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The effect of intensive fertilization on the structure and productivity of meadow ecosystems				

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11. THE EFFECT OF MINERAL FERTILIZATION OF A MEADOW ON THE *AUCHENORRHYNCHA (HOMOPTERA)* FAUNA*

The diversified rate of meadow treatment with mineral fertilizers (0–NPK and 680 kg NPK/ha) used in this experiment caused primarily a higher plant production, and a simplification of the plant association involved. *Auchenorrhyncha (Homoptera)*, associated with the meadow vegetation by trophic relations, responded to high fertilizer rates by an increase, about 15%, in the number of emerged individuals, and a reduction and changes in the species composition of the community. On the basis of the index of "similarity" among *Auchenorrhyncha* communities it may be found that their variation was relatively high, and with the successive years of treatment with fertilizers the similarity between the *Auchenorrhyncha* communities of the control area and those of the treated area, especially those emerged in the experimental plots, decreased. Environmental conditions caused by the application of high rates of fertilization resulted in an abundant occurrence of *Auchenorrhyncha* species known to be pests of crops.

INTRODUCTION

Auchenorrhyncha (Homoptera) represent a permanent, and in most cases a numerous component group of meadow entomofauna. It is a homogeneous group of insects in respect of their trophic relations, because the only food ingested by them is plant sap. At them same time, within the *Auchenorrhyncha* group a considerable variation can be seen of the requirements both with regard to the types of host plant, and to moisture, thermic and light conditions (MÜLLER 1955, REMANE 1958, WHITTAKER 1969, MÜLLER and FRÖGER 1971, MORRIS 1974 . These characteristics of *Auchenorrhyncha* determine their close relationships with the environment.

Treatment of meadows and pastures with mineral fertilizers, more and more commonly applied, causes changes primarily in the chemistry of the environment and in the structure of vegetation and of plant production. In the present study attention was paid to the response of

*Praca wykonana w ramach problemu węzłowego Nr 09.1.7.2.

an *Auchenorrhyncha* community to changes taking place in a meadow environment as a result of mineral fertilization.

ENVIRONMENT

The meadow, in which the fertilizing experiment was carried out, was occupied by the plant association *Arrhenatheretum medioeuropaeum* developed by successional changes from a mixture of meadow grasses that had been sown there more than ten years before. The study plots were located in a complex of meadows on gleyed alluvial brown soils on an old accumulation terrace of the Vistula on the north-eastern borders of Warsaw (TRACZYK 1976, TRACZYK, CZERWIŃSKI and KOTOWSKA 1976). A uniform meadow patch about 2.5 ha in area, was divided into experimental plots, each of the size of 1250 m^2 (50x25 m). Some of the plots were treated with a mixture of mineral (NPK) fertilizers at the rate of 680 kg (of pure constituent) per a hectare per season (2–NPK). Thus the rate was more than twice as high as before the experiment. In the remaining control plots (0–NPK), fertilization was stopped. Six replications of these two variants, treated and control, were used in plots of a random spatial distribution.

The entire meadow, including the experimental plots, was utilized as before, that is, it was mown three times during the growing season: in May, July and September (Fig. 1). The fertilizing experiment was started in the spring of 1972. In the same growing season an over four-fold increase in plant production (green parts of the crop) was recorded for the treated plots, relative to the controls, this ratio persisting through the next growing seasons. During the years 1973 and 1974 there occurred more marked differences in the number of plant species (83 species in variant 0–NPK, and 38 in 2–NPK) and in the structure of the vegetation cover. In spite of the great difference in the number of species (45), the basic plant biomass in both plots, as much as 79–92%, was formed by the following four grass species: *Dactylis glomerata* (L.), *Arrhenatherum elatius* (L.), *Poa pratensis* (L.), and *Festuca rubra* L. (TRACZYK and KOTOWSKA 1976).

A detailed botanical analysis showed that the sward left after mowing of the meadow, that is, the biomass of the about 5 cm layer of the green aboveground vegetation, and the tillering nodes varied during the growing season over a small range (TRACZYK T., TRACZYK H. and PASTERNAK 1976a, 1976b) whereas the average biomass of this layer was greater only by about 12% in the treated plots, relative to the controls (Fig. 1).

MATERIAL AND METHODS

The density and species composition of the *Auchenorrhyncha* inhabiting the grass layer of the experimental plots were assessed in a series of samples collected by means of a biocenometer from randomly selected sites at 1 up to 2-weeks' intervals, from May to October in the years 1972–1974. A series consisted of 20 samples of an area of 0.1 m^2. To remove the *Auchenorrhyncha* from under the biocenometer a suction apparatus was used (ANDRZEJEWSKA and KAJAK 1966).

