THE LIFE OF A BUTTERFLY.

OTHER WORKS ON BUTTERFLIES BY THE AUTHOR.

THE BUTTERFLIES OF THE EASTERN UNITED STATES AND CANADA, with Special Reference to New England. 3 vols., Imp. 8vo, 2,000 pp. 96 Plates and Maps, plain and colored. Half Levant, gilt top, $75.00.

Published by Houghton, Mifflin, & Co., Boston, Mass.

BUTTERFLIES: Their Structure, Changes, and Life Histories, with Special Reference to American Forms. With an Appendix of Practical Instructions. 12mo, 332 pp. 201 Figures. Cloth, $1.50.

Published by Henry Holt & Co., New York, N. Y.

A BRIEF GUIDE TO THE COMMONER BUTTERFLIES OF THE NORTHERN UNITED STATES. 12mo, 12 + 206 pp.

Published by Henry Holt & Co., New York, N. Y.

FOSSIL BUTTERFLIES. 4to, 100 pp. 3 Plates. Paper, $2.00.

Published by the American Association for the Advancement of Science, Salem, Mass.

HISTORICAL SKETCH OF THE GENERIC NAMES PROPOSED FOR BUTTERFLIES: A Contribution to Systematic Nomenclature. 8vo, 203 pp. Paper, $1.00.

Sold by the Cambridge Entomological Club, Cambridge, Mass.

IN PREPARATION.

A STUDENTS' MANUAL OF THE BUTTERFLIES OF NORTH AMERICA, NORTH OF MEXICO.

THE

LIFE OF A BUTTERFLY

A Chapter in Natural History for the General Reader

BY

SAMUEL H. SCUDDER

He hath set the world in their heart, yet so that man cannot find out the work that God hath done from the beginning even unto the end. — ECCLESIASTES iii. 11.

NEW YORK
HENRY HOLT AND COMPANY
1893

TO

THE FOREMOST STUDENT OF THE LIFE HISTORIES
OF AMERICAN BUTTERFLIES,

WILLIAM HENRY EDWARDS,

OF WEST VIRGINIA,

This Little Work

CONTAINING THE STORY OF ONE OF THEM,
IS RESPECTFULLY DEDICATED.

CONTENTS.

PREFACE.

In the following work I have tried to present in untechnical language the story of the life of one of our most conspicuous American butterflies. At the same time, by introducing into the account of its anatomy, development, distribution, enemies, and seasonal changes some comparisons with the more or less dissimilar structure and life of other butterflies, and particularly of our native forms, I have endeavored to give, in some fashion and in brief space, a general account of the lives of the whole tribe. By using a single butterfly as a special text, one may discourse at pleasure of many; and in the limited field which our native butterflies cover, this method has a certain advantage from its simplicity and directness, and I trust may in this instance be of service.

There is little in the volume, either in the statement of facts or their discussion, which has not already been published. But as such accounts are scattered in many bulky works, which only occasionally come under the eye of the general reader, for whom this work is intended, the presentation of the facts within the compass of a single volume may interest a larger audience, and perhaps gain for butterflies the serious study of some who had before looked at them as merely pretty creatures, — types of the frivolous.

There is, however, one point barely suggested before, which is here pretty fully discussed, — the question whether the particular butterfly chosen as the centre-piece of the work can strictly be regarded as a proper denizen of regions as far north as New England, where it nevertheless occurs abundantly year after year. In short, in a volume devoted to our native butterflies and meant to inspire an interest in them, I am attempting to show that my principal figure is, after all, but a tropical interloper.

SAMUEL H. SCUDDER.

CAMBRIDGE, MASS.

THE LIFE OF A BUTTERFLY.

I.

General Account of the Milkweed Butterfly.

THERE is probably no other butterfly so well known in every part of the United States as the Milkweed Butterfly, *Anosia plexippus*. This is due to its large size, conspicuous coloring, wide distribution, and its occasional remarkable abundance. Of easy, quiet flight when undisturbed, often sailing smoothly with wide-spread wings, yet ever ready to do battle with a tempestuous wind, a reckless adventurer in its contrasted livery of orange and black, it seems the very beau-ideal of the contented, happy-go-lucky butterfly. It has a spread of wing of between four and five inches.

Examined close at hand we note the different form of the fore and hind wings, — both broad and ample, but the former somewhat falcate, with smoothly rounded curves; the latter rather triangular, but with the outer margin strongly arched. A deep orange red forms the ground color, but there is a wide margin of black on both wings more or less dotted with pure white, while the veins forming the framework of the wing are all traced in black, and across the falcate tip of the fore wings is a broad oblique black band almost or quite merging into the outer black border, and within it a couple of rows of more or less sordid white spots of a squarish form. The body is black, but the thorax is dotted with round white spots, and the abdomen is narrowly ringed with the same. The antennae, nearly as long as the abdomen, are not scaled at all, and have a drooping club; and the black palpi are conspicuously marked with white, the apical joint protruding like a pin tip. Beneath, the wings are paler than above, but are very similarly marked; the sides of the body are conspicuously dotted with white; and the legs are purplish black with some white markings and very long, hardly divergent claws. The fore pair, however, are very different, being much shortened, the tarsal joints reduced to a single one (with signs of division in the female) and without apical claws. The male is further distinguished by possessing at the tip of the abdomen an extensile brush of long hairs, and on the lower and inner branch of the vein, forming the inner margin of the discal cell of the hind wings, an apparent thickening of the membrane on one side of the vein, really a pouch, which is made more conspicuous by its black color.

The eggs are exceedingly pretty objects, somewhat in the shape of a blunted sugarloaf, a little more than a millimetre — or less than a twentieth of an inch — high, amber green in color, the glistening surface broken up by about twenty-two slight longitudinal ridges, and the interspaces traversed by straight and fine cross-lines, while the summit of the egg is crowned with a little rosette of cells of extreme delicacy.

The caterpillars are striking objects, — cylindrical, plump, naked worms, growing to the length of nearly two inches, with transverse bands of yellow and black. The body tapers a little in front, and the head is of much smaller diameter than the middle of the body, with the face, which is yellow, conspicuously marked with two parallel black bows; from the top of the second thoracic segment grows a pair of long and slender flexible black filaments, thrust upward, forward, and a little apart, and which have a twitching motion when the caterpillar is feeding or alarmed, and move alternately forward in marching; a similar, but shorter, more erect and inactive pair of black filaments is also found on the top of the eighth abdominal segment. These filaments are scarcely observable in the first stage of the caterpillar, which is then armed with several series of simple, short hairs arising from papillae, which are practically lost afterward.

The chrysalis is again a very striking object, but simply on account of its coloring. It hangs by a slender little peduncle of shining black, and is very compact and stout, with plump, rounded form and only the slightest projections, all of which are rounded; the plumpness is in part due to the shortness of the abdomen, the joints of which, beyond the third, rapidly shorten and contract, leaving at the hinder edge of the latter a ridge which encircles the body (except the wings) at its stoutest part, and is made the more conspicuous by bearing little tubercles set in a belt of color, shining black in front, nacreous in the middle, and golden behind, while the entire body of the chrysalis is of an emerald green, except for a few gilt or black dots on other definitely scattered tubercles. It is over an inch long, and from eleven to twelve millimetres in diameter at the stoutest part.

The first spring eggs are usually laid near the base of the midrib of either surface of the terminal or next to the terminal leaves of the young plant of an Asclepias, or milkweed, while they are still erect or nearly erect. The under surface seems to be preferred. Generally but one egg will be found on a leaf, and not often more than two or three on a plant. Later they are also laid upon the pedicel of the flower. The egg hatches in four days or even slightly less, but is sometimes delayed so as not to emerge for five days or more.

The caterpillar feeds upon different species of milkweed, Asclepias, although "it shows a wonderful dislike," Riley remarks, "to the poke milkweed (*A. phytolaccoides* Pursh.). . . . Larvae furnished with this plant would wander about their breeding-cages day after day, and would eventually die rather than touch it." In the north it generally appears to confine itself to *A. cornuti* Dec., but has been found on *A. purpurascens* Linn. and *A. incarnata* Linn.; in the south and in Missouri, it also feeds on the butterfly weed, *A. tuberosa* Linn., *A. amplexicaulis* Michx., *A. tomentosa* Ell., and *A. curassavica* Linn., and has been taken in Cuba by Dr. Gundlach on *A. nivea* Linn. It has been discovered, too, on the dogbane, Apocynum, *A. androsaemifolium* Linn., and according to Coquillet will feed also on Acerates.

The caterpillar eats voraciously, and ordinarily matures rapidly. Sometimes, however, it takes three or more weeks to attain its growth. When observed toward evening it will ordinarily be found quiet, apparently resting for the night, planted on the under surface of the midrib of a leaf, half way between the base and apex, its head outward. From this it might appear that it fed only by day, but caged specimens certainly eat at night, and I have found it resting early in the morning on the top of the leaves on a cloudy day. It is almost always found near the top of a plant, and when disturbed, so as to be knocked off a leaf, the caterpillar coils like a galley worm. Dewitz, writing of the larva in Venezuela, says it spins a thread on being seized, but I cannot understand the statement; it spins less thread than almost any caterpillar known to me.

When preparing to moult it spins an extra amount of silk upon the leaf for a good foothold, and rests immovable for many hours. The new skin has begun to form beneath the old, and while still soft, the new head-case is withdrawn from the old into the region of the thoracic segments, till finally the old skin splits on the first segment behind the old head-case, and the new caterpillar walks out from its old skin; the old head-case falls to the ground, and the old skin shrivels to almost nothing, and is usually eaten up by its former owner.

I once observed one of these caterpillars while moulting; it had been stationary at least twenty-four hours, and now first began swaying its body from side to side, — falling over so far that the thoracic filament of the upper side became perpendicular, and then drawing itself forcibly back to an opposite position. The muscular effort caused a considerable indentation along the falling side of the swaying larva at the point where the white band widens, and at which muscles are attached. The motion was repeated about once in three seconds, and continued for nearly three-quarters of an hour; now and then the larva would violently shake its filaments or strain forward the front of the thoracic segments, thus gradually detaching the old skin from the new.

At last, after remaining quiet, as if to gather strength for a final effort, it began to make violent contortions, especially about the thoracic region. These at first seemed ineffectual, but suddenly the integument parted between the head and body, and by the movements of the larva, passed backward over the new skin, slipping over the whole body at once, and leaving a little empty pellicle at the hinder extremity. The skin was with difficulty removed from the filaments, especially from one whose tip had been bent in the former stage, and which only parted after strong exertions; the fresh filaments lay limp along the back until they were gradually drawn forward, the tip clinging to the moist body until the last; but they did not regain their full elasticity for some time. The remaining process scarcely lasted a minute; the head, however, still remained attached, and was only removed after repeated lateral abrasions and violent efforts with the front legs.

After these efforts the insect remained quiet, resuming the same attitude, with bent head, which it had taken before moulting, — awaiting, undoubtedly, the hardening of its integuments; and it was nearly two hours before the colors of the head became bright and fixed. The larva now first devoured all the old pellicle, except the head, and then moved off in search of daintier diet.

The chrysalis usually hangs for about twelve days, ranging in New England generally from nine to fifteen; but in the South, according to Edwards, from five to fifteen days; in one case he reports it as reduced to two days! On the other hand, Gundlach says it hangs from eight to twelve days in Cuba, and Dewitz gives twelve days as the season in Venezuela. I have known it to be extended in New England to three weeks.

"At last," says Peale, "the golden spots begin to lose their brilliancy and the beautiful green disappears; the orange wings of the imprisoned butterfly now become visible through its temporary sarcophagus, which it bursts open on the following day, and the liberated insect soon takes wing to join its comrades, select its mate, and pass the happy hours of a brief existence in revelling in the sweets of the flowers among which it sprang into being."

II.

The Tongue and How it Works.

ONE of the most striking things about butterflies, and one which never fails to excite the admiration of the observer, is the way in which they feed. Every one has seen them at the blossoms of clover, of milkweed, of golden-rod, thistle, and phlox; and any one who, approaching cautiously, has then looked at them from near at hand, has seen a wonderful apparatus like a watch-spring suddenly uncoil from the lower part of the head; and while the tremulous excitement and eagerness of its owner is shown by the rapid and repeated uncoiling and half coiling again of this organ, as well as by the shivering palpitation of the wings, the tentative thrusts to probe the bottom of the gauzy dish and the quiet satisfaction of the butterfly when this is reached show that it is through this slender, flexible thread that the sweet fluids of the clover and other blossoms are drawn into the body. This flexible conduit, moreover, is the most characteristic of all the structures peculiar to the order of insects to which butterflies belong, and may well merit particular attention.

Notwithstanding its delicacy, and although almost entirely concealed when coiled, this "tongue" is frequently as long as the entire body, and consists of two lateral halves united down the middle; each part is composed of an immense number of short, transverse rings, which are convex on the outer surface, concave on the inner; and *it is by the union of these inner concavities that a central tube is formed.* The lateral rings are also partially hollow, and were therefore formerly supposed by some to form sucking-tubes, in which case the insect might be said to have two mouths, for there would be two entrances to the throat. This, however, is not the case, the interior of each lateral half being closed at the end and filled with nerves, air-tubes, and muscles. The rings of which it is composed are made up of a great number of plates, united by the more yielding part of the cuticle, allowing of great freedom of motion. These rings, at the points where the convex and concave sides meet, are furnished with a series of oblique, curving plates or hooks, which, when the two lateral halves are brought together, interlock in the most complete manner, to form a perfectly flexible yet impervious tube.

The external walls of the lateral tubes are supplied with curious minute papillae of greatly varying shape, size, and abundance in different groups, but in general, more highly organized and abundant in the highest butterflies. In our Milkweed

Butterfly, Burgess tells us, they are seated on little circular plates, and are dotted all over the outer wall, but especially near the tip, and occur also, though in much less number, within the central canal. In this simple development they must be regarded as organs of taste or touch, as suggested by Fritz Müller; but in some moths, as in the orange moth, they become notched spines, and even act as a saw or file, so that the tongue may work its way through plant tissues in search of juices. The muscles mentioned as found in the interior of each lateral half of this wonderful structure are obliquely disposed, serving to coil the whole into the watch-spring-like form in which it is packed away when not in use.

Where was this curious and complicated organ in the caterpillar? From what, that is, did it take its rise? One will have to look carefully to discover it at all! The principal organs one will find in the mouth of the caterpillar are a pair of stout nipping jaws by which it bites the leaves on which it feeds; but just behind them, on either side of the spinneret, will be seen little hemispherical prominences, each with a pair of minute appendages, the outer consisting of several joints and closely resembling the antennae, the inner and smaller of only one; and it is this wee stiff thing, capable only of the slightest motion of withdrawal and protrusion on its cushiony base, that becomes so enormously developed into the complicated watch-spring tongue of the butterfly, while the outer appendages become in the perfect stage the feathery-scaled side-pieces which protect the tongue when rolled.

But now that we comprehend the structure of this wonderful piece of mechanism, and can appreciate the change that has been wrought in its development from an utterly simple, almost microscopic joint, do we understand any better its actual use in extracting honey from flowers?

Some have thought that the upward flow was due to capillary motion; others to the action of the so-called sucking stomach, a sac-like expansion of the alimentary canal just in advance of the true stomach; others still that it is forced on by successive undulations and contractions of the tube itself.

The investigations, however, of one of our own naturalists (who afterward distinguished himself in the construction of the swiftest yachts in the world) has shown the existence of a minute muscular sac within the head, furnished with a valve at its front extremity, where it opens into the base of the tongue. When the radiating muscles running from the walls of the head to the periphery of this sac are contracted, the sac is expanded, and into the vacuum thus produced the fluids into which the tongue is plunged necessarily ascend. On the relaxation of these muscles and the squeezing of the sac by the other muscles which encircle it, the fluids now in it, prevented by the valve from retreating the way they came, are forced down the alimentary canal. When, then, we see a butterfly busily engaged upon a flower, it requires little imagination to picture to one's self a little force-pump steadily at work within the dear creature's diminutive head, transferring the fluid nectar from the base of the flower to the greedy stomach.

