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THE ROLE OF SPIDERS IN THE DECREASE OF DAMAGES CAUSED BY *ACRIDOIDEA* ON MEADOWS – EXPERIMENTAL INVESTIGATIONS

The results of experiments concerning the elimination of *Acridoidea* by spiders of the species *Araneus quadratus* Clerck are described. It was established that their elimination due to spiders depends on the initial density of the prey population – the percentage of the insects caught in the webs rises with the increase of the density of the insects in the environment. The elimination also increases if the spiders are already stabilized in the environment at the moment of introduction of the prey and when they deal with a population new to the given environment, not adapted to the new conditions. The losses in the yield of vascular plants caused by grasshoppers were two times smaller in the experiments in which spiders were present as compared with those occuring in an environment with the same initial number of insects in the absence of spiders.

There is increasing evidence that polyphagic predators to which spiders belong play an essential role in the regulation of the number of insects, preventing their mass occurrence (Voûte 1946, Mac Arthur 1955, Kaczmarek 1961, 1963).

The present paper reports the results of experiments undertaken with the aim of establishing the role of spiders in the elimination of grasshoppers, and indirectly their influence on plant yield.

The experiments were carried out in enclosures 1m high, and covering 0.64 m² area set upon the meadow. The environmental conditions in the enclosures have been resembled those of the meadow, since they were covered with thin tulle which practically did not change the atmospheric conditions and the specific composition of the prey used in the experiments was the same as on the meadow. The predator used in the experiments was *A. quadratus* Clerck one of the dominating species of web spiders as regards production in this environment.

Number of experiments carried out (sets with grasshoppers and spiders)

Tab. I

Years	Initial density of:		Number of replications
	grasshoppers	spiders	
1964	200	10	2
	200	30	4
	200	50	4
1965	150	15	5
	150	25	5
1966	50	25	3
	100	25	3
	150	25	3

The main factor changed in the experiments in relation to the environment was the size of the animal populations.

In the particular sets of experiments the initial number of the victims was 50, 100, 150, and 200 (Tab. I). This density was more than a dozen times higher than on the meadow, however, such high densities do occur in nature on artificial meadows.

The initial number of the predators in various experimental sets was 10, 15, 30 and 50 individuals (Tab. I). The density was at most four times higher than the mean density of the given spider species on the meadow, but it was always lower than the total density of all spider species occurring in the field layer.

Simultaneously with the experiments proper two kinds of control experiments were set up in identical enclosures, one with the same initial density of the grasshoppers but without spiders, which served to calculate the elimination not due to the predators, and a second in which no animals were used and which aimed at the evaluation of the plant production undamaged by insects.

The experiments were started in July and continued up to the moment when the grasshopper population was reduced almost to zero (from 20 to 50 days). At several days (2–5) intervals the grasshoppers and spiders in the enclosures were counted and the extent of the elimination was calculated.

The elimination was expressed as the per cent of individuals disappearing from the population per one day of the experiment.

$$E = \frac{N_{t_1} - N_{t_2}}{N_{t_1} \times t} \times 100 \qquad (1)$$

where: E – elimination, N_{t_1} – number of animals at the beginning of the period considered, N_{t_2} – number of animals at the end of the period considered, t – time in days.

Elimination due to spiders (E_A) was calculated as the difference in the number of individuals eliminated in the analogous experimental cages including only grasshoppers (E_G) and both grasshoppers and spiders (E_S).

$$E_A = E_G - E_S \qquad (2)$$

Twice in the course of each experiment vegetation samples were taken from under the enclosures and the dry weight of the grass and the damage caused by the insects were determined. The method of sampling of the vegetation is described in the paper by Andrzejewska and Wójcik (in press).

RESULTS

Extent of elimination due to spiders

In all the experiments most intensive elimination occurred in the first two days after introduction of the animals into the enclosures. In the enclosures including only grasshoppers the population decreased within this period by 52–65 per cent. The presence of spiders raised the elimination by a further 5–35 per cent (Figs. 1, 2). After this high initial decrement, elimination decreased drastically, and in some experiments in which spiders were not present even reached zero. The over-all decrement (E_G) did not exceed several per cent. In the cages comprising spiders, elimination increased again after several days. The oscillations of elimination due to spiders (E_A) were periodical, the intensification recurring every 8–12 days (Fig. 2). In the periods of intensified elimination the dayly mortality of the grasshoppers due to the spiders reached several per cent (Fig. 2). As a result of this effect of the presence of spiders the number of grasshoppers was, in the experiments including spiders, about one half that in the experiments deprived of them (Fig. 1).

