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Lucyna ANDRZEJEWSKA

STRATIFICATION AND ITS DYNAMICS IN MEADOW COMMUNITIES OF *AUCHENORRHYNCHA* (*HOMOPTERA*)*

The subject of this study is analysis of the distribution of *Auchenorrhyncha* in the layers of meadow plants. It was found that species of *Auchenorrhyncha* tend to occupy definite layers of plants regardless of the type of the meadow habitats examined. Vertical movements of *Auchenorrhyncha* during the growing season are connected with their life cycle. The habitat influences the vertical distribution of the population through the change in the life cycle of the species. The layer distribution of *Auchenorrhyncha* in the layers of meadow plants is also influenced by the population density and the place occupied by the population in the domination structure of the community.

CONTENTS

The problem of the distribution in layers of species forming communities of *Auchenorrhyncha* in plant associations has not formed the subject of homopterological research and studies. In the more or less detailed elaborations dealing with *Auchenorrhyncha* fauna of natural and cultivated plant associations the authors most often compare the species composition and also the abundance

*From the Institute of Ecology, Polish Academy of Sciences, Warszawa.

of the species forming the *Auchenorrhyncha* communities in the given habitats (Kuntze 1937, Kontkanen 1950, Strübing 1955, Remane 1958, Afscharpour 1960 and others). Remarks on the biology of *Auchenorrhyncha* can also be found in these papers. Kuntze (1937) states that when the weather is cold and windy the insects become inactive and remain in the lower parts of plants. Fewkes (1961) observes in general that vertical movements during the diurnal cycle form a common property of insects, and the phenomena described are due to the reaction of insects to a certain factor: weather, time of day etc. Certain information on the biology and ecology of different species can also be found in keys or monographs. Data of this type, however, generally serve only as a more or less generalized indication as to the habitats and places in the habitat, and under which conditions, the species of *Auchenorrhyncha* with which we are concerned is to be found. The vertical distribution of insects in studies so far published was not treated as an element of the organization of the *Auchenorrhyncha* community occurring in a given habitat.

Layer distribution of insects in grass associations is of considerable importance in investigations of intrapopulation structures and the structures of animal communities forming the meadow biocenosis. As stated by Petrusewicz (in press) the distribution of individuals in space, the way in which space is utilized by different groups of individuals or population may have a significant effect on the lot of individuals. It therefore forms one of the significant and important elements of population organization affecting the life processes of the population and its connections with other populations in the community or biocenosis. It is for this reason that investigation of the structures of animal communities is one of the more important and basic problems of ecology.

When collecting and working on *Auchenorrhyncha* material[1] in the present study, attention was paid to the distribution in the plant layers of species forming the *Auchenorrhyncha* community in several types of meadow habitat. Work was next carried out on the variations in the layer distribution of different species during the growing season from the spring until the disappearance in the autumn of the insects. Analysis of the effect of population abundance on its distribution in the plant layers formed the next stage of investigations.

I. DESCRIPTION OF THE STUDY AREA

Quantitative material of *Auchenorrhyncha* was collected in several types of meadow habitats. The meadow chosen differed from each other as to their

[1] Use was made of Ribaut's (1936, 1952) keys in identifying the *Jassidae* and *Typhlocybidae* families; the super-family *Fulgoroidea* was identified by means of Haupt's (1935) key.

origin (natural and cultivated meadows) and the degree of formation of the various layers of plants.

Observations were made in 1955 on four meadows belonging to the complex known as the Kuwaskie Marshes (Bagna Kuwaskie) in the Grajewo district. Two of them (A_1 and A_2) were sown on the places of the meadow moors. The other two (N_1 and N_2) were low-productive, not cultivated meadow moors[2].

Meadow A_1, formed in 1949, occupied an area of several hectares between two land drainage canals. It was given regular agrotechnical treatment and mown twice a year. It was sown with *Poa palustris* L. and from year to year was increasingly invaded by weeds, that is, other species of grasses and dicotyledonous plants. In 1955 the turf was formed by *Poa pratensis* L., while the following species occurred numerously: *Deschampsia caespitosa* P. B., *Festuca pratensis* Huds., *Juncus effusus* L., and weeds, primarily *Sonchus arvensis* L., *Taraxacum officinale* Web. and *Cirisium arvense* Scop.

Litter on this meadow was very poorly formed and consisted of a layer a few centimetres thick of dry plants and compact turf.

Meadow A_2 had been sown in 1952 with a mixture of two grasses: *Phleum pratense* L. and *Trifolium hybridum* L. In 1955 the grasses which had been sown formed large tufts. The lower layer was formed by a new species, *Trifolium repens* L. This meadow was used in a similar way to meadow A_1.

The litter of meadow A_2 was even more weakly formed than on meadow A_1. In places where the tufts of grass were less well grown bare patches of soil could be seen. A larger amount of dry grasses and compact turf occurred on the tufts and in their vicinity.

The natural meadow N_1 was characterized by the high level of ground water. The water, which lay stagnant on the surface throughout the whole of the spring to the end of June, resulted in *Carex* species being included in the composition of the basic elements of ground vegetation. The most numerous of these are: *Carex panicea* L., *C. flava* L. In addition to the grasses: *Poa palustris*, *P. pratensis*, *Festuca rubra* L., dicotyledonous plants occurred: *Ranunculus acer* L., *R. flammula* L., *R. repens* L., *Caltha palustris* L., *Lythrum salicaria* L., *Linum catharicum* L., and also *Dryopteris thelypteris* A. Gray. The litter layer, apart from the lower parts of living plants, was formed here by a thick carpet of mosses. Meadow N_1 was mown once during the year.

Meadow N_2 – formed part of an extensive complex of the *Carex* meadows characteristic of the district. The meadow is covered chiefly by large tufts of *Carex* (*Magno-* and *Parvocaricetum*) and in places by single small birches (*Betula pubescens* Ehrh.) and willow (*Salix rosmarinifolia* L.). The species

[2] The floristic description of the Kuwaskie meadows was prepared on the basis of unpublished material collected by Dr. Z. Wójcik and of the study by Niewiadomski (1954).

occurring most numerously apart from *Carex* are: *Calamagrostis neglecta* (Ehrh.) P. B., *Molinia coerulea* Moench., *Poa pratensis*, *Lythrum salicaria*, *Epilobium palustre* L., *Sagina nodosa* Fenzl., *Caltha palustris*, *Lysimachia vulgaris* L., *Linum catharicum*, *Dryopteris thelypteris*.

The litter, similarly to that on meadow N_1, is well formed with a thick carpet of moss. Only small parts of the meadow were mown during the summer.

In 1956 and 1957 additional material was collected in the Kampinos National Park near Warsaw, from which the data relating to one species of *Auchenorrhyncha* only was used – *Cicadella viridis* L. The study area was formed by small meadows in the forest area (N_3, N_4, N_5) which are covered by plant associations of the *Caricetum elatae* (W. Koch 1926) type. There is standing water between the high tufts of *Carex* up to July, and in wet years throughout the whole year. It forms an eutrophic habitat in which many species of higher plants occur (34). The character of these meadows is, however, determined by the high clumps of *Carex*, often reaching a height of 70 cm. The dominating species is *Carex Hudsonii* (Bennet) (= *C. elata* Bell.), and in addition the following species occur numerously: *C. acutiformis* Ehrh., *C. vesicaria* L. and *C. riparia* Curt. In addition to *Carex* the following occur in far smaller numbers, scattered between the *Carex* clumps: *Calamagrostis canescens* Druce, *Comarum palustre* L., *Lysimachia vulgaris*, *Caltha palustris*, *Ranunculus repens*, *Galium palustre* L. (Traczyk in press).

Between the clumps there is a layer of *Carex* peat which is covered by water for the greater part of the year, while a thick layer of *Carex* litter and moss forms on the clumps of stiff *Carex*. These meadows were not used for farming purposes.

Three distinct layers can be distinguished in the vertical cross-section of the plant association. The highest of these layers includes the upper parts of meadow plants – P–III, the second chiefly the stalks and lower plants – P–II, and the lowest, stalks located in moss and the dry and rotting parts of plants – P–I.

The layer differences in the structure of the plants coincide with the differences in the microclimatic conditions which occur in plant associations. As has been found by many authors (Gumiński 1951, Tomanek 1955, Molga 1958, Geiger 1961) the temperature, humidity and intensivity of air currents are elements which are subject to fundamental variations in the vertical cross-section of grass plant associations.

Studies by the above authors show that horizontal air currents flowing over the plants and in the highest layer of grass quickly eliminate over a considerable area the differences formed in temperature and humidity. Simultaneously the convection currents and the turbulence of air masses even up the temperature and humidity in the whole upper layer of the plants. Wind velocity decreases with the distance from the litter and in the layer of plants immediately above the litter the movements of air masses are minimum. The stagnation of the air in that part of plants immediately adjacent to the litter results in an increase in the water vapour contents, hence the layer of plants immediately above the litter is characterized by considerable humidity and also slow changes in temperature. This is due to the warming of the lower layers of air chiefly owing to warmth conduction. The group of meteorological features characteristic of the air in the near-litter layer of plants distinctly differs from the conditions occurring in the higher parts of plants.

In the actual litter layer the variations in meteorological elements are even smaller, due to the absence of motion of air masses. In this layer the tension of water vapour and also atmospheric humidity is very high. Fluctuations in temperature depend on the density of the plant cover which absorbs and reflects solar radiation.

II. RESEARCH METHODS AND MATERIAL

Individuals of almost all species of *Auchenorrhyncha* occur in each plant layer, but the distribution of the number of individuals of the different populations of these species is not equal in all the layers.

An entomological net of standard shape and size was used for collecting insects from the upper layer of grass. The series taken over one observation period consisted of 8 samples, each consisting of 25 sweeps made over the grass with the net. According to Tarwid (1953) series of this size yield samples representative of the given habitat.

The net collects insects from the upper parts of the plants, generally only from layer P–III or partly from P–II. It has been stated in the numerous papers on the suitability of this method that the net does not collect all the animals uniformly from the habitat, but has a selective action on account of the size of the insects, their weight, capacity for rapid escape, etc. (De Long 1932, Carpenter, Ford 1936, Balogh 1958). Also the way itself in which the net is swept, the strength and rate of sweeping over the grass tends to priviledge certain groups of insects (Łuczak 1958). On account of the diurnal vertical movements of the insects it is also important to adhere to an established period for taking samples (Fewkes 1961).

When elaborating the problem of the layer distribution of *Auchenorrhyncha* the following condition must be observed in collecting material by entomological net: over the period of the growing season the same degree of selection by the net in relation to insects of different size, rapidity of movement etc. must be maintained. It was therefore essential to eliminate situations in which the time of sampling, or change in the way the net was swept, might affect this selective action. With this aim in view sweeps with the net were made always at the same time of day (between 10 a.m. and 2 p.m.) and by the same person.

The biocenometer used in sampling was constructed of metal rods. It was shaped like a cube, measuring 0.5 × 0.5 × 0.5 m, the lateral and upper walls of which were covered with gauze. The biocenometer was thrown on the grass and then all the individuals of *Auchenorrhyncha* under it were taken separately from the grass and litter. During one observations period a series of samples were taken consisting of 16 "throws" of the biocenometer. No time limit was set to collection of the insects, which was continued until the person sampling failed to observe any insects after parting the grasses and searching. Insects from all layers of the plants are obtained from samples taken by means of the biocenometer, the insects being collected from the grass almost in their entirety. The litter, on the other hand, provides more possibilities for the insects to hide, it is more difficult to make a thorough search of this layer and even so yields a far smaller number of insects than the real number living there.

