some Neuroptera, and the male Coccus, with its long anal stylets and the single pair of fore wings, may be likened to an Ephemera. The genera Aspidiotus and Lecanium are parthenogenous, as in the *Aphidæ*.

In *Aleurodes* both sexes are winged and of similar form, the antennæ are six-jointed, with the second joint lengthened, and in the fore wings, which are spread out as in Lepidoptera, there is but a single vein, the median. We have received from Mr. J. L. Russell, the young and adult of a species which occurred in great numbers on his house-plants and especially on the tomato leaves.

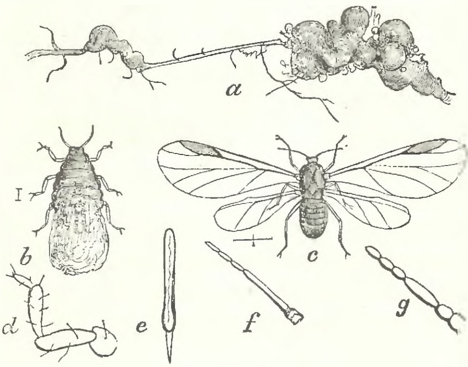


Fig. 526.

The winged forms appeared early in September. The larvæ are green and scale-like, rounded oval, and the pupæ retain the same form and are smooth beneath, but with minute hairs above and on the edges. The adult is yellowish white, with snow-white wings, and is about .04 of an inch in length. The body of the imago nearly formed, with black eyes, can be seen through the thin pupa skin. In *Dorthesia* the males only are provided with wings; the antennæ are long, nine-jointed, and the abdomen is oval, ending in a bushy mass of threads. The genus *Coccus* differs in that the two-winged males have ten-jointed antennæ and two anal bristles.

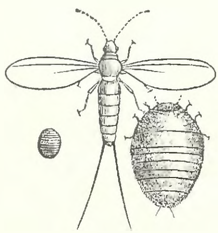


Fig. 527.

The females have nine-jointed antennæ, and are covered with a flattened, hemispherical scale. The Cochineal insect, *Coccus*

(Pseudococcus) *cacti* (Fig. 527, male, with wingless female, natural size and enlarged) secretes masses of Cochineal from its body. The males are carmine red, with light brown wings, and the anal setæ, or bristles, are two and one-half times longer than the body, which is three-fourths of a line long, while the female is one line in length, rounded in form, and covered with a heavy bloom. It lives in Mexico on the Cactus coccinellifer, and has been introduced into Spain and Algiers and the Madeira islands. *Coccus manniparus* of Ehrenberg is found at Sanai growing on the Tamarix, and produces by its attacks the gum-like secretion called "manna." *Coccus lacca* Kerr lives in the East Indies on the Ficus religiosa, and produces the *lac* of commerce. When found on the twigs it is called stick lac, but after it has been pounded, and the greater part of the coloring matter extracted by water, it is called seed lac; when melted down into cakes after it has been strained and formed into thin scales, lump lac and shell lac.

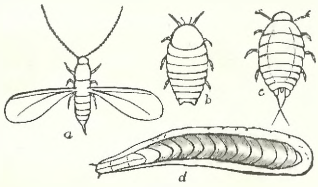


Fig. 528.

Mr. T. Glover has figured three species of Coccus found by him living on the orange in Florida, and all seem to be new to science. The first we may call *Coccus Gloverii* (Fig. 528, *a*, male; *b*, female; *d*, linear scale, enlarged) which differs from the others by not having, according to Glover's drawing, the usual pair of caudal filaments. It occurs on the bark and leaves, especially on the outer edge, and along the midrib. Another species is represented at Fig. 528, *c*. The third species is allied to the *Coccus citri* Boisduval, which has been very injurious to the orange in the Maritime Alps in Northern Italy. It has, besides a linear scale like that represented in Fig. 528, *d*, an oval scale (Fig. 529, *a*, male; *b*, female, enlarged; *c*, oval scale), and the female has two long caudal filaments. The hymenopterous parasite, Coccophagus, preys on this genus.

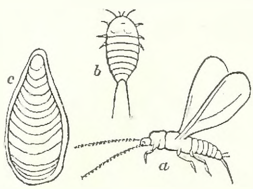


Fig. 529.

Other bark-lice belonging to another genus, *Lecanium*, are found in hot-houses; they differ from the preceding in being flat, scale-like, without any traces of rings, and have eight-jointed antennæ, while the males have nine joints to the antennæ, and are two-winged. *L. hesperidum* Linn. is found on the orange.

The Editors of the American Entomologist (p. 14) describe the *Lecanium Macluræ* (Fig. 530, *b*) which lives on the twigs and leaves of the Osage orange. "The dark part is the scale covering the insect, and this scale, as usual in the genus to which the insect belongs, is of a blood brown color. The pale part is snowy white, and is composed of a fine cottony down enveloping the eggs and young larvæ." A similar species, *L. acericola* (Fig. 530, *a*) "infests the bark as well as leaves of the common maple."

Fig. 530.

The common bark-louse of the Apple tree belongs to the genus *Aspidiotus* (A. conchiformis) and does more injury to that tree than any other insect known. It is also found on the currant, plum and pear. (Riley.) The female is shaped like an oyster shell. There are from ten to one hundred eggs laid by the female. Westwood states that the males of this genus are very broad, with broad wings, and a central anal appendage, but without the usual caudal filaments. The puparium has a double shield.

Mr. Riley has studied the habits of the *A. conchiformis*

Gmelin (Figs. 531, 532) in Illinois, and states that June 6th most of the eggs were hatched, though the young had not left the scales; on the 9th the weather being "exceedingly warm," the young (Fig. 532, 2) were found running all over the twigs; on the 11th they all became fixed, and the day after a white waxy secretion began to issue from the body in the shape of very fine, delicate threads (3). On the 22d they had increased materially in size, the waxy secretion vanished soon after the last date, leaving what appeared to be the body of a yellowish brown color, though in reality the body is underneath and separate, and has lost all trace of members. On the 6th of July the secretion rapidly increased and assumed an oval form, and the insect was of the form indicated at 5. On the 10th the scale presented the appearance indicated at 4. Two days after a third plate began to be secreted from the posterior end of the insect, and enlarged rapidly, becoming of the same color as the back. By the first of August their growth was to all appearance completed, the scale measuring .12, while the insect is only .05 of an inch long, thus occupying about half the space within (7). On the 12th of August they began to lay eggs, and by the 28th all had ceased egg-laying, while the body shrivelled up. There is but a single brood,

Fig. 531.

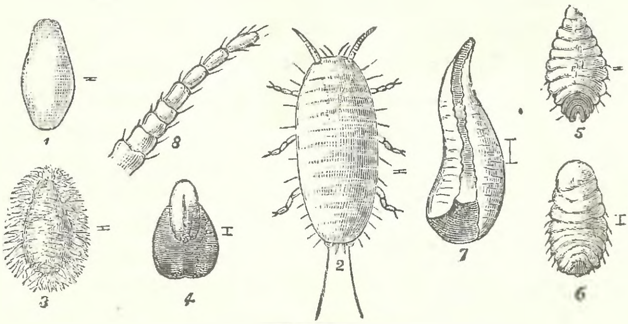


Fig. 532.

the eggs laid late in summer, hatching in the following spring. Thus it appears, according to Riley's observations, and as Harris supposed, that the shell-like scale is secreted from the surface of the body, and is identical with the flocculent matter, or down, that exudes from certain Aphides and the shell lac insect and related forms. On the other hand, Dr. Shimer, who has given the fullest history of this insect, and was the first to make observations for the most part similar to those recorded above, considers that the scale consists of the several (three) cast skins of the larva, "cemented by some kind of an exudation to the bark." This insect can be best exterminated by scraping the bark, and then washing the trees with soapsuds a few days after the trees blossom, just as the young are about hatching. Dr. Shimer has discovered a mite (Acarus? malus Shimer) which sucks the eggs in autumn.

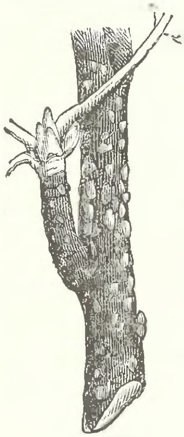


Fig. 533.

Another species, which is native, the *Aspidiotus Harrisii* of Walsh (Figs. 533, 534, A, B, showing the two kinds of scales) differs in the scale being oval, "almost entirely flat, and of a pure milk white color," with red eggs, while those of the Oyster shell bark-louse are milk white, and the larvæ are at first blood red. It occurs on the apple and pear, and is far less injurious than the other species.

PSYLLIDÆ Latreille. These small Leaf-hoppers are found hopping over the surface of leaves and often raising galls. They are flattened and provided with short legs and a broad head, and covered with a white cottony mass in the larva state. In the mature insect the forked antennæ are eight to ten-jointed, with two slender terminal bristles forming the fork. There are three remote ocelli; the beak is three-jointed, reaching to the middle of the chest, and the epimera of the metathorax terminate behind in an acute spine on each side. The limbs are short, with thickened shanks, and two-jointed tarsi. The wings are thickened and folded roof-like over the body, and the three

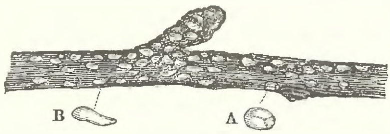


Fig. 534.

veins, costal, median and submedian, are usually each divided but once.

The genus *Psylla* has the bristle-shaped antennæ as long as the body, and a distinct pterostigma. The species are very numerous, each species of tree having its peculiar leaf-hopper, but scarcely any have been yet described. *Psylla pyri* is brownish orange, with a greenish abdomen. It is very injurious to the pear tree.

In *Livia* the antennæ are shorter than the body, with a very large and thick basal joint, and flattened eyes. *Livia vernalis* Fitch is bright ferruginous; the breast and tips of the antennæ are black, while the legs are pale rust-red. It is .15 of an inch in length, and is found in vessels of sap of the sugar maple, according to Dr. Fitch.

CICADELLINA Burmeister. The true Leaf-hoppers have a broad, triangular head obtusely pointed in front, with a large triangular scutellum not concealed by the wings when at rest, and the ocelli are either two in number or entirely wanting. The short, two-jointed antennæ end in a bristle, being inserted on the upper edge of the front, just before the eyes. The large prothorax is broad and flattened and transversely oblong. The fore wings are thickened, and the hind legs are long, being fitted for leaping.

Many species inhabiting grasses, such as Heleochara and Aphrophora, while in the larva state suck the sap of grasses and emit a great quantity of froth, or in some cases a clear liquid, which in the former case envelops the body, and thus conceals it from sight. It is then vulgarly called "toad's spittle." In *Typhlocyba*, which comprises many small species, there are no ocelli; the scutellum is rounded, and the front is slightly concave. The species of this and the following genera by their attacks on various vines and fruit trees often kill them. They are among the greatest pests of gardeners. The injury is produced by their beaks in feeding, and by the ovipositor in puncturing the leaves, in which they lay their eggs.

In *Erythroneura* the head is crescentiform, about as broad as the thorax, with the vertex rounded down to the front, without an angular edge; the ocelli are situated between the vertex and the front, and almost as near each other as the eyes, while the fore wings are without closed cells in the disk. The species most injurious to the grape-vine is the *Erythroneura vitis* Harris (Fig. 535). It is pale yellow, with two red lines on the head, while the hinder edge of the thorax, including the scutellum, the base of the fore wings, with a broad band across their middle, are scarlet, and the wings are tipped with black.

In *Jassus* the species are larger than the foregoing, with stouter bodies. The head is very broad and short, concave at base, and the ocelli are placed between the eyes on the front, which is broader than long, and the ovipositor is recurved. *Jassus irroratus* Say is not uncommonly seen on herbage.

The common *Heleochara communis* Fitch, a grass green species, is found in great abundance in damp, grassy places, in company with the yellow-legged, closely allied, *Aulacizes mollipes* Say and the *Proconia quadrivittata* Say, which has the vertex flattened and four scarlet stripes on the wings. In *Tettigonia* the antennæ are half as long as the body. *T. bifida* Say is common in grass. In *Cercopis* the prothorax is large and hexagonal.

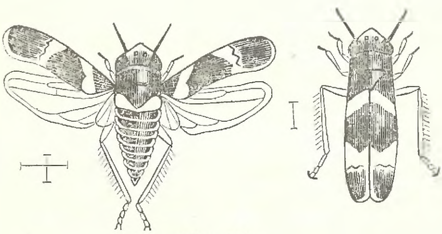


Fig. 535.

The *Clastoptera proteus* of Fitch is a common insect in blueberry fields and cranberry pastures. It is short and thick, with a bright yellow head, with a black band on the front margin of the vertex, and a broader one on the front, and a black dot near the apex of the clytra, while the legs are yellowish white, and the tarsi are black. It varies greatly in its colors. In *Aphrophora* the head is of moderate size, with two ocelli approximate on the crown of the head; the prothorax is trapezoidal and the posterior tibiæ have two teeth. *A. quadrinotata* Say is found on grape-vines.

Fulgoridæ Leach. This family, as stated by Westwood, is at once known by having only three distinct joints in the antennæ, and the two ocelli are placed beneath the eyes. The head is very large; the body is high and convex, often compressed laterally. The hind legs are thickened and enlarged, adapted for leaping purposes. Some of the strangest shapes among insects are found in this group. This is due to the great development of the forehead, or vertex of the head, which is prolonged either angularly, or into a long snout-like process, as in Fulgora, while in other species it is as long as the entire body.

"The species of some genera, such as *Flata limbata*, *Phenax variegata*, *Lystra auricoma* and *L. lanata*, emit a waxy white secretion, made into a fine white wax, which is much esteemed in China and the East Indies." (Westwood.)

The Lantern-fly, *Fulgora*, attains an immense size when compared with other Hemiptera, being between two and three inches long. The head is large with a prolongation much longer than the head, which is said by novices and some naturalists, though doubted by others, to be luminous at night, whence its name. The *Fulgora lanternaria* Linn. occurs in Surinam, and *F.* (Hotinus) *candelaria* Linn. is found in China. Mr. Caleb Cooke of Salem, who resided several years in Zanzibar, Africa, informs me that the Lantern-fly is said by the natives to be luminous. They state that the long snout lights up in the night, and in describing it, say "its head is like a lamp." (*Keetchua kana-tah.*)

In *Flata* the base of the head is concealed by the front edge of the prothorax, the front of the head is long and slender, without any middle keel; the wings are very broad and rounded.

Anotia Bonnetii Kirby is found, according to Fitch, on willows about the middle of September. *Otiocerus Coquebertii* Kirby is found on beech and oak trees, and sometimes on the grape-vine, according to Fitch.

The genus *Delphax* has a very broad front, with sharp edges and a forked keel along the middle; the antennæ are two-jointed, the articulations long and thickened at the end. *Delphax arvensis* Fitch is pale yellow, unspotted, with the elytra and wings nearly pellucid. It is common in fields of wheat early in June.

Cicadariæ Latreille. These interesting insects, commonly called "locusts," are large and wedge-shaped, with a large broad head and prominent eyes. The males have a musical apparatus beneath the wings on the basal ring of the abdomen, which acts like a kettle drum, producing a loud, penetrating, shrill sound. *Cicada rimosa* of Say, our smallest species, begins to be heard a little before the middle of June. The *C. pruinosa* Say is larger and appears later, being an autumnal species. Professor A. E. Verrill

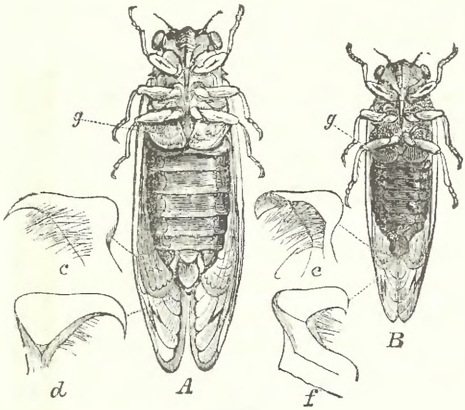


Fig. 536.

has observed this species in Norway, Me., laying its eggs in the stems of Solidago or Golden-rod. It made a longitudinal incision with ragged edges into the pith of the plant, then with its ovipositor forced its eggs a little distance down in the pith below the external opening; there were two rows of eggs succeeding the first single one, each pair diverging outwards, the lower ends

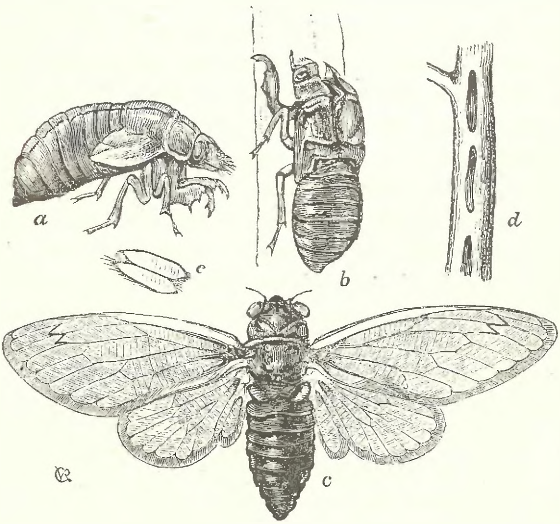


Fig. 537.

of each pair nearly touching each other, and all placed very near together. The habits of the Seventeen year locust, *Cicada* *septendecim* Linn. (Fig. 536, A; *g*, drum; *c*, *d*, male genital hooks; B, *C. Cassinii* Fisher; *g*, drum; *e*, *f*, genital hooks. Fig. 537, *c*, with expanded wings) which does not inhabit Northern New England, are well described by Harris and Fitch. The young larvæ feed on the roots of the oak and apple, clustering upon the roots and sucking the sap with their beak-like mouths. They live seventeen years. Different broods appear in different localities, so that each year they are seen in some part of the country.

Fig. 538.

The Editors of the American Entomologist, p. 63, give additional information regarding its habits. It appears during the last half of May, and disappears about the fourth of July, and the eggs hatch between the twentieth of July and the first of August. The eggs (Fig. 537; *d*, *e*, enlarged) are deposited in pairs in the terminal twigs of different species of deciduous trees, especially the oak (Fig. 538, punctured twig; Fig. 539, a twig which has been punctured and then healed over). The larvæ hatch out in about six weeks after they are laid, and (Fig. 540, newly hatched larva) drop to the ground in which they live feeding on roots of trees for nearly seventeen years, the pupa state (Fig. 537; *a*, *b*, cast pupa and skin; *c*, adult) lasting but a few days. When about to transform into the winged state they ascend to the surface, making cylindrical burrows, "firmly cemented and varnished so as to be waterproof." Mr. S. S. Rathvon has observed that in low and wet localities the pupæ extend these "galleries from four to six inches above ground (Fig. 541; *a*, full view; *b*, section) leaving an orifice of egress even with the surface (*e*). In the upper end of these chambers (*c*) the pupæ would be found awaiting their approaching time of change. They would then back down to below the level of the earth, as at *d*, and issuing forth from the orifice would attach themselves to

Fig. 539.

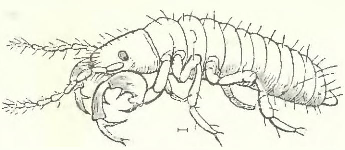


Fig. 540.

the first object at hand, and undergo their transformations in the usual manner." (American Entomologist, p. 64.)

The ovipositor of Cicada, as we have observed it in a rudimentary state in the pupa, closely resembles that of Æschna (Fig. 21), and essentially agrees with that of Bombus, the basal pair of blades arising from the eighth segment of the abdomen, as in the humble bee, and the two succeeding pairs forming the ovipositor itself (the outer pair forming a sheath) arising from the ninth segment.

Notonectidæ Latreille. The Water Boatmen somewhat resemble the Tettigoniæ, but their habits are aquatic; their hind legs are very long, ciliated, and formed for swimming. The body is convex above, but flat beneath; the head is large and nearly as wide as the rest of the body, with a broad and rounded front; the antennæ are four-jointed, concealed beneath the eyes, and the ocelli are wanting. The different species of *Corixa* are common in every pool. Their motions are rapid, diving when disturbed rapidly to the bottom and seizing hold of submerged objects. They fly well, but walk with difficulty. The genus is characterized by the single-jointed fore tarsi, which are flattened and strongly ciliated; the prothorax is large, covering the mesothorax. *C. interrupta* Say is not uncommon in pools.

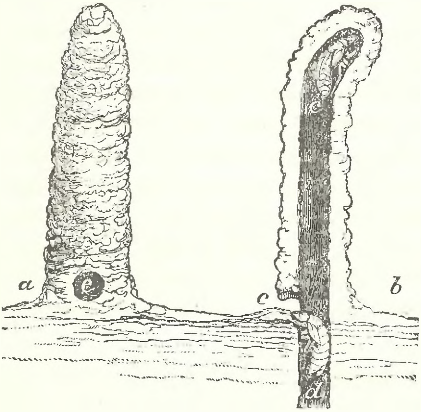


Fig. 541.


Fig. 542.

In *Notonecta* the body is somewhat prismatic in form, and hairy beneath, where in Corixa it is smooth. The fore tarsi are three-jointed, and the hind legs are very long. Roesel states that "the eggs (which are attached to the stems and leaves of aquatic plants, and are of an oval form) are hatched in fifteen days; the young make their appearance at the beginning of the spring, and the parent survives until they have arrived at maturity." (Westwood.) The recently hatched young are broad, oval and flattened. *Notonecta undulata* Say (Fig. 542) and *N. irrorata* Say are our more common forms. The genus *Ploa* differs from the preceding, in the fore wings being coriaceous, and "united together by a straight suture."

Nepidæ Leach. These insects have very flat bodies which are either oval or very long and linear. The head is sunken into the thorax, with large eyes, but no ocelli. The antennæ are short, three or four-jointed, and concealed in a cavity under the eyes; the beak is three-jointed. The fore wings are membranous, and the fore feet are raptorial, while the hind limbs are formed for swimming. In *Nepa* and *Ranatra* the body terminates in a long breathing tube, and the tracheary system in these two genera is very peculiar, being very largely developed on the under side of the body. There is a large air-bladder within the metathorax, leading from the spiracle, which evidently lightens the insect during its flight. In the abdomen the spiracles are only present on the third to the fifth rings; they are not, however, simple clefts in the walls of the body but are closed by a sieve-like membrane, so that they perform the function of tracheal gills. (Gerstaecker.)

The genus *Belostoma* comprises the most gigantic forms of the suborder, some species being from three to four and a half inches long. The body is oval, elliptical, flattened; the eyes are large and the second to the fourth antennal joints provided with hook-like expansions. The fore tarsi are two-jointed, with a single claw, and the hinder limbs are broad, flat, but not fringed. The larvæ are provided with two claws on the fore tarsi. "The females of some species of Belostomæ carry their eggs upon their backs, arranging them in a single layer with great symmetry." (Westwood.) *Belostoma Haldimanum* Leidy is not uncommon in our waters. It is three inches and a half in length, and has black patches on the under side of the body, while in *B. grisea* Say, which is of the same size, the under side is unspotted. Professor A. E. Verrill has sent me the eggs and freshly hatched young of one of our New England species of Belostoma, the former of which he found in the spring "under an old log just at, but above, the edge of the water. On the 18th of June they hatched out a most amusing flock of young bugs, nearly as large as squash bugs, and light yellowish green in color, which soon changed to dark gray." The young, two days old and previous to moulting, were .35 of an inch long. The eggs are smooth, cylindrical, .16 of an inch long, and are deposited in a mass of about ninety eggs, attached by the posterior end to a mass of silk-gum. They partially overlap each other, and the young escape by a round lid, indicated by a semicircular white line.

The genus *Ranatra* is remarkable for its long linear body, terminating in the long respiratory tube. The prothorax is greatly elongated, while the mesoscutellum is short. "The eggs of the genus Ranatra are more elongated than in Nepa, and are furnished above with two slender setæ. According to Rösel, they are deposited at random in the water, but Geoffroy states that they are introduced into the stems of aquatic plants, the elongated filaments being alone exposed. Our most common form is *Ranatra fusca* Beauvois (Fig. 543).

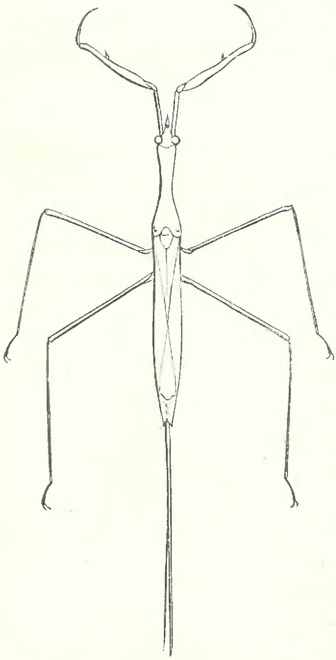


Fig. 543.

The genus *Nepa* has very short three-jointed antennæ, the two last joints being expanded laterally. The body is flat, oval, with two long respiratory tubes, while the thorax is trapezoidal, and the mesoscutellum is very large; the thighs are dilated, with a notch to receive the tibia, which is curved and soldered to the tarsus. The genus is very predaceous, feeding like Ranatra and others on the larvæ of Ephemeræ. "The eggs are deposited in the water; they are oval, and surmounted by seven elongated filaments, which serve, while the egg is in the oviduct, to form a kind of cup for the reception of the succeeding egg, but which are recurved when the egg is discharged." (Westwood.)

GALGULIDÆ (Galgudini) Burmeister. This small group consists of a few species which have the hind legs formed for running. The body is short, broad, flattened, and the head is broad with pedunculated eyes, and the four-jointed antennæ are concealed beneath the eyes, while the ocelli are present. These insects are said to live on the edge of the water, "burying themselves in the sand, especially in the larva state." The group is interesting as forming a connecting link between the aquatic and terrestrial plant-eating species.

In *Galgulus* the third antennal joint is small, the fourth minute and rounded. *G. oculatus* Fabr. is uniformly brown, the upper surface granulated, and beneath blackish.

PLOTERES Latreille. These insects are long, narrowing alike towards both ends, being shaped like a wherry, and with their long legs they course over the surface of ponds and streams, moving backwards and forwards with great facility. They are among the earliest spring insects. The body beneath is furnished with a coating of plush, to repel the water. The four-jointed antennæ are long and slender, and the fore legs are partially raptorial for seizing their prey. Wingless insects (evidently mature as they are found coupling) occur in this family, as among the *Cimicidæ*. Thus, there are apterous forms in the genera Gerris, Hydrometra and Velia, while in *Pyrrhocoris apterus* and *Prostemma guttula* there are individuals partially winged,

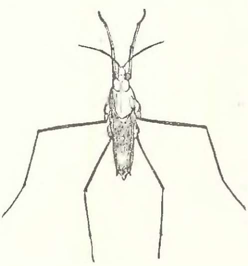


Fig. 544.

"which no one regards otherwise than as specifically identical with the full-winged specimens of the same species, . . . but must be compelled to regard them as imagines with peculiar characters of their own, somewhat analogous to the neuters, or undeveloped females of the bee; but yet more perfect than that kind of imago, being capable of reproduction." (Westwood.)

In *Velia* the triangular head is sunken in the thorax up to the eyes; the ocelli are wanting; the thorax is large, and the wings are present.

The well known genus *Gerris* has the ocelli present, the abdomen long and slender, while the prothorax is very large, covering the mesothorax. The eggs of a European species are preyed upon by a species of Telias, according to Mecznikow. *Gerris paludum* Fabr. (Fig. 544) and *G. rufoscutellatus* Fabr. a reddish species, are abundant on our streams. The larvæ are much shorter and with broader bodies than the adults.

The genus *Hylobates* has the first antennal joint as long as the two following ones together; both ocelli and wings are wanting; the mesothorax is very large, and elongated posteriorly, and the fore legs are short, outstretched, with thickened femora, while the middle pair of limbs is the longest. The species are found swimming on the surface of the ocean in the tropics far from land.

Reduviidæ (Reduvini) Latreille. The characters of this family are these: head free from the thorax, elongated, nearly cylindrical, with prominent eyes and two ocelli; the antennæ are of moderate length, slender towards the end, and the beak is stout and incurved; the tarsi are three-jointed and the legs are long and fitted for running. These insects are among the most predaceous of the Hemiptera.

The group begins with an aquatic genus *Limnobates*, which connects this family with the preceding one; it runs over the surface of pools like Gerris. The body is linear; the prothorax is as long as the rest of the thorax, and the hind wings are wanting.

Ploiaria is a remarkably slender, thread-like insect, with long hair-like posterior legs, reminding us of Tipula. The species are raptorial and are frequent in gardens. *P. brevipennis* Say is reddish, with wings, and the feet are ringed near the knees. Its ally, *Emesa*, resembles "the thinnest bits of sticks fastened together," according to Westwood. The body is long and thin, hair-like, and the antennæ are long and delicate; the fore legs are raptorial, with long and thin coxæ. The wings are either wanting, or they reach only to the middle of the abdomen. *Emesa longipes* DeGeer has a white head, with a brown band under the eyes; the femora are annulated with brown, and tipped with white.

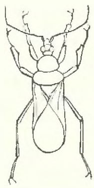


Fig. 545.

In *Salda* the body is small, elliptical and flat; the antennæ are long and thread-like, half as long as the body. The beak reaches to the end of the breast, the second joint being at least six times as long as the first, and the legs are short and slender. The species are found mostly in Europe along the shores of the ocean and inland waters.

The genus *Nabis* is known by the anterior tibiæ having an apical cushion; the beak is slender, extending to the hind legs. *Nabis ferus* Linn. is abundant in gardens, feeding on insects. An allied and common form is the *Pirates picipes* of Herrich Schaeffer (Fig. 545). The *P. biguttatus* Say has been found between the mattrasses of a bug-infested bed in south Illinois, and probably feeds on the bed-bug. (American Entomolgist, p. 37.)

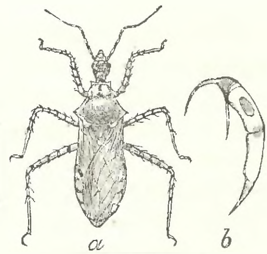


Fig. 546.

The allied genera *Prostemma* (P. guttata), and *Coranus* (C. subapterus) "are interesting on account of their being generally found in an undeveloped imago state; the latter being either entirely apterous or with the fore wings rudimental, although occasionally met with having the four wings completely developed." Mr. Westwood thinks that, *especially in hot seasons*, these apterous insects acquire full sized wings, in accordance with the same opinion of Spinola, whom he quotes.

The type of the family is the genus *Reduvius* of Fabricius, which may be recognized by its second and third antennal joints being much longer than the first, while the fourth is hair-like. The limbs are densely hirsute, and the beak is short and stout. *Reduvius personatus* Linn., a black species, is said to feed upon the bed-bug. "The larva and pupa have the instinct to envelope themselves in a thick coating of particles of dust (DeGeer) and so completely do they exercise this habit that a specimen shut up by M. Brullé, and which had undergone one of its moultings during its imprisonment, divested its old skin of its coat of dust, in order to recover itself therewith." (Westwood.) The *Evagoras viridis* Uhler MS. is said, by the Editors of the "American Entomologist," to devour the plum curculio.

In *Harpactor* the head is convex behind the eyes; the ocelli are distant, knobbed, and the first antennal joint is as long as, and stouter than, the two succeeding ones together. *Harpactor cinctus* Fabr. (Fig. 546; *b*, beak) attacks the larva of the Colorado Potato-beetle. Another member of this family, the *Conorhinus sanguisuga* of Leconte, is said to occur in beds, its bite being very painful. (American Entomologist, p. 87.)

CORISLÆ Latreille. In this very extensive family, which is especially rich in species in the tropics, where they are gaily colored, the head is flat, extended horizontally, and sunken up to the eyes within the prothorax. The antennæ are long, filiform, often clavate at the tip, and from three to five-jointed. The two ocelli are almost always present, while the beak-sheath (labium) is four-jointed. The tarsi are generally three-jointed, and the claws are provided with two suctorial pads. The membranous wing-covers have distinct, often forked, longitudinal veins.

We follow Gerstaecker in retaining Latreille's family Corisiæ, which includes the "Lygaeidæ," "Coreidæ" and "Pentatomidæ" of recent authors, as they all agree in the general form of the body, and, as stated by Gerstaecker, in the structure of the antennæ, the uniform presence of two ocelli, the longitudinal veins of the fore wings, and the hardness of the crust of the body; these characters separate them from the preceding groups.

In Lygæus and allies (Lygæidæ) the scutellum is of the normal size; the antennæ are four-jointed, and are attached to the under side of the head, and the beak is tolerably long. In *Lygæus* the head is elongated acutely, the eyes globular, the ocelli distinct, and the antennæ are slender, scarcely half as long as the body, and slightly clavate. *Lygæus turcicus* Fabr. is a typical form. *Pyrrhocoris apterus* Linn. is usually apterous; occasionally specimens are found with wings. It inhabits Europe.

The Chinch bug, *Rhyparochromus leucopterus* Say (Fig. 547) is a great enemy of our wheat crops, and, as its specific name indicates, it may be known by the white fore wings, contrasting well with a black spot on the middle of the edge of the wing. It is about three-twentieths of an inch in length. Harris also states that "the young and wingless individuals are at first bright red, changing with age to brown and black, and are always marked with a white band across the back." Shimer says the female is "occupied about twenty days in laying her eggs, about 500 in number. The larva hatches in fifteen days and there are two broods in a season, the first brood maturing, in Illinois, from the middle of July to the middle of August, and the second late in autumn." According to Harris, the "eggs of the chinch bug are laid in the ground, in which the young have been found, in great abundance, at the depth of an inch or more. They make their appearance on wheat about the middle of June, and may be seen in their various stages of growth on all kinds of grain, on corn, and on herds-grass, during the whole summer. Some of them continue alive through the winter in their places of concealment." They also attack every description of garden vegetables, attacking principally "the buds, terminal shoots, and most succulent growing parts of these and other herbaceous plants, puncturing them with their beaks, drawing off the sap, and from the effects subsequently visible, apparently poisoning the part attacked." This species is widely diffused. I have taken it frequently in Maine, and

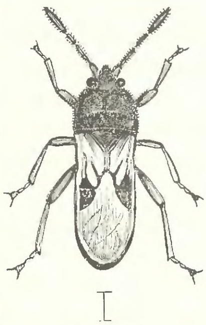


Fig. 547.

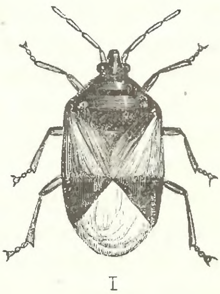


Fig. 548.

even on the extreme summit of Mount Washington, in August.

Dr. Shimer in his "Notes" on the chinch bug, says that it "attained the maximum of its development in the summer of 1864, in the extensive wheat and corn fields of the valley of the Mississippi; and in that single year three-fourths of the wheat and one-half of the corn crop were destroyed throughout many extensive districts, comprising almost the entire North-west, with an estimated loss of more than one hundred millions of dollars in the currency that then prevailed," while Mr. Walsh estimates the loss, from the ravages of this insect in Illinois alone, in 1850, to have been four millions of dollars.

In the summer of 1865, the progeny of the broods of the preceding year were almost entirely swept off by an epidemic disease, so few being left that on the 22d of August, Dr. Shimer found it "almost impossible to find even a few cabinet specimens of chinch bugs alive" where they were so abundant the year before. "During the summer of 1866 the chinch bugs were very scarce in all the early spring, and up to near the harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities." "This disease among the chinch bugs was associated with the long-continued wet, cloudy, cool weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat and electricity, combined with an excessive humidity of the atmosphere." In 1868 it again, according to the Editors of the "American Entomologist," "did considerable damage in certain counties in Southern Illinois and especially in South-west Missouri." Fig. 548 represents the *Anthocoris insidiosus* Say, called the False Chinch bug; it is often mistaken for the chinch bug, with which it is sometimes found associated.

In the "Coreidæ" the scutellum is still of the usual size; the antennæ are four-jointed; while the basal joint of the beak is generally the longest.

Westwood states that the *Coreus marginatus* of Europe "in flight makes a humming noise as loud as the hive bee," and the eggs of this species have been observed by Andouin to be "of a splendid golden appearance." The larvæ and pupæ of several species of Coreus have been observed by Westwood to "differ from the imago in wanting ocelli, possessing only two joints in the tarsi (although there is a slight indication of an articulation in the middle of the terminal joint); their antennæ also are much thicker, especially the intermediate joint. The pupa of *C. scapha* differs also from the imago in having the margins of the abdomen notched." Several adult forms of this group are known to be partially wingless.

The Squash-bug, *Coreus* (Gonocerus) *tristis* DeGeer (Fig. 549) is very destructive to squash-vines, collecting in great numbers around the stem near the ground, and sucking the sap with its stout beak. It is a large, blackish brown insect, six-tenths of an inch long, and dirty yellowish beneath. It hibernates, leaving the plant in October. About the last of June the sexes meet, and the females "lay their eggs in little patches, fastening them with a gummy substance to the under side of the leaves. The eggs are round, and flattened on two sides, and are soon hatched. The young bugs are proportionally shorter and more rounded than the perfect insects, are of a pale ash color, and have quite large antennæ, the joints of which are somewhat flattened. As they grow older and increase in size, after moulting their skins a few times, they become more oval in form, and the under side of their bodies gradually acquires a dull ochre-yellow color." (Harris.) The young attack the leaves, causing them to wither up. Successive broods are said to appear through the summer. Professor Verrill has found, with the assistance of Professor S. W. Johnson, of Yale College, that the odor of this and other hemipterous insects bears the most resemblance to that of the formate of oxide of amyl, or the formate of amylic ether. It is probable that this substance is its most essential and active ingredient. (Proceedings of the Boston Society of Natural History, xi, p. 160.)

Fig. 549.

In *Neïdes* the body is remarkably thin and slender, repeating the form of Ploiaria, or of Spectrum among the Orthoptera.

In *Alydus* the body is small, slender, the head prolonged, while the ocelli are very near together, and the last antennal joint is often twice as long as the two preceding ones together. *Alydus eurinus* Say is a widely diffused species. An allied genus is *Rhopalus*. Another species of this group is the *Metapodius nasalus* of Say, which, in the Western States, injures cherries by sucking them.

In the last group (Pentatomidæ, which we place next to the Membranacei, because they are less allied to the Homoptera, and are more nearly related to Cimex) the scutellum is very large, often covering more than one-half the abdomen, and in this respect they at least remind us of those Orthopterous genera in which the same character prevails.

This is a group of great extent, with bright colors and often of large size. The head is received into the large broad, short prothorax, and the body is generally ovate. The second joint of the beak is the longest.

The various species are found on shrubs, sucking the leaves or often transfixing caterpillars on their beaks and carrying them off to suck their blood at leisure. DeGeer describes the eggs as being generally of an oval form, attached to leaves at one end by a glutinous secretion, the other being furnished with a cap, which the larva bursts off when it hatches out. The larvæ are more convex and less flattened than the adults. "DeGeer has made an interesting observation relative to the care with which the females of a species of this family (Acanthosoma grisea), found on the birch, defend their young. In the month of July he observed many females accompanied by their respective broods, each consisting of from twenty to forty young, which they attended with as much care as a hen does her brood of chickens." (Westwood.)

In *Pentatoma* the antennæ are five-jointed; the beak is slender, reaching to the end of the breast, with its first joint lying in the furrow on the throat. The scutellum is two-thirds the length of the abdomen. *Pentatoma tristigma* Harris has a series of three or four black dots on the under side of the abdomen, of which the posterior one is largest. It is seven-twentieths of an inch long. *Pentatoma ligata* Harris is a large green species, widely edged all around, except the head, with pale red.

In *Phloëa* the body is much flattened, and expanded laterally into leaf-like flaps. The antennæ are three-jointed, the first joint of which is longest. *P. corticata* Drury is a peculiar form, which occurs in Brazil.

Arma spinosa Dallas (Fig. 550, *b*; *a*, beak, seen from beneath; *c*, beak of Euschistus punctipes Say) is useful since it preys on the larva of the Doryphora. Another bug of this group, the *Stiretrus fimbriatus* Say (Fig. 551) has similar habits.


a b c
Fig. 550.

In *Thyreocoris* the wing-covers are nearly covered by the scutellum, which is wider behind than before. The body is short and transverse, being broader than long, and scale-like or semicircular in shape. *Thyreocoris histeroides* Harris resembles a Hister beetle, and is greenish black, with dull honey yellow antennæ. The species of *Corimelæna* are of much the same form, and usually shining black. *C. pulicaria* Germar, according to Riley, injures strawberry-vines and grape-vines in Illinois. In the genus *Tetyra* the scutellum covers nearly the whole abdomen, but leaves the side of the wing-covers exposed. The antennæ are slender; the first joint is longer than the second, the third being the shortest, and the fifth is twice as long as the fourth. *Tetyra marmorata* Say is a variegated species, the costal margin of the wing being provided with transverse fuscous lines.

