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INFLUENCE OF SPIDERS ON THE BEHAVIOUR
OF MOSQUITO POPULATIONS

(Ekol. Pol. 18: 531-537). Studies were made of the influence of the wandering spider *Dolomedes fimbriatus* Clerck and the web spider *Tetragnatha montana* Simon on the behaviour of their preys - mosquitoes. It was found that these predators caused changes in the intensivity with which the mosquitoes penetrated the habitat and in their vertical distribution in the vegetation and above it. A relation was found between the behaviour of the mosquitoes and the rate of their reduction by spiders.

The studies were carried out from June to October 1967 in the Kampinos Forest near Warsaw. Experiments were made in isolators set up in a humid alder wood, the natural habitat of the predators - the spiders *Dolomedes fimbriatus* Clerck and *Tetragnatha montana* Simon and their prey - mosquitoes. 24 individuals of either *Tetragnatha montana* or *Dolomedes fimbriatus* were introduced into each isolator. Every three days a certain number of mosquitoes - 10, 30, 50 or 90 individuals - were released into the isolators, which ensured that the spiders' prey was constantly present in the habitat. Investigations were made of the natural reduction of mosquitoes in control isolators (without spiders) from which all other predators appearing there were carefully removed (e.g. those hatching out during the period of investigations).

Observations were made of the reduction in the number of mosquitoes, their distribution in the isolator and their movement activity twice daily (morning and evening). The fairly large size of the isolators ($1.5 \times 1.5 \times 1.0$ m), and the presence in them of luxuriant herb layer vegetation and single shrubs, enabled the predator and prey populations to move about and to be distinguishable into the part hidden in the vegetation and the part present on plants and the sides of the isolators and thus visible to the observer.

Examination made earlier on revealed the fact that predators cause a fundamental change in the behaviour of mosquitoes (Dąbrowska-Prot 1966, Dąbrowska-Prot, Łuczak, Tarwid 1968). In the studies given numbers of preys were introduced into the isolators, after which the observer waited until these insects had been completely liquidated by the predators before introducing more of them into the habitat. In the experiments described in the present study the addition of victims to the isolators every three days created a situation in which mosquitoes were continuously present in the habitat and there was thus constant reciprocal stimulation of activity between predators and preys. This kind of situation is closer to the conditions observed in a natural habitat.

The reaction of mosquitoes to the presence of spiders was examined by analyzing variations in their activity and vertical distribution in the habitat. This analysis was based on an index of relative activity (percentage of mosquitoes in flight at the time of observation in relation to all the mosquitoes observed at a given moment) and an index of flights above the herb layer (percentage of mosquitoes observed above the vegetation in relation to all the mosquitoes observed in the isolator).

The investigations made in this new variant of the experiments confirmed the earlier results on stimulation on the preys activity by predators (Dąbrowska-Prot 1966). It is significant that the result was also confirmed by both the morning observations made during the daytime reduction in the mosquito activity, and also the evening observations when, as is well known, mosquitoes naturally increase their activity in connection with the change in the microclimatic conditions of the habitat (Fig. 1, 2). The presence of the two species of spiders, both the web spider *T. montana* and the wandering spider *D. fimbriatus*, increased the mosquito activity. In the case of the latter species this applied only to lesser densities of mosquitoes (10–30 individuals introduced in the isolators every three days). It is possible that with greater densities of mosquitoes some phenomena took place inside the mosquito population which effectively counteracted the increase in their activity caused by the predators. The possibility of this being the correct interpretation is indicated by the fact that increase in the density of mosquito populations caused a reduction in their

activity, both when predators were present and also in the control, when they are absent (Fig. 1, 2).

Differences in the level of activity exhibited by mosquitoes in the experiment with spiders and in the control were maintained during the successive days of the experiment, despite the distinct effect exerted on their activity by the density itself of the mosquitoes, resulting in minimum activity of these insects being observed in both the control and experiment when 90 individuals were present, and maximum activity when 10 individuals were introduced every 3 days (Fig. 3).

The distribution of mosquitoes in the isolator also changed under the predators' influence. The presence of *T. montana* had a markedly weakening effect on the flights of mosquitoes towards the top of the isolator. When spiders of this species were present in the habitat the mosquitoes tended to keep to the herb layer (Fig. 4). The presence of spiders of the species *D. fimbriatus*, on the other hand, had a stimulating effect on flights of mosquitoes above the vegetation (Fig. 5).

