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R. BAŃKOWSKA, E. CHUDZICKA, E. NOWAKOWSKI, M. STERZYŃSKA

STRUCTURE OF FAUNA OF MOIST MEADOWS ON THE MAZOVIAN LOWLAND

ABSTRACT

The authors present a brief recapitulation of the findings of a research project on invertebrate fauna of moist meadows on the Mazovian Lowland, carried out in 1979–1983 by research workers of the Department of Zoocoenology of the Institute of Zoology, Polish Academy of Sciences.

Synecological studies on grassland fauna were carried out in many research centres, both in Poland and abroad. The literature dealing with this subject is very voluminous, however, the majority of works concern only certain chosen groups of animals and only occasionally do they deal with the whole complex of grassland fauna.

Among the studies which profoundly examined interrelations among communities of animals inhabiting meadows, there should be mentioned an extensive work on the fauna of wet meadows in northwestern Germany (Boness 1953). Also in Czechoslovakia there was conducted a thorough research on grassland fauna (Doskočil, Hůrka 1962). Apart from faunistic and ecological data, the two mentioned works examined also the effect of grass mowing on the abundances of particular groups of animals. In recent years Czechoslovak scientists have completed a number of interesting MAB-inspired studies on meadow fauna, the findings of which have been published in a collective work (Rychnoská 1979).

Furthermore, also American scientists carried out several research projects on groups of animals of grasslands (Ford 1935, Evans and Murdoch 1968, Henderson and Whittaker 1977, Cole 1980). Most numerous were the studies concerning pastures and dealing with the effect of grazing by domestic animals on invertebrate abundance (Morris 1967, 1968, 1969, 1970, 1971, Hutchinson and King 1980).

As regards Polish studies, attention should be paid to many IBP-programmed studies carried out by the Institute of Ecology, Polish Academy of Sciences, on productivity of meadow ecosystems (Łuczak 1976, Breymeyer 1971).

The research workers of the Institute of Zoology, Polish Academy of Sciences, studied fauna of urban grassy communities of the association *Arrhenatheretum* on the area of the city of Warsaw (Czechowski, Pisarski 1981, Czechowski, Garbarczyk, Pisarski, Sawoniewicz 1982).

The present studies deal with invertebrate fauna of moist meadows under use on the Mazovian Lowland.

SOIL FAUNA

In European literature only a few works deal more widely with soil fauna of moist meadows. Apart from Doskočil and Hůrka (1962) mentioned above, other studies in Czechoslovakia were carried out by Bilý and Pavliček (1970) and Majzlan (1985). In Germany works on the subject in question were contributed by Frenzel (1936), Franz (1950), Leuthold (1961), Rabeler (1952) and Witsach (1975).

In the present studies soil fauna was classified according to Dunger's criteria (1983) of animal body size.

MESOFAUNA

In all the studied mesofauna communities in soil of the examined moist meadows, the dominating were *Acarina*, constituting approximately 72.8% of the community; the proportion of *Collembola* accounted for an average 19.9%, while that of *Enchytraeidae* — 7.4% on average. Estimations of uniformity of proportions of the two dominating groups, i.e. *Collembola* and *Acarina*, were completed on the basis of Margovski and Prusinkiewicz index (1953). The lowest value of this index for mesofauna communities was recorded in the soil of the meadow C at Białołęka Dworska and of the pasture at Zbroszki, i.e. relatively dry habitats, while its greatest value was noted in more humid soil of the meadows A and B at Białołęka Dworska and of the meadow at Klembów (Tab. 1).

In the soils of the examined Mazovian moist meadows the greatest mesofauna density was recorded on the meadow A at Białołęka Dworska and in the long-exploited meadow at Chylice (Tab. 1). Both meadows were marked for a much advanced sodding process and a high humus content in the A_1 level of humus accumulation. The lowest mesofauna density was observed on the pasture at Zbroszki and on the meadow B at Białołęka Dworska.

Mesofauna communities in soils of the studied meadows evidently reacted to sand fraction content in the subsoil (Fig. 1). A decrease in the density of the

Table 1. Mean density of mesofauna (n — thousand of individuals/m²) in soils of the studied meadows (*Arrhenatheretum medio-europaeum*) on the Mazovian Lowland

Plot	Klembów		Białołęka plot A		Białołęka plot B		Białołęka plot C		Chylice		Zbroszki		Białołęka plot D	
Group	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Acarina	20.9	69.2	25.0	53.2	15.8	68.4	24.7	89.9	29.2	73.7	15.6	76.4	21.2	78.5
Collembola	7.3	24.2	12.8	27.2	7.0	30.3	2.1	7.6	9,0	22.7	2.4	11.8	4.1	15.2
Enchytraeidae	2.0	6.6	9.2	19.6	0.3	1.3	0.7	2.5	1.4	3.5	2.4	11.8	1.7	6.3
Total	30.2		47.0		23.1		27.5		39.6		20.4		27.0	
Index of *Collembola*: *Acarina*	1 : 2.9		1 : 2.0		1 : 2.2		1 : 11.8		1 :3.2		1 : 6.5		1 : 5.2	

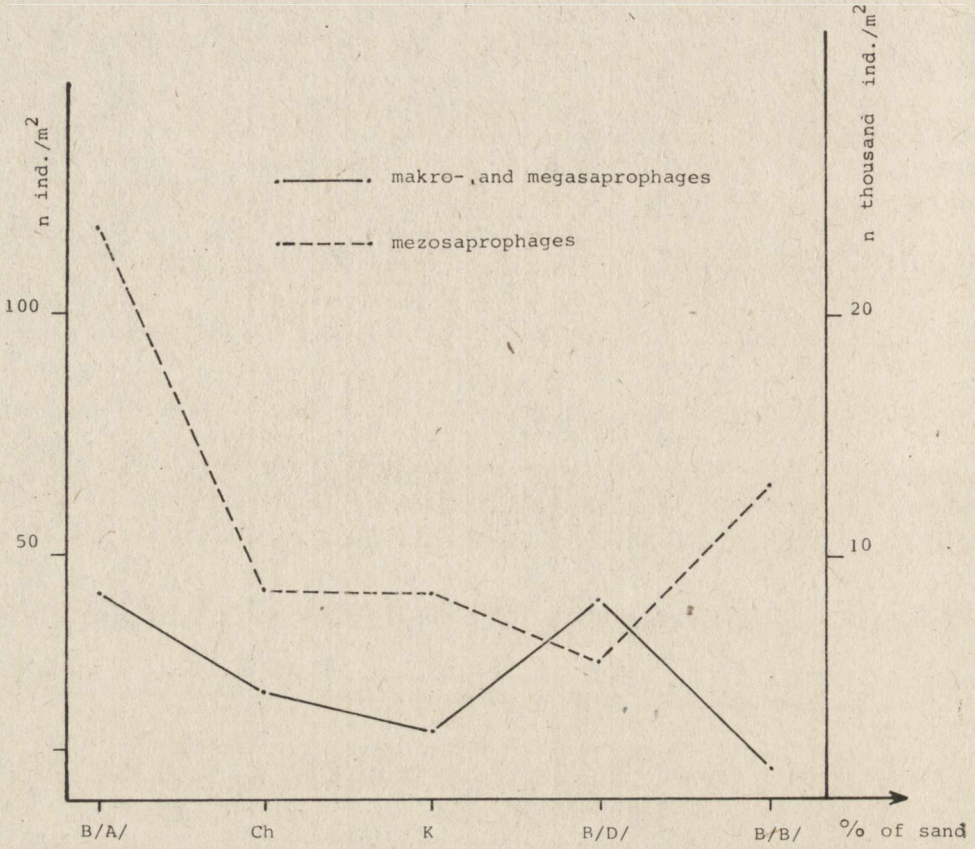

Fig. 1. Changes of abundance (n) of saprophagous groups in studied meadow soils along with increasing sand fraction: B(A), B(B) and B(D) — plots A, B, and D in Białołęka Dworska, Ch — Chylice, K — Klembów

examined animals was likely to result from a diminution of the amount of organic substance content in soil and a lower soil humidity. In the soil of the studied meadows there occurred 62 species of *Collembola*, out of which a majority were eurytopes or species characteristic of fields and meadows. The species dominating in the examined communities were *Isotoma notabilis*, *Folsomia quadrioculata*, and *Isotoma viridis*. The similarity indices of species composition in the communities of dominating species, as well as in total communities were very low: 0.21–0.37 (Sterzyńska 1989).

Seventeen *Enchytraeidae* species were recorded.[1] The most stable in the studied *Enchytraeidae* communities were *Bucholzia appendiculata* (Buchh.), *Fridericia*

[1] The locality at Białołęka Dworska was described by K. Kasprzak (1981, unpublished data), while the remaining meadows — by R. Szybkowska (unpublished data).

bisetosa (Lev.) and *F. galba* (Hoffm.) — i.e. small species characteristic of arable lands of little fertility. The highest density was noted in the humid, rich in organic substances meadow A at Białołęka Dworska, while the lowest density — at the meadow B (Tab. 1).

MACROFAUNA

As regards macrofauna *sensu stricto*, there was observed a considerable diversity of the constituting taxonomic groups on particular sites. *Chilopoda* and *Staphylinidae*, soil larvae of *Lepidoptera* and larvae of *Coleoptera* and *Diptera* were constant elements of macrofauna on all the meadows, all very varied with respect to their body size, food preferences and, consequently, their significance to soil environment (Tab. 2).

The dominating group of soil macrofauna on the examined meadows were larvae of *Coleoptera*, contributing 14–50%. The group included, above all, larvae of *Elateridae* and a so-called group of "predatory larvae" (*Carabidae* and *Staphylinidae*). Furthermore, the group also comprised larvae of *Curculionidae*. Besides larvae of *Coleoptera*, in the soil of examined meadows there also numerously occurred *Diptera* larvae and *Staphylinidae* imagines and, on some localities, also *Chilopoda*. The percentage of remaining groups was by far much lower (Tab. 2).

Macrofauna of the studied meadows was observed to have been much diversified as regards the percentage of its constituent groups. The macrofauna community in the soil of the meadow at Klembów was dominated by *Diptera* larvae (61.4%), *Coleoptera* larvae accounting there in lower proportion. A high proportion of *Diptera* larvae to macrofauna communities was also noted in the soil of the meadows B and D at Białołęka Dworska. Another characteristic feature was a small proportion of *Chilopoda* to these communities (Tab. 2).

Among the six Mazovian meadows under studies, the greatest density of soil macrofauna (excluding *Formicidae*) was estimated on the long-cultivated meadow C at Białołęka Dworska and in Klembów (Tab. 2), while the lowest — on meadow B at Białołęka Dworska and on the meadow at Chylice. As regards meadow B, the low animal density resulted from a short period of time over which the area was utilized as grassland, as well as from soil conditions (brown soil formed from loose sandy soil). As regards the latter, a vehement reduction in the animal abundance was caused by intensive chemical and protective treatments. Macrofauna of these two plots was observed to have been the least varied, on the meadow at Chylice in particular, where many macrofauna groups were totally eliminated (Tab. 2).