III.

The Course of its Life: one Phase of the "Struggle for Existence" among Butterflies.

THE course of life of the Milkweed Butterfly is a simple one. Winter is passed in the perfect or "imago" state, but in what sort of places is not known; in the extreme south it remains on the wing, but that is not the case further north, where the cold would make it impossible. In the proper range of the species (of which we shall have somewhat to say later on) the warmth of the early spring lures the hibernating butterflies from any places of concealment they may have had, faded in color but not so often ragged in attire. In West Virginia, according to Edwards, they may be seen on the blossoms of the wild plum the last of March, and on lilacs and other flowering shrubs in April. The tender leaves of the milkweed, on which the caterpillar feeds, are just appearing above the ground, and on these the females hasten to deposit their eggs; they are usually laid on the under surface of the terminal leaves while these are still vertical. They hatch in four or five days; later in the season, in the south at least, in two or three days.

Immediately it has escaped from the egg, the caterpillar completely devours the shell, as if to leave no manifest token to the wily and vigilant ichneumon-fly that its former inhabitant was near at hand, and then attacks the leaf on which it was born, eating a slender hole often entirely through it, and when it has done feeding retires to the concealed side of the leaf, — if it be still erect, to the inner, that is the upper side; if extended horizontally, to the lower surface. As soon as appetite returns, — and it is a voracious feeder,—it has its food ready at hand. So it eats and rests, and rests and eats, at night—to judge from a few observations I have made—quite as well as by day, except that it is more sluggish in cool weather, and nights are cooler than the day. In a day or two (the time depending partly upon the weather), the caterpillar makes its first moult, but its habits remain much the same. Three other similar moults follow before the caterpillar has attained its growth, which may be acquired in eleven days from the egg, though it is usually longer than that, and in cool weather may be greatly extended.

Then comes the change to chrysalis, to seek a good place for which the caterpillar usually leaves the plant (though I have found the chrysalis hanging pendant from the leaf) and seeks some such stable place as the under side of a fence rail or a jutting rock from which to suspend. Mr. Edwards once found one on the

under side of the T rail of a railway track! Here it hangs for a variable period, — two to fourteen days, according to the season and temperature, and perhaps the exposure; and the butterfly again makes its appearance, the cycle of changes complete.

How often this cycle may be repeated during the year is doubtful and certainly variable, the weather and latitude being undoubtedly again important factors; it has been a matter of some dispute. Riley, making his observations in Missouri, considers that there are but two broods annually in that region. Edwards, in West Virginia, believes there may be four or five in his district, and one would hardly look for more in the one than in the other; but Edwards' belief appears to be founded upon the fact of finding the insect in all its stages at nearly all times the summer through, and upon his observations of the time required for the entire cycle, which is sometimes as short as three weeks.

He leaves out of account entirely the possibility that the parent butterfly may lay eggs for a considerable length of time, because he does not believe this to be the case, and it certainly would be very difficult to prove it to be or not to be the case in a Southern district; but in a more Northern region, where the number of broods would be likely to be less than at the South, it would not be so difficult, and from what information I can gain I am very strongly inclined to believe that there are at the most two broods a year north of the latitude, say, of Washington.

I shall on a future page explain this more fully, in considering the distribution of this butterfly, of which I believe there is but one brood a year in most of New England and northward. I should not be surprised if it should turn out that there were nowhere in the United States more than three broods a year, and it may even yet be proved that there are but two.

In any case, this is one of the simplest life-histories we have among our native butterflies; and the dispute regarding it, and the uncertainty that still surrounds it and probably will surround it for a long time, show how wide a field for observation is open to young naturalists. The variations on this theme among our butterflies are endless. The cycle is invariable; but winter may intervene at any stage, usually at an identical stage in any given species, though occasionally at two different stages.

Relatively few butterflies, in New England at least, winter as butterflies; such are mostly confined to the Angle-wings and their allies, of which *Euvanessa antiopa*, the Mourning-cloak, is the best known example. A considerable number are dependent for their perpetuity upon the power of resistance to cold possessed by the egg; and then the egg is never laid upon the leaf of the food plant, which would fall to the ground in the autumn, but upon the twigs of the same or upon some stable point near by if the plant be an annual. The caterpillar then usually hatches in the earliest spring and feeds upon the tender leaves before they are fairly unfolded. Such is the case with some of the delicate Lycaenids, the Hair-streaks, Blues, and Coppers; apparently it is more common in this subfamily than elsewhere, but it is known to occur in a number of widely different butterflies, one striking case being that of Parnassius, an alpine genus.

What the condition of the embryo may be in these instances is not at all known, but it is certain that the cases are not few in which the caterpillar hibernates without tasting a morsel of food besides its own egg-shell, much the same as if it had wintered fully formed in the egg. The doctors tell us we should never go to bed hungry, but here are creatures which go to their long winter's rest before they have tasted any proper food; this is tolerably common among the Satyrids or Meadow-browns.

Then there are others which hibernate as partly grown or fully grown caterpillars; and these with the last — that is, such as hibernate in some larval stage or other — include a very considerable proportion of our Northern butterflies, perhaps even a majority of them. Among them should be counted, perhaps, such butterflies as our Dusky-wings of the genera Thanaos and Pholisora, which in the autumn prepare for the change to chrysalis by making a sort of cocoon for the purpose; these they never leave again as caterpillars, but in them remain quite unchanged until the early spring, when after a short period in chrysalis they are among the earliest butterflies of the season. Finally, there is the chrysalis, which really seems made to be the normal stage for hibernation for Lepidoptera, and one which appears to be the nearly universal condition among the moths, but which is vastly less common among the butterflies, aspiring creatures whose lives are as variegated as their broad wings.

With such a variety, all possible variety, in the matter of hibernation, what wonder that the lives of butterflies are varied? Some pass a single cycle in the course of the season, ending where they began, some two or more; some among the Northern insects appear to take two years to complete the cycle, wintering successively in two different periods of life; or they may take sometimes one and sometimes two years, as would appear from recent observations in Canada; while to cap the climax, there are not a few instances, confined apparently to regions where winter is a prime factor in life, and probably resulting therefrom, where a butterfly may be at the same time single and double brooded, the progeny of a single batch of eggs giving birth to butterflies partly in the course of the same season, partly in the season following, the later butterflies flying with the descendants of the earlier; that is, with their nephews and nieces! This comes about in a curious way, by the premature hibernation from midsummer on of a certain portion of the original brood at just that particular time of life when their nephews and nieces will hibernate. The tendency to hibernate at that specific time of life is thrown back into midsummer, when there are no signs of provocation thereto.

The study of the influence of winter life upon the histories of our butterflies unfolds a curious and perplexing chapter. We see what an element it has been in the development of these creatures, how they have always had to contend with it, and in what manifold ways they have made their struggle for existence. How many may have succumbed!

IV.

Its Vagrancy: a Lesson in Geographical Distribution.

HARDLY any other of our North American insects equals our Milkweed Butterfly in interest when we consider its distribution. With the exception of a few butterflies which we possess in common with Europe, and which may have had their origin there, no other species is so wide-spread. There is still some question whether certain butterflies found in the American tropics are to be regarded as, with this, varieties of one species, or as distinct forms; but without discussing a somewhat unprofitable question, we may better assume, what is probably the case, that all belong to a single species with local variations.

This granted, we find our butterfly to be a distinctly American form, belonging properly to the tropics. It is found all over the West India Islands, as well as on the mainland, and extends beyond the tropics much farther in the north than in the south, for its southernmost known location in South America is the very northern border of Patagonia, in latitude 40°, while in North America it extends over almost every part of the United States, no part of which lies within the tropics, and even over a large part of Canada, having actually been reported from the southern borders of Hudson Bay, and even from the Athabascan region in the far northwest, nearly twenty degrees farther from the tropics than in South America.

Belonging as it does to a distinctively tropical group of butterflies, it appears here quite out of place. The semi-tropical character of the southern United States, somewhat more marked than in similar latitudes in South America, does not make its appearance there surprising; but farther north, beyond Philadelphia (which would be latitudinally equivalent to its farthest in South America), it clearly appears like an interloper. Precisely here comes in the interesting feature in its distribution. We are accustomed to think of the butterflies we see as born and bred in the district where they are seen. It is otherwise with birds; we know that very many among them come and go with great regularity and for great distances, though it is only within given latitudinal boundaries that they will breed, each in its own domain. It has hardly occurred to entomologists to inquire whether this may not sometimes be the case with butterflies. The very fact that some birds do and some do not move northward and southward with the seasons, should suggest the possibility that this may be the case with other flying creatures.

Particularly should such a suggestion

be heeded in those groups where great flocks are known to occur and apparent migrations take place. There are two such groups represented among our butterflies, one of them that to which our Milkweed Butterfly belongs; and there seems to me nearly every reason to believe (what every recurring season of observation serves only to strengthen) that the natural northern limits of our butterfly are not farther north (perhaps much farther south) than about latitude 40° on the Atlantic border, and that the eggs, caterpillars, and chrysalids of the butterfly found much north of this are in all cases the production of *immigrants from farther south,* — no perfect butterfly born at any considerable distance north of this assumed limit ever laying an egg the same season.

Indeed, it is probable — such is in my belief the vagrant habit of the butterfly — that a butterfly successfully hibernating farther south may fly to some distance still beyond this before depositing all her eggs; and the progeny from these, though born so far north, would again lay eggs. But by far the greater part of the eggs laid beyond the limit -- almost the whole of them — are laid by butterflies of the second generation, born farther south, and wandering northward in search of "fresh fields and pastures new;" and their progeny will not lay eggs the same season.

This, let it be at once asserted, is a theory only, made to explain the observed facts, but appearing at present the best way of explaining them. Let us state some of these. We have already seen that in West Virginia the butterflies appear as soon as the first shoots of milkweed arise above the ground in April. The same is the case at least as far north as Newburgh, New York; that is, the first butterflies seen are those which by their faded colors are believed to have hibernated, and they lay their eggs on the milkweed when it first comes out of the ground. At Newburgh the season is perhaps three weeks or a month later than in West Virginia, and at least as far north as this, it would seem to be perfectly easy for the hibernating butterfly to have flown from even as far as Florida. It would have had to fly no faster than a man walks, counting only the daytime and deducting half of that for bad weather.

Still farther north, where observations have been quite as numerous as south of it, a hibernated butterfly of this species is an extraordinary rarity, and the first butterflies of the season are those which appear when the milkweed is already a foot or more above the ground, synchronous with or slightly later than the descendants of the hibernators farther south, fresh and bright butterflies, certainly born the same season. According to my observations in different parts of New England, they are long-lived, laying but a few eggs at a time, and probably not depositing all until several weeks after birth. The butterflies are on the wing the rest of the season, — first the parents, next their children, the parents gradually dying out.

There is no evidence whatever of a second brood of *caterpillars* in New England; that is, that these children ever lay eggs the same season. In all double-brooded butterflies known in New England, the limits of their broods can be told, sometimes it is true rather vaguely. Still there appears to be more definiteness here than farther south, where the summer is longer; and from observations made in numerous places by scores of individuals, it appears quite plain that our Milkweed Butterfly passes in New England but once through the entire cycle of its changes; and though the theory here proposed finds no known counterpart elsewhere, it appears to be gaining ground among observers. Of course it will require many further observations to establish it.

Among butterflies it is only when

large numbers are concerned that their movements attract attention. Very many such observations are on record, but the purpose of the movements has rarely been even guessed at. With most butterflies which have more than one brood in a year, and notably in our Milkweed Butterfly, the number of individuals upon the wing toward the end of the season is far greater than at the beginning, and it would therefore be easier to detect massive movements in the later than in the earlier part of the season. Now, nobody has ever observed that the prevalent movement of our butterfly in the earlier part of the season was northward, as on the theory here upheld should be the case, and this is undoubtedly its weak point. Nevertheless I look confidently to seeing this observed and proved at no distant day, particularly by observers in New York and Ohio.

The fact that the butterfly has been seen on the shores of Hudson Bay and in the Athabascan region, beyond the limits of the growth of its proper food plant,* is another proof of its northward migration in the warm season. But of the return movement in the autumn there is plenty of evidence. Apparently wherever it abounds in any part of the United States, certainly from Ontario to Florida and from Massachusetts to Iowa and Missouri, the butterfly shows a tendency in the autumn to swarm in immense numbers, and at night to settle down upon trees or shrubs, so as to change the whole effect in color. I will give one instance of the many that have been published. Writing of Brigantine Beach, New Jersey, in 1885, Dr. John Hamilton, of Alleghany, Penn., says: —

"The multitude of this butterfly that assembled here the first week in September is

* Asclepias is not found about Hudson Bay nor north of the Saskatchewan, according to the Canadian botanists; and although Apocynum does occur both in the valley of the Moose River and in the Athabascan region, it is too exceptional a food plant to be considered.

almost past belief. Millions is but feebly expressive, — miles of them is no exaggeration. On the island is a strip of ground from one hundred and fifty to four hundred yards wide, and about two and one half miles in length, overgrown with *Myrica cerifera* (bayberry). After three o'clock these butterflies, coming from all directions, began to settle on the bushes, and by evening every available twig was occupied. To see such multitudes at rest, all suspended from the lower sides of the limbs, side by side, as is their well known custom, was something well worth seeing. One evening I travelled more than half the distance of their encampment, and learned that it extended the whole length and breadth of the bushes. In the morning they gradually separated, and did not appear unusually numerous during the day, but in the afternoon they came again as described. I found them on the second, the day of my arrival, as related above; and this was repeated daily till the sixth, the forenoon of which was rather calm and sultry. A storm of wind and rain came on about two o'clock, p. m., continuing till midnight. The

4

next afternoon few came to camp; the great army had disappeared. But how? when? where to? During the next few days they appeared again in considerable numbers,—about as they had been observed in former Septembers,—but insignificant when compared with those that preceded. The males and females were about equal in numbers. Not a single stalk of their food plant (Asclepias) grows on the island." *

This gathering of the clans is but the first step in the southward movement, which also has been observed in numerous places. One of the earliest accounts we owe to Riley, who states that P. B. Sibley, of St. Joseph, Missouri, on September 19, 1868, saw "millions of them, filling the air to a height of three or four hundred feet for several hours, flying from north to south."

I was myself fortunate enough to observe a movement of this sort during the autumn of 1888; between nine and ten

* Can. Ent., xvii. 204.

o'clock in the morning of September 2, while sitting on the piazza of a house facing the sea-shore at Hampton, N. H., and only a stone's throw from the water, a continuous stream of these butterflies passed before me toward the southwest, following the line of the sea-coast, with the wind about northwest. There were never less than three or four directly in front of me, often a dozen or twenty. In the hour that I watched them, I calculated that at least fifteen hundred passed me, and without exception in the same direction.

As flocks also occur in Florida, it seems highly probable that the southern movements may extend over the entire United States, and that the northern limit of the returning hibernators may be the limit within which the butterfly is double-brooded. As Riley, the first to suggest an annual migration of this butterfly, remarks: "There is a southward migration late in the growing season in congregated masses, and a northward dispersion early in the season through isolated individuals."

Another fact in support of this theory is that no one has ever found a butterfly of this species in hibernation, while there is hardly a single one of our butterflies which hibernates in the perfect stage of which there is not some record of its having been found; and yet our Milkweed Butterfly is nearly twice as large as any of these, and would therefore be more readily noticed; and if it hibernates, would naturally seek just such spots as are sought by them. It is by no means improbable, then, that in the winter the species *does not exist* north of, say, latitude 31°.

