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Head: Dr. Alicja Breymeyer

Anna KAJAK, Alicja BREYMEYER, Joanna PĘTAL

PRODUCTIVITY INVESTIGATION OF TWO TYPES OF MEADOWS IN THE VISTULA VALLEY

XI. PREDATORY ARTHROPODS

(Ekol. Pol. 19: 223–233). Comparison was made of the predatory arthropods in a natural meadow in a nature reserve and in cultivated meadows. It was found that predators were as a rule more numerous in the nature reserve meadow in which no agricultural practices were carried out. Analysis was made of the trophic relations in two of the most numerous predatory groups in the study habitats, that is spiders and ants.

INTRODUCTION

This paper sums up data on dominant groups of predatory meadow arthropods. It is based chiefly on an analysis of two groups – spiders and ants – which are dominant in respect to biomass and even in respect to numbers. The authors describe the differences in abundance and biomass of predators, the relationships occuring between spiders and ants and the possible effect of these two groups of predators on non-predatory groups of insects.

A comparison is made of a forest meadow situated in a nature reserve and consequently not used (symbol SM), and two cultivated and mown meadows

(K I and K II). Meadow SM is one of the very common natural meadows beloning to the *Deschampsietum* association, while meadows K I and K II belong to the order *Arrenatherethalia*. A detailed description of the study areas can be found in the study by Traczyk (1971).

METHODS

The whole of the methods used for investigating the ants and field layer spiders has been discussed in previous studies (Pętal, Pisarski 1966, Pętal 1967, Kajak 1965, 1967, 1971). Determination of the number of ant nests per unit of area and density of individuals in each ant nest was the basis for estimating the density of ants. The abundance of field layer spiders was assessed by careful inspection of frames 0.25 m^2 in area.

Density of epigeic spiders was estimated using smaller frames 0.1 m^2 in area. All the spiders found were collected by hand and placed in test tubes containing alcohol; during periods when the grass was high it was pulled up and thrown on to a white plastic sheet, and then carefully inspected. When a female with a cocoon was found it was placed in a separate test tube to ensure that there was no difficulty in later identifying the owner of the cocoon.

Consumption by field layer spiders and by ants was assessed mainly on the basis of field data, by collecting food from marked webs of spiders (Kajak 1965, 1967, 1971) or by removing food carried to the nest by ants (Pętal 1967, 1968).

Data obtained from rearing spiders of the *Lycosidae* family were used for assessing the consumption of epigeic spiders. Some of these data have been published (Breymeyer 1967); additional data were obtained in this experiment concerning the relation between the size of the spider and the amount of food it requires. As it is possible to overfeed spiders under laboratory conditions, parallel experiment were made in the meadow and laboratory data were corrected in the light of results obtained from field conditions, where the spiders fed on their natural food only (Breymeyer in litt).

ABUNDANCE AND BIOMASS OF PREDATORS

The predatory macrofauna is represented, as mentioned in the introduction, mainly by two groups – spiders and predatory species of ants. Among other groups in which predation is the most frequent or only way of obtaining food the following were relatively numerous – *Hymenoptera* parasitica and *Odonata* in the field layer, *Chilopoda, Opiliones, Staphylinidae* and *Carabidae* in the litter layer, and predatory larvae of *Diptera* (*Tabanidae, Syrphidae*) and *Coleoptera* (*Carabidae, Cantharidae, Staphylinidae*) in the soil.

Field layer spiders mainly belong to the families: *Argiopidae, Theridiidae, Thomisidae, Salticidae, Clubionidae;* the families *Dictynidae, Linyphiidae* and *Tetragnathidae* were represented by small numbers. The species *Theridion bimaculatum* (L.), *Tibellus maritimus* (Menge), *Araneus quadratus* Clerck, *Singa heri* (Hahn), and *Cheiracanthium erraticum* (Walck.) were dominant, and jointly formed 87% of the number of all field layer spiders.