In spite of this the density of the grasshoppers decreased to the level prevailing on the meadow after some twenty odd days in the cages with spiders, and after 30–60 days in the cages including only grasshoppers.

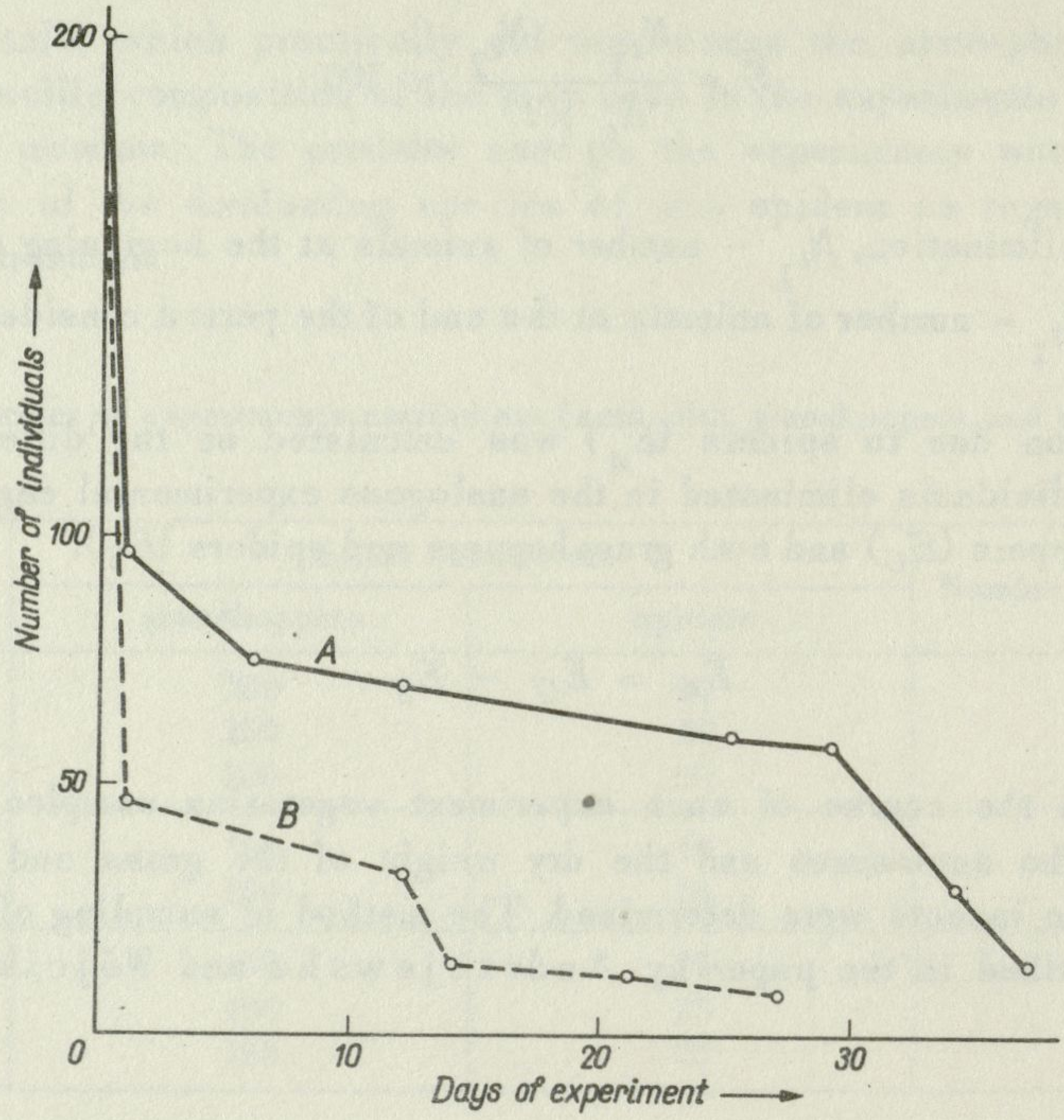

Fig. 1. Changes in number of grasshoppers in experiments
A – in the absence of spiders, *B* – in the presence of spiders (means from data of 1964)