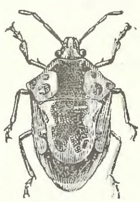


Fig. 551.

The genus *Scutellera* is remarkable for the great size of the scutellum, whence its name is derived. This piece, which is elongated triangular, covers not only the entire abdomen, but also the wings; the antennæ are five-jointed, the two first joints small, the three last ones long, quite large. The species are adorned with gay metallic colors, and are especially abundant in the Island of Sunda. (Gerstaecker.) *Scutellera viridipunctata* Say is piceous, with green impressed punctures. It is seven-twentieths of an inch long, and is found in Florida.

THRIPIDÆ (Thripsides) Fallen. This interesting group bears much the same relation to the *Corisiæ* as the lice do to the *Membranacei* (Cimex), or Podura and Lepisma to the Neuropterous families above them. A comparison with the *Mallophaga* is still better, for in Thrips (Fig. 552) we find, as in the last named group, free, biting mouth-parts, accompanied by a general degradation of the body. Though the species are winged, yet the wings are partially aborted; they are long, narrow, linear, both pairs of equal size, as in the typical Neuroptera, and by the frequent absence of any veins, either longitudinal or transverse, and the long delicate silky fringe, remind us strikingly of some minute degraded hymenopterous *Proctrotrypidæ*, Pteratomus (Plate 3, fig. 8), for example. The mandibles are bristle-like; the maxillæ are flat, triangular, bearing two to three-jointed palpi, and the labial palpi are present, but very short, and composed of but two or three joints.

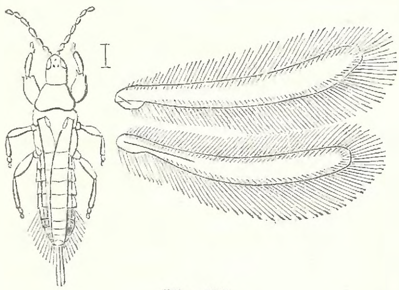


Fig. 552.

Chiefly on account of these characters these insects were placed in a distinct order, termed *Thysanoptera* by Haliday, and by many recent authors they have been widely separated from what seem to us their nearest allies. Latreille, however, recognized their affinities to the Homoptera, while stating that in their free biting mouth-parts they resembled the Orthoptera, to which Geoffroy referred them. To us they appear to be, as it were, degraded Lygæids, and to preserve the general form of that group, in the long head, the stout, thickened fore limbs, and the large, square prothorax. They have both compound and simple eyes, the latter three in number.

The antennæ are long and slender, with from five to nine joints. In some species the fore wings are comparatively well developed, or, as Haliday states, they are "transformed into broadish elytra, ciliated only behind, and with longitudinal and transverse nerves. In some species the wings are wanting, at least in the males." (Westwood.) "The abdomen is terminated in the male by a long attenuated joint, by a four-valved borer in the female."

The eggs of Phlæothrips have been compared to those of Culex, by Haliday, "being cylindric, rounded at one end, and crowned with a knob at the other." Both the larva (Fig. 554) and pupa are active, being found in the same situations as the adult. The larvæ are of softer consistence, pale, or reddish, and the thoracic rings are similar to each other, while in the pupa "the articulations of the limbs are obscured by a film, and the wings enclosed in short fixed sheaths. The antennæ are turned back on the head, and the insect, though it moves about, is much more sluggish than in the other states." (Haliday in Westwood's "Introduction," etc.)


Fig. 554.

The different species occur under the bark of trees, and are very injurious to grain and flowers, eating holes in the leaves or corollas, and sucking the sap from the flowers of wheat, in the bottom of which they hide.

In *Phlæothrips* and allies (Fig. 553, P. coriacea Haliday?) both sexes have the abdomen terminating in an acute point, being either the ovipositor of the female, or the slender terminal tube-like joint of the male. The wings are almost without veins, with long ciliæ, and at rest folded one upon the other. The antennæ are eight-jointed. Three ocelli are present in the winged species, but in the wingless forms they are absent.

The *Phlæothrips mali* of Fitch appears "in a roundish cavity near the tip end of the young fruit." Dr. Fitch describes another species (P. caryæ) which is found in singularly shaped galls on the hickory, "which resemble a long, slender pod thrust half-way through the leaf." This author doubts, however, whether these galls are made by these insects. He also states that "the insect within, when disturbed, turns its tail upward over its back in a menacing manner, the same as the rove beetles (Staphylinidæ) do, and when the point of a needle, which had been pressed upon one of these insects, is touched to the tip of the tongue, unless my imagination greatly deceives me, it will frequently be found to impart a peculiar acid biting sensation."

A second group (*Terebrantia* Haliday) includes the genus

Thrips, in which the females are provided with a four-valved compressed ovipositor which lies in a furrow in the two last abdominal segments. The fore wings are thickened, elytriform, with two longitudinal continuous veins. The antennæ are, for the most part, nine-jointed. *Thrips cerealium* Haliday is dark reddish brown, and very injurious to wheat.

CAPSINI Burmeister. The species of this family are very numerous and very active in their habits, running swiftly and easily rising on the wing. They are fond of fruits, and it is the little Capsi which give such a nauseous taste to the raspberry, which they feed upon. The females are distinguished from the males "by having the ovipositor nearly half the length of the body, somewhat sabre-shaped, and received into a slit on the under side of the abdomen." The body in this group is convex, oval, and of a soft consistence, and "distinguished by the elongated antennæ having the second joint often thickened at the tip, and the terminal joints very slender, the rostrum long and four-jointed, while the ocelli are wanting. The pupa of Capsus Danicus is clothed with short and somewhat clavate hairs." (Westwood.)

In *Capsus* the body is elliptical or oval; the head is triangular, convex. *Capsus quadrivittatus* Harris is yellow, with four black bands. *Phytocoris* differs from Capsus, according to Harris, in having a smaller head, while the thorax is wider behind and narrower in front. *P. linearis* Beauv. is a fifth of an inch long; the head is yellowish with three narrow, longitudinal, reddish stripes; the thorax has a yellow margin, with five longitudinal yellow lines upon it. The male is much darker colored. It is excessively common on all kinds of plants. It appears early in April, but is most abundant in summer. In the genus *Miris* the head is elongated triangular; the basal joint of the antennæ is thickest, whereas in the preceding genus the second joint is the stoutest. *Miris dorsalis* Say is pale yellowish rufous, immaculate, and the antennæ are rather stout, tapering, and rufous.

MEMBRANACEI Latreille. This family includes the Bed-bug, and it is from this insect that the name "bug" has been extended to the entire suborder. The antennæ are four-jointed, with the tip clavate or knobbed. The ocelli are, for the most part, wanting; the beak is gutter-like, with a three-jointed sheath (labium). The tarsi are three-jointed, without any foot-pads. In *Cimex* the beak reaches, when laid upon the breast, as far as the fore coxæ; the legs and antennæ are covered with fine hairs; the second antennal joint is longest. The prothorax is elliptical, and the metathorax is nearly as broad as the circular abdomen; the wings are wanting.

The habits of *Cimex lectularius* Linn., the bed-bug (Fig. 555), are too well known to require any farther mention here. It is exceedingly tenacious of life, and ordinary bug-powders and other applications are useless unless the most scrupulous cleanliness is exercised besides. The eggs are oval, white, and the young bugs escape by pushing off a lid at one end of the shell. They are white transparent, differing from the perfect insect in having a broad triangular head, and short and thick antennæ. Indeed, this is the general form of the louse, to which the larva of Cimex has a very close affinity. Some Cimices are parasites, infesting pigeons, swallows, etc., in this way also showing their near relation to the lice.

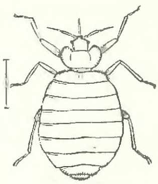


Fig. 555.

The bed-bug is rust-red, with brown hairs, and is two and a half lines in length. It lives as a parasite on the domestic birds, such as the dove. Mr. James McDonald writes me that he has found a nest of swallows on a court house in Iowa, swarming with bed-bugs. In Europe the *Cimex hirundinis* Herr. Schaeff. lives on the swallow; *Cimex pipistrelli* Jenyns lives on the bat; and *Cimex columbarius* is found in pigeon houses.

Westwood states that the bed-bug is eleven weeks in attaining its full size. DeGeer has kept full sized individuals in a sealed bottle for more than a year without food. The Cockroach is the natural enemy of the bed-bug, and destroys large numbers. Houses have been cleaned of them after being thoroughly fumigated with brimstone.

Bed-bugs, as well as other bugs, plant-lice, etc., may be destroyed by a preparation consisting of thirty parts of unpurified cheap petroleum, mixed with 1,000 parts of water. It can be introduced into holes and cracks in houses, and sprin-

Fig. 556.

kled on plants. The cracks of bedsteads may be filled with mercury; and benzine will also effectually dislodge them, as well as boiling water. The benzine may be applied by means of a surgical instrument called the Atomizer.

In *Syrtis* the head is small, compressed laterally, and the fore legs are raptorial, thus allying the genus with Reduvius. *Syrtis* (Phymata) *erosa* Fabr. (Fig. 556) has swollen fore legs, and a deep groove on the head; it is useful in devouring Aphides.

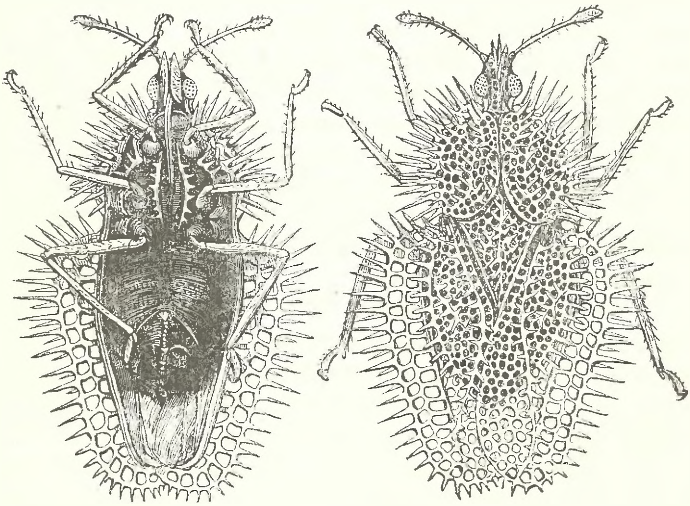


Fig. 557.

In *Tingis* the beak reaches to the end of the breast, and the fore legs are simple, the thorax and wing-covers are spread out leaf-like, and the species are of small size. *T. hyalina* Herrich-Schaeffer is abundant on the willow. *T. hystricellus* Richter (Fig. 557, upper and under side, magnified twenty diameters) is a Ceylonese species. It "sticks close to the under side of the Bringall leaf, and there undergoes all its changes, from the larval to the perfect state. The larvæ are black." (Science-Gossip, p. 84, 1869.)

In *Aradus* the beak is longer than the head, the prothorax is widely expanded, while the wing-covers are rounded at the base. *A. crenatus* of Say has the cylindrical edge of the abdomen obtusely crenated. The species are found under the bark of trees.

PEDICULINA Burmeister. Lice. In these low degraded Hemiptera, which stand in the same relation to the rest of the Hemiptera as the Flea does to the more perfectly organized Diptera, the body is wingless, with a small indistinctly jointed thorax, while the abdomen is large, oval, with nine segments. The antennæ are filiform, five-jointed, and the eyes are minute, not faceted. The tarsi are two-jointed, with a large hook-like terminal joint, which is bent back towards the basal joint. The mouth-parts still preserve the form of a beak-like sucker, but it is fleshy and retractile, and the body is white, and of minute size. The species of *Pediculus* are blood-suckers, and parasitic on man and various species of Mammalia; different species being found on different regions of the body. Different varieties, according to Dr. W. I. Burnett, are found living on the bodies of different races of men.

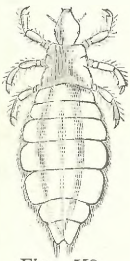


Fig. 558.

Two species live on man; *Pediculus humanus capitis* DeGeer (Fig. 558) inhabits the head, while the Body Louse, *P. corporis* of DeGeer (*P. vestimenti* Nitzsch) is found elsewhere. These two species are difficult to distinguish, they are so closely allied. Professor J. C. Schiödte, a Scandinavian naturalist, has recently published an elaborate treatise on this genus, and describes the mode of attack used by these disgusting creatures. It thrusts its minute beak into the skin, and sucks in the blood by means of its large sucking stomach or "pumping ventricle." Schiödte placed one of these insects on his hand, and observed its movements through a glass. After the creature had fixed its beak or haustellum into his hand this naturalist noticed that "at the top of the head, under the transparent skin, between and a little in advance of the eyes, a triangular blood-red point appears, which is in continual movement, expansion and contraction alternating with increased rapidity. Soon this pulsation becomes so rapid that several contractions may be counted in a second. However, we must turn our attention elsewhere, for the whole digestive tube is now in the most lively peristaltic movement, filling itself rapidly with blood, as is easily observed; the long œsophagus is particularly agitating, throwing itself from one side to another inside the neck, bending itself so violently as to remind one of the coiling of a rope when being shipped on deck."

Schiödte states that the sucking organ or beak is a "dark brown protruding haustellum, provided with hooks at each extremity, out of which an excessively delicate membranaceous tube, of varying length, is hanging. This pumping "ventricle" (which is undoubtedly homologous with the pumping stomach of most sucking insects, such as the Diptera, Lepidoptera and Hymenoptera) Schiödte has discovered in "those Coleopterous larvæ which have powerful organs for biting, placed at a distance round a very minute mouth-opening, such as the larvæ of Carabi, Hydrophili, and Hister, as well as in the larvæ of Dytisci, which suck through the mandibles."

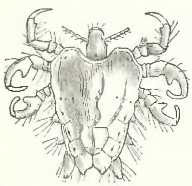


Fig. 559.

The same author also shows that the mouth of Pediculus differs from that of Hemiptera generally in the circumstance that the labium is capable of being retracted into the upper part of the head, which therefore presents a little fold, which is extended when the labium is protruded. He also shows that those parts which were, by mistake, thought to be palpi and mandibles by Erichson, Jurine and Landois, are simply lobes on the under side of a chitinous band.

In *Pediculus* the thorax is a little smaller than the elongated abdomen, and all the tarsi are two-jointed. The genus *Phthirius* has a very small thorax, with the abdomen much wider than the head, and the fore tarsi have but a single joint. *Phthirius pubis* Linn. (Fig. 559), the Crab louse, is found on the pubic region of man and also on the head.

MALLOPHAGA Nitzsch. The Bird-lice live on the hair of Mammalia and feathers of birds. In this group there are distinct jaws. The flattened body is corneous, hard above, and the head is horizontal, with three to five-jointed antennæ; the eyes are small and simple; the mandibles are small, like a hook, and the maxillary palpi, when present, for they are sometimes wanting, are four-jointed, while the labial palpi are two-jointed. The thorax is small and but two-jointed apparently, as the meso- and metathorax are united together. The abdomen is from nine to ten-jointed, while the short thick limbs have two-jointed tarsi and one or two claws.

Nearly every mammal and bird has its special mallophagous parasite, so that the number of species is actually very large.

These insects are considered by Burmeister as forming a passage from the Hemiptera into the Orthoptera, as they possess free biting mouth-parts, especially free mandibles, which are not as in the rest of the suborder fused together with the other parts to form a sucking tube.

In the genus *Philopterus* of Nitzsch the antennæ are filiform, five-jointed, and the labial palpi are wanting. *Nirmus* is an allied genus; both live on birds.

Trichodectes canis DeGeer lives on the dog, and has three-jointed antennæ, and the tarsi are provided with a single claw. The females have two movable hooks on the penultimate ring of the abdomen.

In the genus *Liotheum* and allies, the antennæ are club-shaped, four-jointed, and the labial palpi are distinct. *Liotheum anseris* Sulzer lives on the goose and swan.

Gyropus has no labial palpi; there is a single tarsal claw for clinging to the skin of its host. *Gyropus porcelli* Schrank is a third of an inch long and lives on the Porpoise.

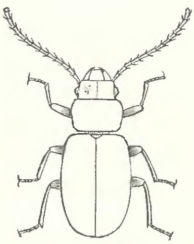


Fig. 560.
Læmophlœus adustus Lec., a Cucujid; see p. 446.

ORTHOPTERA.

This suborder may be briefly characterized as having free biting mouth-parts, with highly developed organs of nutrition and digestion. The first pair of wings are somewhat thickened to protect the broad net-veined hinder pair, which fold up like a fan upon the abdomen, and the hind legs are large and adapted for leaping. The transformations are less complete than in the previous groups, the larvæ and pupæ being both active and closely resembling the imago. All the species are terrestrial, the more typical forms having remarkable powers of flight, besides leaping powerfully.

The grasshopper is the type of the group, the other families bearing more or less resemblance to the allied suborders, especially the Neuroptera. The head is very large, and much more bulky than in the Coleoptera or Hemiptera, the mouth-parts being so large, requiring large and broad pieces to support the muscles of the head; its position is vertical, rarely becoming horizontal. The ocelli are two or three in number, while often obsolete. The eyes are small, very convex, and placed far apart. The antennæ are filiform, often of great length, and exceeding the length of the body several times, the joints being very numerous and much alike in size and shape. The clypeus is large, the suture very distinctly separating the base, and the labrum is large, with the edge rounded, slightly bilobate, and partially concealing the mandibles, which are strong and large, and toothed within. They are more perfect than in other insects, presenting both cutting and grinding surfaces. The maxillæ are very distinctly lobed, the outer lobe (galea) somewhat dilated and (in the Blattariæ) ensheathing the long, sharp-toothed inner lobe, and the palpi are five-jointed. The mentum is large and transverse, while the labium is divided into four lobes like the maxillæ, the outer pair (paraglossæ) resembling those of the maxillæ, and in the true grasshoppers (Acrydium), being expanded into a broad, flattened, smooth, concave plate. The labial palpi are from three to four-jointed. The lingua is large, fleshy and channelled above.

As in the Coleoptera, the prothorax is greatly developed over the other segments, and the mesothorax is rather smaller than the metathoracic ring. The pronotum is very large, broad and flattened above, while the other two segments are concealed by the wings when at rest, and the parts are soft and membranous. The sternum of each ring is very large, broad and flat, resembling that of Libellula, while the two fore pairs of legs are normal in size, though the fore legs are often raptorial, as in Mantis; or fossorial, as in Gryllotalpa. The hinder pair are enormously developed for leaping purposes.

The fore wings are generally long and narrow, somewhat thickened, like parchment, or thin, transparent, and more or less rounded, while the hind pair are broad and large, folding in longitudinal plaits on the back. Both wings are net-veined, but not so much so as in the Neuroptera, as the longitudinal veins are larger and more regular, while innumerable cross veins, still more regular than in the Neuroptera, though more numerous, give a characteristic facies peculiar to the Orthopterous wing. There are also numerous wingless, degraded genera, which resemble the young of other genera. The body is usually much compressed, or greatly flattened (Blattariæ), or long and cylindrical, as in the Walking Stick. The abdomen consists of eight or nine distinct segments, while the tenth forms part of the ovipositor, being somewhat aborted, the tergite only in some cases remaining, and there is in addition in the *Locustariæ*, according to the views of Lacaze-Duthiers, the tergite of an eleventh abdominal ring. We will notice more fully than usual the structure of the ovipositor, as it is of great systematic value. The genital armature is more complex than in the Hymenoptera, and is generally very large and exserted, so as to form a conspicuous part of the body. In its simplest form, in Forficula, it is represented only by a single tergite, all the other appendages being absent. In the *Locustariæ*, however, the typical form is seen, consisting of a tergite and the epimera supporting the tergo-rhabdite, while the episternum supports the sterno-rhabdites, and the oviduct opens out under the sternite. There are thus four pieces attached to the single ninth ring; the oviduct opening between the eighth and ninth segments, while the anal opening is under the eleventh ring in all the Orthoptera, according to Lacaze-Duthiers' researches. The female genital armature is farther complicated, in the *Locustariæ* especially. The eleventh segment is composed of five parts, which surround the anus.

Two of these are lateral filaments which are, in one case, as in Mantis tessellata (Fig. 23), multi-articulate, and are proper sensory organs, like the antennæ, and must be regarded, in our view, as homologous with the anal prop-legs of Lepidoptera and other insects, and as true-jointed appendages like the thoracic legs, and jointed appendages of the head, such as the palpi and antennæ. They also form the anal stylets of the *Gryllidæ*, etc. These anal stylets are articulated to the posterior edge of the tenth tergite, as Lacaze-Duthiers states, and thus seem to us to be properly appendages of that ring, which, as this author affirms, "presents two articulating teeth for this purpose." The two other elements are "triangular, surrounding the anus with three valves, which, by their union, form a sort of pyrimidal body," which he calls the "subgenital or pregenital plate." There are then, two systems of appendages, as we have before stated; *i. e.*, the genital armature, consisting of two pairs of non-articulated stylets, and the single pair of anal articulated stylets, which are the homologues of the thoracic legs, together with the pre-anal plate.

The same parts are present in the male, being converted into large, clasping, hook-shaped stylets, for retaining a firm hold of the female during sexual union.

The eggs as they pass from the oviduct between the valves are deposited in a hole in the ground, made by the powerful ovipositor. Certain *Locustariæ* imitate the Cicada in laying them methodically in the stems of plants, which are drilled out by the valves of the ovipositor, which are slightly toothed on the outer sides and easily move on one another, somewhat as in the Saw-fly and Cicada. "The eggs of the *Gryllidæ* are laid either singly in the ground, in irregular clusters in subterranean passages, or uniformly in a single row, in the pith of twigs; those of the *Locustariæ* are never laid singly, but either in the pith of plants, in regular clusters in the ground, or in regular rows on stems of plants; those of the

Acrydii are always laid in rudely regular clusters, in the ground." (Scudder.)

The nervous system closely resembles that of the Neuroptera; it is in all three stages composed of three thoracic, and six or seven abdominal ganglia, extending the whole length of the body, and united by double commissures. The splanchnic system, or analogue of the great sympathetic nerve in vertebrates, is highly developed in the *Acridii* and in Gryllotalpa, having in front two pairs of ganglia, and posteriorly one or two, while in the *Blattariæ* and *Phasmida* the single nerve is most developed.

Organs of hearing are stated by Siebold to occur in the *Acridii*, consisting of two fossæ or conchs, surrounded by a projecting horny ring, and at the base of which is stretched a membrane resembling a tympanum. On the internal surface of this membrane are two horny processes, to which is attached an extremely delicate vesicle filled with a transparent fluid, and representing a membranous labyrinth. This vesicle is in connection with an auditory nerve, which arises from the third thoracic ganglion, forms a ganglion upon the tympanum, and terminates in the immediate neighborhood of the labyrinth by a collection of cuneiform, staff-like bodies, with very finely pointed extremities (primitive nerve-fibres?), which are surrounded by loosely aggregated, ganglionic globules. The *Locustariæ* and *Gryllidæ* have a similar organ, situated in the fore legs directly below the coxo-tibial articulation. M. Hensen confirms the accuracy of this description in the "Zeitschrift für Wissenschafliche Zoölogie," vol. xvi, 1867.

The highly developed alimentary canal has the crop (proventriculus) separated by a deep constriction from the œsophagus, and the gizzard is provided internally with from six to eight rows of horny denticulated plates situated on ridges, with numerous smaller teeth between, so that the whole num ber of teeth amount to 270. The stomach is of even width, not usually making more than one-half of a turn, or one turn; its cardiac extremity is provided with from two to eight cæca. The salivary glands are highly developed, "consisting of two, four, or six botryoidal masses, situated in the thorax, and having long excretory ducts, besides, also, often having long pedunculated reservoirs.

The number of chambers in the dorsal vessel is usually eight. The respiratory system does not differ essentially from that of other insects, though in the *Acridii* most of the transverse anastomosing tracheæ have large air-reservoirs, greatly assisting in lightening the body for their long-sustained flight.

The urinary tubules are short and very numerous, from twenty to one hundred and fifty and over, surrounding the pylorus. The ovaries, two in number, consist of numerous multilocular tubes, while the seminal receptacle consists of a pedunculated vesicle, whose closed extremity is dilated into a pea-shaped vesicle, forming the *capsula seminis*. In most Orthoptera the testes consist of long fasciculated follicles surrounded by a common envelope, and many have in addition highly developed accessory glands, surrounding a short *ductus ejaculatorius*.

The larvæ of the Orthoptera materially differ only in size from the adult, and the pupæ are distinguished from them by having the rudiments of wings. They attain the adult state by simple moultings. Several cases are on record of pupæ of grasshoppers being found sexually united. In 1867 Mr. Trimen exhibited to the Entomological Society of London "a grasshopper of the genus Pœcilocerus, of which he had found the pupæ *in copula*; it was not an isolated case, for he had seen hundreds of pairs of the nymphs at Natal."

Some of the largest insects are included in this suborder, in fact the majority are larger than those of other suborders, and it will probably be found that many large grasshoppers and *Mantidæ* will weigh nearly as much as any Goliath or Hercules beetle, the largest of insects.

The Orthoptera range, in time, from the Upper Devonian formation; and among the earliest forms were some Neuropterous-like *Locustariæ* and *Blattariæ*, which are likewise, with the Neuroptera, the earliest known forms of insect life. In the carboniferous rocks they become more numerous, but the forms are most numerous and best preserved in the Tertiary formation, especially in the Amber of Prussia.

There are about 5,000 species known, which attain their greatest development in size and numbers in tropical countries.

In studying these insects, the proportions of the head, of the prothorax, of the wings, of the hind legs, and the external genital parts, should especially be taken into account. The ornamentation varies greatly even in the same species, and therefore large numbers of individuals are necessary to ensure a proper knowledge of any species.

The different sounds produced by Orthoptera should be carefully studied; every species can be distinguished by its peculiar note, and as in different families the musical apparatus varies, so each family has a characteristic chirrup, or shrilling, consisting of a harsh, grating, rasping noise.

Mr. Scudder has contributed to the "American Naturalist," ii, p. 113, an interesting article on the sounds produced by some of our native species of Grasshoppers, and has even reduced their notes to a written music. He states that grasshoppers stridulate in four different ways: "first, by rubbing the base of one wing-cover upon the other, using, for that purpose, the veins running through the middle portion of the wing; second, by a similar method, but using the veins of the inner part of the wing; third, by rubbing the inner surface of the hind legs against the outer surface of the wing-covers; and fourth, by rubbing together the upper surface of the front edge of the wings and the under surface of the wing-covers. The insects which employ the fourth method stridulate during flight, —the others while at rest. To the first group belong the Crickets (Gryllidæ); to the second the Green or Long-horned Grasshoppers (Locustariæ); to the third and fourth, certain kinds of Short-horned or Jumping Grasshoppers (Acrydii)."

The transformations of grasshoppers need careful study. For this purpose their eggs should be sought for, and the development of the embryo in the egg be noted; also the following facts should be ascertained: the date of deposition of the eggs; the manner of laying them; how long before the embryo is hatched; the date of hatching; how many days the pupa lives; so also of the pupa and of the imago, while the intervening changes should be carefully observed. Crows and blackbirds feed on their eggs and larvæ, and hens and turkeys feed greedily upon young and old. Ichneumon parasites prey upon them, and also the lower worms, such as Filaria, Gregarina and Gordius, and the red mites attack them. Mud wasps provision their nests with the young.

Orthoptera can be easily preserved in strong alcohol, and may afterwards be taken out and pinned and set at leisure. They can be killed with cyanide of potassium, or ether, without losing their colors, as they would do after remaining long in alcohol. They should be pinned through a little triangular spot between the bases of the elytra, or fore wings, when the wings can be spread to advantage. They are also often pinned through the prothorax, or through the right elytron, as in Coleoptera. In pinning these insects for transportation care should be taken to put in additional pins crossing each other on each side of the abdomen, and in like manner to steady the hind legs, which are very apt to fall off if too much jarred.

GRYLLIDÆ Latreille. The Crickets have a somewhat cylindrical body, a large vertical head, with elliptical eyes; the ocelli are often wanting, and the long filiform antennæ arise from in front of and between the eyes. The wings are of moderate size, net-veined, lying flat on the back; the fore pair are ovate, the costal edge of the fore wings being bent abruptly down on the sides of the body, while the hinder pair are triangular. They, like the succeeding families, leap actively, the hind femora being enlarged. The genital armature is largely developed, forming long and slender stylets, often nearly as long as the body. "The subgenital plate is formed by the seventh sternite. The eighth abdominal segment is rudimentary and concealed beneath the seventh segment. The ninth segment, situated beyond the outlet of the ovipositor is incomplete. Its elements, appearing to be four in number, are developed into a large solid borer. The ninth sternite is bifid, its episternite not being developed." (L. Duthiers.) A second type is observed in Gryllotalpa, where the subgenital plate is formed by the eighth sternite, instead of the seventh, and the incomplete sternite and tergite of the ninth segment are present, much like those of the other abdominal rings. The ovipositor is very long, while the hairy stylets arise from the eleventh abdominal ring and are very long. In the male the long anal hairy stylets are retained, while the parts representing the ovipositor are aborted. The *shrilling* of the male is a sexual call, made by raising the fore wings and rubbing them on the hind wings. The noise is due to the peculiar structure of the fore wings, the middle portion of which forms, by its transparent elastic surface, on which there are but few veinlets, a resonant drum, increasing the volume of sound emitted by the rubbing of the *file* on the upper surface of the hind pair of wings. This file is the modified internal vein, the surface of which is greatly thickened, rounded and covered closely with fine teeth. In the females the wings are not thus modified, and they are silent. They have been known to lay 300 eggs, glued together in a common mass. In July the larvæ appear, and by the last of August the grass is alive with fully grown crickets, their loud chirruping resounding through the warm days and nights of autumn. The species are generally dull black or brownish, and in the tropics attain to a large size.

In the genus *Tridactylus* the males have the anterior tibiæ three-fingered, *i. e.*, the tibia has a lateral hooked appendage to which the tarsus is attached, while a long hooked projection takes the place of the feet. The species are minute, the largest known, *T. apicalis* Say, being one-fifth of an inch long. It is found in the Southern States, while *Tridactylus terminalis* Uhler is found northward. The Mole-cricket, *Gryllotalpa*, so-called from the enlarged fossorial fore feet, lives in wet, swampy soil, by ponds and streams, where it raises ridges while constructing its subterranean galleries in search of insects. Its fore legs are adapted like those of the mole for digging, and are remarkably short and stout, much flattened and armed with solid tooth-like projections. Their eggs, from 300 to 400 in number, are laid in the spring in tough sacks, in galleries. Very rare northward, they are more common in the Middle and Southern States.

Gryllotalpa borealis Burmeister is found in New England, burrowing in moist earth near ponds. The Southern species is *Gryllotalpa longipennis* Scudder, and in the West Indies another species ravages the Sugar-cane. The genus *Gryllus* includes the common crickets. The European House-cricket, *G. domesticus* Linn., has been introduced into the vicinity of New York, as stated by Mr. James Angus. Our two largest species are the *Gryllus luctuosus* Serville, known by the great length of the fore wings, which project beyond the abdomen; and *Gryllus abbreviatus* Serville, which is found in the Middle States. The most common New England species is the *Gryllus neglectus* of Scudder, from which *Gryllus niger* Harris differs in its much shorter ovipositor. The small cricket so abundant in our fields is *Nemobius vittatus* Harris, a brownish striped species; the genus differs from Gryllus in the last joint of the maxillary palpi being double the length of the penultimate, while in *Gryllus*, it is of the same length. In *Œcanthus niveus* Serville (Fig. 561, male; fig. 562, female; fig. 30, fore wings of male and female, showing the broad thin portion between *b* and *c*, used in producing the shrilling noise) the wings are broad and very transparent, narrower in the female, the hind legs very long and slender, and the male is ivory white. The males make a loud shrilling noise, and both sexes are found on plants, especially the grape-vine. Mr. W. Saunders states that the female does considerable injury to the raspberry and plum twigs by boring into the branches for the purpose of laying its eggs, and the Editors of the "American Entomologist" state that it severs grapes from the branches. This genus leads to the next family.

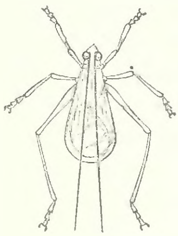


Fig. 561.

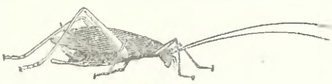


Fig. 562.

Mr. Scudder has described in the "Proceedings of the Boston Society of Natural History," *Archegogryllus priscus*, a fossil cricket from the coal formation of Ohio. "One broken hind leg and a fragment of a wing were found; the leg was noticeable in having the tibia furnished with several large prominences, while the femur was smooth."

LOCUSTARIÆ Latreille. The large green Locusts are easily distinguished by their large heads, and their compressed bodies. The front from being vertical often inclines inwards, owing to the greatly enlarged vertex, which is often produced into a horn. The ocelli are either present or obsolete, and the eyes are globular in shape. The antennæ are of great length, as are the legs, which are long and slender. The prothorax is saddle-shaped, and the wings are thin, the anterior pair slightly thickened, while the hinder pair are broad, these insects taking long flights. The base of the upper wings is transparent, forming a drum by which the males produce a loud shrilling; and they also rub the hind legs against the wings as do the *Acrydii*. Scudder states that "the day song of some Locustarians differs from that of the night." The abdomen is not of great length, while the ovipositor and male claspers are greatly developed, and are of much importance in classification. Lacaze-Duthiers describes the typical form as having the subgenital plate formed by the eighth sternite, while the ninth ring is complete. Its elements form the ovipositor, composed of six pieces, which are large and long, for boring into the earth and twigs in laying the eggs. The ninth sternite is bifid. Similar parts in the males are formed for clasping the body of the female, and are large and long. The eggs are laid in the autumn, and the young hatch in the spring.

The wingless genera have curved, cylindrical bodies, with long antennæ, and are very active, leaping very vigorously; they are brown in color, and inhabit caves or live under stones. *Ceuthophilus* is a wingless genus, in which the pronotum does not extend over the mesonotum. *C. maculatus* Say has the posterior tibiæ of the male waved. It is common under stones. *C. stygius* Scudder is found in the caves of Kentucky, and *Hadenœcus subterraneus* Scudder is found in Mammoth Cave. It is a slender form, the antennæ exceeding the length of the body several times. *Udeopsylla* differs from the following genus, *Daihinia*, according to Scudder, "in the longer, more slender, less robust, and less spiny legs, in the somewhat more slender body and smaller head, in the shorter maxillary palpi, and in the structure of the tarsal joints," the first and fourth being equal in length, while the two middle ones are small, the second joint overlapping the third above. *U. robusta* Haldeman is found in Nebraska. In the interesting genus *Daihinia*, the "tarsal joints of the anterior and posterior pair are only three in number, the first and last being of nearly equal length, with a single small joint between them, a very interesting exception to the almost universal rule among the *Locustariæ*." The Katydid, *Cyrtophyllum concavum* Say (Fig. 563), has the fore wings concave, much produced in the middle. The eggs, according to Harris, are "slate colored, and are rather more than one-eighth of an inch in length. They resemble tiny, oval, bivalve shells in shape. The insect lays them in two contiguous rows along the surface of a twig, the bark of which is previously shaved off, or made rough with her piercer. Each row consists of eight or nine eggs, placed somewhat obliquely, and overlapping each other a little, and they are fastened to the twig with a gummy substance. In hatching the egg splits open at one end, and the young insect creeps through the cleft." In *Phylloptera* the wings are narrower, but still concave, and the ovipositor is of moderate size, while in *Microcentrum* it is very small. *P. oblongifolia* Burmeister is abundant in September, in New England, being found farther northward than the Katydid, and when it flies it makes a whizzing noise, compared by Harris to that of a weaver's shuttle. He also states that "the females lay their eggs in the autumn on the twigs of trees and shrubs, in double rows, of seven or eight eggs in each row. These eggs in form, size and color, and in their arrangement on the twig, strikingly resemble those of the Katydid. *Phaneroptera* has still narrower wings than the genera hitherto noticed, and the ovipositor is more sharply turned upwards. The *P. curvicauda* of DeGeer (P. angustifolia Harris) is very abundant, being the most common species in Northern New England.

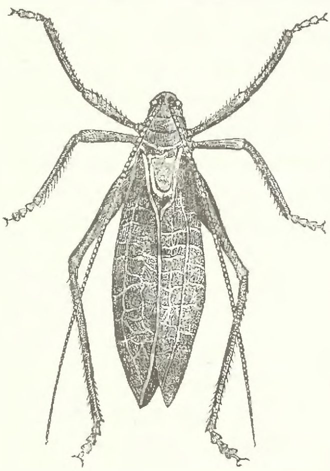


Fig. 563.

In *Conocephalus* the front of the head is produced into a cone. The species, generally pea green, often present brown individuals. *C. ensiger* Harris is a commonly distributed species. Mr. S. I. Smith has observed a female of this species "with the ovipositor forced down between the root-leaves and the stalk of a species of Andropogon, where the eggs are probably deposited."

Xiphidium is a genus of smaller size, with the ovipositor nearly straight. *X. fasciatum* Serville is green, with a brown stripe on the head and thorax. It is common in gardens. According to Hagen and Scudder an undescribed species of Xiphidium makes longitudinal punctures in the pith of the Cotton plant.

In *Orchelimum* the ovipositor is large, ensiform, and upcurved. *O. vulgare* Harris (Fig. 32, *d*, the file in the male wing which rubs on the concave expansion of the other wing) has a large transparent shrilling organ, and is a more robust form than the preceding species. *Locusta viridissima* Linn. is a common form in Europe. Westwood states that "*Hyperhomala virescens* Boisd. from New Guinea, is distinguished by the prothorax extending completely over the abdomen like a pair of elytra," and that *Condylodera tricondyloides* from Java, in the elongated, constricted prothorax and fine blue colors, exactly imitates the Cicindelous genus Tricondyla.

Acrydii Latreille. Grasshoppers have the body much compressed, the head large, the front vertical, the ocelli generally present, while the antennæ are short, the greatest number of joints being twenty-four. The prothorax is very large, sometimes reaching beyond the abdomen, and the wings are deflexed; the hind legs are enlarged for leaping, and the tarsi are three-jointed. The stridulating noise is produced by rubbing the thighs against the fore wings, which are long and narrow, while the hind wings are broadly triangular. The ovipositor, with its accessory pieces, consists of a subgenital plate formed by the seventh sternite; the ninth segment is complete, and the blades (tergo-rhabdites) composing the ovipositor consist of three secondary pieces united together between them. These rhabdites are short, thick, somewhat conical, and corneous. The eggs are laid in a cocoon-shaped mass covered with a tough glutinous secretion, and containing from fifty to one hundred eggs. The pupæ are distinguished from the larvæ in having large wing-pads. On the basal joints of the abdomen are two cavities covered each with a membrane, and containing a vesicle filled with liquid, which is supplied by a nerve sent from the third thoracic ganglion. They were considered by Latreille and Burmeister to be vocal organs, but more correctly it would seem, by J. Müller and von Siebold as organs of hearing.

This family embraces insects of gigantic proportions. The migratory locust (Acrydium migratorium) is a most destructive insect from its voracity and immense numbers. Swarms of grasshoppers are common in the far West where they commit great havoc in crops. Our Caloptenus femur-rubrum has at times, though not of late years, gone in immense swarms. The larvæ of many species live through the winter, and appear often in March on unusually warm days.

In the genus *Opomalea* the acute antennæ are broad and flattened at base. In *O. brachyptera* Scudder the fore wings are but little more than one-half the length of the body. In *Chloeältis* the hinder edge of the pronotum is square or rounded; there are no foveolæ on the vertex, and the lateral carinæ of the pronotum is parallel, or quite nearly so.

Chloeältis conspersa Harris is light bay, sprinkled with black spots, with a black line on the head behind each eye, and extending upon the thorax. *Stenobothrus* differs in having foveolæ on the vertex, and the lateral ridges on the pronotum incurved. Mr. S. I. Smith states that the structure of the ovipositor of this species is "beautifully adapted to a remarkable habit in the manner of depositing the eggs, which seems not to have been noticed before among Orthoptera. The eggs are deposited in old logs, in the under sides of boards, or in any soft wood lying among the grass which these insects inhabit. By means of the anal appendages the female excavates in the wood a smooth round hole about an eighth of an inch in diameter. This hole is at first almost perpendicular but is turned rapidly off in the direction of the grain of the wood, and runs nearly parallel with, and about three-eighths of an inch from the surface; the whole length of the hole being an inch or an inch and a fourth. A single hole noticed in the end of a log was straight. The eggs, which are about a fourth of an inch in length, quite slender and light brownish yellow, are placed in two rows, one on each side, and inclined so that, beginning at the end of the hole, each egg overlies the next in the same row by about half its length. The aperture is closed by a little disk of a hard gummy substance. I have seen many of the females engaged in excavating the holes, and they always stood with the body in the direction of the grain of the wood, and apparently did not change their position during the operation. When one was just beginning a hole it was very easy to see the upper appendages rise and open, and each time scrape away a little of the wood. During this operation a frothy fluid is emitted from some part of the abdomen, but whether it serves to soften the wood or to lubricate the appendages and the sides of the hole I did not determine." (Proceedings of the Portland Society of Natural History, i, p. 146.) *S. curtipennis* Harris is a very common species, and at once recognized by its very short wings.