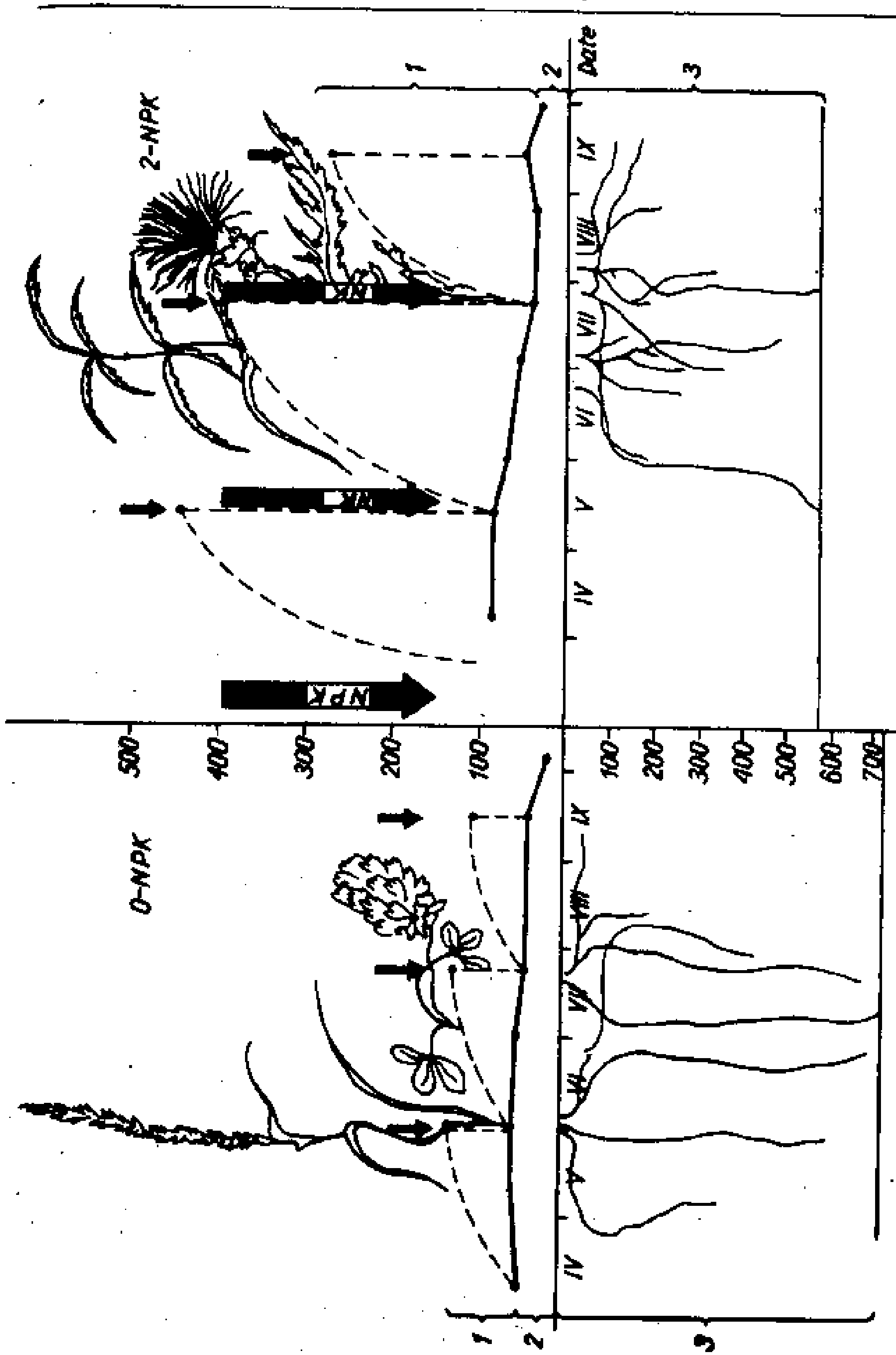

Fig. 1. Changes of vegetation biomass (g/d.wt./m^2) in the experimental plots during the growing season of 1974
1 – layer of aboveground parts of plants, *2* – sward, *3* – roots. The arrows indicate dates of mowing

The number of adult *Auchenorrhyncha* that emerged in the experimental plots was determined separately. After their emerging the adult insects were collected from under the "permanent" isolators (20 isolators of an area of 0.1 m^2) that remained at one place for a month, where after they were moved to new, not used areas of the meadow (OLECHOWICZ 1970). From the permanent isolators *Auchenorrhyncha* were removed on an average twice a week in the years 1973 and 1974.

The density of early larval stages of *Auchenorrhyncha*, hatched in the litter and soil, was determined on the basis of extraction of 30 sections of soil with litter, each of 100 cm^2 in area and 5 cm thick. These samples were collected at one-month's intervals in 1973 and 1974[1]. Extraction of the fauna from blocks of soil and sward was performed in Tullgren's apparatus modified by Kempson and others.

RESULTS

During the three successive years of the fertilizer experiment the contribution of *Auchenorrhyncha* to the numbers of the entomofauna inhabiting the grass layer in the plots ranged

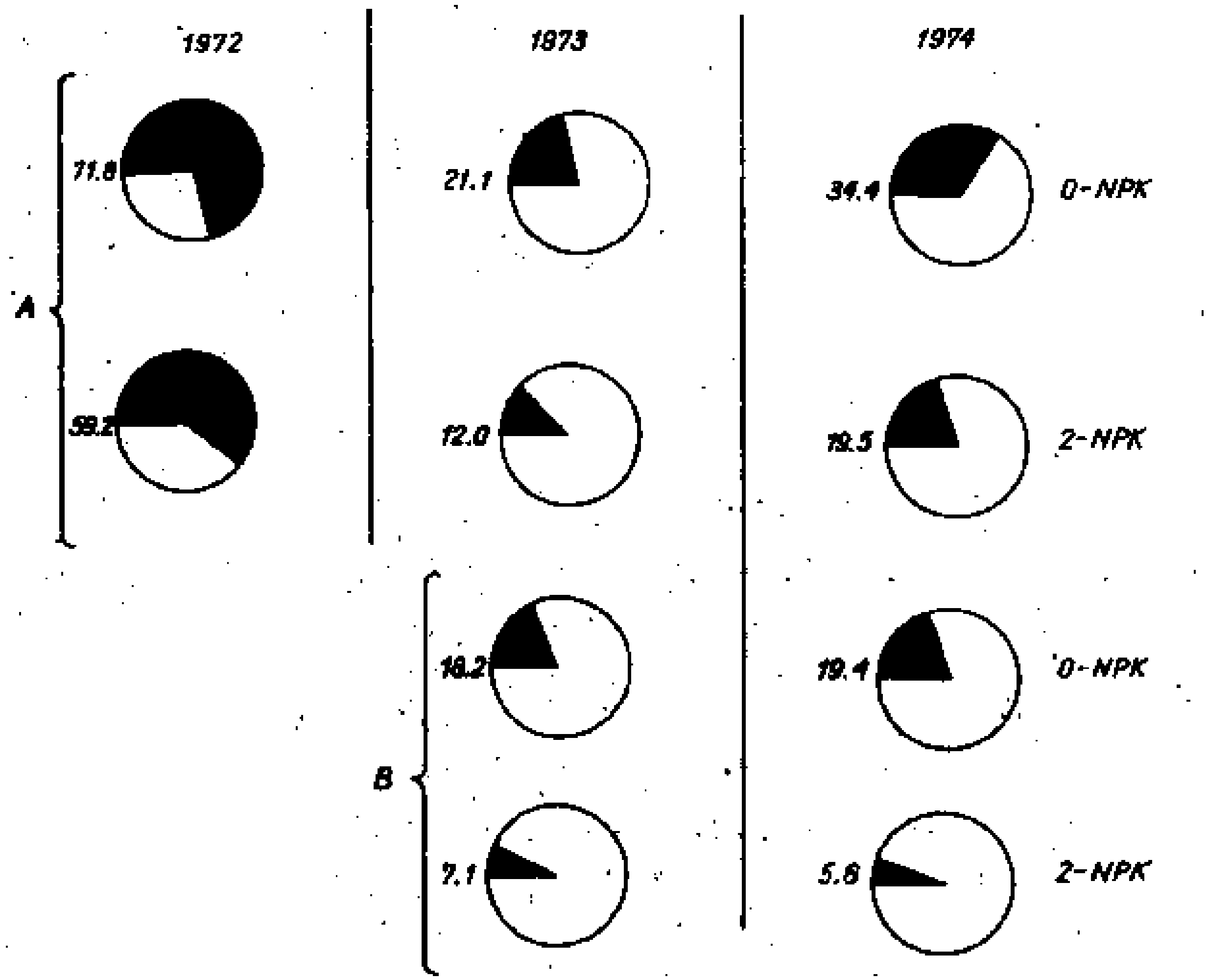

Fig. 2. Contribution of *Auchenorrhyncha* (in %) to total entomofauna occurring (*A*) and emerged (*B*) in the experimental plots

[1] This material was made available to me by Dr. A. Kajak, for which I wish to express my cordial thanks.

from 12% to about 72% (Fig. 2). During the first year of experiment (1972) the highest percentage of *Auchenorrhyncha* was recorded for both the control (0–NPK) and the treated (2–NPK) plots when it amounted to 71.7% and 54.9%, respectively. During the next year (1973) a considerable reduction in the abundance of the whole entomofauna was observed, and the numerical ratios of individual groups of entomofauna changed. *Auchenorrhyncha* represented about 21% in 0–NPK, and 12% in 2–NPK plots. During the third year of the experiment the number of *Auchenorrhyncha* increased, and so did their percentage in the entomofauna inhabiting the meadow: 34.3% in the control plots, and 18.8% in the fertilized plots.