A total of 4,248 samples were taken and 22,401 insects collected by means of the net and biocenometer methods of capture. Detailed numbers of the samples taken from the meadows by the Biebrza (Kuwaskie Marshes) and the Strzeleckie meadows in the Kampinos National Park are given in Table I, II, and the numbers of insects collected in Table III and IV. The abundance of the different species forming the communities of *Auchenorrhyncha* on the Biebrza meadows is shown in Table V. In order to classify the different species of *Auchenorrhyncha* according to a definite layer, calculation was made of the index of distribution in layers of the species forming the community. Those species which live entirely in a given layer of plants or which are most abundant in it were considered as species characteristic of and connected with the given layer of plants.

Comparison of numbers of samples taken in 1955 from the Biebrza meadows (Kuwaskie Marshes)

Tab. I

Methods		Stations				Total
		A_1	A_2	N_1	N_2	
Net		104	104	104	104	416
Biocenometer	grass	416	400	352	352	1,520
	litter	272	256	208	208	944
Total		792	760	664	664	2,880

Comparison of numbers of samples taken in 1956–1957 from meadows in the Kampinos National Park

Tab. II

Years	Methods		Stations			Total
			N_3	N_4	N_5	
1956	net		104	–	96	200
	biocenometer	grass	80	–	80	160
		litter	80	–	80	160
1957	net		80	80	80	240
	biocenometer	grass	104	104	96	304
		litter	104	104	96	304
Total			552	288	528	1,368

Comparison of numbers of insects collected in 1955 from the Biebrza meadows (Kuwaskie Marshes)

Tab. III

Methods		Stations				Total
		A_1	A_2	N_1	N_2	
Net		1,019	689	1,431	1,120	4,259
Biocenometer	grass	4,094	1,965	1,766	776	8,601
	litter	851	743	390	245	2,229
Total		5,964	3,397	3,587	2,141	15,089

Comparison of numbers of individuals of *Cicadella viridis* caught on meadows in the Kampinos National Park

Tab. IV

Years	Methods		Stations			Total
			N_3	N_4	N_5	
1956	net		1,095	–	367	1,462
	biocenometer	grass	694	–	568	1,262
		litter	17	–	5	22
1957	net		1,245	872	170	2,287
	biocenometer	grass	800	1,002	447	2,249
		litter	12	12	6	30
Total			3,863	1,886	1,563	7,312

Moving average calculated from the number of insects of the given species caught over a 20-day period, were used as a basis for further calculations. The beginning of each period was counted as from the 1st, 11th and 21st day of each month in which observations were made. Longer periods were totalled in order to render results independent of slight differences in weather conditions.

Since when using the methods applied to captures of *Auchenorrhyncha* the insects were collected from different areas of the meadow and different volume of grass, it is impossible to draw conclusions as to their vertical distribution from direct comparison of the mean values of abundance of the different populations of the insects. Even comparison of direct numbers from the material collected from the same area (biocenometer) from the whole of the grass and litter layers is in principle unjustified, in view of the fact that the conditions and possibilities of thorough collection of insects differ in these two layers.

It is also on this account that conclusions have been based on comparison of variations in the quantitative relations of *Auchenorrhyncha* in different layers of plants and during the growing season. Index values were used for comparison of the quantitative relations of these insects.

The capture methods used supplies the following data: $\bar{a}$ – mean abundance of individuals of the given species in the upper layer of grass P–III obtained by net; $\bar{b}$ – mean abundance of individuals in P–III and P–II determined from captures by biocenometer; $\bar{c}$ – mean abundance of individuals in P–I obtained from the biocenometer. Means $\bar{a}$, $\bar{b}$ and $\bar{c}$ were calculated for successive periods from the spring to the autumn. In relation to the sum of three means ($\bar{a} + \bar{b} + \bar{c} = 100\%$) obtained for the same period for each species calculation was made of the percentage of insects in the upper layer of grass $a = \frac{\bar{a}}{\bar{a} + \bar{b} + \bar{c}} \cdot 100$; in the whole grass layer $b = \frac{\bar{b}}{\bar{a} + \bar{b} + \bar{c}} \cdot 100$; and in the litter $c = \frac{\bar{c}}{\bar{a} + \bar{b} + \bar{c}} \cdot 100$. The value of the percentage for each population, in the upper layer of grass (a) was taken as the index of layer distribution of species W_a. The numerical values of the index for different species fluctuated within limits of 0 to 100.

When the species exhibited a tendency to keep to the upper layer of grass there was a rise in the value of the index. Low values for the index pointed to the species' tendency to remain in the lower parts of grass or in the litter.

Calculation was made of the index of layer distribution for the more numerous species. In several cases the index was calculated for the less numerous species also, but only in cases in which the calculated values of the index from each period did not exhibit much divergence. Considerable jumps in the value of the W_a index in different periods for the scantily occurring species might be due to the movement of insects actually taking place; it may also be assumed that they are due to the insects accidentally coming within range of the capture area.

The results of the index obtained for different species in the meadows examined (Tab. VI, VII, VIII, IX) are independent of the absolute numbers of the given species and depend only on the quantitative relations of the given species in the different layers of the plants, and therefore permit of comparing the vertical distribution of species in relation to each other and of tracing variations in the layer distribution of species in time and in different meadow habitats.

III. STRATIFICATION AND ITS DYNAMICS IN MEADOW COMMUNITIES OF *AUCHENORRHYNCHA*

1. Vertical distribution of meadow species of *Auchenorrhyncha* communities

The meadow in vertical cross-section (as described in section I) is a habitat with greatly varying microclimatic conditions and plant structure. The different layers of plants have a definite group of conditions more or less favourable to each of the species and their stages of development. It must therefore be assumed that this affects the numbers of *Auchenorrhyncha* in different layers of the meadow, these insects being conditioned to a great extent by the habitat on account of their physiological properties and their dependence on food.

Even when taking samples in the area it was easy to see that the layer distribution (vertical) both of the number of insects in general and also of species of *Auchenorrhyncha* is not even. This is also clear from the values obtained for the index of distribution of these species in the habitats examined. During the growing season index W_a for the different species exhibits certain fluctuations which are due to the movements of the species in the grass layer (Tab. VI, VII, VIII, IX). In order to define the layer of plants with which a given species is most closely connected, calculation was made of mean $\bar{W}_a$ values from indices of layer distribution W_a. The means obtained make it possible to separate the species living only or most numerously in a given layer. The species at the tops of the grass are in layer P–III; near the litter in P–II; and in the litter in P–I.

Under the conditions created by the methods used and the numbers of insects it was taken that when the value of the index is from 60–100, the species may be allocated to the group of species P–III at the top of the grass. When the value is from 15 to 60, they were allocated to the near-litter species (P–II), Values of the index of layer distribution W_a of different species of *Auchenorrhyncha* in consecutive periods in cultivated meadow A_1

Tab. VI

Species	Periods 1: 20.V–10.VI	2: 1.VI–20.VI	3: 11.VI–30.VI	4: 21.VI–10.VII	5: 1.VII–20.VII	6: 11.VII–31.VII	7: 21.VII–10.VIII	8: 1.VIII–20.VIII	9: 11.VIII–31.VIII	10: 21.VIII–10.IX	11: 1.IX–20.IX	12: 11.IX–30.IX	13: 21.IX–10.X
Calligypona spinosa	–	0	0	–	–	–	0	0	0	0	0	–	–
Calligypona pellucida	31	2	2	53	64	56	11	11	13	20	32	80	–
Calligypona pellucida – larvae	6	–	–	–	–	12	–	–	27	37	50	25	0
Calligypona albostriata	–	–	–	–	–	70	33	18	12	0	63	–	–
Neophilenus lineatus	–	–	–	–	61	60	66	82	97	81	83	100	–
Philenus spumarius	–	–	–	20	37	47	57	67	76	81	79	91	94
Macrosteles laevis	–	–	–	88	80	49	34	86	69	75	29	92	–
Macrosteles laevis – larvae	–	0	0	0	0	–	–	–	–	0	0	–	–
Streptanus sordidus	–	–	–	0	4	5	0	0	0	0	–	–	–
Athysanus argentarius	–	–	–	–	23	23	23	27	0	0	0	–	–
Elymana sulphurella	–	–	–	–	–	31	40	57	62	69	72	33	–
Rhopalopyx flaveola	–	–	–	–	0	0	0	0	0	0	–	–	–
Rhopalopyx preyssleri	–	–	–	–	0	0	0	0	0	0	0	–	–
Deltocephalus pulicaris	–	–	–	7	10	5	2	2	2	6	38	53	0
Errastunus ocellaris	–	–	–	60	41	0	0	0	4	17	49	84	–
Verdanus abdominalis	–	–	–	0	63	65	36	33	33	47	37	–	–
Arthaldeus pascuellus	–	–	–	29	36	19	4	8	24	10	32	52	3
Aphrodes bicinctus	–	0	–	–	–	0	0	0	0	0	0	0	–
Cicadella viridis	–	–	–	–	0	0	39	50	0	0	83	100	–
Dikraneura citrinella	–	–	–	30	47	30	3	30	37	44	52	36	–

Values of the index of layer distribution W_a for different species of *Auchenorrhyncha* in consecutive periods in cultivated meadow A_2

Tab. VII

Species	Periods 1: 20.V–10.VI	2: 1.VI–20.VI	3: 11.VI–30.VI	4: 21.VI–10.VII	5: 1.VII–20.VII	6: 11.VII–31.VII	7: 21.VII–10.VIII	8: 1.VIII–20.VIII	9: 11.VIII–31.VIII	10: 21.VIII–10.IX	11: 1.IX–20.IX	12: 11.IX–30.IX	13: 21.IX–10.X
Calligypona striatella	–	0	0	–	–	100	44	42	18	47	60	67	–
Calligypona pellucida	3	4	4	67	47	33	8	9	11	33	44	–	–
Calligypona pellucida – larvae	0	0	0	–	39	20	0	0	0	–	–	–	–
Neophilenus lineatus	–	–	–	–	67	45	32	40	83	95	100	100	100
Philenus spumarius	–	–	–	–	58	58	53	41	61	85	77	65	83
Macrosteles laevis	–	–	–	60	76	70	52	33	52	66	81	74	51
Macrosteles laevis – larvae	–	0	0	0	0	–	–	0	0	0	0	0	0
Athysanus argentarius	–	–	–	29	36	38	21	36	42	49	61	25	50
Elymana sulphurella	–	–	–	–	14	30	83	33	13	39	59	58	100
Cicadula quinquenotata	–	–	–	–	0	0	12	4	9	47	70	61	20
Psammotettix alienus	–	–	–	100	100	100	–	–	67	68	83	71	–
Deltocephalus pulicaris	–	–	–	100	84	19	0	0	–	–	0	0	–
Arthaldeus pascuellus	–	–	–	64	39	22	5	0	9	8	14	13	16
Cicadella viridis	–	–	–	100	57	18	23	56	0	43	76	–	–
Dikraneura citrinella	–	–	–	–	0	0	0	0	29	36	45	42	–

Values of the index of layer distribution W_a for different species of *Auchenorrhyncha* in consecutive periods in natural meadow N_1

