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BEHAVIOUR OF SPIDER POPULATIONS IN THE PRESENCE OF MOSQUITOES

(Ekol. Pol. 18: 625–634). Studies were made of the influence of different factors (including the period of the season and the size of the food ration) on the behaviour of populations of *Tetragnatha montana* Simon and *Dolomedes fimbriatus* Clerck in isolators set up under field conditions.

Several methods were used to examine the population reactions of spiders to their prey, in this case of the web spider *Tetragnatha montana* Simon and the wandering spider *Dolomedes fimbriatus* Clerck, analysing the influence of the presence and initial density of mosquitoes on the hunting activity of spider populations. For this purpose spiders were placed in large isolators (1.5 × 1.5 × 1 m), set up in a natural habitat of these spiders i.e. in the herb layer of a *Cariceto elongatae-Alnetum* association, and given different food rations consisting of mosquitoes.

The hunting activity of the spiders was determined by means of indices relating to amount of web activity, that is, the percentage of individuals in a population which spin webs and then sit in wait on them ready to catch their

prey, and the extent of movement activity, i.e. the percentage of individuals in a population which preying mosquitoes shift to the walls of the isolator, where they either actively hunt their prey directly on the walls, or spin webs on the walls and roof of the isolator. The hunting activity of spiders was also defined by the value of the absolute number of spiders sitting on webs or on the walls of the isolator, the number of spiders on webs in one isolator per day and the index of distribution of spiders on vegetation and on the walls in the upper part of the isolator above the vegetation. Calculation of these indices was based on data from 6 isolators, into which different numbers of mosquitoes were introduced every 3 days. Observations were continued from the beginning of June to the end of September 1967, a given number of mosquitoes being introduced from 15 to 22 times into isolators containing 24 individuals of *Tetragnatha montana* (20 females and 4 males).

TETRAGNATHA MONTANA

Web activity of the spider

1. Relation to length of the spiders' stay in the isolator

It was found that both the absolute number of webs and also web activity of a population are always lesser during the first 6 days after the introduction of spiders into the isolator than during the following 6 days (Tab. I). This would appear to be due to the spiders' failing at first to adapt themselves to the new habitat in which they find themselves. After a few days they begin to accustom themselves to and take up their usual activites in the new habitat and the web activity of the population at once increases.

2. Relation to size of the mosquito ration

The relation between the spiders' web activity and initial density of mosquitoes was examined. The following numbers of mosquitoes were introduced into 6 isolators: into one isolator – 10, into two – 30 each, a further two – 50 each and to one only – 90 mosquitoes. Each isolator contained 24 individuals of *T. montana*. It was found that the maximum number of webs (Tab. II) and maximum web activity (Fig. 1) in the evening observations are characteristic in populations into which 30 mosquitoes were introduced every 3 days, whereas the population supplied with the maximum number of mosquitoes (90) was characterized by the smallest number of webs and lowest web activity (Fig. 1). This phenomenon has already been observed in a different type of experiment with *T. montana* and mosquitoes (Dąbrowska-Prot, Łuczak, Tarwid 1968a). Large rations of mosquitoes cause considerable stimulation of *T. mon-*

Number of webs of *Tetragnatha montana* and value of web activity index during 6-day period after introduction of spiders into isolator and during next 6-day period (evening observations)

Tab. I

Number of mosquitoes introduced every 3 days	Sum total of webs of *T. montana*	
	in first 6 days	in next 6 days
10	36	43
30	49	67
30	46	67
50	59	62
50	42	60
90	39	42
	web activity index in %	
10	43	55
30	41	56
30	39	65
50	49	52
50	36	52
90	31	33

Sum total of webs of *Tetragnatha montana* from 50 evening observations in isolators with different number of mosquitoes introduced (maximum number of webs was taken as 100%)

Tab. II

Number of mosquitoes introduced every 3 days	Sum total of webs	%
10	281	71
30	397	100
50	347	87
90	248	62

tana spiders, which begin actively to hunt their prey outside their own webs. The introduction of 30 mosquitoes every 3 days, on the other hand, does not distract the spiders from spinning webs or from sitting on the webs in wait for prey, but causes stimulation of the population's web activity, which is greatest with this density of mosquitoes.