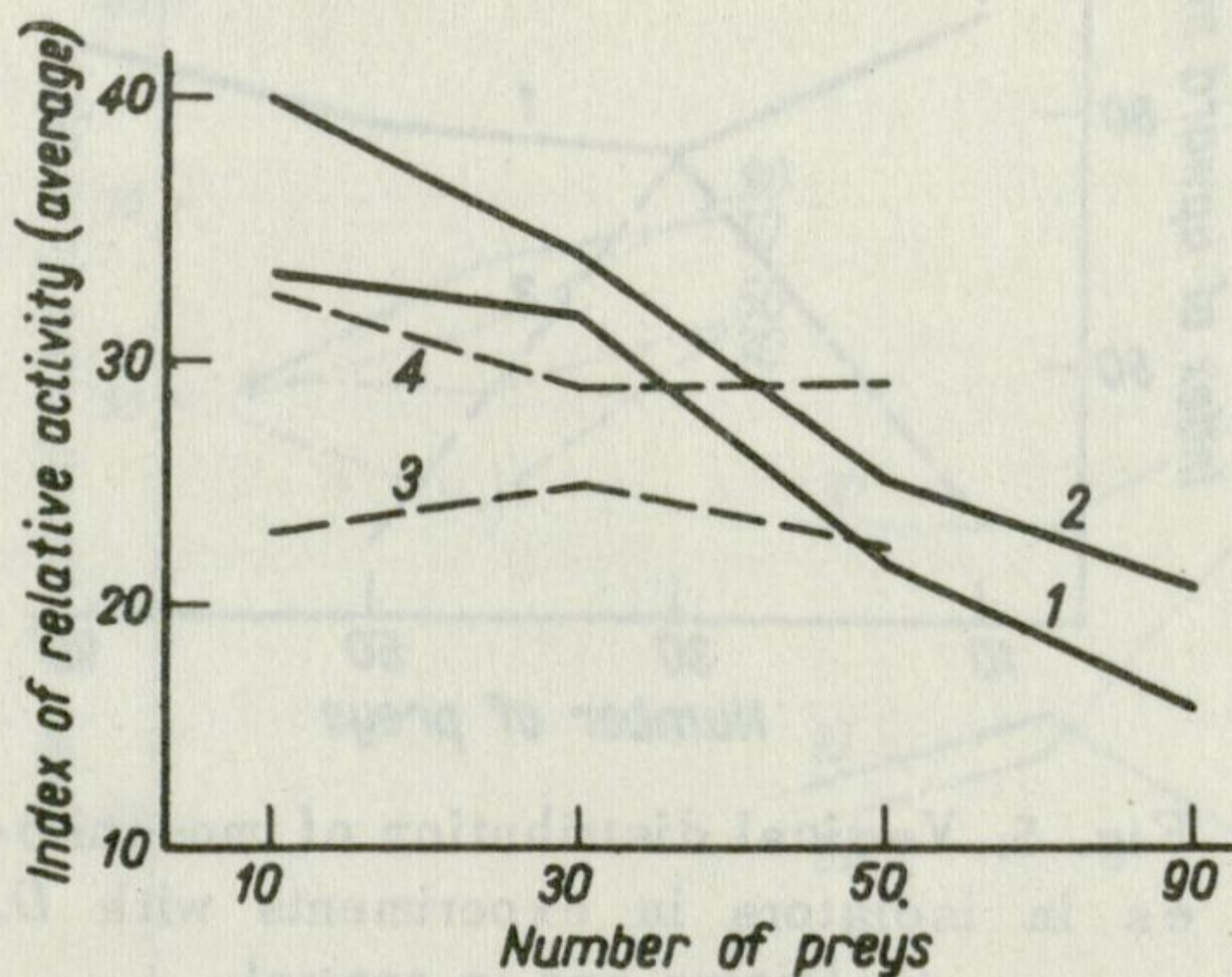
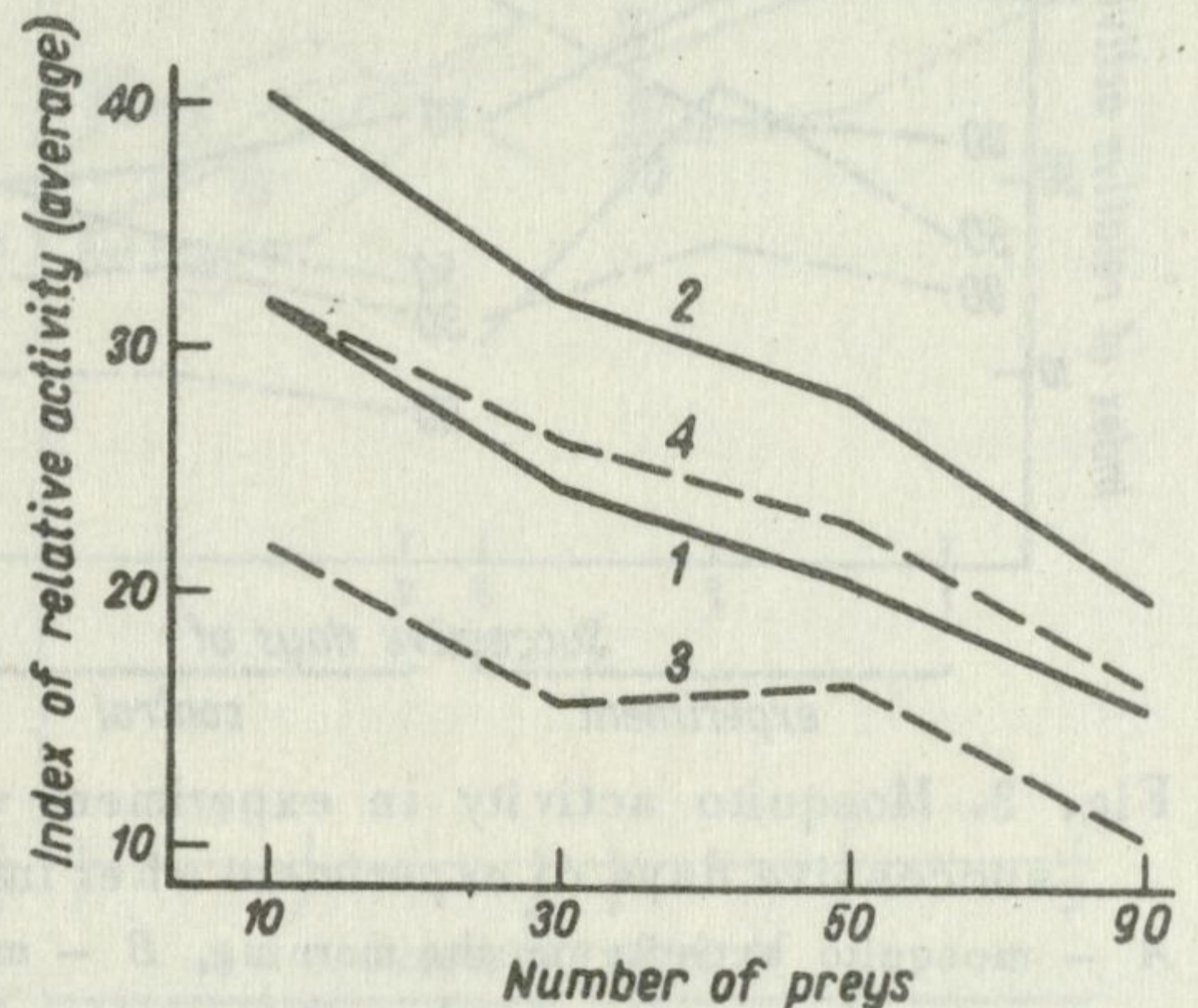