Formicidae reached the highest abundance (over 1.000 individuals per m^2) on meadows C and D at Białołęka Dworska, while their low abundances were recorded on the meadow at Klembów and Chylice, amounting to 35.2 and 7.0 individuals/m^2, respectively. The estimated low value of ant density on the moist meadow at Chylice was furthermore corroborated by complementary studies

Table 2. Macrofauna density in soils of the studied meadows (*Arrhenatheretum medioeuropaeum*) on the Mazovian Lowland (n — number of individuals/m²)

Plot	Klembów		Białołęka A		Białołęka B		Białołęka C		Chylice		Białołęka D	
Group	n	%	n	%	n	%	n	%	n	%	n	%
Gastropoda (shelled snails)	1.50	0.4	5.88	2.0	—	—	6.25	1.6	—	—	36.25	11.9
Gastropoda (slugs)	—	—	5.88	2.0	1.18	0.8	6.25	1.6	—	—	0.63	0.2
Isopoda	—	—	2.94	1.0	—	—	4.38	1.1	—	—	1.25	0.4
Chilopoda	4.83	1.3	52.94	17.6	2.94	1.9	45.00	11.8	0.67	0.6	13.75	4.5
Diplopoda	—	—	17.65	5.7	3.55	2.3	8.13	2.1	—	—	11.25	3.7
Staphylinidae	81.83	21.3	60.59	20.1	41.76	27.5	36.88	9.7	26.67	23.2	37.50	12.3
Coleoptera larv.	54.17	14.1	119.42	39.7	43.53	28.7	183.14	48.1	57.83	50.4	109.38	35.7
Hymenoptera larv.	0.17	0.1	0.59	0.2	—	—	1.25	0.3	—	—	1.25	0.4
Lepidoptera larv.	5.50	1.4	1.76	0.6	4.12	2.7	6.25	1.6	17.00	14.8	0.63	0.2
Diptera larv.	235.17	61.4	33.53	11.1	48.24	31.8	59.38	15.7	12.67	11.0	85.63	28.0
Aphididae	—	—	—	—	6.47	4.3	24.38	6.4	—	—	8.13	2.7
Total	383.17		301.18		151.79		381.29		114.84		305.65	

on the density of ant nests on the area of 24 × 10 m². Only one nest of *Myrmica rugulosa* Nyl. was found on the examined site (Czechowski — unpublished data).

Some another results were arrived at in the course of the analysis of earthworm density. The greatest density of this important group of humificators was observed on meadows C and D at Białołęka Dworska, namely, 51 and 44 individuals/m², respectively. Merely 2 ind./m² were found to occur on the meadow B at Białołęka Dworska. Five species of *Lumbricidae* were reported in the present research to occur in soil of the studied meadows. A majority of communities were dominated by the genus *Allobophora* (*A. caliginosa* among mature forms). Different types of community were observed on the meadow at Chylice, where species of the genus *Lumbricus* dominated (*L. rubellus* among mature forms) as well as in soil of the meadow D at Białołęka Dworska, where the genus *Dendrobaena* dominated (*D. octaedra* among mature forms). *D. octaedra* also dominated in the community of earthworms on the meadow at Klembów (Pilipiuk 1989).

The second group of macrofauna systematically considered was click beetles (*Coleoptera, Elateridae*). Fourteen species of *Elateridae* were identified on the studied meadows. In heavier soils (sandy-loamy and loamy soils) the dominating was *Agriotes sputator*, in soil of the mown meadow B — *Selatosomus latus*. A different type of community was found in soils with a large sand fraction content (sandy alluvial soils), where the dominating was *Agriotes obscurus* (Nowakowski 1989).

EPIGEON

In the course of the present studies on meadow ecosystems, catchability index was analysed. The constant groups of epigeon included: *Gastropoda, Isopoda, Diplopoda, Aranei* and *Opiliones*, imagines and larvae of *Coleoptera*, larvae of *Lepidoptera, Orthoptera, Blattoidea* and *Formicidae*.

The largest percentage to the total epigeon catchability was estimated for *Aranei* — an average 26%, *Formicidae* — 25%, and *Coleoptera* larvae — 24%, the proportion of *Formicidae* having been most diversified, ranging from 1% on the meadow at Chylice up to over 60% on the grazed meadow in Zbroszki.

The greatest catchability index was recorded for meadow A at Białołęka Dworska, while the lowest — for the meadows at Klembów and Chylice (Tab. 3). The obtained data closely corresponded to approximate data on epigeon density estimated on the basis of soil samples (Tab. 4). A low value of epigeon catchability index and of epigeon density on the meadow at Klembów and Chylice resulted from disadvantageous conditions on the two areas, namely from unfavourable water conditions in soil at Klembów, causing occasional floodings

Table 3. Epigeon abundance of the studied meadows (*Arrhenatheretum medioeuropaeum*) on the Mazovian Lowland (n — number of individuals/ /10/traps/14 days)

Plot	1980/81 Klembów		1980/81 Białołęka A		1980/81 Białołęka B		1976/77 Białołęka C		1982/83 Chylice		1983/84 Zbroszki		1976/77 Białołęka D	
Group	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Gastropoda	11.9	7.0	31.3	8.5	34.6	13.2	10.7	5.3	2.1	1.2	1.2	0.4	19.5	9.1
Isopoda	0.1	0.1	6.4	1.7	1.2	0.5	6.6	3.3	0.2	0.1	0.3	0.1	5.3	2.5
Chilopoda	0.3	0.2	0.7	0.2	1.1	0.4	0.5	0.2	0.6	0.3	0.2	0.1	1.0	0.5
Diplopoda	0.1	0.1	5.0	1.3	6.3	2.4	0.3	0.1	0.1	0.1	0.2	0.1	4.6	2.1
Aranei	49.8	29.4	63.0	16.9	55.3	20.3	48.5	24.0	76.6	42.8	41.3	14.7	66.0	30.9
Opiliones	1.2	0.7	20.3	5.4	10.0	3.8	2.2	1.1	1.4	0.8	0.6	0.2	9.5	4.4
Dermaptera	—	—	2.1	0.6	1.2	0.5	3.6	1.8	0.3	0.2	4.0	1.4	2.6	1.2
Heteroptera	—	—	1.3	0.3	1.9	0.7	—	—	0.5	0.3	—	—	—	—
Hymenoptera	—	—	—	—	—	—	—	—	13.6	7.6	9.1	3.2	—	—
Orthoptera & *Blattodea*	0.2	0.1	0.8	0.2	1.8	0.7	0.2	0.1	8.5	4.7	2.3	0.8	0.2	0.1
Coleoptera imag.	35.4	20.9	80.4	21.6	66.0	25.1	79.3	39.2	57.9	32.3	25.2	9.0	55.0	25.7
Coleoptera larv.	25.5	15.0	19.5	5.2	12.7	4.8	4.1	2.0	7.4	4.1	7.4	2.6	1.5	0.7
Diptera larvae	21.6	12.7	2.9	0.8	0.3	0.1	0.2	0.1	—	—	1.2	0.4	3.5	1.7
Lepidoptera larv.	1.1	0.6	1.5	0.4	1.1	0.4	0.4	0.2	2.5	1.4	2.3	0.8	0.4	0.2
Formicidae	21.7	12.8	136.9	36.7	70.1	26.7	38.8	19.2	1.2	0.7	169.5	60.4	39.8	18.6
Symphyta larvae	0.7	0.4	0.9	0.2	1.0	0.4	—	—	—	—	—	—	—	—
Varia	—	—	—	—	—	—	6.8	3.4	6.1	3.4	16.0	5.8	4.9	2.3
Total	169.6		373.0		264.6		202.2		179.0		280.8		213.8	

Table 4. Epigeon density of the studied meadows (*Arrhenatheretum medioeuropaeum*) on the Mazovian Lowland (n — number of individuals/m²)

Plot	Klembów		Białołęka A		Białołęka B		Białołęka C		Chylice		Białołęka D	
Group	n	%	n	%	n	%	n	%	n	%	n	%
Aranei	7.33	22.8	48.24	65.1	32.55	59.1	19.38	48.5	1.67	7.6	28.13	34.3
Opiliones	0.83	2.6	1.76	2.3	—	—	—	—	—	—	—	—
Carabidae	3.67	11.4	4.71	6.3	10.59	19.2	6.25	15.6	13.00	59.1	8.75	10.7
Flateridae	0.33	1.0	3.53	4.8	0.59	1.2	5.00	12.5	3.67	16.7	19.38	23.7
Curculionidae	3.00	9.3	11.76	15.9	10.59	19.2	8.13	20.3	2.33	10.6	17.50	21.4
Hymenoptera imag. (without *Formicidae*)	17.00	52.9	4.12	5.6	0.73	1.3	1.25	3.1	1.33	6.0	8.13	9.9
Total	32.16		74.12		55.05		40.01		22.00		81.89	
Formicidae												
larvae & pupae	—	—	71.76	42.1	—	—	121.89	7.5	—	—	163.95	15.7
imagines	35.17	100.0	98.82	57.9	170.59	100.0	1,497.50	92.5	7.00	100.0	888.13	84.3
Formicidae total	35.17		170.58		170.59		1,619.39		7.00		1,051.88	

and plant drenching, and from intensity of cultivation treatments at Chylice, and, to some extent, also from chemical pollution of environment.

In epigeon we have worked out following groups: *Carabidae* and *Aranei*.

The environments most abounding in *Carabidae* were meadow B at Białołęka and the meadow at Chylice (43 and 40 species respectively), while evidently poor were the meadow at Klembów and the pasture at Zbroszki (19 and 13 species respectively).

Carabidae community was marked for a considerable variety of dominance structures. *Pterostichus vulgaris* dominated on three sites, namely in Chylice and on the meadows A and B at Białołęka. The species dominating the community on the pasture at Zbroszki was *Amara aenea*, while *Harpalus rufipes* dominated the communities on the meadows C and D at Białołęka. The dominating in the community on the meadow at Klembów was the forest species *Pterostichus niger*. Moreover, the analysis of the *Carabidae* communities evidenced that in times when water covered of the soil surface, a considerable part of epigeic fauna migrated from flooded areas to return there later from neighbouring environments, especially from a linden-oak-hornbeam forest (Czechowski 1989).

The environment most abundant in *Aranei* was the moist meadow at Chylice, from where 76 species were reported, while communities very poor in species occurred in Klembów (27) and on the grazed meadow at Zbroszki (26 species). Similarly as in the case of *Carabidae*, there were reported low values of the similarity index of species composition of the studied communities, whereas *Aranei* dominance structure was relatively uniform contrary to *Carabidae* communities. The first dominant on all the areas was *Pardosa palustris* (Staręga 1989). On the seven sites under studies, the estimated *Aranei* catchability index ranged from 41.3 to 76.6 individuals, reaching the highest values on the intensively exploited mown meadow at Chylice, and the lowest — on the pastured meadow at Zbroszki (Tab. 3).

A considerable diversity of soil and epigeic fauna in the studied environments, both with respect to proportions and estimated density, was further confirmed by the analysis of species composition of taxocoenoses, thoroughly worked out with regard to systematics. Values of similarity indices of species composition of most studied communities were very low, ranging between 20–40%. It resulted mainly from differences in local soil conditions, which, most frequently, were likely beyond the research possibilities. This phenomenon had already been emphasized by Wood (1966), who had observed it while analysing communities of *Collembola* and *Acarina*. In our investigations the communities were also diversified as regards their dominance structure. At least three types of dominance structures were noted for *Elateridae* (*Coleoptera*), three — for *Lumbricidae*, and at least four — for *Carabidae*. Only epigeic *Aranei* had a stable dominance structure of the community with only one eudominant.

