KOMITET EKOLOGICZNY - POLSKA AKADEMIA NAUK

EKOLOGIA POLSKA — SERIA A

Tom XIV Warszawa 1966 Nr 33

Eliza DĄBROWSKA-PROT

CHANGES OF THE VERTICAL DISTRIBUTION OF MOSQUITOES IN FOREST ENVIRONMENT*

Investigations were carried out on the vertical distribution of mosquitoes in forest environment from the young trees layer to the layer above the canopy. Differences in the structure of mosquito fauna caught by night in light-traps were stated as compared with the fauna caught by day in this environment. The investigated forest layers differed in the total mosquito abundancy, males and females participation and the degree of preference by individual species. *Aedes maculatus* Meig. and *Aedes excrucians* Walk. were most numerous by night in the young trees layer and below the canopy, *Aedes cinereus* Meig. and *Aedes communis* De Geer in the canopy and *Culex pipiens* L. above the canopy.

The problem of the vertical differentiation of animals occurrence in the environment is particularly important if it is analysed from the point of view of the co-occurrence of species or animal groups in the given layers of the vegetation and hence the possibility of arising of biocenotic connections between them. In forest environment the vertical differentiation of animals is particularly evident. It may be traced either in a permanent connection of certain animal species with the definite layers of vegetation or, as is the case with mosquitoes, the temporal occurrence in different forest layers. As it is well known, mosquitoes change the place of their occurrence during 24-hours moving from the litter and understorey upward to the canopy and back. Elton and Miller (1954), appreciating theoretical and practical importance of partitioning the ecological niche of species, have worked out the classification

* From the Institute of Ecology, Polish Academy of Sciences, Warszawa.

of forest animals associations taking as their basis the stratified arrangement of forest vegetation giving in consequence the stratified arrangement of the animals. The occurence of mosquitoes in these different strata enables mosquitoes, first of all, various contacts with their potential enemies, different in different layers of vegetation. The experimental investigations carried out recently by the author concerning the rate of mosquito abundancy reduction by some species of wandering and web spiders have proved a considerable influence of these predators on the level of mosquito abundancy in experimental conditions. We can expect that in natural conditions spiders can also play an important part in limiting the numbers of mosquitoes. But their activity is mainly limited to the undergrowth and shrubs and consequently the effectiveness of their influence is in some degree dependent on the time in which mosquitoes stay in these layers.

The differentiation of the vertical distribution of mosquitoes and its changes in the 24-hour cycle, as it is evident from the literature devoted to this problem, may occur on a different scale. For example Beklemišev (1934) in his work on the subject of vertical migrations of invertebrates registered the fact that mosquitoes, according to the microclimatic conditions, move from the lower to the upper part of the undergrowth or from the undergrowth to the shrubs. The majority of the works has been devoted to the problem of the vertical distribution of mosquitoes in forest by day upward from the undergrowth to the canopy and above and also to the changes of this distribution in the 24-hour cycle. As a rule, they were investigations carried out in rain-forest having at their disposal materials even from considerably high levels (Bates 1944; Haddow 1945, 1954, 1961; Haddow, Gillett, Highton 1947; Haddow, Mahaffy 1949; Mattingly 1949; Lumsden 1952; Platt, Love, Williams 1958, Corbet 1961; Corbet, Haddow 1961). These investigations led to the statement that microclimatic conditions (temperature, humidity, light) which are to be found in rain-forest forming a gradient from the undergrowth to the canopy, condition the vertical distribution of mosquitoes, Some species stay during the day chiefly in the canopy, others below the canopy and some others in the undergrowth. This diurnal vertical structure of mosquito fauna changes in the evening and at night when the microclimatic conditions enable an activation of mosquitoes and their movement from the undergrowth and understorey to the upper forest layers. Investigations of many authors indicate quite a regular course of 24-hour changes in the vertical distribution of individual species (Haddow 1954, 1961; Corbet 1961, 1964; Corbet, Haddow 1961). As a rule, except for the species which are characteristic of the higher forest layers, these changes consist in shifting of the abundancy maxima of individual species upward to the canopy at the nightfall.