In the genus *Tragocephala* the vertex of the head is prominent, the front rather oblique, sloping inwards, and the prothorax is acutely angulated posteriorly. *T. infuscata* Harris and *T. viridifasciata* Harris are common species; the former is dusky brown, the hind wings transparent, pale greenish yellow next to the body, with a large dusky cloud near the middle of the hind margin, and a black line on the front margin; while the latter is green, with dusky fore wings broadly banded with green.

Pezzotettix closely resembles Caloptenus, except that in some of the species it is wingless. *P. borealis* Scudder is found in British America, and also on the tops of the mountains of New Hampshire and Maine. In the *P. alpinus* Kollar of Europe there are short wings. The genus *Caloptenus* has but a slight mesial ridge on the prothorax; the lateral ridges vary in size, and the sternal tubercle is very large, while the tip of the male abdomen is much swollen. *Caloptenus femur-rubrum* Harris (Fig. 564, *b*) is the common Red-legged grasshopper. It varies greatly and has been so abundant in New England and Canada, though not of late years, as to become a public calamity. It has been seen very rarely on the Labrador coast, and it is a very widely distributed species, ranging from

Labrador to the Mississippi. The *Caloptenus spretus* Uhler (Fig. 564, *a*), appears in immense numbers in the country between the Mississippi and the Rocky Mountains, and extending from the Saskatchewan river on the north to Texas. Mr. Scudder states that "a third, whether belonging to the same species or not is still uncertain, has invaded at different times, nearly all the country lying within the boundaries of the United States, between the Rocky Mountains and the Pacific Ocean."

Dr. Lincecum thus describes the ravages of C. spretus in Texas: "Last spring the young were hatched from the egg in the early days of March; by the middle of the month they had destroyed half the vegetation, although the insects were wingless and not larger than a house-fly. The first winged specimens were seen high in the air at about three in the afternoon; as a light northerly breeze sprang up, millions dropped to the earth, covering the ground in an hour, and destroying every green thing with avidity. During the night they were quiet, but at daybreak commenced to eat, and continued until ten in the morning, when they all flew southward. At about three o'clock in the afternoon of the same day another swarm arrived, ten times as numerous as the first; these again took flight the following day; and thus they continued, coming and going, day after day, devouring the foliage and depositing their eggs. At first they selected bare spots for this purpose, but finally the whole surface of the earth was so broken up by their borings that every inch of ground contained several patches of eggs. This visitation was spread over many hundreds of miles." *C. bivittatum* Say is a large dull green, or olive colored species, with red legs, and is very abundant in gardens.

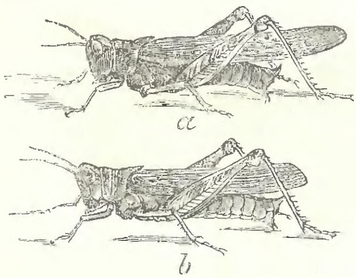


Fig. 564.

Romalea microptera, called the "Lubber grasshopper" in Florida, feeds on the leaves of the orange. (Glover.) It is nearly three inches long; the prothorax is keeled, and the wings only cover half of the abdomen. The larva is reddish, while the adult is yellowish brown with dark patches and spots.

In *Acrydium* the spine on the chest is very prominent, and the mesial crest above is well marked, while the tip of the male abdomen is not swollen. *Acrydium alutaceum* Harris is nearly two inches long, and expands over three inches. It is brownish yellow, with a paler yellow stripe on the top of the head and thorax.

To the genus *Tropidacris*, separated from Acrydium by Mr. Scudder, belongs certain gigantic grasshoppers nearly four inches in length and expanding some eight inches, with gaily colored hind wings. *T. cristata* Linn. has pale, greenish blue hind wings; it is reported from Asia and Africa, and is widely distributed through tropical South America. *T. dux* Drury has brick red hind wings and expands nearly seven inches; its range is from Texas to Panama.

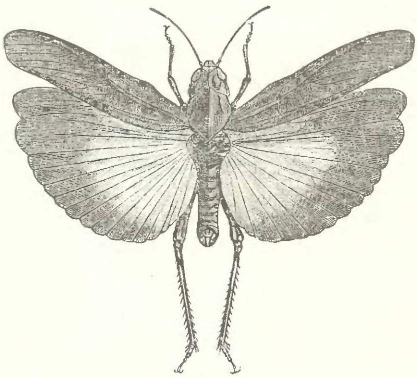


Fig. 565.

Œdipoda is a large and well known genus, in which there is no spine between the fore legs, and the front of the head is vertical and swollen. *Œdipoda Carolina* Linn. is pale yellowish brown, the wings black with a broad yellow hind margin, and it expands over three and a half inches. It is abundant everywhere. *Œ. sulphurea* Fabr. has deep yellow wings, with a broad dusky band beyond the middle, while *Œ. corallina* Harris has hind wings of a rich coral red. *Œ. xanthoptera* Germar (Fig. 565) ranges from New England to the Mississippi. It is reddish brown; the prothorax has a high rounded unbroken ridge; the fore wings are flecked with small dusky spots; the hind wings are yellow at the base, fuscous beyond and clouded at the tip; the hind shanks are dusky, with a pale band below the knee. The wings of the male expand two and a quarter inches; those of the female three inches. Mr. Scudder has discovered a chalcid parasite in the eggs of *Œdipoda Carolina*.

In *Tettix* the pronotum is prolonged beyond the abdomen, and the antennæ are thirteen to fourteen-jointed, while *Tettigidea* differs from it by having twenty-two-jointed antennæ, and a thicker, shorter body. *Tettix granulata* Kirby has a very prominent vertex, with the front border angulated.

Tettigidea lateralis Say is a common species, and may be found, like all the other allied species, in the spring and autumn. It is pale brown, with the sides of the body blackish; the prothorax is yellowish clay colored, and the fore wings have a small white spot at the tips.

Batrachidea has but twelve joints to the antennæ, and otherwise differs from Tettix in its more compact shorter body, and more distant eyes, while the mesial crest on the prothorax is very high. In *B. cristata* Harris the crest is high, regularly arched, and on each side of the prothorax are two shallow grooves; the surface is rough, with a dark squarish spot on each side above the terminal half of the fore wings. Saussure describes an aquatic Tettix from Ceylon.

The genus *Proscopia* is wingless, with the front produced into a long slender cone, while the whole body is long and cylindrical, somewhat as in Diapheromera. The antennæ are very minute, six to eight-jointed, and the legs are long and slender. *P. gigantea* Klug is six inches long, and occurs in Brazil at Para.

PHASMIDA Leach. The Walking-sticks, or Spectres, are sluggish insects found on twigs and leaves, to which they bear a strong resemblance, and are neither raptorial as regards their fore legs, nor leapers, like the grasshoppers. Their bodies are remarkably long and linear, and the wings either aborted and very small, or strikingly leaf-like. The head is horizontal, long, while the antennæ are rather short, and the abdomen is nearly twice as long as the rest of the body.

The subgenital plate is formed by the largely developed eighth sternite, while the ninth segment is incomplete, the sternum consisting of a membranous fold. According to L.

Duthiers there are eleven abdominal segments, and the anal stylets are not articulated as in the *Mantidæ*, but are long corneous claspers, and in some cases, very much like those of Libellula, as in *Acrophylla*, while the eleventh ring is a little triangular tergite, situated between the anal claspers. The egg-sac in *Diapheromera femorata* Say (Fig. 566, ♂), our commonly diffused species, is flattened elliptical, with a lid in front which can be pushed open by the embryo when about to hatch, and is deposited in the autumn. The young when hatched are linear, and much like the adults except that they are wingless. The male is considerably smaller than the female, and much more slender. In *Phasma*, a tropical genus, the two sexes are winged, the antennæ are about as long as the body, and the limbs are slender. *P. 4-guttatum* Burmeister is between two and three inches in length, and green on the costal border of the hind wing, and rose colored behind. It lives in Borneo. The genus *Prisopus* differs from the other two genera in the shortened mesothorax; the legs are much flattened and leaf-like; the abdomen is longer than the thorax, flattened beneath, and widened on the sides posteriorly. *P. spiniceps* Burmeister is a Brazilian species, and is two and a half inches long. *P. flabellicornis* Stoll, according to A. Murray, spends the whole of the day under water adhering to stones in the mountain streams of Brazil, and towards dusk flies about; it is the only truly aquatic Orthopteran known.

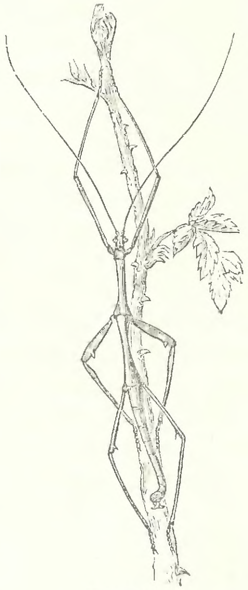


Fig. 566.

The genus *Phyllium*, found only in the East Indies, most remarkably imitates various leaves, one species having its fore wings so veined and colored as to resemble most strikingly a dried and withered leaf. The wings are often very large and broad, and as if to aid in carrying out the analogy the legs have broad leaf-like expansions. The antennæ of the males are twenty-four-jointed, while in the females they are much shorter, consisting of but nine joints. The *P. siccifolium* Linn. is green, and about three inches long. It lives in the East Indies.

MANTIDÆ Latreille. These raptorial Orthoptera are easily recognized by their large size, the enormous spinous fore legs,

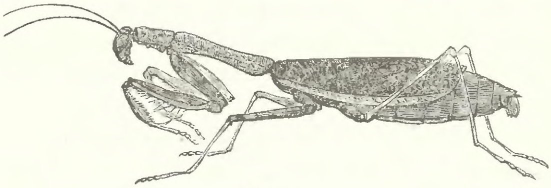


Fig. 567.

adapted for seizing other insects like the raptorial Hemiptera, and which has given them the name of Soothsayers and Prophets, from their devotional attitude when watching for their prey. They are worshipped by the Hottentots as tutelary divinities. The head is horizontal, triangular in front, with long filiform antennæ; the prothorax is very long, and the broad wings are thin, net-veined, with long parallel veins, more strongly resembling the Neuroptera in this respect than any other family. The abdomen is long, linear oval. "The subgenital plate is formed by the eighth sternite, the oviduct opening between the seventh and eighth segments. The ninth segment is complete. The elements of this ring are but little developed, scarcely surpassing the subgenital plate; the two episternites are distinct, and between them is the small ninth sternite." The stylets are concealed by the broad expanded sternum of the seventh segment, while the antenna-like appendage (or anal style, Fig. 23) is sometimes many jointed, and is said by Lacaze-Duthiers to be appended to the eleventh segment of the abdomen. The mass of eggs laid by the female is attached to twigs, and enclosed in a flattened subovate case (oötheca) of hardened silk. The eggs are infested to some extent by chalcid para-

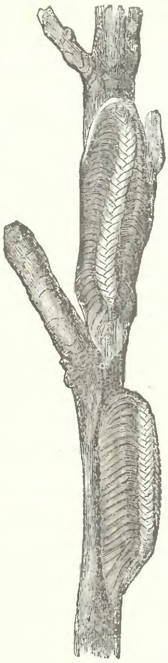


Fig. 568.

sites. The young are long and linear. The Race-horse, *Mantis Carolina* Linn. (Fig. 567; fig. 568, eggs, natural size), occurs in the Southern and Western States, and in the tropics occur the allied genera *Vates*, *Empusa*, *Harpax* and *Schizocephala*. According to Mr. T. Glover the eggs of Mantis Carolina are laid in a packet about an inch long attached to leaf-stalks and twigs. The body of the recently hatched young is linear and turned up at each end, and it devours caterpillars and insects, holding them in the fore legs with a firm grasp by applying the spined tibiæ and tarsi against the more stoutly spined femora, and then sucking their blood at its leisure. Professor Sanborn Tenney tells me he has observed the female after sexual union devour the male. Burmeister says that *Mantis argentina* Burm., of Buenos Ayres, seizes and eats small birds. The genus *Eremophila* (E. Ehrenbergi of Burmeister) inhabits the deserts of Northern Africa, where it resembles the sand in color.

BLATTARIÆ Latreille. The Cockroaches are flattened ovate, with the head rounded and partially concealed by the expanded prothorax. The fore wings are large, ovate, not much smaller than the hind wings; the antennæ are long and filiform, many jointed. The bilobate subgenital plate is formed by the eighth sternite; the ninth abdominal ring is complete, the sternite being small and lodged between the two episternites which are soldered into a single annular piece. The anal stylets are short. The species, which are almost invariably reddish brown, or paler, are nocturnal, hiding by day, and are found under stones. They are fond of heat, the house cockroaches frequenting heated rooms. While the common species are troublesome from eating garments, etc., they do great service in clearing houses and ships of bed-bugs, which they greedily devour. The eggs are laid in a bean-shaped capsule (oötheca) which is divided into two apartments, each containing a row of separate chambers, about thirty in number, each of which encloses an egg. Many days are required for oviposition, and the female may be seen running about with the capsule partially protruding from her body. During this period embryos are forming within the capsule, and very soon after it is dropped the larvæ are hatched. The common cockroach, *Blatta* (Stylopyga) *orientalis* Linn. has rudimentary wings in the female, while in the male they are shorter than the body. In *Periplaneta* the wings are longer than the body, and the supraänal plate is deeply fissured and the abdomen much swollen. *Periplaneta Americana* Linn. is a commonly distributed species. The genus *Platymodes* differs from the preceding one in its narrower and longer body, and the supraänal plate is not fissured; the anal stylets are much shorter and turned down, while the wings extend beyond the abdomen, the anterior pair being well rounded at the tips. *Platamodes Pensylvanica* DeGeer is pale, shining, reddish brown, and the antennæ reach back to the tips of the fore wings. It is found in woods under stones, entering houses by night.

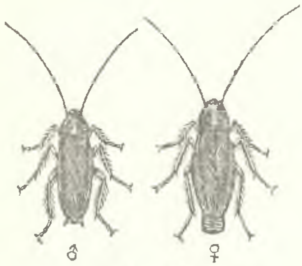


Fig. 569.

In *Ectobia* the wings are well developed, and the basal joints of the tarsi are shorter than the others. The *Ectobia Germanica* Stephens (Fig. 569, male and female) is a pale species, and is very abundant in houses in and about Boston, where it is called the "Croton bug." *Ectobia lithophila* Harris is very common in woods under stones in New England. The third joint of its antennæ is as long as the next five, collectively.

In *Cryptocercus* both sexes are wingless; the antennæ are half as long as the whole body, and the abdominal appendages are not exserted, being very short. *C. punctulatus* Scudder is known by its thickly punctured body and dark mahogany brown color, with reddish beneath. It is found southwards.

In *Pycnoscelus* the males are wingless; no females have yet been found. It differs from *Cryptocercus* in having a larger head; the eyes are placed closer together, and the stylets are slender, cylindrical, of about the same length as the cerci and inserted just within them. Plate 1, fig. 2 represents the wing of an extinct species of cockroach (Blattina?) discovered by Mr. Barnes in the coal formation of Nova Scotia. While most of the remains of cockroaches found in the Carboniferous rocks of this country and Europe have been referred to the genus Blattina, Mr. Scudder describes, in the "Palæontology of Illinois," a form under the name of *Mylacris anthracophila* (Fig. 570, upper wing; Fig. 571, prothorax) which was found in the lower part of the true coal measures at Morris, Illinois.

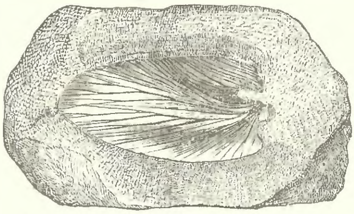


Fig. 570.

FORFICULARIÆ Latreille. The Earwigs are very unlike other Orthoptera, and are readily distinguished by their narrow flattened bodies, with short wing-covers, like the *Staphylinidæ* among beetles, on which account Linnæus placed them among the Coleoptera. The head is free, flat, horizontal; the ocelli are wanting, and the eyes round; the antennæ arise from under the eyes, and are filiform and twelve to forty-jointed. The elytra are short and thick, while the rounded, broad, hind wings are folded underneath so as to be almost entirely concealed by the anterior pair. The female genital armature is described by Lacaze-Duthiers as composed of a subgenital plate formed by the eighth sternite, while the eighth and ninth abdominal rings are partly aborted, and only represented by two horny arcs closely soldered to the tergite of the tenth ring. The rhabdites of the eleventh ring are greatly developed, forming the immense forceps, which are often as long as the whole body. This family was ranked as a separate order by Leach and Kirby, under the name of *Dermaptera*, and were called *Euplexoptera* by Westwood.

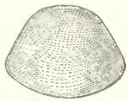


Fig. 571.

They are nocturnal insects, hiding in the day time between leaves and in flowers, flying about at dark. They feed on the corollas of flowers and on fruit, and will eat bread and meat. They are rare insects in this country, though troublesome in Europe from their great numbers. An Alpine species lives under stones in Europe. In *Forficula* the antennæ are fifteen-jointed. *Spongophora bipunctata* Scudder has two pale spots on the elytra. In *Labia* the antennæ are less than twelve-jointed. *Labia minuta* Scudder is yellowish brown, with the sides of the abdomen and the head reddish brown.

NEUROPTERA.

These insects have the body, as a whole, more elongated than in other insects, with large broad, net-veined, thin, membranous wings, both pairs being very equal in size, the anterior pair being sometimes smaller than the hind wings, while in some genera the hind ones are either diminished in size or obsolete. The mouth-parts are free, the mandibles being well developed, and the abdomen is long and slender, with the genital armor always present, but made on the simplest plan, not forming a sting. The metamorphosis is either incomplete or complete; accordingly the pupa is either active or inactive and when inactive resides in a cocoon. The greater number of species are aquatic; and several degraded forms (Lepisma, etc.) bear a strong resemblance to the Myriapods.

The description of the head and mouth-parts of the Orthoptera applies well to the Neuroptera, but the head is horizontal, flatter, and the mouth-parts are less symmetrical, certain parts being greatly developed over others. As a general rule that part of the head situated behind the mouth is larger, in proportion to the rest of the head, than usual in the larvæ of the higher insects, and also the mouth-parts are much larger and less compact. Thus the head of a Neuropterous larva may be actually larger than the entire thorax of the same insect; in the Hymenopterous and Lepidopterous larvæ it is the reverse, the head is often smaller than even the prothoracic ring.

The mouth-parts are inclined to become very large, and in the larva of Libellula the labium is enormously developed, masking the jaws and other parts when at rest, and capable of great extension, while it is armed with powerful hooks, being modified palpi, for seizing other insects.

The thorax is large, the segments being well developed, and the prothorax is usually large and square, but in what in many respects are the most typical insects of the group, the *Ephemeridæ* and *Libellulidæ*, the prothorax is very small, as in the highest insects, and in the latter group the greatly enlarged flanks of the mesothorax seem to take its place.

The wings are large, and in the *Libellulidæ* they are in constant use. The legs are generally of simple structure, these insects neither walking nor leaping much. Rarely, as in Mantispa, are they adapted for seizing their prey, as they are in many Hemiptera and Orthoptera.

The abdomen of the Neuroptera is composed, according to Lacaze-Duthiers, of eleven segments (arthromeres), and the ovipositor is constructed on the same plan as in the Hymenoptera, Hemiptera and Orthoptera, though in the different families the characters vary much more than in the higher suborders, in this respect perfectly according with the anatomy of the other parts of the body in the different groups. He states, however, as observation has taught us, that in its structure the ovipositer is simpler than in other insects, and the farthest removed from that of the Hymenoptera.

Lacaze-Duthiers, whose work is necessarily incomplete from treating of the female ovipositor alone, not regarding the analogous parts in the other sex, considers the Neuropterous ovipositor (tarière) as having three types of structure. The simplest is found in Libellula, in the abdomen of which there are ten segments much alike; "the eleventh is more complex than the others; it has the same structure as in Æschna. It is especially in the division of [the family containing] Libellula and its allies that the two appendages take the form and the function of pincers, and that the special word 'forcipate,' has been used. These forceps serve, as is well known, for clasping organs, and to enable them to perform the very long preliminaries to fecundation." The outlet of the oviduct lies between the eighth and ninth segments.

The nervous system of the Neuroptera consists of the cerebrellum, with its lateral productions, the optic nerves, forming a cylinder extending between the eyes and presenting four swellings. (Leidy.) There are three thoracic and eight abdominal ganglia which are of very uniform size, and connected by double commissures. (See Fig. 43.) The nervous cord is very equably developed and the brain portion is relatively smaller than in the higher suborders.

Professor Leidy has described the digestive organs of *Corydalus cornutus*, which may serve as a type for the rest of the suborder. It agrees with most other genera of the group in having a long œsophagus, which is dilated posteriorly into a spacious proventriculus, which extends as far back as the fifth abdominal segment. The large intestine presents a large convolution, and abruptly dilates into an oval or fusiform cœcum in its lower third, which latter opens into the rectum. In some genera there is a long sucking stomach inserted on one of the sides. In Corydalus this is only present in the pupa, and is aborted in the imago; so also in the larva the "proven triculus, with its apparatus of stomachal teeth," is adapted to the carnivorous habits of the insect, but in the pupa the teeth disappear, "while in the imago we find the œsophagus again lengthened, still contracted at its commencement, but gradually dilating until it forms a capacious Florence flask-shaped proventriculus, or gizzard." (See Fig. 45.)

"With the *Perlidæ* the gizzard is wanting, but the upper extremity of the stomach has from four to eight cœca pointing forwards. With the *Libellulidæ* the œsophagus is long and large, and protrudes somewhat into the straight, oblong, constricted stomach, which is without cœca, and is succeeded by a very short ileum and colon. The digestive tube of the *Ephemeridæ*, which in their perfect state take no food, is feebly developed. Its walls are very thin throughout, and the œsophagus is directly continuous with the stomach, which is a bladder-like dilation, and succeeded by a short, straight intestine. The predatory *Panorpidæ*, which are rapacious, differ notably from the other Neuroptera, and resemble rather the preceding order (Orthoptera). The œsophagus is short and straight, and in the thorax is succeeded by a spherical muscular gizzard which is lined internally with a brown chitinous membrane covered with stiff hairs. The stomach is tubular and straight; the ileum makes two convolutions before passing into the long colon." (Siebold.) In Lepisma the œsophagus terminates in a "kind of crop, which is succeeded by a globular gizzard provided with six teeth."

There are two simple, short, salivary glands in the *Sialidæ*, while in the *Phryganeidæ* and *Hemerobidæ* "they are ramified and highly developed. It is quite remarkable that there is, in this respect, a sexual difference with the *Panor-*

pidæ; the males have three pairs of very long, tortuous tubes, while with the females the only vestiges of this apparatus are two indistinct vesicles." (Siebold.)

In their larval state the aquatic Neuroptera breathe by false gills, or branchial tracheæ; these generally consist of slender filaments situated on the sides of the abdominal segments. These filaments are fleshy, and penetrated by tracheæ, which take up the oxygen from the water. In the larvæ of the *Phryganeidæ* these false gills are simple, "rarely ramified, and united in groups of from two to five, which stand out towards the back." Siebold also states that "with those of the *Ephemeridæ* each of the anterior abdominal segments has a pair of these branchiæ which are sometimes ramified in the most varied manner, and sometimes consist of two kinds, some being lamelliform and alternating with the others which are fasciculate. With all the *Ephemeridæ* these organs have movements which are sometimes slow and rhythmical, and sometimes rapid and oscillatory. . . . The trachean branchiæ of Æschna, Libellula and the other *Libellulidæ* are formed upon a wholly different plan. They are situated in the very large rectum, and consist of numerous epithelial folds which are traversed by a great number of very fine branches of many large trachean trunks. (Fig. 62, *x*.) The rectum is, moreover, invested by a very highly developed muscular tunic, and its orifice has three pyramidal valves which regulate the entrance and the escape of the water required for respiration."

In the larval and adult insect there are four main trunks to the tracheary system, two on each side, and much less complicated than in other insects.

There are generally six or eight long, flexuous urinary or Malpighian vessels. In the Neuroptera the ovaries "consist always of multilocular tubes," and the two testes are, in the *Perlidæ*, *Ephemeridæ* and *Libellulidæ*, composed of "a multitude of round follicles, disposed botryoidally around a long dilated portion of each of the deferent canals. . . . With Panorpa the two testicles are very simple and ovoid; but with the other species they consist of two tufts of long or round follicles. With Myrmeleon and Hemerobius they are oval and surrounded by a distinct envelope. The two deferent canals are short, and always have on their lower extremity two long or ovoid accessory follicles." (Siebold.)

The classification of the Neuroptera is difficult from the lowness of the type, which presents an unusual number of degradational forms, such as are indicated beyond, and because the different families vary so much among themselves, and contain forms which mimic the higher groups of insects. Though the type is the lowest among hexapodous insects, yet there constantly recur characters which are found only in the highest insects. For example the *Phryganeidæ* are Neuropterous throughout, yet there are many of the less important characters which ally them most intimately with the Lepidoptera, especially the *Tineidæ*.

However all Neuroptera agree in the lax composition of the body, inducing a worm-like, elongated form. The metamorphoses are, in the more typical families, less complete than in other insects, except the Hemiptera and Orthoptera, and upon the whole the organs of vegetative life are largely developed over those of animal life, making them generally very sluggish in their motions (though the adult Libellulidæ are an exception), and inducing an abnormal size of the body, as this suborder contains many of the largest and most monstrous of insects. The researches of Professor Dana and Messrs. Hartt and Scudder show that the Neuroptera shared with the Orthoptera the possession of the low marshy lands of Devonian and Carboniferous times, and the forms discovered in the rocks of those periods indicate that they were often of gigantic proportions, and among the most degraded of their type.

Dr. Anton Dohrn has described, under the name of Eugereon Böckingi (Fig. 572), perhaps the most remarkable fossil insect yet discovered. It occurred in the Permian formation in Germany. He considered it as combining Hemipterous and Neuropterous characters, though more closely allied to the Neuroptera. Dr. Hagen writes me that "Eugereon belongs to *Dictyoneura* Goldenberg, and is perhaps identical with one of the species described and figured by Goldenberg." Dictyoneura is said by Goldenberg to resemble the Neuropterous genus Semblis. Dr. Hagen also informs me that Gerstaecker, after an examination of Böcking's specimen, "thinks Eugereon is next related to the Ephemerina. The parts of the mouth have nothing of the Hemiptera about them and they are even more related to the Diptera." While we would defer to the judgment of these distinguished entomologists who have actually studied the fossil itself, yet judging from Dohrn's drawing we would refer the insect to the Neuroptera, and would suggest that in certain characters we are strongly reminded of certain more abnormal genera of *Hemerobidæ* and the *Panorpidæ*. The wings while closely resembling the Ephemerids, as Dr. Hagen has suggested to us, also, in our opinion, recall those of an African species of Palpares, and of the fore wings of Nemoptera, and the antennæ and beak-like mouth-parts seem analogous to those of Panorpa and Boreus.*

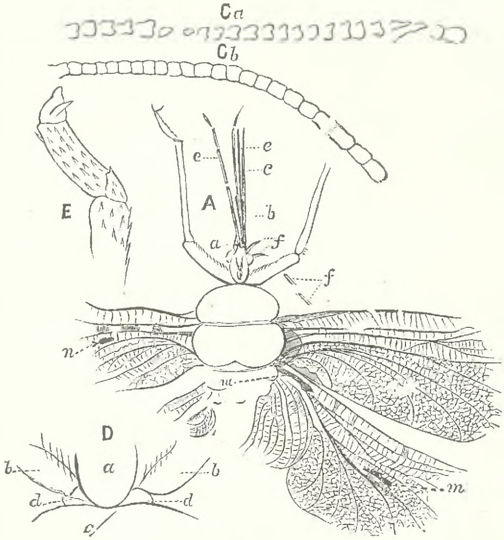


Fig. 572.

FIG. 572. *Eugereon Böckingi* Dohrn, enlarged three diameters; A, *a*, labrum; *b*, first pair of jaws (mandibles); *c*, second pair (maxillæ); *e*, labial palpi; *f*, fragments of antennæ; *m*, portion of legs; *n*, middle tibiæ. C, *a*, *b*, antennæ; D, *a*, head; *b*, fore femora; *c*, prothorax; *d*, prosternum (?); E, tarsus and end of the tibia of the left fore leg. — *After Dohrn.*

*Erichson and Siebold have grouped the *Termitidæ*, *Psocidæ*, *Embidæ*, *Ephemeridæ* and *Libellulidæ* under the name of "false" Neuroptera, and considered them as Orthoptera, restricting the Neuroptera to the *Sialidæ*, *Hemerobidæ*, *Panorpidæ* and *Phryganeidæ*, and this classification has been adopted by most continental entomologists. Now while believing in the unity of the Neuropterous type, and that the so called "false" Neuroptera (especially the May-flies and the dragon-flies) are really the most typical of the suborder, being the most unlike other insects, do not we have many characters in these palæozoic net-veined insects, which unite more intimately the so called false and true Neuropters? We would not forget the analogies shown in these fossil net-veined insects

It is a rather large insect, the head and mouth-parts measuring thirty-nine millimetres, the three thoracic rings twenty-eight millimetres, and the part preserved of the right upper wing forty-four millimetres, and of the right under wing fifty-one millimetres. The antennæ are long and thread-like, as in Panorpa, and the venation of the wings are of the Neuropterous type, while the elongated mouth-parts are Hemipterous in appearance, though the labial palpi (A *e*) are well developed, being usually absent in the Hemiptera. It is the most puzzling form yet brought to light, and has been compared by Dr. Dohrn to the fossil Archæopteryx of the Solenhofen slates, referred by some naturalists to the birds, and by others to the reptiles.

We have shown elsewhere* that the Neuropterous families, except the most typical, *i.e.*, the *Ephemeridæ* and *Libellulidæ*, mimic every other suborder of insects. They are in fact comprehensive or synthetic types, combining, as do all decephalized, embryonic forms, the structures of the other suborders of insects, and thus presenting, in advance, features which remind us of characters more fully wrought out in higher and more compactly finished groups of insects.

As regards the preservation of the dragon-flies, Mr. Uhler states that "the large, brilliant green dragon-flies (Cordulina), as well as the yellow, brown-striped Gomphina, having the eyes wide apart, will furnish new species in almost all parts of the country. In order to preserve specimens in the neatest manner it is well to slip them immediately, when caught, into paper bags of suitable size; first taking care to lay back the wings so that they will be applied together, to prevent mutilation. These paper bags may be placed loosely in a box carried for the purpose. They can thus be taken out at leisure, killed by applying a camel's hair pencil, dipped in sulphuric ether, chloroform, or benzine, to the under side of the body, and then have the wings spread by placing them upon the setting

to the Orthoptera, and which serve to unite the two suborders more intimately than ever. Indeed entomologists in the future may unite the Orthoptera and Neuroptera (in the Linnæan sense) into a single suborder equivalent to the Coleoptera or Hymenoptera, and these two groups may stand as two subordinate divisions just as the "Homoptera" and "Hemiptera" are subdivisions of the Linnæan group of Hemiptera.

*Journal of the Boston Society of Natural History, viii, p. 590.

boards. In most species the colors change after death, hence it is important to make short descriptions of the colors before killing the specimens." The smaller, more slender and delicate Neuroptera should be pinned directly in the collecting box. Many species are caught by a light in the night time, such as Polystoechotes nebulosus and the *Phryganeidæ;* and a bright light placed in damp situations by streams, etc., will attract large numbers, the smaller species, like moths, being attracted a great distance by light. For the proper study of the genera of these insects, and often of the species, they should be collected in alcohol, so as to be studied in a flexible state. Dr. J. L. Leconte has published in the "American Naturalist," iii, p. 307, some new directions for the preservation of insects which will apply to these as well as other insects. "Surgical art has given to us an instrument by which a poisonous liquid can be rapidly and most effectively applied to the entire surface of large numbers of specimens as they stand in the cabinet boxes, without the trouble of moving them. I refer to the 'Atomizer.'

"Opinions may vary as to the nature of the liquid poison to be used, but after several trials I have found the following formula to be quite satisfactory; it produces no efflorescence, even on the most highly polished species, while the odor is quite strong, and persistent enough to destroy any larvæ or eggs that may be already in the box:—Saturated alcoholic solution of arsenious acid, eight fluid ounces; Strychnine, twelve grains; Crystallized carbolic acid, one drachm; Mineral naphtha (or heavy benzine) and strong alcohol, enough to make one quart. I have not stated the quantity of naphtha, since there are some varieties of light petroleum in commerce which dissolve in alcohol only to a slight extent. These should not be used. The heavier oils which mix indefinitely with alcohol are the proper ones, and for the two pints of mixture ten to twelve fluid ounces of the naphtha will be sufficient. Care should be taken to test the naphtha on a piece of paper. If it leaves a greasy stain which does not disappear after a few hours it is not suitable for this purpose.

"The best form of atomizer is the long, plated, reversible tube; it should be worked with a gum elastic pipe, having two bulbs to secure uniformity in the current. The atomizing glass tubes and the bottle which usually accompany the apparatus are unnecessary: a common narrow-necked two ounce bottle will serve perfectly to hold the fluid."

The aquatic larvæ and pupæ can easily be reared in aquaria in jars and tumblers, taking care that the weaker species are separated from those more powerful and bloodthirsty. The little Entomostraca, or water-fleas, serve as food for many of the smaller species. With very little care many species can be raised in this way, and so little is known of their transformations that figures and descriptions would be of great value. The interesting and varied habits of the different families can be also easily noted. They can be called summer insects, since few are found late in the fall or early in the spring, though several *Perlidæ*, Hemerobius, Boreus and several species of Phryganeids are found ere the snow has gone in the spring, and a few species of the latter family are found in November.

TERMITIDÆ Leach. The White Ants in the different grades of individuals, and their complex economy, foreshadow the formicaries of the ant and the hive of the bee. The bodies of the winged individuals are shaped somewhat like that of the ant, but they differ in the long, narrow, straight, finely net-veined wings, the costa of which is remarkably straight, while both wings are equal in shape and size, with the veins arranged in the same manner in both. The head is of moderate size, horizontal; the eyes are rather small, globose, and between them are two ocelli, the third and more anterior one being nearly obsolete. The antennæ are short, with about twenty joints, and the mandibles are small triangular, with fine teeth on the cutting, or inner edge. The abdomen is ovate and shorter than in the Neuroptera generally. In all these points, as well as in their habits, the white ants are the most perfectly organized of the Neuroptera. They are more cephalized, their bodies are developed more headwards, and their intelligence and remarkable instincts ally them also, intellectually, with the most perfect of insects, the Bees, Wasps and Ants. Thus in the lowest suborder of insects we find features which strikingly remind us of the highest insects. Nature constantly repeating the same idea in different groups, here leaps over as it were whole groups of insects, as if by prophecy pointing out the advent of still more perfect forms and higher intelligences. Geology teaches us that the white ant and other Neuroptera preceding in time, as they do in structure, their higher analogues.

The genus *Calotermes* differs from Termes in its small head, the large, transverse, oblong prothorax, the veined costal area, and in the tarsi being furnished with an apical plantula (or foot-pad situated between the claws). *C. castaneus* Burmeister is almost cosmopolitan, occurring in Western and tropical America. In *Termopsis* the head is large, the ocelli are absent, and the prothorax is small, otherwise it agrees with Calotermes. *T. angusticollis* Linn. is found in the Pacific States. The type of the family, *Termes*, has a large rounded head, with two ocelli, and a small heart-shaped prothorax; the costal area is free, while the foot-pad (plantula) is absent. Our common white ant, *Termes flavipes* Kollar is found from Massachusetts southward, under stones, sticks and in stumps. It is of a chestnut color, head and prothorax black brown, with brownish antennæ ringed with a paler hue, with white, very delicate wings, and the mouth, tibiæ and tarsi are yellow. The workers are white, with honey yellow heads. The white ants of Africa live together like ants in colonies of vast extent. The males and females are winged and closely resemble each other as usual. There are two wingless forms; the *soldiers*, which have large square heads, and long powerful mandibles, with a large prothorax, and the *workers* which have small rounded heads and minute, nearly obsolete mandibles. There also occur among the workers certain individuals (Nasuti) which have the front of the head prolonged into a horn. All these wingless individuals are asexual, the organs of reproduction being undeveloped. They have been considered to be larvæ by eminent authorities, but they are found in the nest in abundance when the males and females have arrived at maturity. They must, therefore, be considered like the workers among bees and ants, as individuals specialized, or set apart for the performance of certain duties involving the increase and preservation of the entire colony. Thus the soldiers, as they are termed by Smeathman, with their warlike aspect, act as "sentinels and soldiers, making their appearance when the nest is invaded, attacking the intruders and inciting the laborers to work. The more peaceful and laborious workers are estimated to be one hundred times more numerous than the soldiers." "They collect food, form covered ways, guard the males and females and take care of the eggs and young." (Westwood.) While most of the species burrow in wood, or under ground, others, as in the *Termes fatale* Linn. (T. bellicosus Smeathman), raise conical hillocks of remarkable strength and firmness, often ten or twelve feet high. After impregnation the females, as in the case of the ants, lose their wings. They are then conducted into the interior of the nest by the workers. Here the body of the female gradually becomes enormously distended with eggs, being over two inches in length, and it is known to lay 80,000 in the course of a day.

The pupa of *Termes lucifugus*, a French species, was found by Latreille in the spring, with four white tubercles, or wing pads. Other pupæ are described and figured by Westwood, which by their long wing-pads, prolonged beyond the abdomen, closely resemble the Homopterous adult *Cercopidæ*. Fossil Termites occur in the coal formation of Germany.

Embidæ Burmeister. These are small insects, forming a connecting link between the white ants and Psocus; they are characterized by the linear depressed body, with the head free from the thorax, the wings equal in size, with few veins, and triarticulate tarsi. The larvæ are found under stones and are protected by a cocoon which they renew at each moulting of the skin. (Gerstaecker.) *Embia Savigni* Westwood is found in Egypt.

A species of *Olyntha?* the only genus of this family found in North America, is stated by Hagen to occur in Cuba.

Psocidæ Leach. These minute insects would be easily mistaken for Aphides, both the wingless as well as the winged individuals. Their bodies are oval, the head free from the prothorax, which is small and partially concealed by the wings. The wings are unequal in size, and with few veins, thus departing widely from the usual Neuropterous type of venation, and closely resembling that of the plant-lice. Mr. R. McLachlan states (Entomologist's Monthly Magazine) that "the eggs are laid in patches on leaves, bark, or other objects, and the females cover them with a web. The larvæ and pupæ greatly resemble the perfect insects." The larvæ closely resemble the pupæ; the ocelli in these states are absent, and the tarsi are two or three-jointed, according to the species. He has observed individuals with but partially developed wings. "In all their states they probably feed on dry vegetable substances and lichens. They are universally common, living more or less in societies on tree trunks and palings, and amongst the herbage of trees, especially firs, larches and yews, and some species in houses and warehouses. I believe that both sexes possess the power of spinning a web, not distinguishable from that of spiders. They are exceedingly active and difficult of capture." (McLachlan.)

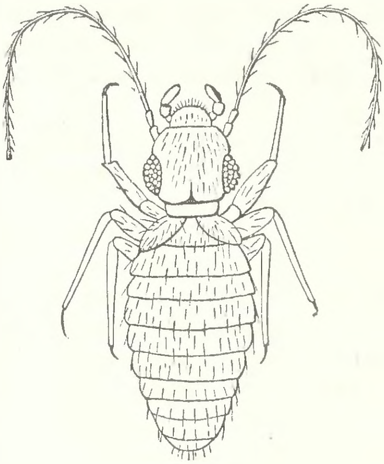


Fig. 573.