Fig. 2. Mosquito activity in experiments with *D. fimbriatus* and in control
Explanations as in Fig. 1



Rys. 1. Mosquito activity in experiments with *T. montana* and in control

Experiment - 1 - morning, 2 - evening; control - 3 - morning, 4 - evening

The presence of spiders of the species *D. fimbriatus*, on the other hand, had a stimulating effect on flights of mosquitoes above the vegetation (Fig. 5).

This effect, characteristic of the two species of predators, on the spatial distribution of the victims was manifested even in the evenings, when the mosquitoes, in accordance with their biting activity, exhibited a natural tendency to fly upwards from the vegetation to the higher zone of the isolator (Fig. 6, 7).

The behaviour of mosquitoes thus changed under the influence of the predators' presence. The latter also affected intensivity of the mosquitoes' penetration of the habitat and their

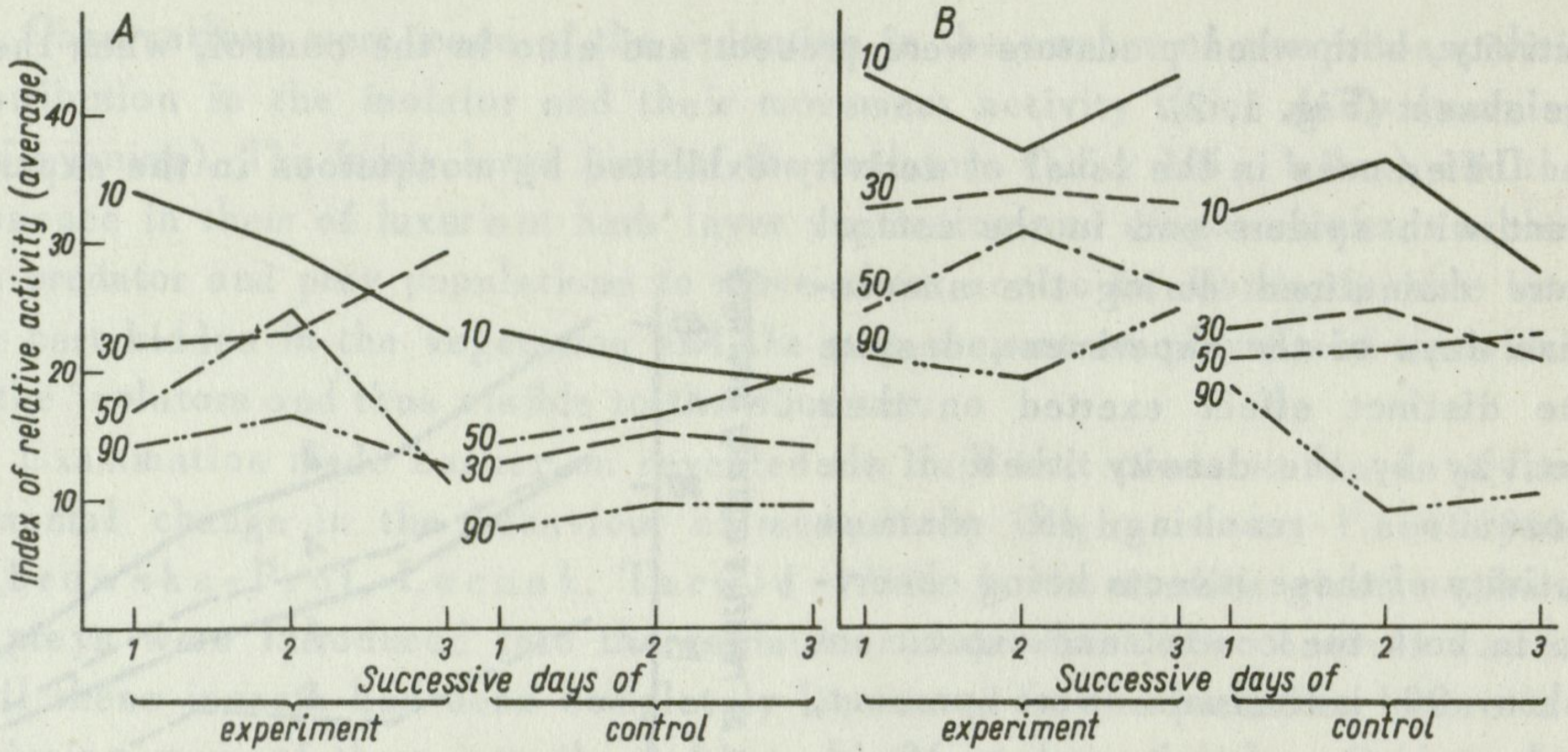


Fig. 3. Mosquito activity in experiment with *T. montana* and in control during three successive days of experiment after introduction of mosquitoes into the isolator
 A - mosquito activity in the morning, B - mosquito activity in the evening, 10, 30, 50, 90 - number of mosquitoes introduced into the isolator