VARIABILITY OF SOIL FAUNA

For proper evaluations of fauna variability, an analysis should be conducted of density and percentage of specified trophic groups. The most important in soil fauna is the level of saprophages, which stimulate decomposers' activity. The saprophages group re-introduces dead organic matter into matter cycling through mineralization and humification processes. With regard to mesofauna, microsaprophages included both *Collembola* and *Enchytraeidae*. It was ascertained that in the soil of the studied meadows there existed a clear quantitative and, most likely, also a functional compensation between microsaprophages and macrosaprophages (Fig. 1). In the latter group neither *Isopoda* nor *Diplopoda* were of any significance on account of their low density in the studied meadow ecosystems. Due to the lack of data on the structure of *Diptera* larvae, some of which may significantly participate in the processes of humification of dead organic matter, the only important group of macrosaprophages to be dealt with were *Lumbricidae*. On the basis of differences in the species composition and dominance structure of *Lumbricidae* communities, it may be assumed that the humid meadow at Białołęka Dworska contains a large litter layer (the dominating *Dendrobaena octaedra*). On the remaining localities comminution of litter proceeded mainly in deeper layers of soil profile (dominance of species penetrating mineral soil) and only on the meadow at Klembów litter was temporarily observed to lay on the soil surface (the subdominating *D. octaedra*).

The analysis of proportion of other trophic groups was based on the macrofauna communities. The larvae of *Coleoptera* and *Lepidoptera* were regarded excluding other groups (carnivorous *Chilopoda*, *Staphylinidae*, phytophagous *Gastropoda*, rhizophagous *Hymenoptera – Symphyta* and *Diptera* larvae). Rhizophages were the dominating group in the studied meadows. Only the macrofauna communities of the two humid meadows, i.e. in Klembów and the meadow D at Białołęka Dworska, were dominated by predatory larvae of *Coleoptera*. The proportion of pantophagous larvae was low and did not exceed 11%. In relation to rhizophagous larvae the most numerous in a majority of soils of the studied meadows, were *Elateridae* larvae. Only in the soil of meadow B *Curculionidae* larvae prevailed. The proportion of *Elateridae* was there as low as 1% (Tab. 5).

The analysis of fauna functioning should not disregard a unique compatibility of the estimated data on density of root aphids with the quoted density of *Formicidae*. On the sites, where root aphids were not recorded, ants occurred in very small numbers (Fig. 2). Low density or total absence of root aphids indicates their little, if any, significance as piercing rhizophages to meadow ecosystems, especially when compared to an urban ecosystem, where aphid density in soil of certain sites exceed 100 individuals/m² (Nowakowski E., unpublished data).

From the analysis of trophic structure of epigeon it follows that the domina-

Table 5. Density of predatory, pantophagous and phytophagous larvae of *Coleoptera* and phytophagous larvae of *Lepidoptera* on the meadows *Arrhenatheretum medioeuropaeum* of the Mazovian Lowland (n — number of individuals/m²)

Plot / Group	Klembów		Białołęka plot A		Białołęka plot B		Białołęka plot C		Chylice		Białołęka plot D	
	n	%	n	%	n	%	n	%	n	%	n	%
Coleoptera larvae:												
— „carnivorous larvae"	48.33	80.6	8.24	6.8	7.65	16.3	78.75	40.8	22.33	28.4	66.88	59.8
— *Elateridae*:												
carnivorous	—	—	—	—	—	—	1.25	0.6	2.67	3.4	5.00	4.5
pantophagous	2.17	3.6	10.44	8.6	1.72	3.7	20.63	10.7	1.33	1.7	1.88	1.7
rhizophagous	2.33	3.9	42.92	35.5	0.58	1.2	65.01	33.7	32.17	41.0	37.51	33.5
— *Curculionidae*	1.67	2.8	57.06	47.2	32.94	70.1	11.25	5.8	3.00	3.8	—	—
— *Scarabaeidae*	—	—	0.58	0.5	—	—	3.13	1.6	—	—	—	—
— *Chrysomelidae-Halticinae*	—	—	—	—	—	—	6.88	3.6	—	—	—	—
Lepidoptera larvae	5.50	9.2	1.76	1.5	4.12	8.8	6.25	3.2	17.00	21.7	0.63	0.6
Total	60.00		121.00		47.01		193.15		78.50		111.90	

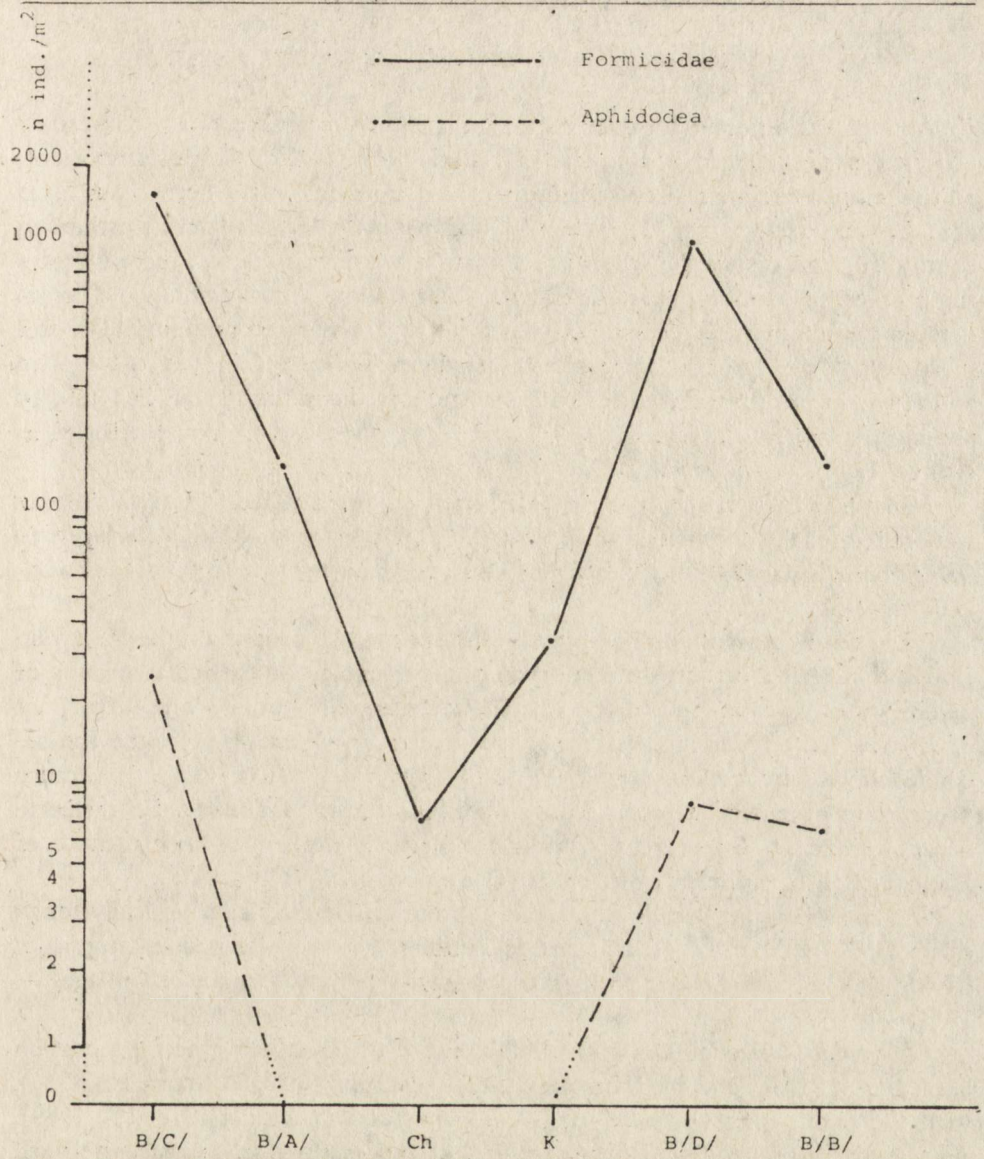

Fig. 2. Changes of abundance (n) of *Aphidodea* and *Formicidae* in studied meadow soils: B(C) — plot C in Białołęka Dworska, other denotations as in Fig. 1

ting group were predators, which seems to confirm the assumption that the basic function of an epigeon is to regulate the abundance of fauna of other biocoenotic levels, as the majority of mature forms of *Coleoptera* and their larvae (*Carabidae*, *Staphylinidae*) and *Aranei* are predators. Also the proportion of pantophagous forms was high in this group, due to high catchability of pantophagous *Formicidae* and hemizoophagous *Carabidae*. The proportion of the remaining groups, i.e. phytophages and saprophages in particular, was negligible.

FAUNA OF THE HERBACEOUS LAYER

Abundance differentiation of particular groups of invertebrates in meadow ecosystems is influenced by many factors, climate being one of the most important. In the temperate zone of Central Europe, the dominating in the herbaceous layer are: *Diptera*, *Heteroptera*, *Thysanoptera* and parasitic *Hymenoptera*. Further on southwards and eastwards, where the climate is warmer and drier, there increase the proportions of *Orthoptera*, *Lepidoptera*, *Apidae* and *Heteroptera*. To a considerable degree animals depend on the type of grassland community. On wet meadows of the order *Molinietalia* in northern Germany, *Diptera*, *Coleoptera* and *Hymenoptera* prevail (Boness 1953). Arid swards on sandy soils in Hungary abound in *Orthoptera*, *Formicidae*, *Aranei*, *Heteroptera* and *Coleoptera* (Balogh, Loksa 1948).

Moist meadows of the type *Arrhenatherion elatioris* studied in Czechoslovakia were noted for the dominance of *Diptera* (32%), *Thysanoptera* (24%), *Homoptera–Auchenorrhyncha* (23%), *Coleoptera* (9%) and *Hymenoptera* (8%) (Doskočil, Hůrka 1962).

The present research on epiphytous fauna of moist meadows on the Mazovian Lowland revealed certain differences in the percentage of particular groups of invertebrates as compared to the quoted Czechoslovak studies. The proportion of *Diptera* (46%) was higher, *Homoptera–Auchenorrhyncha* (24%) came the second, followed by *Hymenoptera* (8.9%) and *Thysanoptera* (5%) (Tab. 6). Similar proportions of particular insect groups were found in the fauna of the Strzeleckie Meadows and at Kazuń near Warsaw by research workers of the Institute of Ecology, Polish Academy of Sciences (Olechowicz 1971).

Diptera inhabiting meadows formed a group ecologically and biotically much diversified. In the sampled material 53 families were represented, phytophages having accounted for about 65%, saprophages — about 25%, and zoophages — 10%.