In the nearly wingless genus *Clothilla*, from California, there are no ocelli, the wings are incomplete, and the tarsi three-jointed. *Clothilla picea* Motschulsky is but .04 of an inch long and pitchy black in color, with a brassy reflection. In the nearly wingless *Atropos* the ocelli are wanting and the tarsi are three-jointed, while the rudimentary wings form minute square pads. The *A. divinatorius* of Otho Fabricius is a little pale, louse-like insect, seen running over books and in insect cases, where it does considerable injury to specimens. The Atropos is in England called the "death-watch," and is supposed to make the ticking sound heard in spring. Mr. E. Newman (Entomologist, iii, p. 66) has bred "*Psocus pulicarius*, or some allied species, from *Atropos pulsatorius*" (Fig. 573.)

The genus *Psocus*, which closely resembles in its appearance and habits the Aphides, though the species are not sucking insects, has three ocelli, two or three-jointed tarsi, and well developed wings. The species are very numerous, and abound during the close of summer. *Psocus venosus* Burm. is said by Fitch to live on the maple, while *P. salicis* he describes as being found on the willow.

PERLIDÆ Leach. This group comprises those Neuroptera with long flattened bodies, the sides of which are parallel, while the prothorax is large; the antennæ are long and thread-like, and the wings are unequal in size, the posterior ones being broad, triangular. The labial palpi are present, while the mandibles exist ordinarily in a rudimentary state. The wings are usually charged with many irregular transverse veins, and when folded flat on the back, extend beyond the abdomen. The tarsi are three-jointed, and there are, in the typical genera, two terminal setæ on the abdomen. The pupæ are active, with prominent wing-pads. They are found in rivers under stones, while the adults are found resting on leaves and in low damp places. The larvæ resemble the adult, except in being wingless, and bear a general resemblance to the larvæ of certain Ephemerids, showing the near relationship of the two families.

The genus *Pteronarcys* is remarkable for retaining in the adult state external gill-like filaments attached to the under side of the prothorax. It consequently lives in exceedingly moist places, much nearer the water than Perla. *P. regalis* Newman is fuscous, the head is no broader than the thorax, while in *P. proteus* Newman the head is broader than the prothorax and the abdomen is yellowish beneath.

In *Perla* the wings are veiny, the transverse veins few and very regular, while the hind wings have a large, plicated anal space. The palpi are thread-like, and there are two abdominal setæ. Westwood remarks that "there is a very great diversity in the sexes of the typical genus Perla, the males being much smaller than the females, with very short wings." *Perla abnormis* Newman is yellowish fuscous, and the wings are subhyaline with the veins clay-yellow.

The genus *Isopteryx* is characterized by the wings having the transverse veins few in number, almost absent, and there is no basal space in the posterior wings. The palpi are setaceous, the last joint being shortest. *Isopteryx Cydippe* Newman is pale yellow and immaculate.

Capnia is known by the wings being veiny, with the transverse veins very few and regular; the anal area of the posterior wings is large, plicate, and the palpi are filiform, with the last joint ovate, longer than the preceding one, and there are two setæ. *Capnia pygmæa* Burm. is shining black, with gray hairs. It is common in New York in February, according to Dr. Fitch. The species of *Tæniopteryx* have the wings inrolled and veined, with the transverse veins very scarce, rather regular; the anal area of the posterior wings is large and plicated; the palpi are filiform, with the last joint ovate. There are no abdominal setæ, and the tarsi are divided into three long equal joints. They fly early in spring and late in the autumn, and southwards, during the winter. *T. frigida* Hagen is black, with grayish hairs, with a gray band on the middle and another at the apex of the nearly transparent wings. In *Nemoura* the wings are veiny, flat, and the transverse veins are few, very regular, the veins of the pterostigma forming an X. The anal area of the posterior wings is large and plicate, and there are no caudal setæ. The males are smaller than the females, with shorter wings. *N. albidipennis* Walker is piceous, shining, with whitish wings. The genus *Leuctra* differs from Nemoura in the wings being rolled in when at rest. *L. tenuis* Pictet is fuscous, with three elevated lines on the disk of the thorax.

Under the name *Palæopterina*, Scudder has described a group considered by him as a distinct family which comprises but three fossil species discovered in the Carboniferous formation at Morris, Illinois. The fragments of the first species found were described by Professor J. D. Dana in 1864, under the name of *Miamia Bronsoni* (Plate 1, fig. 1, the dotted lines represent the parts restored by Mr. Scudder). He states that this insect "while Neuropterous in wings, closely approaching the Semblids, has broad costate femurs, and even a large spinous joint to the anterior legs, peculiarities which seem to be almost inconsistent with the Neuropterous type, although in part characterizing the Mantispids, and which are in complete harmony with the Orthopterous type." (American Journal of Science and Arts, 1864, p. 33.)

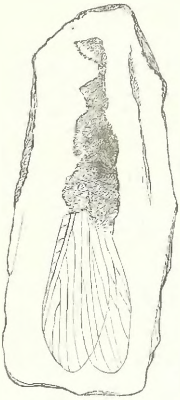


Fig. 574.

Professor Dana farther states "that in the broad costate femurs of the second pair of legs and the form of the prothorax, it approaches the Orthopters of the Phyllium family, and is very unlike any known Neuropters. The anterior legs are peculiar in having a large and broad femur armed above with very slender spines as long as the joint, three of which, though mutilated, are seen in the specimen. But something of this kind is observed under Neuropters in the Mantispids. It is quite probable that these anterior legs were prehensile, as in Mantispa, and the fact that the tibia and tarsus are not in sight in the specimen, favors this conclusion. . . . There appears to have been a pair of short obtuse appendages at the extremity of the abdomen, much as in Phyllium. The head is mostly obliterated."

Fig. 575.

Mr. S. H. Scudder in the "Memoirs of the Boston Society of Natural History" for 1867, shows that the venation of this genus recalls features of several other Neuropterous families, such as the *Termitidæ*, the *Hemerobidæ* and *Sialidæ*.

Mr. Scudder, who has given a restoration of this remarkable insect, states that the head is somewhat like that of Perla, being oval, depressed, with long oval lateral eyes. These two authors disagree as to the "fore legs" (Dana), Mr. Scudder calling the parts so designated by Professor Dana, the head. Gerstaecker states his opinion that Miamia is "without doubt a Perlarian."

Mr. Scudder has more recently described in the "Palæontology of the Illinois Geological Survey," iii, p. 566, two other forms of this group. He remarks, "the two specimens before me, with wings better preserved than in the individual of Miamia Bronsoni, prove that my delineation of the conjectural parts of the wing structure of the *Palæopterina* was in part erroneous, and give evidence of a closer relationship of the Palæopterina to the ancient *Termitina* than I had supposed possible." A second species of Miamia from Morris, Illinois, he calls *M. Danæ* (Fig. 574; all the specimens occurred in balls of iron stone). It is four-fifths smaller than M. Bronsoni. He also remarks, "the other fossil which I would refer to the *Palæopterina* is *Chrestotes lapidea* (Fig. 575). The genus differs from Miamia in the shortness and rotundity of the wings," and in the venation, some points of which remind him of the *Blattariæ*.

EPHEMERIDÆ Leach. The May-flies, or Ephemerids, as their name implies, are, when fully grown, very short-lived insects, the adult living but a few hours. The body is slender and weak, being very long; the prothorax is of moderate size; the antennæ are subulate, or awl-like, being very small, as in the *Libellulidæ*, while the parts of the mouth are rudimentary, the insect taking no food in the adult or imago state. The wings are very unequal in size, the hinder pair being much smaller, or in some instances (Cloë and Caenis) entirely aborted; the transverse veins are either few or numerous; the tarsi are four or five-jointed, and appended to the long, slender abdomen are two or three long caudal filaments.

The sexes unite while on the upper surface of the water, and after a short union the female drops in the water her eggs "in two long, cylindrical yellow masses, each consisting of numerous minute eggs." Walsh states that he possesses a "subimago of Palingenia bilineata, which oviposited in that state." The larvæ live in running water and prey on small aquatic insects, the body being long and flat, with long hair-like antennæ, and small eyes situated on the side of the head, the ocelli not usually being present, and long sickle-shaped jaws, while along each side of the abdomen are leaf-like or bushy false gills, and the body ends in long feathered anal hairs. They live, it is stated, two or three years, and reside in burrows in the mud, under stones, or among grass and weeds, where they may be taken with the water-net in great abundance, and are beautiful objects for the aquarium. Lubbock states that Chloëon passes through twenty-one moultings of the skin before it assumes the imago state; the pupæ are active and have, as a general rule, the rudiments of wings. After leaving the pupa skin the insect (subimago), when its wings are expanded, takes a short flight, and then casts another skin before reaching the final imago state. They often fly in immense numbers, and become stranded in winrows along the borders of lakes. The perfect insects should be preserved in alcohol for study, as they shrivel up when pinned. They should be described when alive if possible.

The genus *Ephemera* of Linnæus has three long and equal caudal setæ; the fore wings are present, with very numerous transverse veins, while the eyes are remote, and in the males simple. *Ephemera decora* Walker is luteous, with the end of the antennæ black and a reddish band on the side of the body.

The remains of a gigantic form described by Mr. Scudder under the name of *Platephemera antiqua* (Plate 1, fig. 3) has been discovered by Mr. C. F. Hartt in the Devonian formation of New Brunswick. Another fossil wing, *Haplophlebium Barnesii* (Plate 1, fig. 8), accompanying the preceding, has been doubtfully referred to the May-flies by Mr. Scudder. It indicates a very large species. Mr. Scudder also figures, in the Palæontology of the Illinois Geological Survey, certain fossils from lower Carboniferous strata, which "appear to be the wings of insects, and, being probably more nearly allied (p. 571) to the *Ephemeridæ* than to other Neuroptera, should be grouped under the generic name *Ephemerites*."

In *Palingenia* there are three caudal setæ, the middle one being short, and sometimes almost absent in the males. There are four wings with very numerous transverse veins, and the eyes are remote and simple. *P. bilineata* Say is a common species and one of the largest of the family; it is found floating on the surface of lakes. It is greenish yellow, with a reddish stripe on the side of the prothorax. The genus *Baëtis* has but two abdominal setæ, while the four wings are provided with numerous cross-veins. The eyes are simple, and in the males of large size and placed very near each other. *Baëtis interpunctata* Say is a yellowish white species tinged with green, with an arcuate black line on the front, and a lateral black point, while the prothorax has one black stripe on the side.

The singular genus *Bætisca* is very thick-bodied, and differs from the other Ephemerids in the fifth abdominal joints being twice as long as any of the others. The pupa (Fig. 576, I; *a*, lateral tooth; II, antenna; III, section of the abdomen, the numerals indicating the segments; *a*, branchiæ, above which is a flap, *b*) "differs," according to Walsh, "from all described Ephemerinous pupæ in the antennæ being eight-jointed or thereabouts, not multiarticulate, and also in the branchiæ being internal and not used for locomotive purposes, and from all larvæ and pupæ, and indeed from all known hexapod insects in any of their states, in the pro-, meso- and metanotum being connate and confluent, and extending over one-half of the abdomen in the form of a large, dilated, convex carapace, or shield, thus giving the insect a very Crustacean appearance." The larva, early in its life, has rudimentary wings, as in many grasshoppers, but in the pupa state they are not present.

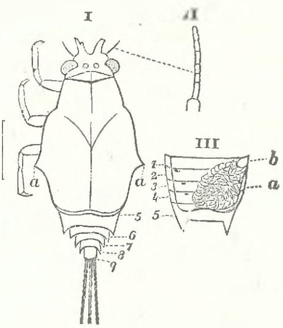


Fig. 576.

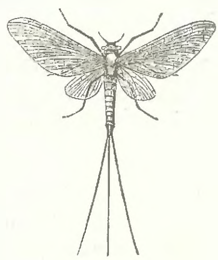


Fig. 577.

Near Baëtis comes *Potamanthus*, which has three caudal setæ and four wings provided with numerous cross-veins; the eyes in the males are double, large and approximate. The *Potamanthus cupidus* of Say is black, with a broad dorsal stripe and a lateral impressed line on each side of the thorax. *P. marginatus* Zetterstedt (Fig. 577), a boreal European species, we have found in abundance in Labrador flying over pools in July.

In *Cloë* there are but two caudal setæ, and though there are usually four wings, yet the hinder pair are sometimes wanting, and there are few transverse veins. The eyes in the males are double, large and approximate. *Cloë pygmæa* Hagen is brownish gray, with the feet and setæ white, and the wings hyaline. It is a Canadian species.

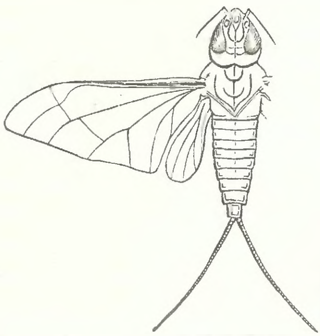


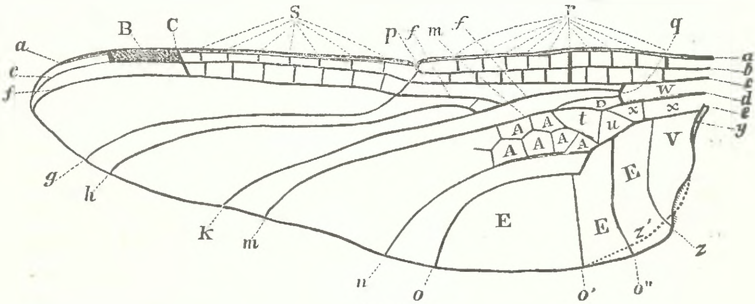
Fig. 578.

Cœnis differs in having three caudal setæ, with no hind wings developed, and few cross-veins, and the eyes in the males are very simple and remote. *Cœnis hilaris* Say is small and whitish, with black eyes, and the thorax is pale fulvous, with short obscure lines beneath and on the sides.

Hagen states that the most abnormal Ephemerid is *Oligoneuria*, distinguished by the abortive condition of the legs, the large size of the longitudinal veins of the wings, the rarity of the transverse veinlets, and by a long bristle-like appendage at the base of the fore wing. A closely allied genus has been described by Dr. Hagen under the name *Lachlania*. It has two caudal filaments, where Oligoneuria has three, and there are three strong transverse veins in the fore wings. *L. abnormis* Hagen (Fig. 578, enlarged) is a Cuban species.

Mr. Scudder regards as the type of a distinct family, which he calls the *Hemeristina*, a single form, the *Hemeristia occidentalis* of Dana, which occurred with Miamia Bronsoni in the Lower Carboniferous rocks of Illinois. Mr. Scudder defines this family as consisting of "Neuroptera of large size. The prothorax is quadrangular, narrower than the meso- and metathorax, though not proportionally so much so as in the *Palæopterina;* the femora (probably the front pair) are as in the *Palæopterina*, but proportionally broader. Wings large, long, about twice as broad beyond the middle as near the base, the costal border convex in its outer half, with numerous and prominent cross-veins but no reticulations; when at rest, overlapping quite completely, even close to the base, much as in the *Perlariæ*, and probably with the sides protected near the base by the deflected marginal and scapular (subcostal) areas." Scudder shows that while the venation is much the same as in Hemerobius, as stated by Professor Dana, it also resembles that of the *Sialidæ* and *Ephemeridæ* and *Libellulidæ*. Gerstaecker thinks that Hemeristia "at least stands nearer to the *Ephemeridæ* than to any other family." (Bronn's Klassen und Ordnungen des Thier-Reichs, vol. v.)

LIBELLULIDÆ Latreille. Dragon-flies, Devil's-darning-needles, or Mosquito Hawks, are readily known by the enormous head and thorax, with the remarkably long, slender, cylindrical abdomen. The head is large and globular, with immense eyes often encircling the head. The large square thorax is remark-



* Fig. 579.

able for the small size of the tergal parts, while the pieces composing the flanks are greatly enlarged, rising up especially in front, taking the place of the prothorax, which is usually very large in the Neuroptera generally, but is in this family greatly aborted, as these insects scarcely ever walk. As in the *Ephemeridæ* the antennæ are short and setiform, and the mouth is not furnished with palpi. The wings* are large,

* Fig. 579. Venation of a fore wing of Gomphus. *Veins.*—*a*, *a*, costal vein; *b*, subcostal vein; *c*, *c*, median vein; *d*, submedian vein; *e*, postcostal vein. *Sectors*—(branches springing from areas, veins, cross-veins, or other sectors). *ff*, *f*, principal sector; *g*, nodal sector; *h*, subnodal sector; *k*, median sector; *mm*, short sector; *n*, upper sector of the triangle (normally a prolongation of *d*); *o*, lower sector of the triangle (normally a prolongation of *e*); *o'*, *o''*, its branches. (The figure gives an angle where *o'* bifurcates from *o*, which should have been a flowing curve. Both *n* and *o* should have been engraved as springing from the lower angle of the triangle, *t*.) *Cross-veins.*—*p*, nodus; *q*, arc or arculus; *rrr*, - - - antecubitals. (The basal antecubital is wrongly engraved as dislocated with that of

densely reticulated, very equal in size, and in some cases the hind wings are a little larger than the fore wings. The tarsi are three-jointed, and the second abdominal segment of the males is furnished with accessory genital organs.

"Landois notices a peculiar sound-producing organ in this family, and figures that of Æschna juncea. It is situated in the prothoracic stigmata, which are placed quite at the front of the thorax, and concealed by the head. These stigmata are large elongated slits, one margin of which is simple, whilst the other bears a sort of chitinous comb of about twenty teeth, between which an exceedingly delicate membrane is extended. The metathoracic stigmata, which in general are the chief organs of sound in this part of the body, are smaller, and bear on one side a semilunar valve with stiff hairs." (Günther's Zoological Record for 1867.)

"During the pairing of the sexes, which takes place during flight, the male seizes the neck of the female with his anal claspers; the female then curves the end of its abdomen to the second abdominal ring of the male, which has a swollen expansion of the under surface, containing in a longitudinal cleft the intromittent organ, which conveys the seminal fluid from the bladder-like cavity into the body of the female. But since the outlet of the testicle opens on the ninth segment of the abdomen, the males previous to union with the other sex, must fill the copulating sac with the seminal fluid, by curving its abdomen upon itself. After the union has been effected the females generally let go of the males. In many

the second or subcostal series); *sss*, - - - - postcubitals. *Areas* and *Angles.* — *t*, the triangle (discoidal); *u*, internal triangle; V, anal triangle; W, basal area (or space); *xx*, median area (or space); *y*, membranule; *z*, anal angle in the male, the dotted line *z'* showing the form of the anal corner of the wing in the female *Gomphus*. (The angle *z* ought to have been engraved as much more acute and salient.) A A, discoidal areolets (in the figure two ranges of them commencing with three). *B*, pterostigma; *C*, its basal (or internal) side prolonged in the normal manner; *D*, "quadrangle," "quadrilateral," or "area above the triangle," bounded above by *m*, below by *d*, basally by *q*, and terminally by an unnamed cross-vein; *EEE*, postcostal area (or space).

Of the above pterological parts, *q* and its sectors, *r*, *s*, *t*, *W*, *y*, *B*, and in the Calopterygina and Agrionina "the quadrilateral" (D), and "the postcostal area" (E), are the most important in classification. — *From Hagen with modifications by Walsh.* Following the nomenclature adopted in this work, *aa* would indicate the marginal vein; *b*, the costal; *c*, the subcostal; *d*, probably the median, and *e*, the submedian vein.

species of Libellula, however, during oviposition, the male retains his hold on the neck of the female, and both fly over the surface of standing water, the female touching the surface of the pool with the tip of her abdomen, and letting the eggs fall into the water.

"In some genera (Libellula, Agrion) the two sexes of a species differ greatly in color, the males having bright variegated colors, while the females are dusky, being more of one color. The males of many species have, on the abdomen, several days after exclusion from the pupa case, a bluish powdery exudation. The genus Calopteryx and allies differ sexually in the color of the wings." (Gerstaecker.)

"Brauer indicates the occurrence of dimorphism in the females of some species of the genus Neurothemis, some of them having the wings very richly veined, as in the males, whilst others have widely netted veins like those of the ordinary Libellulæ." (Günther's Zoölogical Record for 1867.)

During July and August the various species of Libellula and its allies most abound. The eggs are attached loosely in bunches to the stems of rushes and other water-plants. In laying them, the dragon-fly, according to Mr. P. R. Uhler's observations, "alights upon water-plants, and, pushing the end of her body below the surface of the water, glues a bunch of eggs to the submerged stem or leaf. *Libellula auripennis* I have often seen laying eggs, and I think I was not deceived in my observation that she dropped a bunch of eggs into the open ditch while balancing herself just a little way above the surface of the water. I have also seen her settled upon the reeds in brackish water with her abdomen submerged in part, and there attaching a cluster of eggs. I feel pretty sure that *L. auripennis* does not always deposit the whole of her eggs at one time, as I have seen her attach a cluster of not more than a dozen small yellow eggs. There must be more than one hundred eggs in one of the large bunches. The eggs of some of the Agrions are bright apple-green, but I cannot be sure that I have ever seen them in the very act of oviposition. They have curious habits of settling upon leaves and grass growing in the water, and often allow their abdomens to fall below the surface of the water. Sometimes they fly against the surface, but I never saw what I could assert to be the projecting of the eggs from the body upon plants or into the water. The English entomologists assert that the female Agrion goes below the surface to a depth of several inches to deposit eggs upon the submerged stems of plants." The Agrions, however, according to Lacaze-Duthiers, a French anatomist, make with the ovipositor a little notch in the plant upon which they lay their eggs.

Fig. 580.

These eggs hatch during the middle of the summer, and the young larva (Fig. 62) when first hatched differs from the more mature larva (Fig. 580), in not having the rudiments of wings, and in the long, spider-like legs. The larva is very active in its habits, being provided with six legs attached to the thorax, on the back of which, after the first one or two moults, are the little wing-pads, or rudimentary wings. The large head is provided with enormous eyes, while a pair of simple, minute eyelets (*ocelli*) are placed near the origin of the small bristle-like feelers, or antennæ. Seen from beneath, instead of the formidable array of jaws and accessory organs commonly observed in most carnivorous larvæ, we see nothing but a broad, smooth mask covering the lower part of the face, but when some unwary insect comes within striking distance the battery of jaws is unmasked, and opens upon the victim. This mask (Fig. 581, under side of head of a dragon-fly larva, with the labium fully extended; x, x', x'', the three subdivisions; y, maxillæ. For other details of the head of the larva of Diplax, see p. 60) is peculiar to the young, or larva and pupa, of the dragon-fly. It is the labium, or under lip greatly enlarged, and armed at the broad spoon-shaped extremity (x) with two sharp hooks, adapted for seizing and

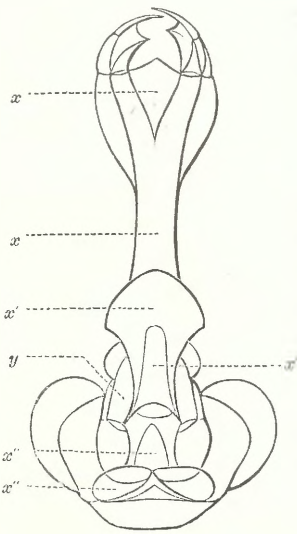


Fig. 581.

retaining its prey. At rest, the terminal half is so bent up as to conceal the face, and thus the creature crawls about, to all appearance, the most innocent and harmless of insects.

Not only does the immature dragon-fly walk over the bottom of the pool or stream it inhabits but it can also leap for a considerable distance, and by a most curious contrivance. By a syringe-like apparatus lodged in the end of the body, it discharges a stream of water for a distance of two or three inches behind it, thus propelling the insect forwards. This apparatus combines the functions of locomotion and respiration. There are, as usual, two breathing pores (*stigmata*) on each side of the thorax. But the process of breathing seems to be mostly carried on in the tail. The tracheæ are here collected in a large mass, sending their branches into folds of membrane lining the end of the alimentary canal, and which act like a piston to force out the water. The entrance to the canal is protected by three to five triangular horny valves (Fig. 582, 9, 10; Fig. 583, side view), which open and shut at will. When open the water flows in, bathing the internal gill-like organs which extract the air from the water. This is then suddenly expelled by a strong muscular effort.

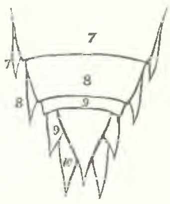


Fig. 582.

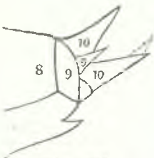


Fig. 583.

In the smaller genera, *Agrion* (Fig. 584, side view of false-gill, showing but one leaf), *Lestes* and *Calopteryx*, the respiratory leaves, called the tracheary, or false-gills, are not enclosed within the body, but form three broad leaves, permeated by tracheæ, or air-vessels. They are not true gills, however, as the blood is not aerated in them. They only absorb air to supply the tracheæ, which aerate the blood only within the general cavity of the body. These false gills also act as rudders to aid the insect in swimming.

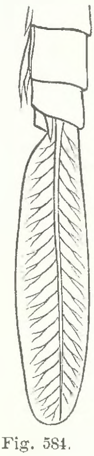


Fig. 584.

It is easy to watch the dragon-flies through their transformations, as they can easily be kept in aquaria. Little, almost nothing, is known regarding their habits, and any one who can spend the necessary time and patience in rearing them, so as to trace up the different stages from the larva to the adult fly, and describe and figure them accurately, will do good service to science. Mr. Uhler states that we know but little of the young stages of our species, but "the larva and pupa of the *Libellulæ* may be always known from those of the *Æschnæ* by their shorter, deeper, and more robust form, and generally by their thick clothing of hair."

The pupa (Fig. 585, pupa probably either of Æschna constricta or Æ. clepsydra) scarcely differs from the larva, except in having larger wing-pads. It is still active, and preys on other insects. When the insect is about to assume the pupa state the body, having outgrown the larva skin, by a strong muscular effort opens a rent along the back of the thorax, and the insect having fastened its claws into some object at the bottom of the pool, the pupa gradually works its way out of the larva skin. It is now considerably larger than before. Immediately after this tedious operation its body is soft, but the crust soon hardens. This change, with most species, probably occurs early in summer.

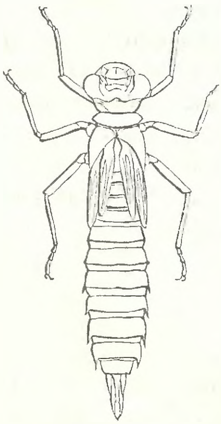


Fig. 585.

When about to change into the adult fly the pupa climbs up some plant near the surface of the water. Again its back yawns wide open, and from the rent our dragon-fly slowly emerges. For an hour or more it remains torpid and listless, with its flabby, soft wings remaining motionless. The fluids leave the surface, the crust hardens and dries, rich and varied tints appear, and the dragon-fly rises into its new world of light and sunshine.

In Agrion and its allies (*Agrionina*) the antennæ are four-jointed, the eyes are small compared with those of Libellula, and distinct; the wings are equal, while the abdomen is cylindrical and long and slender. In *Calopteryx* the wings are very broad and densely reticulated; the pterostigma is absent in the males, that of the females irregular and areolate; the basal space has no transverse veins, and the male appendages are forcipate. (Hagen.) *Calopteryx apicalis* Burm. is shining brassy green, with long black feet.

In *Lestes* there are two antecubital transverse venules; the fourth apical sector is broken; the postcostal space is simple; and the quadrangular space is trapezoidal, with the exterior inferior angle acute; the pterostigma is large, oblong, and the appendages in the male are forcipated. *Lestes eurina* Say is blue, varied with green and violet. The beautiful genus *Agrion* has the apical sector straight, the postcostal space simple, the quadrangular space trapezoidal, with the exterior inferior angle acute; the pterostigma small, rhomboidal, while the male abdominal appendages are short. *Agrion civile* Hagen is brassy-black, varied with blue or green, with a hairy head and thorax. *A. saucium* Burm. (Fig. 586) is red, variegated with black, and is a common species.

Fig. 586.

In the group *Æschnina* the wings are unequal, and all the triangles of the wing are of the same form. In *Gomphus* and its allies the wings are unequal, the hinder ones being broader, and the triangles of both pairs of wings have no transverse veins. *Gomphus fraternus* Say is yellow spotted with black, with black feet. The genus *Anax* differs in the anal angle of the posterior wings being rounded in the male, and the abdomen has a lateral interrupted ridge. *Anax Junius* Drury is a large and widely spread species; it is green, spotted with blue and fuscous, with a yellow head. *Æschna* differs

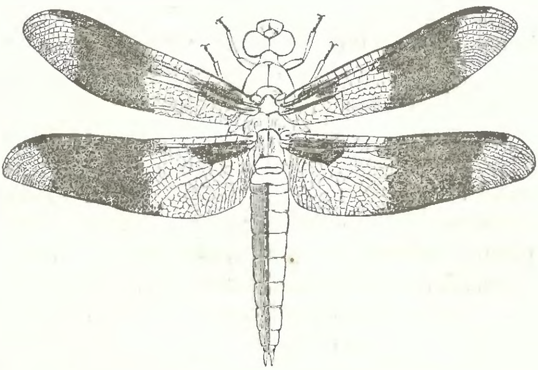


Fig. 587.

in having the anal angle of the posterior wings of the male acute. *Æschna heros* Fabr. is one of our largest and most abundant dragon-flies. It is fuscous, marked with yellowish green, and with two oblique green stripes on the side of the thorax.

In the third group of this immense family, the Libellulina, the wings are unequal, and the triangle of the anterior wings

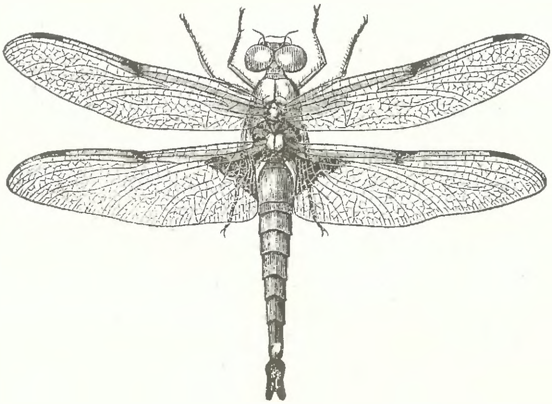


Fig. 588.

is dissimilar, while the anterior genital hamule of the male is free. In *Cordulia* the anal angle of the posterior wings of the male is acute, and the body is brassy green. *C. tenebrosa* Say is found in the Western States.

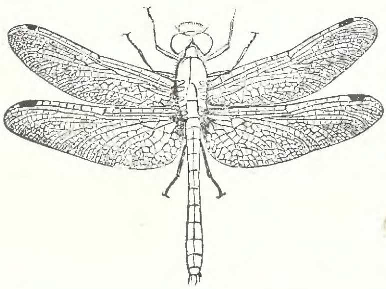


Fig. 589.

The genus *Libellula* is characterized by the short, rather flattened abdomen, narrowing rapidly towards the tip, and the male clasping organs are scarcely visible. *Libellula trimaculata* DeGeer (Fig. 587, male) is so called from the three dark clouds on the wings of the female. The male differs in having a dark patch at the front edge of the wings, and a single broad cloud just beyond the middle of the wing. *Libel-*

lula quadrimaculata Linn. (Fig. 588) is reddish yellow, with four dark clouds on the wings which are yellow anteriorly on the base. In *Diplax* the abdomen is a little shorter than the wings, and is slender, flattened, compressed at the base, while the feet are long and slender. *Diplax rubicundula* Fabr. is a very abundant species, being yellowish red. *Diplax Berenice* Drury (Fig. 589, male ; fig. 590, female) is black, with the head blue in front, spotted with yellow, while the thorax and abdomen are striped with yellow. There are fewer stripes on the body of the male. *D. Elisa* Hagen (Fig. 591) is black, with the head yellowish and with greenish yellow spots on the sides of the thorax and base of the abdomen. The *Nannophya bella* of Uhler (Fig. 592) is a smaller form, with an unusually short abdomen, and the reticulations of the wings are large and simple. It is black, while the male is frosted over with a whitish powder.

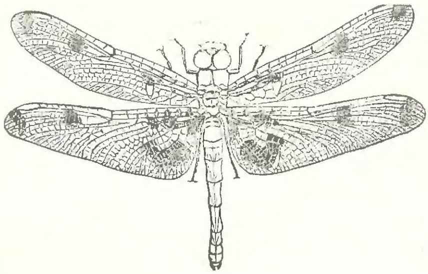


Fig. 591.

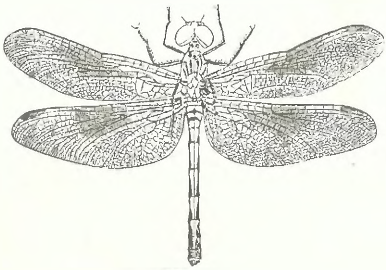


Fig. 590.

SIALIDÆ Leach. This family is not a numerous one, but the species are interesting as comprising some of the largest of insects. Hagen defines the group briefly as having the body short and thick, while the prothorax is large and square. The antennæ are long and setaceous ; the wings are large, reticulated, the posterior ones with the anal space plicated, and the tarsi are five-jointed.

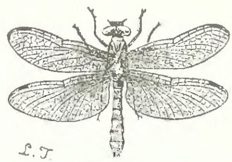


Fig. 592.

"The female of Sialis," according to Westwood, "deposits an immense quantity of eggs, which she attaches one by one to rushes or other aquatic plants. They are of a cylindrical form, terminating at the top in a sudden point; they are attached side by side with the greatest regularity." The larvæ, as in those of Corydalus, are broad and flattened, with a pair of long, thick, respiratory filaments attached to the side of each ring of the abdomen. The body of the pupa is curved, with the wings laid along the breast, much as in the Phryganeid pupæ. The larva is active and predaceous, being armed with strong jaws. When full-fed it leaves the pools or streams in which it has been living and makes an earthern cell in the bank, in which the inactive pupa undergoes its remaining transformations.

In *Sialis* the prothorax is large and square, almost equal in size to the head; there are no ocelli; the antennæ are filiform, and the wings irregularly net-veined, the veins being stout. The fourth joint of the tarsi is dilated and twice lobed. The larva is much like that of Corydalus, but differs in having the abdomen terminating in a "long and slender setose tail."

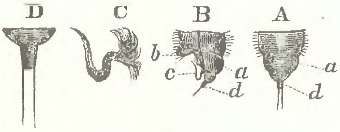


Fig. 593.

Sialis infumata Newman (Fig. 593, caudal appendages of the male, from Walsh) is black, with the head not narrower behind, while *S. Americana* Rambur is rust-red, and the head is narrower behind. The wings expand about an inch.

Chauliodes is a much larger insect, with a quadrangular prothorax nearly as large as the head. There are three ocelli placed close together, and the antennæ are either pectinated or serrated. The wings are veiny, the transverse veins slender. The joints of the tarsi are cylindrical, and the caudal appendages of the male are conical and simple. Walsh describes the larva of *C. rastricornis* Rambur as resembling that of Corydalus, but being much smaller, measuring 1.60 of an inch, and the abdomen has one segment less, with no caudal setæ, "so that Chauliodes forms a connecting link in this respect between Corydalus and Sialis, the larva of which is said to have 'one long, slender, setose tail,'" and the under side of the abdomen is "entirely destitute of the remarkable paddle-like branchiæ found in Corydalus." The pupa resembles that of Corydalus.

Chauliodes pectinicornis Linn., our most common species, is yellowish ashen, with reddish pectinated antennæ. In *C. serricornis* Say the antennæ are serrate. In *Corydalus*, the largest form known, the prothorax is square but narrower than the head and the antennæ are stout but filiform. The male of *C. cornutus* Linn. (Fig. 594, female; fig. 595, male; fig. 596, pupa; fig. 597, larva), has very long mandibles, about twice as long as the head, whence its specific name. According to the Editors of the "American Entomologist," the eggs of this insect (Fig. 598) are "oval, about the size of a radish seed, and of a pale color, with some dark markings. They are usually deposited in a squarish mass upon reeds or other aquatic plants overhanging the water." Hagen does not "think that the lateral filamentous appendages are connected with respiration; the little sponges at the base of the filaments and a little behind them are the true branchiæ." "The reason that the larva of Corydalus has both branchiæ and spiracles is, that it lives, like Sialis, some weeks out of the water before its transformation." (Hagen.)

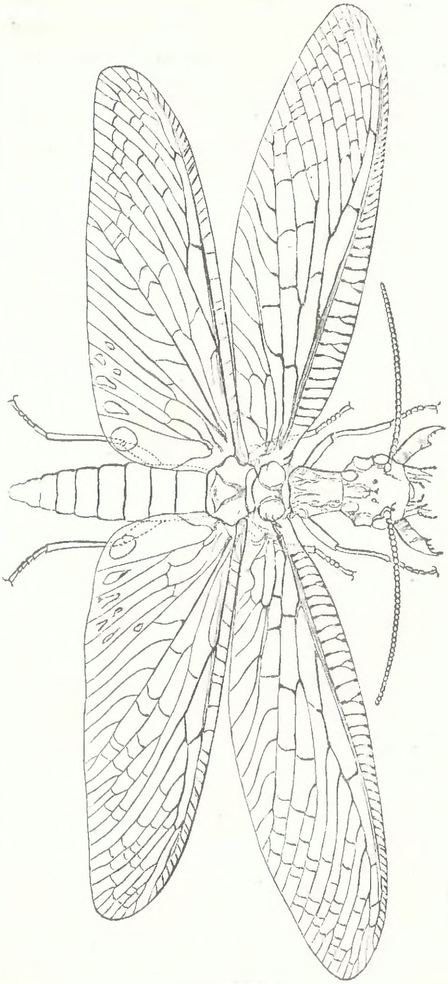


Fig. 594.

The genus *Raphidia* is not aquatic in its habits as it is found under the bark of trees pursuing small insects. The adult has a long neck (prothorax), which is much narrower than the head, and the antennæ are short and filiform, while the ovipositor of the female is long and ensiform, probably enabling it to deposit its eggs in the chinks in the bark. The larva is long and slender; before transforming it makes no cocoon. At first the pupa is inactive, but according to Mr. Waterhouse (Westwood's Introduction), it becomes active while the imago skin is developing, and walks about, as the pupa skin is exceedingly thin. The genus is only found on the Pacific coast of this continent, another proof of the analogy of the insect fauna of the Western shores of this country to that of Europe, where this genus also abounds.

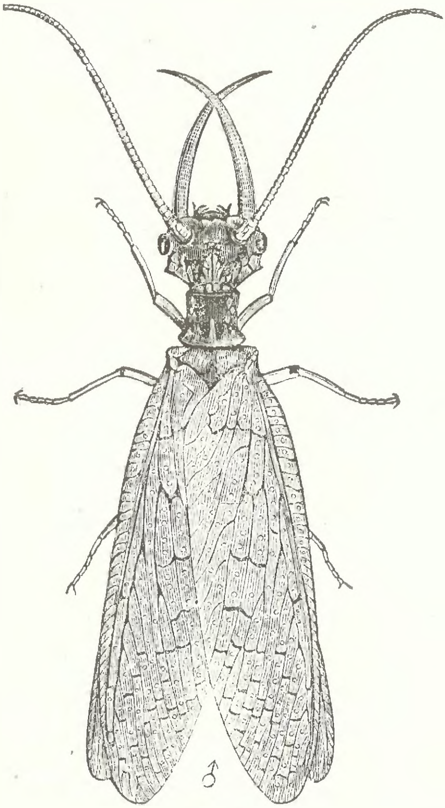


Fig. 595.

In their form and habits, including both those of the larva, and of the partially active pupa, which wiggles violently and even leaps, as the larva does, as stated by Percheron, whom Mr. Westwood quotes (*jouit de la meme faculté de contorsion et de sauts, que la larve execute a un si haut degré*), have we not brought forcibly before us the Thysanura?

HEMEROBIDÆ Leach. The Aphis Lions and Lace-winged flies, which are included in this family, have long, slender, cylindrical bodies. The wings are large, with numerous veins, the posterior ones with no anal space; the ocelli are usually absent, and the tarsi are five-jointed.

The larvæ vary considerably in form, but are usually flattened or short, thick, ovate and fleshy, with large sickle-like mandibles; "the under side of these organs is deeply grooved, and the maxillæ, which are nearly equal to them in size, and of a similar form, play in this groove." (Westwood.) With these they pierce the bodies of their victims and suck out their juices. The sides of the abdominal segments are fringed and have lateral tubercles bearing a thin tuft of radiating hairs.

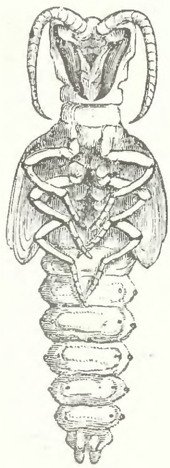


Fig. 596.

The body of the pupa is more cylindrical, being curved, and with the limbs and wings folded to the breast. The larva spins a silken cocoon, and the pupa is inactive.