Tab. VIII

Species	Periods												
	1	2	3	4	5	6	7	8	9	10	11	12	13
	20.V–10.VI	1.VI–20.VI	11.VI–30.VI	21.VI–10.VII	1.VII–20.VII	11.VII–31.VII	21.VII–10.VIII	1.VIII–20.VIII	11.VIII–31.VIII	21.VIII–10.IX	1.IX–20.IX	11.IX–30.IX	21.IX–10.X
Kelisia vittipennis	–	–	–	–	–	–	0	2	9	31	19	6	17
Delphacodes venosus	0	–	–	0	0	–	0	0	0	0	0	0	0
Calligypona straminea	–	0	0	0	33	23	0	0	0	0	0	0	0
Calligypona pellucida	–	–	–	0	0	18	27	13	9	–	–	–	–
Neophilenus lineatus	–	–	–	40	47	61	66	84	91	81	78	87	88
Philenus spumarius	–	–	–	64	63	68	63	52	45	54	72	71	100
Athysanus argentarius	–	–	–	–	71	36	21	11	28	42	40	0	0
Athysanus quadrum	–	–	–	–	–	39	4	44	19	15	22	100	–
Cicadula quadrinotata	–	–	–	50	67	55	59	71	68	71	88	91	100
Arthaldeus pascuellus	–	–	–	–	18	5	3	4	12	39	65	60	25
Sorhoanus assimilis	–	–	–	–	67	48	57	74	56	53	72	83	100
Aphrodes bicinctus	–	–	–	–	0	12	26	21	24	0	–	–	–
Strongylocephalus agrestis	–	–	–	–	–	0	13	6	8	9	0	0	–
Cicadella viridis	–	–	–	0	25	22	15	23	14	27	45	40	14
Cicadella viridis – larvae	–	0	0	0	10	47	0	–	0	0	33	–	–
Agallia brachyptera	–	–	–	–	–	0	0	0	0	0	0	–	–
Dikraneura citrinella	–	–	–	–	0	0	0	0	52	45	56	67	67

Values of the index of layer distribution W_a for different species of *Auchenorrhyncha* in consecutive periods in natural meadow N_2

Tab. IX

Species	Periods												
	1	2	3	4	5	6	7	8	9	10	11	12	13
	20.V–10.VI	1.VI–20.VI	11.VI–30.VI	21.VI–10.VII	1.VII–20.VII	11.VII–31.VII	21.VII–10.VIII	1.VIII–20.VIII	11.VIII–31.VIII	21.VIII–10.IX	1.IX–20.IX	11.IX–30.IX	21.IX–10.X
Calligypona straminea	–	–	–	12	14	0	0	0	0	–	–	–	–
Ommatidiotus dissimilis	–	–	–	–	–	0	73	74	76	79	58	59	100
Lepyronia coleopterata	–	–	–	79	83	81	69	65	65	68	63	100	100
Neophilenus lineatus	–	–	–	32	52	70	85	86	87	88	82	84	92
Philenus spumarius	–	–	–	0	0	0	100	100	–	–	–	–	–
Rhopalopyx preyssleri	–	–	–	–	0	0	0	16	13	13	39	–	–
Cicadula quadrinotata	–	–	–	–	–	–	100	92	83	77	73	71	–
Cicadula quadrinotata – larvae	–	–	–	17	12	29	83	83	–	–	–	–	–
Arthaldeus pascuellus	–	–	–	0	0	18	48	45	49	50	0	0	0
Arthaldeus pascellus – larvae	–	–	–	11	20	39	–	–	–	–	0	0	–
Sorhoanus assimilis	–	–	–	–	71	57	75	74	65	78	82	–	–
Strongylocephalus agrestis	–	–	–	–	–	–	0	0	0	0	0	0	0

and from 0 to 15 to litter species (P–I). A list of species characteristic of the different layers of plants is given in Table X.

Mean values of the index of layer distribution $\overline{W}_a$ for different species of *Auchenorrhyncha* on the study stations

Tab. X

Kind of layer	Species	Stations			
		A_1	A_2	N_1	N_2
Litter – P–I	*Kelisia vittipennis*	–	–	12	–
	Delphacodes venosus	–	–	0	–
	Calligypona spinosa	0	–	–	–
	Calligypona straminea	–	–	5	5
	Calligypona pellucida – larvae	14	7	–	–
	Macrosteles laevis – larvae	0	0	–	–
	Streptanus sordidus	1	–	–	–
	Rhopalopyx preyssleri	0	–	–	12
	Rhopalopyx flaveola	0	–	–	–
	Arthaldeus pascuellus – larvae	–	–	–	14
	Aphrodes bicinctus	0	–	14	–
	Strongylocephalus agrestis	–	–	5	0
	Cicadella viridis – larvae	–	–	10	–
	Agallia brachyptera	–	–	0	–
Lower parts of plants – P–II	*Calligypona striatella*	–	42	–	–
	Calligypona pellucida	28	24	11	–
	Calligypona albostriata	33	–	–	–
	Athysanus argentarius	24	39	28	–
	Athysanus quadrum	–	26	–	–
	Elymana sulphurella	52	48	–	–
	Cicadula quinquenotata	–	25	–	–
	Deltocephalus pulicaris	13	29	–	–
	Errastunus ocellaris	28	–	–	–
	Verdanus abdominalis	45	–	–	–
	Arthaldeus pascuellus	22	19	26	21
	Cicadella viridis	34	34	25	–
	Dikraneura citrinella	34	30	32	–
Upper parts of plants – P–III	*Ommatidiotus dissimilis*	–	–	–	74
	Lepyronia coleopterata	–	–	–	77
	Neophilenus lineatus	79	74	72	76
	Philenus spumarius	70	68	65	40
	Macrosteles laevis	67	62	–	–
	Cicadula quadrinotata	–	–	72	83
	Psammotettix alienus	–	54	–	–
	Sorhoanus assimilis	–	–	64	72

The index of distribution of the species is similar in the four meadow habitats examined for the majority, in particular of the more numerous species. The range of fluctuations is restricted. It was only in the case of *Philenus spumarius* (L.) on one meadow N_2 that the difference in the value of the index in relation to the remaining meadow is over 20.

In addition to species characteristic of layer P–I there were also larvae of species from layers P–III and P–II here. Species living in the higher layers of plants at times occur in the litter more or less abundantly (Tab. VI, VII, VIII, IX). In meadows in which the litter is poorly formed (A_1, A_2) the number of litter species and their abundance is far smaller than in meadows N_1 and N_2 (Tab. X). In comparison with the natural meadows with well–developed litter (N_1, N_2) the species, the whole life cycle of which takes place in the litter and which were caught only sporadically outside the litter towards the end of the growing season, did not occur at all or only single specimens were found (Tab. VI, VII, VIII, IX). Among these species were: *Agallia brachyptera* (Boh.), *Delphacodes venosus* (Germ.), *Kelisia vittipennis* (Sahlb.), *Strongylocephalus agrestis* (Fall.).

Thus the type of habitat and formation of the different layers of plants determine the number and abundance of the species occurring there; they do not, however, have any significant effect on variations in the layer distribution of species. This is clear from the absence of fundamental differences in the mean values of the index of distribution of different species ($\bar{W}_a$), between the meadow habitats examined (Tab. X).

In relation to the whole part of plants above the litter, on account of the absence of a sharp boundary between layer P–III and P–II, the index of layer distribution of the insects is only a measure of the tendency of certain species to live nearer P–I or near the tops of plants.

In summing up the problems discussed in this section it follows: 1) Different species forming meadow communities of *Auchenorrhyncha* exhibit a tendency to occupy definite layers in the meadow habitat, regardless of the character of this habitat. 2) Vertical movements of different populations during the growing cycle are conditioned mainly by the life cycle of the given species of insect. 3) The number and abundance of the species and its variations in time are dependent on the character of the habitat, while vertical movements of the population are affected by the habitat, which exerts a direct influence on them through variation in the life cycle of the species.

The distribution of species in the layers of plants (described above) is not a static distribution. As is shown by variations in the value of the distribution index of species W_a at different periods of time, movement of the insects from layer to layer takes place during the growing season. A detailed analysis of variations in the distribution index of *Auchenorrhyncha* is made in the following sections.

2. Variations in the layer distribution of *Auchenorrhyncha* species in different periods

The layer distribution, described in the preceding section, of species forming the *Auchenorrhyncha* communities in meadow habitats, points to a general tendency of certain populations to occupy definite layers of plants. It is, however, clear from the variations in the value of the distribution index of species W_a that there is no question of a constant (in the time sense) degree of connection between the population of different species with a certain definite place in the layer distribution of the meadow (Tab. VI, VII, VIII, IX).

During the growing season from the moment of formation of the *Auchenorrhyncha* community, from early spring to late autumn, there is continual movement by the species between layers. The movement rhythm in time does not coincide for all species. Also, in different habitats, even the same species may have a different movement cycle within the various layers (Tab. VI, VII, VIII, IX).

These differences may be due to certain deviations in the development cycle of different species of *Auchenorrhyncha* in the meadows examined. As stated in the preceding section, the type of habitat, and formation of the different layers determine the number and abundance of species; it is also a known fact that this affects the development rate of the population, the number of generations and the domination system of the *Auchenorrhyncha* community (Andrzejewska 1959, 1962).

Hence, despite certain differences in layer movements in the majority of the species of the community of meadow *Auchenorrhyncha*, it is possible to find a general regularity in the cycle of movements connected with the development cycle of the species.

In the early spring, apart from a few species which overwinter in the form of imagines, the more or less numerous first larvae begin to appear. This moment is extended in time depending on weather conditions.

In cultivated meadows chiefly one species of *Auchenorrhyncha*, *Calligypona pellucida* (Fabr.) appears as early as May. The larvae of this species, which overwintered in P—II, grow and move to the higher layer. There also at first there are adult insects, which towards the end of May and in June return to the lower layer of the plants (Fig. 1).

The maximum intensity of hatching of the larvae of many species of *Auchenorrhyncha* on cultivated and natural meadows takes place in the second half of June and they then most often live in layer P—I or in the part of plants near the litter — P—II. As they grow they move to the upper layers of plants before the final moult. The same is found in the case of species the larvae of which it was possible to identify (*Cicadella viridis* — Fig. 2, *Cicadula quadrinotata* (F.), *Arthaldeus pascuellus* (Fall.) — Fig. 3). As a rule the adult

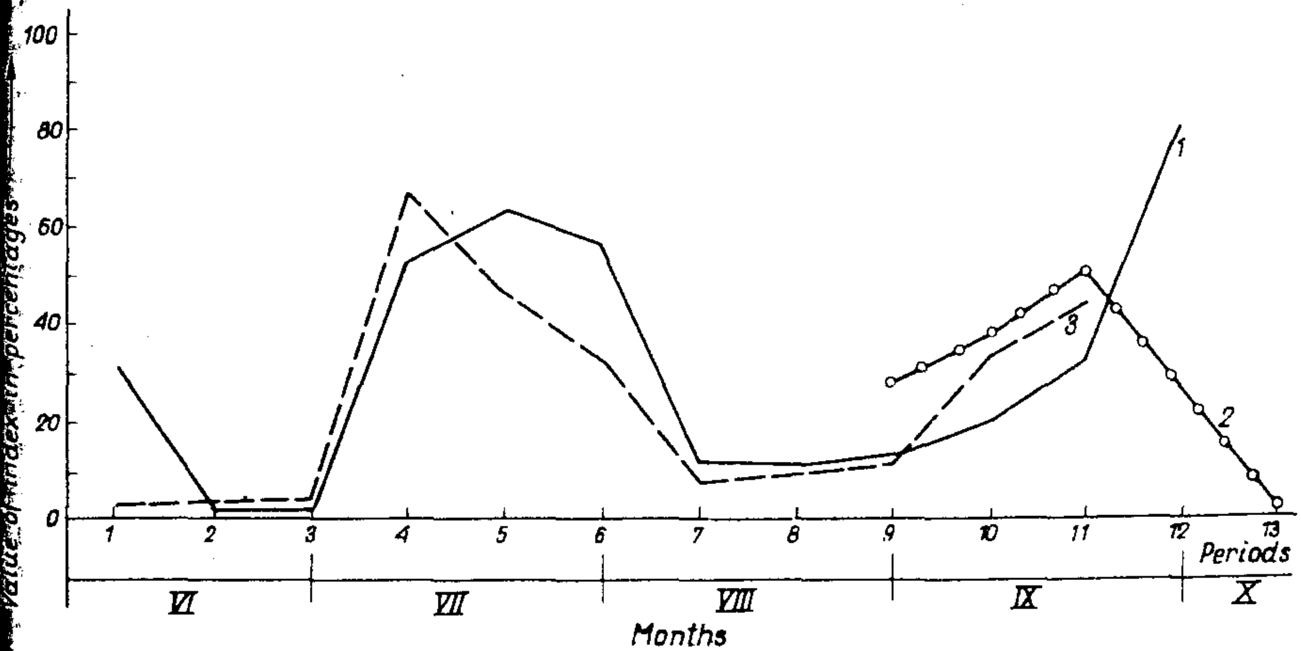

Fig. 1. Variations in the value of the index of layer distribution W_a in different periods of time for *Calligypona pellucida*

1 — imagines from cultivated meadow A_1, *2* — larvae from cultivated meadow A_1, *3* — imagines from cultivated meadow A_2

freshly transformed insects move to the upper layer of plants. It is for this reason that at the beginning of July during the hatching period of the imagines of almost all species of *Auchenorrhyncha* the greatest concentration of numbers of species and of their abundance occurs in the upper parts of plants (Tab. VI, VII, VIII, IX).