Chloropidae were of the highest abundance on meadows, their proportion exceeding 55% (Tab. 7). The prevailing were phytophagous species (85%), with the dominating *Oscinella frit*, *O. hortensis* and *O. pusilla* (Siedlar 1989). As regards the remaining *Diptera* families of the group *Acalyptratae*, the most numerous were phytophagous *Agromyzidae* (with dominating *Cerodonta denticornis*, *Chromatomyia nigra* and *Phytomyza wahlgreni*), *Opomyzidae* (*Opomyza nigra*), *Anthomyzidae* (*Anthomyza gracilis*) and *Tephritidae* (Nowakowski J. T. 1989). Among saprophages the most numerous were the species of the families *Sphaeroceridae*, *Sepsidae*, *Drosophilidae* and *Ephydridae*. A great deal of these *Diptera* lead a coprophagous mode of life in their larval stage (numerous species of the genera *Sepsis* and *Limosina*). The group of zoophages included predatory *Sciomyzidae* and *Chamaemyiidae*, yet they occurred in small numbers on the

Table 6. Abundance and percentage of particular groups of invertebrate fauna of the herbaceous layer on the meadows (*Arrhenatheretum medioeuropaeum*) on the Mazovian Lowland (n — number of individuals in a sweep-netted sample)

Sites	Klembów 1980–81		Białołęka 1976–77		Chylice 1981–83		Zbroszki 1983–84		Mean	
Group	n	%	n	%	n	%	n	%	n	%
Orthoptera	0.1	0.11	2.05	1.58	5.11	4.02	1.17	0.51	2.11	1.47
Psocoptera	0.01	0.01	0.01	0.007	0.21	0.17	0.02	0.009	0.06	0.04
Thysanoptera	19.2	21.28	1.09	0.84	5.37	4.22	4.59	2.02	7.56	5.26
Homoptera:										
Auchenorrhyncha	15.7	17.40	8.00	6.17	29.30	23.02	85.02	37.41	34.51	24.03
Psyllodea	0.01	0.01	0.12	0.09	0.14	0.11	0.30	0.13	0.14	0.10
Aphidodea	0.4	0.44	6.69	5.16	5.98	4.70	9.08	4.00	5.54	3.86
Heteroptera	4.7	5.21	6.32	4.87	4.38	3.44	4.86	2.14	5.07	3.53
Coleoptera	2.4	2.66	11.14	8.59	3.56	2.80	4.11	1.81	5.30	3.69
Neuropteroidea	0.02	0.02	0.04	0.03	0.06	0.05	0.04	0.02	0.04	0.03
Hymenoptera	8.2	9.08	8.82	6.80	13.55	10.65	19.86	8.74	12.61	8.78
Lepidoptera	0.08	0.09	0.84	0.65	0.20	0.16	0.23	0.10	0.34	0.24
Diptera	35.6	39.46	78.97	60.90	55.61	43.69	95.45	42.00	66.41	46.24
Aranea, Opiliones	3.5	3.88	4.26	3.29	2.21	1.73	1.44	0.63	2.85	1.98
Other	0.3	0.33	1.33	1.03	1.59	1.25	1.09	0.48	1.08	0.75
Total	90.22		129.68		127.27		227.26		143.62	

studied meadows. All the minute *Diptera* are closely bound to meadow biocoenoses and constitute their integral part.

A relatively large proportion was also observed of flies of the group *Calyptratae* (Tab. 7). Only some of them are more closely associated with meadow communities, e.g. several species of *Anthomyiidae*, coprophagous *Scatophagidae* or *Muscidae*. Parasitic species of this group from such families as *Tachinidae*, *Calliphoridae*, *Sarcophagidae* or *Rhinophoridae*, are not likely to find many hosts on meadows, hence their numerous occurrence on the studied meadows should rather be ascribed to attracting properties of meadow flowers, where imago find pollen and nectar.

Predatory *Diptera*, occurring in considerable numbers on meadows, ranked primarily among the families *Dolichopodidae*, *Hybotidae*, *Asilidae* and aphidophagous *Syrphidae*. Some of them are closely associated with meadows, where they complete their developmental cycle and feed when adult — many species of the genera *Chrysotus* and *Dolichopus* (*Dolichopodidae*) and numerous species of the genera *Sphaerophoria*, *Melanostoma* and *Platycheirus* (*Syrphidae*). Other predators enter the meadows from adjacent forests in search of suitable food consisting of other, small insects.

Table 7. Abundance and percentage of *Diptera* families on the meadows (*Arrhenatheretum medioeuropaeum*) of the Mazovian Lowland (n — number of individuals in a sweep-netted sample)

Diptera	Klembów		Chylice		Zbroszki		Mean	
	n	%	n	%	n	%	n	%
Tipulidae	0.02	0.06	0.03	0.04	0.04	0.05	0.030	0.05
Limoniidae	0.07	0.20	0.02	0.03	0.01	0.01	0.030	0.05
Psychodidae	0.01	0.03	0.01	0.01	—	—	0.006	0.01
Culicidae	0.68	1.92	0.19	0.28	0.01	0.01	0.290	0.46
Bibionidae	0.02	0.06	0.15	0.22	—	—	0.060	0.09
Scatopsidae	0.29	0.82	0.15	0.22	0.02	0.02	0.150	0.24
Mycetophilidae	0.02	0.06	0.03	0.04	0.02	0.02	0.020	0.03
Sciaridae	2.52	7.11	3.28	4.83	1.62	1.88	2.470	3.91
Chironomidae	1.94	5.47	8.22	12.12	1.07	1.24	3.740	5.92
Ceratopogonidae	0.19	0.53	0.21	0.31	0.16	0.18	0.190	0.30
Cecidomyidae	0.58	1.64	0.24	0.35	0.18	0.21	0.330	0.52
Tabanomorpha	0.01	0.03	0.15	0.22	0.06	0.07	0.070	0.11
Asilidae	—	—	0.58	0.85	—	—	0.190	0.30
Hybotidae	0.32	0.90	0.91	1.34	1.09	1.26	0.770	1.22
Dolichopodidae	2.32	6.54	0.68	1.00	1.28	1.48	1.430	2.26
Phoridae	0.66	1.86	1.08	1.59	1.23	1.43	0.990	1.57
Lonchopteridae	2.83	7.98	0.45	0.66	1.20	1.39	1.490	2.36
Pipunculidae	0.07	0.20	0.06	0.09	0.07	0.08	0.070	0.11
Syrphidae	0.29	0.82	0.32	0.47	0.21	0.24	0.270	0.43
Acalyptratae (excluding *Chloropidae*)	10.24	28.88	3.56	5.24	21.83	25.33	11.880	18.82
Chloropidae	10.25	28.91	44.60	65.74	49.97	58.00	34.940	55.36
Calyptratae	2.12	5.98	2.92	4.30	6.10	7.08	3.700	5.86

As regards *Nematocera*, the most abundant on meadows were *Chironomidae*, accounting for approximately 6% of all the sampled *Diptera* (Tab. 7). Not all the species sampled on meadows were closely associated with this type of habitat, as only the species which complete their larval development cycle in soil belong to this group, whereas larvae of a large proportion of *Chironomidae* develop in adjacent water basins, and enter meadows only occasionally (Demska 1989).

Among saprophagous *Diptera*, *Sciaridae*, *Lonchopteridae* and *Phoridae* were rather abundant. It should be stressed that hardly any individuals of the family *Stratiomyidae* were recorded, the sampled material having included only a few species of coprophagous *Diptera* of the genera *Geosargus* and *Chloromyia*.

As regards *Diptera* feeding on blood of homoiothermal animals, they were represented by rather scarce *Culicidae* and *Ceratopogonidae*. Also *Tabanidae* occurred on the moist meadows in very little numbers, the most numerous having been small species of the genera *Chrysops* and *Haematopota*.

The second abundant group of invertebrates on the studied meadows were *Homoptera-Auchenorrhyncha* (Tab. 6). They form a trophically uniform group,

evidently associated with grass communities, which in consequence of their high ecological amplitude makes possible the observation of man-caused changes in meadow zoocoenoses. Out of 70 species found on the studied moist meadows, the most abundant were: *Macrosteles laevis*, *Javesella pellucida*, *Deltocephalus pulicaris*, *Arthaldeus pascuellus* and *Psammotettix confinis* (Chudzicka 1989). The species in question, *M. laevis* and *J. pellucida* in particular, were observed to be a regular and dominating element in the communities of *Homoptera-Auchenorrhyncha* on a majority of cultivated meadows (Andrzejewska 1971, 1976, 1979). From the studies on *Homoptera* fauna conducted by other authors it follows that a majority of species dominating on the Mazovian Lowland also dominated on moist meadows located in other regions within the range of the temperate climatic zone in Europe (Doskočil, Hůrka 1962, Marchand 1953).

The third in abundance group of insects prevailing on the Mazovian moist meadows were *Hymenoptera* (Tab. 6). Like *Diptera*, this group was marked for a large heterogenesity. The most numerous were parasitic *Hymenoptera* (approximately 80%). The sampled material included 719 species of 29 families. Among *Chalcidoidea*, the dominating on the moist meadows was *Semiotellus mundus* — the parasite of leaf-mining *Diptera* of the families *Chloropidae*, *Agromyzidae* and *Cecidomyidae*. Also *Anaphes stygius* and *Anagarus atomus*, the parasitoids of piercing phytophage larvae, were abundant (Głogowski 1989). Quite numerous were also parasitoids of leaf-mining phytophages of the subfamilies *Alysiinae* and *Opiinae* (*Braconoidea*). The dominating species comprised *Orthostigma maculipes*, *Chorebus senilis*, *Dacnusa maculipes* and *Opius exiguua* (Marczak 1989).

Among *Proctotrupoidea* two species dominated on the meadows, namely *Platygaster verrucosa* and *Trichopria inermis*. The former parasitizes on leaf-mining insects and reaches high abundances on mown meadows in particular, while the latter — the parasitoid of coprophagous *Diptera* — was very numerous on the pasture (Garbarczyk 1989).

Out of 282 species of *Ichneumonidae*, as many as 160 were parasitoids of phytophagous insects. The remaining species parasitized in other zoophages and saprophages. Among parasitoids of phytophages dominated: *Aclatus minutus*, a parasitoid of spiders' egg deposits and *Stenomacrus* sp., parasitizing on larvae of saprophagous *Diptera* (Sawoniewicz 1989).

Apart from parasitic *Hymenoptera*, there also were much less abundant, predatory *Hymenoptera* of the genera *Sphaecidae*, *Vespidae*, *Pompilidae* and *Chrysididae* (Skibińska 1989).

As regards *Apidae*, the species most frequently occurring on the studied meadows included: *Andrena haemorrhoa*, *Lasioglossum calceatum* and *Apis mellifera* (Banaszak 1989).

Apart from the insect groups mentioned above, the following also occurred abundantly on the studied meadows: *Thysanoptera*, *Aphidodea* and *Heteroptera* (Tab. 6). The most abundant among *Coleoptera* were phytophagous species of *Curculionidae*, *Barypithes pellucidus* being dominant, and of *Chrysomelidae*. Predatory *Coleoptera* of the herbaceous layer were scantily represented by *Coccinellidae*.

The studied meadows did not abound in *Orthoptera*. Out of the six distinguished species, distinctly dominated *Chorthippus albomarginatus*, accounting for 84% of all *Orthoptera* (Winiarska, Gniazdowska 1989).

Aranea of grass communities should be dealt with separately. Their abundance in the herbaceous layer was very large (Tab. 6), yet they perform a significant function in regulation of zoocoenoses of moist meadows, constituting, besides predatory *Diptera* and parasitic *Hymenoptera*, the most numerous groups of reducers.