Particular investigations showed that not only those elements of the mosquito fauna structure of the separate layers like abundancy and specific composition but also age-composition and sex relations undergo regular 24-hour changes. Lumsden (1952) suggests that females attacking their prey at night belong to either of the two groups: older and younger age-groups. Both these groups show preference to different levels and attack their prey at different hours of day and night. Corbet (1961) stated that the flight activity of parous and nulliparous females of *Mansonia fuscopennata* Theo. species in the evening is identical for both these age groups but the age ratio of females active above and below the canopy is different. During the night nulliparous females were most numerous at the undergrowth level and parous females at 120 feet. The average age of females increased progressively with the height. But the males of this species were most numerous at night at 120 feet, while the females were equally numerous at all the investigated levels.

All the above mentioned elements of differentiating mosquito fauna, i.e. sex relations, occurrence of parous and nulliparous females, number of biting

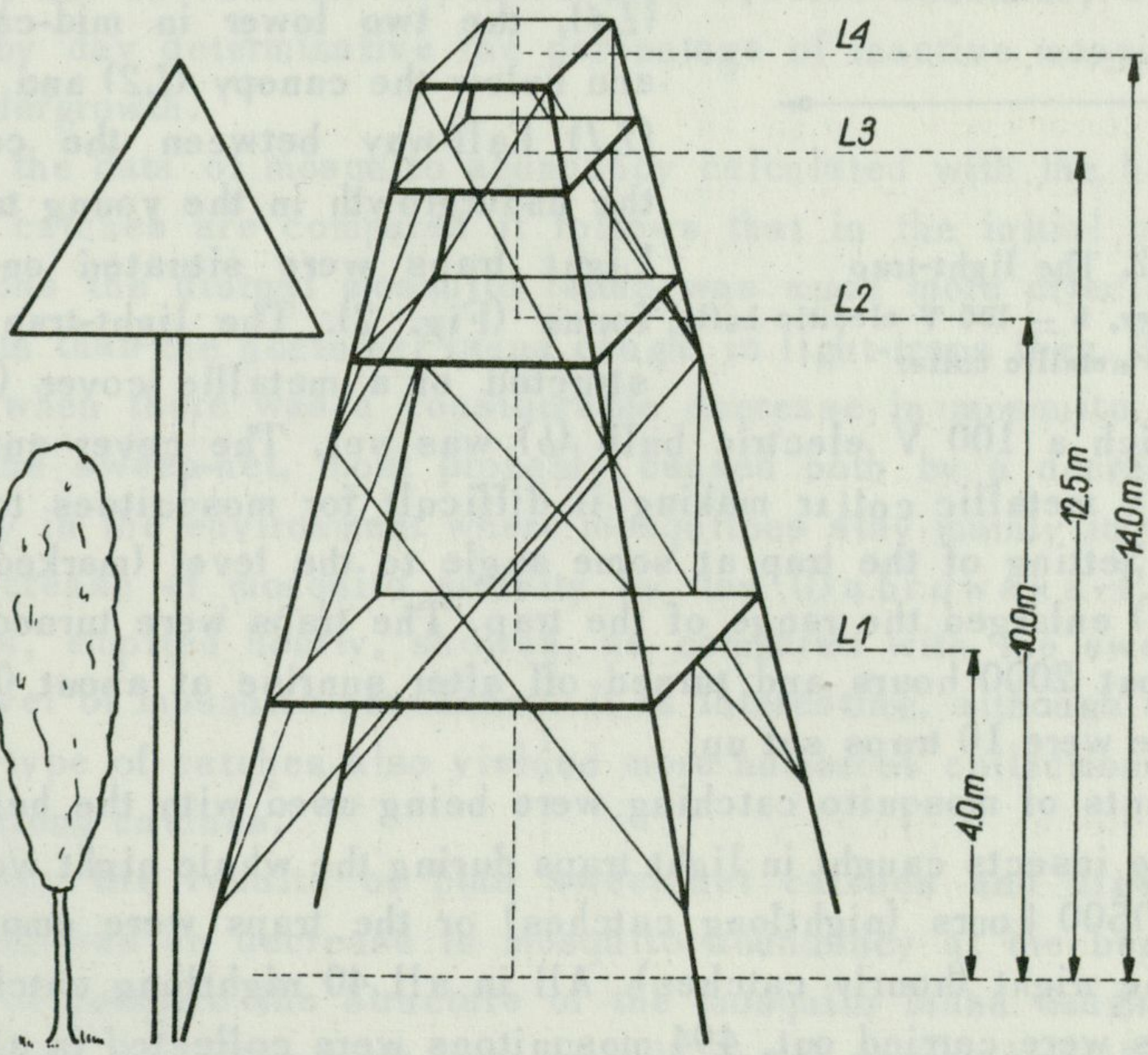

Fig. 1. The tower with four platforms which were estabilished at different levels of forest vegetation

L1 – in small trees, *L2* – below the canopy, *L3* – mid-canopy, *L4* – above the canopy

females have an important epidemologic significance because they enable mosquitoes to get to their prey.