At the turn of July and beginning of August the majority of *Auchenorrhyncha* species move in the direction of the litter.

The second period of movement of the population into the upper layers of grass takes place towards the end of the growing season, that is, at the end of August and beginning of September. During this period a more of less numerous second generation, preceded by the occurrence of larvae, appears in some of the species. After the emergence of insects of the first and second generation into the upper layer of grass during the autumn, there is a relatively rapid liquidation of *Auchenorrhyncha*. This takes place in the case of species which overwinter in the form of eggs[3]. In situations in which the population

[3] Parallel to two periods of intensive movements of *Auchenorrhyncha* to the upper layer of grasses (end of June, beginning of July and end of August, beginning of September), there is intensive exploitation of this layer by web spiders. Investigation of variations in the trappability of two species of the meadow populations of *Araneus quadradtus* Clerck and *A. cornutus* Clerck showed (Kajak in press) that the number of *Auchenorrhyncha* caught in the spiders' webs are not uniform over the growing

overwinters as imagines (*Delphacodes venosus* (Germ.) – Fig. 4) or larvae (*Calligypona pellucida* – Fig. 1) towards the end of the growing season the adult insects or larvae move to the lower layers of grasses or to the litter – P–I.

The degree of formation of layer P–I – the litter, determines the occurrence of litter species and their abundance. In natural meadows N_1 and N_2 with a rich P–I layer, there are far better conditions for the development of litter species than in meadows A_1 and A_2. These species (*Agallia brachyptera* (Sch.), *Strongylocephalus agrestis* (Fall.), *Delphacodes venosus*) appear in layers P–II and P–I as imagines later than the species of the higher layers of plants, i.e. towards the end of July.

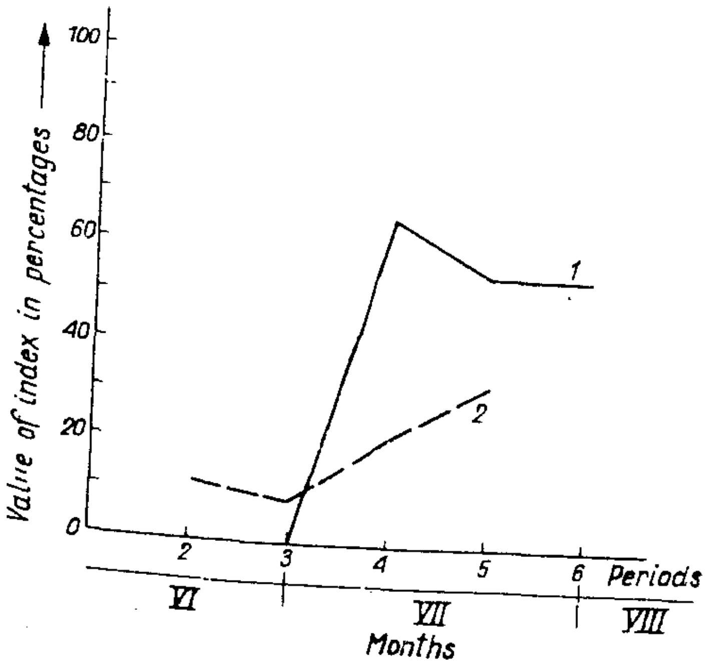

Fig. 2. Variations in the value of the index of layer distribution W_a in different periods of time for *Cicadella viridis*
1 – imagines, *2* – larvae

The variations described in the value of the distribution index in time, variations in the vertical movement of *Auchenorrhyncha* during the growing season, are connected mainly with the life cycle of the species. Since they agree in the majority of the species they can be treated as a general plan of the movements in time of insects in this systematic group (Fig. 1, 5).

In the habitats of the cultivated meadows A_1 and A_2, these species of *Auchenorrhyncha* exhibit fairly close agreement with the plan described above. In the habitats of natural meadows N_1 and N_2, during the growing season variations in the index for different species exhibit greater differentiation. Differences in the movements between layers of the insects are probably con-

season and are independent of the abundance of these insects living in the meadow. At the beginning of July, during the period of their real increased intensity of settlement of this layer, only single individuals were found in the webs. As from July there is a gradual increase in the numbers of *Auchenorrhyncha* caught in webs, reaching a peak during the period of intensified physiological mortality of the population, i.e. towards the end of August and beginning of September. It may therefore be concluded that not only abundance and distribution of the population in the habitat, but also the physiological condition of the population and increased activity determines its accessibility to a definite type of predator.

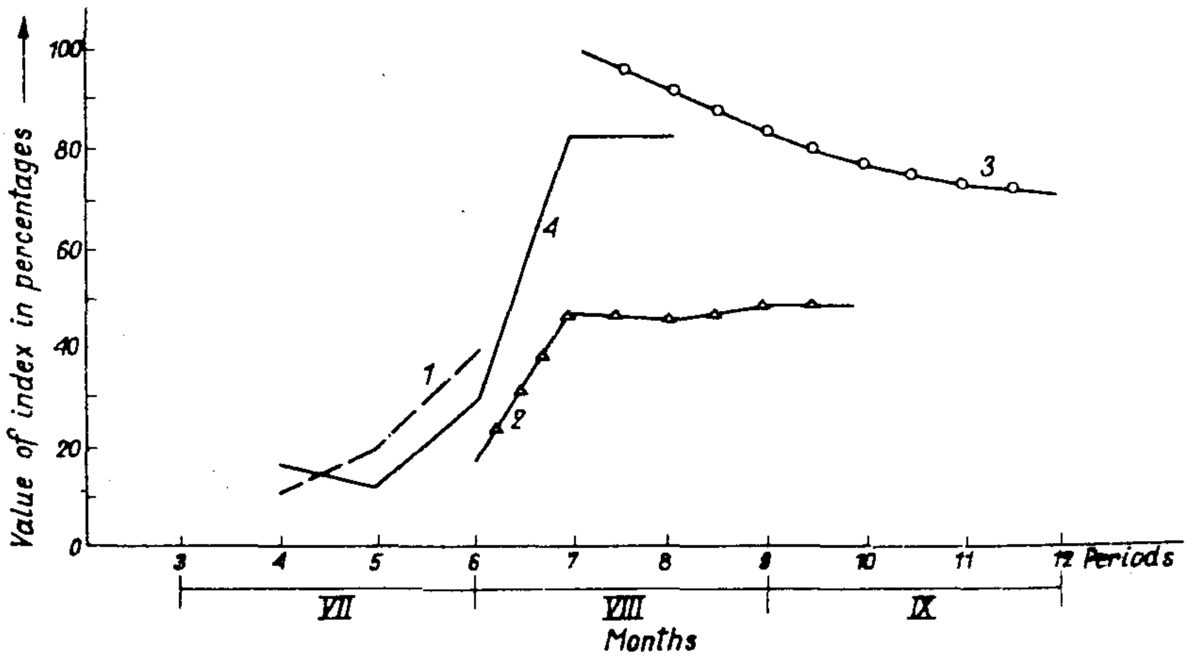

Fig. 3. Variations in the value of the index of layer distribution W_a in different periods of time for *Arthaldeus pascuellus* and *Cicadula quadrinotata*

1 — larvae *A. pascuellus*, 2 — imagines *A. pascuellus*, 3 — imagines *C. quadrinotata*, 4 — larvae *C. quadrinotata*

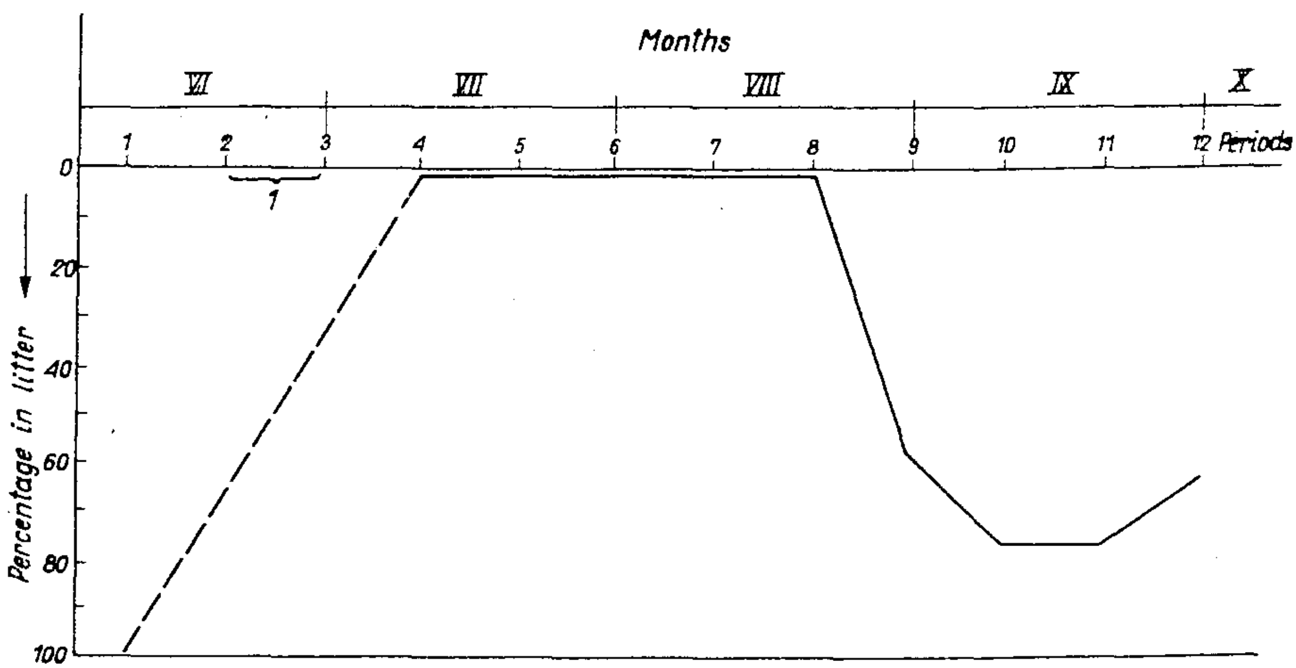

Fig. 4. Variations in the vertical distribution of *Delphacodes venosus* in litter

1 — data were not collected for both periods

nected with the different character of these two types of meadow habitats. It is well known from earlier studies that natural and cultivated meadows are characterized by different ecological characters (Andrzejewska 1959, 1961, 1962). The course taken by variations in abundance of *Auchenorrhyncha* is different. In cultivated meadows during the growing season there are three peaks of abundance of these insects corresponding to three communities of *Auchenorrhyncha* (spring, summer, and autumn), whereas in natural meadows there is one summer community. Also the life cycle of the same species of *Auchenorrhyncha* may take place differently in these two types of meadow habitat.