The fauna of the herbaceous layers on the studied moist meadows of the Mazovian Lowland was composed mainly of phytophagous insects. The prevailing were phytophages having a sucking mouth apparatus, such as *Heteroptera*, *Homoptera-Auchenorrhyncha*, *Aphidodea*, *Psyllidae*, or *Thysanoptera* (Fig. 3). Equally large was the group of leaf-mining insects, small *Diptera* of the group *Acalyptratae* contributing the greatest part. The other leaf-mining insects, such as *Lepidoptera* or *Coleoptera*, were of secondary importance to meadows. As regards phytophages having a grazing mouth apparatus, the most numerous were *Coleoptera* (*Curculionidae*, *Chrysomelidae*) and *Orthoptera*, *Lepidoptera* and *Symphyta* occurred in small numbers.

The proportion of saprophagous insects to epiphytone was relatively modest

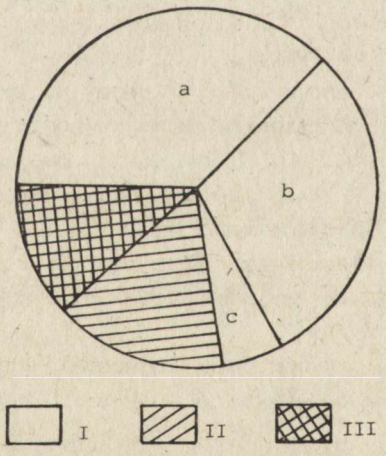

Fig. 3. Percentage of trophic guilds of invertebrate fauna in the herbaceous layer of moist meadows: I — phytophages: a — piercing phytophages, b — mining phytophages, c — grazing phytophages; II — zoophages, III — saprophages

(11%). They were represented mainly by small *Diptera*, whose larvae developed in meadow soil or in cattle manure.

Zoophages included parasitic and predatory *Hymenoptera*, *Diptera* and predatory *Heteroptera*, *Aranea*, *Neuroptera* and a few *Coleoptera*. Their proportion in the fauna inhabiting the herbaceous layer did not exceed 16% (Fig. 4). Due to their function in reducing the number of many insects noxious to meadow crops (phytophagous insects) as well as the useful ones (saprophagous and zoophagous insects), zoophages are of primary importance in regulating zoocoenoses and hence they will be dealt with in details below.

In the group of zoophages on the studied meadows, the most abundant were parasitic *Hymenoptera* (Fig. 4). From the point of view of meadow cultivation, large abundance on the studied meadows of parasitoids of phytophagous insects — both of leaf-mining insects as well as of piercing phytophages and grazing egzophytophages — is very advantageous. This group accounted for approximately 50% of the total parasitoid abundance (Garbarczyk 1989).

The prevailing were parasitoids of mining phytophages, mainly from *Hymenoptera* of the superfamily *Proctotrupoidea* (60–80%), and, to a smaller extent, of *Braconoidea* and *Chalcidoidea*. They parasitized mainly in mining *Diptera* of the family *Chloropidae* and *Agromyzidae*, which occurred numerously on the studied meadows. The dominating parasitoids were *Platygaster verrucosa* (*Proctotrupoidea*), *Semiotellus mundus*, *Meraporus graminicola* and *Callitula bicolor* (*Chalcidoidea*).

On the meadows quite high abundance was observed of *Hymenoptera* parasitizing in predators (17%), especially in aphidophages (mainly in aphidophagous *Syrphidae*) — of the subfamily *Diplazontinae*. Parasites of eggs of *Carabidae*: *Trimorus punctulator* and *T. opacus* (*Proctotrupoidea*) were also abundant.

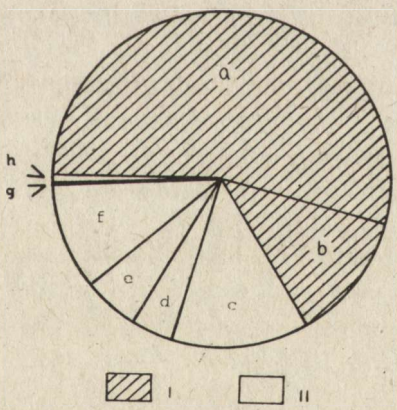

Fig. 4. Percentage of particular groups of zoophages in the herbaceous layer of moist meadows: I — parasitoids, II — predators, a, h — *Hymenoptera*, b, c — *Diptera*, d — *Coleoptera*, e — *Heteroptera*, f — *Aranei*, g — *Neuroptera*

Parasitoids of saprophagous insects constituted approximately 33%. The dominating were parasitoids of saprophagous larvae of *Diptera*, i.e. *Opazon parvulus* and *Trichopria verticillata* (*Proctotrupoidea*) and *Stenomacrus* sp. (*Ichneumonidae*).

Parasitic *Diptera* occurring on meadows included representatives of the family *Calliphoridae*, with a dominant *Pollenia rudis*, parasitizing in earthworms. Other species of this family infest land snails. Moreover, earthworms are hosts of parasitic *Diptera* of the genus *Sarcophaga* (*Sarcophagidae*). *Diptera* of the family *Tachinidae* are included into the group of polyphages. Their hosts are various insect groups: *Coleoptera*, *Heteroptera*, caterpillars of butterflies or *Symphyta*.

Among *Diptera* which contribute to reduction of pests, attention should be paid to *Pipunculidae*, which parasitize in *Homoptera-Auchenorrhyncha*. Their abundance on the studied meadows, as evidenced by sample analyses, was relatively low (Tab. 7). The dominating species were *Alloneura silvatica* and *Budorylas fuscipes* — parasites of *Macrosteles laevis*, i.e. a species of *Homoptera-Auchenorrhyncha*, numerously occurring on the meadows (Bańkowska 1989). The sampled material did not contain any *Diptera* of the family *Conopidae*, which parasitize in *Aculeata*.

The group of predatory aphidophages comprised *Coccinellidae*, *Neuroptera*, some species of *Sphaecidae* as well as predatory species of flies of the families *Syrphidae* and *Chamaemyidae*. On the studied moist meadows there were recorded six species of zoophagous *Coccinellidae* with *Tythaspis sedecimpunctata* as a dominant. The abundance of *Coccinellidae* on particular meadows differed in index values ranging between 0.14–0.77 individuals per sweep-net sample (Czechowska 1989). Very low abun dance was estimated of *Neuroptera*, ranging from 0.01 to 0.06 individuals per sample, as well as of aphidophagous *Aculeata* of the family *Sphaecidae*. Six species of aphidophagous *Aculeata* were sampled on the studied meadows, namely: *Passaloecus singularis*, *Stignus pendulus*, *Mimumesa dahlbomi*, *Psenulus fuscipennis* and *Ps. schnecki* (Skibińska 1989). More abundant were predatory *Syrphidae*, i.e. 0.07–0.21 individuals per sample. The dominants included the following spec ies: *Sphaerophoria scripta*, *S. menthastri*, *Melanostoma mellinum* and *Platycheirus clypeatus*. As regards *Chamaemyidae*, three species dominated on the moist meadows, namely *Chamaemyia juncorum*, *Ch. geniculata* and *Ch. polystigma* (Bańkowska 1989).

On the unspecialized predators the most abundant were *Aranei*, contributing from 1.44 individuals per sweep-net sample in Zbroszki to 4.26 in Białołęka. The dominating species in the spider community on the studied meadows were *Pardosa palustris*, *P. pullata*, *Pachygnatha degeeri* and *Tarentula pulverulenta* (Staręga 1989).

Ectemnius continuus, *Oxybellus uniglumis* (*Sphaecidae*) and *Paravespula germanica* (*Vespidae*) were the most abundant representatives of *Aculeata* on the meadows. However, the abundance of *Aculeata* was low, hence their part in reducing

animals inhabiting the studied meadows was negligible (Skibińska 1989). Similarly *Formicidae*, even though fairly numerously sweep-netted, seemed to be of secondary importance to this process. They penetrate grass blades in search of aphid colonies and to attack newly hatched small *Diptera* and *Heteroptera* (Kajak et al. 1972).

Hybotidae and *Empididae* occurred in relatively high abundance among predatory *Diptera* (Tab. 7). Their diet is very diversified — they feed on minute flies, *Hymenoptera* and some *Heteroptera*. The dominating species of *Hybotidae* on the studied meadows was *Platypalpus infectus*.

Another significant group of predatory *Diptera* were *Dolichopodidae*. Their abundance ranged from 0.70 individuals per sample in Chylice to 2.33 in Klembów. The dominating on the meadows were small forms belonging to the genus *Chrysotus*, namely *Ch. femoratus*, *Ch. gramineus*, *Ch. cilipes* and slightly larger *Dolichopus plumipes*, *D. longicornis* and *Sciopus longulus* (Bańkowska 1989). The other predatory *Diptera* of the families *Asilidae*, *Rhagionidae* and *Therevidae* hardly ever occurred in the sampled material.

VARIABILITY OF THE HERBACEOUS FAUNA

Meadow communities are subject to pronounced changes over the period of several years. Species composition and production of plant matter may vary on one and the same meadow from year to year depending on weather conditions. Consequently, the composition and structure of animal communities on the meadow may also change. Furthermore, fauna abundance may also be directly influenced by persisting low temperatures or hot and arid summers.

All these factors, which cause fluctuations of fauna over the period of several years, make it extremely difficult to evidence changes in animal communities which are brought about by human activity solely.

In the course of the three-year studies on the mown meadow at Chylice (1981–1983), considerable changes in the abundance of invertebrate fauna were noted (Fig. 5). In 1982 a very high increases in the abundance of almost all the larger groups of animals was observed. The abundance of both phytophagous and zoophagous insects almost doubled as compared to those estimated for 1981 and 1983. This phenomenon was directly related to weather conditions. The weather in 1982 was exceptionally warm and dry. The spring of 1982 came early and was unusually warm and sunny; day-time air temperatures in May were well over 20°C, which much advanced the development of the first generation of many insects found on the meadow. The weather in other years, on the other hand, was not so advantageous, as it was marked for long-lasting periods of rain and cold. The diagrams of abundance dynamics of more significant groups of phytophagous insects over a vegetative season, presented in Figs 6, 7, 8, 9, 10, show a pronounced variability.

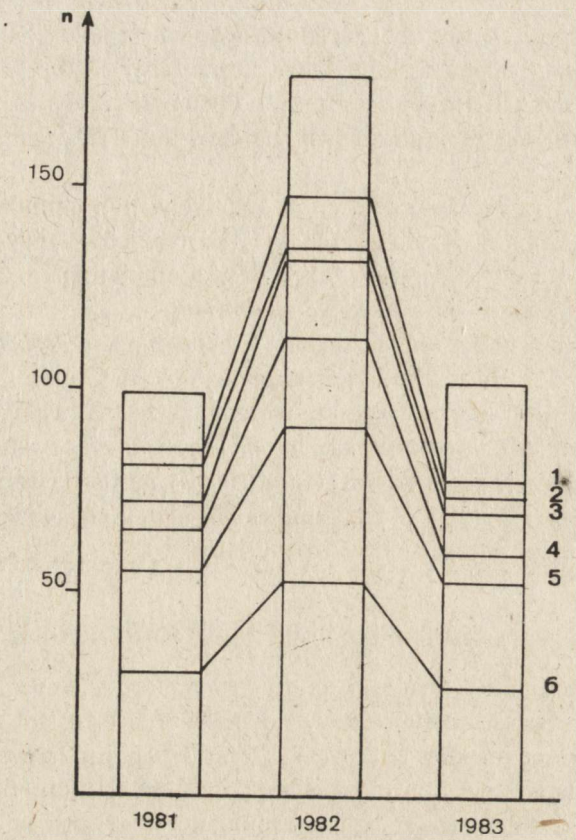

Fig. 5. Fauna abundance and the abundances of dominating groups on the repeatedly mown meadow at Chylice in 1981–1983: n — the number of individuals in a sweep-net sample: 1 — *Aphidodea*, 2 — *Nematocera*, 3 — *Thysanoptera*, 4 — *Hymenoptera*, 5 — *Homoptera-Auchenorrhyncha*, 6 — *Acalyptratae* (*Diptera*)

A single-peaked curve of aphid abundance, almost identical in the course of the three successive years, is very characteristic. Mass appearance of these insects on meadows began in mid-June and ended in mid-July. Autumn appearance was not always so clear-cut. A similarly short period of mass appearance was also characteristic of *Thysanoptera* — the curve rose in mid-June, fell abruptly in mid-July to culminate again at the end of July.