Epigeic spiders are represented chiefly by the family *Lycosidae*, representatives of this family formed 78% of the numbers of all epigeic spiders on the stand SM, 79% on K I and 39% on K II. In respect to abundance the dominant species is *Lycosa pullata* (Clerck), while in respect to biomass *Trochosa ruricola* (Degger) is dominant. In addition to *Lycosidae* species of the *Clubionidae, Gnaphosidae* and *Thomisidae* families are encountered in fairly largo numbers. The only representatives of the *Tetragnathidae* family are two species of the genus *Pachygnatha – Pachygnatha degeeri* Sund. and *P. clerckii* Sund. They are very numerous, particularly on station K II.

A very characteristic feature of the habitats examined is the numerous occurrence of predators on the natural SM meadows, and the far smaller numbers on mown meadows. The percentage of these predators in the total abundance of macrofauna was about twice as great at station SM as at the remaining stations (Fig. 1). This phenomenon was repeated in all the layers – field, litter and soil layers.

The percentage of predatory species within the groups possessing a wide food spectrum is also greatest on station SM. As many as 63% of the total number of ants on this station are predators, whereas on K I they make up 45%, and on K II 26%. Similarly predatory *Diptera* make up 8% on meadow SM, and only 3% on the other meadows.

The most strikingly difference between the natural meadow and the used meadows occurred in the numbers of the field layer spiders (dozens times); epigeic spiders were 3–4 times more numerous on the natural meadows. The smallest difference occurred in the numbers of predatory ants; the difference between the natural meadow and meadow K I was very slight, whereas on meadow K II the number of ants was about three times smaller than at SM (Tab. I).

Field layer spiders are either web spiders using plants for attaching their webs, or species forming cocoons on plants and building shelters in flowerheads or on leaves. Meadows cultivated and mown twice a year form a habitat very unfavourable to this group of spiders, which need a suitable plant structure. Similarly in these meadows epigeic spiders cannot find the moss and decomposing vegetation which provide them with a suitable microclimate and shelter on the surface of the soil. Absence of agricultural practices and the consequent well-formed litter layer and constantly high field layer contribute to rendering this habitat fairly stable, which encourages the abundant occurrence of these predators.