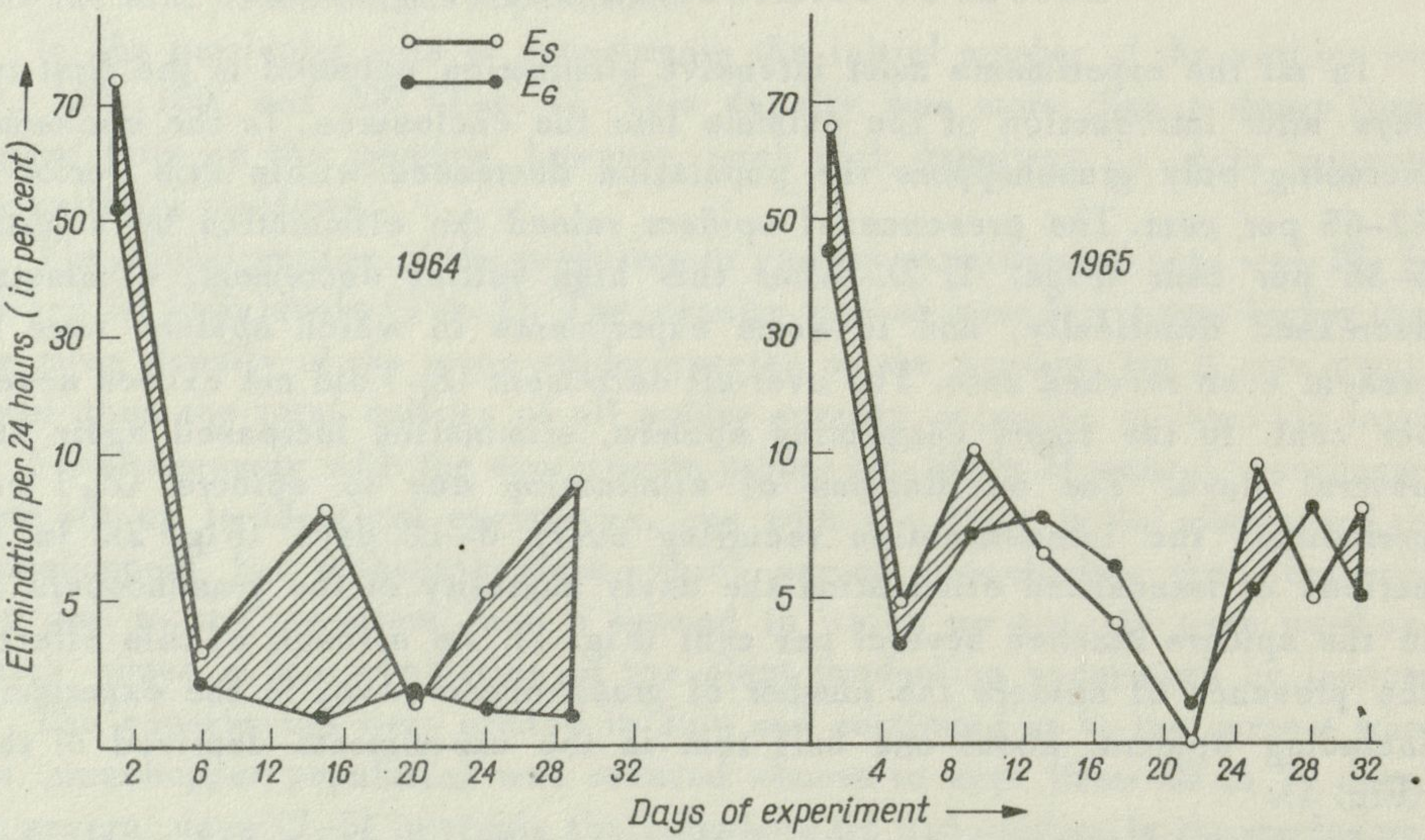

Fig. 2. Course of elimination of grasshoppers in the experiments of 1964 and 1965
Shaded areas – elimination due to spiders (E_A). E_S– elimination in enclosures with grasshoppers and spiders, E_G – elimination in enclosures with grasshoppers only