3. Relation to period of the season

It was found that both the absolute number of webs per isolator per day Tab III) and the spider population's web activity (Fig. 2 and 3) are greatest during the second half of June (period *III*). The population of adult spiders,

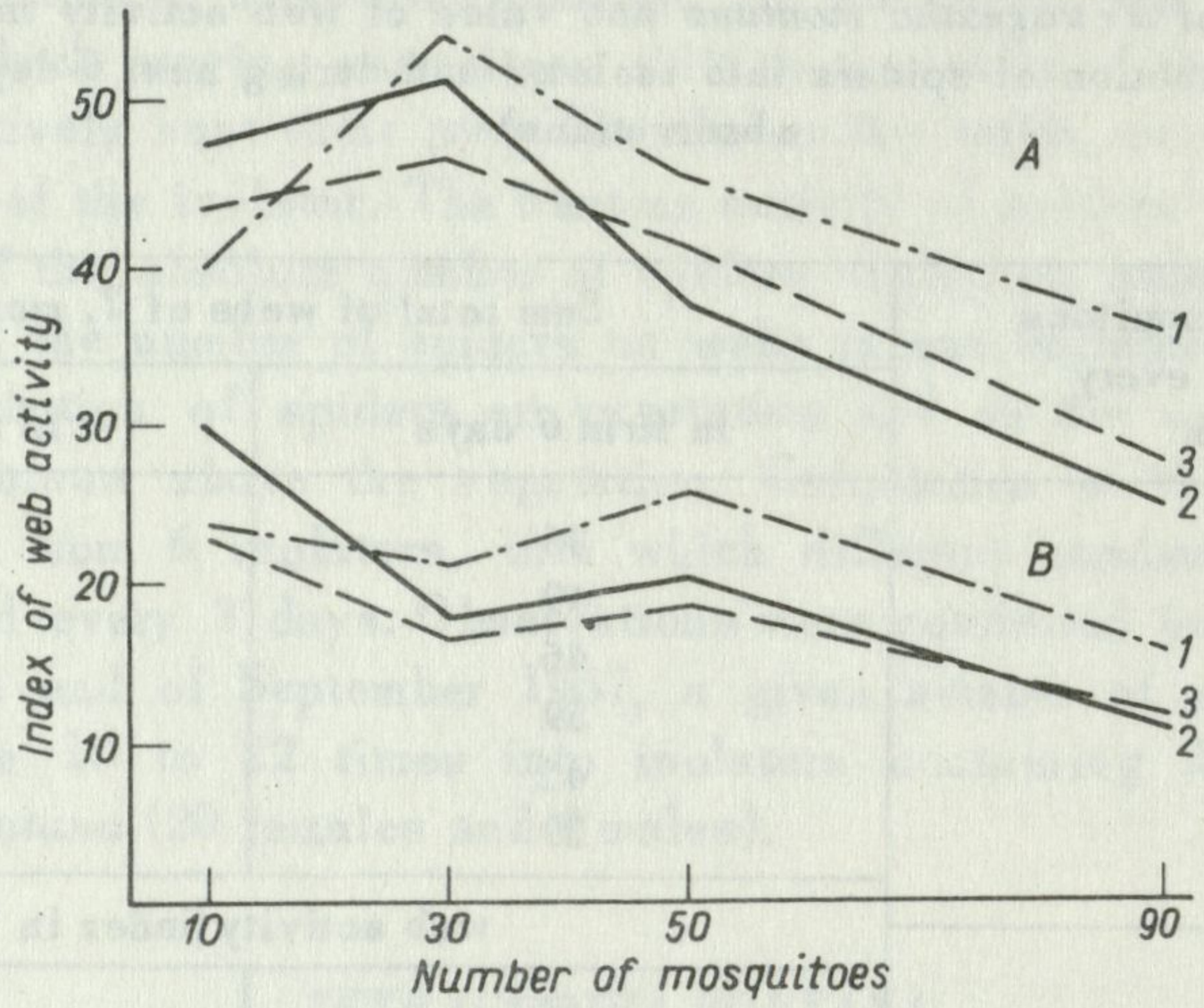

Fig. 1. Web activity of *Tetragnatha montana* in the evening (*A*) and daytime (*B*) in isolators into which a different number of mosquitoes were introduced (10, 30, 50 and 90 mosquitoes a time)