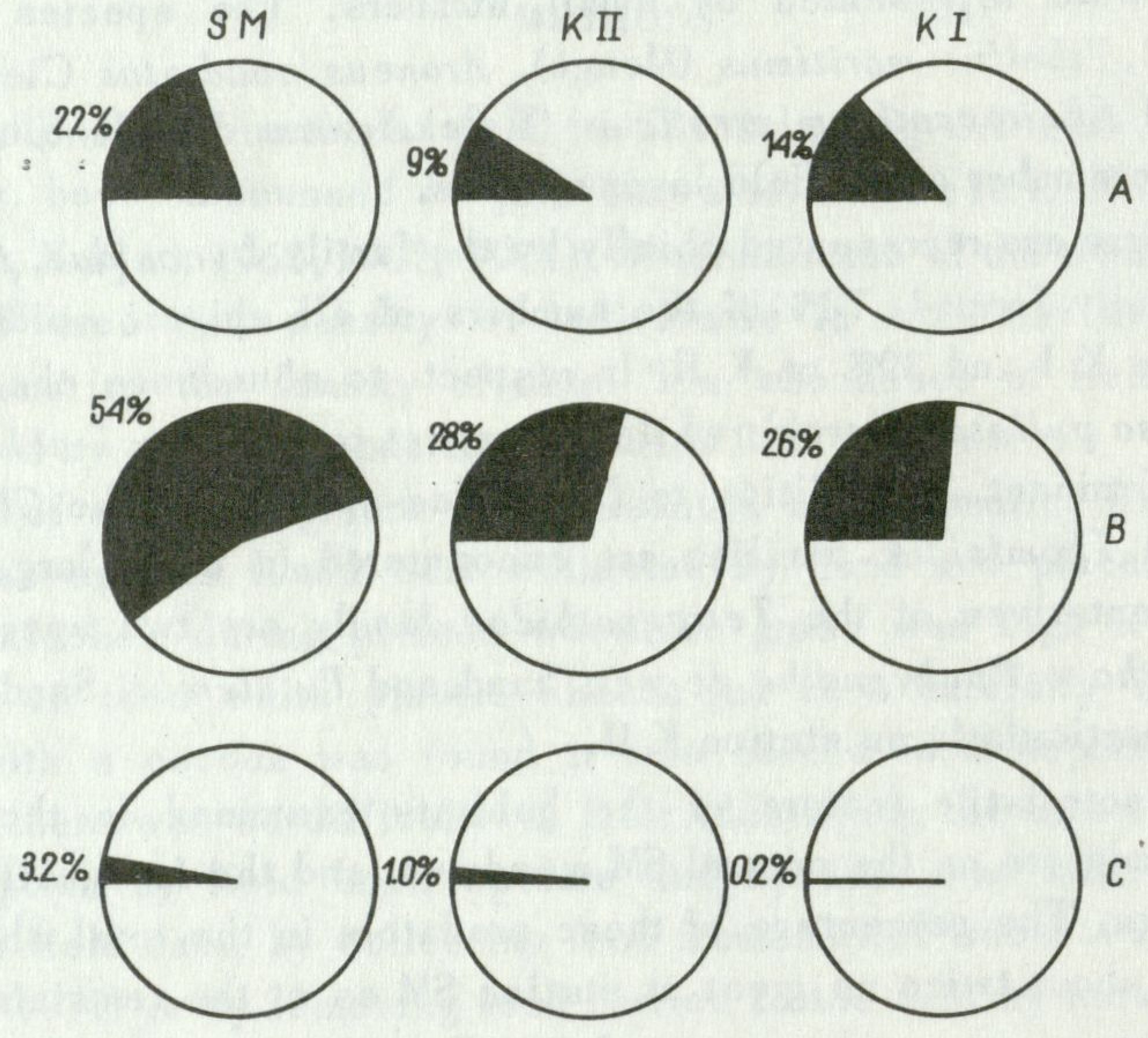

Fig. 1. Comparison of percentage of predators in arthropod numbers in three meadows
A — field layer, *B* — litter layer, *C* — soil

Density, biomass and consumption of ants and spiders

Tab. I

Animal groups	Stands							
	Density — individuals/m²			Biomass mg/m²			Consumption mg/m²/year	
	SM	K I	K II	SM	K I	K II	SM	K II
Ants	142.0	132.9	46.4	71.0	66.5	23.0	13 400	1 160
Epigeic spiders	45.3	14.2	10.0	175.0	55.0	25.0	2 630	840
Field layer spiders	52.0	0.64	4.4	78.3	1.3	5.2	2 482	54
Total	239.3	147.7	60.8	324.3	122.8	53.2	18 512	2 054

The largest number of predatory forms, in comparison with the numbers of macrofauna as a whole, occurred in the litter, and the smallest number in the soil. In the litter on station SM predators formed as much as half the macrofauna, but there was only a small percentage in the soil (Fig. 1).

It appears probable that it is on the litter that the most intensive reduction of meadow entomofauna takes place during the vertical migrations connected with insect development. A large proportion of meadow insects develop in the soil, from which the adult forms emerge or fly away. The epigeic layer probably acts like a sieve, reducing the numbers of the insects migrating to the field layer.

CONSUMPTION

The estimates of consumption by invertebrate predators discussed below must be treated as approximate values. With regard to spiders the source of error may lie in extrapolation on the basis of only a few species examined. Also, perhaps too little attention has been given to the influence of changes in weather which determine the feeding of ants.

The way in which consumption was assessed differed for epigeic spiders and for web spiders and ants. In the case of epigeic spiders the amount of matter they consume was determined, while in the case of web spiders and ants the weight and number of animals they caught from habitat was assessed (Kajak 1971, Pętal, et. al. 1971).

Consumption was assessed for the whole season. It was assumed that ants and epigeic spiders are active for 180 days (April to October), whereas in the case of field layer spiders the period of their activity was assumet to be 90 days. In order to define this period of activity the number of insects found in webs was correlated with several climatic factors – temperature atmospheric humidity and wind velocity. This made it possible to define the range of conditions under which spiders are active and, in consequence, to calculate the number of days during the season in which conditions were favourable for building webs and catching prey.