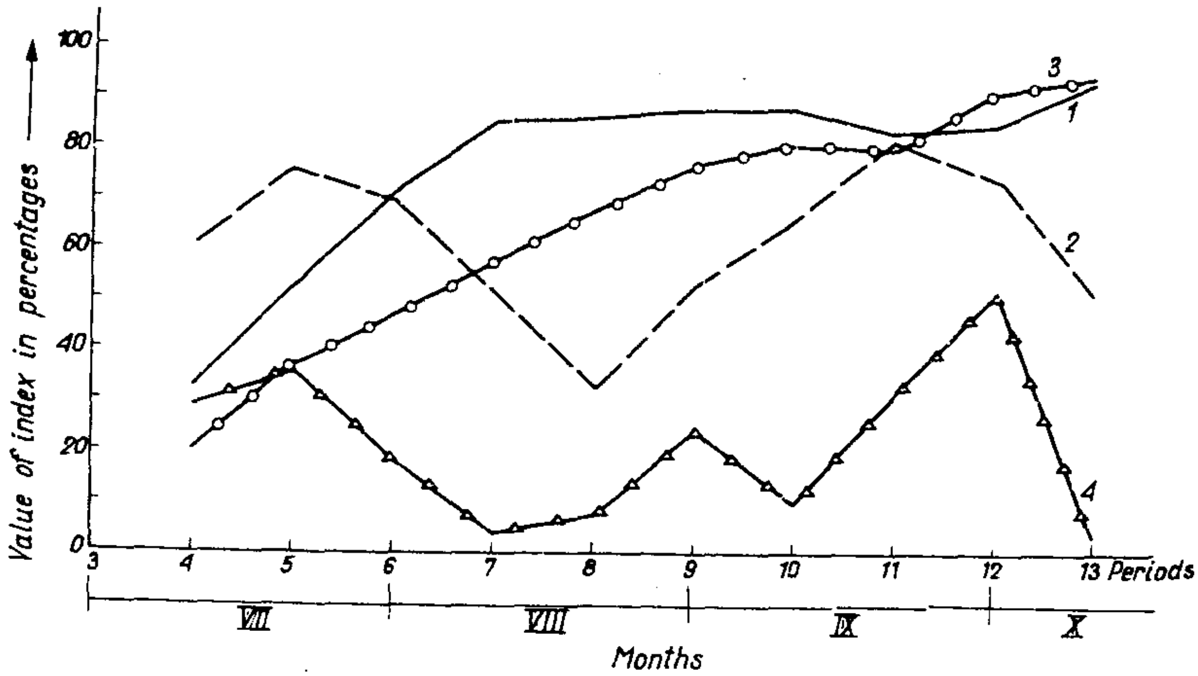

Fig. 5. Variations in the value of the index of layer distribution W_a in different periods of time for *Neophilenus lineatus*, *Macrosteles laevis*, *Philenus spumarius*, and *Arthaldeus pascuellus*

1 – *N. linneatus*, *2* – *M. laevis*, *3* – *P. spumarius*, *4* – *A. pascuellus*

Differences in ecological conditions and differences in the formation of the different layers of plants in the meadows examined produce deviations in the layer movements of insects[4].

Analysis of the variations in the index of vertical distribution of the population shows that only certain parts of each population of *Auchenorrhyncha* species occur in the upper layer of grass. Depending on which layer the species is connected, that is, whether it is a species living on grass, near the litter or in the litter, the number of individuals in the upper layer of grass will form a different percentage of abundance of the whole population living in that

[4] These problems require further detailed elaboration, since on the basis of the material given it is not possible to obtain a clear-cut and reliable answer to the question as to what degree biotic relations and what elements of the habitat exert a decisive influence on the index of vertical distribution of the insects.

habitat. Litter species in P–III or in that part of grasses near the litter (P–II) may not occur at all, or only accidentally as single individuals.

In addition vertical movements of the population during the growing season result in the percentage of their abundance in the upper layer of grasses not being constant, but changing from spring up to the autumn disappearance of the insects.

3. Variations in layer distribution depending on the abundance of the population of the given species

On the basis of the mean values of the distribution index $\overline{W}_a$ it is possible to define the layer of plant with which the given species of *Auchenorrhyncha* is connected. The question then arises as to whether the general cause of uneven distribution of insects in the plant layers is formed by the requirements of the species in relation to definite habitat conditions: or whether in certain ecological situations factors dependent on the organization of different populations composing the *Auchenorrhyncha* community in the meadow may also exert some influence, – that is, whether under conditions of great abundance and also overwhelming domination of a certain species in the community a change may take place in the latter's layer distribution.

In order to explain the above in relation to species occurring in meadow habitats, an analysis was made of the relation between the abundance of the species in the given layer of plants and its corresponding percentage. The mean abundance of the different species from two layers in which the given species is most numerous and from all the meadows examined were correlated by the graphic method with the percentages corresponding to them for the different periods of time.

Comparison of the correlative percentage values and abundance of species from the upper layer of grass revealed concentration of cases for the net ($\bar{a}$) with higher percentage values and low cases for the biocenometer ($\bar{b}$). Correlated comparisons are given for several species as examples: *Sorhoanus assimillis* (Fall.), *Cicadula quadrinotata* (F.), *Macrosteles laevis* (Rib.), *Neophilenus lineatus* (L.), *Philenus spumarius* (L.) (Fig. 6, 7, 8).

For species from the near-litter part of plants (P–II): *Cicadella viridis*, *Arthaldeus pascuellus*, *Dikraneura citrinella* (Zett.), *Kelisia vittipennis* (Sahlb.). mean values from the biocenometer ($\bar{b}$) were characterized by a high percentage, mean abundance values from the net ($\bar{a}$) by a low percentage (Fig. 9, 10). For species occurring only in layers P–I and P–II (*Agallia brachyptera* and *Delphacodes venosus*) the mean values from $\bar{c}$ (P–I) were characterized by high percentages and from $\bar{b}$ by low (Fig. 11). The more the species is connected with a definite plant layer, the sharper the division of cases between low and high percentage values.

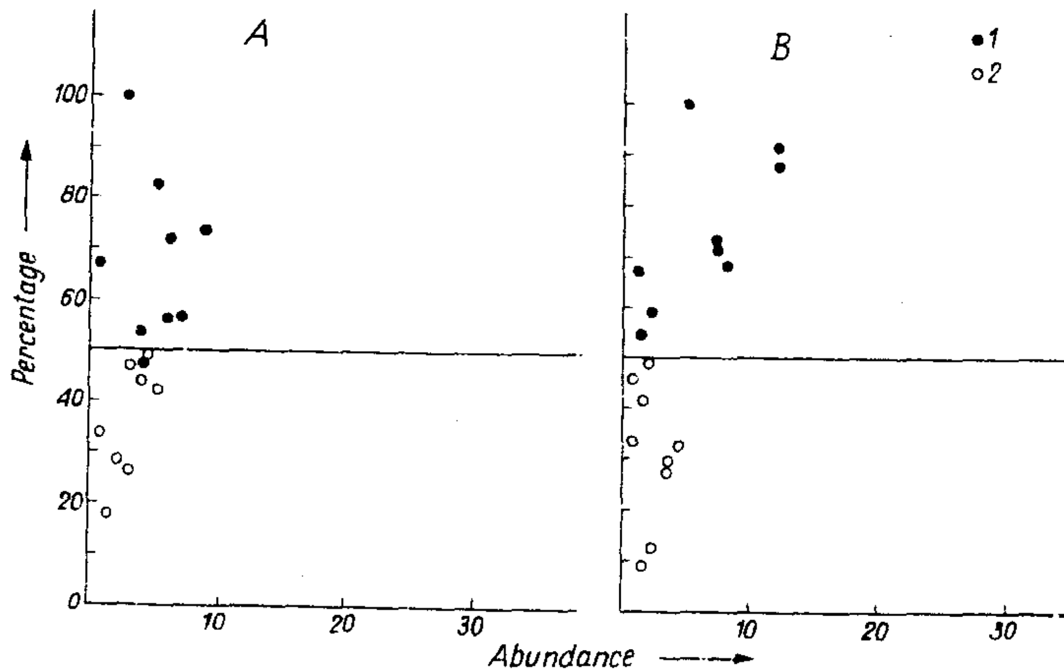

Fig. 6. Correlative comparison of abundance of the species *Sorhoanus assimilis* (*A*) and *Cicadula quadrinotata* (*B*) with their percentage in the given layer
1 — percentage of *a*, *2* — percentage of *b*

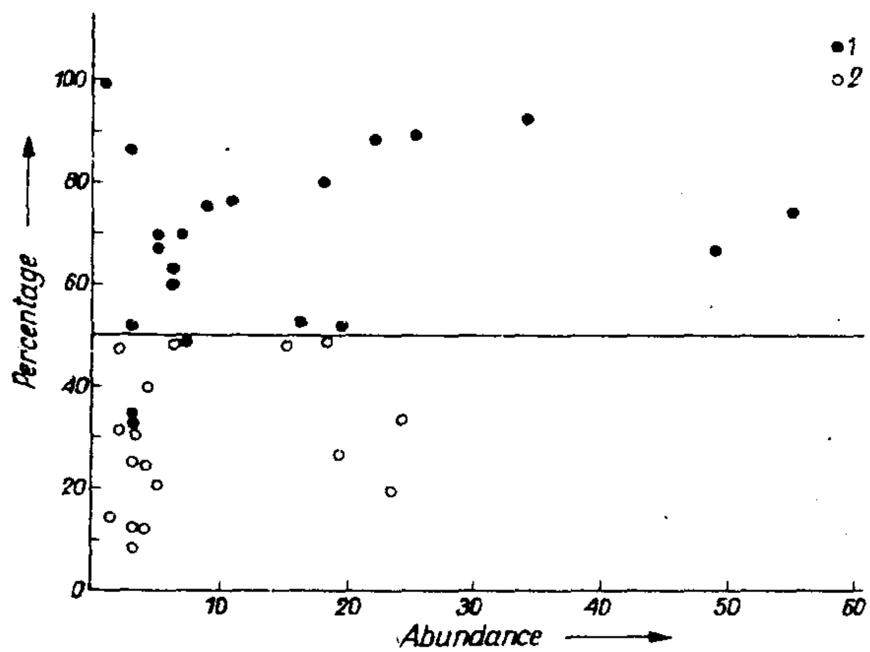

Fig. 7. Correlative comparison of abundance of the species *Macrosteles laevis* with its percentage in the given layer
1 — percentage of *a*, *2* — percentage of *b*

The distribution of cases from mean values $\bar{a}$, $\bar{b}$ and $\bar{c}$ and their concentration near high or near low percentage values is not even in certain numerously occuring species; it varies with increasing abundance of the given species.