Days in 3-day cycle of introducing mosquitoes: *1* – first, *2* – second, *3* – third

Absolute number of webs of *Tetragnatha montana* in different periods of the season in isolators (evening observations)

Tab. III

Number of mosquitoes introduced	Periods				
	*I**	*II*	*III*	*IV*	*V*
	date				
	3–8 VI	9–14 VI	15–30 VI	1–20 VII	21 VII-5 VIII
10	5	6	5	7	4
30	4	8	11	10	5.8
30	5.2	8	8	6.3	3.4
50	5	9.3	9.7	9	5
50	3.3	7	7.3	4.3	4.7
90	6.3	6.5	7.7	3.7	3.2
Averages**	4.8	7.5	8.1	6.7	4.4

*Spiders were not given mosquitoes during this period.
**Average number of webs per isolator per day.

which are still young, entering the reproduction phase exhibit maximum web activity during this period. Analysis of web distribution shows that expansion of the population is greatest in this period, as the spiders endeavour to occupy the whole of the space in the isolator.

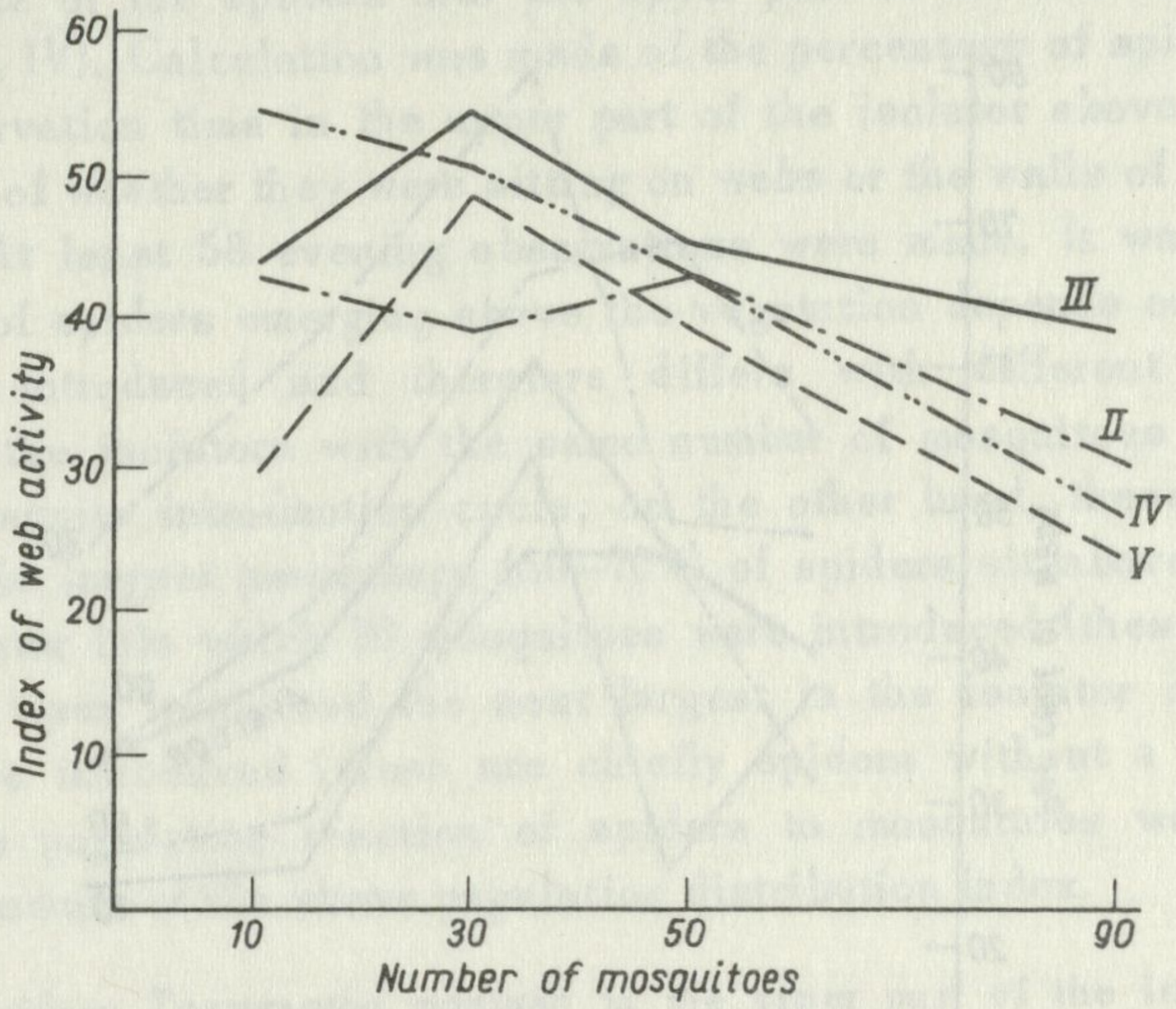

Fig. 2. Variations in web activity of *Tetragnatha montana* in five periods of the season (the spiders were not as yet given prey during period *I*) and with a different number of mosquitoes introduced. Data from evening observations

Periods: *I* – June 3–8, *II* – June 9–14, *III* – June 15–30, *IV* – July 1–20, *V* – July 21-August 5

Shifting activity of the spiders

1. Relation to size of the mosquito ration introduced

It was found that a smaller percentage of the spider populations shift to the walls of the isolator when portions of 10 and 50 mosquitoes are given, and a larger percentage with portions of 30 and 90 mosquitoes introduced every 3 days (Fig. 4). A detailed analysis was made of this apparently strange phenomenon. It was found that with a portion of 30 mosquitoes the majority of the spiders which shifted on to the walls spin webs on them (maximum web activity of the population in the evening, cf. Fig. 1) whereas the high percentage of shifts made by individuals of the population given rations of 90 mosquitoes is due chiefly to individuals without webs, actively hunting mosquitoes on the walls (minimum web activity of the population, but maximum stimulation of the spiders to hunt actively for the mosquitoes on the walls, cf. Fig. 1).

2. Relation to period of the season

It was found that the maximum percentage of individuals in the population shift to the walls of the isolator in the second half of June.