A comparison of the entomofauna hatched in the experimental plots in 1973 and 1974 with the entomofauna inhabiting the grass layer shows that the contribution of *Auchenorrhyncha* was smaller: 18.2% and 19.4% in the control plots, and 7.1% and 5.6% in the fertilized plots (Fig. 2). The percentage of *Auchenorrhyncha* being always smaller in the entomofauna of the fertilized plots.

DENSITY OF *AUCHENORRHYNCHA*

Changes in the numbers of *Auchenorrhyncha* during the three successive years of observation in the control and in the fertilized parts of the meadow were similar (Fig. 3). No significant differences in average density of *Auchenorrhyncha* could be seen between the two kinds of plots compared (0–NPK and 2–NPK). During the particular years of the experiment the average density for the entire growing season was: 116.6 (0–NPK) and 110.2 individuals/m^2 (2–NPK) in the first year, 1972; 3.7 and 3.6 individuals/m^2 in 1973; and 24.3 and 25.9 individuals/m^2 in 1974.

Much greater differences were seen in the number of *Auchenorrhyncha* hatched in the experimental plots (in 0–NPK and 2–NPK).

The number of eggs laid by *Auchenorrhyncha*, and the percentage of larvae hatched were not estimated during the present studies. However, it was found that larvae, which during their short stage lived in a thin layer of soil and litter, were more numerous in the fertilized plots. Throughout the growing season in 1973 the number of *Auchenorrhyncha* larvae produced per m^2 was 251 in the control plots, and 280 larvae in the treated plots. During the third fertilization year 610 and 717 larvae/m^2, respectively hatched (Table 1*A* and *B*).

As they grew the larvae moved to upper plant layers and their numbers became reduced considerably. Adults emerged in the experimental plots represented about 20% of the total number of larvae in 1974, and a much higher percentage, 28 up to 37% in 1973. In the control plots, 71.4 adults emerged in 1973, and 127.3 in 1974, whereas in the treated plots 118.2 and 142.2 individuals/m^2/season (Table 1*A* and *B*).

Only a small proportion of the total number of adult *Auchenorrhyncha*, emerged in the experimental plots throughout the growing season, inhabited the grass layer. In the control plots the average density was 3.7 individuals/m^2 in 1973, and 24.3 individuals/m^2 in 1974, while in the treated plots 3.6 and 25.9 individuals per m^2, respectively. A comparison of these values with the density of larvae shows that in 1973 the density of adult *Auchenorrhyncha* inhabiting the grass layer in the untreated plots represented about 1.5% of the density of larvae, whereas in the fertilized meadow – 1.3%. In 1974 the percentage of *Auchenorrhyncha* inhabiting the meadow (relative to the number of larvae hatched) was higher, amounting to 4.0% and 3.7%, respectively (Table 1*A* and *B*). As has been mentioned above, the number of