The problem of abundancy changes of individual mosquito species and the occurrence of males and females in the 24-hour cycle in different rain-forest layers has been comparatively best analysed, but we have no data concerning this problem for the forests of our climatic zone. The author has undertaken investigations of this type in the forest complex Puszcza Kampinowska near Warsaw. The present investigations were carried out in the summer of 1964 from 1st June to 29th August in the wet part of the forest adjacent to the open dune areas. The catches were carried out on a wooden tower (Fig. 1) set up in the old pine forest, the canopy of which formed a compact carpet. Young leafy trees (oak, hornbeam, alder) grew below reaching up to the lower parts of the pine canopy. The undergrowth was formed mainly by compact patches of *Vaccinium myrtillus*. The tower was equipped with four platforms, the highest of them was situated above the canopy (*L4*), the two lower in mid-canopy (*L3*) and below the canopy (*L2*) and the lowest (*L1*) half-way between the canopy and the undergrowth in the young trees layer. Light traps were situated on the platforms (Fig. 2). The light-trap was constructed of a metallic cover (*a*), on the bottom of which a 100 V electric bulb (*b*) was set. The cover entrance was protected by a metallic collar making it difficult for mosquitoes to fly away once caught. Setting of the trap at some angle to the level (marked in Fig. 2 with an arrow) enlarged the range of the trap. The traps were turned on before sunset at about 2000 hours and turned off after sunrise at about 0500 hours. All in all there were 10 traps set up.