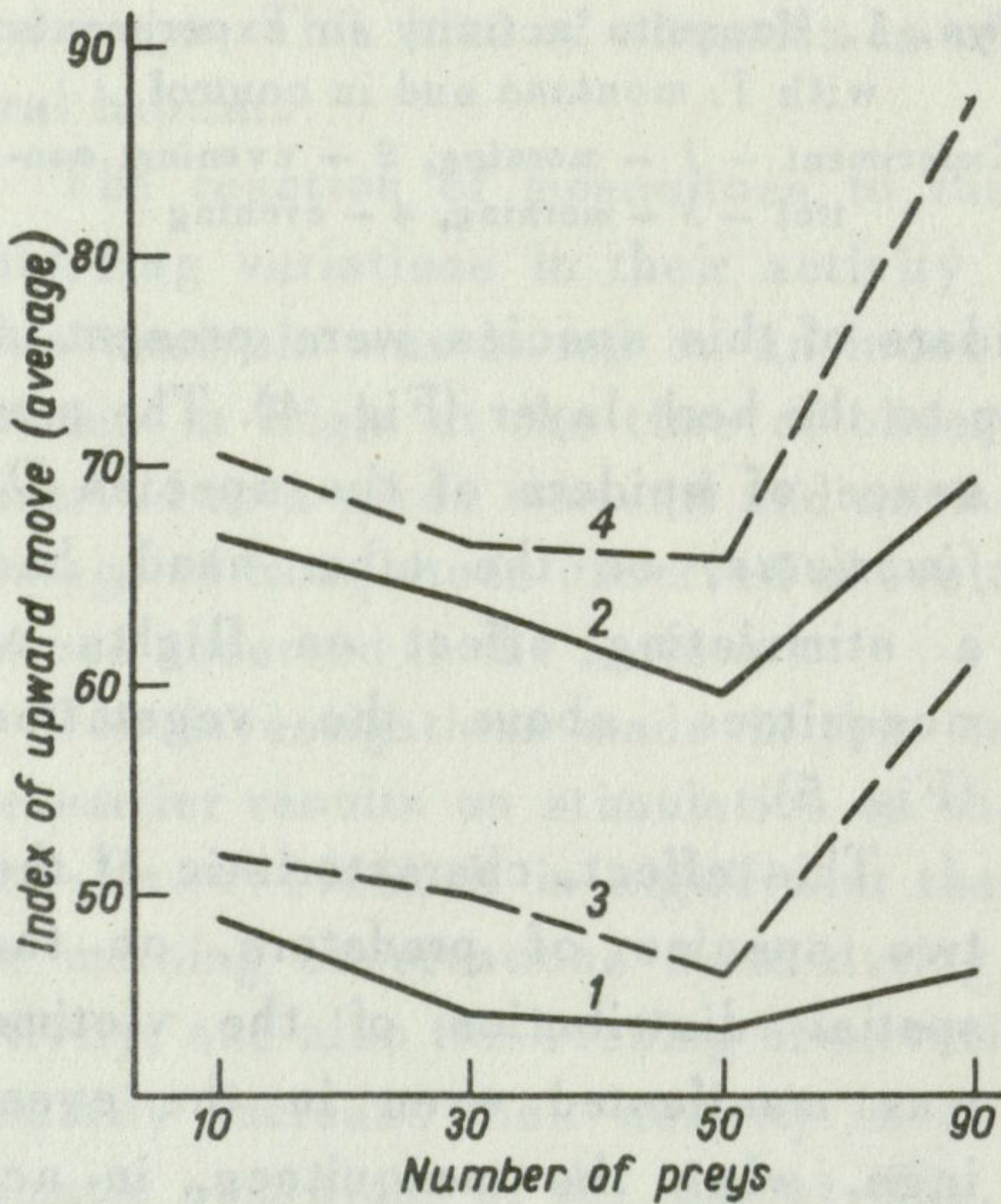


Fig. 4. Vertical distribution of mosquitoes in isolator in experiments with *T. montana* and in control
 Explanations as in Fig. 1