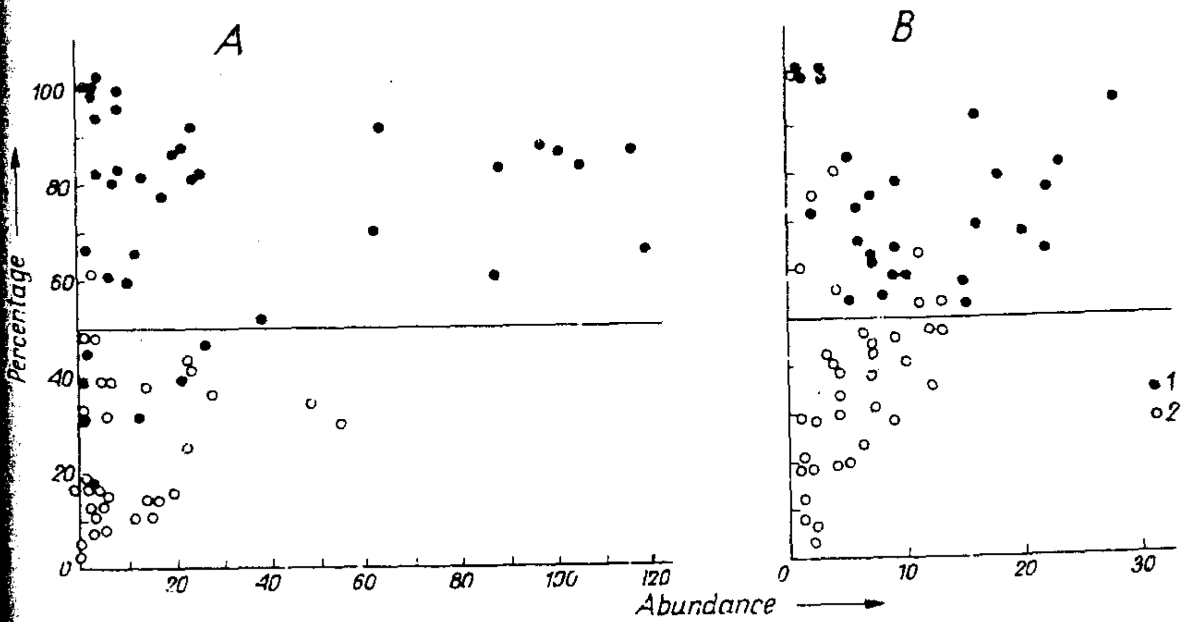

Fig. 8. Correlative comparison of abundance of the species *Neophilenus lineatus* (*A*) and *Philenus spumarius* (*B*) with their percentage in the given layer

1 — percentage of *a*, *2* — percentage of *b*

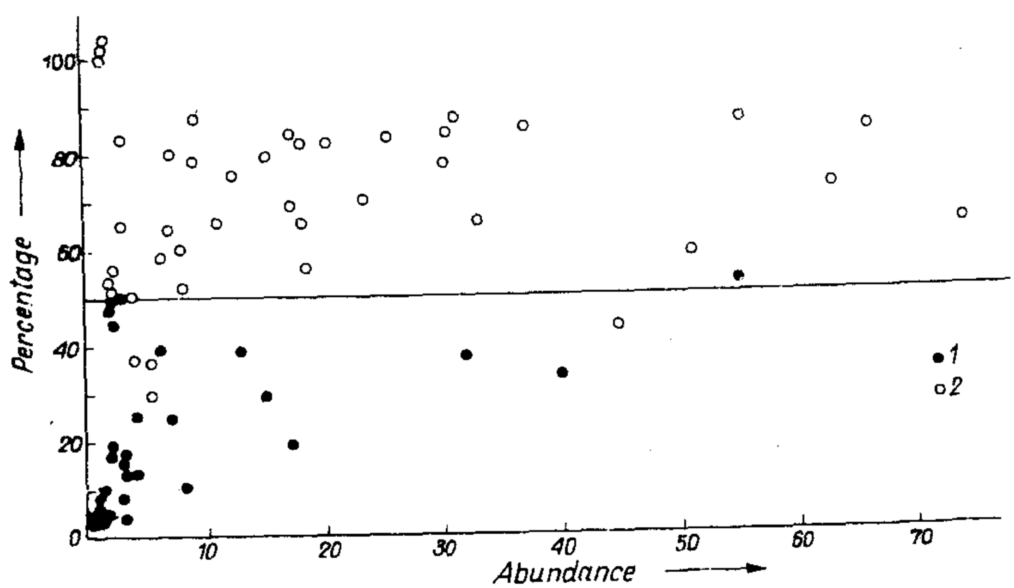

Fig. 9. Correlative comparison of abundance of the species *Arthaldeus pascuellus* with its percentage in the given layer

1 — percentage of *a*, *2* — percentage of *b*

Variations in the distribution of concentrations of cases from $\bar{a}$ and $\bar{b}$ with increasing abundance of the species was traced in relation to a drawn axis. Since the value of the percentage of a species in a definite layer fluctuates

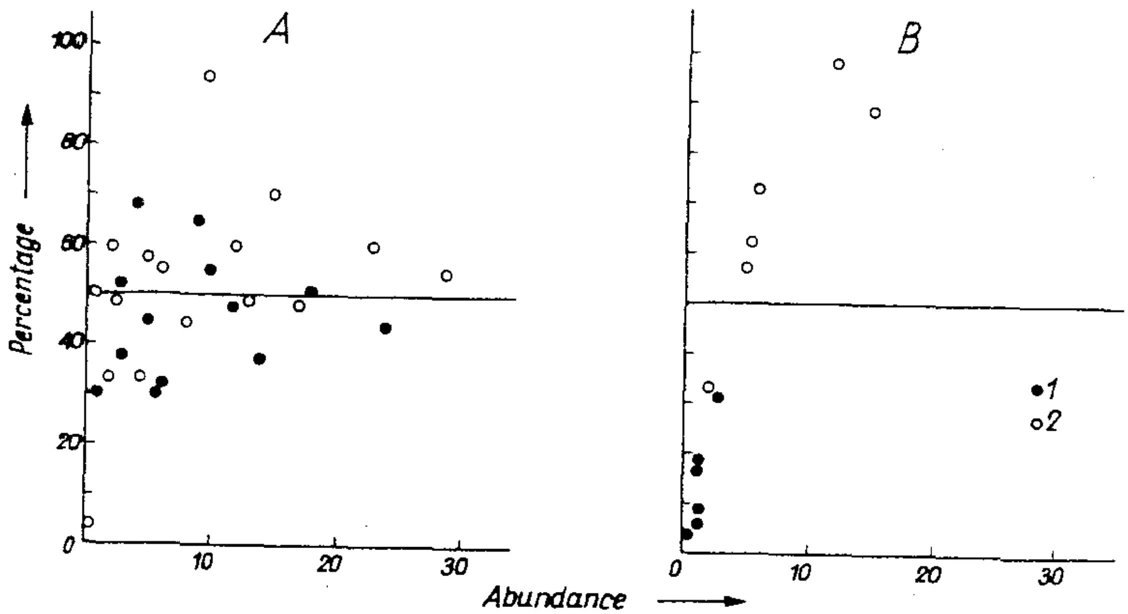

Fig. 10. Correlative comparison of abundance of the species *Dikraneura citrinella* (*A*) and *Kelisia vittipennis* (*B*) with their percentage in the given layer
1 — percentage of *a*, *2* — percentage of *b*

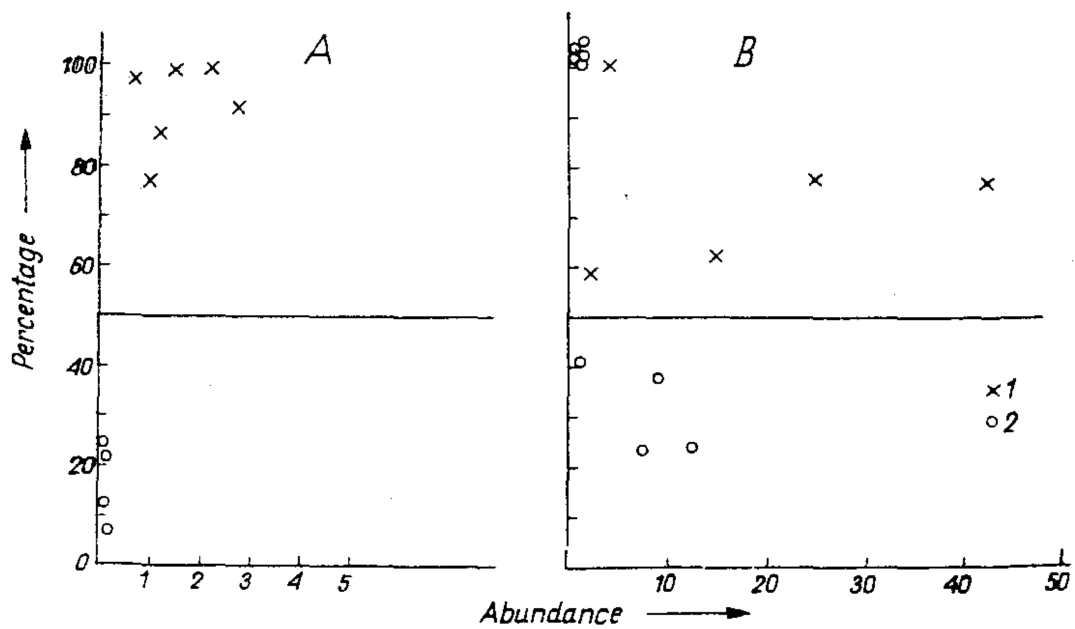

Fig. 11. Correlative comparison of abundance of the species *Agallia brachyptera* (*A* and *Delphacodes venosus* (*B*) with their percentage in the given layer
1 — percentage of c, *2* — percentage of *b*

within limits from 0 to 100, the value 50 was taken as the axis dividing cases with either predominant, or conversely, lesser localization of the population in a given layer.

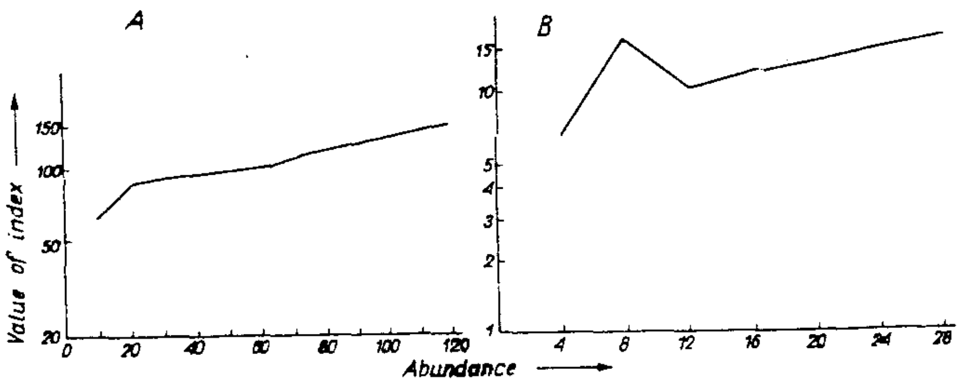

Fig. 12. Variations in value of index *h* for *Neophilenus lineatus* (*A*) and *Philenus spumarius* (*B*)