Heteroptera were noted for an increase in the dynamics of their occurrence in May or at the beginning of June and this period lasted all summer long to end in August.

Homoptera-Auchenorrhyncha were marked for a multi-apex curve throughout the vegetative season. The spring abundance peak caused a mass hatching of the first generation of *Javesella pellucida*; the abundance peaks in summer were caused by the two other dominating species, i.e. *Macrosteles laevis* and *Psammo-*

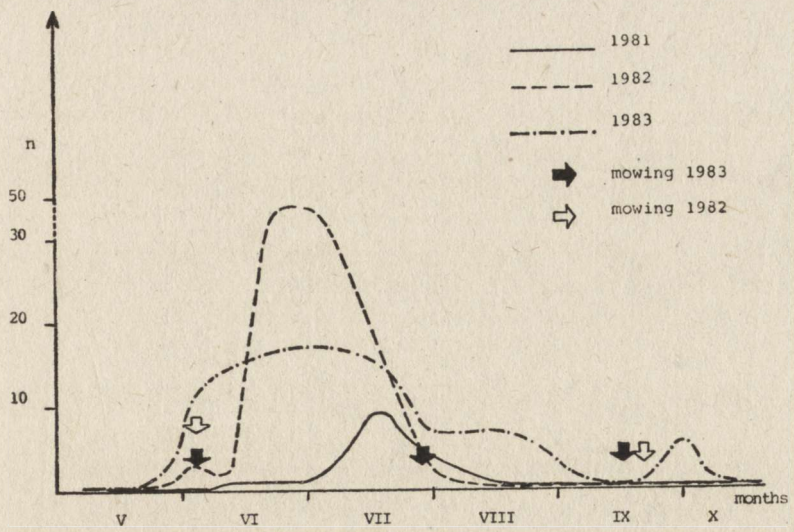

Fig. 6. Seasonal dynamics of *Orthoptera* abundance on the meadow at Chylice: n — the number of individuals in a sweep-net sample

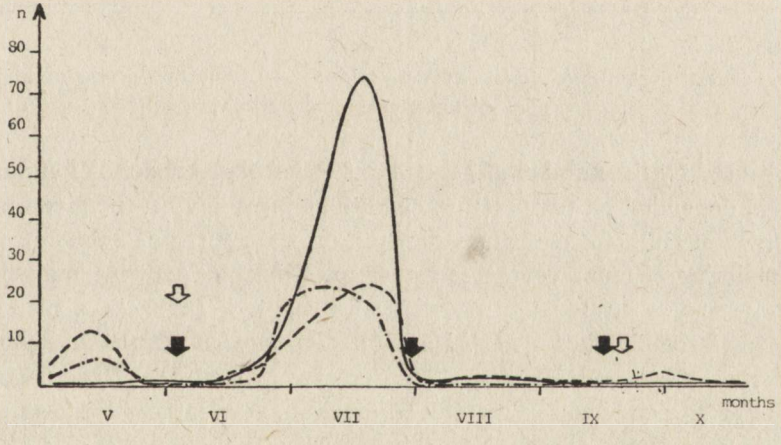

Fig. 7. Seasonal dynamics of *Thysanoptera* abundance on the meadow at Chylice (denotations — as in Fig. 6)

tettix confinis, completing on meadows two or, under favourable weather conditions, even three generations a year.

A multi-apex curve of abundance dynamics was also recorded for *Diptera* of the family *Chloropidae*. In the climatic conditions of Poland the dominating species of the genus *Oscinella* produced two or three generations over the vegetative season.

It may be assumed that differences in seasonal dynamics of meadow insects

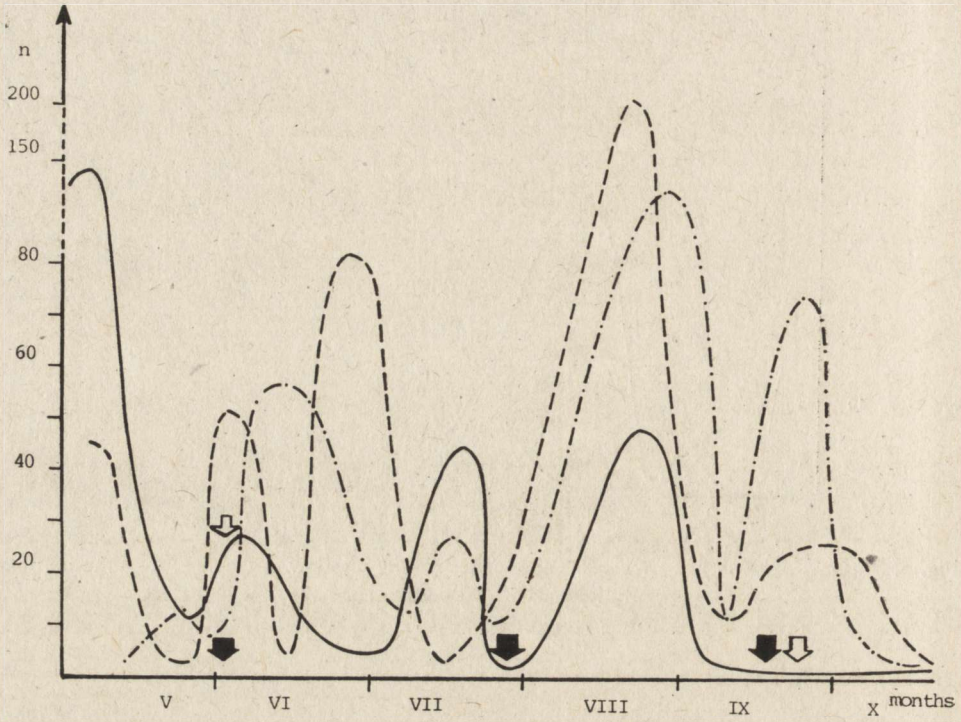

Fig. 8. Seasonal dynamics of *Auchenorrhyncha* (*Homoptera*) abundance on the meadow at Chylice (denotations — see Fig. 6)

were caused by the number of generations of particular species of animals, which, in turn, depended on temperature conditions prevailing in the given period.

Unfavourable effect of grass mowing on the course of abundance dynamics of a majority of fauna groups is rather questionable. Mowing may significantly affect insects associated with flowers and seeds of herbaceous plants, such as *Diptera* of the families *Tephritidae* and *Cecidomyidae*, numerous *Thysanoptera* and certain species of *Coleoptera*. The remaining groups of phytophagous insects, even after an occasional migration, re-emigrate very rapidly from adjacent crops and are sometimes observed to increase their abundance, i.e. *Chloropidae* or *Homoptera*.

The comparison of the abundance of *Oscinella frit* on mown and grazed meadows to that on totally uncultivated meadows in England revealed that it was over ten times greater on the areas overgrown with short cut grass (Southwood, Jepson 1962). Similar results were arrived at by Frydlewicz-Ciesielska (1961), who studied *Diptera* fauna on natural and cultivated meadows in Poland. The present studies on dynamics of fauna on the cultivated moist meadows fully confirmed the previous findings.

The phenomenon may be explained by the fact that young, growing grass blades

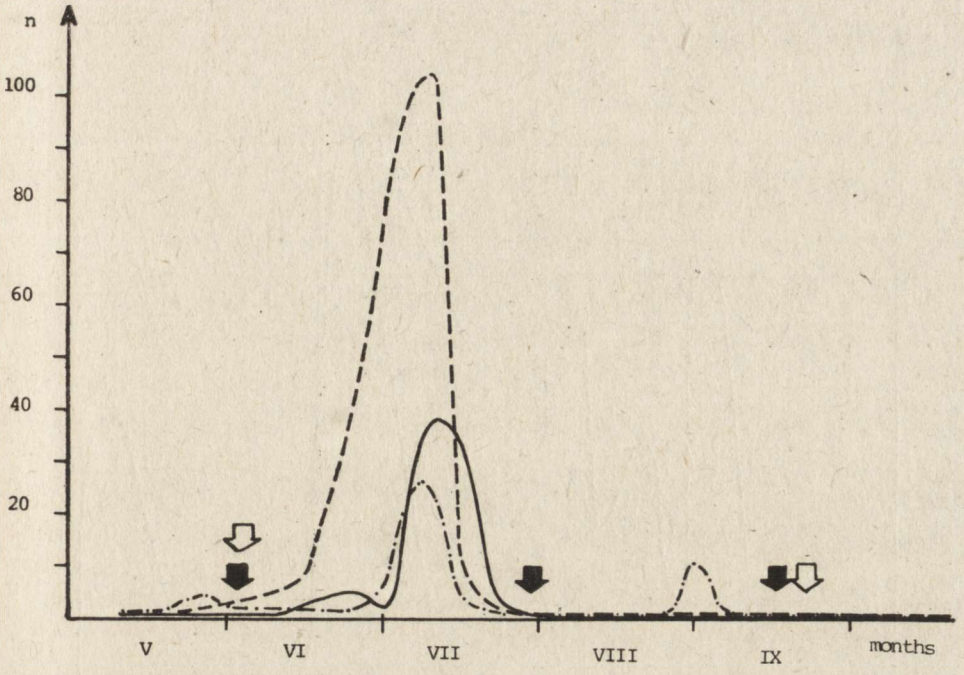

Fig. 9. Seasonal dynamics of *Aphidodea* abundance on the meadow at Chylice (denotations — see Fig. 6)

are by far a better food resource for many insects than old, lignified during summer, grass blades on uncultivated meadows.

Various types and intensities of meadow exploitation cause marked changes in the abundance of many fauna crops, their species composition and dominance structure.