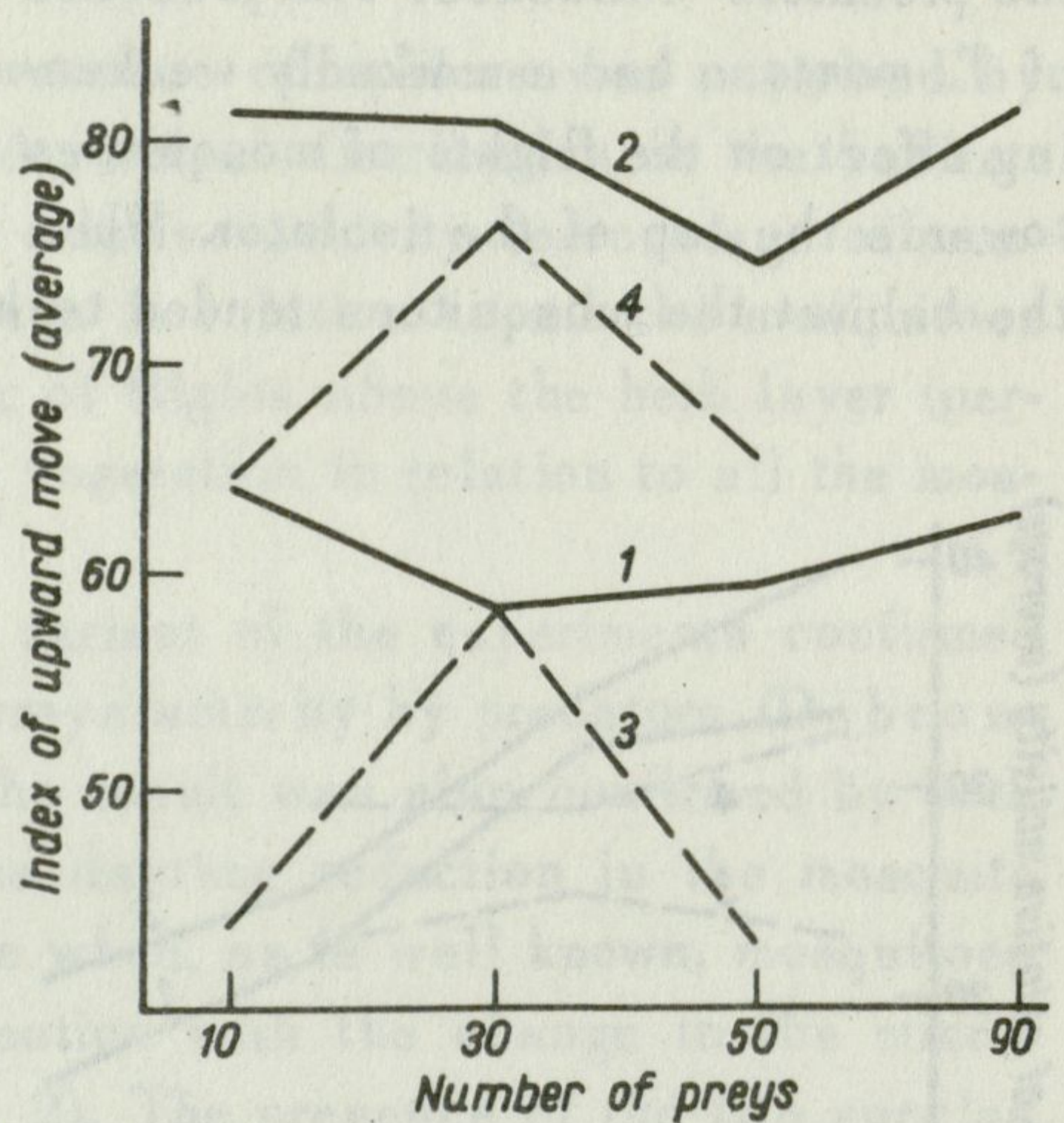


Fig. 5. Vertical distribution of mosquitoes in isolators in experiments with *D. fimbriatus* and in control
 Explanations as in Fig. 1

vertical distribution in the isolator. Both these phenomena affect intensity of contacts between prey and predator and hence must affect the rate at which the predators reduce the population of their preys. The relation occurring be-