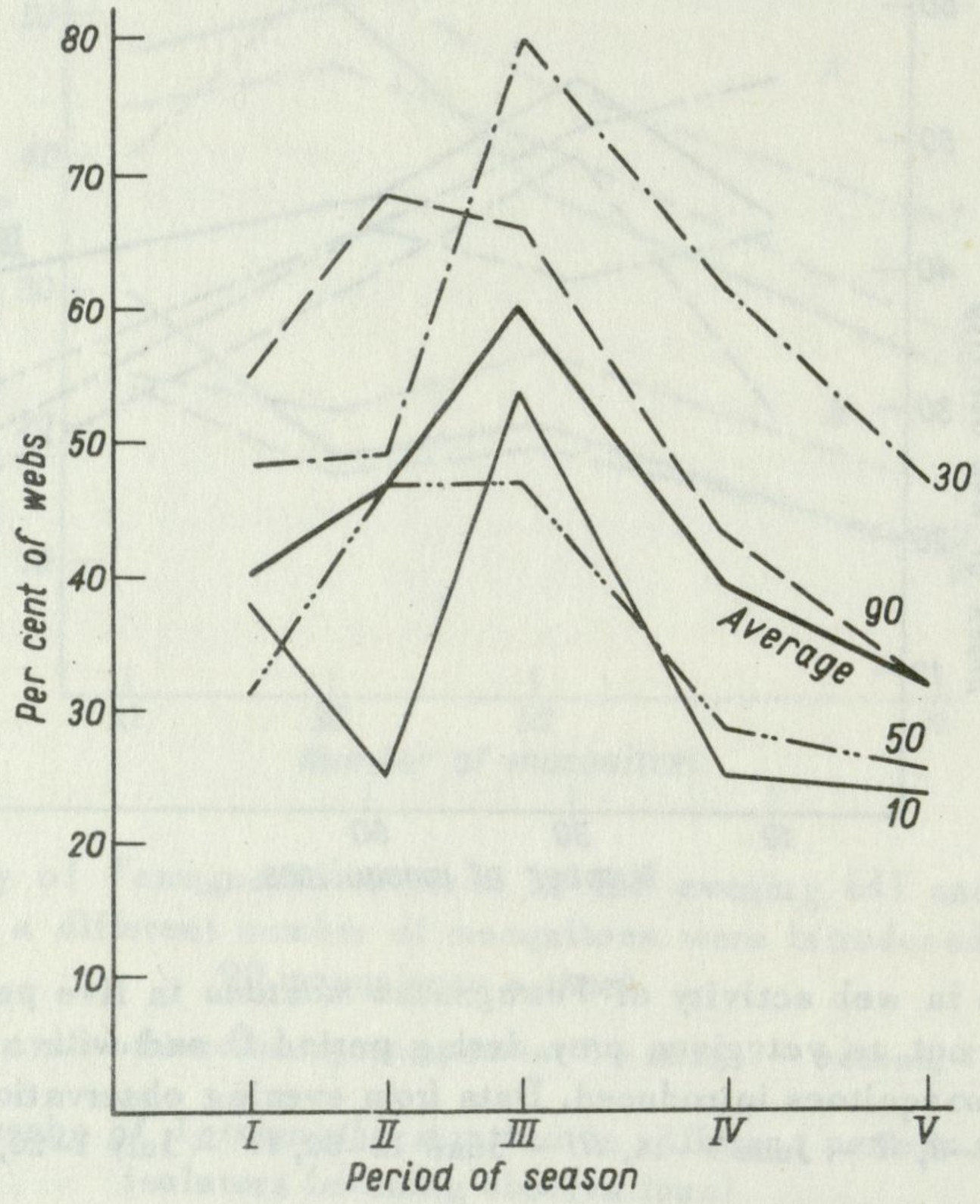

Fig. 3. Percentage of webs of *Tetragnatha montana* on walls of isolators in five periods of the season and with different number of mosquitoes introduced (10, 30, 50 and 90 mosquitoes)