On the studied meadows of the Mazovian Lowland there was recorded over a two times greater invertebrate abundance in the herbaceous layer on the pasture (Zbroszki) as compared to mown and mown-grazed meadows (Tab. 6). The mown-grazed meadows (Białołęka, Klembów), extensively cultivated and hardly ever fertilized, were marked for an abundant and diversified fauna. On the mown meadow at Chylice, intensively exploited and fertilized with NPK, a depletion in fauna was observed, namely several species of many animal groups were subject to decrease in number and an increase was noted in the abundance of phytophagous groups, such as *Homoptera-Auchenorrhyncha* or phytophagous *Diptera*. The greatest fauna depletion and unfavourable structural changes in many invertebrate communities were observed on the intensively cattle-grazed pasture at Zbroszki. Here an increase was noted in the number of *Homoptera-Auchenorrhyncha*, *Apidodea*, phytophagous *Diptera* of the family *Chloropidae* in particular, coprophagous species of the families *Sepsidae* and *Sphaeroceridae* as well as parasi-

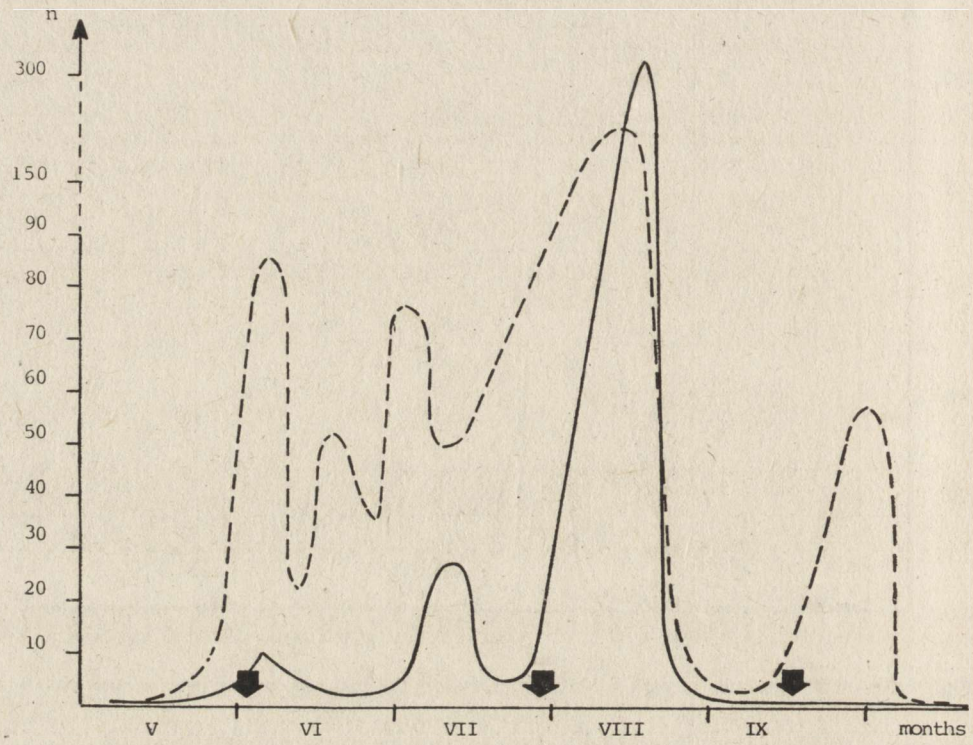

Fig. 10. Seasonal dynamics of *Chloropidae* (*Diptera*) abundance on the meadow at Chylice (denotations — see Fig. 6)

tic *Hymenoptera*. The abundance of predatory *Diptera* and *Aranea* was much reduced at the same time.

According to intensity of meadow exploitation, there may be observed varied tendencies in the structure of particular animal communities (Figs 11, 12). In the gradient of the degree of meadow exploitation there may be noted:

1. An increase in the community abundance along with an impoverishment of species composition. This tendency was observed in the case of *Diptera* of the family *Chloropidae*, where always dominated the same three species of the genus *Oscinella*.

2. An increase in the community abundance, at a steady number of species. Diversification of dominance structure was also noted. A typical example were *Homoptera-Auchenorrhyncha*, with *Macrosteles laevis* and *Psammotettix confinis* dominating on the mown meadow and *Deltocephalus pulicaris* on the pasture.

3. A decrease in the community abundance and a marked depletion of species composition. Often the abundances of several dominating species may also increase. Such tendencies were observed at certain communities of phytophages, namely *Orthoptera*, *Lepidoptera* and *Symphyta*, and *Chrysomelidae* among *Coleoptera*. Furthermore, it was also noted at some groups of saprophagous *Diptera* and a ma-

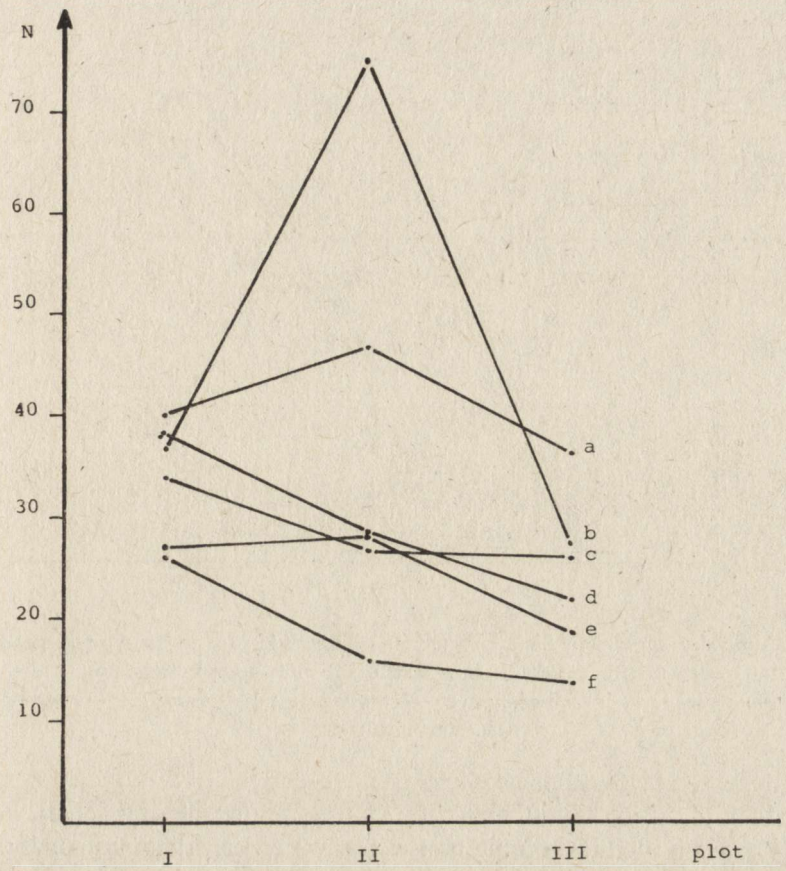

Fig. 11. Relation between the number of species (N) of some invertebrate groups and the type of meadow exploitation: I — mown-grazed meadow, II — fertilized, multi-mown meadow, III — pasture; a — *Auchenorrhyncha*, b — *Aranei*, c — *Agromyzidae*, d — *Chloropidae*, e — *Chrysomelidae*, f — *Dolichopodidae*

jority of representatives of *Nematocera*, i.e. *Sciomyzidae* and *Ephydridae*. Furthermore, in the same way reacted numerous groups of zoophages, especially spiders and predatory *Diptera* of the families *Dolichopodidae* and *Syrphidae*.

In conclusion of the findings of the research on the moist meadow fauna it may be said that an increase in human interference is subsequently followed by unfavourable changes in the fauna of cultivated meadows. Hence there may be observed a depletion of the species abundance, whole groups of animals being eliminated, and a vehement increase may be noted in the abundance of certain phytophagous insects, causing great losses in green matter. At the same time the number of zoophages, i.e. spiders and predatory and parasitic insects, drops down (Fig. 13). Moreover, a decrease is visible in the proportion of specialized reducers, i.e. aphidophages, at a simultaneous increase in that of aphides (Fig. 14).

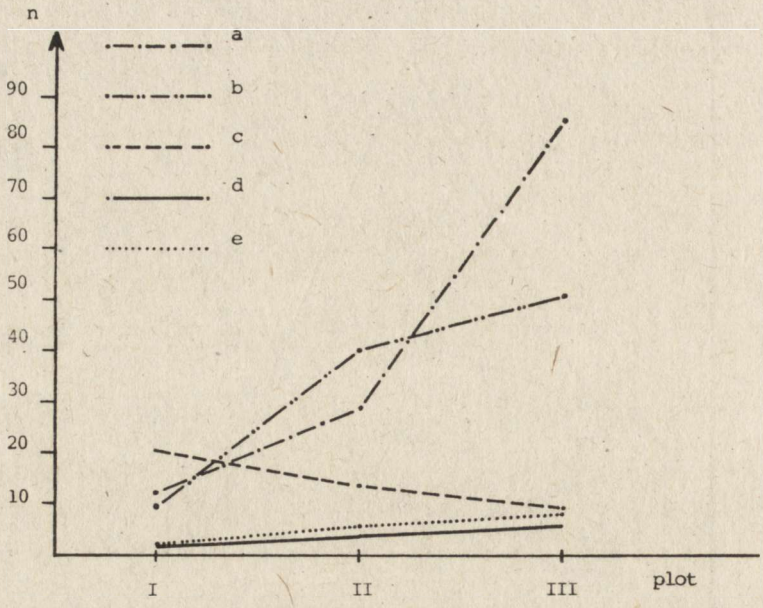

Fig. 12. Abundance changes in some invertebrate communities due to the type of meadow utilization: I — mown-grazed meadow, II — fertilized, multi-mown meadows, III — pasture; a — *Auchenorrhyncha*, b — *Chloropidae*, c — *Hymenoptera*, d — *Aranei*, e — *Aphidodea*; n — abundance index

Meadows are primarily inhabited by animals preferring open areas, however, there also may be found ubiquitous species, which can flourish equally well in forest environments. Many meadow species may also be found on crop fields, especially on perennial crops of *Papillionaceae* as well as on cereals and root plants.

The greatest number of species was identified as the types of a wide range of ecological tolerance, i.e. poly- or even eurytopic ones. Stenotopic species were scanty.

A majority of invertebrate species occurring on the moist meadows might have been classified as mesohygrophiles and, in the case of some groups, even xerophiles (e.g. *Collembola*, certain groups of *Diptera*).

Species of wide geographical ranges prevailed in a majority of animal groups. This is typical of semi-natural and man-made environments. The most numerous were Palaearctic and Holarctic elements, the elements of narrower ranges, the Euro-Siberian and European to begin with, occurring scantily. Species of wide geographical ranges contributed mostly on the most modified areas, i.e. on fertilized meadows and pastures.