In further support of the theory may be mentioned its observed remarkable powers of flight, and particularly its commercial extension in recent years, which forms a chapter in its history quite exceptional in a butterfly; for within thirty years, or a little more, it has begun to invade so many regions of the world as to make one think at first blush that it may some day vie with *Vanessa cardui* in cosmopolitan character. The facts concerning its exotic distribution, so far as I have been able to gather them, are as follows.

It first reached the Hawaiian Islands, fully two thousand miles distant from America, some time not far from 1845 to 1850. At any rate we have the direct statement of Rev. Luther H. Gulick, who was born upon the islands, that in 1852, after eleven years' absence, he returned to the islands, and his brother drew his attention to the fact that Asclepias had been introduced during his absence, and had already become a troublesome weed; that his brother had noticed that wherever the milkweed appeared, there also the Milkweed Butterfly made its advent, a butterfly unknown until after the milkweed had been introduced.

We next find it in 1857 as far away as the Island of Ponape, in the Caroline Islands of Micronesia, a distance of another two thousand miles or so from the Hawaiian Islands. This fact we also owe to Dr. Gulick's personal testimony. He was for some time a resident of Ponape, and the butterfly was first seen by him in the year mentioned, not long after he had discovered several young milkweeds, which had sprung up in earth in which various other plants had been brought from the Hawaiian Islands in a Wardian case. The plants were brought in a missionary vessel which sailed from Honolulu, and on its way to Ponape touched only at Apaiang of the Gilbert Islands and Ebon of the Marshall Group, both low coral atolls, and at Kusaie, which is of basaltic formation and richly clothed with verdure, but where the butterfly did not then occur. It is evidently impossible that in a voyage consisting in the whole of fifty-four days, the insect in any stage or stages could have been transported in the Wardian case itself, for it easily undergoes all its transformations in warm regions in a month or five weeks at most.

If the butterflies were introduced at that time, as there is every reason to believe from Dr. Gulick's accounts, there seems no other supposition possible than that an impregnated female flew into the hold of the vessel while lading at Honolulu, and was carried perforce to Ponape; or possibly a pair of butterflies. It would certainly be absurd to suppose that a gravid female could have flown over two or three thousand miles of ocean, and in addition have appeared on Ponape Island almost simultaneously with a few plants of Asclepias. As the butterflies live through the entire winter and then lay eggs in the spring, there is nothing in any way really surprising in Dr. Gulick's statements, unless it be impossible for an impregnated female to live in enforced hibernation a couple of months without laying; when it would be necessary to suppose a pair to have been transported, which would of course be more strange.

Granting our explanation to be just, it is highly probable that it was from this single ancestor (or pair) that the swarms which have now spread over the entire South Seas, in many of which it is the commonest butterfly known, have sprung. Our knowledge of the period and extent of this later distribution we owe largely to Professor Semper, who states that the butterfly was first seen in 1863 by Captain Rachan, one of the numerous collectors of the Museum Godefroy, on the islands of the Tonga or Friendly group, again nearly another two thousand miles from Ponape. The first specimen actually obtained was secured in 1866 on Niuafau, one of the islands of this group; and in the same year caterpillars were discovered on *Asclepias curassavica*, a plant now spread quite as far as the butterfly.

We now begin to be able to record in part the rapidity of its spread, for it was first seen in Tutuilla, one of the islands of the neighboring Samoan group, in 1867; but upon Upolu and Savaii, islands of the same Samoan group, distant at the nearest some fifty miles, not until 1869. Yet in Upolu it became one of the commonest butterflies in 1870. It was not until 1868 that it was discovered at Tongatabu, one of the southern of the Tonga Islands, but in the same year it was seen in the open sea five hundred nautical miles to the southeast. In 1869 it had appeared at Rarotonga, one of the Hervey Islands, five hundred miles or more away. In 1870 to 1872 it was found on Huahine and Tahiti of the Society Islands, again five hundred miles or more distant.

So far the account of Professor Semper. But Mr. James J. Walker, who sailed in the South Seas in 1883, and nearly everywhere found this one of the commonest butterflies, states that he was informed at the Marquesas Islands (which lie to the northeast of the Society Islands, again at the distance of some five hundred miles), by a Roman Catholic missionary residing there forty years, that he distinctly remembered seeing the first specimen there about the year 1860; it should be noted that the Marquesas Islands are nearly as distant in a southeasterly direction from the Hawaiian Islands as the Carolines are to the southwest. Mr. Walker also found the butterfly on the Hervey and Society Islands, and at Oparo, one of the Andaman group, in 28° south latitude, though it had not then reached Pitcairn Island, which lies much farther east and somewhat farther north.

These statistics indicate its movements from the Caroline Islands, in an easterly and southeasterly direction, but it has also left its marks by the way, in a southward extension from this route of travel.

For it has reached Waigiou, New Britain, New Ireland, New Guinea, the Louisiade Islands, every part of the Solomon and New Hebrides groups, the Duke of York Island, the Loyalty and Fiji Islands, New Caledonia, Norfolk Island, the northern island of New Zealand, the entire eastern coast of Australia, from Cape York southward even as far as Hobart Town in Tasmania. It reached Lord Howe's Islands in 1870; Clarence River, on the opposite coast of Australia, in 1871; Melbourne in 1872, and has now extended even to Celebes, and according to Kirby, to Java.

It thus appears that it now possesses a territory in the Pacific Ocean of at least 110° of longitude and 65° of latitude. But this is by no means all; it has moved also in some strange way in the opposite direction from the American continent. It has long been known at Bermuda as one of the extremely few butterflies to be found on that island.

Specimens now in the collection of Messrs. Godman and Salvin were taken in 1864 on the islands of Fayal and Flores, but it seems not to have been since recorded at the Azores. In 1877, however, it made its appearance on the continent of Europe at La Vendée, on the Atlantic coast of France, and a number of instances of its capture in England have since been signalized. These instances are so numerous, and recorded for so many different years, that it would seem highly probable that the butterfly has been endeavoring to maintain a foothold ever since 1876, when the first instance of its occurrence was recorded.

The first specimen was found at Neath, in South Wales, in September; a second one in Sussex in the same month, and a third at Hayward's Heath in October. In 1877 one was taken at Poole Harbor. It did not appear again till 1881, when a specimen was taken in Kent in September. Again in 1884, one was taken in the Isle of Wight. In August and September, 1885, nine specimens were taken in the counties of Dorset, Devon, Cornwall, and the Isle of Wight. It was again taken in 1886 in the south of England, in Guernsey, at Gibraltar, and in Portugal.

I have spoken of this extension of its natural region as one due to commercial agencies, because it would seem that the distance to which the insect has been carried must be due to something more than its very remarkable powers of flight. The fact that the butterfly has been seen flying at sea an immense distance from land is a sufficient proof of the latter, and we should be far from questioning its power to compass with no very great difficulty one-half the extreme distances to which we know it has been carried without power of alighting. But that this should occur with a female heavy with eggs, or two individuals together, male and female (and no other supposition would permit us to understand its subsequent propagation in the regions visited) is past credence, — more especially as we have in the instance of its spread from the Hawaiian Islands to the Caroline group an almost certain proof of the method of its transport, through artificial aid. The alighting of one of these butterflies laden with fertile eggs upon some part of a vessel or within its hold would be a strange but by no means impossible occurrence; and this is all that is necessary to explain its transport over the wider regions.

That having once established itself in one of the Micronesian Islands, it could easily spread over the whole of Polynesia through the insect's natural powers of flight, will hardly be questioned. But that this has taken place not only within historic times, but within the last twenty or thirty years, as has been shown by Semper, makes it almost certain that its first introduction to the South Seas was by artificial means; for if it could have been brought about solely by the powers of flight of the insect, aided by the natural currents of the air, it would have happened long ago; and the facts that the insect has been able to establish itself wherever it chose when it got a foothold, and that until a very recent period it has not so established itself, are sufficient proofs that commercial agencies, so much more abundant in later times than formerly, have been the great means of introducing these butterflies to the islands of the Pacific. It is highly probable that it owed its first introduction to the Hawaiian Islands to similar agencies, and that its appearance in Europe is due to the same cause.

This is all I have now to say of the theory here advanced, that the butterflies of this species found annually in the northern United States and northward must be regarded as a wave of migrants from the south which have come north like the birds to breed, after which their young return, or if they fail to do so, perish. What after all is this but an exaggerated case of the perpetual flux which has been going on with all our Northern butterflies ever since at least the glacial epoch? There were certainly no butterflies here when the country was flooded with ice, and all that have since appeared are but immigrants from the South; and at the northern limits of their distribution there have no doubt ever been a continual struggle and an ebb and flow of life as a severer winter or an excessive drought destroyed the species *in toto* over a certain range, replenished later by migrants from the border.

In short, the present distribution of life is the result of the constant attempt of every species to extend its territory, to gain more room to live, the outcome of the balance of forces which have held all in restraint. And though our Milkweed Butterfly presents phenomena in its distribution of an apparently exceptional kind, showing it to be an unusual vagrant, it is probable that any species we might select for discussion would in the last analysis serve equally well to show how the struggle for room to live in has been but one phase of the ever-present struggle for existence.

V.

The Critical Periods of its Life.

NOW-A-DAYS it is not necessary to insist upon "the struggle for existence;" popular literature has made it a household phrase. Every creature, all its life long, may be said to be subject to the bondage of danger and fear; and every creature is furnished with structural or physiological resources to meet danger. Still, there are in the lives of the lower animals, as well as of man, certain critical periods when more than at others they are liable to destruction.

Although through most of its life protected to a certain extent, as we shall see, by its noxious qualities, I see no reason to suppose that in its egg state the Milkweed Butterfly is not subject to the same decimation to which I believe all or nearly all butterflies are doomed. From my experience (not very extended) in observing eggs of butterflies laid in the free air, I should indeed judge that decimation was rather a feeble term to apply to the destruction of egg life. I have in fact seen spiders at their meals upon them; and Mr. W. H. Edwards, speaking of the Violet-tip, *Polygonia interrogationis*, once wrote: —

"When it is considered how many eggs are laid, and that so short a time intervenes between the egg and the imago, it is surprising how few butterflies of this species are the result. From eggs that were laid on my vines in July and August, amounting I am sure to many hundreds, very few larvae were hatched. . . . The eggs are destroyed by spiders and various insects by wholesale. I have had the contents of one of my [breeding] kegs swept away in a night, leaving not a trace of shell behind."

Not a few eggs, too, are eaten dry by minute parasitic Hymenoptera so small as to look like mere grains of dust. Little attention has been paid to these by naturalists, but from my fortune with eggs I have found in the open air and attempted to rear, a good tenth must be ruined in this way; they will even invade the muslin net under which eggs are laid by butterflies in captivity, and pierce them. Among the dozen and a half of our butterflies whose eggs have been actually found so pierced, the Milkweed Butterfly must be counted. If, then, any possible noxious qualities in the egg are of no avail against that speck of dust the Trichogramma, spiders and crickets are not likely to eye it askance. It is highly probable with this butterfly, as it is certain with many others, that the egg is the most perilous period of its life, one whose mortality will show the greatest percentage of loss to the species.

To counterbalance this, the egg state is usually the shortest of any of the four the saved remnant are to pass. In the Milkweed Butterfly, its duration does not exceed three or four days. It is very rarely less than that in any butterfly, even in the hottest season or region, but is sometimes prolonged considerably; and curiously enough, this is particularly the case in those same species in which the larval stages are also prolonged, as if a certain inertness belonged to the whole life. In view of the dangers to the egg, the fact we have already mentioned, that some species winter solely in the egg state, is not a little surprising. It should be noted, however, that with almost no exception, the species of temperate regions known to winter in the egg belong to the gossamer-winged butterflies, the Lycaeninae, the shells of whose eggs are as a rule of exceptional thickness; and the same is true (or the eggs are very coarsely ribbed) in every known case outside this group, with a single published exception, which I believe erroneous.*

* *Coenonympha pamphilus,* said by Assmuss to winter in western Russia in the egg. This butterfly is double-

Small as it is, the newly hatched caterpillar has almost equal peril, and from the same larger enemies — spiders, crickets, and bugs — which have threatened the egg. Edwards, in the passage quoted, adds: "And in the same way I have lost scores of small larvae." It is highly probable, as suggested in a previous chapter, that this is the reason why the young caterpillar ordinarily devours nearly or quite all the shell it has left the moment it enters upon free life; for by removing this indication of its proximity, the caterpillar indulging in such a propensity is the more likely to live to leave descendants, and thus a habit may become fixed. But it is perhaps in greater peril, because to obtain its food it must move, and a

brooded in England, — the first brood appearing, according to Buckler, in May, impossible to have come from a wintering egg; indeed one instance is on record of pupation on April 5. It is double or triple brooded in Silesia, according to Prittwitz, and the caterpillar is full grown at the beginning of May. It must surely hibernate as a caterpillar, as Schwartz claims.

moving object, especially to insect vision, is more apparent than one at rest. It satisfies its appetite therefore at the risk of its life, and after its meal remains rigidly still.

It is probable, however, that it is at its next stage, after once moulting, that the caterpillar's danger is at its greatest. For with its growth in size, it has now become a mark for a new class of enemies, the ichneumon flies and tachinid flies, which nourish their young within its body. Our Milkweed Butterfly is certainly more exempt from danger from them than is perhaps any other of our native species, and was long thought to be totally free from them, but we already know of two kinds of four-winged ichneumon flies — a larger and a smaller — and one kind of two-winged tachinid flies which prey upon it.

I believe that it is at this early stage in their life that caterpillars are ordinarily stung, giving the worms hatched within time to prey their life long upon the nourishment meant for the bodies of their hosts. How often caterpillars taken at large and brought to the breeding cage to rear yield these concealed villains, only those who have tried it realize; nor how many such harpies may be carried within one caterpillar and the caterpillar still thrive, — a peripatetic banqueting hall for unbidden guests!

When larger the caterpillars have the birds, and if they be low feeders, the reptiles to contend with; but though one of our ornithologists says he has found the caterpillars of our commonest yellow butterfly in the stomachs of as many as twenty different kinds of our native birds, it is not probable that the destruction by birds is nearly as great as by insect foes. Against the birds they have only their form and color to oppose, through which by their resemblance to their surroundings or to some uneatable object they may escape detection or be left undisturbed;

and this resemblance is often more striking than one would believe, seeing them shut up in a naturalist's box or prepared for the cabinet. To gain any conception of it one must see them, if he can, in their natural haunts, and he will discover either how hard they are to find or what grotesque or inanimate things they appear to be.

This is not at all the case with the subject of our sketch, for the plump caterpillar of the Milkweed Butterfly, though when at rest it usually conceals itself beneath a leaf to which it clings upside down, is a most conspicuous object, with its transverse belts of black upon a white and yellow or orange ground; but in this case, and probably in a few others, such as the almost equally conspicuous caterpillars of our Swallow-tails, we are brought into that class which owes its immunity to attack to the nauseous qualities of its members, which these "warning colors" by their very conspicuousness appear to proclaim.

One would think, at first, that one danger to caterpillars might be in finding proper food supply, especially if it were known how very particular many kinds of caterpillars are, — starving to death unless they can find the single species on which they feed. Doubtless this is an occasional cause of death. I once found several eggs of *Anthocharis genutia* on a slender Arabis which would not have yielded enough nutriment for one caterpillar, and after an hour or more of search — and I was very eager to find more eggs — could not find another stalk of that or any similar cruciferous plant (on which alone the caterpillar is supposed to feed) within an area of several acres. But such cases are rare, and it is to the parent the credit is to be given, who with careful search almost invariably selects the very choicest spots for the progeny that shall spring from her eggs.