When consumption of these groups is compared the relatively enormous amount of food caught by ants in relation to the spiders' consumption is remarkable, however the spiders dominate in respect to biomass. The reason for this is a very low ant productivity. The ratio of production to consumption $\left(\frac{P}{C}\right)$ is only 2% for ants (Pętal 1967, 1968), whereas in different species of web spiders this ratio varies from 5 to about 30% (Kajak 1967, 1971). Certain probable causes of these differences can be indicated. Ants, as found in the study habitats, develop over a period of several months and live about three years as imaginal forms (Pętal 1968); the developmental period of spiders is similar to that of ants, but adult spiders live anly a few months at most. It is likely that this ratio of growth period, i.e. tissue production, to the period of imaginal life, contributes to the great difference in productivity between these two groups of animals. The generally smaller body dimensions of ants are also of importance here. The ratio of biomass to consumption $\left(\frac{B}{C}\right)$, which may be the measure of energy retention in the bodies of these animals is only 0.5% in the case of ants. The remainder of the energy obtained from food is dissipated. Spiders are better storers of living organic matter; web spiders assimilate into their bodies about 3% to the matter they consume, and wandering spiders – 7% of consumed energy. In view of these differences ants are more effective as predators but the energy they obtain is to a great extent dissipated.

The combined consumption of all three groups of predators was about 18 g d.w./m^2/season on SM, and about 2 g d.w./m^2/season on K II. In the natural meadow the number, and consequently the consumption, of predators is nearly tenfold greater than in the cultivated meadows.

Comparison of consumption with primary production stresses the differences between the meadows. Primary production in the natural meadow in 1968 was 470 g of dry mass/m^2, the production of meadow K II during an analogical period – 564 g (Traczyk 1971). Thus consumption by predators forms 4% of the primary production in the reserve meadow and 0.3% of production in the natural meadow.

The fact should be taken into consideration that plant production does not reach predators directly, but passes through the links of preceding consumers, which use only a few per cent of the matter consumed for body production. It is, however, very difficult to state how much of the plant production is required for predators, as their food is formed not only by phytophages, but also saprophages, predators and parasites with complicated connections and relationships with primary production.

RELATIONSHIPS BETWEEN PREDATORS

The relations between the groups of animals under discussion are complicated – these are predators simultaneously competing with each other and consuming each other.

The composition of the food of ants and web spiders differs fairly considerably. In ant food young spiders of the family *Lycosidae* and larval of *Homoptera Auchenorrhyncha* are dominant; *Diptera* form 5–12% of ant food in different years (Pętal, Breymeyer 1969, Pętal et al. 1971). In the case of web spiders *Diptera* form the main food group, constituting from 70 to 80% of all the insects caught (Kajak 1965, Kajak, Olechowicz 1970). Even so the number of flies caught by dominant web spiders and by ants is similar being about 10 individuals/m² per day (Fig. 2). The composition of *Diptera* caught by the two groups was also similar (Kajak 1965, Pętal et. al. 1971). The distribution of consumption by the two groups over the season is, however, different. Ants collect the greatest amount of *Diptera* in spring – in May and June. Their activity decreases as early as the beginning of July, and ceases completely at the beginning of September (Fig. 2).