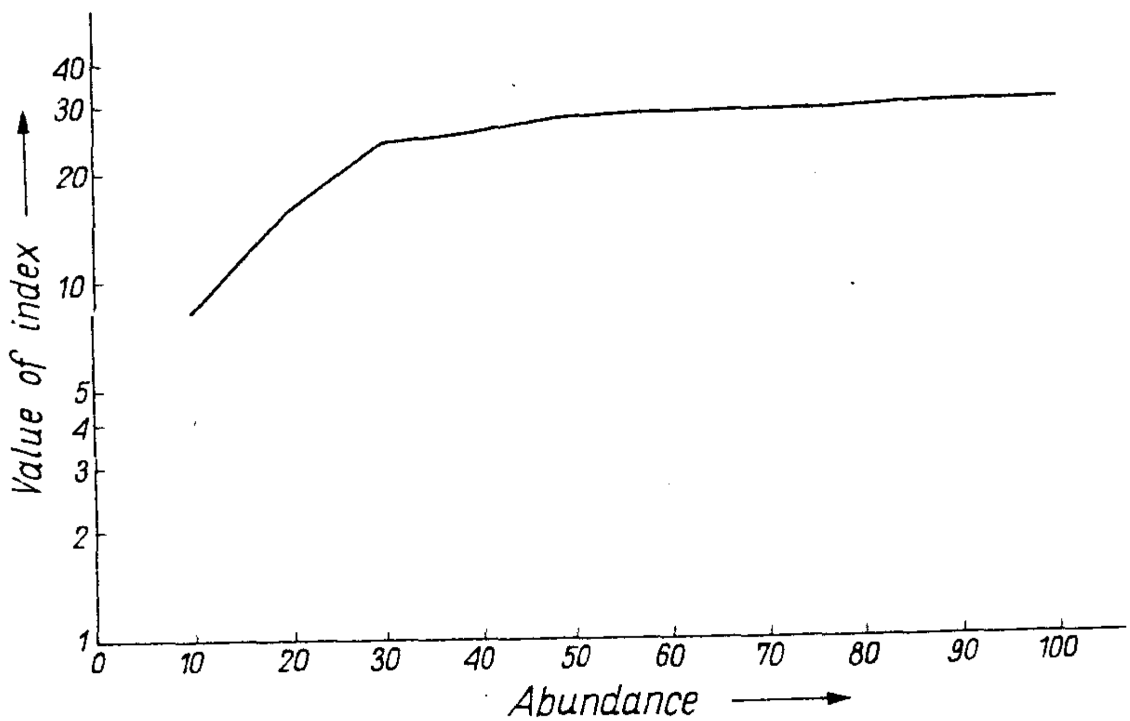

Fig. 13. Variations in value of index *h* for *Macrosteles laevis*

If the distribution of the species in the plant layers did not depend on its abundance, then the ratio (*h*) of number of cases from the net to the number of cases from the biocenometer above and below the axis of variation should be constant. Variations in the value of *h* together with increase in the abundance of the species point to the movements of the species in the layers of the plant. The increase in value *h* with increasing abundances of the species points to a tendency to move to the higher layer of plants. This relations was found for *Neophilenus lineatus*, *Philenus spumarius*, *Macrosteles laevis* (Fig. 12, 13). The *h* index in the case of *Dikraneura citrinella*, a species of the lower layer of plants P–II, takes a different course. With medium abundances the population occupies the higher parts of plants, and with the lowest and highest, the lower layer (Fig. 14).

No distinct relation between abundance and movements between plant layers was found for the remaining species with the abundances occurring on the meadows studied, as has been shown, e.g. for *Arthaldeus pascuellus* on Figure 15.

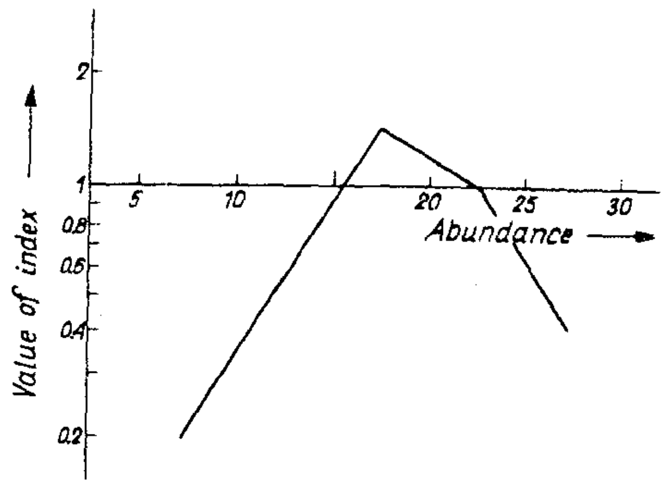

Fig. 14. Variations in value of index *h* for *Dikraneura citrinella*

The species referred to occurred on the meadows studied together with other and equally numerous species. In such cases it might be anticipated that the co-occurrence of numerous species of the community might modify their layer distribution. In order to be free of the influence of other species it was necessary to find an *Auchenorrhyncha* population which had a different percentage of participation in the *Auchenorrhyncha* community on several meadows and which in part of the meadow habitats was an absolute dominant, that is, which greatly predominated numerically over the other species. One species complied with these conditions – *Cicadella viridis*. This species occurred very abundantly on meadows with a plant association of the *Caricetum elatae* type, in the Kampinos National Park, and apart from it there was no similar species of considerable numbers in P–III or P–II.

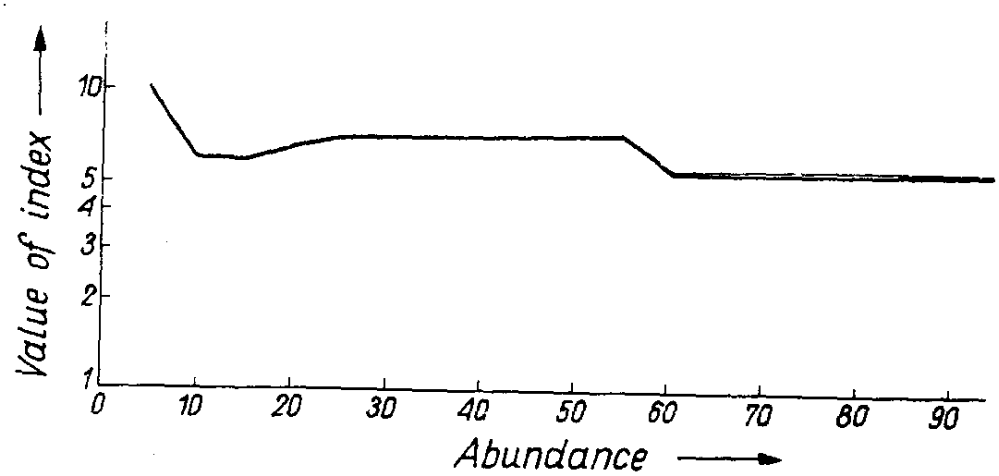

Fig. 15. Variations in value of index *h* for *Arthaldeus pascuellus*

Comparison of variations in the index (h) of distribution and abundance of the species shows that together with an increase in abundance the population of *Cicadella viridis* moves to the upper parts of plants also (P–III) (Fig. 16).

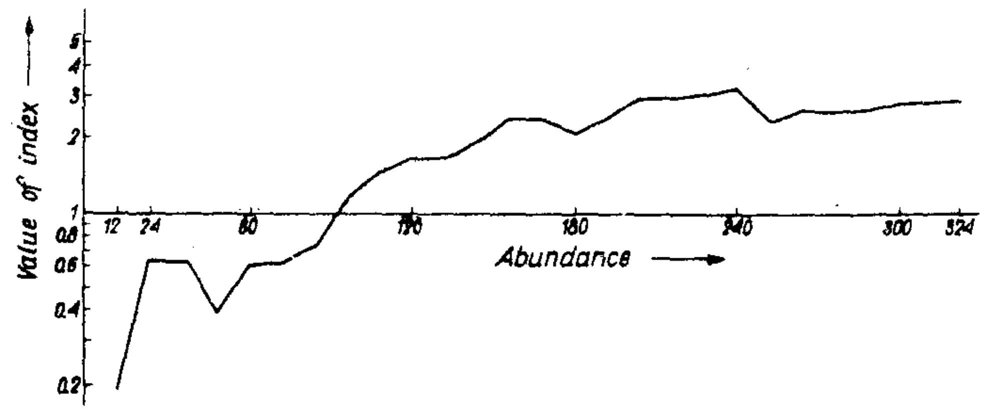

Fig. 16. Variations in value of index h for *Cicadella viridis*

Simultaneously the increase in the abundance of *C. viridis* is connected with the increase in the percentage of this species in the community of *Auchenorrhyncha* occurring in the same meadow during the same period. This is clear from the correlation of the index of layer distribution $\overline{W}_a$ with the percentage of *C. viridis* in the community of the meadows examined (Fig. 17).

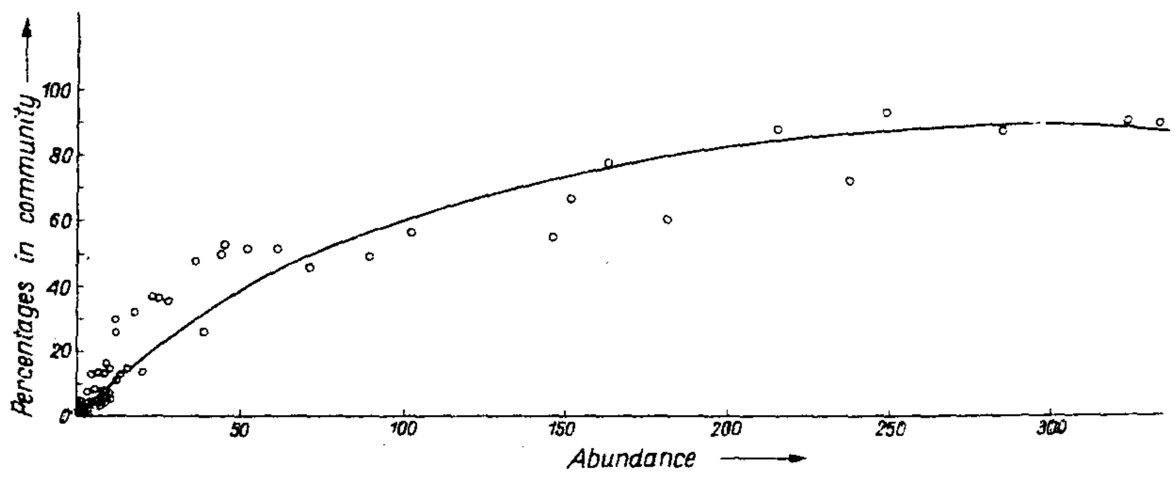

Fig. 17. Correlation between percentage in the *Auchenorrhyncha* community and abundance of species for *Cicadella viridis*

Under conditions in which the population of *C. viridis*, a species connected with layer P–II, is an absolute dominant in the *Auchenorrhyncha* community, this species may also live in considerable numbers in the higher parts of plants.

It must therefore be assumed that in the case of the population described not only the life cycle, abundance and meadow habitat conditions determine the place in which the population lives. The factor which conditions its distribution is also the system of relations between the populations of the *Auchenorrhyncha* community which live on the given meadow.

To sum up the problems dealt with in this section it must be said that the place which a given population occupies in the vertical cross-section of the meadow is determined by: 1) the abundance of the population, and 2) the place which this population occupies in the domination system of *Auchenorrhyncha*.

IV. SUMMARY OF RESULTS

1. The populations forming the community of meadow *Auchenorrhyncha* are distributed unevenly in the habitat. They divide the habitat between themselves, occupying different layers of it.

2. Groups of species living exclusively or most abundantly in one of three layers were distinguished: species on the tops of grasses – occurring in layer P–III; species in the layer near the litter (in P–II), and those in the litter (P–I), i.e. litter species.

3. The layer distribution of different populations is variable. During the growing season the insects move between the different plant layers. Hence the percentage of abundance is not constant in the upper layer of grasses but varies during the growing season from spring to autumn.

4. The distribution of species in a definite plant layer depends on the microclimatic conditions prevailing in it and the habitat requirements and life cycle of the species.

5. The abundance of a population may determine the place which it occupies in the vertical cross-section of the meadow.

6. In cases in which the percentage of the population in the *Auchenorrhyncha* community increases, the factor conditioning distribution in the plant layer is the system of population relations and the place occupied by the species in the domination system of the community occurring on the given meadow.