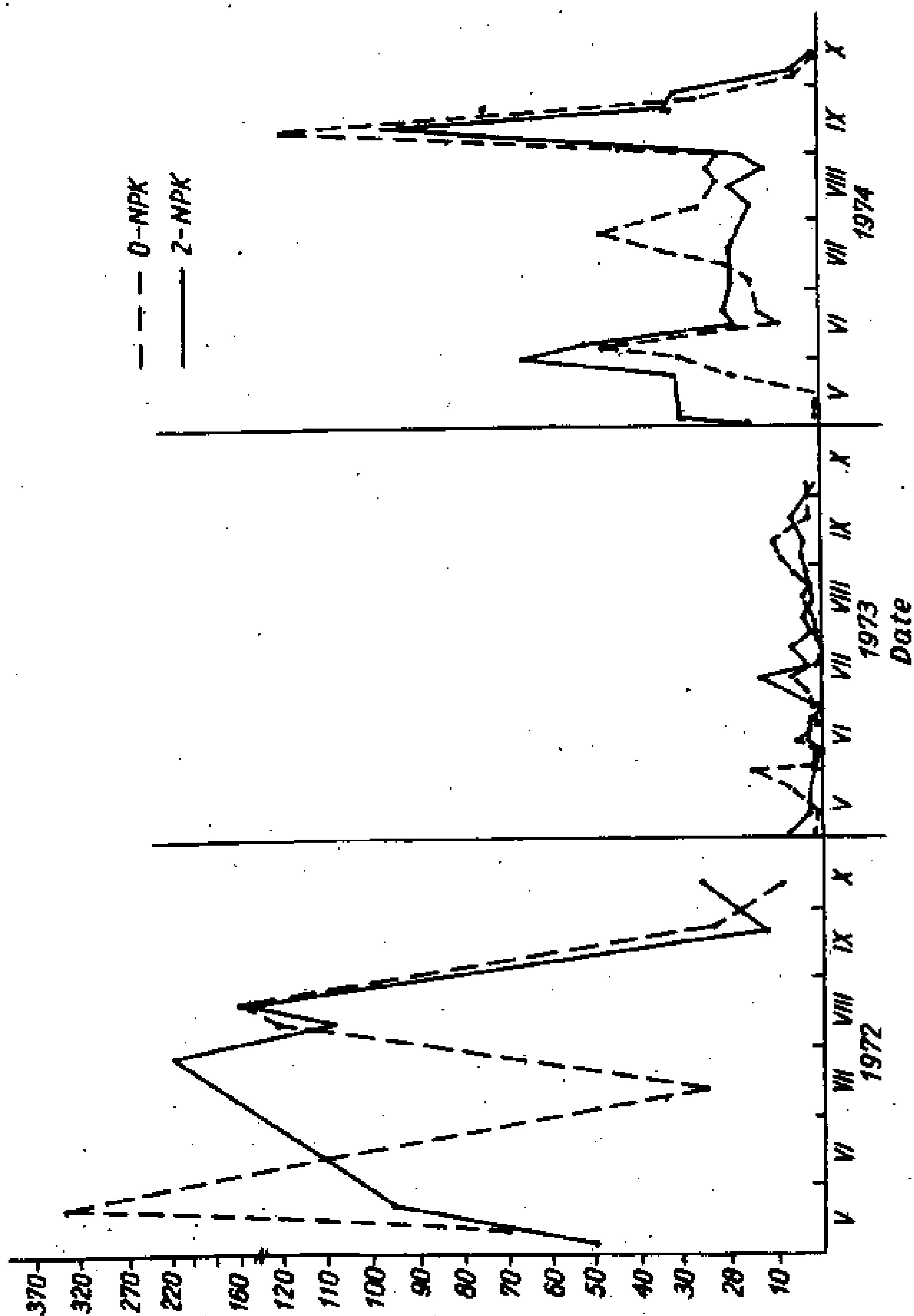

Fig. 3. Density of Auchenorrhyncha occurring in the experimental plots

SPECIES COMPOSITION OF *AUCHENORRHYNCHA*

During the three successive study years the number of species making up the *Auchenorrhyncha* community living in the experimental plots varied. The largest number of species in both areas was found in the first year of the experiment: 25 in 0–NPK, and 19 in 2–NPK. During the subsequent years a considerably smaller number of species inhabited the grass layer in both plot series: 15 and 16 in 0–NPK, and 14 and 15 in 2–NPK (Fig. 4). Except 1972, very similar numbers of *Auchenorrhyncha* species inhabited the grass layer in the control and the treated plots, and, likewise, similar were the numbers of *Auchenorrhyncha* species emerged in the same areas (in 1973: 16 species in 0–NPK and 14 in 2–NPK; in 1974 – 11 and 9, respectively) (Fig. 4).

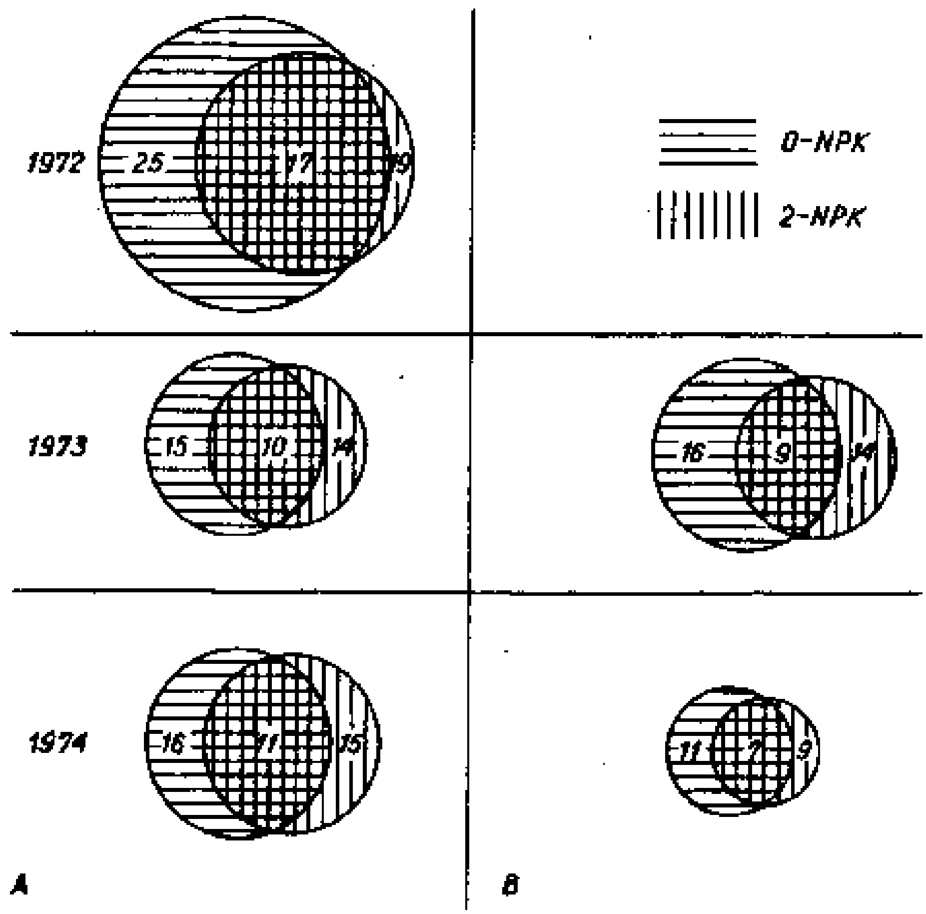

Fig. 4. Number of *Auchenorrhyncha* species captured in the experimental plots
A – *Auchenorrhyncha* occurring in the meadow, *B* – *Auchenorrhyncha* emerged in the meadow

Much more marked than the differences in the number of species were differences in the species composition of the *Auchenorrhyncha* communities in the two kinds of plots. Only slightly more than half the species captured in the experimental areas were found to occur simultaneously in the fertilized and control plots. In 1972 – 63%, 1973 – 53%, and in 1974 – 55% (Table 2). Similar was the percentage of common species of *Auchenorrhyncha* emerged in the experimental plots: 64% in 1973, and 54% in 1974 (Table 3).

A greater variation in the species composition of the *Auchenorrhyncha* communities, even in the same plots, could be observed between the successive years of the experiment. In both the control and the fertilized plots, for the growing season of 1973 and for that of 1974 only

Table 2

The number of *Auchenorrhyncha* species occurring in the experimental plots

Year	1972	1973	1974
0–NPK	25	15	16
2–NPK	19	14	15
Total in 0–NPK + 2–NPK	27	19	20
Common species	17	10	11
Per cent contribution of common species	63%	53%	55%

Table 3

The number of *Auchenorrhyncha* species hatched in the experimental plots

Year	1973	1947
0–NPK	16	11
2–NPK	14	9
Total in 0–NPK + 2–NPK	25	13
Common species	9	7
Per cent contribution of common species	64%	54%

about 40% of common species were recorded (in the fauna emerged in the meadow). A similar variation in the number of *Auchenorrhyncha* species was found in the communities inhabiting the grass layer during the three successive experimental years (Table 2).

Most marked differences in the density of *Auchenorrhyncha* and number of species present in the experimental plots occurred between the first and second year following the application of the varied rate of fertilization. In the third year, in spite of an almost 6-fold increase in the density of *Auchenorrhyncha*, only one new species occurred in the 0–NPK plots, and one in the 2–NPK plots, whereas considerably fewer species were represented among the *Auchenorrhyncha* emerged in both areas, the number of species in the control plots and in the fertilized plots was reduced by five (Table 3).