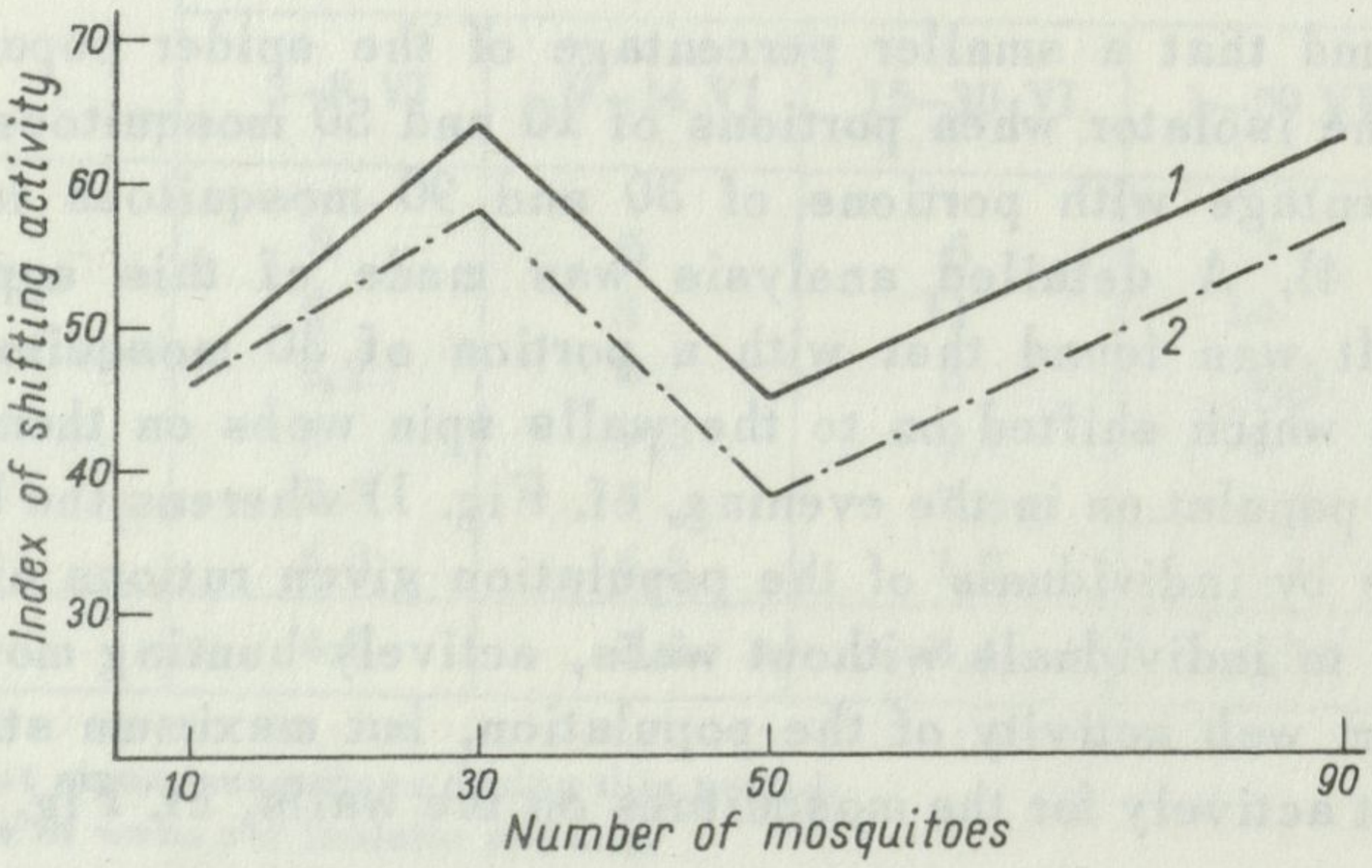

Fig. 4. Relation between shifts in location of spiders *Tetragnatha montana* and number of mosquitoes introduced

1 – data from evening observations, *2* – data from daytime observations

The spiders' reactions to mosquitoes were examined by means of yet another index: emergence of the spiders into the upper part of the isolator above the vegetation (Tab. IV). Calculation was made of the percentage of spiders present during the observation time in the upper part of the isolator above the vegetation, regardless of whether they were sitting on webs or the walls of the isolator, without webs. At least 58 evening observations were made. It was found that the percentage of spiders emerging above the vegetation depends on the number of mosquitoes introduced and therefore differs with different numbers of mosquitoes. In the isolators with the same number of mosquitoes on all three days of the mosquito introduction cycle, on the other hand, these figures are very similar. The largest percentage (60–70%) of spiders sit above the vegetation in the isolator into which 30 mosquitoes were introduced (these are chiefly spiders with a spun web), and the next largest in the isolator into which 90 mosquitoes were introduced (these are chiefly spiders without a regular web) (Tab. IV). The population reaction of spiders to mosquitoes was thus also ascertained by means of the above population distribution index.

Percentage of spiders *Tetragnatha montana* in the upper part of the isolators (above vegetation) during 1st, 2nd and 3rd days of 3-day cycle of introduction of mosquitoes

Tab. IV

Number of mosquitoes introduced every 3 days	Percentage of spiders		
	1st days	2nd days	3rd days
10	14	23	18
30	61	62	59
30	71	73	68
50	37	40	39
50	32	37	39
90	50	53	65

The emergence of the spiders into the upper part of the isolator also depends on the period of the season. It is most intensive in the second half of June (Tab. V). It is thus clearly, under the climatic conditions in 1967, the period of maximum expansion of populations of *Tetragnatha montana*.

All these studies concerned with both web and movement activity of populations of the spider *T. montana* show that the spiders' maximum activity occurs in the second half of June, before the main period of cocoon forming by females. The above studies also show that this species of spider is stimulated by a large number of mosquitoes; the reaction of the stimulated spiders alters and a large number of the individuals in a population change to a more active way of hunting mosquitoes on the walls of the isolator, without spinning a web. These spiders also exhibit the population reaction to the presence of mosquitoes (Dąbrowska-Prot, Łuczak, Tarwid 1968a, 1968b).