In *Aleuronia* the body is covered with a whitish powder; the eyes are reniform, and the antennæ are moniliform. The wings are ciliated; the longitudinal veins are few in number, while the transverse ones are almost absent. *Aleuronia Westwoodii* of Fitch is a very small insect, being black, covered with a whitish powder, with a pale abdomen and feet. The singular genus *Coniopteryx*, whose larva somewhat resembles a Smynthurus, one of the Thysanura, showing the close relationship of these aberrant forms, is characterized by Hagen as being powdered with whitish scales, having globose eyes and moniliform antennæ. The wings are not ciliated, the longitudinal veins are few, and there are some transverse veins. The posterior wings of the males are small. *Coniopteryx vicina* Hagen is black, covered with grayish powder, and the wings have eight longitudinal veins, all joined together by a single transverse vein. It is about one-seventh of an inch in length. Haliday (in Westwood's Introduction) thinks that the larva of the European *C. tineiformis* preys on plant-lice. When about to transform it spins an "orbicular pouch of fine white silk of close texture, generally on the trunk of a tree, in chinks of the bark, or among moss. The pupa is quiescent."

The singular genus *Nemoptera* is at once recognized by the remarkably long, narrow, linear hind wings which reach far beyond the abdomen. The larva has a remarkably long, almost filiform thorax, and was described under the name of Necrophilus. The species are found in Western Asia and in Northern Africa.

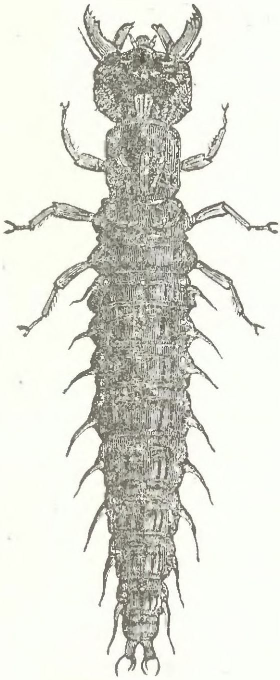


Fig. 597.

The genus *Hemerobius* has moniliform antennæ, the wings having the subcostal and median veins joined together at the apex, and the costal space of the anterior wings is broader at the base, with a recurrent forked vein; the transverse series of venules are gradate (like a pair of steps). We have found in Maine a larva (Fig. 599, tergal and side view) of this genus on the bark of a birch tree in October, where it was seen preying on Aphides, and had covered its abdomen with the empty skins of its victims, forming a thick mantle as seen in the figure. *Hemerobius alternatus* Fitch is white or yellowish, varied with fuscous, with tawny hairs. According to Fitch it is found upon pine and hemlock bushes. *H. occidentalis* Fitch has hyaline wings, not mottled as usual with smoky dots or clouds, but adorned with two faint parallel lines; it expands .38 of an inch. I have raised specimens, referred to 'this species by Dr. Hagen, which occurred in the pupa state (Fig. 600), in considerable numbers under a cloth wrapped around a pear tree in a garden in Salem. The cocoon is oval, cylindrical, dense, and surrounded by a much thinner mass of silk more globular in form. The partially active pupæ crawled out of the cocoons, and were found scattered about in the paper containing them.

The genus *Polystœchotes* is of much larger size than Hemerobius or Chrysopa, and Hagen suggests that the larva is aquatic. *P. punctatus* Fabr. is widely distributed, flying lazily at night-fall. The aberrant genus *Mantispa* is a most interesting form, from the great length of the prothorax, which with other characters remind us strikingly of the Orthopterous genus Mantis. The fore legs are, like those of Mantis, adapted for seizing other insects. *Mantispa brunnea* Say is our most common species, occurring in the Middle and Western States and southwards to Central America.

Fig. 598.

Chrysopa (Fig. 601, eggs, larva, and adult of C. perla of Europe), the Lace-winged Fly, is abundant and of great use, as in the larva state it preys on plant-lice. Its body is slender, with delicate gauze-like wings, and is generally green, with golden eyes. When disturbed it often emits a fœtid odor. Their eggs, supported by long pedicels, are often laid in a group of Aphides or in plants infested by them. When hatched the voracious larva finds its food ready at hand, and destroys immense numbers of plant-lice, whence its name, Aphis-lion. It turns to a pupa late in summer, and thus passes the winter within a very dense, round, whitish cocoon situated in the crevices of bark, etc.

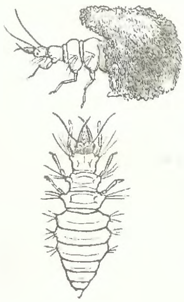


Fig. 599.

In Europe gardeners search for these Aphis-lions and place them on fruit trees overrun with lice, which they soon depopulate. The *Chrysopa oculata* of Say (Fig. 602, and eggs) is our most abundant form. It gives out a foul smell when handled. By this genus we are led to the Ant-lion, or *Myrmeleon*. It is a larger insect than any of the foregoing genera, and reminds us in many respects of the dragon-flies. The antennæ are short and stout, clavate, while the body

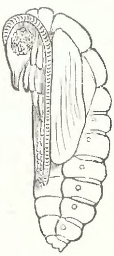


Fig. 600.

is very long and slender, and the wings are long, narrow and densely veined. The larva (Fig. 603) bears a close resemblance to that of Chrysopa. It makes a pitfall in fine sand at the bottom of which it hides, leaving only the tips of its mandibles in sight, which are extended and ready to seize any insect which may fall into them. The pupa retains the large mandibles and uses them in cutting its way out of its cocoon.

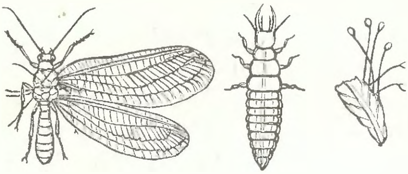


Fig. 601.

Myrmeleon obsoletus Say (Fig. 604) is not rare in the warmer parts of the country, and has been found at Salem, Mass., by Dr. E. P. Colby. *M. abdominalis* Say has also been found as far north as Milton, Mass., by Mr. J. Schofield. Mr. R. Trimen, speaking of the Entomology of Natal, South Africa (Entomological Monthly Magazine), notes the habits of a "huge Myrmeleon, of the genus *Palpares*, the spotted and variegated aspect of whose wings will cause you to mistake them for moths. . . . These great insects are very unlike *Libellulidæ* in their flight, flapping wildly and irregularly about, as if their muscular apparatus were too weak to wield their stretch of wings. In repose the wings are folded above each other so as to form an acute-angled roof above the abdomen. They differ in this respect from the long-horned *Ascalaphi*, which deflect the wings on either side, and hold the abdomen erect or nearly so."

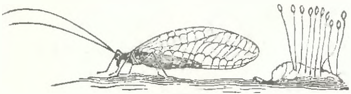


Fig. 602.

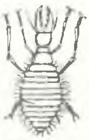


Fig. 603.

Ascalaphus with its long filiform knobbed antennæ, and broad wings and gay colors is the butterfly among Neuroptera. It flies in the heat of the day, seeking the hottest places and is abundant in the deserts of the East. The body and feet are short and the large wings are less densely veined

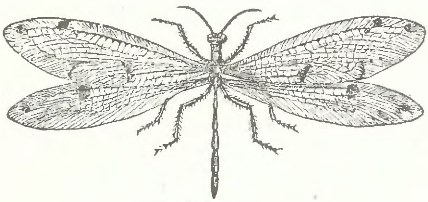


Fig. 604.

than in Myrmeleon. The eggs when laid are hedged around by little pales like a fence "and are so placed that nothing can approach the brood; nor can the young ramble abroad till they have acquired strength to resist the ants and other insect enemies. The abdomen of the larva is depressed and oval, with ten pectinations on each side." (Westwood.) It closely resembles that of Myrmeleon. McLachlan states that the eggs of *Ascalaphus macaronius* were observed by Kollar deposited on a grass stem. *Ascalaphus hyalinus* Latr. is found in the Southern States and Mexico.

PANORPIDÆ Leach. This family is interesting as affording a passage from the winged Neuroptera to the degraded wingless forms which are often excluded from the suborder by writers, and placed apart by themselves under the title of Thysanura. Hagen thus defines the group: "body cylindrical or conical; head exserted; antennæ shorter than the wings; mouth rostrated; lateral palpi biarticulated; prothorax small; wings either almost absent or narrow, equal, longer than the body, narrowed at base; the posterior wings with no anal space; tarsi of five joints."

In *Panorpa*, the Scorpion Fly, so called from the long forceps-like tip of the male abdomen, there are three ocelli and the wings are narrow. The genital organs of the male are greatly lengthened out, and are forcipated, with the last segment inflated; the two tarsal hooks are serrated, and the antennæ are bristle-like.

Lacaze-Duthiers selects the ovipositor of Panorpa as being an intermediate type, as regards complexity, between Libellula and Æschna. "When disturbed, the female of *Panorpa Germanica* or *communis*, darts out a long slender tube towards the disturbing object. Soon a little drop of a whitish liquid appears at its extremity; it is a means of defence. While at rest the conical abdomen, terminating in a point, appears to be composed of a less number of segments." At first sight there seems to be but two, though in reality there are three segments between the oviduct and the anal outlet, since the ninth ring is very small and partly aborted, being concealed beneath the others. The eleventh segment consists of five pieces, a tergite, two sternal scales, and two appendages articulated to the tergal piece.

M. Lacaze-Duthiers does not extend the comparison of the ovipositor of Panorpa to those of Podura and Smynthurus, but we can see how easy the transition is. Only let the long flexible ovipositor of Panorpa be permanently extended, which in insects usually involves its being bent and appressed to the under side of the abdomen, and with a few other slight modifications we have the leaping ovipositor of the Podura and its allies!

The larva is terrestrial, as Stein has found the pupa buried an inch deep in moist earth, at the foot of an alder stump. (Westwood.) Brauer states that the larva is long, cylindrical, with long filaments arising from tubercles on the body. In its general appearance it resembles certain caterpillars, and also Phryganeid larvæ. *P. rufescens* Rambur (Fig. 605, enlarged) is the most common form in New England. It is of a yellowish red color, with the antennæ black, except the three or four basal joints which are reddish. It is about half an inch long and the wings expand an inch.

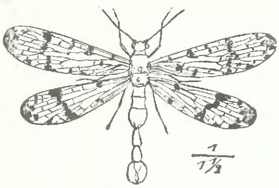


Fig. 605.

The Tipula-like genus *Bittacus*, though it has four wings, is, in its remarkably slender body and long legs, much like the Crane-flies. There are seven species in this country, one of which, *B. pilicornis* Westwood, has been found in Canada and New York. The winter insect, *Boreus*, is wingless in the female sex, and in its habits and form as well as its minute size, reminds us strikingly of Podura and Lepisma, though the resemblance has not to our knowledge been specially noticed by entomologists. In this genus the ocelli are absent, and the males have very imperfect style-like wings, while the females are entirely wingless. "The abdomen of the female is terminated by a three-jointed ovipositor, the under side of which is defended by a produced valve-like bilobed plate arising from the under side of the seventh segment. The male has the abdomen terminated by two short, recurved, attenuated, pilose styles." (Westwood.) In this description we are reminded of the Spring-tails (Podura), which leap by means of the long ovipositor, and corresponding male organs, bent beneath the body.

Dr. Fitch has described two forms of these winter insects which, like Podura, occur in moss and are found leaping on the snow. *Boreus nivoriundus* is about one-seventh of an inch long, and is reddish, with a bronze tinge, while *B. brumalis* is entirely brassy-black, and is a still smaller species.

We must not pass over the singular genus *Merope*, which is interesting in this connection. It has no ocelli, while the compound eyes are large, reniform and united on the top of the head. The antennæ are short and thick, narrowed at the apex, while the wings are broad, with numerous transverse veins, and the male abdomen has large forceps. The *Merope tuber* of Newman is very rare. It is clay yellow (luteous), and expands nearly an inch. Hagen remarks that "the genus and species are very singular and abnormal; perhaps the most remarkable of all hitherto known Neuroptera. It certainly belongs to the *Panorpina*."

Phryganeidæ Latreille. Some of the members of this family bear a striking resemblance to the smaller moths, such as the *Tineidæ*. As characterized briefly by Dr. Hagen, their bodies are compressed, cylindrical; the head is free, antennæ long, thread-like, the mouth is imperfectly developed, and the labial palpi are triarticulate. The prothorax is small; the wings longer than the body, with few transverse veins, while the posterior wings have the anal space large, plicated (rarely absent), and the tarsi are five-jointed. In all these characteristics, together with the cylindrical form of the larva, the quiescent pupa which is very much like that of a moth with its wings and limbs free, instead of being soldered together, and in the habits of the larva, which in some genera resemble those of the *Sialidæ*, this family stands above the Neuroptera to be hereafter mentioned, and in a serial arrangement, such as we are forced to make in our books, this seems to us to be their proper place, while in nature they appear to us to stand off by themselves parallel with the *Sialidæ* and *Hemerobidæ*, certain genera of which, in the imago state (such as Coniopteryx), they closely resemble, while they seem to rank higher than the *Panorpidæ*, which next to the Thysanura are in our view the lowest family among the Neuroptera.

The larvæ are more or less cylindrical, with well developed thoracic feet, and a pair of feet on the end of the abdomen, varying in length. The head is small, and like that of a Tortricid larva, which the Caddis or Case-worm, as the larva is called, greatly resembles, not only in form, but in its habit of rolling up submerged leaves. They also construct cases of bits of sticks, sawdust, or grains of sand, which they drag over the bottom of quiet pools, retreating within when disturbed. They live on vegetable matter, and on water-fleas (Entomostraca) and small aquatic larvæ. When about to pupate they close up the mouth of the case with a grating, or as in the case of Helicopsyche by a dense silken lid with a single slit, and in some instances spin a slight, thin, silken cocoon, within which the pupa state is passed. The pupa is much like that of the smaller moths, except that the wings and limbs are free from the body. Dr. Hagen informs me that after leaving its case it makes its way over the surface of the water to the shore, sometimes going a long distance. "Westwood states that "the females deposit their eggs in a double gelatinous mass, which is of a green color, and is retained for a considerable time at the extremity of the body; the mass is subsequently attached to the surface of some aquatic plant, and Mr. Hydeman has observed the female of Phryganea grandis creep down the stems of aquatic plants under the water, very nearly a foot deep, for the purpose of oviposition." A. Meyer mentions several instances of the union of the sexes of different species of this family, with the production of fertile eggs. (Günther's Zoölogical Record for 1867.)

Only one exception to the aquatic habits of this family is the *Enoicyla pusilla* Burmeister which, according to McLachlan, in Europe "lives out of the water amongst moss at the roots of trees. The larva is destitute of the external respiratory filaments common to almost all caddis-worms, but the spiracles are not very evident. E. pusilla is also remarkable, inasmuch as the female is wingless, and little resembling the male." Von Siebold discovered that an Ichneumon (Agriotypus armatus) attacks the fully grown larva of a Phryganea (Aspatherium), which inhabits a smooth cylindrical case, which the Ichneumon converts into a pupa case by spinning a long broad band of silk around the anterior opening. (Gerstaecker.)

In *Neuronia* and *Phryganea* the maxillary palpi differ in the two sexes, and there are two spurs on each of the fore legs, and four on the middle and hind legs. The maxillary palpi in the males are four-jointed, in the females five-jointed, and there are three ocelli. Neuronia differs from Phryganea in having its antennæ a little shorter than the wings, whereas in the latter they are longer, and the fore wings are hairy. *Neuronia semifasciata* Say is fulvous, with the fore wings transversely flecked with brownish-black, a small basal spot, and an abrupt, median streak at the hinder margin of the wing, while the disk has two yellowish spots, and there is a short fuscous subapical band on the hind wings. Fig. 606 represents the case of the European *Phryganea grandis* Linn.

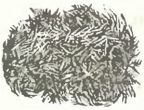


Fig. 607.

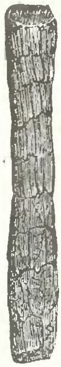


Fig. 606.

In the group *Limnophilides* the maxillary palpi of the males are three, those of the females five-jointed; ocelli three; anterior wings rather narrow, the apex obliquely truncated or rounded. In *Limnophilus* the tibial spurs of the three pairs of legs are arranged thus, 1, 3, 4 (*i. e.*, one spur on the front pair of tibiæ; three on the middle, and four on the hinder pair), and the apex of the anterior wings is truncated. *L. perpusillus* Walker is a boreal species, occurring at Hudson's Bay. *Limnophilus rhombicus* Linn. (Fig. 607, case made of bits of moss) is an ochreous species, with luteous hairs. Fig. 608. *a*, case, represents a case-worm which we have found in great abund-

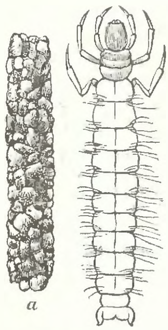


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Fig. 608.

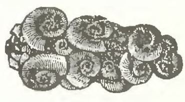


Fig. 609.

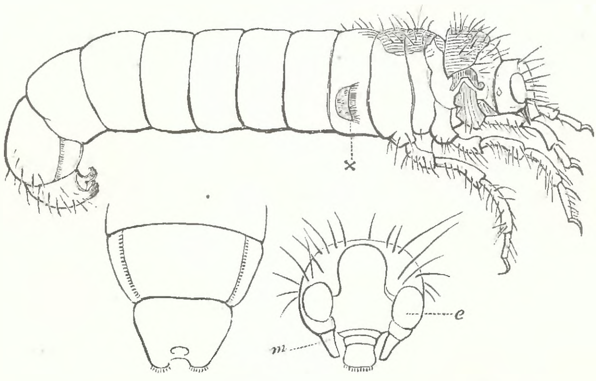
Fig. 610.

ance in Labrador. Though we have not reared the imago we suppose it to be the *Limnophilus subpunctulatus* of Zetterstedt, the most abundant species we met in Labrador. The case is straight, cylindrical, and built of coarse gravel, and the larva is a thick, cylindrical, whitish worm. Fig. 609 represents the case of *L. flavicornis* Fabr., a European species, which is often constructed of small shells. Fig. 610 illustrates the case of the European *L. pellucidus* Olivier, which is formed of large pieces of leaves laid flat over each other.


Fig. 611.

In *Sericostoma* the ocelli are wanting, and the palpi are pilose, the maxillary palpi of the males are four-jointed, covering the face like a mask. *S. Americanum* Walker is black with black hairs; the antennæ are twice the length of the body, while the anterior wings are much longer than the hind ones. Fig. 611 represents the tube of a European species of this genus.

In *Helicopsyche* the spurs are arranged thus: 2, 2, 4, and the maxillary palpi of the males mask the face, being recurved. We have found the larvæ of *Helicopsyche glabra* Hagen (Fig.



b Fig. 612. a

612, x, lunate patch on the basal abdominal ring; a, front view of the head, enlarged; m, mandible; e, eye; b, vertical view of the end of the abdomen, enlarged), about changing to pupæ, the middle of July, in Wenham Lake, Mass. One had spun its operculum and lay with its head just behind it. The body of the larva is curved, though not spirally, and when out of the case it is cylindrical, thickest on the basal ring of the abdomen, and is pale greenish, while the head, thorax and legs are brownish; it is .25 of an inch in length. The head is hairy and is smaller than usual, a little narrower than the thorax, with black, acute unidentate mandibles. The thoracic rings are horny above, somewhat hairy, and the legs are slender and hairy. The abdomen ends rather abruptly, with two short tubercles ending in a hook, both sides being alike, the body throughout as symmetrical as other larvæ of this family, though living in a helicoid case. On each side of the basal segment of the abdomen is a lunate, corneous, hairy spot, by which the larva probably retains its hold in the case when the head and thorax are protruded. The case is usually very regularly helix-like in form, though the umbilicus varies in size. It is composed of fine grains of sand so arranged that the outer surface is smooth. It is closed during the pupa state by a dense, silken concave, suborbicular operculum, with concentric lines, rounded on the side, and but slightly convex on the other, with a slightly curved slit for the passage of water situated on the less convex side, each side of the slit being provided with slender straight teeth which nearly touch each other, thus forming an imperfect grate. The larva does not spin a cocoon. Fig. 613 represents the case of *H. arenifera* Lea, from Indiana.

Fig. 613.

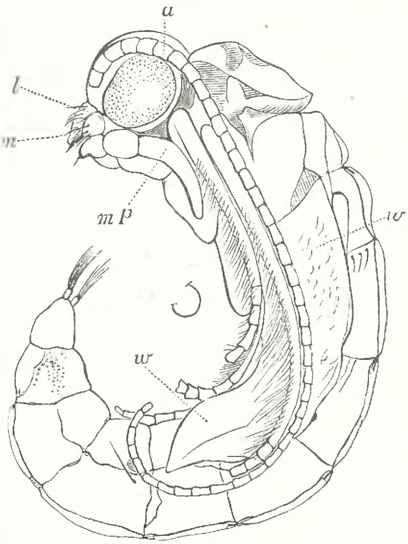


Fig. 614.

Mr. J. A. McNiel has brought from Pulvon, west coast of Nicaragua, similar larvæ, belonging to a species very closely allied to that described above. They differ in being a little larger and more hairy. The case is similar, though with a rough exterior. The pupa (Fig. 614, *a*, antennæ, curved back behind the eyes; *l*, labrum; *m*, mandibles; *mp*, maxillary palpi; *w*, wings) of this Nicaraguan larva is curved in a slightly spiral manner, the antennæ are curved over and behind the eyes, reaching to the seventh abdominal ring; the maxillary palpi are laid backwards on the side of the thorax, and the labial palpi lie between them, though diverging from each other. The wings are pressed to the body under the legs, the latter being fringed with long hairs. On the end of the abdomen are two slender tubercles ending in fine hairs, and alike on both sides, the pupa, like the larva, being symmetrical throughout. The larvæ seem to live in clear water on a sandy bottom, often attached to submerged sticks, unio shells, etc.

Fig. 615.

In *Leptocerus* the antennæ of the males are extremely long; tibial spurs thus: 2, 2, 2. *L. niger* Linn. is black, shining, with black hair; the antennæ are black, the basal half annulated with snow-white, while the basal joint is reddish; the feet are luteous, the intermediate ones being snow-white, while the anterior wings are steel-blue black, and the hind wings blackish. It is found in Europe and the United States. Fig. 615 represents, Dr. Hagen informs me, a case of either this species or *L. sepulchralis* Walker, or else a similar species. The larva builds a thin, long, conical, sandy tube supported between two needles of the pine. The specimens figured were found by Rev. E. C. Bolles at Westbrook, Maine.

In *Setodes* the species are snow-white; the spurs are arranged thus: 0, 2, 2. *S. candida* Hagen is pale yellow, with the anterior wings snowy white. It occurs in the Southern States. McLachlan states that "some species of Setodes make delicate little tubes, entirely formed of a silky secretion, without any mixture of extraneous matters." Fig. 616 represents a tube of a European species of Setodes formed of sand.

Fig. 616.

In *Hydropsyche* and allies the ocelli are three in number, or entirely wanting, while the last division of the maxillary palpi is very long, filiform and multiarticulate. In *Hydropsyche* the spurs are arranged thus: 2, 4, 4. The antennæ are rather long and slender, the ocelli are absent, and the intermediate feet of the female are dilated. *H. scalaris* Hagen is black gray, with white hairs, and the antennæ are yellowish, and obliquely striated with black at the base; the first joint is covered with snow-white hairs. *Philopotamus* has three ocelli, and the tibial spurs are arranged thus: 2, 4, 4.

In *Rhyacophila* the maxillary palpi have the last joint entire, straight, shorter than the rest; while there are three ocelli, and the tibial spurs are arranged thus: 3, 4, 4. *R. fuscula* Walker is rust-red, with some black hairs and a subfuscous spot on each side of the thorax. It comes from Hudson's Bay.

Another curious Neuropterous insect found in the iron-stone concretions of Morris, Ill., is the *Megathentomum pustulatum* of Scudder (Fig. 617, natural size), described and figured by him in the "Palæontology of the Illinois State Geological Survey." "The fragment represents a wing (apparently an upper one) of a Neuropterous insect. It is gigantic in size, very broad, with distant nervures, simple infrequent divarications, and in the outer half of the wing, which alone is presented, a

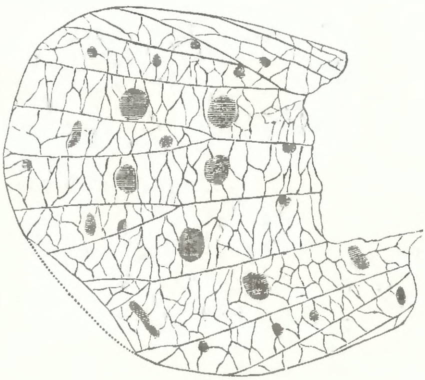


Fig. 617.

cross neuration, composed solely of most delicate and irregular veinlets. The wing is also furnished with a great number of larger and smaller discolored spots, the surfaces of the larger ones irregularly elevated." Mr. Scudder thinks the wing is allied to that of Coniopteryx, adding "it appears to belong to a family hitherto undescribed. I do not know of a single insect, living or fossil, which approaches it in the structure of the wings."

The two succeeding families were by Latreille placed in a group by themselves (Thysanura), which was considered equivalent to the Neuroptera, or Diptera, for example. More recently they have been placed among the Neuroptera, though Burmeister considered them as Orthopterous, by the close resemblance of the mouth-parts of Lepisma, especially the labium, to those of the *Blattariæ*. But in descending through the last three families thysanurous characters have constantly revealed themselves, as we have shown above, and the transition from some Sialidan, Hemerobid and Panorpid forms is not so abrupt as it might seem. Indeed these low, apterous insects stand in the same relation to the rest of the Neuroptera as the Flea does to the rest of the Diptera, or the Lice and Thrips to the higher Hemiptera. In all these degraded forms the metamorphosis is but slightly marked. The pupa is active and closely resembles the larva, where in the higher insects, such as the butterfly or bee, the pupa bears a close resemblance to the adult, winged form.

These interesting, minute, wingless forms, also afford a passage from the true winged insects to the Myriapods, by the uniform size of the rings of the body, which form a continuous series from the head to the opposite extremity, as in the genus Lepisma and allies, without showing the usual well marked division into head, thorax and abdomen. Even the place of abdominal legs is supplied in Lepisma by the rows of small stylets which prop up the long slender abdomen.

LEPISMATIDÆ Burmeister. Bristle-tails. These agile creatures, which are revealed by turning over stones and sticks in damp situations, and are often seen about houses, have a long flattened body, with metallic scales, in form somewhat like those of butterflies. The antennæ are very long, setiform, many-jointed; the mouth-parts are free, with long palpi; the maxillary palpi being seven-jointed and the labial palpi four-jointed. The mandibles are stout, sunken in the head, and armed with teeth for gnawing. The prothorax is very large, and all the rings of the body are of much the same size, so that the insect bears a general resemblance to the Myriapods. The anal stylets are long and large, which with the smaller ones inserted on the subterminal rings of the abdomen aid greatly in locomotion, though these insects run with great rapidity and do not leap like the *Poduridæ*, and thus remind us, as well as in their general appearance, of certain wingless cockroaches.

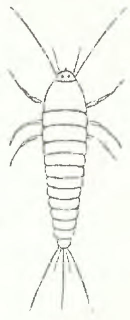


Fig. 618.

In *Lepisma* (Fig. 618) the eyes are minute, consisting of twelve simple eyes, with short bristles on the tip of the abdomen, of which three are longest, while *Machilis* differs in having compound eyes, and longer abdominal bristles. *Lepisma saccharina* Linn., or an allied species, is often very common in houses, where it eats holes in silks and silken tapestry, devours the paste and eats holes in the leaves of books. Mr. W. C. Fish has sent me several pieces of willow from a wicker basket which he said had been bored longitudinally by these insects, the holes being perfectly round and less in diameter than the body of the insect; hundreds of these animals were scalded out of the basket.

Campodeæ Meinert. Under this name Dr. Meinert has established a family consisting of two but little known genera, which have flat and elongated bodies and no springing apparatus, nor eyes, and though the author excludes the Lepismæ from the Thysanura, we would suggest that the Campodeæ seem intermediate between the running Lepismæ and the springing Poduræ. The antennæ are setaceous or filiform, and the feet are adapted for running, with distinct, elongated, two-clawed tarsi. There are two anal cerci arising from the tenth and last abdominal segment. There are six thoracic spiracles, the Poduræ having none (Meinert). The genus *Japyx* of Haliday has short, inarticulate, horny anal cerci. *J. solifugus* Haliday lays few eggs, but those very large. It lives under stones and when disturbed resembles "a Lithobius in the character of its movements," and bears a remarkable resemblance to a young Forficula. The other genus, *Campodea* Westwood, has long, many-jointed, filiform anal cerci, and the body, especially the upper side, is covered with setæ. *C. fragilis* Meinert of Europe lives in moist earth and under stones.

PODURIDÆ Burmeister. The Spring-tails are the typical Thysanura, as they differ more than Lepisma and allies from all other insects. The anal bristles, which are free in Lepisma, are here united and bent beneath the body, forming the "spring" by which they leap to a prodigious height for such minute insects. The body is cylindrical, not flattened, and is covered either with hairs or scales. The four or six-jointed antennæ are short and thick, and the eyes are simple, usually four to eight on each side. The mouth-parts are not well developed, though mostly present, the mandibles being small, with minute teeth, and the maxillary palpi entirely wanting (Gerstaecker), though Lubbock states that the "second pair of maxillæ [labium] are membranous and delicate." The prothorax is small, convex, while the two hinder thoracic rings are large and similar to each other. The legs are stout, with tarsi consisting of but a single joint. The abdomen consists of six, sometimes only three segments, with a long anal stylet forming the forked tail, or "spring," beneath. (Gerstaecker.) They are found in gardens, or hot-beds, on manure heaps in winter, and on the snow; they may also be seen leaping on the surface of the water in quiet pools. "According to Nicolet these insects are very prolific, as he found 1360 eggs in a single individual. The embryo is developed in twelve days. They moult often, and at periods of fourteen days each.

The intestinal canal consists in great part of a long and voluminous chyle-making stomach, into the lower end of which six free Malpighian tubes pour their contents. (Nicolet.) In *Papirius Saundersii*, as in many other apterous Articulata, the testis is formed on the same type as the ovary. On each side of the body is a simple tube opening into a triangular reservoir with its base in front. The nervous system of Smynthurus consists, according to Nicolet, of four ganglia, with a double connecting cord. Two of these ganglia occupy the head and form the œsophageal collar. The two others consist of a thoracic and one abdominal ganglion. There are in Podura four pairs of stigmata in the four basal rings of the abdomen. Next to the two main tracheæ are six pairs of rather long vesicles united with them by loops. (Gerstaecker.)

Lubbock states that in Smynthurus there are but two spiracles, adding that "it is very unusual for an articulate animal to have only two spiracles, and their position is still more extraordinary, for they open on the under side of the head, immediately below the antennæ, . . . on the inner side of the basis of the mandibles." "In the manner of subdivisions the tracheæ of Smynthurus differ from those of the true insects, and agree more closely with the Myriapoda and tracheal Arachnida, in the fact that they do not often give off branches nor form tufts, but generally divide dichotomously, and run considerable distances without a separation." (Mr. Lubbock, whom we have just quoted, states that *Papirius* has no tracheæ.) In Smynthurus the ovaries consist, according to Lubbock, of a single egg-tube. (He also states that he has been unable to detect the presence of any such tubes in the species of Smynthurus he examined. Linnæan Transactions, p. 441.)

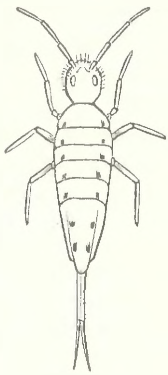


Fig. 619.

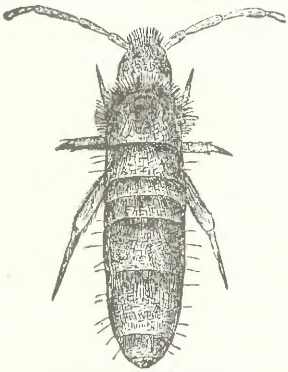


Fig. 620.

In the genus *Podura* the body is long, with four-jointed antennæ, and the flexible spring-tail is short, while in *Desoria*, which is found in the Alps, the tail is long. The genus *Degeeria* is known by the ovate body, and basal half of the spring equalling the fork in length. A species (Fig. 619) closely resembling the European *D. nivalis* Nicolet, we have found in summer resting on the leaves of the Clematis. The *Lepidocyrtus albinos* Nic. (Fig. 620) is a minute pearly white species found in Europe; its scales (Fig. 621) are thin and with distinct markings.

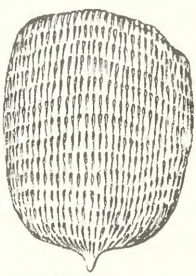


Fig. 621.

Smynthurus is short, differing greatly in form from Podura, and bears a striking resemblance to the larva of Coniopteryx. The body is short, nearly spherical, and in its form approaches the spiders, as noticed by Latreille. The four-jointed antennæ are long and elbowed, while there are eight simple eyes on each side of the head. The species are found on the leaves of garden plants, and when disturbed leap like fleas, which they much resemble. In *Papirius* of Lubbock, the antennæ are said to be "four-jointed, but without a well marked elbow, and with a short terminal segment, offering the appearance of being many-jointed."

ORDER II. ARACHNIDA.

THE typical forms of this order have the body divided into two regions, the head-thorax (cephalothorax) and abdomen. The head is sometimes quite distinct, but is generally sunken into the thorax, which bears four pairs of legs, while the abdomen has no organs of locomotion, though the abdomen is provided with three pairs of jointed appendages (the *spinnerets*), which are, however, homologous with the legs. The metamorphosis is very incomplete in the lower forms, while in the spiders there is none at all after the animal leaves the egg. The head is without antennæ, or compound eyes. The order shows its close relationship with the Dipterous insects, especially when compared with the wingless Chionea and Nycteribia, and its lowest forms (certain mites) bear a close resemblance to some of the lower Crustacea, as the young stages and embryonic development are remarkably similar. The typical forms of the order homologize too closely with the apterous insects to allow them to be separated as a distinct class. We shall see below that the rank here assigned to the group accords well with their anatomical characters and habits.

In some genera there is a decided line of demarcation between the head and the thorax, which is, however, very distinct during embryonic life, and we do not perceive that gradual transition from mouth-parts to swimming legs which obtains in the Crustacea. The order, however, has much lower, more degraded forms than the Myriapods even, as the genus Demodex testifies, which may recall readily certain intestinal worms. This we would consider as but an example of what often occurs among all degraded forms, of a recurrence to the archetypal form of the articulate type, and not for this reason, as some authors have done, would we place the Arachnids of Latreille in a class by themselves, below the Myriapods; nor on recurring to the spiders alone, with their high organization and wonderful instincts, would we follow Professor Owen and others in placing them even above the true insects.

We must look upon the Spider as a hexapodous insect, degraded, wingless, and partially *decephalized*. A part of the elements, constituting the head in insects, have been, as it were, withheld from the head and detained in the thorax, which has thus an increase in one pair of limbs. On the other hand, the sensorial, or pre-oral, region of the head, is wanting in two most important members, *i. e.*, the compound eyes and the antennæ. Both Zaddach and Claparède state that there are no organs in the spiders homologous with the antennæ of insects. The simple fact that the homology of the organs generally is so close between the two groups shows that they must fall into the same class. The same can be said of the Myriapods.

The circulatory system is very perfect in the spiders and scorpions, but in most of the lower mites there is no dorsal vessel, or vascular system at all, the fluids being supposed to circulate in the general cavity of the body, "and by the aid of the muscular movements and the contractions of the intestinal canal, transferred in an irregular manner hither and thither in the visceral cavity and in the extremities." (Siebold.) In the *Phalangidæ* there is a distinct, three-chambered dorsal vessel, or heart. In the spiders and scorpions, however, the vascular system is highly organized, as shown by Newport (in the Scorpions), and Claparède (in Lycosa). Here then, is, as in Sphinx, a dorsal and ventral vessel with lateral veins, or venous sinuses, performing the functions of true veins. The main dorsal vessel is mostly situate in the abdomen, as the lungs have their seat in that region, where the most important respiratory function, that of supplying the blood with fresh oxygen, is performed. Claparède has shown that in Lycosa the blood flows through the dorsal vessel from the head, instead of towards the head, as in the six-footed insects.

The nervous system consists of a small brain, a group of thoracic ganglia and a few abdominal ganglia, which, however. are aborted in the spiders. The cerebral ganglia, or brain, lie just above the œsophagus, and send down two cords embracing the throat, and also distribute nerves to the ocelli and mouth-parts.

In the mites (Acarina), where the body is oval, and not divided into the two distinct regions, there is no brain, and but a single ganglion lodged in the abdomen, from which are distributed the nerves supplying the head and the peripheral parts. In the spiders the brain is of considerable size, and the thoracic ganglia or "subœsophageal ganglia," are large, sending off on each side four large processes from which proceed the nerves supplying the feet.

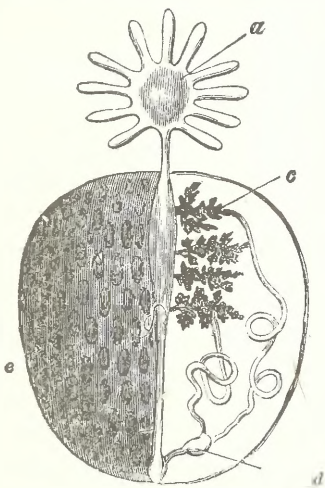


Fig. 622.

In the scorpion (Pedipalpi) the nervous system is still more highly organized. The brain is not large; it is composed of the two spherical superœsophageal ganglia fused together, sending off the usual nerves to the mouth-parts. This brain-like organ is connected by two filaments with the ventral ganglionic mass, formed by the probable union of several ganglia, and situated in the middle of the false cephalothorax. The continuation of the nervous cord consists of seven abdominal ganglia, with the commissures united into a single cord.

The maxillary palpi, functionally, take the place of antennæ, showing how one organ may perform the office of another in a different group of animals. It is also evident that the spider combines in the same organ the senses of taste, smell and feeling, which are supposed in insects to reside in the two pairs of palpi and the antennæ.

The alimentary canal is formed, according to Siebold, on two types. In the mites and spiders, the stomach is produced laterally into large cœcal appendages (Fig. 622, alimentary canal of Tegenaria civilis; *a*, stomach, with cœca; *c*, liver; *d*, renal organ; *e*, fat body), and then passes into a short, small intestine, going straight to the end of the body. In the Pedipalpes (Phrynidæ and Scorpions) the intestinal canal is more simple, not having any cœcal dilatations to the very small stomach.

The salivary glands are often of large size, especially in Ixodes, and are thus adapted to their flesh-eating habits, much saliva being needed to moisten their food. In the spiders and scorpions the liver is well developed and distinct from the intestinal tube, being in the spider a brown or dirty yellow mass filling a large part of the abdominal cavity and enveloping most of the other viscera.

As during the growth of the young spider the head is thrown back on top of the thorax to which it is thus most closely united, it follows that the simple eyes, from two to twelve in number, are situated on the upper surface of the cephalothorax, while no other sensory organs, *i. e.*, the compound eyes and antennæ, are ever developed. Thus in the adult spider the mandibles seem to be pushed far in front of the ocelli, and to occupy what is originally the proper or normal site of the ocelli, and in insects of the antennæ, which no doubt has led most authors to homologize them with the antennæ of hexapodous insects. Claparède says "all the appendages are postoral, hence there are no organs homologous with the antennæ." Thus the mouth-opening is brought far forward; it is flanked on each side by a mandible (Plate 11, fig. 3, *c*, *a*, movable claw, or fang), a large, powerful limb, which does not move horizontally but vertically; behind are the large, well developed maxillæ (Plate 11, fig. 2, *b*; 7, maxillary palpus; 8, male palpus), with their long, leg-like palpus. Thus the function of the insectean antennæ must, in the spiders, reside in the maxillary palpi. Claparède's researches on the embryology of the spiders and mites have demonstrated that the front pair of legs of Arachnids are homologous with the labial palpi of insects, which, as we have previously stated (p. 59), in the latter, are late in embryonic life thrown forwards, and associated with the maxillæ and other mouth-parts, while in the Arachnids they retain their embryonic position and are grouped with the legs (see fig. 59, 4) and are usually of the same form. Thus one cephalic segment of insects is permanently retained in the thorax among the Arachnids, whereas we have seen in the embryo of the dragon-fly (Figs. 59, 61, 4) it assumes an intermediate position between the head and thorax, the remaining anterior part of the head being clearly separated by a deep suture. In Fig. 59, we see the labial palpi (4) grouped with the three pairs of legs; a position permanent in the Arachnida. The dragon-fly, at the period represented by Fig. 59, p. 57, may be legitimately compared with the scorpion, especially Cyclopthalmus, from the coal measures.