Table 4

Dominance structure of *Auchenorrhyncha* communities occurring in the experimental plots

1972	1973	1974
Per cent in community		
0–5% / 5–10% / > 10%	0–5% / 5–10% / > 10%	0–5% / 5–10% / > 10%
0–NPK	0–NPK	0–NPK
Agallia venosa (Fall.)	*Rhopalopyx vitripennis* (Fl.)	*Rhopalopyx preisleri* (H. S.)
Xanthodelphax sp.	*Diplocolenus abdominalis* (F.)	*Acanthodelphax spinosus* (Fieb.)
Rhopalopyx monticola Rib.	*Graphocraerus ventralis* (Fall.)	*Empoasca flavescens* (F.)
Dicranoneura citrinella (Zett.)	*Deltocephalus pulicaris* (Fall.)	*Ribautodelphax albostriatus* (Fieb.)
Sorhoanus assimilis (Fall.)	*Doratura stylata* (Boh.)	*Athysanus argentarius* Metc.
Arocephalus languidus (Fl.)		
Streptanus sordidus (Zett.)		
Doratura homophyla (Fl.)		
2–NPK	2–NPK	2–NPK
Psammotettix alienus (Dhlb.)	*Doratura homophyla* (Fl.)	*Rhopalopyx vitripennis* (Fl.)
Elymana sulphurella (Zett.)	*Athysanus argentarius* Metc.	*Arocephalus languidus* (Fl.)
Megadelphax sordidulus (Stål)	*Javesella pellucida* (Fabr.)	*Javesella pellucida* (Fabr.)
Ribautodelphax albostriatus (Fieb.)	*Psammotettix confinis* (Dhlb.)	*Psammotettix confinis* (Dhlb.)
Doratura stylata (Boh.)	*Macrosteles laevis* (Rib.)	*Macrosteles laevis* (Rib.)
Athysanus argentarius Metc.	*Errastunus ocellaris* (Fall.)	*Errastunus ocellaris* (Fall.)
Deltocephalus pulicaris (Fall.)	*Turrutus socialis* (Fl.)	*Turrutus socialis* (Fl.)
Javesella pellucida (Fabr.)	*Arthaldeus pascuellus* (Fall.)	*Arthaldeus pascuellus* (Fall.)
Psammotettix confinis (Dhlb.)	*Cicadula quadrinotata* (Fabr.)	*Cicadula quadrinotata* (Fabr.)
Macrosteles laevis (Rib.)	*Streptanus aemulans* (Kbm.)	*Streptanus aemulans* (Kbm.)
Errastunus ocellaris (Fall.)	*Empoasca flavescens* (F.)	*Graphocraerus ventralis* (Fall.)
Turrutus socialis (Fl.)	*Aphrodes bicinctus* (Schrk.)	*Streptanus sordidus* (Zett.)
Arthaldeus pascuellus (Fall.)	*Philaenus spumarius* (L.)	*Aphrodes fuscofasciatus* (Goeze)
Cicadula quadrinotata (Fabr.)		*Psammotettix cephalotes* (H. S.)
Streptanus aemulans (Kbm.)		
Empoasca flavescens (F.)		
Aphrodes bicinctus (Schrk.)		
Arthaldeus striifrons (Kbm.)		
Notus flavipennis (Zett.)		

The lenght of the lines under each species indicates its place in particular percentage group; solid lines – 0–NPK, broken lines – 2–NPK.

Table 4

Dominance structure of *Auchenorrhyncha* communities occurring in the experimental plots

Per cent in community (0–5% | 5–10% | > 10%)

Plot	1972	1973	1974
0–NPK	*Agallia venosa* (Fall.)	*Rhopalopyx vitripennis* (Fl.)	*Rhopalopyx preyssleri* (H. S.)
0–NPK	*Xanthodelphax* sp.	*Diplocolenus abdominalis* (F.)	*Acanthodelphax spinosus* (Fieb.)
0–NPK	*Rhopalopyx monticola* Rib.	*Graphocraerus ventralis* (Fall.)	*Empoasca flavescens* (F.)
0–NPK	*Dicraneura citrinella* (Zett.)	*Deltocephalus pulicaris* (Fall.)	*Ribautodelphax albostriatus* (Fieb.)
0–NPK	*Sorhoanus assimilis* (Fall.)	*Doratura stylata* (Boh.)	*Athysanus argentarius* Metc.
0–NPK	*Arocephalus languidus* (Fl.)		
0–NPK	*Streptanus sordidus* (Zett.)		
0–NPK	*Doratura homophyla* (Fl.)		
2–NPK	*Psammotettix alienus* (Dhlb.)	*Doratura homophyla* (Fl.)	*Rhopalopyx vitripennis* (Fl.)
2–NPK	*Elymana sulphurella* (Zett.)	*Athysanus argentarius* Metc.	*Arocephalus languidus* (Fl.)
2–NPK	*Megadelphax sordidula* (Stål.)	*Javesella pellucida* (Fabr.)	*Javesella pellucida* (Fabr.)
2–NPK	*Ribautodelphax albostriatus* (Fieb.)	*Psammotettix confinis* (Dhlb.)	*Psammotettix confinis* (Dhlb.)
2–NPK	*Doratura stylata* (Boh.)	*Macrosteles laevis* (Rib.)	*Macrosteles laevis* (Rib.)
2–NPK	*Athysanus argentarius* Metc.	*Errastunus ocellaris* (Fall.)	*Errastunus ocellaris* (Fall.)
2–NPK	*Deltocephalus pulicaris* (Fall.)	*Turrutus socialis* (Fl.)	*Turrutus socialis* (Fl.)
2–NPK	*Javesella pellucida* (Fabr.)	*Arthaldeus pascuellus* (Fall.)	*Arthaldeus pascuellus* (Fall.)
2–NPK	*Psammotettix confinis* (Dhlb.)	*Cicadula quadrinotata* (Fabr.)	*Cicadula quadrinotata* (Fabr.)
2–NPK	*Macrosteles laevis* (Rib.)	*Streptanus aemulans* (Kbm.)	*Streptanus aemulans* (Kbm.)
2–NPK	*Errastunus ocellaris* (Fall.)	*Empoasca flavescens* (F.)	*Graphocraerus ventralis* (Fall.)
2–NPK	*Turrutus socialis* (Fl.)	*Aphrodes bicinctus* (Schrk.)	*Streptanus sordidus* (Zett.)
2–NPK	*Arthaldeus pascuellus* (Fall.)	*Philaenus spumarius* (L.)	*Aphrodes fuscofasciatus* (Goeze)
2–NPK	*Cicadula quadrinotata* (Fabr.)		*Psammotettix cephalotes* (H. S.)
2–NPK	*Streptanus aemulans* (Kbm.)		
2–NPK	*Empoasca flavescens* (F.)		
2–NPK	*Aphrodes bicinctus* (Schrk.)		
2–NPK	*Arthaldeus striifrons* (Kbm.)		
2–NPK	*Notus flavipennis* (Zett.)		

The lenght of the lines under each species indicates its place in particular percentage group; solid lines – 0–NPK, broken lines – 2–NPK.