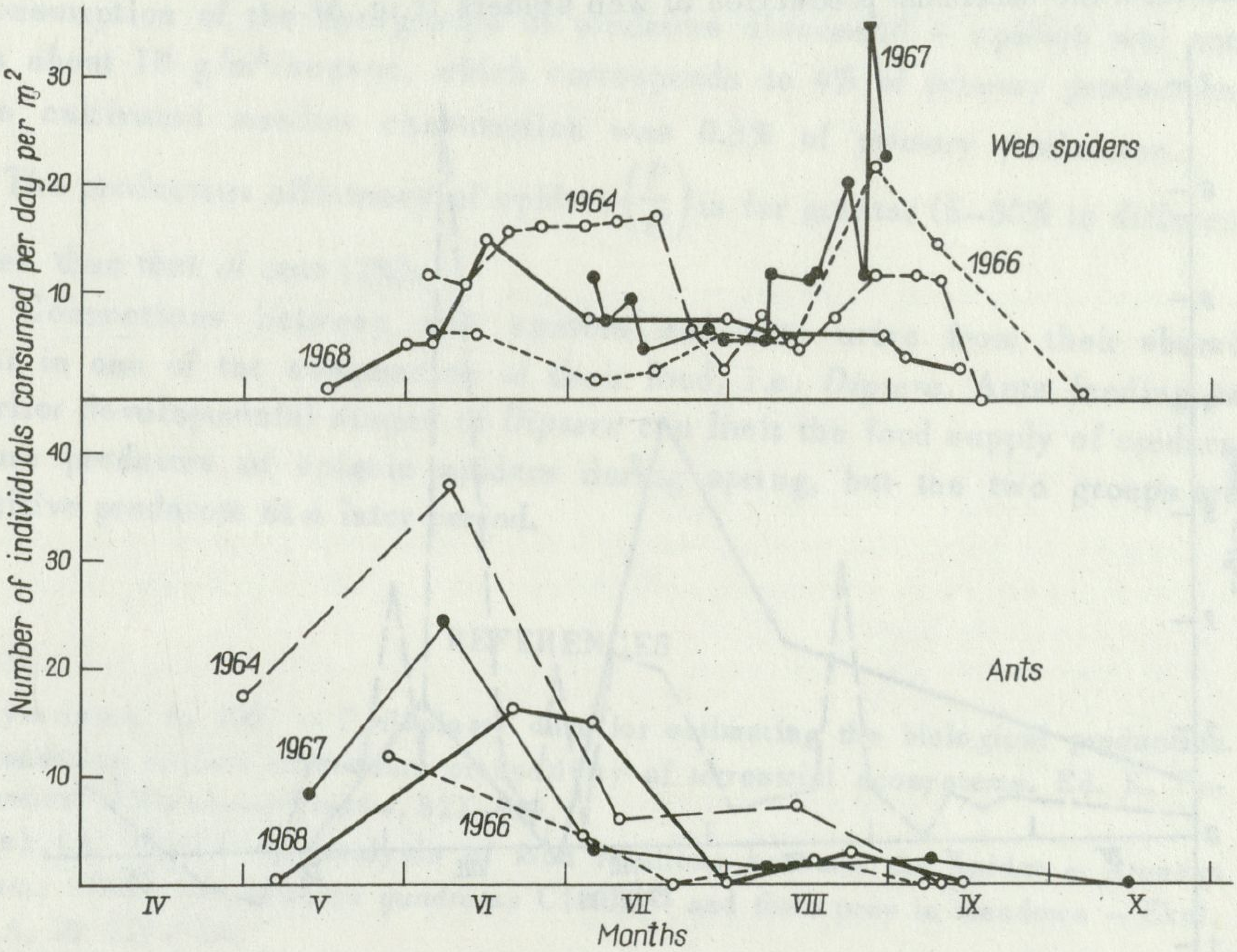

Fig. 2. Diptera in food of web spiders and ants – variations over the season (meadow SM, summer 1964, 1966, 1967, 1968)

In web spiders two periods of intensive hunting for prey occur: the frist in spring and the second, usually more intensive, in late summer, at the end of August and beginning of September. This pattern was repeated over a large number of consecutive years (1964–1968). The intensity of the web spider predation was correlated, as shown in preceding studies, with the intensiveness of emergence of adult *Diptera*; the periods of maximum captures of prey by spiders corresponded with periods of intensive emergence (Kajak, Olechowicz, Pętal in press).

Consumption by ants, in view of the fact that they feed on different groups of animals, does not depend on the amount of *Diptera* production. However, ants would appear to influence the amount of the food of spiders. Ants form an earlier link in the predator chain – they catch *Diptera* just before or immediately after metamorphosis into imagines, when they are still immobile. Ants thus determine inter alia, how many of the pupae reach the field layer as imagines. The very intensive hunts of *Diptera* by spiders during the period when the activity of ants is greatly reduced is probably a result of the existence of this relationship.

Production by ants and field layer spiders takes a similar course to that of consumption. Here also the maximum production by ants occurs in a different period from the maximum production of web spiders (Fig. 3).