A more obvious danger is to be found in the necessity for those repeated sloughings of the skin which its growth necessitates; at such times the caterpillar is completely helpless, generally incapable of more than a feeble wriggle, and continues in this condition for hours, sometimes for days at a time. Sometimes it seeks special concealment for the change, but in a great many cases, strange as it seems, ecdysis occurs in plain sight of all, upon the surface of a leaf; it has then only its immobility to protect it.

A similar critical period is found during the change to chrysalis, which generally occupies a day or two; this frequently occurs under protection of some concealment, though this is less often the case among the brush-footed butterflies, to which our milkweed species belongs, than with others. But when the change has taken place and the at first flabby chrysalis has gained its form and color, the matter at most of but a few hours, there is rarely an instance where resemblance or color-harmony with its surroundings is not a very effective protection; and in many the angularities of the surface, like the spines of many caterpillars, may be an additional source of safety. It would seem, indeed, that having fairly reached the chrysalis state, there was relatively little danger until it was upon the wing. It is true that many chrysalids give forth not the butterfly, but two-winged or four-winged parasites, but these are a legacy from the caterpillar and not an independent production; these insect parasites are not known to sting the chrysalis.*

It is usually but a meagre remnant that passes through all these stages to

* I had supposed this to be absolutely true, but Howard, in his excellent account of the biology of one family of these parasites (Proc. U. S. nat. mus., xiv. 569), says: "The pupa [of Lepidoptera] itself is seldom attacked, yet certain of the Pteromalines which preferably oviposit in larvae about to transform will also lay their eggs in just-formed pupae. The same is the case with certain members of the genus Chalcis, particularly those parasitic upon diurnal Lepidoptera, and I am not sure that *C. flavipes* does not oviposit by preference on the fresh chrysalids of *Chlorippe clyton* and *Agraulis vanillae.*"

finally attain the winged state. Probably in the Milkweed Butterfly the remnant is exceptionally large, but with the mass of our butterflies it seems extremely doubtful whether five per cent of the embryos which are deposited in their egg-shell ever attain their majority; and when these have gotten them wings and fly away, new dangers interpose. There must be more or less delay about laying the eggs; in many species the eggs are not ripe to lay for several days, in some apparently not for weeks; suitable places must be chosen, and in nearly all instances the eggs must be laid one by one, and are laid on different plants; all of this of course takes time, and only in sunshine can they or do they so occupy themselves. Meanwhile there come the storms which destroy them in large numbers, and the birds which snatch them up; especially do the more sluggish females suffer, heavy with their burden of eggs. It seems quite safe to say that not one half the possible eggs of a given brood of butterflies ever get laid at all.

And so it comes about that for every pair of butterflies a given season, with its potentiality of a brood of hundreds, the next season witnesses but still one pair. The balance of Nature is kept up. Yet now and again there are fluctuations, beats of the biologic pendulum. One year vast numbers of one kind are seen, which was scarce or almost not to be found the very year before. This is probably to be explained by the fact that their scarcity the first year meant paucity of food to their parasites, which consequently starved, and were not present in sufficient force the second year to make their usual inroad upon their numbers. Just so does the entire animal world show a struggle between herbivore and carnivore for the occupation of the ground. "Increase and multiply" is the primal law of each.

VI.

A Favored Race: Mimicry and Protective Resemblance.

RILEY tells us that in Missouri the tachinid parasites of the Milkweed Butterfly, its most meddling insect foe, are sometimes so active that not one in fifty of the caterpillars escape them; yet it will, I think, be agreed by all observers that as compared with the caterpillars of other butterflies it enjoys a very considerable immunity. Is it possible that this is simply because it is not attacked by birds or toads? Its "warning" colors, at any rate, are more likely to be the result of immunity from the attack of vertebrate than of insect foes, and the former are of a relatively greater importance in the tropics, which it must not be forgotten is the real home of this insect, than in the temperate region.

Nor should it be overlooked that the three most striking insects which — in New England at least — ordinarily accompany the caterpillar upon the milkweed, the caterpillar of the moth, *Euchaetes egle*, the longicorn beetle, *Tetraopes tetraophthalmus*, and the chrysomelid, *Doryphora clavicollis*, are equally conspicuous and have similar coloring, a contrast of black and orange in broad markings. Have they, perchance, gained these colors by unconscious mimicry? Why should four such striking insects with similar colors preponderate upon the milkweed?

However this may be, — whether or no the gayly banded caterpillar and the gold-and-black-dotted pea-green chrysalis of the Milkweed Butterfly are specially protected from vertebrate foes, there can be no doubt that this is the case with the perfect butterfly. Indeed all the members of this group of insects the world over, so far as known, have a more or less rank, in our species a carroty, odor; and some of them contain a pungent fluid which will exude under pressure and stain the skin. They are evidently malodorous or nauseous to birds, and their easy movements on the wing are an added proof that they are rarely or never then attacked.

One observer in Brazil, watching a pair of puff birds catching butterflies to feed their young, noticed that the butterflies of this group were never attacked, though flying lazily about in great numbers. Their abundance wherever found — and they frequently swarm — is another silent evidence of their safety on this score; and since the statement was first made, thirty years ago, that they were probably proof against attack on the ground of their unpalatableness, it has, I believe, never been denied by any observer, and has been so many times verified and confirmed that there is now general consent to the proposition.

But this is only the beginning of the matter. Here again we meet with the old story of "the struggle for existence." Life is such a warfare that artifice and deceit are to be looked for on every hand. Given a favored race, it will be a gain to their unfavored persecuted friends to resemble one of them, and so a prize — the prize of a better hold on life — is offered for a forgery. It was an astonishing fact that was brought to light by Bates, — that a group of butterflies occurred in Brazil of vivid coloring and slow and easy flight, which were the constant subjects of mimicry by butterflies of quite a different type, normally white and tolerably uniform in color, but which had so changed their livery, and even the form of their wings, as closely to resemble the objects they mimicked in brilliancy of color and variegation, and even in mode of flight.

Some, says he, "show a minute and palpably intentional likeness which is perfectly staggering." Indeed, the likeness proved so close that even after he became aware of the mimicry his practised eye was often deceived. Or if he wandered to a new locality, where occurred a new set of Ithomyiae (the most numerously represented among the mimicked genera), the Leptalides (the mimickers) would vary with them so as to preserve the mockery, band for band and spot for spot. It is now known that wherever these protected butterflies are found, the world over, they are accompanied by a set of mimicking forms of some totally different group. We have in our own country two such instances of a conspicuous kind, one species of Basilarchia (Nymphalinae) mimicking *Anosia plexippus* (Euploeinae), and another species of Basilarchia mimicking *Tasitia berenice* (Euploeinae).

The fact of a resemblance so close that

it is to all appearances a "palpably intentional likeness" is impossible to question. But how explain it? How can a butterfly change its appearance to such a degree? "Can the Ethiopian change his skin or the leopard his spots?"

The answer, as Bates clearly saw, was to be looked for in the same direction as when accounting for the assumption by animals of the color of their surroundings. Both are produced in the same way, and have the same cause and end. It is only by keeping in view this tolerably obvious truth that we can explain all the freaks of mimicry. "The specific, mimetic analogies," says Bates, "are adaptations, — phenomena of precisely the same nature as those in which insects . . . are assimilated in superficial appearance to the vegetable or inorganic substance on which or amongst which they live."

To gain an idea, then, of the processes by which the "staggering" examples of mimicry are produced, we must look first at the simplest forms of protective resemblance. Go to the seashore and observe the grasshoppers among the beach grass. They fly up at your approach, whiz off a rod or so, and alight. Can you see them? They are colored so nearly like the sands they live upon that detection of one at rest is almost impossible unless one has seen it alight. On yonder grassy bluff, a stone's throw away, you will find none of them, but other kinds equally, or almost equally, lost to sight by their harmony with *their* surroundings. What chance of life for either if they suddenly changed places? They would be so conspicuous that every passing bird or other insectivorous creature would sight them.

Of course these protective colors have been gained by very slow steps. Every grasshopper that lived by preference among the sands was liable to be eaten. In the long run just those would be eaten which were most easily seen. One which varied in coloring in never so small a degree, so as to be less easily seen than his brother, would live to perpetuate his kind, and his brother would come to an untimely end; the progeny would show the fortunate variation, and be more likely to be spared to transmit in increased volume the probability of the happy coloring.

Given, then, a brood of grasshoppers that find their preferred food in sandy spots, and unless other and more powerful forces act upon them, it *must* result, from their liability to be eaten by creatures fond of grasshoppers, that in time they will resemble in coloring the sand on which they live, — it is impossible that they should not. Any creature not specially protected by nauseousness or habit or special device of some sort must in the very nature of things, if it is to live at all, have some other protection; and that afforded by color and pattern is by far the most common. The world is made up of eaters and eaten, of devices to catch and devices to avoid being caught.

We may apply the same reasoning to two kinds of butterflies subject naturally to the same class of enemies; that is, living in the same region and flying at the same time. If one has the slightest advantage over the other in the fight for life, by being, for instance, distasteful to one class of common enemies, so that these forbear to attack it after experiment or by instinct (the result of ancestral experiments), and there be among the less favored flock, here and there, an individual which, under circumstances favoring it, such as distance or shadow, may more often than its fellows be mistaken by the enemy for one of its distasteful neighbors through its possession of a little more than usual of a certain tint on a part of the wing, a little larger spot here, or more of the semblance of a band there, — how small soever this difference may be, it must, by the very laws of natural selection, be cherished, perpetuated, increased, by slow but sure steps. Nor is there any limit to its increase except its absolute deception of the enemy. So long as there is the slightest advantage in variation in a definite possible direction, the struggle for existence will compel that variation. Knowing what we now know of the laws of life, mimicry of favored races might even have been predicted.

It would seem, then, to be plain that all cases of protective coloring and mimetic form come under one and the same law, and have been produced by the same means (the survival of the best mocker), whether the object imitated be animal, vegetable, or mineral. The actual outcome is, indeed, vastly more surprising in some cases than in others, — in some "perfectly staggering," as Bates says; yet though there be to all appearances a "palpably intentional likeness," there is found to be no intention in the case so far as mocker and mocked are concerned, but the result of a natural selection against which neither could even strive, and of which neither was ever conscious.

The process has been a long one, so that in the case of parastatic mimicry, as that form which involves the copying of one's fellows might be termed (or if one prefers an English term, neighborly mimicry), we may readily presume far less difference between mocker and mocked when the mimicry between them first began than now exists between the mocked and the normal relatives of the mocker. It is argued, indeed, with great show of reason, that as the resemblance grew stronger the birds became more sharpsighted, which reflected again on the mimicry, and that thus the final departure from the normal type was intensified; but this assumption is not necessary.

It is to be presumed that the actual colors found in a mimicking butterfly are, with rare exceptions, such as existed somewhere in the ancestral form. In the case of our own mimicking Basilarchia, for example, whose orange ground tint is so totally at variance with the general color of the other normal members of the group, it will be observed that all the normal species possess some orange. Without this as a precedent fact, such perfect mimicry might perhaps never have arisen. Individuals among the normal species vary somewhat in this particular, so that it is easy to suppose that some of the original *B. archippus*, with more orange than usual, may have escaped capture, on occasion, from this cause. From such a small beginning, such as one may now see every year in *B. astyanax*, sprang doubtless the whole story, and at last we have a butterfly which has for a ground color of both surfaces of the wings an orange which is the exact counterpart of that of *Anosia plexippus;* by reason of which, in all probability, it enjoys a freedom from molestation comparable to that attributed to *A. plexippus*, so that it ventures more into the open country than its allies, and thus gains a wider pasturage and surer subsistence.

It is not necessary for our purpose to enter here into further details about the various forms and phases of mimicry; * it is sufficient to point out that in some instances only one sex, and that the female, departs from the livery of its kind to mimic that of its pattern; that in others a normal male of the mimicking group may have several forms of female, one mimicking one, another another, of the protected type; that some butterflies of the protected group are mimicked by others within the same group; and that butterflies of other than the protected group are the subjects of mimicry.

Of this last we have one of the most

* Those wishing to pursue this matter further are referred to my paper on the subject in the Atlantic Monthly for February, 1889, printed also in my "Butterflies of the Eastern United States," as Excursus xxiii. pp. 710–720, to which latter will be found appended a bibliography of the subject.

curious cases in our own country. One of our fritillaries, *Semnopsyche diana*, is remarkable for the great difference in coloring between the male and the female: the male would be taken at once for a fritillary from the general tone of coloring both above and below; but at first glance one would say the female was a Basilarchia (a butterfly of quite a different tribe), from its close resemblance to *B. astyanax*. Indeed, when first seen alive by Edwards, then on the hunt for the species and ignorant of the female, he actually thought it a species of Basilarchia near *B. astyanax*. Its range in the South, too, is completely covered by that of *B. astyanax*.

The fact of mimicry in this instance must be regarded as unquestionable; but the strangeness is the greater that in our country it is just in this genus Basilarchia, here mimicked, and in no other, that striking mimicry of the "favored tribe" occurs. It is a case somewhat parallel to mimicry within the favored tribe, but the more striking that the cases mentioned stand alone among all the American genera. Mimicry is far more common (even relatively) in the tropics than in the temperate regions; so, too, are insectivorous animals. And it should be remarked that if we are correct in our opinion that our Milkweed Butterfly is, in the strictest view of the matter, an autochthone in our country only in the extreme South, then it is easier to explain the mimicry of Basilarchia, for there would not seem to be any occasion for mimicry of *B. archippus* in the higher North. I have myself never *seen* a butterfly (but often a moth) pursued or snatched by a bird, though I once came across the evident signs of capture in the scattered wings of *Euphoeades troilus* on a damp roadside where I had just missed its coursing back and forth. Mimicry in the perfect stage is only needed where their vertebrate foes are numerous and pressing.

When we take a general view of mimicry as exhibited by one butterfly for another, how strange it seems! and what an interesting illustration it is of the adaptability and pliancy of natural forces that for the evident protection of one species in the struggle for existence so exact and beautiful a resemblance should be brought about! Consider for a moment that the subjects of mimicry are at the final stage of life; they have already passed through nearly all the dangers to which the species, as a species, is subjected, — so rudely subjected that they are a mere remnant of those brought into the world with them. During the early period of their life they were exposed to vastly more dangers than they can now experience. At times they were absolutely helpless, without the power of movement. They are now endowed with powers of flight sufficient to thwart the purpose of many a foe; yet it is in just this period that these special and extraordinary provisions for their safety — and for the accomplishment, so far as the species is concerned, of the end of their life — are given them. All this has been brought about for the sole purpose of prolonging their aerial life for the exceedingly few days which are necessary for pairing and the deposition of eggs. The more we contemplate so strange and perfect a provision, and the means by which it is accomplished, the more are we impressed with the capabilities of natural selection, and begin to comprehend how powerful an element it has been in the development of the varied world of beauty about us.

VII.

Scent-Scales: a Question of Sexual Selection.

PERHAPS it will be remembered that in describing the Milkweed Butterfly in our first chapter, the male was said to be distinguished by the presence of a small but conspicuous black pouch or pocket, like a swelling or blister, on one of the veins of the hind wings. It is so heavily clothed with scales that we hardly notice that it is a pouch, open by a narrow slit on the upper surface of the wing on the side farthest from the vein to which it is attached. What does it contain? And what is it for?

These questions open to us one of the most curious, one of the most interesting, and yet one of the least studied chapters in the life and structure of butterflies. The interior of the pouch is filled with scales attached to the membrane, of which there are two kinds, differing in form and in setting: one kind is long oval, with uniform margins, and which differs from the scales exposed on the surface of the wing only in being slenderer and in not being toothed or notched at the tip; the other kind, however, can scarcely be called scales, for they are more properly rods, seated in the centre of little raised rings which are quite absent from the base of the other scales, whether within or without the pouch. The pouch is evidently for their protection, and we naturally ask what they are for, that they should be so carefully guarded.