Table 5

Dominance structure of communities of *Auchenorrhyncha* emerged in the experimental plots

Per cent in community (0–5% | 5–10% | > 10%)

Plot	1973	1974
0–NPK	*Ribautodelphax albostriatus* (Fieb.)	*Deltocephalus pulicaris* (Fall.)
0–NPK	*Doratura stylata* (Boh.)	*Arocephalus languidus* (Fl.)
0–NPK	*Athysanus argentarius* Metc.	*Acanthodelphax spinosus* (Fieb.)
0–NPK	*Arocephalus languidus* (Fl.)	*Cicadula quadrinotata* (Fabr.)
0–NPK	*Acanthodelphax spinosus* (Fieb.)	*Rhopalopyx vitripennis* (Fl.)
0–NPK	*Streptanus aemulans* (Kbm.)	
2–NPK	*Cicadula quadrinotata* (Fabr.)	*Doratura homophyla* (Fl.)
2–NPK	*Rhopalopyx vitripennis* (Fl.)	*Errastunus ocellaris* (Fall.)
2–NPK	*Deltocephalus pulicaris* (Fall.)	*Turrutus socialis* (Fl.)
2–NPK	*Errastunus ocellaris* (Fall.)	*Aphrodes fuscofasciatus* (Goeze)
2–NPK	*Turrutus socialis* (Fl.)	*Psammotettix confinis* (Dhlb.)
2–NPK	*Aphrodes fuscofasciatus* (Goeze)	*Arthaldeus pascuellus* (Fall.)
2–NPK	*Dicraneura citrinella* (Zett.)	*Javesella pellucida* (Fabr.)
2–NPK	*Javesella pellucida* (Fabr.)	*Macrosteles laevis* (Rib.)
2–NPK	*Macrosteles laevis* (Rib.)	*Streptanus aemulans* (Kbm.)
2–NPK	*Psammotettix confinis* (Dhlb.)	
2–NPK	*Arthaldeus pascuellus* (Fall.)	
2–NPK	*Balclutha punctata* (Fabr.)	
2–NPK	*Streptanus sordidus* (Zett.)	
2–NPK	*Sorhoanus assimilis* (Fall.)	

Explanations see Table 4.

DOMINANCE STRUCTURE

During the three study years, with the density and the number of *Auchenorrhyncha* species varying, there always occurred a large number of species common to the control and fertilized plots, and some species found only in 0–NPK plots, or only in the 2–NPK plots. To determine the places occupied by these species groups in the dominance structure of *Auchenorrhyncha* communities, the species were divided into three groups, according to their percentage in the community. Group I included abundant species representing over 10% of the *Auchenorrhyncha* community; included in group II were species constituting 5 up to 10% of the community, and group III consisted of accessory species, below 5%.

During the first year of the experiment the group of *Auchenorrhyncha* common to the 0–NPK and 2–NPK plots included dominant species, abundant species, and a certain number of accessory species. Species captured only in 0–NPK, or only in 2–NPK were included only in group III – a group of accessory species (Table 4).

During the next years the number of species decreased, mainly at the expense of accessory species. It was these species, immigrants from the neighbouring environments, that formed the group of species characteristic of the control and treated plots, and also a certain proportion of species common to both habitats.

Least variable was the group of abundant species and dominants forming the main body of the *Auchenorrhyncha* communities in the control and the treated plots, and at the same time the permanent part of the common species. They included the following: *Errastunus ocellaris, Arthaldeus pascuellus, Turrutus socialis, Cicadula quadrinotata, Psammotettix confinis, Javesella pellucida, Macrosteles laevis, Streptanus aemulans* (Table 4).

The disturbance caused by stopping the treatment of 0–NPK plots with mineral fertilizers, and applying high fertilization rates to 2–NPK plots affected more strongly the structure of the communities of *Auchenorrhyncha* emerged in the meadow. There occurred a clear division of the species originally "common", that is to say, those that were still "common" in 1973, into species emerged only in 0–NPK, and those emerged in 2–NPK during 1974. Among the species common to both plot series only three emerged during two successive growing seasons (1973 and 1974): *Errastunus ocellaris, Turrutus socialis* and *Psammotettix confinis*. In the third study year, more numerous became the following species associated with the control plots: *Deltocephalus pulicaris, Arocephalus languidus*, and less numerous: *Rhopalopyx vitripennis, Acanthodelphax spinosus*, and *Cicadula quadrinotata*. In the fertilized plots the following emerged: *Javesella pellucida, Macrosteles laevis* and *Streptanus aemulans* (Table 5).

ASSESSMENT OF DIFFERENCES AMONG *AUCHENORRHYNCHA* COMMUNITIES IN THE EXPERIMENTAL PLOTS

During the three successive years following the change in the fertilization rate of the meadow there occurred considerable changes in numbers, in the number of species, and in the dominance structure of *Auchenorrhyncha* communities. In addition to the variation in time, as a result of variable weather conditions during the three seasons of study (Table 6), there occurred differences between the *Auchenorrhyncha* communities in the control and in the treated plots.

The degree of similarity (or difference) between the communities of the two areas was determined by using the index of similarity of species populations, worked out by Marczewski and Steinhaus and modified by Romaniszyn: $S = \frac{W}{200-W}\,100$, where W is the total lower

Table 6

Temperature, precipitation and ground water table in the Bródno meadow during May–October (according to TRACZYK, CZERWIŃSKI and KOTOWSKA 1976)

Parameters	Years		
	1972	1973	1974
Ground water table in cm	107.78–124.90	150.67–161.44	120.85–135.52
Sum of precipitation in mm	609.40	315.25	498.2
Mean temperature of soil surface in 0°C	13.90	12.46	14.25

percentage of a particular species in the two communities compared. The value of the index varied between 0 and 100%. A high value of the index indicates a high similarity between the communities compared, and a value approaching 0% indicates a lack of similarity.

Table 7

Indices of similarity of communities of *Auchenorrhyncha* occurring in the experimental plots (in %)

<table>
<tr><th rowspan="2">Experimental plots</th><th colspan="6">Years of experiment</th></tr>
<tr><th colspan="2">1972</th><th colspan="2">1973</th><th colspan="2">1974</th></tr>
<tr><td>0–NPK</td><td></td><td colspan="2">24</td><td colspan="2">20</td><td></td></tr>
<tr><td>0–NPK/2–NPK</td><td colspan="2">49*</td><td colspan="2">40*</td><td colspan="2">38*</td></tr>
<tr><td>2–NPK</td><td></td><td colspan="2">21</td><td colspan="2">30</td><td></td></tr>
</table>

*Indices of similarity of communities in 0–NPK and 2–NPK.

During the three successive years after the introduction of the experimentally changed rate of meadow fertilization the variation of *Auchenorrhyncha* communities occurring in the plots was high in both the control and treated plots. The value of the index of similarity of the communities in the same areas ranged from 22 to about 30% (Table 7). During the first year of the experiment already the communities of *Auchenorrhyncha* occurring in the control and treated plots differed, there being only 49% similarity between them. During the next years, 1973 and 1974, the value of the index decreased gradually down to the values 40% and 38% (Table 7). It may be assumed on this basis that the changes which occurred in the communities, found in the 0–NPK and 2–NPK plots during the three successive years, proceeded in different directions, and thus the differences in species composition and dominance structure of the *Auchenorrhyncha* communities increased.

Much greater differences (lesser similarity) were recorded for communities of *Auchenorrhyncha* emerged in the experimental plots. Between the years 1973 and 1974 faster changes occurred in the control plots. The index value for the control area was 13%, that for

Table 8

Indices of similarity of communities of *Auchenorrhyncha* emerged in the experimental plots

<table>
<tr><th rowspan="2">Experimental plots</th><th colspan="2">Years of experiment</th></tr>
<tr><th>1973</th><th>1974</th></tr>
<tr><td>0–NPK</td><td colspan="2">13</td></tr>
<tr><td>0–NPK/2–NPK</td><td>24*</td><td>7*</td></tr>
<tr><td>2–NPK</td><td colspan="2">25</td></tr>
</table>

*Indices of similarity of communities in 0–NPK and 2–NPK.

the treated area – 25% (Table 8). A more marked decrease of similarity could be seen between a community of *Auchenorrhyncha* of a control and treated plots emerged in succesive years, the index value being 24% in 1973, and only 7% in 1974 (Table 8).