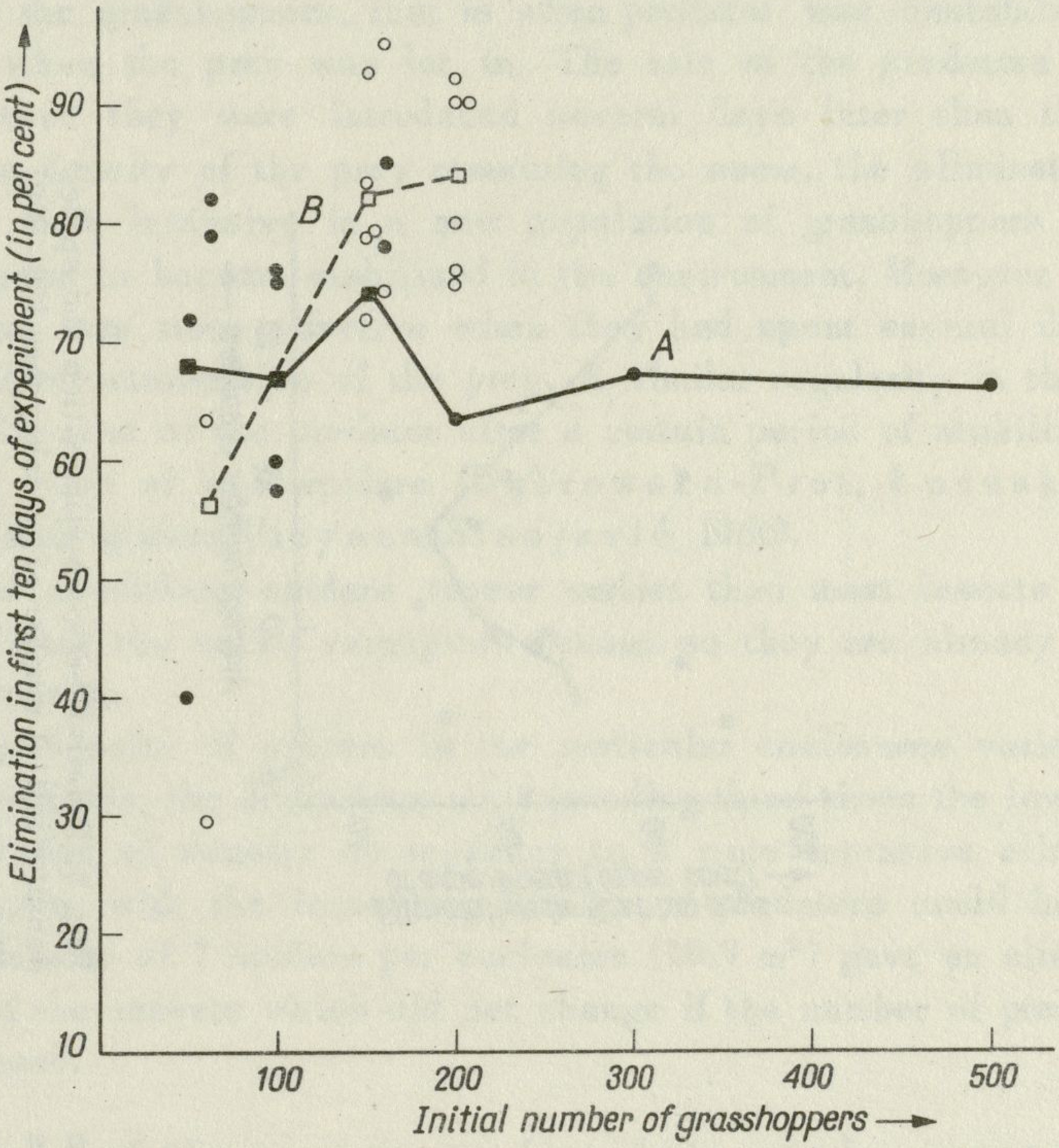

Fig. 3. Relation between elimination and initial number of preys
A – sets with grasshoppers, *B* – sets with grasshoppers and spiders. Black spots – data from particular enclosures with grasshoppers, light spots – data from particular enclosures with grasshoppers and spiders

The value of elimination caused by spiders (E_A) was dependent on the density of the prey and on the time at which the predators were introduced.

The percentage of eliminated individuals rose with the increasing numbers of the prey. The elimination in the first ten days of the experiment was not higher in the enclosures including spiders than in those without them in the case of lowest density (initial value 50 individuals); with increasing numbers of the insects the influence of the spiders also became more important reaching 9 per cent at the initial density of 150 individuals and 20 per cent when the initial density was 200. The extent of elimination in the sets without spiders changed slightly, the fluctuations did not exceed 8 per cent and were not dependent on the density (Fig. 3).