To answer this inquiry, we shall have to go further afield, and see what other butterflies may have comparable with these; and we may well be astonished at the revelation that will be forthcoming, for we shall discover these singular scales in every direction and in every form, but usually concealed in major part or entirely, either by the other scales or by folds of the wing membrane.

Sometimes they differ but little from ordinary scales, or may be lopsided; at others, they assume the form of a battledore and are studded with beads; in many they terminate in a longer or shorter fringe of the most excessive tenuity, quite invisible without a tolerably strong power of the microscope; very generally they are exceedingly slender and even then may be fringed at the tip; or they may assume the form of hairs shaped like a shepherd's crook, or a straight rod with a whip-lash at the end; or a twisted ribbon or a chain of links; or they may be spatulate or even fan-shaped at the extremity. The range, indeed, of their form is strikingly at variance with their concealment and microscopic size, and they are infinitely more varied than the exposed scales, which are almost always toothed or combed at the tip, which is rarely or never the case with these.

They are sometimes scattered more or less sparingly over the upper surface of the wings, all but their tips concealed even from the microscope by the overlapping of the ordinary scales; but they are generally gathered more or less abundantly into clusters on either surface of the wings, ordinarily on the upper, in definite patches visible as a sort of clouding to the naked eye, or along veins which they then appear to thicken. In nearly all, if not all, of these cases the visibility to the eye does not, however, result from the multitude of the special scales, but from the exceptional development and varying color of the attendant normal scales, which are either larger, darker, or more opalescent than their neighbors, or are raised or turned at an angle which catches the eye by the general effect; it is much as if the special scales we are investigating were playing hide-and-go-seek among the others, crying "here we are" by signs, but still hiding from view.

In other cases these patches are concealed by being placed where the front and hind wings overlap; or, as in the case of our Milkweed Butterfly, a special membranous pouch is developed for their benefit. In one great division of the Skippers the membrane of the front margin of the fore wing is expanded and folded over upon itself, but so deftly that it is often hard to see that this is the case; and in many of the allied Swallow-tails, the plaited part of the hind wings next the abdomen will be found put to service in a similar manner; while the space within, in both these instances, is so crammed with these special scales that when the folds are opened the scales may be removed *en masse* as a bunch of silken floss.

The study of these scales has only just begun, and the above gives only a faint notion of the wonderful variety in form and curious disposition so far seen; but we have learned one thing at least which gives a clew to their meaning and purpose. They are absolutely peculiar to the male sex, just as much so as that whole class of structures known as secondary sexual characteristics, upon the presence of which Darwin bases his theory of sexual selection, — the one prime feature of his philosophy not subscribed to by his colleague in the introduction of the modern doctrine of evolution, Wallace.

On account of this restriction to the male sex they have been termed androconia, or male-scales; and Wallace may well employ them as an argument upon his side, for while they will not yield the palm to other secondary sexual features in variety and beauty, they are so placed that with the exception of such cases as the folds of the hind wings of Swallow-tails (the wider expansion of which may open the fold and expose the androconia), they are concealed either absolutely or all but their tips, where at the most nothing but a fringe or an edge is exposed, and the size of this so infinitesimally small that the wildest adherent of the hypothesis of clear vision by insects would hardly regard vision as a possible factor in the case.

The patches of accessory scales might be regarded differently; but these are not always present, and an explanation must cover both cases, whence the presence of *absolutely concealed* androconia in as great a variety of form and position as that of other secondary sexual characteristics must be regarded as a fatal blow to Darwin's view of sexual selection. Otherwise there should be no need of his efforts to show how the male displays these particular charms to his consort at the breeding season.

But we know more about these androconia. About fifteen years ago, Fritz Müller, a naturalist who by his researches in various fields has done much to bring new evidence in support of the theory of evolution, astonished naturalists with a long list of odors emitted by butterflies and moths; and among the sources of these odors he claimed various patches of scales, which are nothing more nor less than those where androconia lie concealed, as he has pointed out in a series of papers where these are figured and termed scent-scales.

This view of their function has been found more plausible since minute canals have been traced through certain androconia, canals which in some cases continue through and open at the extremities of the delicate threads which form their fringe; and also since Weismann has clearly shown that there is a living tissue in the wings which would allow of the production of an odor through local active scent-glands. Moreover the number of instances of aromatic butterflies in which the odor is referable to the androconia is constantly increasing, although as this odor is lost after death, observations on this head can only be made in the field.

A few instances may suffice, all of which, it must be remembered, are confined to male butterflies.

Antirrhea emits a strong odor from a patch of scales near that part of the hind wings, which is covered by the fore wings, and which is further protected by a curving mane of pale buff hairs; a faint odor "resembling that of sable fresh from the furrier's shop" is given out in Stichophthalma by a patch on the hind wings accompanied by an erectile wisp of hairs; a black spot of scales near the base of the under side of the fore wings in Didonis gives out a musk-like odor.

In our own fauna we have a striking instance of this odor in the scent emitted by the scales clustered along the median nervules of the upper surface of the fore wing in *Argynnis atlantis*, — scales which have a distinct odor of sandal-wood, so strong that it is hardly possible to handle living specimens without recognizing it, and which I have known to be retained for many weeks after death, when the insect had been enclosed at capture in a paper envelope. This is the more remarkable because I have never detected the same or any odor in the two allied species of *Argynnis* of New England, which nevertheless possess precisely the same scales, and in the same position. Finally, we have the instance of our Milkweed Butterfly; the scales found in the little pouch which we are considering emit a slightly honeyed odor over and above the carroty smell which all the scales possess. All these are instances from a single family of butterflies.

In other families may be mentioned our common blue butterfly of the spring, *Cyaniris pseudargiolus*, which has an exceedingly delicate odor, which I can only describe as that of newly-stirred earth in the spring, or of crushed violet stems; our large *Callidryas eubule*, which has a slight violet odor; *Melete*, where the upper side of the wings, especially if parted after having been closed some time, gives a rather faint but "very delicious perfume;" our white butterfly, *Pieris oleracea*, where a faint odor of syringa blossoms may be detected; the European *P. napi*, said by different writers to have the odor of thyme, verbena, orange, or balsam; *Papilio polydamas*, which, according to Müller, has "two sets of males emitting equally strong but quite different odors," — a case of diosmism!

These instances, with the many others known, clearly prove that very many butterflies emit odors, apparently in most cases agreeable to us, which it is in the highest degree probable are emitted through microscopic canals, which course through microscopic scales to microscopic glands at their base within the wing membranes; that while these are in some cases easily perceptible by man, he is unable to detect any odor whatever in their very next neighbors, which possess the very same apparatus. The only explanation of this which appears plausible is that odors exist imperceptible by us but perceptible by them, an explanation which requires us to attribute to these insects an exceedingly delicate and high perception of odors.

This requirement will hardly appear to present the remotest difficulty to persons who have witnessed what is termed the "assembling" of moths; that is, the habit of the males of many species, notably of the Bombycidae, to collect in swarms around a female that has been disclosed from its cocoon entirely out of sight of and often at a great distance (sometimes miles) from her visitors, — in a dwelling, for instance, in the middle of a great city. Instances of this sort are numerous and well known, and compel us to admit a power or a delicacy of sense perception in the direction of smell which opens the door to many mysteries in the understanding of the lives of these humble creatures; they do not so much "walk by sight" as fly by smell!

This, then, is the probable function of all these androconia, as we know it to be the property of some, — a property which seems founded in and not accessory to their structure; we may easily believe that the concealment of the androconia is to prevent the too rapid dissipation of the odor, to offer the opportunity for its sudden flush, — in other words, to place it under some control.

The exquisite and varied form of the androconia is another matter. They differ marvellously from ordinary scales in the variety of their form and exquisite structure. Ordinary scales seem made on a single pattern; they are minute enough, but they are huge as compared with most androconia. Why such delicate and exquisite patterns on such a microscopic scale? Who is to see and enjoy them? Assuredly not the butterflies themselves;

they may profit, indeed, by their function, and no doubt natural selection has perfected that to an extraordinary degree, well beyond our ken; but the androconia must practically be quite invisible to them. Is there not here, then, a beauty of form and of structure which is an end in itself, of no possible profit to the possessor?

[Readers wishing to look into this subject more fully will find it discussed in detail in my "Butterflies of the Eastern United States" (see particularly Excursuses xvi. xxxi. xl. lxvii. and lxx. and plates 43–51), where also references will be found to the literature of the subject.]

VIII.

Insect Vision. Does Sight or Smell most control the action of Butterflies?

IN the last chapter we pointed out the existence in many male butterflies of structures of extraordinary variety, and considering their microscopic size, of remarkable complexity, which are so hidden from sight that they can rarely or never be seen by their neighbors, even if we credit the latter with exceptional powers of vision. A lurking feeling may yet exist in many minds that they may, after all, be thus endowed; and we therefore depart a moment from the general method employed in the present work of setting forth the life of a single butterfly, to inquire whether it may or may not be true that insects, our Milkweed Butterfly of course included, have remarkable powers of sight, for then we shall be better able to interpret many of their lines of conduct.

Vision in insects with compound eyes has been a subject of discussion for very many years, and the views of naturalists regarding it have differed from time to time very considerably. The question has recently received much new light from the anatomical investigations of Patten and others, and the experimental researches of Forel and Plateau. The compound eyes of butterflies, as of other insects, are made up externally of a number of adjoining hexagonal facets, each separate facet being the exposed portion of a crystalline lens which is followed beneath by a slender tube containing, first, a terminal body, the crystalline cone or retinidium, — formerly looked upon as a second refracting medium, but by Patten regarded as a retinal body sensitive to the light,—and second, of a collection of rods.

The office of this so-called crystalline cone is the principal point in dispute. The later researches regard it as a receptacle for the termination of the nervous elements, and as performing no office in either modifying or destroying the image; while the old view regarded it as having similar properties to the crystalline lens of our own eye. Now if the later view be regarded as correct, which there seems every reason to believe, the form and nature of this receptacle is such, as Plateau points out, that an image may be formed at any point within its depth; but at the same time all the sensitive points of the cone in advance of or behind an image will be illuminated and will also to some degree be excited by the same object, so that whatever image is formed can in no way be seen as distinct, but only as entirely confused, much as happens in the human eye when the image is focussed beyond the retina.

This theoretical view can be perfectly well subjected to experiment; and this has been done in the most thorough manner by the Belgian naturalist, Plateau. At first his experiments were made almost entirely by placing the insect desired to be experimented upon at one end of a closed compartment at whose other end were two distinct openings to the light, — one simple and large enough for the escape of the insect, the other much larger but covered with a trellis or grating, so that while the actual superficial area of the open spaces might be the same in each case, admitting the same quantity of light, the trellised opening would *appear* greater. At the same time one could modify at will the amount of light which would enter either of these two different classes of openings. The insects almost invariably flew to the trellis. Numerous experiments were made by Plateau upon this basis, resulting in his concluding that insects with compound eyes did not well distinguish between two illuminated openings, being sometimes led astray by the excess of luminosity, sometimes by the apparent excess of surface. In general, he thought they could not distinguish the form of objects, or only in a vague way.

Objections were raised that in these cases it was not objects, but luminous openings, the power of seeing the form of which was tested; and also that the judgment of the insect was brought into service under unnatural conditions, so that the experiments proved nothing very definite or decisive regarding the actual power of vision on its part. Thereupon Plateau devised a new method by which experiments could be made, obviating all these objections, and has carried out these experiments even more carefully and extensively than the previous, instituting, moreover, comparative investigations with the vision of vertebrates under precisely similar circumstances.

To do this he constructed what he has termed a labyrinth, — a table covered with a large number of vertical barriers placed in concentric series in such positions that the creature must take a very circuitous course among them to escape. Of course only crawling insects could be experimented on, but the structure of the eyes is essentially the same in all. Care was taken that the coloration of the surface should be of a neutral tint, and the vertical barriers were painted of various colors, — white, brown, or black; also that the animal should begin its movements without excitement, by the quiet lifting of a glass cover under which it had been placed, near the centre of the labyrinth, when it would find itself surrounded by walls between which were abundant passages.

Where the vision was really good, the animal would be expected to move in a serpentine course between the obstacles, never striking them, usually moving toward the opening which was largest or nearest. When, however, the power of vision was to some extent defective, so that the animal seemed to be aware of the existence of an obstacle only when it had almost reached it, then the movements should be made in a series of zigzags which would change direction somewhat sharply, shortly before the barriers were reached. Or if the vision were absolutely defective, the creature would be likely to find its way only by first striking the objects and then moving around them.

The result of his experiments proved that vertebrates had complete vision, directing their movements with ease without striking any of the obstacles, moving in the nearest path; while insects acted in all cases as if they had a veil before their eyes, — their change of direction before reaching the barriers being such as to indicate that it was only when they reached the shadow of the obstacles before them, when they could distinguish some difference in the intensity of light, that they turned aside to avoid such obstacles.

The result of these experiments has been so uniform and so clear that however the actual anatomical structure of the eyes of insects may be regarded, there can be little doubt that their vision is so extremely imperfect that they perceive sharp images of nothing immobile, and therefore do not distinguish the precise form of objects, though they can readily distinguish objects in motion. Indeed, they are particularly keen in this sort of vision, so that their sight must be best while upon the wing; for in this case it is the same as if they were at rest while all the objects about them were moving. So too, they can distinguish masses of color, but not pattern, except in the vaguest way. The comparative experiments revealed an enormous difference in the behavior of vertebrates and insects under precisely identical circumstances, — the former acting as if they possessed human vision, the latter as if they could distinguish the form and boundaries of objects in a most imperfect way, at the best.

"A flying insect," says Plateau at the conclusion of his various experiments, "has a very lively perception of light and shadow, so that without distinguishing as we should do all the details of its route, it knows how to avoid all masses, such as the trunks of trees, bushes, rocks, walls, etc., and passes them at a convenient distance. Caught from any cause in a mass of shrubbery or any other group of vegetation, it takes advantage, when it wishes to pass on, of those passages through which the greatest amount of light filters, or as between two equal in this respect, of such as seems to it to offer the most room. If the wind move the leaves, these openings may oscillate, but thanks to its good perception of movements, the insect can then see them better. In flying, the insect moves in undulations so as to follow the direction of the displacements and to traverse the openings without striking.

"When its mode of sustenance necessitates a visit to certain flowers, it moves toward them either with certainty, in being guided by its sense of smell only, if its power in this direction is well developed, or by chance if its olfactory powers are relatively slight. Incapable of distinguishing by their forms flowers of the same color, it goes directly toward the colored spots which to it mean corollas or inflorescence, turns, hesitates, and does not decide what to do until the distance has become sufficiently slight to enable it to determine by the odor whether or not it has found what it seeks.

"The sense of smell only, or this combined with visibility of movements, assures the meeting of the sexes; and finally it is the perception of movements which warns of the approach of an enemy and permits escape in time.

"This brief statement is sufficient to show how an insect with facetted eyes, though it only has a confused visual perception of objects at rest, frequently acts in a manner to suggest to one who does not closely analyze the phenomena that the eyesight of these creatures is as distinct as that of the vertebrates."

It may be added that in his experiments Plateau found that the family of butterflies called Lycaenidae, of which our tiny blue butterflies may be taken as a type, were disturbed by a moving object only when at half the distance at which one of the Nymphalidae (like our Milkweed Butterfly) would take alarm. Now, if we examine the eyes of these two groups we find a singular difference which may account for this: each of the eyes of the Nymphalidae covers the continuous surface, roughly speaking, of half a sphere; in the Lycaenidae the posterior half of this half-sphere entirely lacks any facets; indeed their ocellar globe has relatively the smallest visual surface of any butterflies; this fact at once explains their tremulous movement before alighting on an object; they seem to be forever uncertain just where it is best for them to settle.