SUMMARY

The high rate mineral fertilization (NPK) applied caused differences primarily in the production and structure of vegetation, relative to the unfertilized area. In the treated (2–NPK) plots a four-fold increase of the biomass of the crop was found. Simultaneously, there occurred a reduction in the species composition of the plat association. Rare species disappeared, while about 90% of the biomass was made up of four grass species.

Harvesting, mowing the meadow three times during a growing season, caused great variations in the green biomass of the crop. However, the biomass of the green parts of plants, forming the 5 cm layer of sward together with the tillering nodes did not show any considerable variations during the growing season, and was higher in the treated area only by about 12%. This is the layer with which at the same time the hatching of the majority of *Auchenorrhyncha* is connected. It is there that the litter species occur, and the adult *Auchenorrhyncha*, usually inhabiting higher plant layers, seek refuge (ANDRZEJEWSKA 1965).

The value of the difference in the number of *Auchenorrhyncha* larvae and adults in the control and in treated plots was similar (about 15%) to that of the difference in the biomass of sward and tillering nodes (about 12%). The ratio of the green mass of the plants of this layer to the biomass of *Auchenorrhyncha* larvae hatched, or adults emerged, appeared to be fairly stable for both series of plots; its value for the larvae was 4.6 in the control area, and 3.8 in the treated plots, and for the adults 2.7 and 2.2, respectively. It may, therefore, be presumed that the biomass of *Auchenorrhyncha*, one of the most abundant phytophagous insects, is correlated with the biomass of the green parts of plants used as an available pool of food, and also as the main site of hatching and refuge. These conclusions agree with the findings reported by ZLOTIN (1975). For 8 mountain meadows he found a close correlation between the primary production and the total biomass of phytophagous animals. Similar relationships have been reported from grazed prairies in Colorado (VAN DYNE 1973).

As they grew up and moved to the upper plant layers, about 80% of the *Auchenorrhyncha* larvae became reduced, in a similar manner in both plot series. Adult insects were reduced by predators and parasites, and a considerable number of them migrated out of the experimental area. Consequently, in the meadow an *Auchenorrhyncha* community was found consisting of local insects, hatched there, and immigrants. In 1974, the density of adult *Auchenorrhyncha* occurring in the plots, relative to the density of the larvae hatched there, was about 4% in 0–NPK, this value being slightly lower for the treated meadow (3.6%); in the growing season of 1973, the average density of *Auchenorrhyncha* found in the plots, relative to the density of the larvae hatched there, was slightly less than 2%. During the present study the eggs laid, their reduction, as also

the reduction of the earliest larval stages were not taken into account. It may, therefore, be assumed that the reduction of *Auchenorrhyncha* from the egg to the adult stage considerably exceeds 96%, and in some years even 98%.

The fact that the reduction of *Auchenorrhyncha* in the control and in the treated plots was similar indicates a lack of clear differences in predator activity between the two series of plots. This agrees with the assessment of predator densities (KAJAK in press).

During the successive years the number of *Auchenorrhyncha* emerged, and their densities in the control and in the treated plots showed rather a considerable variation (in 0–NPK: 116.5; 3.7 and 24.3; in 2–NPK: 110.2; 3.6; 25.9 individuals/m^2). The parallel course of so drastic changes in the numbers of *Auchenorrhyncha* in both areas permits the presumption that they resulted from superior factors, such as the weather conditions.

The increased crop production due to the high rate fertilization applied did not have any significant effect on the abundance of *Auchenorrhyncha*, but it caused more significant changes in the number of species, and in the structure of *Auchenorrhyncha* communities:

1. A change in the meadow fertilization scheme was followed by simplification in the species composition. There occurred a decrease in the number of *Auchenorrhyncha* species, especially of those inhabiting the grass layer (in 1972 – 27, in 1973 – 19, and in 1974 – 20); the number of species found in the control area was always larger, the common species representing from 53 up to 63% of the species occurring in both plot series in the particular growing season.

2. In 1973, the *Auchenorrhyncha* emerged in the plots, relative to those occurring in the meadow, were represended by a larger number of species (21) than in 1974 (13).

3. The most abundant *Auchenorrhyncha* species (representing over 10% of the total abundance of the community), forming communities in both plot series, constituted a group consisting of 8 species, recurring during the three consecutive years. These were: *Errastunus ocellaris, Arthaldeus pascuellus, Psammotettix confinis, Turrutus socialis, Cicadula quadrinotata, Javesella pellucida, Macrosteles laevis, Streptanus sordidus.* Species occurring only in 0–NPK, or in 2–NPK belonged to the group of least abundant species (below 5% contribution to the community), and to the most variable component of the communities, and it may be presumed that they arrived there by accident during their emigration flights from neighbouring environments.

4. Most marked was the effect of the changed rate of meadow fertilization on the structure of the communities of *Auchenorrhyncha* hatched in the meadow. There occurred a division into species associated with the control area with a diverse vegetation, and species hatched in the treated area. The latter were at the same time known to occur abundantly in simplified habitats, e.g., crops where they might cause a serious damage by directly inflicting injuries, or as viral disease vectors. These included: *Javesella pellucida, Macrosteles laevis, Streptanus sordidus.*

During the three years following the start of the experiment the *Auchenorrhyncha* communities of both areas, treated and control, were subject to changes: of numbers, species composition and of dominance structure. During the successive years responsible for the changes were mainly the varying weather conditions, whereas the differences between the areas considered may be accounted for by differences in the fertilization of the meadow. An analysis of the similarity of *Auchenorrhyncha* communities (by using the Marczewski and Steinhaus index) between the two series of plots, and between individual years of the experiment permits the conclusion that:

a. The termination of fertilization (0–NPK), and the use of a double dose of fertilization proved to have evoked a response of the *Auchenorrhyncha* community of similar intensity. The similarity between the communities occurring in the same plots in different years was on an average 24% (20–30%). The variation of *Auchenorrhyncha* communities in meadows little utilized and unfertilized was also high, but these communities continued to be "similar" from year to year in over 50% (Table 9).

Table 9

Indices of similarity of communities of *Auchenorrhyncha* occurring in a natural meadow Biebrza

Years of collecting the insects	1963		1964		1965
Index value		52		61	

Wielkość zmian zachodzących w zespołach skoczków na powierzchniach eksperymentalnych oceniono wskaźnikiem „podobieństwa": ($S = \frac{W}{200-W} \cdot 100$). Stwierdzono, że:

1. Zaprzestanie nawożenia (0–NPK) i zastosowanie podwójnej dawki NPK, powoduje podobne nasilenie zmian w zespołach skoczków w kolejnych sezonach wegetacyjnych (wartość wskaźnika wynosi około 25%).