An important factor which influenced the E_A value was the system applied in introducing animals to experimental cages. The spiders were most effective when they were introduced into the enclosures several days earlier than the

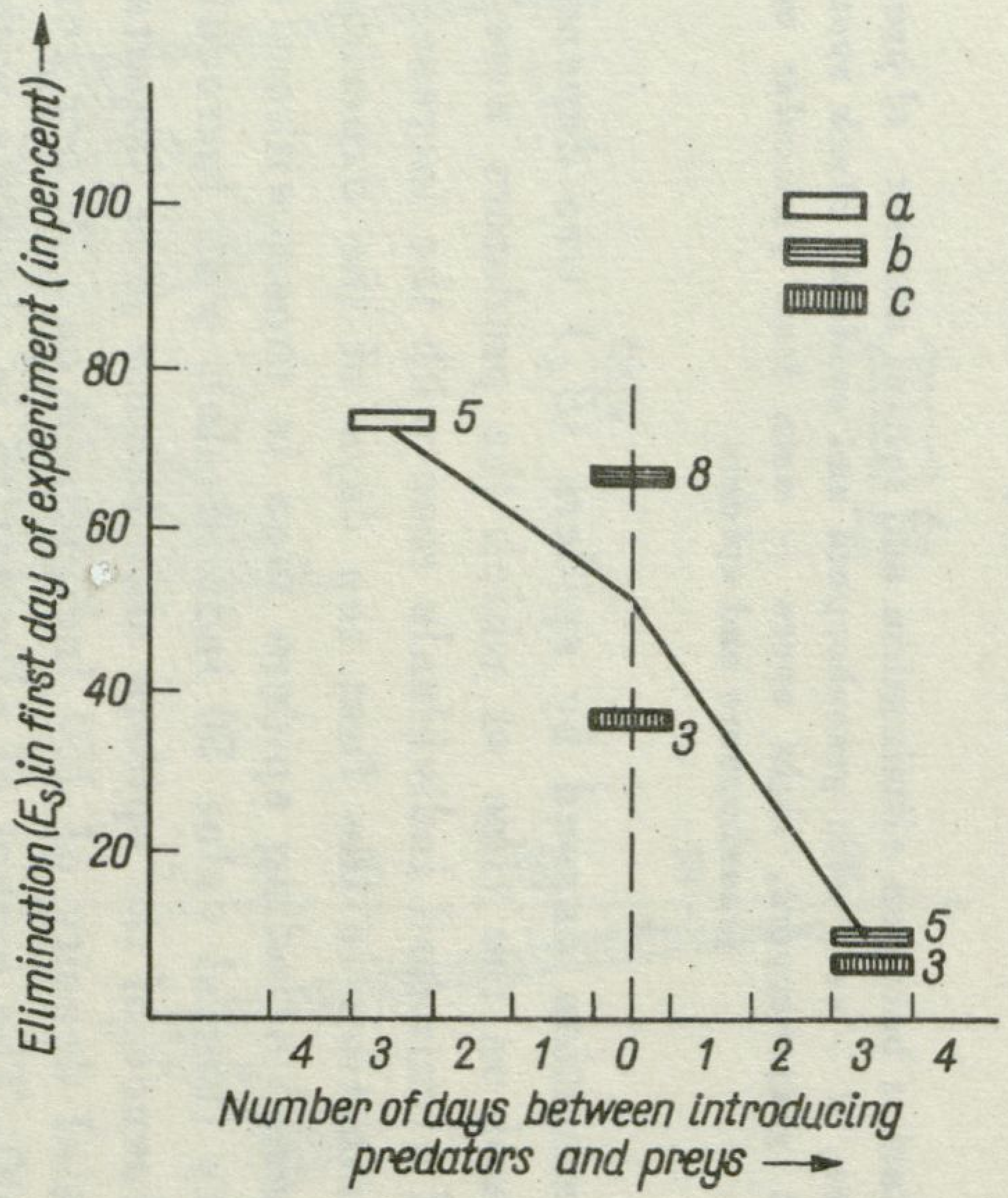

Fig. 4. Relation between extent of elimination and time of introduction of predators and preys

Figures denote the number of replications of the experiment *a* – initial number 200, *b* – 150, *c* – 50