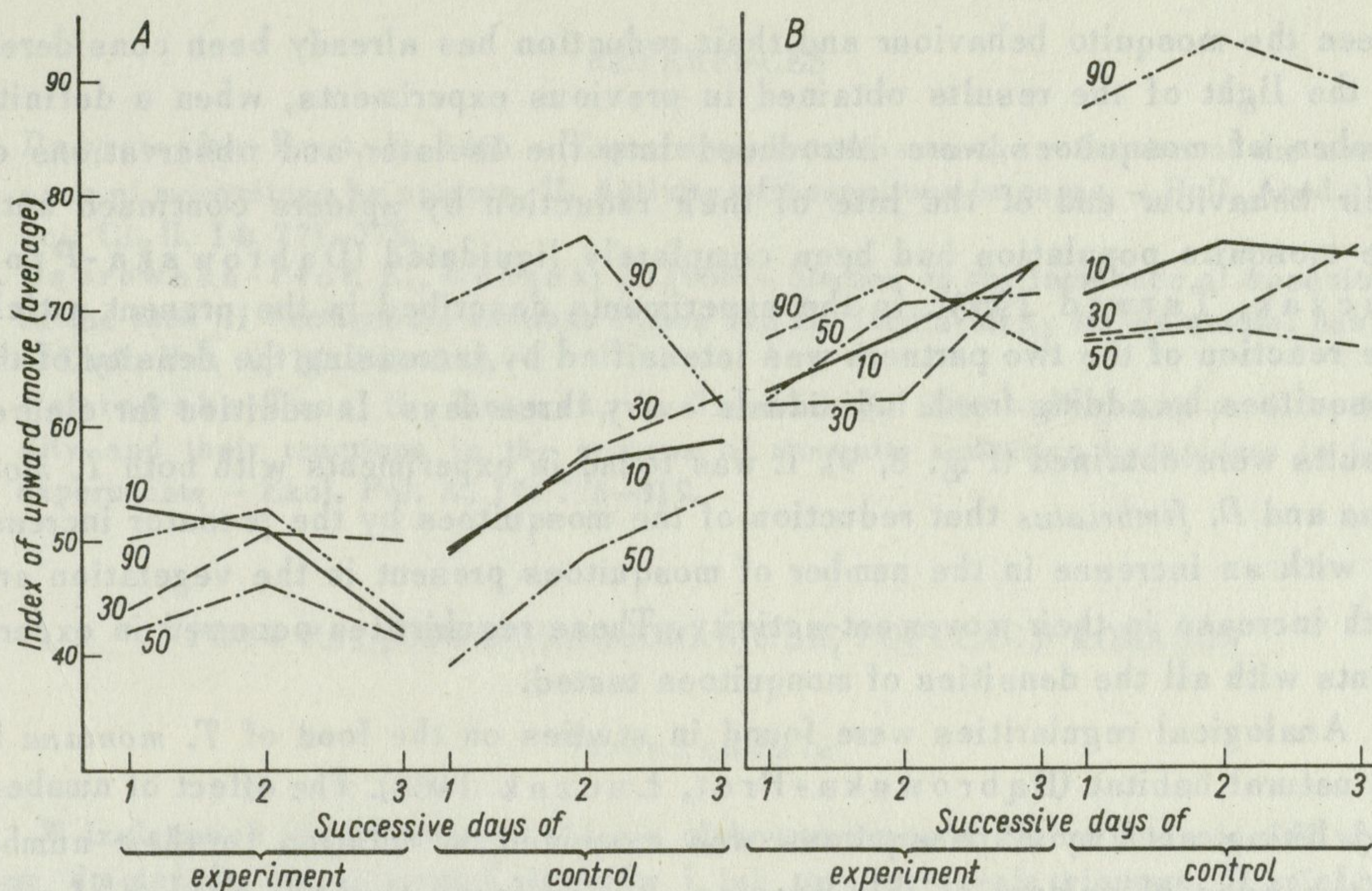


Fig. 6. Vertical distribution of mosquitoes in isolator in experiments with *T. montana* and in control during three successive days of experiment after the introduction of mosquitoes into the isolator

A - vertical distribution of mosquitoes in the morning, B - vertical distribution of mosquitoes in the evening, 10, 30, 50, 90 - number of mosquitoes introduced into the isolator

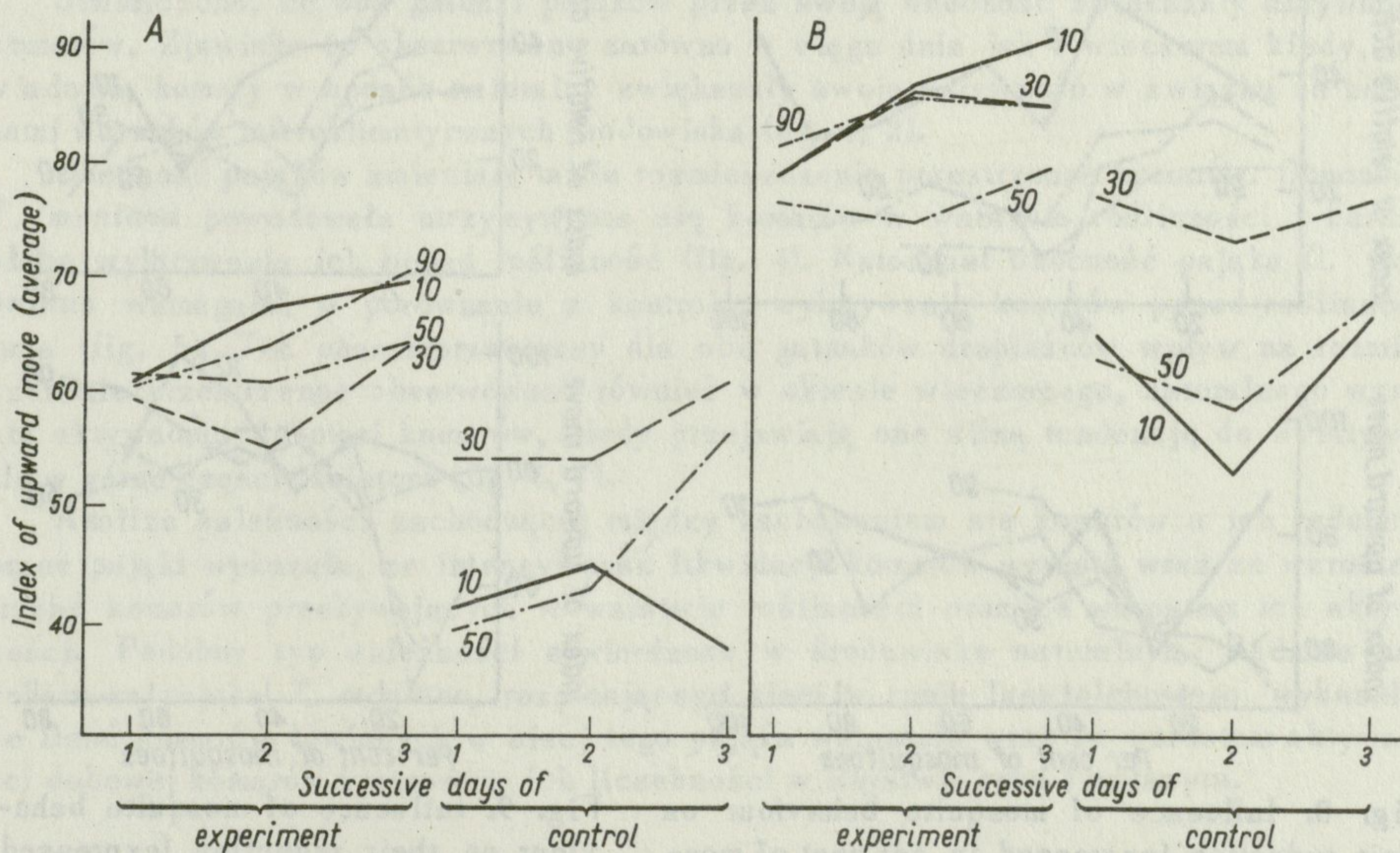


Fig. 7. Vertical distribution of mosquitoes in isolator in experiments with *D. fimbriatus* and in control during three successive days of experiment after the introduction of mosquitoes into the isolator

Explanations as for Fig. 6

tween the mosquito behaviour and their reduction has already been considered in the light of the results obtained in previous experiments, when a definite number of mosquitoes were introduced into the isolator and observations of their behaviour and of the rate of their reduction by spiders continued until the mosquito population had been completely liquidated (Dąbrowska-Prot, Łuczak, Tarwid 1968). In the experiments described in the present article the reaction of the two partners was intensified by increasing the density of the mosquitoes by adding fresh individuals every three days. In addition far clearer results were obtained (Fig. 8, 9). It was found in experiments with both *T. montana* and *D. fimbriatus* that reduction of the mosquitoes by the predator increased with an increase in the number of mosquitoes present in the vegetation and with increase in their movement activity. These regularities occurred in experiments with all the densities of mosquitoes tested.