While, as Blackwall states, nothing is known with certainty concerning the organs of smell and hearing in spiders, Mr. R. Beck "suggests that spiders are capable of distinguishing sounds to some extent by means of very delicate waving hairs which are found on the upper surfaces of their legs. During life they move at their peculiarly cup-shaped bases, with the least motion of the atmosphere, but are immovable after death. It is well known that sound is due to vibrations which are generally conveyed by undulations of the air; now I am perfectly satisfied that if these undulations are of a certain character the hairs I am alluding to, upon the spider's leg, will move, and I wish you particularly to notice that they are of different lengths, so that some might move whilst others would not, and also that the longest is at the extremity of the leg, and therefore can receive an undulation which might die away higher up. I may just mention that there is a group of these peculiar hairs on the flea. The legs of a spider are most sensitive organs of feeling, if they do not also embrace those of hearing." (Entomologist, London, 1866, iii, p. 246.)

The four thoracic feet have seven joints, and it is probable that the two basal joints homologize with the coxa and trochantine of insects, in which the two joints are retracted, side by side, and closely fused together. The tergal part of the thoracic segments is large, overlapping the pleural, while the sternum is a rather large, broad breast-plate. The abdomen is generally somewhat spherical, and in but few instances is it drawn out and the rings well developed, as in the scorpion. In the mites it is fused closely with the cephalothorax.

In the genus Hersilla we see clearly that the three pairs of spinnerets are but modified legs. The second and inner pair are generally the smallest, while the third and largest pair are the most posterior. Their office is to reel out the silk from the silk-glands. The tip of the articulated spinnerets ends in a cone, perforated by myriads of little tubes (over 1,000 in Epeïra, about 300 in Lycosa, and a less number in the smaller species) through which the silk escapes in excessively delicate threads, which unite to form the common thread visible to the naked eye. (Plate 11, fig. 4, spinnerets of Epeïra vulgaris enlarged twenty-five diameters; fig. 5, a spinning tube.)

The Acarina are supposed to have glands analogous to the silk glands, whose product, like silk, hardens on exposure to the air, and by which certain parasitic genera, such as Uropoda, fix themselves solidly to their host. Siebold states also, that "many species of Hydrachna fix, by a kind of glue, the anterior portion of their body on aquatic plants, and in this position await the completion of their moulting. The organs secreting this substance have not yet been discovered. It is well known that the European Tetranychus telarius spins large webs on the leaves of trees and on house-plants.

The reproductive system is much as described in insects, except that the external appendages are rarely developed in either sex. The genital armor is situated at the base of the abdomen; it is concealed when present under the skin.

In the Acarina the two ovaries open on the middle of the abdomen, or on the under side of the thorax, either between or behind the last pair of legs. In Hydrachna the oviduct opens into an ovipositor by which the insect is enabled to lay its eggs under the skin of the fresh-water mussel on which it is parasitic, and other mites oviposit in a similar way under the epidermis of plants.

In most spiders the two ovaries have their outlet in an orifice situated between the two lung-sacs. They have a distinct *receptaculum seminis*, especially marked in Epeïra. "The *Scorpionidæ* have three ovaries, consisting of as many longitudinal ones, united by four pairs of transverse ones." The outer two of the former are oviducts, leading out at the base of the abdomen.

The testes of Ixodes consist of four or five pairs of unequal follicles, opening out near the base of the abdomen." The males are distinguished from the females by their larger "cheliceres" (maxillary palpi) and larger pair of clasping legs. In the spiders the testes are "two long, simple, interlaced cæca, concealed beneath the hepatic lobes," which lead by two deferent canals to the base of the abdomen, through a simple fissure, which, however, is not applied to the vulva. The complicated hollow spoon-shaped palpi are supposed to be the intromittent organs. "They are filled with sperm and applied to the entrance of the vulva. For this purpose the last joint of the palpi, which is always hollow and much enlarged, contains a soft spiral body, terminated by a curved, gutter-like, horny process. Beside this there is an arched, horny filament, and several hooks and other appendages of the most varied forms. These appendages are protractile and serve, some to seize the female, and others as conductors of the sperm." (Siebold.) While the majority of the Arachnida are developed as usual after the laying of the eggs, a few, such as the scorpions and *Oribatidæ* and other mites, are known to be viviparous, and it is probable that an alternation of generations occurs in some of the lower mites. The Tardigrades are hermaphrodites.

The Arachnida breathe both by tracheæ and lung-like organs. The mites, the false scorpions, the harvest-men and *Solpugidæ* are provided with tracheæ, communicating externally by means of spiracles, generally two in number, and concealed between the anterior feet. In Hydrachna, which lives constantly beneath the water, the tracheæ "possess probably, the power to extract from the water, the air necessary for respiration." (Siebold.) In the false scorpions a pair of lateral stigmata are situated on each of the two basal rings of the abdomen. From these spring "four short, but large trachean trunks from which arise numerous unbranched tracheæ spreading through the entire body." In the *Solpugidæ* there are three pairs of stigmata and the tracheæ ramify and are distribbuted much as in insects, and in the *Phalangidæ* the tracheary system is well developed, arising from two stigmata opening between the insertion of the posterior legs.

In most of the spiders (such as Segestria, Dysdera and Argyroneta) there are both a tracheary system and lungs. The two stigmata, from which these tracheæ lead, open near the pulmonary opening. In two other genera, Salticus and Microphantes, there are two stigmata situated at the posterior end of the abdomen. Siebold calls attention to a tracheary system in many Araneæ opening by a transverse fissure placed near the spinnerets. From this opening a main trunk leads in, soon dividing into four simple tracheæ, which are not round as usual, "but are flattened, riband-like, and without the trace of a spiral filament; these extend, with a gradual attenuation, to the base of the abdomen. . . . The air received into these organs is separated into as fine portions as that of the lungs.*

The so called lungs of the spiders are little round sacs opening by transverse fissures on the under side of the base of the abdomen. The inner surface is divided into thin lamellæ, connected together like the leaves of a book. Each of these is formed by a membranous fold, between the two leaves of which the air enters from the general cavity of the lung, and is divided into very minute portions. No traces of blood vessels have been found in these pulmonary lamellæ." (Siebold.)

Among the organs of special secretion the poison and silk glands require description. There are two poison glands emptying into the throat, and thence opening out through hollows in the jaws. (Plate 11, fig. 3, *a*, *b*.) In the scorpion the poison gland is lodged in the last abdominal segment at the base of the sting.

The silk, as contained in the glands, is a viscid transparent fluid, which on exposure to the air hardens into silk; it is drawn out by the legs through three, rarely two pairs of spinnerets. There are usually five of these glands lodged in the abdomen, and the "threads probably have different qualities, according to the glands from which they are secreted." (Siebold.)

"To form the thread this liquid is drawn through the tubes,

*According to Dr. Burnett, Blanchard regards these anomalous tracheæ as only elongated pulmonary sacs. Leuckart, however, considers that these organs are only a sort of tracheæ deprived of the usual spiral filament to keep their walls from collapsing, and he considers that the pulmonary sacs of the spider are simply modified tracheæ.—*Dr. W. I. Burnett's Translation of Siebolds's Anatomy of the Invertebrata.*

which divide it into such small fibres that it dries almost immediately on coming in contact with the air. The spider has the power of uniting these fibres into one or several threads, according to the purpose for which they are to be used. The thread commonly used for the web is composed of hundreds of simple fibres, each spun through a separate tube. As the thread runs from the body it is guided by the hind feet, which hold it off from contact with surrounding objects, until the desired point is reached, when a touch of the spinners fastens it securely." (Emerton, American Naturalist, ii, p. 478.)

The eggs are laid but once a year in June. The evolution of the embryo begins immediately, and goes on with a rapidity according with the temperature. The egg consists, as Herold observed, simply of a vitelline membrane, but no chorion; it is perfectly homogeneous, and has no micropyle. The contents are an emulsion of fatty globules suspended in a scanty amount of liquid, which should not be confounded with the albumen (or white) of the eggs of vertebrates. No trace of the "germinative vesicle" has as yet been traced in the eggs of insects, though perhaps it has been overlooked from its transparency.

The first stages in the egg after they are laid, are the following: at the surface of the vitellus appear, here and there, small, very clear and perfectly circular spots; they are the nucleus of the future blastoderm (primitive skin, from which the organs of the embryo successively originate or "bud" out). These nuclei act as centres of attraction on the molecules of the vitellus for the formation of the cellules. The unmodified vitellus diminishes in the same proportion as the peripheric layer of granules increases. The granules multiply rapidly, and soon the surface of the egg appears to be divided into a certain number of areas, each of which is occupied in the centre by a circular and transparent space surrounded with small opake granules, which become less and less dense as we go to the outer surface. These hexagonal cellules form an uniform layer over the entire surface of the egg; it is the blastoderm. Up to this time the changes precisely accord with those observed in the hexapodous insects.

The next stage is the formation of ventral tubercles, the rudiments of the limbs of the embryo. The first change is the formation of the "primitive streak," or the splitting of the blastoderm, which is due to a local multiplication of the cellules along the median line of the egg.

These tubercles result from a simple thickening of the blastoderm, and what is ultimately destined to be the back (tergum) of the animal, arises from a similar thickening of the blastoderm, which he calls the "primitive cumulus." This mass, easily distinguished by its whiteness, always floats on the top of the yolk of the egg, keeping its position next the eye of the observer. The "cumulus," at first almost hemispherical, elongates over the surface of the blastoderm, becoming pyriform. This region is the posterior, or anal, pole of the egg.

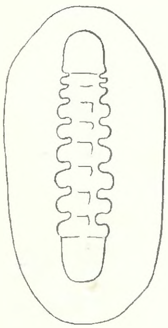


Fig. 624.

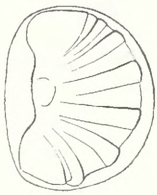


Fig. 623.

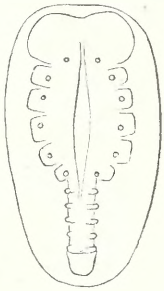


Fig. 625.

We see the "cumulus" spreading from the anal pole over the surface like a veil, but it is less white than the polar region. This veil continues to spread over the entire surface to a pole opposing the anal, which Claparède terms the cephalic pole. Each pole forms a very prominent projection. At this stage the body of the embryo becomes well marked and subdivided, worm-like, into rings. (Fig. 623.) The extent of the dorsal region is greatly limited, while that of the ventral side is greatly increased.

The entire ventral region, occupying most of the whole egg, is homologous with the primitive ventral streak. It is at this time that the formation of the protozoönites (elemental rings, or primordial segments) takes place. Six of these zones or segments arise between the cephalic and anal poles; these zones represent the ventral arcs. The two anterior rings bear the mouth-parts, the mandibles and maxillæ; while the others form rings corresponding to the four pair of feet. These protozoönites are very transitory, only existing for a short period; they gradually retreat towards the ventral side, enlarge and nearly touch each other.

The embryo (Fig. 624) now grows much longer, and new embryonal segments are formed in the abdomen just as they grow out in the worms, and Myriapods, and also in the Crustacea, according to Rathke's researches. Thus while the cephalothoracic rings appear simultaneously the abdominal segments appear one after the other. The first one appears between the last thoracic ring and the anal "hood," or pole. Meanwhile the lateral extremities of the protozoönites have become enlarged; these enlargements form the appendages. These tubercles, or rudimentary limbs, appear on the *abdominal* as well as on the thoracic rings (Fig. 625). This fact is one of great interest, as showing a resemblance to the Crustacean with its abdominal legs, and more especially to the abdominal footed Myriapods, and the larvæ of many true six-footed insects. Thus the young spider is at first like a caterpillar, having "false," deciduous, abdominal legs. Five abdominal rings are present in Pholcus.

Next follows the development of the "post-abdomen," or tail, which being differentiated from the anal pole or "hood," becomes detached from the yolk mass, and is folded back upon the embryo, just as the abdomen of a crab is folded in an opposite way to the ventral side of the body.*

This "post-abdomen," after dividing into three segments, disappears completely during the growth of the embryo. This is the more interesting, as the "post-abdomen" of the scorpion is retained permanently. Meanwhile the two cephalic

*And in like manner the cephalic lobes, containing the ocelli, are seen in the author's figures folded back upon the base of the head, so that the antennæ are never developed, and the mandibles of the spider take their place, in advance of the eyes. The structure and succession of the rings of the insectean head are most readily explained, and some clue is given to their number and succession by comparison with the embryo of spiders.

lobes have developed, and the blastoderm has divided into a dermal, or outer layer, and a muscular, or inner layer of cells. The outer layer forms the chitinous body-wall, or crust, while from the inner layer are developed the digestive, vascular and other organs besides the muscles.

After the rudiments of the appendages are formed the epimera appear. At this period we are struck with the perfect identity between all the appendages of the body at their first origin. In the Arachnida the formation of the primitive segments takes place much sooner than in most other articulates, where they often do not appear until after the rudiments of the limbs are developed.

Another characteristic of the evolution of the spiders is the tardy appearance of the rudiments of the legs. The ventral arcs, or protozoönites, subdivide into ventral and pleural parts, which signalize the formation of the permanent rings of the body. The author's figures and statement show, though he does not state the fact clearly, that development progresses from each end of the body towards the centre, as we have shown* to be the case in insects. Thus the posterior half of the body repeats the mode of development and general form of the anterior, or cephalic pole.

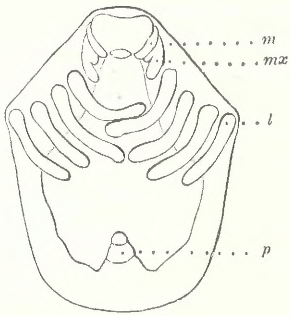


Fig. 626.

The third period in the life of the embryo dates from the formation of the ventral rudiments to the exclusion of the spider. The first change consists in the lengthening and meeting of the rudimentary legs. The mouth-parts develop first. At this period the limb-bearing (pleural) region of the body separates and the sternal piece or breast-plate appears as a "slower, later formation." Now the thoracic legs grow much more rapidly than the mouth-parts and lie interlocked upon the breast. (Fig. 626.†) When the first pair of legs are

* Proceedings Boston Society of Natural History, Feb. 7, 1866.

† Fig. 626, *m*, mandibles; *mx*, maxillæ; *l*, fourth pair of legs; *p*, postabdomen.

long enough to cross each other the jointed structure of the limbs disappears, and they soon become divided into their usual number of joints, though the tarsal joints are the last to be perfected. At this time the maxillæ become differentiated. or split up, into the basal lobe and its appendage, or palpus. Claparède compares the basal lobe to the coxa of the legs, though it is formed long before the coxæ of the feet themselves. The anterior pair of appendages form the mandibles.

The formation of the head is next in order. The "cephalic lobe" is divided into what the author calls two "procephalic lobes," separated by a deep incision, and at this period the head appears very distinct from the thorax. Afterwards the anterior or ante-oral part of the head is, as in the case of the "post-abdomen," folded back on the top, and then closely soldered to the thorax, thus forming the so called "cephalothorax." These procephalic lobes are separated by a third lobe or "triangular plate" which grows up between them, forming the *epichile*. The mouth first appears as a longitudinal furrow in this triangle, the posterior border of which becomes the so called labium ("glossoide" of Latreille). The labium thus originates in the spiders in an entirely different way from the appendages, and is not formed, as Brullé supposed, by the soldering of the maxillæ, hence we shall adopt Latreille's term "glossoide" for this piece.

The two procephalic lobes afterwards unite, and are soldered together on the median line, to form the anterior face of the head. This approach takes place from above, over the buccal frame (epichile). The mandibles are thus in advance of the mouth, though primitively behind it. "The head is then in the embryo of the spider very distinct from the thorax. Only towards the end of embryonic life does the soldering of the 'cranium' and of the prothorax become so intimate that their limits become indistinct. It is only from this moment that there exists a true cephalothorax." (Claparède.)

Towards the end of embryonic life the simple eyes appear, arising from four little furrows, called the "ophthalmic furrows." They are colored by the deposition of a small quantity of pigment. They appear at an earlier period in the Acarina.

Formation of the heart and viscera. After the walls of the body and its appendages have been formed the dorsal vessel appears. It is formed thus: when the division of the blastoderm into its muscular and outer layers takes place the cells multiply and are heaped up along the median line of the body, so as to form a sort of cordon (cord), not only in the abdominal, but in the thoracic region of the body. The vessel probably originates in the spaces between the cells, but the author has been unable to trace either its origin or that of the blood-corpuscles. But the rudimentary heart soon presents rhythmic pulsations, and in the limbs we see the arteries filled with a homogeneous fluid, in which can be detected the presence of small corpuscles, moving by impulses synchronous with the systole of the dorsal vessel, showing that this fluid is the blood. The heart already presents several dilatations (chambers) corresponding to the abdominal segments.

The nervous system does not appear to be formed when the embryo assumes the ventral instead of the dorsal position. The digestive system is very rudimentary when the embryo quits the egg. The alimentary canal is probably hollowed out of the middle of the vitelline mass, being a membranous tube formed around the remaining yolk mass. The lungs and spinnerets are well formed when the embryo is hatched, while the eyes appear later.

The same processes of development go on in the scorpions, the "post-abdomen" of the Araneina (which we have seen folded back on the base of the abdomen and finally to disappear) in them being retained, forming the long, articulated "tail;" thus the distinction into abdomen and post-abdomen is very artificial as the two parts merge into each other, especially in Solpuga, Chelifer and Phrynus.

In the mites the arrest of development is still more marked, as the three regions of the body are in the adult not differentiated, and the entire body assumes an oval form, the abdominal parts being short, thus strikingly resembling the embryo of Pholcus, and the spiders generally, as seen in Claparède's figures.

In the Acarina there is a true metamorphosis, the larvæ of some forms when first hatched being worm-like; then there is an oval stage when the young mite has but three pairs of feet (though in others at this stage there are four pairs), and after another moulting the fourth pair of limbs appear. The young mite is analogous to the "Nauplius" stage of many low Crustacea.

Claparède* has observed in Atax Bonzi, which is a parasite on the gills of fresh-water mussels, that out of the originally laid egg (Plate 9, fig. 3, embryo of Tyroglyphus siro, which closely resembles the earliest stages of the embryo of Atax; *md*, mandibles; *mx*, maxillæ; p'–p''', legs; *vt*, yolk. Fig. 4, front view of the same; R, beak; *p*, maxillæ), not a larva, but an egg-shaped form hatches, which he calls a "deutovum." (Pl. 9, fig. 1, bursting of the egg-shell into two halves, *mo*, on the day that the deutovum, *dm*, hatches out; *md*, mandibles; *mx*, maxillæ; p''', third pair of legs; *lh*, body cavity; *sp*, common beginning of the alimentary canal and nervous system; *amb*, hæmabœba, amœba-like bodies, which represent the blood corpuscles; there being no circulation of the blood, the movements of the hæmabœba constitute a vicarious circulation. Fig. 2, the deutovum free from the first egg-shell; lettering same as in Fig. 1, *oc*, rudiments of the simple eyes; R, beak; *h*, *h'*, rudimentary stomach and liver). From this deutovum (which is not the "amnion" of insects) is developed a six-footed larva. This larva passes into an eight-footed form, the "second larva," (the "nymph" or pupa, of Dujardin and Robin) which transforms into the adult mite. The pupa differs from the adult in having longer feet, and four instead of ten genital cups, the latter being the usual number in the adult.

The larvæ are elongated oval, with six long legs and four ocelli. They swarm for a short time over the gills of the mussel they are living on and then bore into the substance of the gill to undergo their next transformation. Here the young mite increases in size and becomes round. The tissues soften, those of the different organs not being so well marked as in the first larval stage. The limbs are short and much larger

*The development of spiders and of the Arachnids generally, has been traced by Rathke, Herold, and more especially by Claparède, in a work of great ability, from which we have drawn the preceding account, often using the author's own words. His observations were made on various genera of spiders (Pholcus, etc.) His "Studies on Mites," from which Plate 9 is copied, appeared in Siebold's and Kölliker's Journal of Scientific Zoölogy, 1868, part iv.

than before, the whole animal assuming an embryo-like appearance, and moving about like a rounded mass in its enclosure. Indeed is this process not (though Claparède does not say so) a histolysis of the former larval tissues, and the formation of a new body, as in the change of the six-footed insect beneath the larva skin, where the pupa is formed? A new set of limbs grow out, this time there being four instead of three pairs of legs, while the old larval skin is still embraced within the membrane containing the second larval rounded mass. Soon the body is perfected, and the pupa, as we may properly call it, slips out of the larval membrane.

The "second larva" after some time undergoes another change; the limbs grow much shorter and are folded beneath the body, the animal being immovable, while the whole body assumes a broadly ovate form, and looks like an embryo just before hatching, but still lying within the egg. This may also be comparable with the formation of the adult fly within the puparium. (Compare Weismann's account of this process in Musca, pp. 63, 64.) This period seems to be an exact repetition of the histolysis, and the formation of new tissues for the building up of a new body which preceded the pupal stage, while the adult mite slips out of its pupal membrane just as the pupa threw off its larval membrane. This process, again, may be compared to an adult butterfly, or fly, emerging from its pupal membrane.

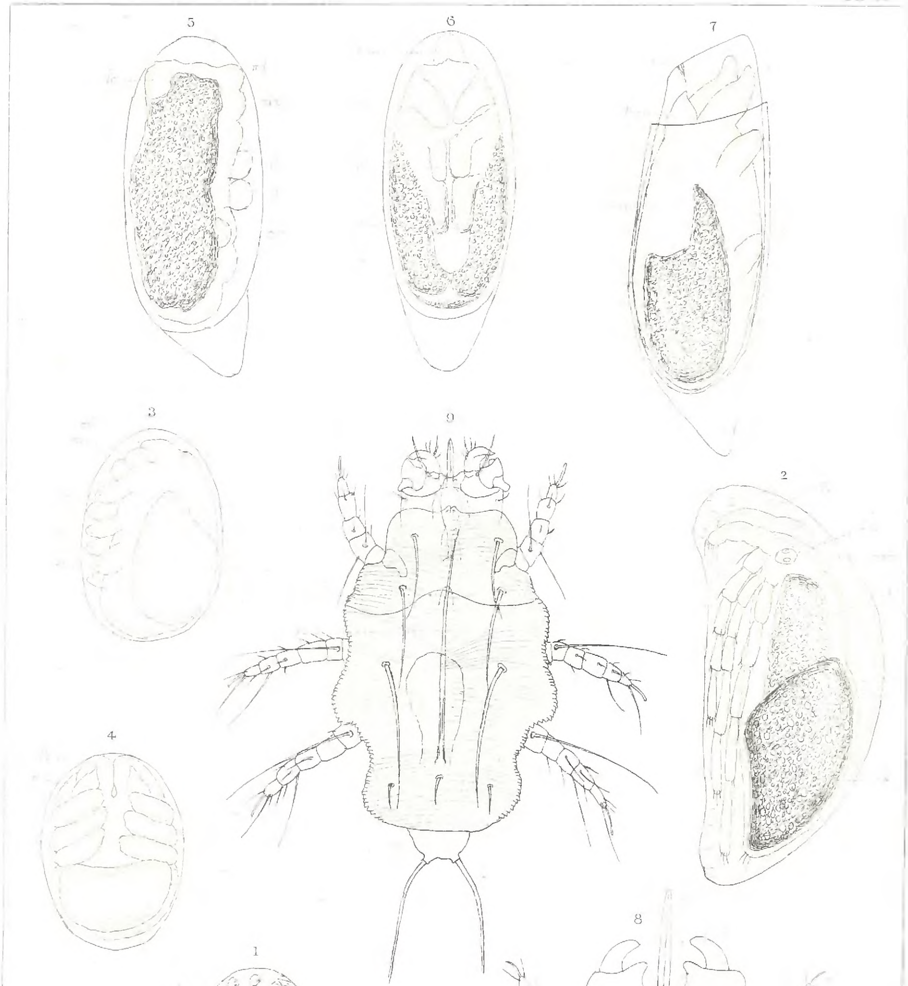
Thus the mites, at least several species, pass through a series of metamorphoses similar to those of such insects as have a complete metamorphosis (except that the Acarian pupa is active), while the absence of such a metamorphosis in the spiders is paralleled by the incomplete metamorphosis of the Orthoptera and many Neuroptera, which reach adult life by simple moultings of the skin.

In the genus Myobia there is not only a deutovum, besides the original egg, but also a *tritovum-stage*. The eggs of this mite are long, oval and conical at the posterior end. The embryo, with the rudiments of limbs, is represented by Fig. 5 of Plate 9. The little tubercles *md* and *mx*, represent the mandibles and maxillæ, while the three pair of legs, $p'p''p'''$, bud out from the middle of the body; *lc* represents the head-plate.

The maxillæ and mandibles finally unite to form a beak (R Fig. 6) and the three pairs of feet ($p'p''p'''$) are folded along the median line of the body. The farther development of the embryo is now for a time arrested, and a peculiar tooth-like process (Fig. 7, *d*) is developed. Claparède thinks that by means of this the anterior end of the egg-shell is cut off, and the embryo protrudes through, when, as in Fig. 7, it is seen to be surrounded by a new membrane, the deutovum (*dt*), equivalent to that of Atax. The front pair of legs (p') have grown larger and stand out in front and on each side of the beak (R). The growing embryo again forces off the anterior end of its deutovum, and the oval end of the egg protrudes through, and is surrounded by another membrane. This is the *tritovum*. The embryo is now surrounded by the membrane of the tritovum, and also by the deutovular membrane and the original egg-shell, the last two having lost a small portion of their anterior ends. During the tritovum-stage the fore pair of feet become curved in like claws, and the beak sinks down into the body.

Now the six-footed larva (Fig. 8) breaks through the shell and closely resembles the adult (Plate 9, fig. 9). The first pair of feet, modified for grasping the hairs of the field-mouse, on which it is a parasite, take the place of the maxillæ, which have been arrested in their development, and the mandibles (*pr*) assume a style-like form. After one or more moultings of the skin a fourth pair of feet (p'''') are acquired, and the adult form results, which the author considers as the type of a new family of Acarina. Claparède also suggests the affinity of Myobia to the Tardigrades (Echiniscus and Lydella), especially from the study of the structure of the style-like mandibles and their supports. We feel convinced, after examining Claparède's figures and descriptions that this comparison is very significant, and this has led us to consider the Tardigrades as a family of true mites. related to Myobia and Demodex.

A French naturalist, C. Robin, has recently observed in certain bird sarcoptids, to which the parasite of the Downy Woodpecker noticed above is allied, "that the males pass through four, and the females through five stages, indicated as follows: (1) the egg, on issuing from which the animal has the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form of (2) a hexapod larva, followed by the stage of (3) octopod nymphæ [four-footed pupæ], without sexual organs. (4) From some of these nymphæ issue: *a*, sexual males, after a moult which is final for them; *b*, from others issue females without external sexual organs, resembling the nymphæ, but larger, and in some species furnished with special copulatory organs. Finally, after a last moult following copulation, these females produce (5) the sexual and fecundated females, which do not copulate, and in the ovary of which eggs are to be seen. No moult follows that which produces males or females furnished with sexual organs; but previously to this the moults are more numerous than the changes of condition." "The larvæ undergo from two to three moults before passing to the state of nymphæ." These latter also undergo two or three moults. (Annals and Magazine of Natural History, 1868, p. 78.)

In some other species of mites no males have been found, and the females have been isolated after being hatched, and yet have been known to lay eggs, which produced young without the interposition of the males. This parthenogenesis has been noticed in several species. But few fossil Arachnids have been yet discovered. Roemer has described a spider from the coal formation of Germany under the name of Protolycosa, while two species of scorpions, and a Phalangium-like spider have been detected in the same formation in this country.

In studying spiders, of which we have several hundred species, the number and relative situation of the eyes, and the relative length of the different pairs of legs, should be noticed; their webs and the manner of constructing them; their habitats, whether spreading their webs upon or in the ground, or in trees, or on herbage, or whether the species are aquatic, or erratic, and pursue their prey without building webs to entrap them, should be observed. So, also, how they deposit their eggs, and the form and appearance of the silken nidus, and whether the female bears her eggs about her, and how this is done, whether holding on to the egg-sac by her fore or hind legs, should all be carefully noticed. Care must be taken not to mistake the young for full-grown, mature species, and describe them as such. Spiders can be reared in boxes as insects. The only way to preserve them is to throw them into alcohol; when pinned they shrivel up and lose their colors, which keep well in spirits.

The colors of spiders vary much at different seasons of the year, especially during the frosts of autumn, when the changes produced are greatest. All spiders are directly beneficial to agriculture by their carnivorous habits, as they all prey upon insects, and do no harm to vegetation. Their instincts are wonderful, and their habits and organization worthy of more study than has yet been paid them in this country. We have no species poisonous to man, except when the state of health renders the constitution open to receive injury from their bite, just as mosquitoes and black flies often cause serious harm to some persons.

The Arachnids are divided into three groups, or suborders, the Araneina, the Pedipalpi, and the Acarina.

ARANEINA.

The Spiders are distinguished from other Arachnids by having mandibles used exclusively for biting, a spherical, sac-like abdomen, not divided into segments, and attached to the head-thorax by a slender pedicel. The maxillæ resemble the thoracic feet. They breathe both by lungs and tracheæ, and do not undergo a metamorphosis, the young on being hatched having four pairs of legs.

The mandibles (Plate 11, fig. 3, front view, with the eight ocelli above) are vertical and end in a powerful hook, in the end of which opens a duct (Plate 11, 3 *a*, *b*) connected with the poison gland situated in the head. The maxillæ, represented by the so called palpi, though in reality the maxillæ themselves, with a flattened coxal lobe at the base (Plate 11, fig. 2, *b*, palpi of female; fig. 8, do. of male) are simple in the female, but in the male the terminal joint is enlarged and modified greatly as an accessory genital organ. The cephalothorax is not jointed, and there are usually eight, rarely six, simple eyes (ocelli). In the genus Nops from Cuba there are, however, only two, while in certain cave-inhabiting species, according to Menge, such as the Anthrobia Mammothia of Tellkampf from Mammoth Cave, and other spiders inhabiting European caves, there are none.

We quote an interesting account of the habits of spiders, especially the mode of spinning their webs, published by Mr. J. H. Emerton in the "American Naturalist" (ii, p. 478), who has studied our native species with much care.

"The feet of spiders are wonderfully adapted for walking on the web. Each foot is furnished with three claws (Plate 11, Fig. 6, *a*, *b*, *b*), the middle one of which (*a*) is bent over at the end, forming a long finger for clinging to the web, or for guiding the thread in spinning. The outer claws (*e*, *e*) are curved and toothed like a comb. Opposite the claws are several stiff hairs (*c*) which are toothed like the claws, and serve as a thumb for the latter to shut against.

"When a spider wishes to build a web she usually selects a corner, so that the structure may be attached on several sides. She then runs a few threads along the objects to which the web is fastened, to facilitate her passage from point to point. The web is commenced by a line or two across the point where the centre is to be, which is not usually the geometric centre, but nearer the top than the bottom. Radiating lines (Plate 11, fig. 1, *b*, *b*, *b*) are then spun from the centre in all directions. In doing this the spider often crosses from one side of the web to the opposite, so that the finished portion is always tightly drawn, and the tension of the completed web is the same in every part."

"Having finished the framework, the spider begins near the centre and spins a thread (Fig. 1, *c*, *c*, *c*) spirally, around the web to the circumference, fastening it to each radius as it crosses. The distance between the spirals varies with the size of the spiders, being about as far as they can reach. This spiral thread serves to keep the parts of the web in place during the rest of the process, and is removed as fast as the web is finished. It also furnishes a ready means of crossing from one radius to another where they are farthest apart. All the thread spun up to this stage of the process is smooth when dry, and will not adhere if touched with a smooth object.

"The spider, having thus formed the web, begins to put in the final circles at the outside, walking around on the scaffolding previously prepared, which she gradually destroys as she proceeds, until in the finished web only a few turns in the centre are left. The thread of the circles last spun is covered with viscid globules, strung upon it like beads at short distances. If an insect comes in contact with the thread, it immediately adheres, and its struggles only bring a larger part of its body into contact with the web. Dust and seeds also stick to the web, so that in a single day it is often so clogged as to be of no farther use. The web also becomes torn by the struggles of the prey, and by wind and rain, so that it requires repair or renewal every night. In mending a web the spider usually removes all except the outside threads, biting them off and rolling them into a hard ball between her jaws, so that when released it will drop quickly to the ground. This probably gave rise to the opinion, sometimes advanced, that the old web is eaten by the spider.

"When the web is finished she stations herself in the centre, where a small circle is left free of the adhesive threads. Her usual position is head downward, with each foot on one of the radii of the web, and the spinners ready to fasten themselves by a thread at the least alarm. She often remains in her hole with one foot out, and resting on a tight thread connected with the centre of the web, so that any vibration is quickly detected. If the web be gently touched the spider will rush into the centre, and face towards the disturbed part. She will then jerk smartly several of the radii leading in that direction, to see if the intruder is a living animal. If this test is followed by the expected struggle she runs out towards the victim, stepping as little as possible on the adhesive threads, seizes it in her jaws, and as soon as it begins to feel the effects of the bite, envelops it in a silken covering, and hangs it up to suck at her leisure. In spinning this envelope the insect is held and turned around mainly by the short third pair of feet, while a flat band of threads is drawn from the spinners by the hind pair working alternately like the hands in pulling a rope, and wound over it in every direction, so that in a few seconds it is so covered as to be unable to move a limb. When a web is shaken by the wind the spider will sometimes draw in all her feet towards her

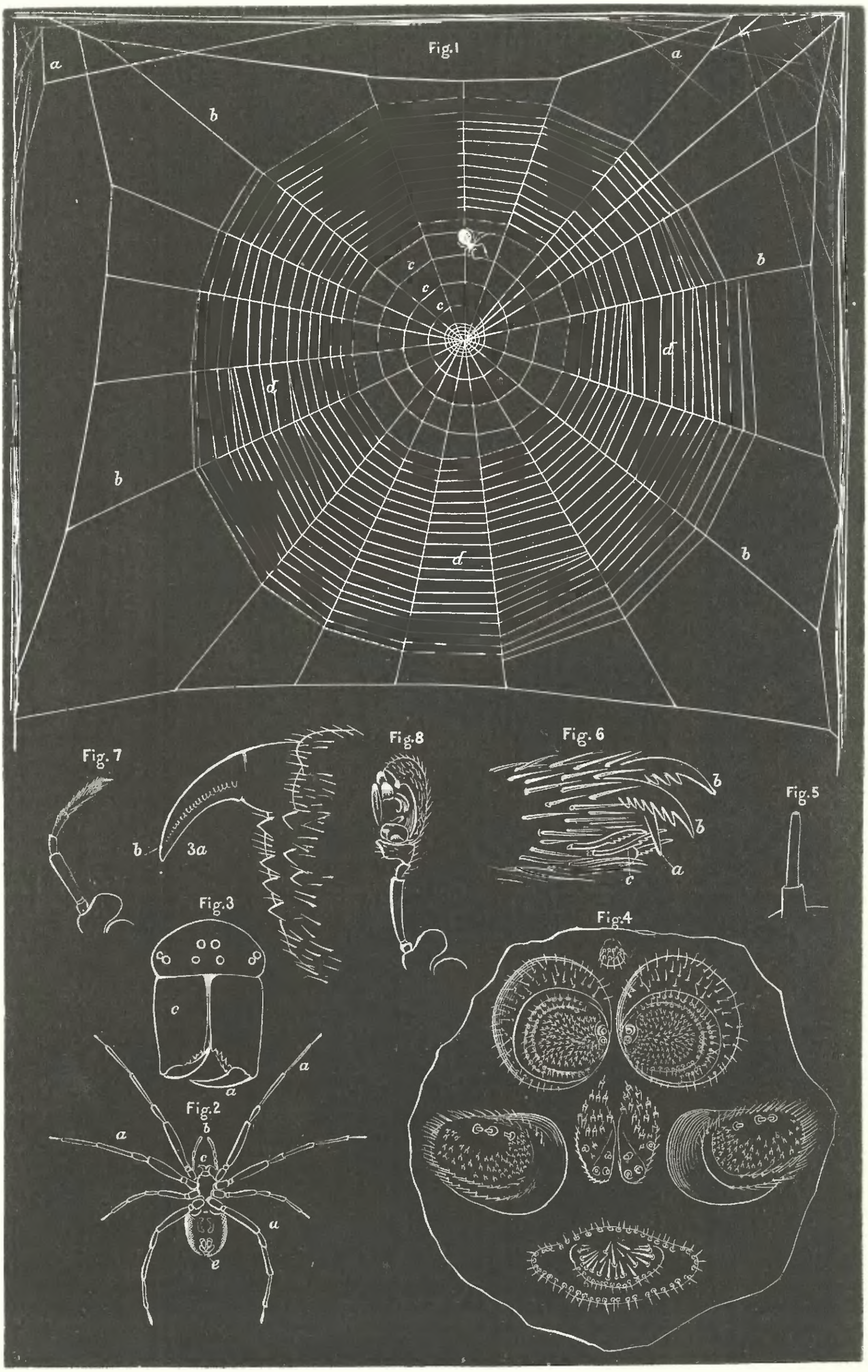

Fig.1
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Fig. 7
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Fig. 6
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Fig.5
Fig.3
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Fig.4
Fig.2
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body, thereby tightening the web in every direction so that the vibration is prevented.

"The construction of nets for catching food is not the only use of the thread made by these spiders. They seldom move from place to place without spinning a line after them as they go. They are able by its use to drop safely from any height, and when suspended by it are carried by the wind across wide spaces without any exertion on their part, except to let out the thread. The crevices in which they pass the winter and the leisure hours of summer, are partly lined and enclosed by a coating of silk resembling that used for confining captured insects. The eggs are enclosed in a cocoon of the same material, and there the young remain until they are strong enough to shift for themselves, growing to nearly double their size without apparent nourishment.

"Several hundred young are produced by a single female, but probably it is seldom that one-tenth of this number ever reach adult size. Nearly all the spiders which we see in webs are females or young. They spend most of their time in the vicinity of their webs, and many doubtless pass their lives within a few yards of the place of their birth. The adult males are seldom seen building or occupying webs: they remain concealed during the day, and at night wander about from web to web. When young there is no obvious difference between the sexes, but as the time for the last moult approaches, the ends of the palpi of the male swell to several times their former size. When the time for the final moult arrives, both sexes retire to their holes and cast off the skins of their entire bodies, even to the claws. This process obliges them to remain concealed until the new skin has acquired sufficient strength and firmness, when they again return to their webs. The females still resemble the young, except in size, but the males are distinguished from them by the greater length of their limbs, the diminished size of the posterior half of the body, and the large and complicated joints of the palpi (Plate 11, fig. 8)."

TETRAPNEUMONES Latreille. The large hairy species of *Mygale* differ from other spiders in having four lung-sacs and as many stigmata, and only two pairs of spinnerets, of which one pair is very small, while there are eight ocelli. The different species make cylindrical holes in the earth; that of *M. nidulans* of the West Indies is closed by a lid of earth covered beneath with silk. *Mygale avicularia* Linn., the Bird spider, seizes small birds and sucks their blood. *M. Hentzii* (Fig. 627, natural size) ranges from Missouri southward.

DIPNEUMONES Latreille. In the remaining genera of spiders there are two lung-sacs, two or four stigmata, and three pairs

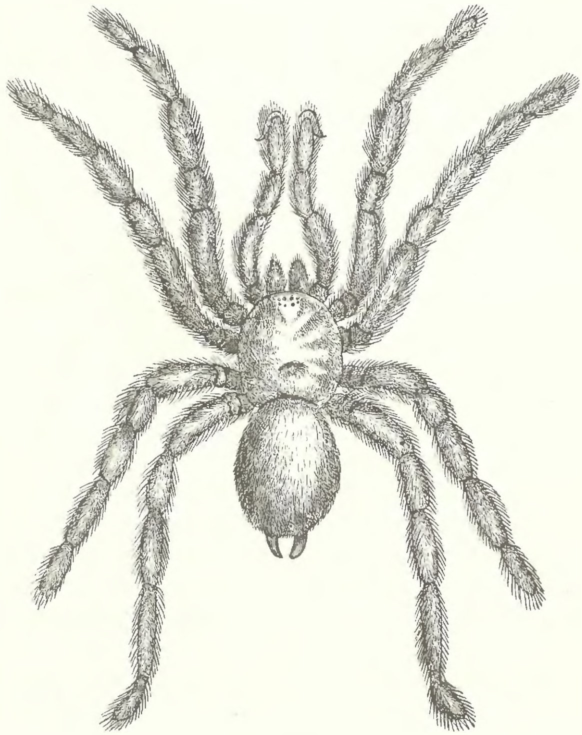


Fig. 627.

of spinnerets. They are divided into two groups, the "Sedentary" and "Wandering" spiders. The sedentary species have the ocelli usually arranged in two transverse rows; they spin webs in which they remain and seize their prey. In the genus *Dysdera* there are six ocelli, of which four lie in the front row; the cephalothorax is small, long, oval, and the first pair of legs are the longest. The species dwell in silken tubes, under stones or in crevices. *D. interrita* Hentz is a New England species. In *Drassus* there are eight ocelli, and the hindermost pair of feet are the longest.