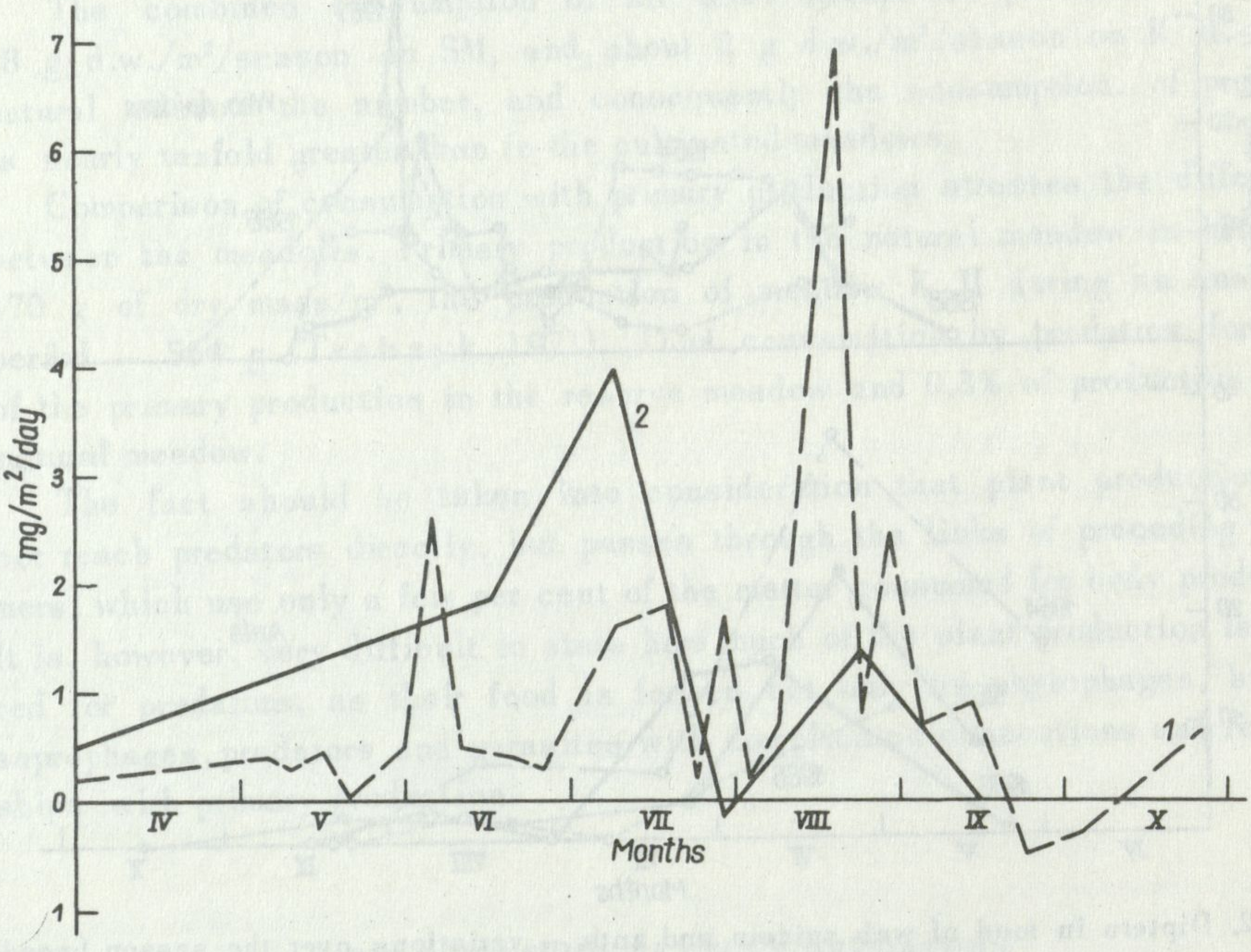

Fig. 3. Daily production of ants and field layer spiders (variations over season, 1968, meadow SM)

1 – spiders, *2* – ants

There are even more complicated relationships between ants and epigeic spiders. During the first of summer – chiefly in June – very large numbers of young epigeic spiders are consumed by ants. The number eaten daily reaches as much as 74 individuals from a square meter per day, resulting in reduction of the population of spiders (Pętal, Breymeyer 1969).

At a later period these two groups become predators competing with each other.

There are thus varied food relationships between the groups of predators discussed, even though they occur in different layers of the vegetation.