Analogical regularities were found in studies on the food of *T. montana* in its natural habitat (Dąbrowska-Prot, Łuczak 1968). The effect of numbers and biting activity of mosquitoes was examined in relation to their number in the webs of spiders of this species. It was found that the number of mosquitoes caught in webs increased together with increase in biting activity of mosquitoes and increase in their numbers in the herb and undergrowth layers.

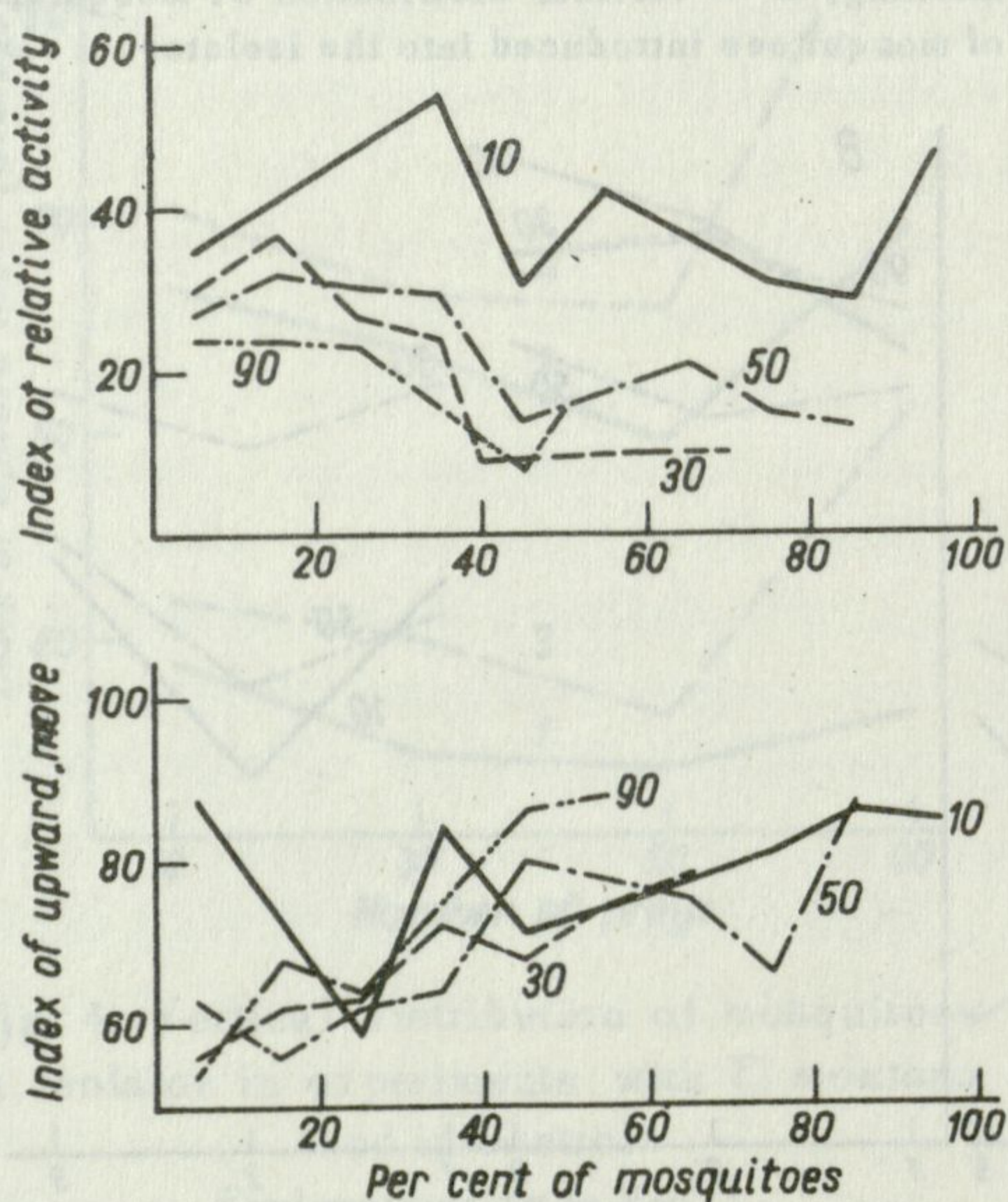


Fig. 8. Influence of mosquito behaviour on their reduction (expressed in per cent of mosquitoes remaining in isolator on third day of experiment) by spider *T. montana*
10, 30, 50, 90, — number of mosquitoes introduced into the isolator