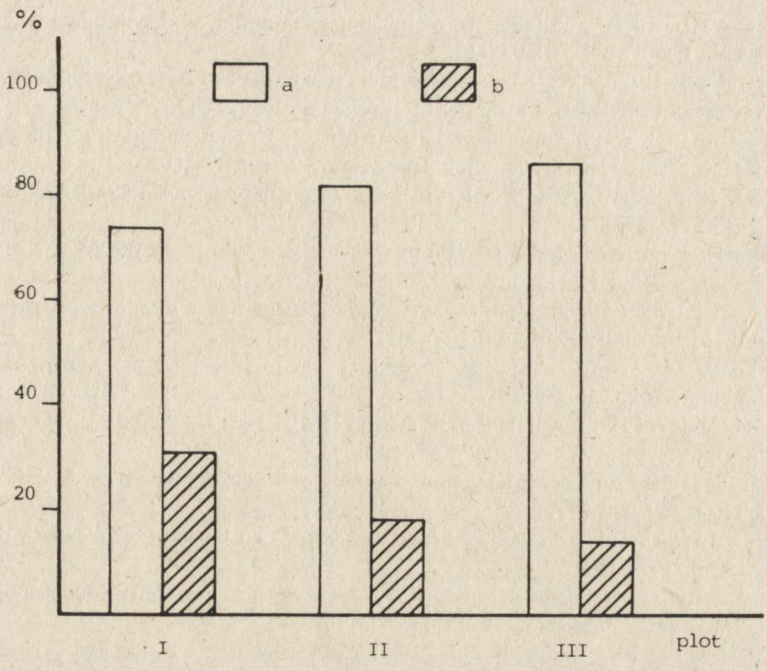

Fig. 13. Percentage of phytophages (a) and zoophages (b) abundances on variously exploited meadows: I — mown-grazed meadow, II — fertilized, multi-mown meadow, III — pasture

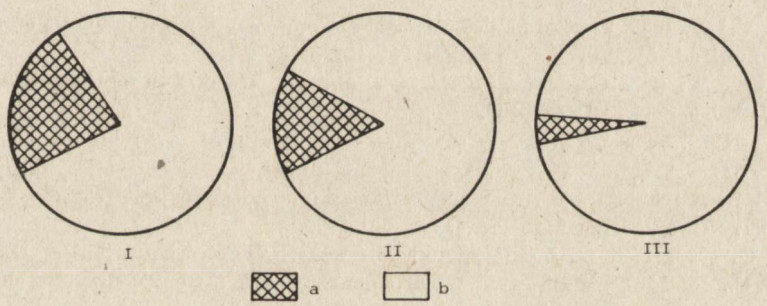

Fig. 14. Percentage of the abundances of aphidophages (a) and aphides (b) on meadows: I — mown-grazed meadow, II — fertilized, multi-mown meadow, III — pasture

Polska Akademia Nauk
Instytut Zoologii
ul. Wilcza 64, 00-679 Warszawa

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STRUKTURA FAUNY ŁĄK ŚWIEŻYCH NIZINY MAZOWIECKIEJ

STRESZCZENIE

Autorzy przedstawiają syntetyczne opracowanie wyników badań nad fauną bezkręgowców łąk świeżych Niziny Mazowieckiej, prowadzonych w latach 1979–1983 przez Zakład Zoocenologii Instytutu Zoologii PAN w Warszawie.

W faunie glebowej najważniejszą rolę odgrywa poziom destruentów. W glebach badanych łąk stwierdzono występowanie kompensacji ilościowej między mikrosaprofagami a makrosaprofagami (rys. 1). Wśród tych ostatnich najistotniejszą rolę odgrywają *Lumbricidae* oraz larwy *Diptera*. *Isopoda* i *Diplopoda* osiągają tu dość niskie zagęszczenie. W glebach łąkowych stwierdzono wyraźną dominację form ryzofagicznych wśród larw *Coleoptera* (tabl. 5), jedynie na łąkach bardziej wilgotnych przeważają larwy drapieżnych chrząszczy. Udział form pantofagicznych nie przekracza 11%.

W warstwie epigeonu dominującą grupą są drapieżce — pająki oraz liczne gatunki chrząszczy zwłaszcza z rodzin *Carabidae* i *Staphylinidae*. Występuje także sporo form pantofagicznych wśród *Carabidae* oraz *Formicidae*. Udział fitofagów, a zwłaszcza saprofagów, jest znikomy.

Na zróżnicowanie liczebności poszczególnych grup zwierząt bezkręgowych, zasiedlających warstwę zielną łąk, decydujący wpływ mają zarówno warunki atmosferyczne, lokalne warunki, siedliskowe, jak i sposób uprawy łąki.

Na łąkach świeżych Niziny Mazowieckiej najwyższą liczebność osiągają muchówki, następnie piewiki, błonkówki i przylżeńce (tabl. 6).

W warstwie zielnej faunę badanych łąk stanowią głównie owady roślinożerne. Najbardziej liczebną grupą są fitofagi o ssącym aparacie gębowym, jak: pluskwiaki różnoskrzydłe, piewiki, mszyce, koliszki i przylżeńce (rys. 3). Drugą co do liczebności grupą wśród roślinożerców są owady minujące, z których największy udział mają drobne muchówki z grupy *Acalyptratae*. Pozostałe minowce, jak motyle (*Lepidoptera*) czy chrząszcze (*Coleoptera*), występują na łąkach w mniejszych liczebnościach. Wśród owadów roślinożernych o gryzącym aparacie gębowym najwięcej jest chrząszczy (*Curculionidae*, *Chrysomelidae*) i szarańczaków (*Orthoptera*). Motyle i rośliniarki występują w niewielkich liczebnościach.

Udział saprofagicznych owadów w epifytonie jest stosunkowo skromny (11%). Są one głównie reprezentowane przez drobne muchówki, których larwy rozwijają się w glebie łąkowej lub w nawozie bydlęcym.

Zoofagi obejmują pasożytnicze i drapieżne błonkówki, muchówki oraz drapieżne pluskwiaki, pająki, sieciarki i nieliczne chrząszcze. Udział ich nie przekracza 16% w faunie zasiedlającej warstwę traw (rys. 4).

Wśród zoofagów występujących na badanych łąkach, największą liczebność wykazują pasożytnicze błonkówki (rys. 4).

Najwyższą liczebność osiągają parazytoidy fitofagów minujących. Kompleks ten tworzą głównie błonkówki z nadrodziny *Proctotrupoidea* (60–80%), w mniejszym stopniu z *Braconoidea* i *Chalcidoidea*. Pasożytują one głównie w licznie występujących na łąkach muchówkach minujących z rodzin *Chloropidae* i *Agromyzidae*. Dominującymi parazytoidami są: *Platygaster verrucosa* (*Proctotrupoidea*), *Semiotellus mundus*, *Meraporus graminicola* i *Callitula bicolor* (*Chalcidoidea*).

Zbiorowiska łąkowe podlegają dużym zmianom w ciągu kilkuletniego okresu czasu. W zależności od warunków atmosferycznych może się zmienić skład gatunkowy oraz produkcja masy roślinnej na tej samej łące. W ślad za tym następują zmiany w składzie i strukturze zamieszkujących łąkę zwierząt. Również duży wpływ bezpośredni na liczebność fauny mogą mieć długotrwałe niskie temperatury lub upalne i suche lata.

W ciągu trzyletnich badań na łące kośnej w Chylicach (1981–1983) zanotowano spore zmiany w liczebności fauny bezkręgowców (rys. 5).

Odmienny sposób i różna intensywność użytkowania łąk wywołuje wyraźne zmiany w liczebności wielu grup fauny, jej składzie gatunkowym i w strukturze dominacyjnej.

Wśród badanych łąk Niziny Mazowieckiej zaobserwowano prawie dwukrotnie wyższą liczebność bezkręgowców w warstwie zielnej pastwiska (Zbroszki) w porównaniu do łąk kośnych i kośno-pastwiskowych (tabl. 6). Łąki kośno-pastwiskowe (Białołęka, Klembów), uprawiane ekstensywnie i prawie nienawożone, charakteryzują się bogatą i zróżnicowaną fauną. Już na łące kośnej w Chylicach — intensywnie uprawianej i nawożonej NPK — zaznacza się ubożenie fauny, zmniejsza się liczba gatunków wielu grup zwierząt, zwiększają liczebność takie grupy roślinożerców jak piewiki, czy fitofagiczne muchówki. Najsilniejsze zubożenie fauny i niekorzystne zmiany strukturalne w wielu zgrupowaniach bezkręgowców uwidaczniają się na pastwisku intensywnie wypasanym przez bydło. Zwiększa się liczebność piewików, mszyc, roślinożernych muchówek, głównie z rodziny *Chloropidae* oraz koprofagicznych gatunków z rodzin *Sepsidae* i *Sphaeroceridae*, a także pasożytniczych błonkówek. Zmniejsza się natomiast liczebność drapieżnych muchówek oraz pająków.

Podsumowując wyniki badań nad fauną łąk świeżych, można powiedzieć, że w miarę wzrostu ingerencji człowieka w faunie upraw łąkowych następują niekorzystne zmiany. Zmniejsza się wyraźnie bogactwo gatunkowe, eliminowane są całe grupy zwierząt, powiększa się gwałtownie liczebność niektórych owadów roślinożernych, powodując ubytki masy zielnej. Jednocześnie zmniejsza się liczba zoofagów — pająków i owadów drapieżnych i pasożytniczych (rys. 13). Ulega także zmniejszeniu udział reducentów wyspecjalizowanych — afidofagów, przy jednoczesnym wzroście mszyc (rys. 14).

Łąki są zasiedlane głównie przez zwierzęta preferujące tereny otwarte, jednak występują również gatunki ubikwistyczne, które mogą równie dobrze egzystować w środowisku leśnym. Duża część gatunków łąkowych występuje także na polach uprawnych zwłaszcza na wieloletnich uprawach roślin motylkowych oraz na zbożach i okopowych.

Najwięcej gatunków reprezentuje typ o szerokim zakresie tolerancji ekologicznej — poli- lub nawet eurytopowy. Gatunki stenotopowe są nieliczne.

Większość gatunków bezkręgowców, występujących na łąkach świeżych to mezohigrofile, a w niektórych grupach nawet kserofile (*Collembola*, niektóre grupy *Diptera*).

СТРУКТУРА ФАУНЫ СВЕЖИХ ЛУГОВ МАЗОВЕЦКОЙ НИЗМЕННОСТИ

РЕЗЮМЕ

Авторы дают синтетическую обработку результатов исследований по фауне беспозвоночных животных свежих лугов Мазовецкой низменности, которые велись в 1979—1983 гг. коллективом сотрудников Лаборатории зооценологии Института зоологии ПАН.

Синэкологические исследования по фауне культивируемых лугов велись многими учреждениями как в Польше, так и за границей. Имеется по этому вопросу обширная литература, однако, большинство исследований охватывали определенные группы животных, а редко весь комплекс луговой фауны.

Среди исследований, в которых более подробно исследованы взаимосвязи между группировками животных, населяющих луга, следует указать на обширную публикацию фауны влажных лугов в северо-западной Германии (Boness 1953). Также в Чехословакии велись интенсивные исследования фауны лугов (Dosko čil и Hůrka 1962). В обеих перечисленных публикациях кроме фуанистических и экологических данных, содержатся также результаты исследований по влиянию кошения трав на численность отдельных групп животных. В последующие годы исследователи из Чехословакии проводили ряд интересных исследований по фауне лугов в рамках программы МАВ. Их результаты опубликованы в коллективном труде (Rychnowska ed. 1979).

Американские ученые также вели ряд исследований по сообществам животных, живущих на культивируемых лугах (Ford 1935, Evans и Murdoch 1968, Henderson и Whittaker 1977, Cole 1980). Особенно много работ касается пастбищ и влияния выпаса домашних животных на численность беспозвоночных (Morris M. G. 1967, 1968, 1969, 1971, Hutchinson и King 1980).

Из исследований, проводимых в Польше, особого внимания заслуживают многочисленные разработки Института экологии ПАН, которые проводились в рамках программы IBP и касались продукции улговых экосистем (Łuczak 1976 и Breymeyer 1971).

Коллектив сотрудников Института зоологии ПАН обработал также фауну травянистых сообществ типа *Arrhenatheretum* на территории Варшавского городского комплекса (Czechowski, Pisarski 1981 и Czechowski, Garbarczyk, Pisarski, Sawoniewicz 1982).

Настоящие исследования посвящены фауне беспозвоночных свежих лугов, используемых для хозяйственной деятельности, на территории Мазовии.