CONCLUSIONS

1. Field-crop techniques: cultivation + mowing reduce the abundance of predators in a meadow, in particular the numbers of field layer spiders.

2. In the nature reserve meadow, where no such operations take place, the consumption of the two groups of predators discussed – spiders and ants – was about 18 g/m²/season, which corresponds to 4% of primary production. In the cultivated meadow consumption was 0.3% of primary production.

3. The production efficiency of spiders $\left(\frac{P}{C}\right)$ is far greater (5–30% in different species) than that of ants (2%).

4. Connections between web spiders and ants arise from their shared interest in one of the components of their food, i.e. *Diptera*. Ants feeding on the earlier developmental stages of *Diptera* can limit the food supply of spiders. Ants are predators of epigeic spiders during spring, but the two groups are competitive predators at a later period.

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BADANIA PRODUKTYWNOŚCI DWÓCH TYPÓW ŁĄK W DOLINIE WISŁY

XI. DRAPIEŻNE STAWONOGI

Streszczenie

W pracy stwierdzono, że drapieżce są znacznie liczniejsze na łące nieużytkowanej niż na łąkach użytkowanych. Dotyczy to całej makrofauny drapieżnej występującej w różnych piętrach roślinności (gleba, darń, piętro roślin) (fig. 1). Przy tym najbardziej radykalnie zmniejsza się na łąkach uprawianych liczebność i biomasa pająków piętra górnego, które z powodu sianokosów nie znajdują tam roślinności odpowiedniej do zaczepienia sieci i zawieszenia kokonów.

Z reguły, na wszystkich porównywanych łąkach stosunkowo najwięcej drapieżców przebywa w piętrze darni, dlatego prawdopodobnie tam zachodzi najbardziej intensywna redukcja entomofauny łąkowej.

Dwie, dominujące grupy drapieżców – pająki i mrówki – były analizowane bardziej dokładnie. Stwierdzono, że ilość pokarmu łowionego przez te obie grupy stanowi ok. 4% produkcji pierwotnej na łące rezerwatowej (18 g suchej masy/m²/sezon) i 0.3% (2 g suchej masy/m²/sezon) na jednej z łąk użytkowanych.

Stwierdzono też, że pająki znacznie wydajniej aniżeli mrówki wykorzystują pokarm na budowę własnego ciała. Mrówki wykorzystują zaledwie 2% pokarmu na przyrost wagi ciała, podczas gdy różne gatunki pająków 5–30%. Zwiększa to bardzo zapotrzebowanie pokarmowe mrówek i sprawia, że ich działanie redukujące jest w porównaniu z ich biomasą znacznie silniejsze niż pająków.

Stwierdzono istnienie powiązań między mrówkami i pająkami i to zarówno pająkami epigeicznymi, jak i pająkami piętra roślinności, mimo że piętro to jest w małym stopniu penetrowane przez mrówki. W pierwszej połowie lata młode stadia rozwojowe pająków epigeicznych stanowią jeden z głównych składników pokarmu mrówek, co – jak wydaje się – prowadzi do obniżenia liczebności pająków.

Mrówki i pająki sieciowe odżywiają się muchówkami, choć w pokarmie mrówek muchówki stanowią mniej ważny składnik pokarmu (5–12%) aniżeli u pająków (79–80%).

Odżywianie się pająków jest wyraźnie uzależnione od wylotu muchówek. Mrówki których pokarm jest zróżnicowany, łowią intensywnie wiosną i wczesnym latem, niezależnie od tego, kiedy przypadają nasilone wyloty muchówek. Łowią one młodsze stadia rozwojowe muchówek niż pająki, głównie poczwarki zaraz po przeobrażeniu w imago, ale jeszcze nieruchome.

Wydaje się więc, że mrówki mogą ograniczać ilość pokarmu pająków sieciowych. Jak wykazały kilkuletnie obserwacje (1964–1968) intensywne okresy żerowania mrówek i pająków, a także okresy maksymalnej produkcji najczęściej wymijają się (fig. 2 i 3).

AUTHOR'S ADDRESS:
Dr. Anna Kajak,
Dr. Alicja Breymeyer,
Dr. Joanna Pętal
Instytut Ekologii PAN
Warszawa, ul. Nowy Świat 72
Poland.