Soon after the publication of Plateau's observations, I was interested in watching at leisure the movements of a couple of wasps searching for flies along the roof of a tent in which I lay upon my back in my camp among the Rocky Mountains. There were a dozen or twenty flies in the tent, which when not in motion were alighted on a rope which stretched loosely just below the ridgepole. The wasps were in incessant motion, and in the course of the morning were seen to capture only three or four flies, the flies usually being able to dodge them whenever an attack upon them was made. I was unable to see that a wasp accelerated its motion in the least when approaching the flies, or directed its flight immediately upon them, until within two or three inches of its intended victim; and as it often passed one by at no greater distance than this without any attempt at capture, the impression was strong that the wasp's distinct vision while in flight did not exceed this distance.

But what was most surprising was the great number of mistakes made by the wasps. Every slight stain or defect in the canvas or minute shadow upon it was repeatedly attacked by the wasps as if they supposed it to be a suitable object for food. There seemed to be no power on their part of distinguishing between a spot of color upon the canvas having no elevation whatever and an object or body resting upon it. Several times the shadow made by a fly alighted upon the outside of the tent was pounced upon by the wasps on the inside, and such objects, mere shadows or stains, were repeatedly attacked by the same wasp over and over again, often with only half a minute's interval or even less than that. I cannot now recollect exactly the estimate I made at the time (but failed to record) of the relative number of attacks upon false objects to those upon proper victims, but I am under the impression that the mistakes were to the correct judgments as twenty or thirty to one. These observations lasted two or three hours, and certainly seem to show that the vision of these insects even when in flight is exceedingly defective, judged by our own standards.

Now let us apply these conclusions (the imperfect and vague power of vision and the keen sense of smell) to two of the principal acts in a butterfly's life, having to do with the perpetuation of its kind, — the meeting of the sexes, and the deposition of the eggs for the next brood.

The presence of scent-producing androconia is supplemented by other known scent-organs in other parts of the body, principally in the abdomen, numerous instances of which have been collected by Fritz Müller, Haase, and others; indeed the literature of the subject is becoming somewhat extensive. Now the mere presence of scent organs confined to one sex is in itself ample evidence that the odors are perceptible to the opposite sex, and we have in certain specific structures in the enlarged antennal club of butterflies what are plainly sense-organs supplied with nerve endings; and inasmuch as there is no structure found in them which could subserve the purpose of hearing, or indeed of any other of the senses known to us excepting that of smell, it is the belief of physiologists that here are situated the organs of smell in butterflies.

The under surface of the antennae of butterflies is invariably naked to a greater or less degree; and more plainly in some joints than in others, little dimples can be readily seen. It is in these little pits that are situated the organs of smell; each consists of a sac-like cavity, the opening into which is often protected by cuticular processes, and at the bottom of which in the hypoderm is situated a fusiform body with a delicate conical ending extended free into the centre of the sac, its other extremity being in direct continuation of a nervous thread.

The assembling of male moths around a concealed female already alluded to, and the strange gathering of the males of our Southern butterfly, *Apostraphia charithonia*, around the female chrysalis just before and at its eclosion, so graphically described in Mr. Edwards's sumptuous work on American butterflies, are indubitable witnesses to the importance of the sense of smell in effecting the union of the sexes. That this sense is endowed with a keen discriminating quality will hardly be questioned by those familiar with the immense abundance of individuals of closely allied species in any of the warmer parts of the world, and the excessive rarity of known hybrids. It is difficult for us, with our dull powers, to appreciate it; but granted, it is amply sufficient to explain the proper union of the sexes in the heterogeneous multitude of butterflies which swarm within the tropics; and when we remember that in a very large number of cases it is impossible for the trained naturalist to discriminate between closely allied butterflies in the field (and often exceedingly difficult in the laboratory) one must be led to the conclusion that the imperfect vision of these creatures can prove in no way sufficient for the continued existence of the species, but that the sense of smell, brought to a high degree of perfection in the struggle for existence, alone has the power of saving them from extermination, by enabling each kind to choose its proper mate.

The same thing appears in the question of food for the young caterpillar just hatched; this must be near at hand, or it will perish. Yet caterpillars are very choice of their diet, some extraordinarily so. That of our Milkweed Butterfly, for instance, will eat nothing but plants of the genus Asclepias, and occasionally Acerates and Apocynum, — one belonging to the same order, the other its next-door neighbor; even in Asclepias it has its favorites.

But there are some butterflies whose food in early life is even confined, so far as known, to a single species of plant; none are indiscriminate feeders, and the great majority are restricted to a very few sorts. Moreover, closely allied butterflies may feed on widely different kinds of plants, as for example, our common yellow butterfly, *Eurymus philodice*, which lives on Leguminosae, and Leguminosae alone, and principally on clover; while its near neighbor, *E. interior*, hard to distinguish from it, has been found to die rather than touch clover or a dozen other kinds of Leguminosae, but feeds instead on Vaccinium, one of the Ericaceae, botanically far removed.

How, then, does the parent infallibly* discover the plant upon which it should lay its eggs? This is an act of instinct, one will say. But is this any explanation? We wish to know how the instinct acts. A parent butterfly that in its caterpillar life has been nourished upon willow, has no means in the winged condition of tasting the willow to recognize it, its organs for obtaining food being suited only for liquid nourishment. Nor can it be by sight.

It is true that butterflies are attracted by flowers through their means of vision. Interesting stories are told of their being deceived by painted or artificial flowers. But in these cases there is no reason to suppose that it is anything but the tint in

* The cases are exceedingly few, may almost be counted upon one's fingers, in which the eggs of butterflies are known to have been laid in free nature on anything but a plant on which the caterpillar will feed; and in those few cases the proper food-plant was near enough for the caterpillar easily to reach it in its wanderings, — within a few feet, for instance.

mass that attracts them to the coveted spot. Pray how differs the green of one plant from that of all others? In the case of those which feed upon a considerable number of plants they must have all the powers a trained botanist has at command if it be by the form of the leaves, when nearly every leaf they might properly choose could be almost exactly duplicated by another as good as poison to them. No! Anatomy and experiment both teach us that butterflies have no vision sufficiently clear for any such powers of distinction as are required of them in selecting special food plants for their young, which yet they discover in an unerring manner.

There remains, then, apparently nothing but smell. Now we know that many plants are odorous quite apart from their flowers, and that the leaves and other parts of plants, as well as the flowers, are furnished abundantly with special structures, like nectar glands, glandular hairs, and other glandular devices, from some of which odors are exhaled perceptible to our dull senses,—perhaps from many others, perceptible to keener organs; and if one with this in mind will but watch the movements of a mother butterfly seeking a spot whereon to lay her eggs, he will not fail to recognize that many of these actions seem particularly in keeping with the notion that she is at work *scenting* the various plants that bear a general resemblance in their aspect to the plant which she seeks (many, indeed, which have no such general appearance), settling or half-settling in a dozen different places in the near vicinity of the plant, reaching it by nearer and nearer approaches, and finally settling with satisfaction at the desired spot. To such an observer it will seem tolerably clear that it is to the sense of smell that butterflies owe their recognition of botanical species.

The consequences of the conclusions at

which we have arrived are far-reaching. If vision plays such a secondary part in the life of insects, then the whole structure upon which the theory of sexual selection in insects has been based is at fault, and it supports the objections to it which Wallace has brought on other grounds. It shows that the recognition of the food plant by the mother, which does not and cannot taste it, must be by some other sense than that of sight. It shows that the very high development of scent scales of varied patterns and character among male butterflies, indicating a direct sexual use, can only be understood if we regard the greater variety and brilliancy of the colors of butterflies as contrasted with moths to have no sexual significance whatever. Brilliant masculine colors may possibly have arisen in birds through sexual selection, but such an origin is impossible in butterflies with their vague vision; and as the males cannot be attractive to their mates by seductive colors, they resort to odors, and vie with each other in the production of sweet-smelling garments. It becomes clear that the exquisite beauty and variety in the butterfly world is not recognizable by themselves, and forms no element in their lives.

IX.

The Fore Legs of the Male and the Hanging of the Chrysalis: a Lesson in Classification.

FACTS, I once heard Agassiz say in one of his lectures, "are stupid things, until they are brought under some general law." It has no special interest or significance, in itself considered, to know that our Milkweed Butterfly when a chrysalis is suspended by its tail. It is curious, of course; but it has no real meaning in itself alone, — it is then a stupid, barren fact. The study of the structure or transformations of any creature has more than a merely transitory interest only when comparisons can be made with the parts and changes of other creatures, and we can ask what are the differences between them and what the causes thereof. It is of far greater interest to compare the morphologically identical but physiologically different human hand and foot than the fore and hind foot of, say, a fox, both morphologically and physiologically the same. So when we come to any repeated structure in an animal, and find it repeated in a different way, we inquire at once into its meaning and are unsatisfied until this be discovered.

Now there is one point of this sort that would particularly pique the curiosity of an inquirer if he were to study the structure of our Milkweed Butterfly; for he would soon learn that while the creature, like all insects, has three pairs of legs, it walks or rests on only two, and keeps the front pair folded against the breast, the ends hanging down. And if he were to examine this pair more closely, he would find that not only are all the parts abbreviated, but that the joints of the tarsi are all run together, particularly in the male, and that the claws, being useless, are entirely wanting; in short, the whole leg, though flexible, is atrophied, and of no actual use at all.

What is the next step the inquirer would be likely to take? Why, naturally, to see whether other butterflies were so made. Suppose him next, then, to catch a Swallow-tail Butterfly, as a larger sort easy to examine. Well! here, with slight variations in length, all six legs are precisely alike, excepting that those in front have a little flabellate appendage to the tibia which is not found on the other legs or on the fore legs of the Milkweed Butterfly. Instead of being deficient, they are redundant; hypertrophy replaces atrophy, and the leg is used like the others. If he have the spirit of the naturalist, nothing will now satisfy our inquirer until he has examined all the butterflies he can lay his hands upon,— the more so as he will find an extraordinary diversity among them, and yet among similar kinds great similarity.

It is by just such comparisons as these, applied to every part, — the subdivisions of the trunk, the structure of the antennae, the eyes, the palpi, the tongue, the wings, and the legs, — that we learn the relationships of butterflies, and group them into their various families, subfamilies, tribes, and genera. And we have to study as well the structure of the insect in its earlier stages, — the egg, its form and sculpture, the caterpillar, its shape and clothing, and the chrysalis with its special mode of suspension, its form, and the relations of its sheathed limbs. Even the habits bear their testimony, and the structure of the internal organs as well.

The proper classification of butterflies thus involves not only the carrying in the mind an endless array of detailed facts drawn from every part of the body of the different creatures in their several stages of existence, but also the proper valuation of the facts, — whether they are of considerable importance to the life of the animal, whether they may be traced through long series, whether they are correlated with others which are equally or almost equally extensive, whether they may be related to a past phase of existence now of no concern, and so on. A successful naturalist, then, is one who with the largest knowledge combines the *keenest insight into valuations*, and can most surely divine the blood relationships of the present and the past; for only so far as our classifications give us an insight into blood relationships do they have any value whatever.

To apply these remarks in more definite fashion, let us proceed to the inquiry whether the structure of the fore legs of the perfect butterfly or the mode of suspension of the chrysalis gives us any probable clew to relationships among these creatures. To do this in the briefest and simplest way it will be convenient to premise that butterflies are generally regarded as divisible into from four to six great families, — the Hesperidae, or Skippers; the Papilionidae, or Typical Butterflies (divided into two subfamilies, the Pierinae, sometimes regarded as a distinct "family," and the Papilioninae proper); the Lycaenidae, or Gossamer Wings (divided into two subfamilies, the Lycaeninae proper and the Lemoniinae, sometimes, perhaps generally, regarded as a separate "family"); and the Nymphalidae, or Brush-footed Butterflies (divided into a number of subfamilies, many of which have been regarded as "families" by different authors).

The "family" or "subfamily" value of a group is of relatively little importance as compared to determining who are its neighbors, and in all the varying cases given above there is no question in this particular on the part of any one. No one would venture to separate by the interpolation of another group the Lycaeninae from the Lemoniinae on the one hand or the Pierinae from the Papilioninae on the other. By universal consent they must accompany each other, whether they are regarded as families or subfamilies. There has, however, been a considerable difference of opinion regarding the relative position of the four great groups among themselves. Will the structure of the legs throw any light upon this question? Let us see.

In the Hesperidae the fore legs, like those of the moths (which form the other and lower extreme of the series of Lepidoptera, to which butterflies belong), differ in no respect from the other pairs, excepting that the hind tibiae are usually furnished with a pair of spurs at the middle as well as at the tip, and the fore tibiae bear near the middle a peculiar flabellate appendage, the use of which is unknown, but which, morphologically, is unquestionably a spur.

In the subfamily Papilioninae, the middle pair of spurs of the hind legs is altogether lost, but the fore-tibial appendages remain, and the fore leg is otherwise entirely similar in character to the other legs. Next, in the closely allied subfamily, Pierinae, the fore-tibial appendages disappear, but the fore legs still remain identically like the other pairs.

As soon, however, as we have reached the Lycaenidae, we notice signs of an abortion of the fore legs, but only in one sex, the male. In the subfamily Lycaeninae, while the fore leg of the female does not differ from the other legs, that of the male begins to lose a part of its armature and to become abbreviated: the tarsal spurs are denuded of scales, and both the tibial and tarsal spines are diminished in number; the paronychia and pads at the tip are invariably absent; and the claws are represented by an apical spine or spines differing from the other spines at most in size. In the subfamily Lemoniinae the change has become much greater; for with scarcely an exception, the fore leg of the male has become very much smaller than in the female, and while each part is reduced in size, the tarsus is represented by a diminished number of joints, totally devoid, as is also the tibia, of any armature whatever, but clothed abundantly with long scales and hairs. There is here also sometimes a faint indication of change in the female, the spines of the tarsus being less abundant than on the other legs.

In the Nymphalidae, the change affects both sexes; not, however, in the lowest subfamily, the Libytheinae, which, on this account, many authors who have given special attention to the structure of the legs have classed with the Lemoniinae. But in all other Nymphalidae, as in our Milkweed Butterfly, we have for the first time both sexes fully represented in the atrophy of the fore legs, and the abortion is also carried to a far greater extent. They are also frequently furnished, especially in the male sex, with a spreading brush of long hairs, which gives them a peculiar lappet-like appearance, on account of which they have been called Brush-footed Butterflies. They are quite useless, and in some are reduced to the extremest degree. *There is in butterflies no other structural feature of so great functional importance which differs so greatly in the different families, and follows as here a progressive course.*

Changing our point of view, let us next consider the different ways in which chrysalids of butterflies are suspended or cared for. It is well known that as a general rule moths undergo their transformations to chrysalis within a cocoon, spun by the caterpillar, or in a cell moulded beneath the surface of the ground. The same is true of the lowest family of butterflies, the Hesperidae, which usually make such a cocoon within a rolled-up leaf or cluster of leaves, and hence had given them by Boisduval the term Involuti, or enrolled. It was not noted by him, nor has it been, as far as we are aware, by any author, though figured by many, that within this cocoon they generally spin a pair of shrouds, into the middle of one of which they plunge their cremaster, while by the other they support the middle of the body.