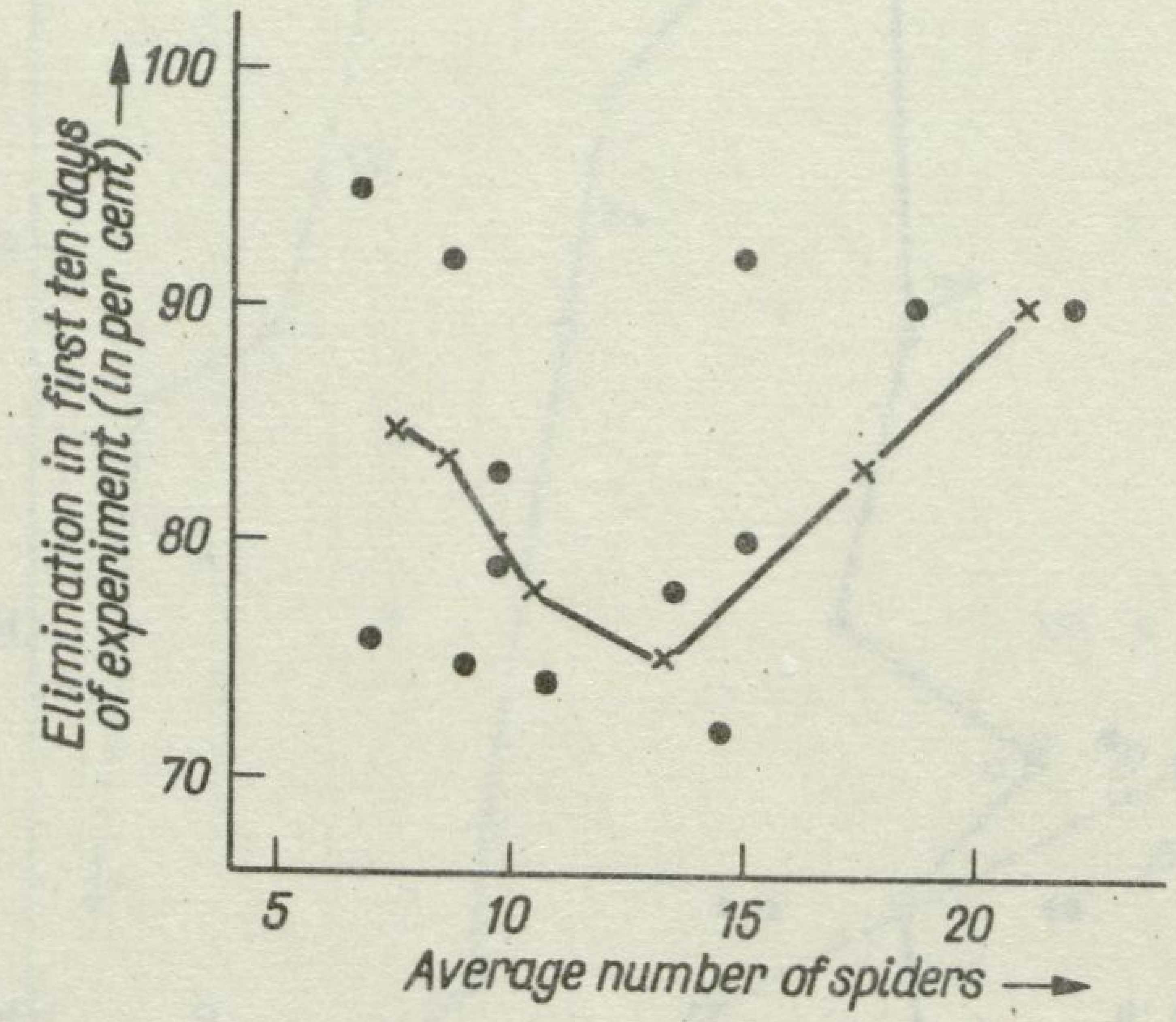

Fig. 5. Relation between elimination and spider density (initial number of grasshoppers 150–200)

Elimination of grasshoppers within 10 days. Spots – elimination in the particular enclosures prey. Their influence was much weaker when the spiders were let in simultaneously with the grasshoppers, that is when predator was unstabilized in the environment when the prey was let in. The role of the predators was least significant when they were introduced several days later than the victims (Fig. 4). The density of the prey remaining the same, the elimination due to spiders was more intensive in a new population of grasshoppers which had not yet had time to become stabilized in the environment. Moreover the action of the spiders was more effective when they had spent several days in the enclosure before introduction of the prey. A similar regularity in the increase of the effectiveness of the predator after a certain period of stabilization was noted in the case of web spiders (Dąbrowska-Prot, Łuczak, Tarwid 1968) and of crab spiders (Haynes, Sisojević 1966).

In natural conditions spiders appear earlier than most insects and occur throughout almost the entire vegetation season so they are already stabilized when insect emerge.

The mean density of spiders in the particular enclosures varied between 7 and 22 individuals, the deviations not exceeding three times the lowest value. Within this range of density no tendency to a more intensive elimination of the grasshoppers with the increasing number of predators could be observed (Fig. 5). A density of 7 spiders per enclosure (10.9 m^2) gave an elimination in the number of the insects which did not change if the number of predators was further increased.