Clubione includes those species which have eight ocelli, the four hinder ones, with the two outer ones on the front row, forming almost a semicircle; the fore legs are the longest. They construct under the bark of trees, under leaves or beneath stones, tubes of very white silk, from which they make nocturnal expeditions for food. *C. tranquilla* Hentz is common in the United States. *C. medicinalis* Walkenaer has been used as a vesicant. The Water spider of Europe, *Argyroneta aquatica* Linn., lives beneath the water, where it makes its nest and cocoon, which is filled with air.

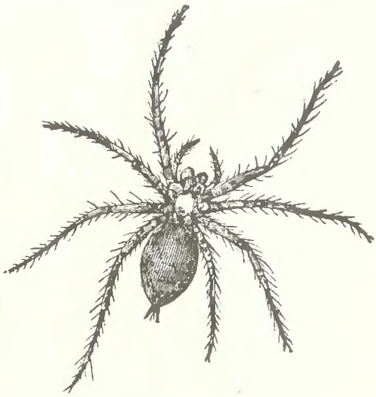


Fig. 628.

The genus *Tegenaria* has the ocelli arranged in two slightly curved rows, the third pair of feet are shorter than the others, and the abdomen is oval. The species are "sedentary, making in obscure corners a horizontal web, at the upper part of which is a tubular habitation, where the spider remains motionless till some insect be entangled in the threads." (Hentz.) *T. medicinalis* Hentz is "pale brown, turning to bluish black; cephalothorax with a blackish band on each side; abdomen varied with black, or plumbeous and brown; feet varied with blackish." It "is found in every cellar or dark place in the country. For some time the use of its web as a narcotic, in cases of fever, was recommended by many physicians." (Hentz.) Fig. 628 (enlarged) represents *T. atrica*, a European species.

Filistata is a closely allied genus. *F. hibernalis* Hentz "makes a tubular habitation of silk in crevices on old walls or rocks, throwing out an irregular web which is spread on the wall or stone around the aperture. . . . In walking it uses the palpi like feet, and these organs are very long, particularly in the male." According to Hentz it is found in South Carolina and Alabama.

The two genera Pholcus and Theridion belong to Latreille's group, "Inæquitelæ," comprising those forms in which the first pair of limbs are usually the longest. In *Pholcus* the legs are very long and slender. According to Hentz the species are "sedentary, making in dark corners a very loose web of slender threads, crossed in all directions. The eggs are collected together without a silk covering, which the mother carries with her cheliceres" (maxillary palpi). This genus "by the extreme length of its legs resembles Phalangium. The species belonging to it may be found in apartments seldom visited, particularly churches and caves. They shake their body when threatened by an enemy, but seem to have very weak means of offence, and to feed on the very smallest prey." *P. Atlanticus* Hentz inhabits the Southern States.

In *Theridion* the four inner ocelli are larger than the four outer ones, and the first and last pair of limbs are the longest. Hentz states that the species are sedentary, forming a web made of threads crossed in all directions, while the cocoons are of various shapes. A majority of the species are very small, and their webs made on the tops of weeds, in bushes, or in retired corners, are familiar to every one. *T. vulgare* Hentz varies "from a cream white to a livid brown, or plumbeous color. The cephalothorax is dull rufous, the abdomen with various undulating lines, and the feet have more or less distinct, dark or plumbeous rings." Hentz says that "there is probably no spider so abundant in the United States. It makes an irregular web in somewhat retired corners, and usually in dark situations, but occasionally also in the open air." It catches large insects and hangs them up to its nest. Hentz says of the *T. studiosum* which he has described, that "when its web is destroyed it does not abandon its cocoon, which is orbicular and whitish, and is placed in the central part of the web. The mother then grasps it with her cheliceres, and defends her progeny while life endures. She also takes care of her young, making a tent like that of social caterpillars for their shelter, and remaining near them till they can protect themselves." It occurs in South Carolina and Alabama. Hentz says of *T. verecundum* Hentz, a jet black species found in the Southern States, that "it is very common under stones, logs, or clods of earth, where it makes a web, the threads of which are so powerful as to arrest the largest Hymenopterous insects, such as humble bees. Its bite, if I can rely on the vague description of physicians unacquainted with entomology, is somewhat dangerous, producing alarming nervous disorders. Fig. 629 represents *Theridion riparium* (lower figure, male; upper, female, enlarged), of Europe.

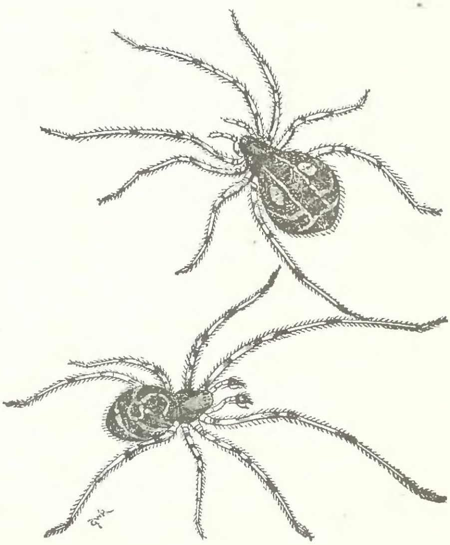


Fig. 629.

Epeïra is readily known by the large globular abdomen. The species are "sedentary, forming a web composed of spiral threads crossed by other threads departing from the centre; they often dwell in a tent constructed above the web; the cocoons are of various forms. *E. vulgaris* Hentz (Plate 11, fig. 12) is pale gray, with a pitchy black abdomen, with various winding white marks, and a middle one in the form of a cross. It spins a regular geometrical web, and is almost domesticated, being found about the outside of houses and in gardens. *E. domiciliorum* Hentz is a gray or brownish species, and is found in dark rooms.

The genus *Nephila* comprises large spiders, with long cylindrical abdomens. *N. plumipes* (Fig. 630, natural size) is found in the Southern States. Dr. B. G. Wilder has given an account of its habits, and considers its silk, if the spider could be reared in sufficient quantities, as of commercial value. The males (upper figure) are minute in size, compared with the females.

The genus *Thomisus* is characterized by the small size of the cheliceres, and the first and second pair of feet are either the longest, or the second alone are longest. The species "wander

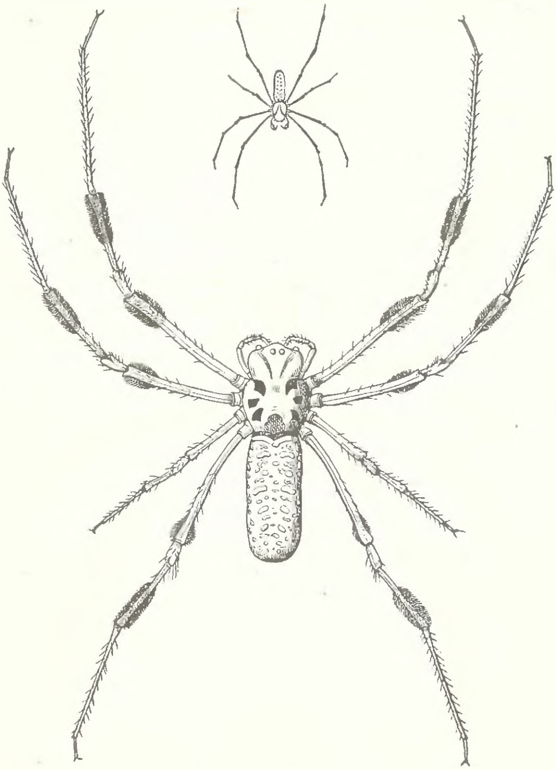


Fig. 630.

after their prey, making no web, but casting irregular threads, with a flattened cocoon, usually placed under leaves, and watched by the mother till the young are hatched." (Hentz.) *T. vulgaris* Hentz is "pale gray, with four impressed dots on the abdomen; the body is flat, and the legs are covered with indistinct darker rings. This spider, commonly seen on fencing or prostrate timber, like those of the same genus, moves sidewise and backwards, but it is much more active than *T. celer*. When pursued by an enemy, like Attus and Epeïra, it leaps and hangs by a thread, which supports it in the air." It is a widely diffused species. *T. celer* Hentz is also a widely distributed species, and is "found usually on blossoms, where it remains patiently waiting for Diptera, other small insects, and even butterflies, which it secures with amazing muscular power."

The three remaining genera belong to Latreille's group of "Wanderers," as they spin no web. The species of *Dolomedes*

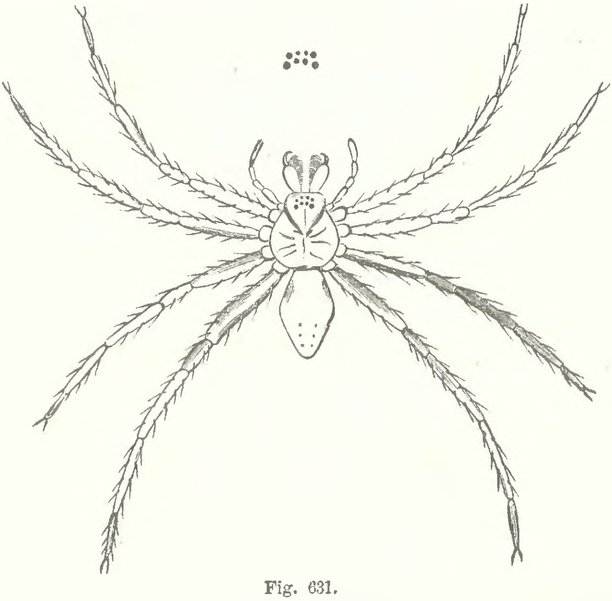


Fig. 631.

(Fig. 631, from Harris' Correspondence) wander after their prey, making no web, except while rearing their young, and hiding under stones, sometimes diving under water; the cocoon is usually orbicular, and is carried by the mother. *D. lanceolatus* Hentz "is always found near or on water, running on it with surprising agility, preying often on large aquatic insects. A female of Dolomedes was twice found on high bushes by my friend, T. W. Harris, in Milton, Mass., 'on a large, irregular loose, horizontal web, at one extremity of which was situated her follicle, or egg-bag, covered with young. The parent appeared watching them at some distance.' This spider can dive and stay a considerable time under water, to avoid its enemies. It was found in March, in Alabama, under stones near a stream of water." It ranges northwards to Massachusetts.

The Tarantula belongs to the genus *Lycosa*, which comprises large stout hairy spiders, with large cheliceres and moderately sized fangs, with the fourth pair of feet the longest and the third pair shortest. The species make no web, wandering for their prey, and hiding under stones. They frequently make holes in the ground in which they dwell, spinning at the orifice a ring of silk which forms a consolidated entrance like a trap door. The cocoon is usually orbicular, and is often carried about by the mother, while the young are borne about on the back of her abdomen. (Hentz.) *L. tarantula* Linn. is the celebrated Tarantula of Italy and Spain. Its bite is commonly supposed to produce the effects termed "tarantism," but Dr. Bergsöe has proved that tarantism is rarely due to the bite of the tarantula, which is comparatively harmless.

The *Lycosa fatifera* of Hentz is said by him to be bluish black, with the cephalothorax deeper in color at the sides; the cheliceres are covered with rufous hairs, and have a red elevation on their outer side near their base. It is one of the largest species of the genus. "This formidable species dwells in holes, ten or twelve inches in depth, in light soil, which it digs itself; for the cavity is always proportionate to the size of the spider. The orifice of the hole has a ring made chiefly of silk, which prevents the soil from falling in when it rains. This Lycosa, probably as large as the Tarantula of the south of Europe, is common in Massachusetts, but we have not heard of serious accidents produced by its bite. Its poison, however, must be of the same nature and as virulent." (Hentz.)

In the leaping spiders, *Salticus*, the cephalothorax is usually large, square, and the abdomen is oval cylindrical. Hentz says that they wander after their prey, making no web, but concealing themselves in a silken valve, for the purpose of casting their skin, or for hibernation. The *Salticus* (Attus) *familiaris* of Hentz is a common species throughout the United States. It is pale gray, hairy, and the abdomen is blackish, with a grayish angular band edged with whitish. Hentz says that it is almost domesticated in our houses, and dwells in cracks around sashes, between clapboards, etc., and may be seen on the sunny side of the house, and in the hottest places, wandering in search of prey. It moves with agility and ease, but usually with a certain leaping gait. . . . Before leaping this Attus always fixes a thread on the point from which it departs; by this it is suspended in the air, if it miss its aim, and it is secure against falling far from its hunting grounds. These spiders, and probably all other species, a day or two before they change their skin, make a tube of white silk, open at both ends; there they remain motionless till the moulting time arrives, and even some days after are seen there still, probably remaining in a secure place, for the purpose of regaining strength and activity."

PEDIPALPI.

Under the term Pedipalpi we would embrace besides the Pedipalps of Latreille, the Solpugids and Phalangids. They all agree in having the maxillary palpi greatly enlarged and usually ending in a forceps, and the abdomen distinctly jointed, with the end, sometimes, as in the scorpions, prolonged into a tail. In the retention of the tail in some of the forms the abnormally enlarged maxillæ, the jointed cephalothorax and abdomen, which in the scorpions reminds us of the Myriapods, we have characters which place the Pedipalps below the true spiders.

Solpugidæ Gervais. In this group, the species of which are large, hairy, spider-like animals, the cephalothorax is clearly jointed, and the abdomen is elongated; respiration is carried on by tracheæ. *Solpuga* may at once be known by the enormous, though not very long, maxillary palpi. *S. araneoides* Pallas inhabits Southern Russia. *S.* (Galeodes) *Americana* Say inhabits the Southern States.

Phalangidæ Gervais. In the group of Harvest-men the cephalothorax is not jointed; the abdomen is short and thick, and the maxillary palpi end in a simple claw; the mandibles are well developed and end in a forceps. The legs are extremely long. They breathe through tracheæ. They occur about houses, especially in shady places and in woods and

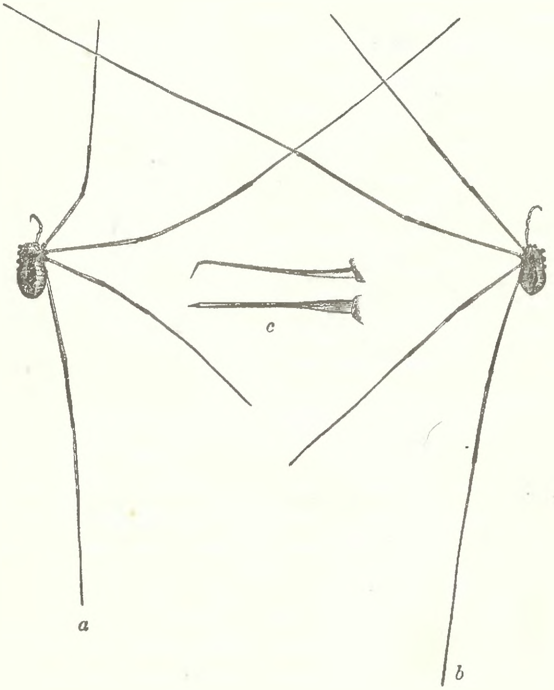


Fig. 632.

fields. "They are carnivorous, feeding on small insects, and are said to be especially addicted to Aphis-eating." (Wood.)

The genus *Phalangium* has no spines on the palpi, and has two simple eyes. The species have been well described by Dr. H. C. Wood, jr. (Proceedings of the Essex Institute, vol. vi), some of whose illustrations appear here, so that the species here mentioned can be easily identified. *P. dorsatum* Say

(Fig. 632, *a*, female, natural size; *b*, male, natural size; *c*, penis, anterior and lateral view, enlarged) has been found from northern New York to Washington. When handled it emits a drop of an odorous clear fluid. We have found it frequently in Salem.

P. ventricosum Wood (Fig. 633, *a*, trochanter; *b*, femora; *c*, mandibles; *d*, maxillary palpus, male? natural size) is widely distributed in the United States. *Acanthocheir* is an eyeless genus with spiny palpi. *A. armata* Tellkampf is found in Mammoth Cave. In *Gonyleptes* the cephalothorax is much enlarged, and overhangs the abdomen. *G, ornatum* Say (Fig. 634, male, *a*, under surface; *b*, upper surface, natural size; *c*, penis) is found in the Southern States; the species are quite numerous in South America.

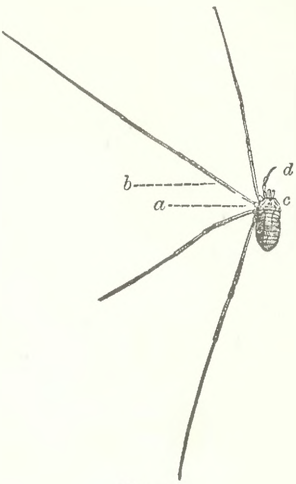


Fig. 633.

Under the name of *Archetarbus rotundatus* (Fig. 635) Mr. Scudder describes a fossil Pedipalp, which seems to be "allied to the *Phalangidæ* and to the *Phrynidæ*. In its fragmentary state one can scarcely judge with certainty of its exact relationship. The arrangement of the legs accords well with both families. The broad attachment of the thorax to the abdomen is a Phalangidan characteristic, while the size and shape of the abdomen, the number of the abdominal segments and the crowded state of the central portions of the basal ones, indicate closer affinities to the *Phrynidæ*.

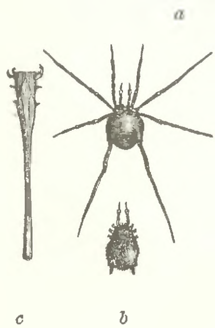


Fig. 634.

PHRYNIDÆ Sundeval. Whip-scorpions. In this group the anterior pair of legs are very long and slender, being much smaller than the others, while the maxillary palpi are very large; there are eight simple eyes, and the abdomen is eleven

Fig. 635.

to twelve-jointed, while there are two pairs of stigmata, and they also breathe by lungs. *Phrynus* is at once known by the excessively long, whip-like, multiarticulate fore legs, which apparently perform the office of antennæ; the body is short and broad, and has no appendage to the abdomen. *P. reniformis* Fabr. is fourteen lines long, and is found in Brazil. *P. asperatipes* Wood occurs in Lower California. No species occur in the United States. The genus *Thelyphonus* is known by the oblong body, ending usually in a slender many-jointed filament. *T. caudatus* Fabr. is fifteen lines long, and inhabits Java. *T. giganteus* Lucas occurs in the South-western States and in Mexico.

CHERNETIDÆ Menge. (Pseudo-scorpiones Latreille.) The False-scorpions are at once known by their large maxillary palpi like the scorpion's claw. The abdomen is eleven-jointed,

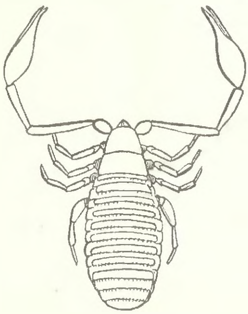


Fig. 636.

flattened, without any appendage, and the living forms are minute; they breathe by tracheæ. They are found running about dusty books and in dark places and feed on mites and Psoci. They are often found attached to the leg of some fly or other insect by which they are transported about. "The female chelifer bears the eggs, seventeen in number, in a little bunch under her abdomen near the opening of her sexual organs. Menge has observed the Pseudo-scorpions cast their skin in a light web made for that purpose. The little animal remained five days in the web after its metamorphosis, and did not assume its dark colors for four weeks. Three months after it returned to the same web for hibernation. Menge describes eight species from the Prussian Amber, belonging to genera still living, and Corda one (Microlabris

Sternbergi) from the coal formation in Bohemia, one inch long. Schiödte has found a curious blind species in the caves of Adelsburg, and it is very probable that a closer examination of the Kentucky caves will give a similar American species." (Hagen.) In *Chernes* there are no eyes. *C. Sanborni* Hagen is found in Massachusetts.

In *Chelifer* there are two eyes. *C. cancroides* Linn. (Fig. 636, enlarged) is dark brown, with many short spines on the thorax. It occurs in Massachusetts and Illinois.

SCORPIONIDÆ Latreille. The Scorpions are well known by the immense forceps-like maxillæ, and the long tail continuous with the thorax, and ending in a powerful sting, in which is lodged a poison sac. The body is more distinctly divided into segments than any other Arachnids, and hence the scorpions bear, as Gerstaecker suggests, a strong analogy to the Myriapods. The genus *Scorpio* is restricted to those species which have six ocelli. *S. Allenii* Wood is our only North American species and is found in Lower California. Our other species are mostly comprised in the genus *Buthus*, which has eight ocelli. *B. Carolinianus* Beauvois (Fig. 637) ranges from the Southern Atlantic States through Texas northward into Southern Kansas. "Scorpions are dangerous in proportion to their size, their age, the state of irritation they may be in, and the temperature of the climate in which they reside. The wounds, however, even of the largest species are rarely fatal." (Moquin Tandon.)

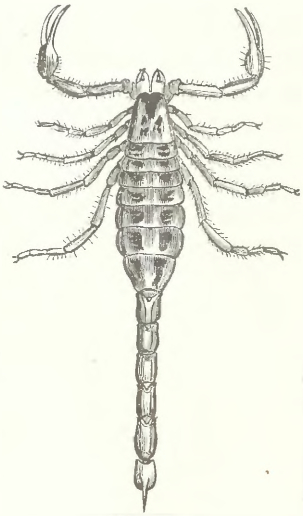


Fig. 637.

Messrs. Meek and Worthen have described (Palæontology of the Illinois Geological Survey, iii, p. 560) two fossil scorpions from the lower part of the coal measures of Illinois, which are as highly developed, and bear a very close resemblance to the living species. The *Eoscorpion carbonarius* of Meek and Worthen is said by them to closely resemble *Buthus hirsutus* from California. The other fossil scorpion is the *Mazonia Woodiana* M. and W., which differs from any known living forms in not having any lateral eyes. Very different and belonging to a much more degraded and embryonic type is the *Cyclophthalmus Bucklandi* from the Coal Measures of Bohemia, in which the tail is continuous with the body, being unusually thick.

ACARINA.

The Mites differ from other Arachnids by their oval or rounded bodies, which are not articulated, the cephalothorax being merged with the abdomen; the mouth-parts are adapted either for biting or sucking, and they breathe by tracheæ. They are usually minute in size; the ticks, which are sometimes half an inch in length, comprising the largest forms. They appear first in geological history in the Prussian Amber, where species of Trombidium and Hydracha occur.

Bdellidæ Dugès. This inconsiderable family is represented by small mites with long, five-jointed maxillary palpi, and from two to six ocelli, which are sometimes wanting. The limbs are long and thick. The young closely resemble the adults. The genus *Bdella* has legs of nearly equal length. *B. longicornis* Linn., an European species, is scarlet red, with four ocelli, and is half a line in length.

Trombididæ Leach. The species of this family are red mites, with either claw-like or style-like maxillary palpi, and short mandibles. with the terminal joints scissor-like and opposed to each other. The genus *Tetranychus* has slender style-like maxillæ, and two ocelli. The two fore pair of legs arise at a long distance from the hind ones, the first pair being the longest. *T. telarius* Linn. the little red mites of our hothouses spin webs on rose leaves. It is yellowish, with two reddish yellow spots on the sides, and is one-half a line long.

It may be killed by showering sulphur over the leaves. In Europe it is found on the linden tree. The young of this species, according to Claparède, passes through an Ixodes-like stage, as regards the mouth-parts, for this reason we place the *Ixodidæ* below them.

HYDRACHNIDÆ Sundeval. The Water-mites are known by having the maxillary palpi short, with five terminal hooks, or bristles, at the end. The legs gradually increase in length, the hindermost pair being longest; they are ciliated, with two claws. There are two ocelli. These mites swim in fresh and sometimes salt water, and are seen running over water-plants. The young differ so much from the adults that they were described by Audouin under the name of Achlysia. In *Hydrachna* the mandibles are needle-shaped, and the third joint of the maxillæ is the longest. The body is oval, with the limbs adapted for swimming, and there are two eyes. *Hydrachna concharum* is parasitic throughout life on the gills of fresh water mussels. Others are parasitic during early life on fresh water Hemiptera and Coleoptera.

In *Atax* the body is oval, solid and corneous. The mandibles end in a stout curved claw, and the five-jointed maxillary palpi end in an acute point. The species are red in color and live in flowing streams; when in their early, and in some cases their adult stages, they are parasitic in the gills of mussels.

IXODIDÆ Leach. The Ticks are mites of gigantic size, with bodies of a leathery consistence. The three to four-jointed maxillæ are small, not reaching beyond the beak. The mandibles are saw-like, being covered towards the end with teeth, with from two to four terminal hooks, and, with the large spatulate, dentate "glossoide" of the maxillæ, form a beak which the tick pushes into the skin of its host. The ocelli are often wanting, and the legs are slender, with two claws, and in the young a distinct membranous foot-pad. The recently hatched young (Fig. 638, *a*, glossoide; *b*, mandibles; *c*, maxillary palpi; *e*, adult gorged with blood) is six-footed, the legs being very long, and the head and mouth-parts are much larger in proportion to the rest of the body than in the adult, while the tripartite division of the body is very distinct, the thorax being distinct from the head and abdomen.

The genus Argas closely resembles Ixodes. Gerstaecker states that the *Argas Persicus* Fisher is very annoying to travellers in Persia. Travellers in the tropics speak of the intolerable torment occasioned by wood ticks, *Ixodes*, which, occurring ordinarily on shrubs and trees, attach themselves to all sorts of reptiles, beasts and cattle, and even man himself as he passes by within their reach. Sometimes cases fall within the practice of the physician who is called to remove the tick, which is found sometimes literally buried under the skin. Mr. J. Stauffer writes me, that "on June 23d the daughter of Abraham Jackson (colored), playing among the leaves in a wood, near Springville, Lancaster County, Penn., on her return home complained of pain in the arm. No attention was paid to it till the next day, when a raised tumor was noticed, a small portion protruding through the skin, apparently like a splinter of wood. The child was taken to a physician who applied the forceps, and after considerable pain to the child, and labor to himself, extracted a species of Ixodes, nearly one-quarter of an inch long, of an oval form, and brown mahogany color, with a metallic spot, like silver bronze, centrally situated on the dorsal region." This tick proved, from Mr. Stauffer's figures, to be without doubt, *Ixodes unipunctata* Pack. (Plate 10, fig. 11, enlarged). It has also been found in Massachusetts by Mr. F. G. Sanborn. The *Ixodes albipictus* Pack. (Fig. 638, adult gorged with blood, and the six-footed young, with the mouth-parts of the young enlarged, and *d*, a foot showing the claws and sucking disc), was discovered by Mr. W. J. Hays in great numbers on a moose which had been partially domesticated. The females lay their eggs from the first of May until the 25th of June, the "eggs being forced out

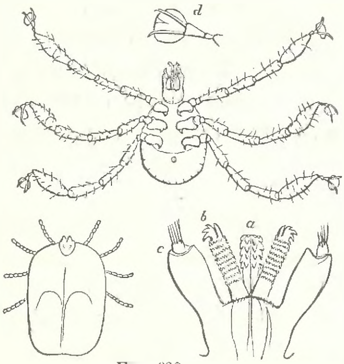


Fig. 638.

in large masses." "On the 3d of July the entire mass of eggs seemed to hatch out at once, the shell opening like a clam and releasing a six-legged insect." (Hays.) The opening of the oviduct is just behind the head, between the anterior pair of feet, so that the eggs appear as if ejected from the mouth.

Another species is the *Ixodes bovis* (Plate 10, fig. 10), the common cattle tick of the Western States and Central America, which is allied to the European *I. ricinus.* It is very annoying to horned cattle, gorging itself with their blood, though by no means confined to them alone, as it lives indifferently upon the rattlesnake, the iguana, small mammals, and undoubtedly any sort of animal that brushes by its lurking-place in the forest. It is a reddish, coriaceous, flattened, seed-like creature, with the body oblong oval, and contracted just behind the middle. When fully grown it measures from a quarter to half an inch in length. We have received it from Missouri, at the hands of Mr. Riley; and Mr. J. A. McNiel has found it very abundantly on horned cattle, on the western coast of Nicaragua.

Gamasidæ Leach. These mites have scissor-like mandibles, free maxillæ, with joints of equal length, and hairy legs of similar size and form, while the ocelli are obsolete. They live parasitically on the bodies of other animals. The genus *Gamasus* has long mandibles, with curved, five-jointed, acutely pointed maxillary palpi; the body is oval, flattened, the skin dense, and the first and last pair of legs are somewhat longer than the middle ones. *G. coleoptratorum* Linn. is clear, reddish yellow, and about a third of a line long. It occurs in Europe on beetles, especially species of Geotrupes and Necrophorus. The same, or a closely allied species, is found in this country. *Uropoda vegetans* DeGeer, a similar form, also lives on beetles. The genus *Dermanyssus* has shorter jointed maxillary palpi than in Gamasus. *D. avium* Dugès lives on birds, and *D. pipistrellæ* Gervais on bats. In *Pteroptus* the terminal joint of the maxillæ is very long. *Pt. vespertilionis* Dufour is a parasite of the bat.

Oribatidæ Nicolet. In these mites the body is very hard and horny. The four-jointed maxillary palpi are short, with the first joint very large, forming a toothed eating surface. The ocelli are nearly obsolete, and the legs have from one to three claws. The cephalothorax has generally two wing-like

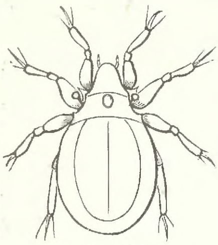


Fig. 639.

projections, and two or three cup-shaped pedicellated stigmata on the edge. They generally live on vegetable matter. In *Oribates* the side of the cephalothorax is produced often into wing-like processes, with the abdomen orbicular, flattened, sometimes emarginate. The European *O. alatus* Hermann is smooth, blackish brown, and lives under moss. In *Nothrus* the body is elongated, somewhat quadrangular, and has no lateral expansions, while the legs are stout, with tripartite claws. We have observed an undescribed species of this genus sucking the eggs of the canker-worm in Salem. It may be called *Nothrus ovivorus* (Fig. 639). It is reddish brown, with a dense hard body, with the edge of the abdomen expanded evenly, and with three slender capitate processes on the cephalothorax.

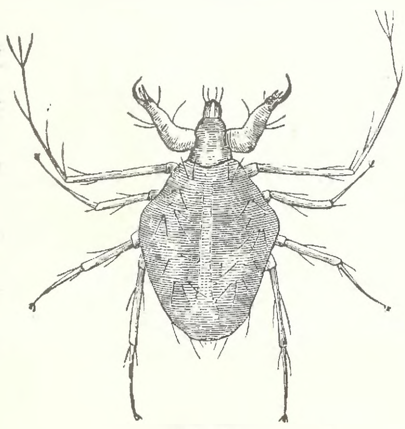


Fig. 640.

Acaridæ. This family comprises the true mites, which have soft, thin-skinned bodies, with either scissor or style-like mandibles, the latter forming a retractile horny tube. The maxillæ are obsolete, as well as the ocelli. The claws are sometimes provided with a sucker. The members of this, and the following groups, are among the most lowly organized of articulates, and are found living parasitically on the skin of other animals, or buried within their integuments, while certain acari have been detected within the lungs and air passages, the bloodvessels and the intestinal canals of vertebrate animals. The genus *Cheyletus* is remarkable for having the maxillæ very large, and like a pair of legs, with the ends tripartite, the outer division being curved and clawlike, while the two innermost are slender lobes pectinated on the inner side; the mandibles are style-like. A European species (Fig. 640) feeds on Cheese-mites. It is thought by Mr. R. Beck that another species of Cheyletus is parthenogenous, as "he obtained several generations from the first individual, without the intervention of a male." (Science-Gossip, 1869, p. 7.) Mr. J. H. Gregory, of Marblehead, Mass., has found a species of this genus, which we may call *Cheyletus seminivorus* (Plate 10, fig. 6). It injured the seeds of the cabbage stored up during the winter by sucking them dry. The genus *Tyroglyphus* is known by the body being elongated oval, with scissor-like mandibles, and outstretched four-jointed feet, with a long stalked sucking disc at the end. *T. domesticus* DeGeer is in Europe common in houses.

Many people have been startled by statements in newspapers and more authoritative sources, as to the immense numbers of sugar mites, *T. sacchari* (Fig. 641), found in unrefined or raw sugar. According to Professor Cameron, of Dublin, as quoted in the "Journal of the Franklin Institute," for November, 1868, "Dr. Hassel (who was the first to notice their general occurrence in the raw sugar sold in London) found them in a living state in no fewer than sixty-nine out of seventy-two samples. He did not detect them in a single specimen of refined sugar. In an inferior sample of raw sugar, examined in Dublin by Mr. Cameron, he reports finding five hundred mites in ten grains of sugar, so that in a pound's weight occurred one hundred thousand. They appear as white specks in the sugar. The disease known as grocer's itch is, undoubtedly, due to the presence of this mite, which, like its ally the Sarcoptes, works its way under the skin of the hand, in this case, however, of cleanly persons.

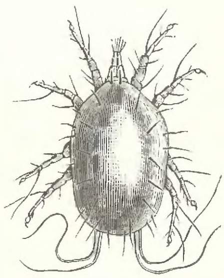


Fig. 641.

Closely allied to the preceding is the Cheese-mite, *T. siro* Linn., which often abounds in newly made cheese. Lyonnet states that during summer this mite is viviparous. *T. farinæ* DeGeer, as its name indicates, is found in flour. Other species have been known to occur in ulcers.

We figure the larva of the European *Typhlodromus pyri* (Plate 10, fig. 4) the adult of which, according to A. Scheuten, is allied to Tyroglyphus, and lives under the epidermis of the leaves of the pear. There are but two pairs of legs present, and the body is long, cylindrical and worm-like. Fig. 5, plate 10, represents the four-legged larva of another species of Typhlodromus.

The Itch mite belongs to the genus *Sarcoptes*, in which the body is rounded ovate, with needle-like mandibles, and with short three-jointed legs. The female differs from the male in having the two hinder pairs of legs only partially developed, and ending in a long bristle. *S. scabiei* Linn. (Plate 10, fig. 7, female) was first recognized by an Arabian author of the twelfth century as the cause of the disease which results from its attacks. It buries itself in the skin on the more protected parts of the body, forming minute galleries, by which its presence is detected, and by its punctures maintains a constant irritation.

Other species are known to infest the cat, dog and swine. They are best destroyed by the faithful use of sulphur ointment. Various species of an allied genus, *Dermatodectes*, live in galleries on different species of domestic animals; thus *D. equi* lives in the skin of the horse, *D. bovis* in cattle, and *D. ovis* in sheep. Various Sarcoptids occur on birds; among them are species of *Dermaleichus*. On March 6th, Mr. C. Cooke called my attention to certain female mites (Plate 10, fig. 1) which were situated on the narrow groove between the main stem of the barb and the outer edge of the barbules of the feathers of the Downy Woodpecker, and subsequently we found the other forms indicated in Plate 10, figs. 2 and 3, in the down under the feathers. These long worm-like mites are probably the females of the singular male Sarcoptes-like mite, represented by Figs. 2 and 3 of the plate, as they were found on the same specimen of woodpecker at about the same date.

The female (though there is probably a still earlier hexapodous stage) of this Sarcoptid, which we may call *Dermaleichus* *pici-pubescentis*, has an elongated, oblong, flattened body, with four short legs, provided with a few bristle-like hairs, and ending in a stalked sucker, by aid of which the mite is enabled to walk over smooth, hard surfaces. The body is square at the end, with a slight median indentation, and four long bristles of equal length. They remained motionless in the groove on the barb of the feather, and when removed seemed very inert and sluggish. The male (Plate 10, fig. 3) is a most singular form, its body being rudely ovate, with the head sunken between the fore legs, which are considerably smaller than the second pair, while the third pair are twice as large as the second pair, and directed backwards, and the fourth pair are very small, not reaching the extremity of the body, which is deeply cleft, and supports four long bristles on each side of the cleft, while other bristles are attached to the legs and body, giving the creature a haggard, unkempt appearance. The genital armature is situated between the largest or third pair of legs. A preceding stage of this mite, which may be called the pupa, is represented on Plate 10, fig. 2. It (all the figures of this sarcoptid being drawn to one scale by Prof. A. M. Edwards, and magnified one hundred and fifteen diameters) looks somewhat like the adult, the body being shorter and broader, but without any genital armature.

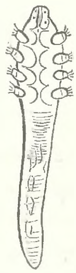


Fig. 642.

We figure on Plate 10, figs. 8 and 9, greatly enlarged, a most remarkable mite, discovered by Newport on the body of a larva of a wild bee, and described by him under the name of *Heteropus ventricosus*. Fig. 8, in the plate, represents the body of the fully formed female. In this stage it reminds us of Demodex and the Tardigrades. After attaining this form its small abdomen begins to enlarge until it assumes a globular form (Plate 10, fig. 9) and the mass of mites look like little beads. Mr. Newport was unable to discover the male, and thought that this mite was parthenogenous. Another singular mite is the *Demodex folliculorum* (Fig. 642), which was discovered by Dr. Simon, of Berlin, buried in the diseased follicles of the wings of the nose in man. It is a long, slender, worm-like form, with eight short legs, and in the larval state has six legs. This singular form is among the lowest and most degraded of the order of Arachnids. It will be seen that the adult Demodex retains the elongated, worm-like appearance of the larvæ of the higher mites, such as Typhlodromus. This is an indication of its low rank, and hints of a close relationship to the Tardigrades.

Tardigrada Doyère. (Arctisca). The Tardigrades, or Bear animalcules, referred by some to the worms, were considered as mites by O. F. Müller in 1785, and a species was described by him under the name of Acarus ursellus. They have also been referred to the Rotatoria by Dujardin, and were, by Schultze, considered as parasitic Entomostraca allied to Lernæa. With Müller we would consider them as insects belonging to the Acarina, and venture, after studying Claparède's admirable work, "Studien an Acariden," containing an account of the genus Myobia, to consider the Tardigrades as a family of mites. In form, as indicated by the accompanying figures, copied from Doyère's valuable memoir, they are essentially mites, and allied in form to Demodex and Heteropus, though in their internal organization differing from all other insects in being true hermaphrodites. Müller observed that they moulted their skins. The mouth is adapted for sucking, with style-like mandibles like those of Myobia. There are two ocelli, and the worm-like body is cylindrical, consisting of four thoracic segments behind the head, bearing four pairs of short, thick legs, ending in three or four claws (in these characters reminding us of the Peripatus, a worm with a large, fleshy

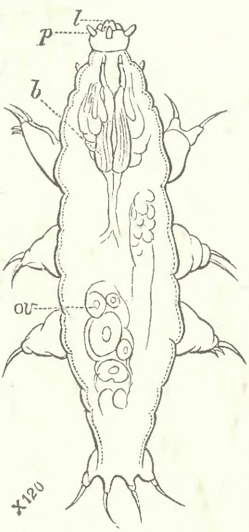
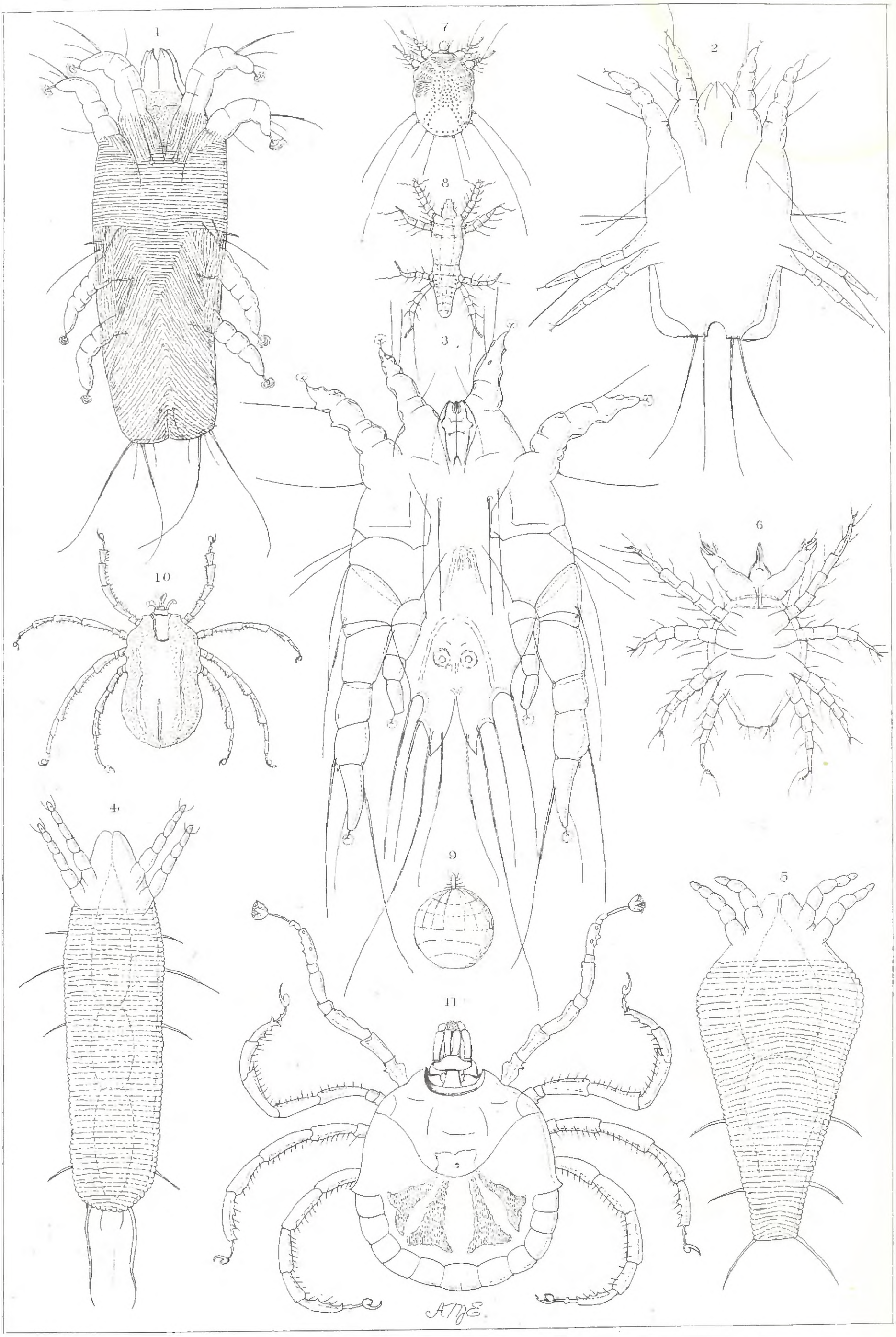


Fig. 613.