Now, remove this outer cocoon and leave the shrouds, and one has, with only such changes as are absolutely required by the lack of the encircling cocoon, the character of the support of the chrysalis of the Papilionidae; namely, a button of silk attached to the object from which the chrysalis hangs, and a loose girt around the middle of the body. In the Lycaenidae, we pass simply to a still closer attachment of these fastenings, so that the rounded chrysalis appears almost glued to the surface to which it is attached; and these two families, the Lycaenidae and the Papilionidae, were classed by Boisduval under his Succincti, or girt.

In the Nymphalidae, by the loss of the median girt, the chrysalis hangs suspended by its hinder end, and forms the group termed by Boisduval Suspensi or Penduli, — that is, hung, — which he and his followers interpose between the Involuti and the Succincti. Yet we have here a regular progression from the cocoon of the moths to the almost total absence of the use of any silk for the quiescent period of life. The few exceptions to this rule seem to be entirely explanable as instances of reversion. Thus the only case among the higher butterflies where a cocoon, properly speaking, is made, is in the subfamilies most closely allied to the Hesperidae, among the groups of Parnassini and Anthocharini,* and again

* Bar asserts that the same is true in some South American Lemoniinae.

in exceedingly feeble instances, where the necessities appear to be overwhelmingly great, among some of the Nymphalidae, which have lost even the last remnant of the cocoon of moths, — namely, in some of the Satyrinae, which lack cremastral hooks and undergo their transformations ordinarily in the rudest form of a cell which they can construct at the surface of the ground, by the mere movements of the body and the spinning of one or two threads of silk.

Moreover, note this: an additional feature appears in the structure of the chrysalis of a large number of the Nymphalidae, which would seem to indicate that they inherit the mark of the "succinct" condition of their ancestors, in the straight ventral surface of the entire chrysalis, — a feature absolutely without value in its present suspended condition, but full of meaning, since it is one necessarily common to all the close-bound members of the Succincti, the

Lycaenidae. That is to say, the straight ventral surface of many hanging Nymphalidae indicates that this group has *passed through and come out of* a "succinct" mode of suspension.

Now it will be observed that these two series, drawn from such independent, important, and different sources as the development or atrophy of the fore legs of the butterfly and the mode of suspension of the chrysalis, are entirely parallel. Indeed, taken together they indicate, with a certainty somewhat rare in the study of animals so nearly allied, the general interrelationship of the families concerned, which a study of other details of their structure only the more strongly confirms, — the Papilionidae, for example, presenting very many more points of contact with the Hesperidae than can be shown to exist between the Nymphalidae and the Hesperidae.

Each of these families contains groups of lesser extent founded on structural or developmental characteristics of lesser value, which it is the aim of the systematic naturalist to set forth in terms which shall be, as nearly as possible, a transcript of the teachings of Nature herself. Just so far as he seeks to make it his own system, will he fail; just so far as he strives to have Nature reveal herself, will he succeed. He must not regard popular opinion, but seek his support solely from Nature. The investigator in this field must be modest, patient, reverent.

X.

What is its Proper Name? A Brief Chapter on Nomenclature as used by Naturalists.

MUCH outcry is made against the terminology of natural history. But if any one can point out a more sensible method than that bequeathed to us by Linné and his followers, none will be more ready to welcome it than the naturalists. In this, as in everything else, the most serviceable method will obtain the most service. Indeed, one sometimes fancies that the critics forget what names are for. They merely stand for things, and convenience is their only hope of life. They must be brief at any rate, whether they have any meaning in themselves or not; and they must follow certain rules, or we shall stand in such a wilderness that no one can find his way, and the very object for which the names are meant will be obscured or lost.

We have seen that there are various groups of butterflies of greater or less value, and that each contains other groups, until we reach the species and variety. Varieties, indeed, were not much considered in Linné's time, and it is only since Darwin's day that they have gained much significance. As the outcome of the disputes and arguments about names, men have pretty generally agreed to give to each different kind of animal a double name, — the first indicative of the ultimate structural group, or genus, to which it belongs; the second a specific name, agreeing in gender with the former, which has or is supposed to have a Latin form; to which has sometimes been added in later times, when needed, a varietal name. To all higher groups single names of a Latin plural form are given; and attempts have been made, with partial success, to have each group of the same category bear a similar termination, families to end in -idae, subfamilies in -inae, etc.

Our Milkweed Butterfly, for instance (which requires no varietal name), is *Anosia plexippus*, and it belongs to the subfamily Euploeinae (named from one of its principal genera, Euploea) and the family Nymphalidae (named after one of its oldest genera, Nymphalis). As a member of the Nymphalidae it shares with the others of its family a certain number of characteristics which are not found combined, and rarely found at all, in any member of the other families. As one of the Euploeinae it has certain peculiarities in common with other genera of the same subfamily, not found combined, generally not found at all, in the other subfamilies of Nymphalidae. And as a member of the genus Anosia it has certain structural characteristics in every, or nearly every, stage of life which separate it from the other genera of Euploeinae.

It bears within itself, then, characters which belong distinctively to family, subfamily, genus, and species, — and it is the province of the naturalist to discriminate these, — and the terminology of the nomenclature is necessary to speak concisely about them and discuss their relationships. Without such a makeshift and tool small progress would be possible. Imagine mechanics without names for their tools, engineers without a nomenclature for the parts of their machines, and you will feebly fancy the naturalist without his terminology.

I have said our butterfly's name was *Anosia plexippus*. Yet if one were to look in the last catalogue of American butterflies, he would not find this name, but in the place where it should stand, the words *Danais archippus*. This is certainly perplexing to a beginner; and the perplexity is unavoidable as long as men will not think alike and act alike. A name once rooted by usage for a few years only, even if it can unquestionably be shown that such usage is in contempt of accepted rules, may have a stronger chance of life, such is the natural conservatism of mankind, than one clearly correct. Especially is this the case where the mistake has been made in some important work by an "authority," and the error corrected by some unknown but patient worker in a less conspicuous volume. In this way the name is apt to vary in different countries.

Now, both names, archippus and plexippus, have been employed and in "usage" from very early times, but it has been shown by several naturalists in different parts of the world that the use of the specific name archippus perpetuates an error; and while in other countries plexippus is now commonly employed, in America, thanks to most of our catalogue-makers, archippus still often retains its usurped place, probably because Boisduval and LeConte used it half a century ago. In many cases the question is one of priority of usage, pure and simple, and then the older name in time gains place, but often only after a struggle which is sometimes ludicrous; proved priority of baptism is the only safe guide, the only chance for real stability.

As to the differing generic name, that is on another basis. Naturalists are not agreed and probably never will agree about the precise limits of "genera," some dividing a given collection of species into several genera, some regarding them as one or two only. Now the old genus Danais, as looked at by those who use this name for our butterfly, comprises a very large number of very diverse forms, which the latest students of these insects have shown should be segregated into a number of groups; and Anosia is the one of these smaller groups into which our species falls.

The use of the generic name, then, indicates to some extent the views of the person employing one or the other term. Certainly the more closely we study butterflies (which in the past have been studied largely upon superficial aspects and by an examination of the perfect insect alone) the more shall we be inclined to look with favor on structural groups of lesser extent, as enabling us, first, to formulate statements regarding their distribution and relationships which will throw new light on many dark spots in science; and second, to correlate their differences with those of other groups of insects where corresponding minor groups are accepted, because the structure of these latter insects is not concealed by a coating of scales, and their study not beset with so many practical difficulties.

There is still a further reason for such a preference. With the beginning of systematic zoölogy, all butterflies were grouped in a single genus, Papilio; study had then progressed only so far as to seize upon the most salient and obvious points in their structure. As the study became deeper and more searching, and new forms of very diverse character swelled by degrees and at last immensely the number of species (even in the last edition of his Systema Naturae, a century and a quarter ago, Linné recognized but about three hundred kinds, while now we know at least ten thousand), it became necessary to subdivide them into a greater and greater number of groups, subordinate to one another, and families, subfamilies, and tribes were introduced to distinguish and class them. The "genus" has been more and more restricted with the growth of our knowledge, and the tendency has all along been to have it represent the structural group of narrowest limitations, while the study of the structure of butterflies in all their stages has constantly narrowed these limitations.

To object, then, to the employment of a "generic" term for the narrowest groups, when they can be shown to have a real foundation, is practically to put a check upon the study of their structure, which it is the very first business of the systematic zoölogist to encourage and indeed to insist upon. No point is so minute as not to merit investigation and fair consideration. The researches of Darwin surely carry this lesson.

XI.

Some Points not touched upon, and some Things we do not yet sufficiently know.— A Suggestion for Future Study.

ALTHOUGH in the preceding chapters we have given a tolerably full history of our Milkweed Butterfly, and have by this means illustrated in a few instances the structure and transformations of other butterflies, there are still many points about *Anosia plexippus* which have not even been alluded to, while our references to others have been so meagre that whole classes of phenomena, some of the highest interest, have been left untouched.

Thus, to confine ourselves for the moment to our principal subject, not a word has been said either about the growth of the creature within the egg or about the internal structure of the caterpillar, chrysalis, and butterfly, — by what processes both the internal and the external changes are brought about, and in what way the new organs, such as the wings of the perfect insect, originate, present as they are *within* the body of the caterpillar from its earliest life. These topics are full of interest both in themselves and in the further comparisons with the same processes in other butterflies or in still other allied creatures. Our present knowledge upon these subjects, however, is more limited than that of the topics already discussed, and they will not yet so readily lend themselves to popular interest; and therefore, though it renders our little book less complete and symmetrical, they are not touched upon at all.

There is, however, one other topic which, having been somewhat widely studied, especially in this country, and not yet more than mentioned here, may be briefly stated. I refer to the remarkable differences between the earliest and latest stages of one and the same caterpillar. This is less marked in our Milkweed Butterfly than in most of our butterflies, especially than is common among other members of the same family, which when adult have bodies and even sometimes heads bristly with compound spines, and altogether lack such a formidable appearance in their tender youth.

The full-grown caterpillar of our Milkweed Butterfly is, as we have seen, a gayly striped yellow, black, and green, naked or nearly naked worm four or five centimetres long, with a black-banded yellow head and two pairs of black flexible filaments on the body. When it first emerges from the egg, however, it is as a pale green cylindrical worm, about three millimetres long, with a black head, and on its body, scarcely to be seen without a microscope, are several rows of minute papillae, one papilla to a segment in each row, each surmounted by a short simple hair about half as long as one of the segments. Careful examination will also show on each side of the second thoracic and eighth abdominal segments a somewhat similar but larger and hairless papilla. These last persist through life, and as we have seen, grow to more importance as filaments; all the others disappear completely with the first change of skin.

What the meaning may be of this infantile clothing, which in one form or another is present in the earliest stages of all butterfly caterpillars, and is altogether lost in the subsequent growth, usually with the first change of skin and completely, but which sometimes persists through one or more subsequent changes, more or less modified, is not perfectly clear. In a large number these hairs, more or less specialized, are plainly the outlets of glands lying at their base, secreting fluids which often may be seen as droplets at the tips of the hairs; and it is possible that in these cases the glandular secretion serves as a protection to the little creature through its odor or offensive taste.

But this is not the case with all, of which our Milkweed caterpillar is an instance; and it is altogether probable, from the universality of this form of clothing and its general simplicity, that it has a phyletic significance yet to be discovered,—an indication of the nature of the clothing of the primitive caterpillar of all butterflies, or better, all lepidopterous insects, and that the glandular structure of some is a secondary feature brought about through natural selection. Here is a highly interesting and important chapter in the phylogeny of insects which will well repay the conscientious student.

Let us now turn for a brief moment to some of the phenomena witnessed in other butterflies, but which cannot be illustrated from the butterfly we have chosen for special consideration. We will mention but one among many.

Among the subjects of general philosophical interest which the study of animals during the Darwinian epoch has brought to notice, few have excited more attention and interest than the existence in a vast number of animals of two or more distinct forms in the same species. That this is very commonly true of the two sexes goes without saying; but besides this it often happens that one sex may appear under two distinct guises, or that alternate broods of the same animals may differ so much from each other as in many cases to deceive the most acute naturalist into the very reasonable belief that they are distinct species.

Much attention has been given to this subject among the butterflies, and we have in our native species a considerable number of instances in illustration. Indeed a large proportion of our butterflies show, in some peculiarities of the scales of the male sex and their arrangement into special patches, a ready distinction from the opposite sex. There are also a very large number which differ from the opposite sex in the general color or pattern of the upper or lower surface of the wings. Curiously enough, when we consider how very generally the under surface of the hind wing is variegated in butterflies, we rarely find in this place any distinction between the sexes. It is largely confined, at any rate with the butterflies of the temperate zone, to the massive coloring of the upper surface; and here, whenever one of the sexes departs from the typical coloring of the group to which it belongs, in order to assume a livery distinct from its mate, it is almost always the female, at least among our own butterflies, which is thus distinguished.

But besides that form of dimorphism which simply intensifies the distinctions between the sexes, we have in some cases a double dimorphism, so to speak, which not only distinguishes one sex from the other, but divides the members of one of the sexes into two distinct groups, one of which more nearly resembles the opposite sex, while the other may depart widely from it. There are cases, such as our common yellow butterfly, familiar to every out-door entomologist, wherein the female, instead of being of nearly the same color as the male, with some distinctions in the marginal bands, is of so very pallid a hue as to strike the observer at once. The contrary is true as regards the female of the Tiger Swallow-tail, *Jasoniades glaucus*, and the male of the Spring Azure, *Cyaniris pseudargiolus*, in which, in certain parts of the country, a dark form of the sex, with nearly uniform brown upper surface, is to be found.

But dimorphism by no means stops here, for we have in some of our other butterflies quite as striking or even more striking peculiarities. Take for instance the case of one of our Angle-wings, *Polygonia interrogationis*. Here is an insect where there are two very distinct forms in each sex, and in each of which the sexes are readily distinguished by the coloration of the wings; they differ in the brightness and variegation of the lower surface of both wings and the obscurity of the upper surface of the hind pair; that is to say, there are four sets of individuals, which may be separated quite as readily as most closely allied butterflies, and more so than a great many acknowleged species of the best-studied faunas. Nor is this by any means the whole statement of the case; these two types, bred from eggs laid by the same parent, differ not only in the markings of the wings, but also in their form and in the structure of the male clasping organs; in fact, we have two sets, permanently distinct from each other, and to which we cannot apply the name of species only because we know them to have the same parent.

Now butterflies seek their own kind for mating, and nothing more is needed to establish these forms as good species than that each should persistently seek its own kind. Indeed, one can hardly help surmising that they already do so to a considerable extent, and that this is an instance of an almost formed species, beyond which it is almost impossible to go without becoming one. Between this condition and that of species in which the sexes do not differ and there is very little variation, there is almost every grade of difference, so that we may fairly imagine that we know one means by which species are originated. Here, perhaps, if anywhere among butterflies, we ought to suspect that physiological selection, the province of which is so well insisted upon by Romanes, is beginning to play its part in the formation or rather the differentiation of species; since besides the colorational marks which may enable the sexes to choose their mates with discrimination, we have the first steps toward those changes in the organs ancillary to generation which everywhere mark absolutely distinct forms, and are safeguards against admixture.

More striking and perhaps more confusing than these examples are those where the dimorphism is seasonal; that is, where the butterflies of the first brood differ, and sometimes to an extraordinary extent, from those of succeeding broods the same season; or even where the earliest appearing members of a spring brood may be separated by coloring, pattern, or form of wings from the later emerging individuals of the same brood.