Influence of the presence of spiders on the vegetation

A good measure of the effectiveness of the spider predation is the evaluation of the effect of their presence on the condition of plants. In the present experiments the spiders exerted a well noticeable influence on the plant yield. The dry weight of the grass in the enclosures with spiders was higher than in those in which the predators were absent (Fig. 6). However, a simple relation could not be established between the density of the grasshoppers and the condition of the plants (Fig. 6).

The damage to plants caused by the grasshoppers in the experiments with spiders was estimated in two ways: 1 – by comparing the dry weight of the grass in the experimental and in the control enclosures deprived of animal population, and the dry weight of grass on the open meadow and 2 – by extrapolation of the results obtained in the experiments including only grasshoppers to lower densities occurring in experiments in which the grasshopper population size was decreased by the spiders.

At high grasshopper densities, i.e. in the experiments in which spiders were absent, an increased damage to plants was observed with the rise of the grasshopper density (Andrzejewska et al. 1967, Andrzejewska, Wójcik, in press). Since the vegetation in the meadow under investigations is

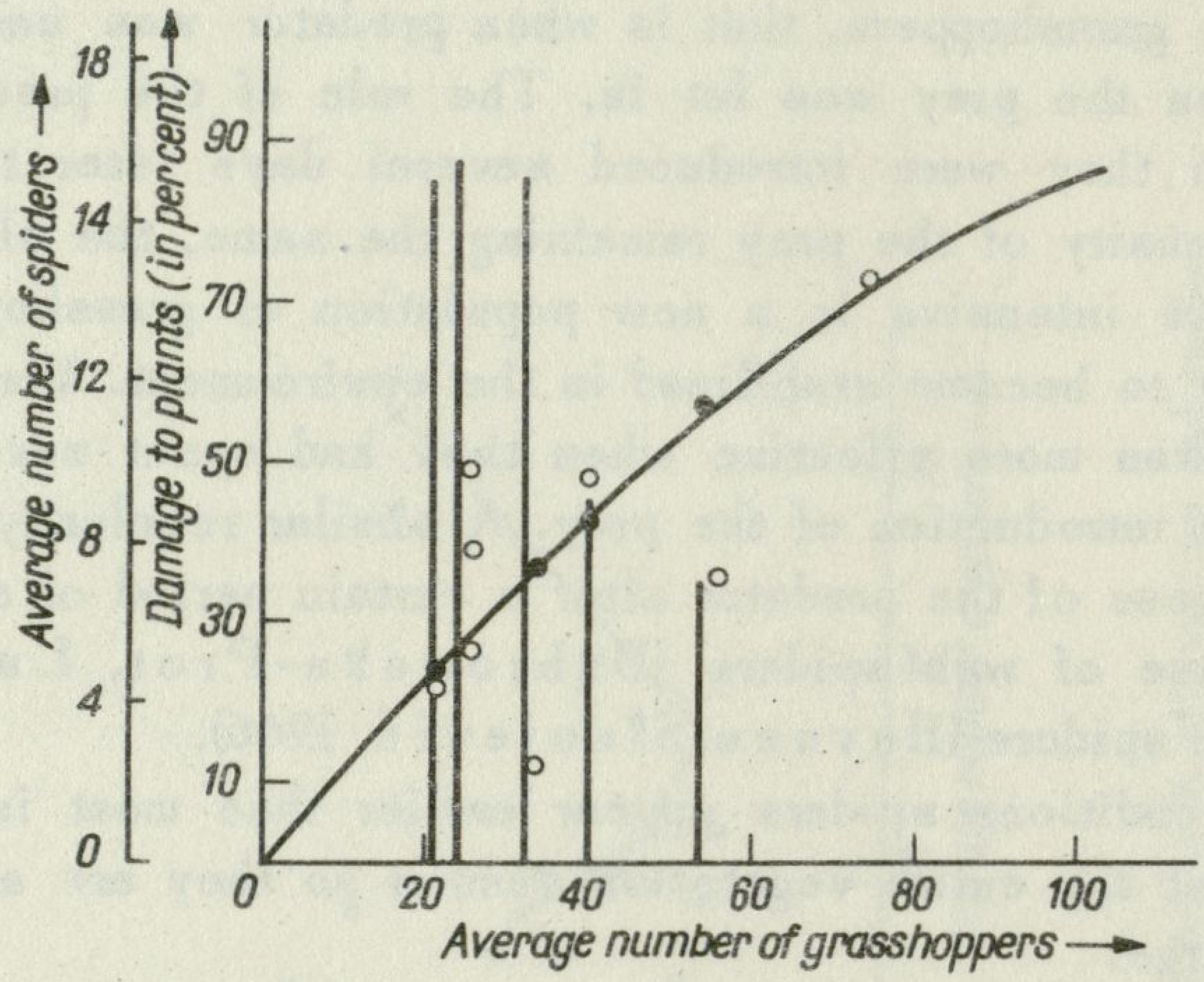

Fig. 6. Relation between damage to plants and density of grasshopper and spider populations