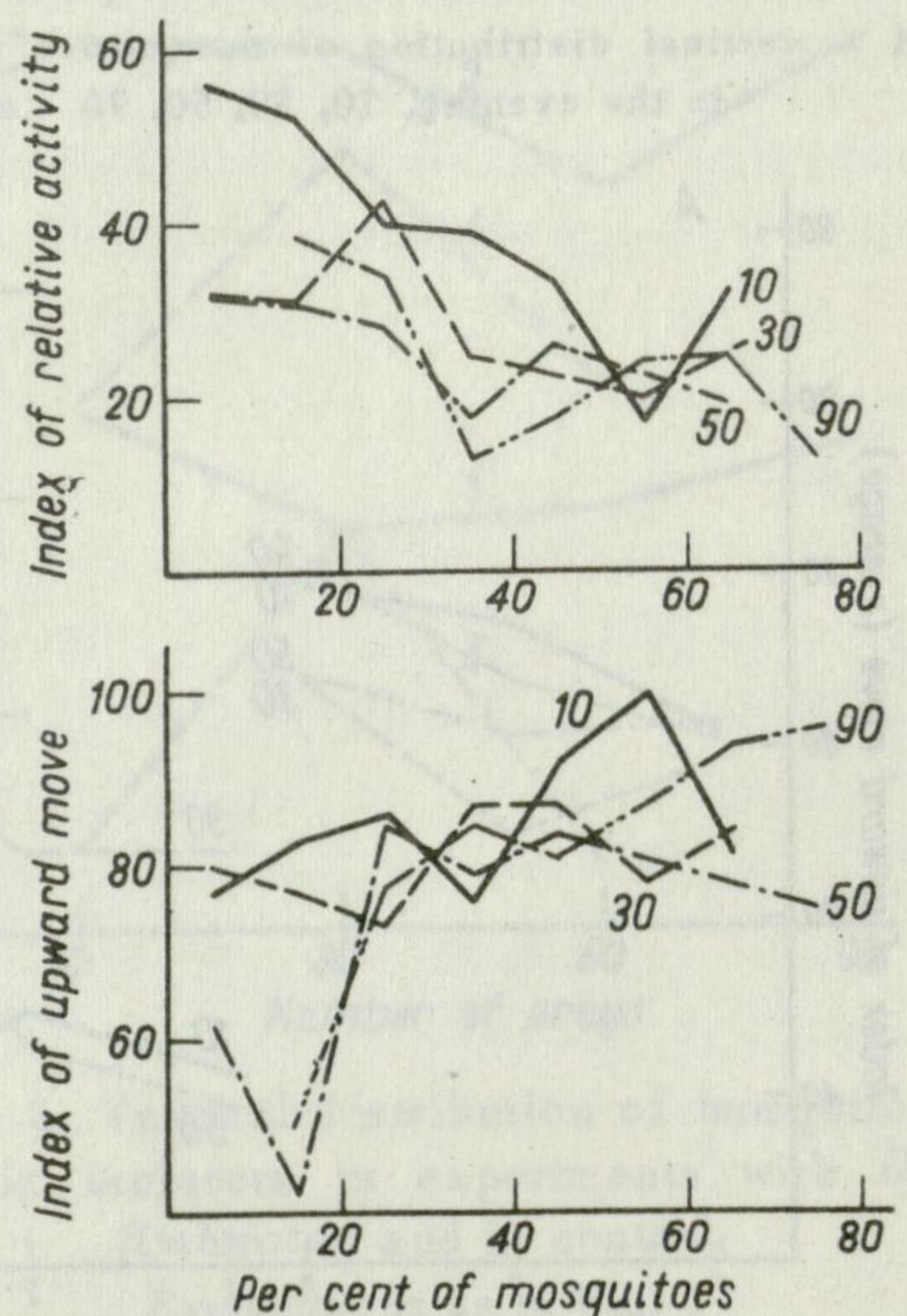


Fig. 9. Influence of mosquito behaviour on their reduction (expressed in per cent of mosquitoes remaining in isolator on third day of experiment) by spider *D. fimbriatus*
10, 30, 50, 90 — number of mosquitoes introduced into the isolator

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WPŁYW PAJĄKÓW NA ZACHOWANIE SIĘ POPULACJI KOMARÓW

Streszczenie

W izolatorach umieszczonych w lesie olchowym przeprowadzono badania nad wpływem drapieżców na aktywność komarów i ich rozmieszczenie pionowe. Drapieżcami były dwa gatunki pająków: pająk sieciowy *Tetragnatha montana* Simon i pająk biegający *Dolomedes fimbriatus* Clerck. Stałą obecność komarów w środowisku uzyskiwano przez wprowadzanie do izolatorów co trzy dni określonej liczby ofiar (10, 30, 50 i 90 osobników). Stwarzało to warunki ciągłego wzajemnego pobudzania aktywności ofiar i drapieżców.

Stwierdzono, że oba gatunki pająków przez swoją obecność zwiększały aktywność komarów. Zjawisko to obserwowano zarówno w ciągu dnia jak i wieczorem kiedy, jak wiadomo, komary w sposób naturalny zwiększały swoją aktywność w związku ze zmianami warunków mikroklimatycznych środowiska (fig. 1, 2).

Obecność pająków zmieniała także rozmieszczenie przestrzenne komarów. Obecność *T. montana* powodowała utrzymywanie się komarów w warstwie roślinności i bardzo słabe wylatywanie ich ponad roślinność (fig. 4). Natomiast obecność pająka *D. fimbriatus* wzmagala, w porównaniu z kontrolą, wylatywanie komarów ponad roślinność runa (fig. 5). Ten charakterystyczny dla obu gatunków drapieżców wpływ na rozmieszczenie przestrzenne obserwowano również w okresie wieczornego, naturalnego wzrostu aktywności dobowej komarów, kiedy przejawiają one silną tendencję do wylatywania w górne części izolatora (fig. 6, 7).

Analiza zależności zachodzącej między zachowaniem się komarów a ich redukcją przez pająki wykazała, że intensywność likwidacji komarów wzrasta wraz ze wzrostem liczby komarów przebywających w warstwie roślinności oraz ze wzrostem ich aktywności. Podobny typ zależności stwierdzono w środowisku naturalnym. Badania nad pokarmem pająka *T. montana*, rozpinającego sieci w runie lasu olchowego, wykazały, że ilość komarów łowionych w sieci tego pająka wzrastała wraz ze wzrostem aktywności dobowej komarów i wzrostem ich liczebności w warstwie runa i podszytu.

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