Perhaps the most striking instance that we have is in the often quoted case of the Zebra Swallow-tail, *Iphiclides ajax*, whose changes have been so thoroughly worked out by Mr. W. H. Edwards. Here each form appears at a different season of the year; marcellus is the early spring type, telamonides the late spring, and ajax the summer and autumn type. Nearly all the butterflies which, in West Virginia, emerge from the chrysalis before the middle of April, are marcellus; between that and the end of May, telamonides; after this, ajax. The first two, however do not represent distinct broods, for telamonides is not the direct conseasonal produce of marcellus, but both are made up of butterflies which have wintered as chrysalids, — those which disclose their inmates earliest producing marcellus, the others telamonides; while all butterflies produced from eggs of the same season — and there are several successive broods — belong to ajax. These forms differ in the length of the long tails upon the hind wings, in the clothing of the front of the head, in the extent of the blood-red spots upon the hind wings, and in other markings, and before their relation was known were regarded by all naturalists as distinct species.

Geographical variation of course occurs in butterflies, as in other animals, but when this is combined at once with seasonal dimorphism, sexual dimorphism, and ordinary simple dimorphism, one becomes almost hopelessly involved in trying to disentangle the threads. One such instance is found in our Spring Azure, *Cyaniris pseudargiolus*.

This species, in which the males and females differ considerably in the markings of the upper surface, is spread over almost the entire North American continent. In the extreme North, from Labrador to Alaska, it is single-brooded, but appears in two forms, lucia and violacea, differing largely in the heaviness of the markings of the under surface. Whether one form flies before the other does not appear from any observations on the spot, as these are too meagre; but there is certainly nothing to show that there is any difference in this respect from what we find farther south. To examine this we must confine our attention to the eastern half of the continent. Not far from latitude 45° north, two new phenomena appear. The butterfly becomes double-brooded and trimorphic; and the third form, with still lighter markings, of which the second brood is exclusively composed, appears also as a member of the first brood, — the three forms succeeding each other at least within a month, in the order of the heaviness of the dark markings of the under surface; namely, lucia, violacea, neglecta. Confining our attention for the present to the first brood, observations would seem to show that in the northern part of the belt of its trimorphism, the form neglecta is comparatively rare, but that in proceeding farther and farther south it becomes proportionally more and more numerous, until, as about Albany, N. Y., it has altogether usurped in numerical importance the place formerly occupied by lucia, which entirely disappears at about the latitude of 41°, except (probably) in mountainous districts. At the same time the second brood, although apparently not more the product of neglecta than of violacea, becomes more abundant.

We now reach another belt of country, in which we find the butterfly again dimorphic in the first generation, — violacea and neglecta, in the order of their appearance and the summer generation as before. But we have not far to pass, say to 38° or 39° north, before we reach a new condition, in which the first form of the first generation becomes sexually dimorphic, — the males appearing under two guises, one blue above, the normal violacea; the other dark brown, violacea-nigra; and this apparently continues as the condition of things as far toward the Gulf as the species extends. There can be little doubt that this succession of changes in passing from north southward is modified and interfered with to a considerable extent by the Alleghanies, and that on their flanks, in very near vicinity, we may find at least some examples of all these forms.

In the extreme West, on the Pacific slope, we have a new form, piasus, most resembling neglecta, which so far as observations have gone appears to be single-brooded in the North, double-brooded in the South, and to show no difference between the broods, — as sharp a contrast as could well be found to the character of the species elsewhere; and it is the more strange since in Arizona (though it should be noted, among the mountains) an ashen-tinted form of violacea appears, to which Edwards has given the varietal name cinerea. The form piasus occurs as far north as Central California. What is found immediately to the north of that is not well known. At Vancouver, however, lucia and violacea are met with, and violacea at least in Oregon; and it would seem as if in the intervening area not only lucia but also violacea must disappear, and leave only the more weakly marked Pacific representative of neglecta as the remnant of the polymorphism of the first brood, and which does not become digoneutic until left in possession of the field.

Enough has been said, even in the few instances given, to show that we find among butterflies topics enough of interest to any one. Yet it should be pointed out that it is only within recent years that these varying phases of life and form have begun to be studied, and that new problems arise with every increase of knowledge, with every forward step in investigation, so that no one may complain that the ground is too trodden, or that new elements of interest may not arise by honest search. Surely the knowledge yet to be gained from the study of the life histories of butterflies will prove far beyond anything we are yet acquainted with, just as the problems discussed the past twenty-five years are of far wider interest than those which went before.

Even in the case of *Anosia plexippus*, no one can say that further study is not required, for although this interesting butterfly is one of our best-known species, there are several points in dispute regarding it, and many features in its history which need further investigation. The movements of the butterfly in the spring and in the autumn will require systematic and concerted observation over a wide extent of territory before their satisfactory solution can be expected. Where swarms and bevies occur, they should be carefully observed from day to day and hour to hour, to study the movements and intent of the throng.

The whole question of the regular or irregular migration of butterflies can be studied better with this species than with any other in the world, because there is none so subject to congregational movements which occurs where so many intelligent observers are stationed. If, as I think I have shown it to be probable, there is over the entire extent of the country inhabited by it, at least east of the Rocky Mountains and north of the Gulf States, a periodic movement of the butterfly, to the south in the season which corresponds to the end of September in New England, and to the north in the time of the first (and in the middle belt, of the second) season of egg-laying, then observers ought to note *at these periods* the general direction of movement — not over a few feet or rods, but as far as the eye can follow them — of as many specimens as possible, tabulate them, and publish the results. By this means I believe a periodic movement could finally be as well established as the annual migrations of birds; to this work every one can contribute who knows the butterfly by sight.

Then we need many more careful observations on the immunity supposed to be enjoyed by this butterfly in its various stages, — an immunity certainly not perfect, and the exact nature and extent of which will reward only patient and conscientious field work. It would be interesting to know the relative willingness with which insectivorous birds would devour the caterpillar and that of the Black Swallow-tail, *Papilio polyxenes*, which feeds on parsley, etc., and bears some resemblance to it. The life history, and particularly the number of broods in a season, should be worked out independently in many places, and for several seasons in each, to determine questions in which writers are at variance. For this the condition and abundance of the butterfly should be observed from week to week, and with it the relative numbers of caterpillars in each stage, tabulating all the facts that can be obtained, including observations of the ovaries of such females as are captured.

The following would seem to be an

interesting and valuable experiment for some one having access to a greenhouse empty in summer to try: place together males and females reared from July caterpillars in the northern half of New England, *without other admixture*, in such a greenhouse, covering the open windows with netting to prevent escape, and placing an abundance of Asclepiads in bloom and in young shoots within. If the butterflies will breed in confinement, then the females should lay eggs, if, as some believe, there are in this district two broods of butterflies from July on; they should not lay eggs if, as I believe, there is but a single generation. Coupled with this there should be similar experiments farther south, where there is more than one brood, to see whether they will breed at all in such confined quarters.

There are still further inquiries that should be made, if we wish to pursue the study of this insect beyond our own borders; for what has been written above regarding its distribution in recent years opens the question as to the progress it is making in overspreading the globe, and what effect its introduction may have upon the other butterfly inhabitants of the regions it invades. In New England our newly introduced cabbage pest, *Pieris rapae*, has practically exterminated our native *Pieris oleracea*, except in wild regions, apparently by getting a few days start of it in the season and monopolizing the best feeding-grounds. Then, as the Milkweed Butterfly has been shown to vary considerably when individuals from North and South America and the West Indies are compared, the origin of the Pacific hordes may perhaps be traced by seeing to what type they correspond. The variation itself has been in no way properly studied, and it remains to inquire whether the wanderers in the Pacific are going to show any departure from the type.

In considering the exotic distribution

of the Milkweed Butterfly, it should, moreover, not be forgotten that in reaching the Old World it may be said to have reached its own, for Anosia does not belong to the exclusively New World type of Euploeinae, Ithomyini, but is one of the exceedingly few New World genera of the otherwise Old World type, Limnaini. The work, then, that still remains to be done on this one insect might well engage a lifetime, and we are the first to show how insufficient a presentation of the subject the present volume affords!

EXPLANATION OF THE PLATES.

(ALL THE PLATES ILLUSTRATE ANOSIA PLEXIPPUS.)

PLATE I.

THE MALE BUTTERFLY; NATURAL SIZE.

PLATE II.

FIGS. 1–5. Front view of the head of the caterpillar, at each of its five stages; the line beneath each indicates the width.

FIG. 6. Caterpillar, last stage; natural size.

FIG. 7. Egg; enlarged about 17 diameters.

FIG. 8. Caterpillar, first stage; enlarged about 14 diameters.

FIG. 9. Longitudinal section through the female butterfly to show the internal anatomy:— *t*, tongue; *p*, palpus; *a*, antenna; *pr*, prothorax; *mes*, mesothorax; *met*, metathorax; *ps*, pharyngeal sac; *b*, brain; *sog*, suboesophageal ganglion; 1–2, blended first and second ganglia of the caterpillar; 3–4, blended third and fourth of same; *l*, *l*, *l*, the three legs; *ac*, aortal chamber; *dv*, dorsal vessel; *oe*, oesophagus; *res*, reservoir for air or food; *st*, stomach; *mv*, malpighian vessels; *i*, intestine;

c, colon; *r*, rectum; *cp*, copulatory pouch; *o*, oviduct; *ag*, accessory glands; *sp*, spermotheca; *ov*, ovaries (not fully developed); *nc*, nervous cord. Enlarged 3 diameters.

PLATE III.

FIG. 1. Side view of the appendages of the butterfly a little enlarged, with some separate parts further enlarged: — *p*, palpus; *f*, fore tibia and tarsus, male and female; *f'*, tip of fore tarsus of female; *m'*, *m''*, side and dorsal view of last joint of middle tarsus of male.

FIG. 2. Side view of the denuded extremity of the abdomen of the male butterfly, showing the pencil of extensile hairs in place. Enlarged.

FIG. 3. Greatly enlarged view of part of dorsal surface of hind wing of the male butterfly, showing the distribution of the scales on and about the lowest median nervule and the adjoining pouch.

FIG. 4. Cross section through the same, showing the nervule and the pouch, the latter the broader.

PLATE IV.

FIGS. 1–6. Scales from the hind wing of the male butterfly: 1–3, from the edge of the pouch; 4, from the vein next the pouch; 5–6, from the interior floor of the pouch. Greatly enlarged.

FIG. 7. Rear view of chrysalis; natural size.

FIG. 8. Longitudinal section of the head to show the pharyngeal sac: — *mx*, left maxilla (the right removed); *mfl*, floor of mouth cavity or

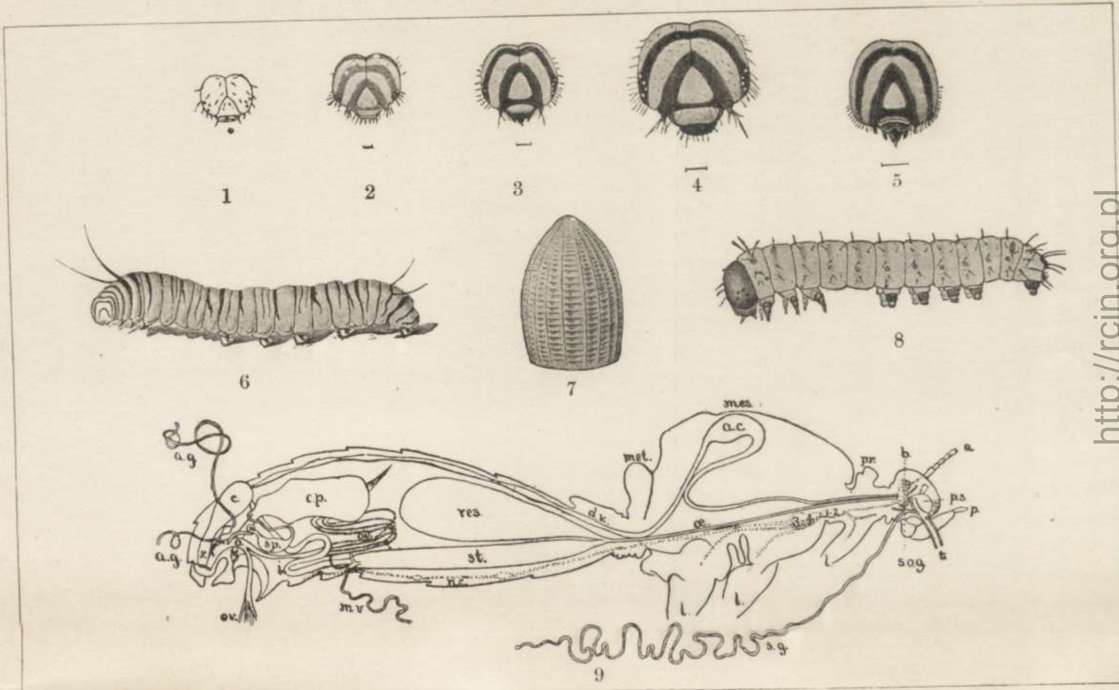
pharyngeal sac; *oe*, oesophagus; *ov*, oral valve; *sd*, salivary duct; *dm*, *fm*, dorsal and frontal muscles which open the sac. Above the sac are seen the cut ends of the transversely encircling muscles which close the sac. Enlarged about 20 diameters.

FIG. 9. Side view of chrysalis; natural size.

FIG. 10. Cross section of the spiral tongue, the anterior portion uppermost, to show the mode in which the two halves unite to form a central canal through which the fluid food ascends:— *c*, central canal; *tr*, trachea; *n*, nerve; *m*, m^2, muscles of one side. Enlarged about 125 diameters.

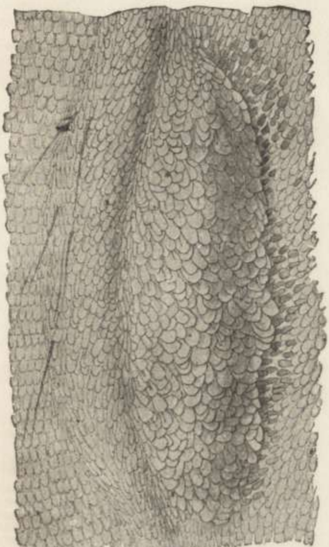
[Plate I. is from the original by C. V. Riley. Plate II. fig. 9, plate III. fig. 2, and plate IV. figs. 8 and 10 are from the originals by Edward Burgess.]

Plate I.

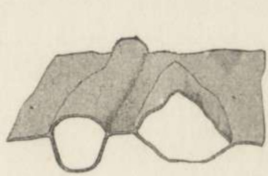

1
2
3
4
5
6
7
8
9
a.g
c
cp.
res.
d.k.
met.
mes.
a.c.
pr.
b.
a.
p.s.
p.
t.
s.o.g.
œ.
st.
sp.
ov.
m.v.
l.
s.g.

1

2



3



4


1

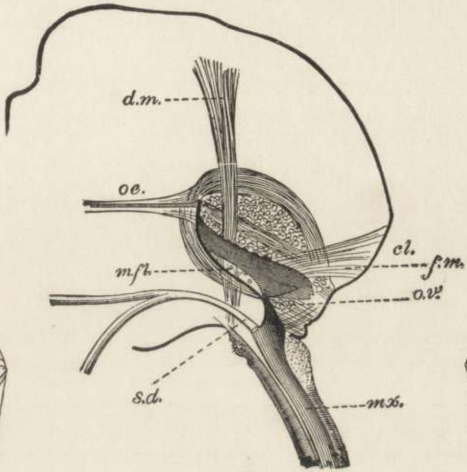

2


3


4


5

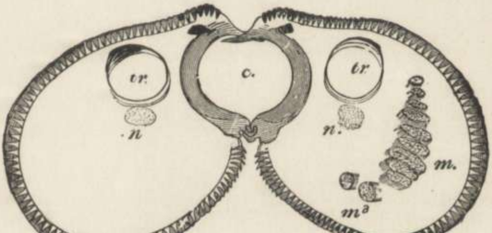

6



8


7


9



10

INDEX.

LIFE
OF A
BUTTER-
FLY

SCUDDER

HENRY HOLT & CO