2. Zróżnicowanie zespołów skoczków występujących na poletkach już w pierwszym roku eksperymentu osiąga wartość około 50%, w następnych latach zmniejsza się podobieństwo między zespołami obu powierzchni do 38%.

3. Znacznie większe różnice występują w strukturze zespołów skoczków, które wylęgły się z jaj na poletkach. Między rokiem 1973 i 1974 podobieństwo zespołów wyraża się wartością 13% dla 0–NPK i 25% – dla 2–NPK. Równocześnie rozbieżne kierunki zmian, w czasie, na poletkach kontrolnym i nawożonym obniżają podobieństwa między nimi. Wartość wskaźnika w roku 1973 wynosi 25%, a w roku 1974 już tylko 7%.

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b. Smaller changes, that is, a higher "similarity" was found between 0–NPK and 2–NPK communities compared in the same growing seasons. However, the similarity between the communities of the two areas, control and treated, decreased from year to year (49, 40, 38%).

c. Change trends similar to those found for the *Auchenorrhyncha* communities occurring in the plots were found among the *Auchenorrhyncha* hatched in the same plots, control and treated, except that the index values were much lower (from 7% to 25%). In the third year of the experiment the *Auchenorrhyncha* communities in 0–NPK were only 7% similar to the communities of the treated area.

The increasing differences between the plots in time, with a simultaneously high variation of the communities in the same plots, indicate different succession trends of the communities, the emigrating and immigrating insects increasing the similarity (reducing the differences) between the communities of the control and treated plots.

d. The *Auchenorrhyncha* communities observed revealed a trend of changes similar to that indicated by the analyses of the structure of vegetation cover (TRACZYK and KOTOWSKA 1976): a reduction in the number of species, disappearance of low-abundance species, increase in the number of individuals.

e. The rate of response of *Auchenorrhyncha* to fertilization and increased plant production was similar to that of other phytophagous insects (aphids, grasshoppers and dipterans) (ANDRZEJEWSKA 1976). Other communities of meadow fauna, belonging to more distant links in the food chain, respond much less intensively, or with some delay. As has been found by ŻYROMSKA-RUDZKA (1976), changes in the number of species in *Acarina* communities do not occur until in the third year of fertilization. Although the dominance structure of predators varied, no significant differences were seen in their biomass in the two plot series (KAJAK in press).

STRESZCZENIE

Zastosowane w eksperymencie nawożenie mineralne (680 kg NPK/ha) łąki rajgrasowej (zespół *Arrhenatheretum medioeuropaeum*) wpłynęło w stosunku do kontroli (0 kg – NPK) na podniesienie około 4-krotne części produkcji roślinnej, plonu. Natomiast w niewielkim stopniu (około 12%) wzrasta biomasa zielonych części, mało zmiennej w sezonie, ścierni pozostającej po koszeniu łąki. Równocześnie ta warstwa stanowi bazę pokarmową i miejsce schronienia skoczków.

W kolejnych trzech latach eksperymentu skoczki zmieniały udział w liczebności całej entomofauny występującej na łące – w granicach od 12% do około 72%.

Udział skoczków w całości entomofauny lęgnącej się na łące był niższy, w granicach 5,6% do około 20%. W liczbie skoczków wylęgłych z jaj na powierzchniach kontrolnej i nawożonej nie ma dużego zróżnicowania: 251,0 osobników/m^2/sezon na 0–NPK i 280,0 osobników/m^2 na 2–NPK w roku 1973 i odpowiednio w roku 1974 610,4 i 717,4 osobników/m^2/ sezon.

W miarę dorostania larw i wylęgu osobników dorosłych i przechodzenia ich w wyższe warstwy roślin, około 80% skoczków ulegało redukcji (podobnie na obu poletkach). Dorosłe owady w znacznej części migrują i również, jak larwy, były redukowane przez drapieżce i pasożyty. W efekcie, zasiedlające łąkę dorosłe skoczki stanowiły 1,3 do 3,8% wylęgłych larw.

Zróżnicowanie w poziomie nawożenia łąki w niewielkim stopniu wpłynęło na zróżnicowanie liczebności skoczków, natomiast spowodowało istotniejsze zmiany w liczbie gatunków i strukturze zespołów skoczków:

1. Zawsze na łące nawożonej występuje mniej gatunków, a udział gatunków występujących w zespołach obu powierzchni (wspólnych) stanowi około 60% (53–63%).

2. Skoczki, które wylęgły się z jaj na poletkach, były reprezentowane przez mniejszą ilość gatunków w stosunku do przebywających na łące; również gatunków wspólnych dla obu powierzchni było stosunkowo mniej (43% w roku 1973 i 54% w 1974).

3. Najliczniejsze gatunki skoczków, na obu powierzchniach (powyżej 10% liczebności zespołu), tworzyły grupę 8 gatunków powtarzających się w ciągu kolejnych trzech lat. Do nich należą: *Errastunus ocellaris*, *Cicadula 4-notata*, *Javesella pellucida*, *Macrosteles laevis*, *Streptanus sordidus*. Gatunki występujące wyłącznie na 0–NPK lub 2–NPK należały do grupy najmniej licznych (poniżej 5% udziału w zespole) i do najbardziej zmiennego komponentu zespołów.

4. W zespołach skoczków, które wylęgły się z jaj na łące następował rozdział na gatunki związane z powierzchnią kontrolną (*Deltocephalus pulicaris*, *Rhopalopyx vitripennis*, *Macrosteles languidus*, *Cicadula 4-notata*, *Acanthodelphax spinosus*) i nawożoną (*Javesella pellucida*, *Macrosteles laevis*, *Streptanus aemulans*). Gatunki te występują zwykle najliczniej na uprawach i w środowiskach o zachwianej równowadze biologicznej.

Table 1

The abundance and reduction of *Auchenorrhyncha* during development

A				
Year 1974		Larva hatched in the soil	Adults emerged	*Auchenorrhyncha* occurring in the grass layer
0–NPK	number/m^2 per season	610.4	127.3	24.3
	reduction in %	78.8		80.6
			96.2	
2–NPK	number/m^2 per season	717.4	142.2	25.9
	reduction in %	80.2		81.2
			96.4	
B				
Year 1973		Larvae hatched in the soil	Adults emerged	*Auchenorrhyncha* occurring in the grass layer
0–NPK	number/m^2	251.0	71.4	3.7
	reduction in %	71.6		93.3
			98.5	
2–NPK	number/m^2	280.0	118.2	3.6
	reduction in %	57.8		96.2
			98.7	

eggs, their reduction, and the number of the youngest larvae were not taken into account in the calculation of the density of the individual developmental stages. It may be assumed, therefore, that in 1974 the reduction of *Auchenorrhyncha* from the egg to the adult insect considerably exceeded 96%, and in 1973 – 98%.