Explanation of Plate 10.—Fig. 1, *Dermaleichus pici-pubescentis* Pack., female. Fig. 2, young male. Fig. 3, adult male. Fig. 4, larva of *Typhlodromus pyri* Scheuten (after Scheuten). Fig. 5, larva of another species of *Typhlodromus* (after Scheuten). Fig. 6, *Cheyletus seminivorus* Pack. Fig. 7, *Sarcoptes scabiei* DeGeer (after Gervais). Fig. 8, *Heteropus ventricosus* Newport, fully formed female. Fig. 9, gravid female of the same (after Newport). Fig. 10, *Ixodes bovis* Riley. Fig. 11, *Ixodes unipunctata* Pack. All the figures are enlarged.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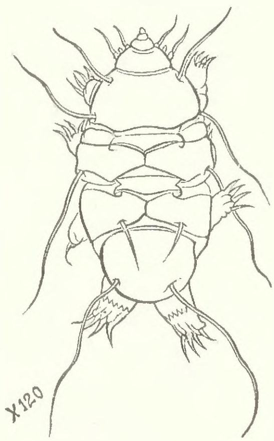
leg-like process attached to the sides of each ring of the body and ending in a pair of claws). In size they are microscopic and live in standing water among plants, and like the Rotatoria revive after being apparently dead and dried up. They were called Tardigrades from their excessively slow motions. The eggs are very large and are laid by the parent after the last moult; the young is born with its full complement of legs, and moults several times before arriving at maturity. The eggs of some genera are smooth, while those of *Macrobiotus* are spherical and covered with little knob-like projections.

Milnesium tardigradum Schrank (Fig. 643, *l*, mouth-parts; *b*, alimentary canal; *ov*, ovary) is a fifth of a line long; while *Emydium testudo* Doyère (Fig. 644, magnified one hundred and twenty times) is another European species. None have yet been noticed as occurring in this country.

Fig. 644.



Emydium testudo.

ORDER III. MYRIAPODA.

The Myriapods are readily known by their long, cylindrical or somewhat flattened bodies, which are composed of from ten (counting the head as one) to over two hundred rings. The head is free from the rest of the body, and is much like that of insects, while the thoracic rings are scarcely distinguishable, either in form or the character of their appendages, from the numerous abdominal rings, so that the head, instead of being soldered to the thorax as in the spiders, is here free, while the thorax is merged in the abdomen.

The head of Cermatia shows how closely the highest Myriapod agrees with the insects. The few (sixteen) segments composing the body (counting the head as one); the large compound eyes, the long filiform antennæ, and well developed palpi, farther show the close relationship of this form to the insects. The habits of this genus also remind us of the spiders, as they are predaceous and are said to leap after their prey.

In the Myriapods generally the mouth-parts are of the same number, and follow each other in the same order as in the insects. Thus in advance of the mouth there are first the ocelli, and immediately behind them the antennæ; behind the mouth are the mandibles, the maxillæ with their palpi, and the labial palpi. As each of these organs is represented by an elemental ring we have at least five segments in the head.

In the embryo of Julus the rudiments of the first pair of legs are soon aborted, and thus the first thoracic ring bears no legs in adult life. The legs are composed of a coxa, a femur, a tibia and a tarsus, as in the higher insects.

As shown by Newport the nervous, digestive, respiratory and reproductive systems very closely resemble those of the larvæ of insects, as does the external form of these animals.

Newport states that the nervous system of Myriapods approaches nearer, in the simplicity of its formation, to that of the Annelids than that of the larvæ of insects. "In the Chilopoda it has the form of a double cord connected by large ganglia in each segment, as in most of the Annelida, Crustacea and Insecta; but in the vermiform Chilognatha, which former researches have proved to me are most nearly connected to the Annelida, the two parts of this double cord, are so closely united laterally as to appear like a single cord that gives off a multitude of small nervous trunks at its sides throughout its whole length, but without distinct ganglionic enlargements at their origin." The brain is "composed of at least four pairs of ganglia."

The digestive system comprises the long, tubular salivary glands, of which two are found on each side of the œsophagus and stomach, opening by a long excretory duct into the mouth; and Professor Leidy has described two others which are placed on each side of the œsophagus, and are pyriform, conglomerate, and cellular in structure. Also the long intestinal canal which is much as described in the higher insects; while, as in Julus, according to Leidy, "at the termination of the proventriculus, there open two biliary tubes, and from it, surrounding the commencement of the ventriculus, is suspended a broad, white, opaque, reticulated band, apparently composed like the *reta adiposa* of insects."

The circulatory system is of a much lower type than in insects, and in Julus it approaches, according to Newport, by its rudimentary development that of the worms. The vascular system consists of a dorsal vessel, or heart, with very numerous separate chambers, almost equal to the segments of the body, which connects with another system of vessels lying on the under side of the body between the alimentary canal and the nervous cord. This plexus of vessels thus forms "a vascular collar around the anterior part of the alimentary canal." "At each constriction of the heart in the *Julidæ*, between two chambers, there are two transverse lateral orifices, as in Insects," which Newport supposes to be either the terminations of delicate veins, or simple apertures admitting the blood from the venous sinuses in the body.

The tracheary system is much as in the six-footed insects, and the stigmata have the same relative position, but are placed on the alternate segments of the body.

In the Chilopoda the sexual system is much as in the six-footed insects, and the orifices are placed at the end of the body. The ovary is a long single tube, which opens in the last ring of the body; while in the lower suborder, Chilognatha, there is only a single long ovarian tube, provided with two short oviducts which open on the *third segment* of the body from the head. The male organs in the Chilopods are much more complicated than in the other Myriapods, and the two or three, or even the single testicular tube, open on the end of the body, while in the Chilognaths, such as Julus, there are two testes which lead out by a *vas deferens* to the orifice situated on the third thoracic ring. The order is divided into two suborders, *i. e.*, the Chilopoda and Chilognatha of Latreille.

CHILOPODA.

This group is characterized by each ring being simple and not divided into subsegments, and bearing but a single pair of feet, while the head is divided into two regions, one placed before the mouth, the other behind the mouth. The sexual outlet is situated at the end of the body.

This suborder is the highest, as it contains those Myriapods which have the fewest segments to the body, thus approaching the six-footed insects and spiders. They are active, rapacious in their habits, and by the division of the head into the two regions, movable on each other, they can almost emulate the insects in their powers of seizing their prey. As stated by Professor Wood*, their highly organized muscular and nervous system, the compactness of their intestinal apparatus, and the length and power of their legs, all betoken habits of great activity; whilst the formidable nature of their mandibles, and the sharp spines, both lateral and terminal, with which their feet are armed, fit them for predatory warfare. Thus it will be seen that the Chilopods are the more animal, while the Chilognaths are the more vegetative; this is due to the greater concentration of the body headwards, and the more compact build of the body behind the head.

* The Myriapoda of North America, by Prof. H. C. Wood Jr., M. D., Philadelphia, 1865.

It is probable that the Centipedes and their allies appeared at a much later period in the earth's history than the Chilognaths, as the earliest form of the present suborder known to us is the Geophilus proavus of Muenster, from the Jurassic rocks, whilst the oldest Myriapod, one of the *Julidæ*, is, according to Dawson, found in the lower Carboniferous rocks of Nova Scotia, and Dr. Anton Dohrn has recently described a Julus from the coal formation of Germany.

Cermatidæ Leach. This group is characterized by having only sixteen rings to the body, while the legs and antennæ have more numerous joints than usual. The head is large, very free from the body, with compound eyes, as in the six-footed insects, and long spiny palpi, while the tergites, or scuta, are but eight in number, and there are nine pairs of spiracles. The female ovipositer is forceps-like, while the corresponding male appendages are style-like. The species are the most gaily colored of the order, being striped along the body and banded on the legs. *Cermatia forceps* Rafinesque is greenish-brown, with three longitudinal stripes of deep green.

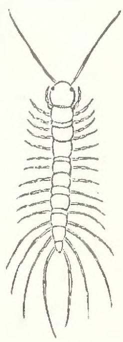


Fig. 645.

Lithobiidæ Newport. In this and the remaining families of this suborder the antennæ are short, and the eyes simple and sometimes wanting. In the present family there are fifteen tergites, and the antennæ are longer than in the succeeding group. In Lithobius the antennæ are forty-jointed, and the head is broad and flat. The species of this genus attack earth-worms, grappling with them for several hours, and after killing them, suck their blood. They will, in confinement, destroy each other. Their bite is poisonous to small articulates. The European *L. forficatus*, according to Newman ("Entomologist" 1866, iii, p. 342) is preyed upon by Proctotrupes calcar of Haliday. *Lithobius Americanus* Newport (Fig. 645) is a widely diffused species, and erroneously passes by the name of Ear-wig. It is found everywhere, under sticks and about manure-heaps, where it feeds upon insects and earthworms.

The genus *Bothropolys* of Wood, differs in having small, almost round punctiform excoriations arranged in three or four series on the coxa. The *B. multidentatus* of Newport is found in the Eastern United States, and is recognized by having from thirty-two to thirty-seven ocelli on each side of the head.

SCOLOPENDRIDÆ Leach. The Centipede is the type of this family. There are from twenty-one to twenty-three feet-bearing segments, with few or no ocelli, while the last pair of feet are thickened and generally spinous. This genus comprises the most gigantic of all Myriapods, *Scolopendra gigantea* Linn. from the East Indies, being nine inches long. *S. heros* Girard is our largest species, and is found in the Southern States. The bite of the Centipede is dangerous; the poison is conveyed from two glands in the throat, along a canal in the jaws.

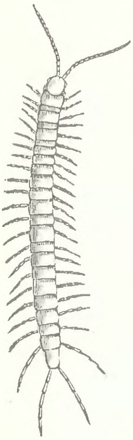


Fig. 646.

The genus *Scolopocryptops* differs in having no ocelli, and twenty-three feet-bearing segments, while the antennæ are seventeen-jointed. *S. sexspinosa* Say (Fig. 646) is common about Philadelphia, and is found in Iowa; it is deep orange, with yellow, somewhat compressed feet, with three spines on each of the last pair of feet. Wood describes the manner of moulting in this species. The skin had been crowded back so as to cover only the last two or three rings. The cast skin contains the skin of the head and all its appendages, even to the maxillæ and maxillary palpi. The anterior portion of the skin was so torn as to show that the process of shedding probably began by the creature's withdrawing its head from its case, and then thrusting it out between some of the anterior sterna, completing the process by pushing the skin back with its legs, and aiding them by a peculiar wriggling motion. The exuvia had most of the posterior segments entire, showing that the occupant had been withdrawn from it like a hand from a glove." Wood also states that the female guards her young by laying on her side, and then coiling her body passes them along by a "rapid cilia-like action of her feet;" thus arranging them satisfactorily to herself.

GEOPHILIDÆ Leach. These Myriapods are very long and slender, with from thirty to two hundred segments, each formed of two complete, but unequal subsegments, and bearing but a single pair of feet. There are no ocelli; the antennæ are fourteen-jointed, and the anal feet are short and style-like.

In *Mecistocephalus* the "cephalic segment," or anterior part of the head is more than twice as long as broad, while in *Geophilus* the same region of the head is square. *M. fulvus* Wood is fulvous, polished, with a light orange head; according to Wood it is most often found under the inner bark of decaying logs of the locust tree. *Geophilus cephalicus* is an unusually broad species found near Philadelphia. *G. bipuncticeps* Wood (Fig. 647) is found in the Western States and Sonora.

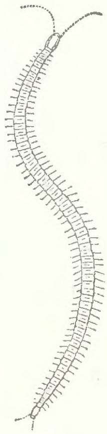


Fig. 647.

In *Strigamia* the cephalic segment is small, short, and generally somewhat triangular. *S. bothriopus* Wood is a bright red robust species, and inhabits Philadelphia. *S. chionophila* Wood is a diminutive species, being only three-fourths of an inch long; it is found far north, at Fort Simpson, on the Red River of the North. The largest species known is *S. epileptica* Wood from Oregon, which is five and a half inches long. The last pair of male feet are represented by Wood to be antenniform, those of the female being small, short, and preserving the usual shape of the leg. This is an interesting instance of the antero-posterior symmetry of these animals, here more strongly marked than usual.

PAUROPODIDÆ Lubbock. The sole member of this family is the *Pauropus*, which Sir John Lubbock discovered in England living among decaying leaves. "The body is composed of ten segments, including the head, and is convex, with scattered hairs; there are nine pairs of legs, and the antennæ are five-jointed, bifid at the extremity and bearing three long jointed appendages." The two species, *P. Huxleyi* and *P. pedunculatus* of Lubbock are white, and about one-twentieth of an inch in length. Lubbock regards this remarkable form as a "connecting link between the Chilopods and Chilognaths, and also as bridging over to a certain extent the great chasm which separates them from other articulata." No tracheæ could be detected. The six-footed young (Fig. 648) had the first pair of legs attached to the first segment behind the head, the two other pairs to the following one. The resemblance of Pauropus to those Poduræ, such as Achorutes, in which the "spring" is very short, is certainly remarkable. We may, therefore, consider the Pauropus as a connecting link between the Myriapods and the Neuroptera.

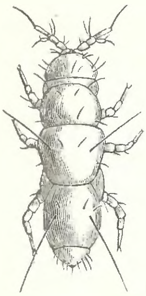


Fig. 648.

CHILOGNATHA.

In this division of the Myriapods the body is divided into numerous segments, each furnished with two pairs of short legs, and the antennæ are short, with but few joints.

They are the lowest insects, and in Julus, with its large number of rings of the same form, we have a good illustration of the vegetative repetition of the zoölogical elements, or segments, composing the body, which is the reverse of what obtains in the cephalized honey bee, for instance, and reminds us strikingly of the Worms. In the genus *Brachycybe*, a remote ally of Polydesmus, we are strongly reminded of some crustaceans, such as the Isopods, and the posterior end of the body of this Myriapod, in the broad lateral expansions of the segments, even recalls the tail of a trilobite.

Wood states that the eyes are frequently absent, and when present they are generally numerous and collected in patches near the base of the antennæ. The long, cylindrical-bodied *Julus* is the typical form of the suborder, while the flattened dilated Polydesmus is a more aberrant form.

The mouth-parts are either, as in Julus, formed for feeding on decaying vegetable matter, or tube-like, as in Brachycybe and allies, the parts being converted into a tube or beak.

GLOMERIDÆ Leach. In this group the eyes are arranged in a linear series, and the antennæ are placed on the front of the head. The body is half-cylindrical, short and plump, with from twelve to thirteen segments. The head is large and free, with the first thoracic ring small, while the last abdominal ring is large and shield-shaped. The genital openings in both sexes are situated just behind the insertion of the second pair of limbs. In *Glomeris* the body consists of twelve rings and seventeen pairs of limbs, while in *Sphærotherium* the body is made up of thirteen rings and twenty-one pairs of feet. The species are exotic, *Glomeris marginata* Latreille being found in Europe, and the Sphærotheria in the tropics.

POLYDESMIDÆ Leach. In this group the body is much flattened, the sterna overarching the scuta, to which they are closely cemented, and the scuta are furnished with lateral laminæ. "The head is large and massive, the absence of eyes and the small antennæ point to a state of low development of the special senses. The female genitalia are placed in the third segment, just posterior to the second pair of legs. They are generally more or less hidden within the body; the male organs are situated in the seventh segment, replacing the eighth pair of legs. They generally project from the body so as to be very prominent." (Wood.)

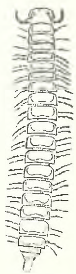


Fig. 649.

In *Polydesmus* the body is much flattened, with broad lateral expansions to the rings. *Polydesmus Canadensis* Newport is deep brown, with pubescent scarcely clavate antennæ; each of the scuta have eight scales, arranged in a double series. The male appendages are hairy, with a curved terminal spine of moderate length. The female appendages "consist of a pair of bodies shaped somewhat like the crest of a helmet. Along their free margin is an opening surmounted by a double series of teeth-like processes. It is found in the Northern and Middle States. *P. erythropygus* Brandt (Fig. 649) inhabits the Middle and

Western States. In *Polyxenus* the body is short, clothed with short penicillate scales, and there are thirteen pairs of feet. (These scales, or hairs, as has been remarked to us by Mr. Sanborn, are remarkably like the hairs of Dermestes, and this homology is another proof that the Myriapods are an order of the class Insecta.) *P. fasciculatus* Say is about a tenth of an inch in length. It has been detected by Mr. Sanborn under the bark of trees near Boston, and I have found it in Salem in the same situations, and also at Nantucket.

JULIDÆ Leach. *Thousand Legs. Millepedes.* This group embraces the typical species of this suborder. The body is almost perfectly cylindrical, with the sternum greatly reduced in size, those of the posterior subsegments being almost absent, while the tergum is greatly in excess. The head is large, with often rather long and filiform antennæ, and simple eyes arranged in variously shaped patches near the base of the antennæ.

In *Julus* the body is slender and seldom more than three inches long; the sides of the first scutum are produced in the female, while the antennæ are long and filiform. Wood says the males are "farther distinguished by a peculiar alteration of the first pair of feet, which are transformed into a pair of very large, thick organs," which probably serve as clasping appendages. *Julus* is found commonly under sticks, etc. It is long, cylindrical, hard, with numerous feet, short and weak, attached to the under surface of the body nearly in the middle of the abdomen. The antennæ are short and filiform. They crawl rather slowly, and at rest curve the body into a ring. They live on vegetable substances, or eat dead earth-worms or snails. "In the spring the female deposits her eggs in masses of sixty or seventy, in a hole excavated for the purpose under the ground; after three weeks or more the young make their appearance." (Van der Hoeven.) Newport states that when hatched the young Julus consists of eight rings, including the head. The body of the embryo, seen from above, is compressed and wedge-shaped, being broadest at the second and third segments. For many days (seventeen) after hatching, the embryo is surrounded by a membrane which Newport regards as the analogue of the amnion, or vitelline membrane, of the vertebrates. This membrane is at the end of the body connected with another, which in the unburst shell is external to the "amnion," and lines the interior of the shell. Newport compares this with the chorion of vertebrates. Before the amnion is thrown off the embryo moults, and six new segments appear (Fig. 650, *b*), and minute tubercles bud out on the under surface of the six and seventh rings, as at *a*. The new segments are always developed between the last and penultimate ones, as has been observed in the worms, the crustacea, the spiders, and as I have observed in the embryo of the Dragon-fly. In the young Julus no legs grow out on the third segment from the head, but the outlet of the oviduct of the female is placed on this segment. The male organs find their outlet on the sixth ring from the head.

Fig. 650.

Julus Canadensis Newp. is brownish chestnut, ornamented with a black dorsal line, and a lateral row of black dots. The body consists of fifty-three segments. It is found in the Northern States and Canada.

J. multistriatus Walsh (Fig. 651) inhabits the Western States. The genus *Spirobolus* has a much larger, thicker body, and a rather small head, with short antennæ, often lying partially hidden in a groove in the side of the head. *Spirobolus marginatus* Say is deep brown, annulated with red, and consists of from fifty-three to fifty-seven segments. The male appendages are described by Wood as formed of two outer parts, and a connecting yoke-like piece.

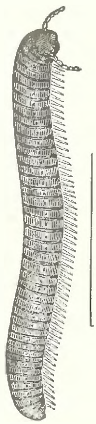


Fig. 651.

To this family without much doubt, as Dr. Dawson states, belongs the *Xylobius sigillariæ* of Dawson (Plate 1, fig. 4) from the Lower Carboniferous rocks of Nova Scotia. This, in its short, thick antennæ, and small head, rather approaches Spirobolus than Julus, though the antennæ are shorter, while the twelve ocelli represented in Dr. Dawson's figure (Air-Breathers of the Coal Period. Montreal,

1863. Plate vi, fig. 58–61) are arranged much as in S. marginatus. It differs remarkably, however, in the raised posterior margin of the segments, giving a serrate outline to the body, while the body tapers more rapidly towards each end than any recent form known to us. In this respect it seems to combine the characters of the present family and that of *Spirostrephon*, a genus in many respects intermediate between the *Polydesmidæ* and the *Siphonantia*, or sucking Myriapods. Four spiracles are represented on the tenth to the thirteenth segments from the head.

The genus *Spirostrephon* is in many respects intermediate between this and the succeeding family. The head is free, as in Polydesmus, but the sterna are soft as in the *Siphonantia*.

SIPHONANTIA Brandt. In the sucking Myriapods (*Sugantia* of Brandt) we meet with the lowest, most vegetative, worm-like forms of the order. According to Wood the head is very small and concealed beneath the prothoracic ring. The parts of the mouth are fused and united into a sucking tube for the imbibition of fluids. The eyes are either present or absent, and the scuta, or tergites, may be prolonged laterally into laminæ which afford protection only to the back and flanks, the central part of the abdomen being soft. The feet are small and hidden beneath the broad body, while the male appendages are placed on the seventh segment.

In the genus *Octoglena* the eyes are eight in number, arranged in two converging rows. *O. bivirgata* Wood is brown, with a reddish stripe on each side, with about forty-five segments to the body.

In *Brachycybe* the rostrum is acute, much shorter than the antennæ, while the body is broad and flattened. The male appendages, or clasping organs, are, as shown in Dr. Wood's figures, simply modified feet adapted for clasping purposes, as they are in Polydesmus, and are, therefore, not homologous with the male appendages of insects, which are differently developed and grow out from a different portion of the segment. The *Brachycybe Lecontei* of Wood is from Georgia, and has long lateral expansions to the tergites.

ENTOMOLOGICAL CALENDER.

THIS calendar applies mostly to the New England states, where the appearances of the insects here enumerated have been recorded. It should be borne in mind that the season of New York city is about two weeks in advance of that of Boston, and that of Virginia and Illinois about a month or six weeks earlier. It is designed to be of special use to farmers and gardeners as indicating the times of appearance of injurious insects. When only the generic name is given several species appear simultaneously. The reader in noticing an insect mentioned here can turn to the index and find in the body of the work an account of its habits.

MARCH.

Bombus, queens; a few Ichneumons and Chalcids; Vanessa; Grapta; a few specimens of Noctuidæ, Tortricidæ and Tineidæ; Ephippophora caryana; Canker worm, females and males; Anthomyia; Tachina; Chironomus; Anophiles; Bibio; Chionea; Valga, on the snow; Trichocera hiemalis; Cicindelæ and Carabidæ; Dytiscidæ, and other water beetles; Aquatic Hemiptera; Capnia and Tæniopteryx; Boreus.

APRIL.

1st–15th.—Formica; Brephos; Adela, on willows; Aphodius; Ptinus fur; Dermestes; Anthrenus; Attagenus; Epuræa; Ips; Ellychnia; Larva and female of Meloë on bodies of wild bees and wasps; Ceuthophilus.

16th–30th.—Polyommatus; Lycæna; Thecla; Coddling moth (Carpocapsa); mosquitoes and larvæ; Bombylius; Burying beetles; Euryomia Inda; Buprestids; Chalcophora Virginica; Castings of Saperda candida; Cylindrical bark borers (Tomicus, Xylographa); Hylurgus; Pissodes strobi; Hylobius pales; Phytocoris.

MAY.

1st–15th.—Xylocopa, Ceratina, Osmia, Andrena and Halictus nesting; Colias; Argynnis Bellone; Melitæa Myrina; Chrysophanus Phlæas; Clisiocampa larva hatching out; Scoliopteryx; Drasteria; Coremia; Gooseberry Pempelia; Tipulidæ; Hessian-fly and Wheat-midge; Cecidomyia; Syrphus; Eristalis; Squash beetle; Plum weevil; Hister; Clerus; Elater; Limonius; Cratonychus; Meloë; Calligrapha; Œlipoda corallina; Tragocephala infuscata, viridifasciata; Libellula; Hemerobius.

18th–31st.—Cynips; Selandria rosæ and cerasi, laying eggs; Strawberry Emphytus larva; Papilio Turnus; Pontia oleracea; Melitæa Phaëton, larva; Argynnis; Thanaos; Hesperia; Alypia octomaculata; Sphinx; Ceratomia 4-cornis; Sesia; Hyphantria textor; Arctia; Leucarctia; Agrotis and cut-worms; Hypena humuli, hop-vine worm; Grapholitha and other leaf-rolling larvæ on apple and pear; Vine Penthina larva; Carpet moth; Chrysops; Geotrupes; Haltica on turnip, tomato, cucumbers, etc; Apion; Asemum mœstum; Gastrophysa cœruleipennis; Galleruca.

JUNE.

1st–15th.—Pristophora identidem, cranberry fly larva; Nematus ventricosus, larva; Cynips; Eurytoma hordei in straw; Pteromalus; Abia, larva; Papilio Asterias; Eudamus Tityrus; Smerinthus; Abraxas ribearia; Scotosia undulata; Antithesia pruniana, larva; larvæ of Lithocolletis salicifoliella, juglandiella; Nepticula villosella; Cranberry Anchylopera larva; Strawberry Anchylopera larva; Grape Pterophorus larva; Anisota pellucida; Icthyura; Tabanus; Tephritis; Oscinis; Laphria; Asilus; Bot-flies; June beetle, Lachnosterna; Areodes lanigera; Pelidnota punctata; Serica sericea; Apion Sayi; Macrodactylus subspinosus, Rose chafer; Dicerca divaricata; Chrysobothris fulvoguttata and Harrisii; Alaus oculatus; Attelabus analis and bipunctulatus; Rhynchites bicolor; Arrhenodes septentrionis; Telephorus; Corymbites; various fireflies, Photinus and Photuris; Colorado potato beetle; Coccinella; Pemphigus vitifoliæ; Apple bark louse, Aspidiotus conchiformis; Cicada rimosa; Œdipoda Carolina; Panorpa.

15th–30th.—Megachile nesting; Pristiphora grossulariæ, larva; Neonympha Eurytris; Grapta Progne, larva; Cynthia cardui, larva, Atalanta larva; Limenitis Missippus; Nymphalis Ephestion; Melitæa Phaëton, Pharos, Harrisii; Satyrus Nephele; Actias Luna; Eudryas grata, larva; Trochilium tipuliforme; Ægeria exitiosa; Platysamia Cecropia; Telea Polyphemus; Hypena humuli; Desmia maculalis; Crambus; Asopia costalis; Gooseberry Pempelia larva; Philampelus; Chærocampa; Halesidota; Datana ministra; Eacles imperialis; Citheronia regalis; Hyperchiria Io; Loxotænia rosaceana; Carpocapsa pomonella, larva; Limacodes; Locust Depressaria larva; Strobisia levipedella; Coleophora; Tinea, clothes-moth; Cerura borealis; Bryophila; Pterophorus larvæ; Sarcophaga; Anthomyia raphani, radish fly; Scolytus pyri; Corasphorus cinctus; Monohammus titillator; Anomala varians; Fidia viticida; Desmocerus palliatus; Hispa suturalis; Lytta cinerea; Grape Cœliodes larva; Squash bug, Coreus tristis; Lecanium quercifex; Chinch bug; Thrips; Cicada 17-decim; Tettigonia rosæ; Chrysopa, Phryganea; Neuronia.

JULY.

1st–15th.—Wasps nesting; Pine Lophyrus larvæ; Melitæa Harrisii; Hesperia Hobomoc; Satyrus Alope; Deilephila; Darapsa; Harrisina Americana; Alypia octomaculata; Phragmatobia rubricosa; Pyrrharctia Isabella; Euphanessa; Hadena arctica; Catocala; Dahlia Gortyna larva, boring the stems; Phlox worm; Ennomos subsignaria, Angerona crotataria and many other Phalænidæ: Phycita nebulo, and many other Pyralidæ and Tortricidæ; Simulium; Œstrus; Ortalis flexa; Acinia; Limnobia; Monohammus scutellatus; Trichodes humeralis; Leptura Canadensis; Buprestis fasciatus; Grape Baridius; Reduvius; many Libellulæ.

16th–31st.—Pristiphora grossulariæ; Tremex Columba; Heteropterus marginatus; Polyommatus Comyntas; Thecla falacer; Danais, larva; Argynnis Idalia and Aphrodite; Ægeria cucurbitæ; Sphinx larvæ; Utetheisa bella; Lithosia casta; Ichthyura albosigma; Clisiocampa; Lagoa crispata; Xyleutes robiniæ; Apatela Americana; Agrotis telifera, devastator; Hypena humuli, 2d brood of larvæ; Brachytænia malana; Antithesia pruniana; Pterophorus; Coleophora; Nepticula; Gracilaria; Elachista; Lema trilineata; Anthonomus prunicida; Eumolpus auratus; Prionus laticollis; Orthosoma unicolor; Leptostylus; Monohammus marmoratus; Lucanus capreolus, dama; Clytus; Saperda; Osmoderma scabra; Cranberry Anthonomus; Tettigonia fabæ; Clastoptera.

AUGUST.

1st–15th.—Many bees and wasps; Crabronidæ; Nyssonidæ; Bembecidæ; Larridæ; Sphex, Pompilus and other fossorial wasps; Cimbex larva; Pelecinus and various Chalcids and Proctotrypidæ; Œceticus makes its cocoon; Gortyna zeæ; Agrotis subgothica; Plusia; Heliothis; Northern Army worm (Leucania); Nepticula; Gelechia; Lyonetia; Phalænidæ and Noctuidæ; Cranberry Antithesia; Saperda calcarata; Clytus; Tettigoniæ and many other Hemiptera, Grain Aphis and other Aphides; Coccidæ; Phymata erosa; Œcanthus niveus; Chloealtis; Acheta; Nemobius, and other grasshoppers.

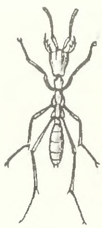
16th–31st. — Orgyia; larvæ of many moths and butterflies; Lycomorpha pholus; Apple Lithocolletis larva; Sac-bearing Lyonetia larva; Tomicus and other bark boring beetles; Girdler Oncideres; Psocidæ; second brood of Chrysopa.

SEPTEMBER.

Ants swarm; Males and females of Bombus; Nymphalis Disippe; Gastropacha Americana, larva; Limacodes, larva; Boll worm (larva); Zerene catenaria; Larvæ of various Lithocolletis, Bucculatrix and other Tineids; Sciara larva; Carabidæ; Clytus pictus oviposits on locust; Meloë; Membracis bimaculata; Pemphigus raising galls; Lachnus strobi.

OCTOBER.

Œceticus, and larvæ of various Tineids; Ægeria pyri; Canker worm moth; Anisopteryx; Hibernia tiliaria; Bdellia somnulentella; Rhagium lineatum matures, but hibernates in its cell; Hemerobius, and larva.



The Driver Ant, see p. 181.

GLOSSARY.

Acuminate. Ending in a prolonged point.
Anastomosing. Inosculating or running into each other like veins.
Annulate. When a leg, antenna, etc., is surrounded by narrow rings of a different color.
Apodous. Footless.
Areolate. Furnished with small areas; like a net work.
Aristate. Furnished with a hair.
Aurelia. Ancient term for pupa.

Blastoderm. The primitive skin of the embryo.
Blastodermic cells. The cells forming the blastoderm.
Bullate. Blistered.

Calcarated. Armed with spurs.
Cancellate. Crossed by lines going at right angles to each other.
Capitate. Ending in a knob.
Carina. An elevated keel-like ridge.
Carpus. The pterostigma.
Cellule. A little space surrounded by veins on the wing.
Chela. Terminal portion of a foot, with a movable lateral toe, like the claw of a crab or mandibles of arachnids.
Chrysalis. The pupa of Lepidoptera.
Concolorous. Of the same color with another part.
Ciliate. Fringed.
Cinereous. Ash color; color of wood ashes.
Cingula. A colored band.
Clavate. Club-shaped.
Coarctate. Contracted; compact.
Confluent. Running into each other.
Connate. United.
Cordate. Heart shaped.
Coriaceous. Leather-like, thick, tough, and somewhat rigid.
Corneous. Of a horny substance; resembling horn.
Crenate. Scalloped, with rounded teeth.
Cupreous. Coppery in color.

Dentated. Furnished with teeth.
Depressed. Flattened down.
Dilated. Widened, expanded.
Dimidiate. Half round.
Discal. Relating to the disk; discoidal.

Edentulous. Destitute of teeth.
Emarginate. Notched; terminating in an acute notch at tip.
Entire. (Wings) with a simple, not indented, edge.
Epistoma. That part of the face between the front and labrum.
Eruca. The larva.
Excurved. Curved outwards.
Exserted. Protruded; opposed to inclosed.
Exuvia. Cast-off skin.

Facies. Appearance, aspect.
Falcate. Sickle-shaped.
Fascia. A stripe broader than a line.
Fauna. An assemblage of animals peopling a region or country.
Fenestrated. Marked with transparent spots surrounded by a darker color, like window panes.
Ferruginous. Rust-colored.
Filiform. Thread-like.
Flavescent. Somewhat yellow.
Flexuous. Almost zigzag.
Foliaceous. Leaf-like.
Forcipated. Forceps-like.
Fovea. A more or less rounded depression.
Free. Unrestrained in articulated movement; not soldered at the points of contact.
Front. The fore-face, bounded by the eyes, the vertex, and often beneath by the epistoma, or clypeus.
Fuliginous. Of the color of dark smoke.
Fulvo-æneous. Brazen, with a tinge of brownish yellow.
Fulvous. Tawny; color of the common deer.
Furcated. Forked.
Fusco-testaceous. Dull reddish brown.
Fuscous. Dark brown; approaching black.
Fusiform. Spindle-shaped; gradually tapering at each end.

Ganglion. A centre of the nervous system, containing nerve cells, and receiving and giving out impressions.
Geminate. Arranged in pairs; twin.
Gemmiparous. Asexual generation by new individuals arising as buds from the body of the parent.
Glabrous. Smooth; opposed to hairy, downy, villous.
Glaucous. Gray; bluish green.

Hamule. A little hook.
Hastate. Halberd shaped.
Haustellate. Furnished with a proboscis or tongue-like mouth.
Hexapodous. Provided with six feet.
Hirsute. Clothed with shaggy hairs.
Hyaline. Transparent; of the color of water.
Hypostoma. The clypeus in diptera.

Incrassated. Thickened; swelled out on some particular part.

Infumated. Clouded.
Infuscated. Darkened with a blackish tinge.
Interrupted. Suddenly stopped.
Involuted. Rolled inwards spirally.
Irrorated. Freckled, sprinkled with atoms.

Lamelliform. Sheet or leaf-like.
Limbate. When a disk is surrounded by a margin of a different color.
Lamina. A plate or sheet-like piece.
Linear. Like a line.
Lineated. Provided with line-like marks.

Mandibulate. Furnished with mandibles; opposed to haustellate.
Marginated. Surrounded by an elevated or attenuated margin.
Membranaceous. Thin; skinny, and semi-transparent like parchment.
Mucronate. Ending in a sharp point.
Mutic. Unarmed.

Nymph. Old name for pupa.

Obcordate. Inversely heart-shaped.
Obovate. Inversely ovate; the smaller end turned towards the base.
Obsolete. Not distinct; or almost lost to view.
Obtected. Covered.
Ochreous. Of a more or less deep ochre color.
Olivaceous. Olive colored.
Operculum. A lid; a small valvular appendage.
Oval. Egg-shaped.
Ovate. More or less oval.
Oviposition. The act of depositing eggs.

Petiolated. Supported on a stem.
Piceous. Pitchy, color of pitch; shining reddish black.
Pilose. Clothed with pile, or dense down.
Process. A projection.
Produced. Drawn out; prolonged.
Pruinose. Frosty.
Pseudova. Unimpregnated eggs, which produce young, as in those laid by virgin Aphides.
Pubescent. Coated with very fine hairs, or down.
Pulverulent. Dusty.
Punctured. Marked with numerous small impressed dots.

Raptorial. Adapted for seizing prey.
Recurved. Curved backwards.
Reniform. Kidney shaped.
Reticulated. Marked like net work.
Revolute. Rolled backwards.
Rostrum. The beak or sucking mouth-parts in Hemiptera.
Rufescent. Somewhat reddish.
Rufous. Reddish.
Rugose. Wrinkled.

Sanguineous. Blood-red.
Scabrous. Rough like a file; with small raised dots.
Scalloped. Edge marked by rounded hollows, without intervening angles.
Sericeous. Having the surface with a silk-like gloss, usually from the presence of minute, dense hairs.
Serrated. Like saw teeth.
Setaceous. Bristle-like.
Sessile. Not stalked.
Sinuated. Scooped out.
Spinous. Armed with spines.
Spurs. Stiff bristles, or spines, on the tibiæ.
Stria. A line usually depressed; sometimes composed of punctures.
Subaduncate. Somewhat hooked or curved.
Subulate. Shaped like an awl.
Sulcate. With groove-like excavations.
Suture. A seam, or impressed line; usually between segments.

Tawny. Fulvous; a pale dirty yellow.
Teneral. A state of the imago (Neuroptera) after exclusion from the pupa, in which it has not fully completed its coloring, clothing, etc.
Tessellate. Spotted like a checker-board.
Testaceous. Dull red; brick color.
Tomentose. Covered with fine matted hairs.
Truncated. Cut squarely off.
Tuberculose. Covered with tubercle-like prominences.

Uncinate. Hooked at the end.
Unequal. Differing in size, or length.
Unguiculate. Armed with a hook or nail.

Valvule. A small valve-like process.
Ventral. Relating to the under surface of the abdomen.
Verticillate. Placed in whirls.
Verriculate. With thickset tufts of parallel hairs.
Verrucose. Covered with wart-like prominences.
Villose. Clothed with soft, rather long hairs.
Vulva. Orifice of the oviduct.

ABBREVIATIONS.

Beauv., Beauvois. Boisd., Boisduval. Burm., Burmeister. Clem., Clemens. Dahlb., Dahlbom. Den., Dennis. Dej., Dejean. Erich., Erichson. Esch., Escholtz. Fabr., Fabricius. Fröhl., Fröhling. Grav., Gravenhorst. G. and R., Grote and Robinson. Guen., Guenee. Gyll., Gyllenhal. Hald., Haldeman. H. Sch., Herrich-Schaeffer. Hübn., Hubner. Latr., Latreille. Lec., Leconte. Linn., Linnæus. Mann., Mannerheim. Mels., Melsheimer. Oliv., Olivier. Pack., Packard. Sauss., Saussure. Schief., Schiefermuller. Schonh., Schönherr. St. Farg., St. Fargeau. Tellk., Tellkampf. Walk., Walker.

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GUIDE
TO THE
STUDY OF INSECTS

PACKARD