Percentage of population of spiders *Tetragnatha montana* in the upper part of the isolators (above vegetation) during different periods of the season (*II-V**) and depending on number of mosquitoes introduced (evening observations)

Tab. V

Number of mosquitoes introduced every 3 days	Periods			
	II	*III*	*IV*	*V*
	date			
	8–15 VI	15–30 VI	1–20 VII	after 20 VII
10	14	58	19	26
30	50	73	63	52
30	40	78	55	40
50	15	54	37	33
50	47	45	27	40
90	43	68	51	45

*Period *I*st was omitted as the spiders were not given mosquitoes during this time.

Percentage of population of spiders *Dolomedes fimbriatus* in the upper part of the isolators (above vegetation) during 1st, 2nd and 3rd days of 3-day cycle of introduction of different numbers of mosquitoes

Tab. VI

Number of mosquitoes introduced	30		30		50		90	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
1st days	16	17	16	17	14	10	22	21
2nd days	15	17	18	15	14	9	16	14
3rd days	9	10	16	10	8	6	14	11

a – morning, *b* – evening.

DOLOMEDES FIMBRIATUS

Examination of the population reaction to mosquitoes of the spider *D. fimbriatus* showed that this species depends to a far lesser extent on the presence and initial density of this type of prey. As in the case of *T. montana*, an increase was observed in the spiders' movement activity (shifting to the walls of the isolator), for several days after the spiders had been introduced into the isolators. The initial density of mosquitoes was also found to influence the activity of the spiders moving to the upper part of the isolator and their localisation above the vegetation (Tab. VI). Table VI shows that during the first days of the 3-day cycle of mosquito introduction the greatest percentage of spiders were located in the upper part of the isolator above the vegetation – in the isolator with the maximum density of mosquitoes (90 individuals introduced

every 3 days). Data for the third day of each cycle (by which time mosquitoes had greatly decreased in number) give the smallest percentage of spiders emerging above vegetation.

CONCLUSIONS

Mosquitoes were found to exert a distinct influence on the behaviour of the spider *Tetragnatha montana* in isolators set up in field conditions. The hunting reactions of the *T. montana* population were found to depend on the period of the season and the presence and numbers of the mosquitoes offered them. The relation between prey, that is, mosquitoes and predator, was less distinct in the case of *Dolomedes fimbriatus*. It would appear that the lesser influence of the presence and initial density of mosquitoes on the behaviour of this species is due to the fact that these insects do not form the chief prey of this large spider and there are no evolutional adaptations of predator's behaviour. It proved possible to establish for *T. montana* (Dąbrowska-Prot, Łuczak 1968) that in the alder forest examined mosquitoes form about 75% of all prey caught and eaten by this species in June. In relation to the species *T. montana* this is a type of prey to which the predator most probably adapted its circadian and seasonal activity during the process of evolution and formed reactions to the presence and density of these victims.

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ZACHOWANIE SIĘ POPULACJI PAJĄKÓW W OBECNOŚCI KOMARÓW

Streszczenie

Badano populacyjną aktywność sieciową i ruchową pająków *Tetragnatha montana* Simon oraz aktywność ruchową pająków *Dolomedes fimbriatus* Clerck w eksperymencie terenowym.

U *T. montana* stwierdzono zależność aktywności od długości okresu przebywania

pająków w izolatorze (przystosowywanie się do nowego środowiska) (tab. I), od liczby wprowadzanych komarów (tab. II, IV, V, fig. 1, 3, 4) i od okresu sezonu (fazy rozwojowej populacji) (tab. III, V, fig. 2). Pająki te wykazują wyraźne populacyjne reakcje na obecność komarów i na wielkość wprowadzanej racji pokarmowej, najprawdopodobniej uwarunkowane ewolucyjnie. Reakcje te rejestrowano badając intensywność tkania sieci i sposób rozmieszczania się pająków w izolatorze. U *D. fimbriatus* stwierdzono znacznie mniejsze uzależnienie populacyjnych reakcji pająków od obecności i liczby komarów niż w wypadku *T. montana*. Jednak badanie rozmieszczania się osobników *D. fimbriatus* w izolatorze wskazuje, że wielkości wprowadzanej porcji ofiar mają pewien wpływ na populacyjne reakcje przemieszczania się pająków tego gatunku (tab. VI).

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