7. It can be seen from the layer distribution of the insects and the vertical movements which take place in different populations of the communities of meadow *Auchenorrhyncha* that intensity of the insects' movements in a given direction varies during the course of the growing season. Hence a different percentage of abundance of the whole population is obtained in samples. In such cases the variations in the indicator number (i.e. the number of insects in a sample) obtained from the sample, are not parallel to variations in the absolute numbers of the population examined.

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PIĘTROWA STRUKTURA I JEJ DYNAMIKA U ŁĄKOWYCH ZGRUPOWAŃ *AUCHENORRHYNCHA* (*HOMOPTERA*)

Streszczenie

W niniejszej pracy przedstawiono wyniki analizy rozmieszczenia skoczków (*Auchenorrhyncha — Homoptera*) w poszczególnych piętrach roślinności łąkowej. Zmienność rozmieszczenia skoczków rozpatrywano w zależności od okresu wegetacyjnego, liczebności populacji poszczególnych gatunków oraz struktury dominacyjnej zgrupowania.

Badania przeprowadzono w roku 1955 na dwóch łąkach naturalnych (N_1, N_2) i dwóch uprawianych (A_1, A_2) w kompleksie Bagien Kuwaskich. Dodatkowe materiały zebrano w latach 1956 i 1957 na łąkach śródleśnych w Puszczy Kampinoskiej. Materiał zbierano czerpakiem ilościowym i biocenometrem. Ogółem pobrano 4 248 prób. Zebrano 22 401 owadów reprezentujących 62 gatunki skoczków.

Stwierdzono, że gatunki *Auchenorrhyncha* mają tendencję do zajmowania określonych pięter roślin, niezależnie od typu badanych środowisk łąkowych.

W badanych zespołach łąkowych wydzielono trzy piętra rozmieszczenia skoczków: ściółkę — P—I, przyściółkowe części traw — P—II oraz ich górne części — P—III.

Gatunkami dominującymi były w P—I: *Kelisia vittipennis*, *Delphacodes venosus*, *Aphrodes bicinctus*, *Strongylocephalus agrestis*, *Agallia brachyptera* (w piętrze tym przebywają również larwy gatunków, których imaginalne formy rozmieszczają się w wyższych warstwach roślin); w P—II: *Calligypona pellucida*, *Athysanus argentarius*, *Elymana sulphurella*, *Arthaldeus /pascuellus*, *Cicadella viridis*, *Dikraneura citrinella;* w P—III: *Neophilenus lineatus*, *Philenus spumarius*, *Macrosteles laevis*, *Sorhoanus assimilis*.

Niezależnie od tendencji poszczególnych gatunków do zajmowania określonych pięter roślin następuje pionowe przemieszczanie się populacji skoczków w tych piętrach, w ciągu okresu wegetacyjnego. Cykl piętrowych przemieszczeń skoczków związany jest z ich cyklem życiowym. Larwy skoczków przebywają głównie w najniższej warstwie roślin; w miarę dorastania przesuwają się w wyższe części roślin. Dorosłe owady przebywają z reguły w wyższych piętrach roślin, aniżeli ich larwy. Wraz z upły-

wem sezonu wegetacyjnego następuje stopniowe przesuwanie się owadów w kierunku ściółki. Tutaj też pozostają do końca sezonu te skoczki, które zimują jako dorosłe owady, lub jako larwy. Owady, składające na zimę jaja, przemieszczają się natomiast w górne warstwy trawy pod koniec okresu wegetacyjnego.

Pionowe przemieszczenia tych samych gatunków skoczków nie przebiegają zawsze zgodnie w różnych środowiskach łąkowych. Różnice te są wynikiem modyfikującego wpływu środowiska, działającego poprzez zmianę cyklu życiowego gatunku.

Na pionowe rozmieszczenie skoczków w piętrach roślinności łąkowej oddziałuje również zagęszczenie populacji. Stwierdzono, że liczniej występujące gatunki (*Macrosteles laevis*, *Neophilenus lineatus*, *Philenus spumarius*, *Cicadella viridis*, *Dikraneura citrinella*) zajmują większą przestrzeń w środowisku, w miarę wzrostu ich liczebności. Nie stwierdzono występowania takiej zależności u pozostałych gatunków.

Organizacja zgrupowania *Auchenorrhyncha* oraz miejsce, jakie zajmie populacja w strukturze dominacyjnej zgrupowania, może również wpływać na jej pionowe rozmieszczenie w środowisku. W przypadku *Cicadella viridis* stwierdzono, że wraz ze wzrostem udziału procentowego tego gatunku w układzie dominacyjnym zgrupowania skoczków, zajmuje on większą przestrzeń w środowisku badanych łąk.

Nasilenie przemieszczeń skoczków w określonym kierunku zmienia się w ciągu okresu wegetacyjnego i dlatego w odławianych próbach znajduje się różny procent liczebności całej populacji. W takim przypadku, zmiany liczby wskaźnikowej (jaką jest ilość owadów w próbie), otrzymanej z próby, nie są równoległe do zmian bezwzględnej liczebności badanej populacji.

AUTHOR'S ADDRESS:
Dr. Lucyna Andrzejewska
Institute of Ecology,
Polish Academy of Sciences, Dziekanów Leśny
k. Warszawy, Poland.

List of numbers of individuals of different *Auchenorrhyncha* species caught on different stations

Tab. V

Species	Stations											
	A_1			A_2			N_1			N_2		
	net	biocenometer		net	biocenometer		net	biocenometer		net	biocenometer	
		grass	litter		grass	litter		grass	litter		grass	litter
Kelisia vittipennis (Sahlb.)	–	–	–	–	–	–	–	82	6	1	18	2
Kelisia pallidula (Boh.)	–	–	–	–	–	–	6	12	4	–	4	–
Kelisia ribauti Wagner	–	–	–	–	–	–	3	8	2	–	2	–
Stenocranus fuscovittatus (Stål.)	–	–	–	1	–	–	8	4	–	–	–	–
Delphacodes venosus (Germ.)	–	–	–	–	33	3	–	65	98	–	24	19
Criomorphus albomarginatus Curt.	–	–	–	–	–	–	–	2	–	–	–	–
Calligypona striatella (Fall.)	2	2	–	13	34	4	1	5	–	–	–	–
Calligypona spinosa (Boh.)	3	14	3	–	–	–	–	10	2	–	–	–
Calligypona straminea (Stål.)	–	–	–	1	–	–	1	20	22	9	31	17
Calligypona dubia (Kbm.)	–	1	–	1	1	–	–	–	–	–	–	–
Calligypona pellucida (Fabr.)	118	649	196	31	266	76	4	26	2	5	–	–
Calligypona pellucida – larvae	11	83	407	1	44	491	–	–	13	–	–	–
Calligypona albostriata (Fieb.)	5	17	1	1	–	–	–	5	4	–	–	–
Ommatidiotus dissimilis (Fall.)	–	–	–	–	–	–	5	–	–	28	13	2
Lepyronia coleopterata (L.)	10	3	–	–	–	–	–	–	–	79	35	4
Aphrophora alpina Mel.	–	–	–	–	–	–	1	–	–	–	–	–
Aphrophora salicira (Goeze)	–	1	–	–	–	–	–	–	–	–	–	–
Neophilenus lineatus (L.)	103	62	1	25	22	2	711	402	36	771	259	32
Philenus spumarius (L.)	174	147	5	71	71	7	138	124	4	1	6	1
Macrosteles laevis (Rib.)	113	62	–	288	246	1	211	25	–	18	6	–
Macrosteles laevis – larvae	–	96	5	8	38	2	1	–	–	–	–	–
Balclutha punctata (Thnb.)	2	–	–	3	1	–	1	1	–	–	–	–
Streptanus sordidus (Zett.)	1	115	11	6	53	9	–	–	–	–	–	–
Athysanus argentarius Metc.	3	18	1	17	59	–	6	31	–	1	2	1
Athysanus quadrum (Boh.)	–	–	–	–	1	–	9	37	2	–	8	–
Elymana sulphurella (Zett.)	77	117	2	53	150	9	2	1	–	–	–	–
Rhopalopyx preyssleri (H.-S.)	–	11	1	–	4	–	4	69	5	4	38	7
Rhopalopyx flaveola (Boh.)	–	15	–	–	–	–	1	1	–	1	–	–
Cicadula quadrinotata (F.)	–	–	–	2	–	–	70	32	–	58	10	3
Cicadula quadrinotata – larvae	–	–	–	–	–	–	–	–	2	–	15	4
Cicadula quinquenotata (Boh.)	–	–	–	61	168	2	6	2	–	2	4	–
Cicadula saturata (Edw.)	–	–	–	–	–	–	–	–	–	1	–	–
Hardya tenuis (Germ.)	–	4	–	2	22	–	–	4	–	–	–	1
Graphocraerus ventralis (Fall.)	–	1	1	1	–	–	–	–	–	–	–	–
Psammotettix alienus (Dhlbm.)	2	1	–	9	4	–	5	2	–	4	–	–
Psammotettix cephalotes (H.-S.)	–	–	–	–	–	–	–	6	–	–	–	–
Psammotettix confinis (Dhlbm.)	9	16	–	1	3	–	3	2	–	–	7	–
Deltocephalus pulicaris (Fall.)	61	498	23	14	17	–	1	–	–	–	–	–
Deltocephalus pulicaris – larvae	–	80	3	–	–	–	–	–	–	–	–	–
Errastunus ocellaris (Fall.)	19	67	6	–	–	–	–	–	–	–	–	–
Verdanus abdominalis (F.)	17	28	–	4	14	–	–	–	–	–	–	–
Arthaldeus pascuellus (Fall.)	156	1,113	65	40	321	20	41	270	25	11	39	3
Arthaldeus pascuellus – larvae	17	400	37	–	80	6	2	1	8	4	16	62
Arthaldeus striifrons (Kbm.)	–	–	–	–	2	–	–	–	–	–	–	–
Sorhoanus assimilis (Fall.)	7	3	–	2	4	–	59	42	1	93	52	2
Doratura stylata (Boh.)	–	1	–	–	–	–	3	5	–	–	9	1
Eupelix cuspidata (F.)	–	–	–	–	–	–	1	2	–	1	–	–
Aphrodes bicinctus (Schrk.)	2	18	4	–	2	1	7	16	4	–	8	4
Aphrodes fuscofasciatus (Goeze)	–	–	–	–	–	–	–	15	–	–	–	–
Aphrodes bifasciatus (L.)	–	1	1	2	5	5	–	–	–	–	–	–
Aphrodes flavostriatus (Don.)	–	4	23	2	6	36	–	6	4	–	–	–
Strongylocephalus agrestis (Fall.)	–	–	–	–	1	–	4	41	4	1	3	46
Cicadella viridis (L.)	2	10	–	8	42	–	63	336	4	3	10	–
Cicadella viridis – larvae	–	3	–	2	10	–	6	10	9	–	14	1
Agallia brachyptera (Boh.)	–	1	11	–	2	15	–	2	13	–	1	7
Agallia venosa (Fall.)	–	–	–	–	15	2	–	1	–	–	–	–
Erythroneura parvula (Boh.)	–	–	–	–	5	–	4	–	–	–	1	–
Erythroneura disjuncta (Rib.)	–	4	–	–	–	–	–	2	–	–	–	–
Empoasca vitis (Goethe)	–	–	–	–	–	–	–	1	–	–	–	–
Eupteryx atropunctata (Goeze)	2	1	–	5	3	–	–	1	–	–	–	–
Dikraneura citrinella (Zett.)	102	279	6	14	67	–	26	37	–	4	3	–
Notus flavipennis (Zett.)	1	–	–	–	–	–	5	–	–	2	–	–
Larvae not identified	–	148	38	–	182	62	12	4	116	18	138	82