Number of spiders denoted by vertical lines, dark spots – damage estimated on the basis of extrapolation, light spots – on the basis of botanical samples

greatly differentiated (Traczyk 1966, 1968) the plant yield from the particular enclosures differed widely already at the outset of the experiments, that is probably the reason why in the experiments with a less dense population, no relation between the damage and the density of the phytophages could be establishes. Therefore the losses to be expected at lower densities of the population of these insects in experiments including spiders were calculated on the basis of the results obtained in the sets including only grasshoppers (Fig. 6). The mean value of the damages estimated by both methods proved to be of a similar order. The damages assayed on the bassis of extrapolation amounted on the average to 51 per cent of the total damage occurring in the absence of spiders, and when calculated by the method of botanical samples – to 56 per cent on the average. Thus, on the average the presence of spiders reduced about two times the losses in plant yield caused by the grasshoppers.

The question remains open, in how far these results may be applied to natural conditions, outside the enclosures. It would seem on the bassis of the results obtained that spiders may exert a significant influence on the plant yield when the phytophagous population is numerous and if at the moment when the latter appears in the environment it is available to spider webs.

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ROLA PAJĄKÓW W ZMNIEJSZANIU SZKÓD POWODOWANYCH PRZEZ SZARAŃCZAKI (*ACRIDOIDEA*) NA ŁĄCE – BADANIA EKSPERYMENTALNE

Streszczenie

Praca omawia wyniki eksperymentów nastawionych na mierzenie wielkości redukcji powodowanej przez pająki w populacji szarańczaków. Eksperymenty polegały na zwiększaniu w stosunku do otoczenia liczebności szarańczaków (tab. I) i mierzeniu tempa ich ubywania przy obecności i przy braku pająków. Liczebność w momencie początkowym eksperymentu zwiększano w poszczególnych seriach od kilkunastu (seria 50) do 60 razy (seria 200) w stosunku do gęstości szarańczaków w otoczeniu. Gęstości tego rzędu są spotykane na łąkach sztucznych.

Eksperymenty prowadzono bezpośrednio na łące, w izolatorach o powierzchni 0.64 m^2.

Stwierdzono, że liczebność szarańczaków jest z reguły mniejsza w seriach zawierających pająki (fig. 1).

Wielkość redukcji wywołanej przez pająki (patrz wzór 1 i 2) zależała od gęstości ofiar – im ofiar było więcej tym większy procent był przez pająki redukowany (fig. 3). Maksymalna redukcja powodowana przez pająki wynosiła 20% liczebności owadów.

Redukcja zależała w znacznym stopniu od czasu jaki upłynął od chwili wprowadzenia drapieżców i ofiar do eksperymentu. Największą redukcję stwierdzono w seriach eksperymentów, w których pająki były wprowadzone o kilka dni wcześniej niż ofiary, i w których pająki działały na populację nową w danym środowisku. Redukcja jest

z reguły największa w ciągu dwu pierwszych dni eksperymentu (fig. 1, 2, 4). Efektywność działania pająków wzrastała, gdy działały na nieustabilizowaną populację ofiary i gdy jednocześnie same były już zorganizowane.

Szarańczaki powodowały znaczne straty plonu roślin naczyniowych, w seriach eksperymentów bez pająków. Przy wyjściowej gęstości szarańczaków 200 sucha masa roślin zmniejszyła się o 73% w stosunku do kontroli. Natomiast w obecności pająków, przy tej samej wyjściowej gęstości owadów, straty zmniejszyły się przeciętnie o połowę, stanowiły około 35% w porównaniu z sytuacją bez szarańczaków (fig. 6).

Wydaje się, że również w warunkach naturalnych, obecność pająków może obniżyć straty plonu powodowane przez owady. Prawdopodobnie populacje nowo pojawiające się w środowisku są bardziej dostępne dla sieciowych pająków, niż przebywające w nim dłuższy czas. Potwierdzają to wyżej omówione wyniki dużej redukcji populacji wprowadzonej do nowego środowiska.

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