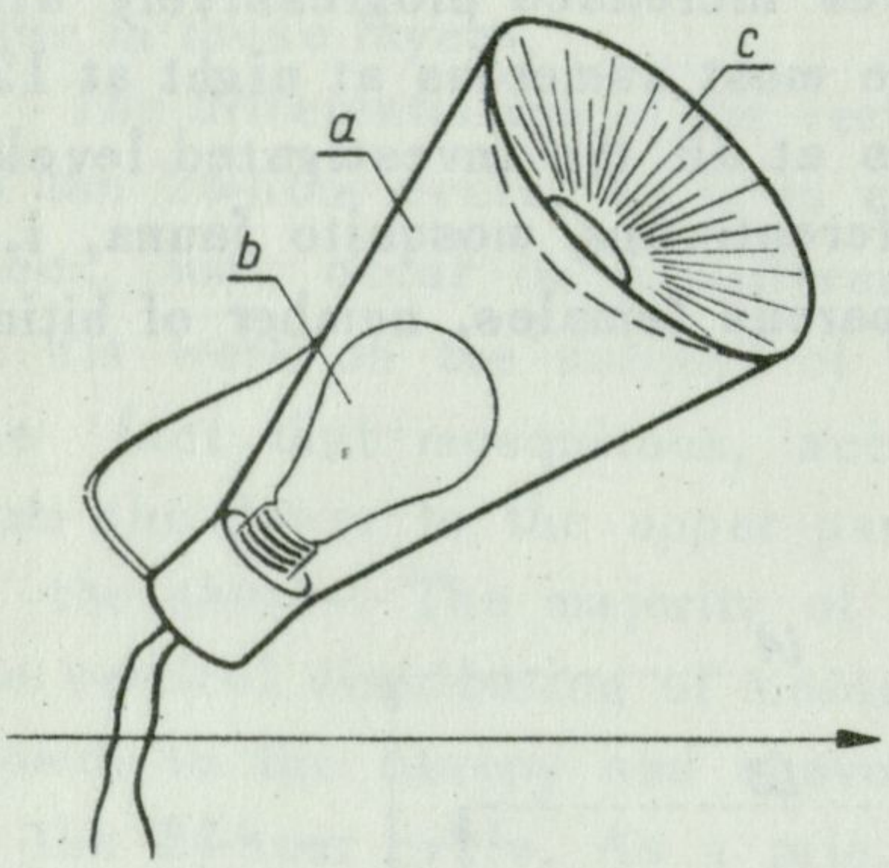

Fig. 2. The light-trap
a – metallic cover, *b* – 100 V electric bulb, *c* – metallic collar

Two variants of mosquito catching were being used with the help of these light traps: the insects caught in light traps during the whole night were collected at about 0500 hours (nightlong catches) or the traps were emptied hourly all through the night (hourly catches). All in all 40 nightlong catches and 13 hourly catches were carried out. 494 mosquitoes were collected in all. Besides 38 series of diurnal sweep-net catches were carried out in the undergrowth and shrubs in the nearest vicinity of the tower and 1,857 mosquitoes were caught with the help of this method. Temperature and humidity readings were being taken simultaneously.

RESULTS

Comparison of mosquito fauna caught with the help of different methods

An aim of the author's was the comparison of mosquito fauna flying at night in the understorey and canopy and attracted to light with mosquito fauna staying during the day in this environment. The majority of mosquitoes, especially at the beginning of the present investigations, was inactive by day and consequently sweep-net catches were used from the undergrowth and understorey. It was to be expected that qualitative and quantitative changes might be found in the diurnal and noctural fauna of the mosquitoes from the investigated environment which are the resultant of differences in the behaviour of mosquitoes by day and by night and a specific character of each of the methods giving characteristic changes in the mosquito fauna picture. Generally speaking three factors influence upon the results obtained with the help of light-traps: abundance of the species in the environment, their activity (swarming, oviposition, biting activity) and light sensibility. The catches carried out by the sweep-net undoubtedly depended upon species abundancy and their limited activity by day determinative the percentage of inactive mosquitoes remaining in the undergrowth.

When the data of mosquito abundancy calculated with the help of the three types of catches are compared it follows that in the initial phase of the investigations the diurnal mosquito fauna was much more effectively caught by sweep-nets than the nocturnal fauna caught in light-traps (Fig. 3). In the middle of July, when there was a considerable decrease in mosquito catches carried out by the sweep-net, most probably caused both by a decrease in mosquito abundancy in the environment where mosquitoes stay mainly in the daytime and by an increase of mosquito activity by day (Dąbrowska-Prot 1964), the light-traps, emptied hourly, showed, as compared with the sweep-net, a much higher level of mosquito abundancy. It is interesting, although a little unclear, that this type of catches also yielded more numerous collections of mosquitoes than nightlong catches.

Because the results of both sweep-net catches and nightlong light-trap catches showed an decrease in mosquito abundancy at the beginning of July, in order to compare the structure of the mosquito fauna caught with the help of sweep-nets and light-traps, two periods in the season have been distinguished: the first characterized by a higher mosquito abundancy including June and the second with a lower mosquito abundancy including July and the first half of August. A quantitative analysis of the mosquito fauna caught with the help of different methods was carried out with reference to these two periods (Tab. I).

In the first period hourly light-trap catches were not carried out and conseguently the analysis concerns only sweep-net catches and nightlong light-trap catches.

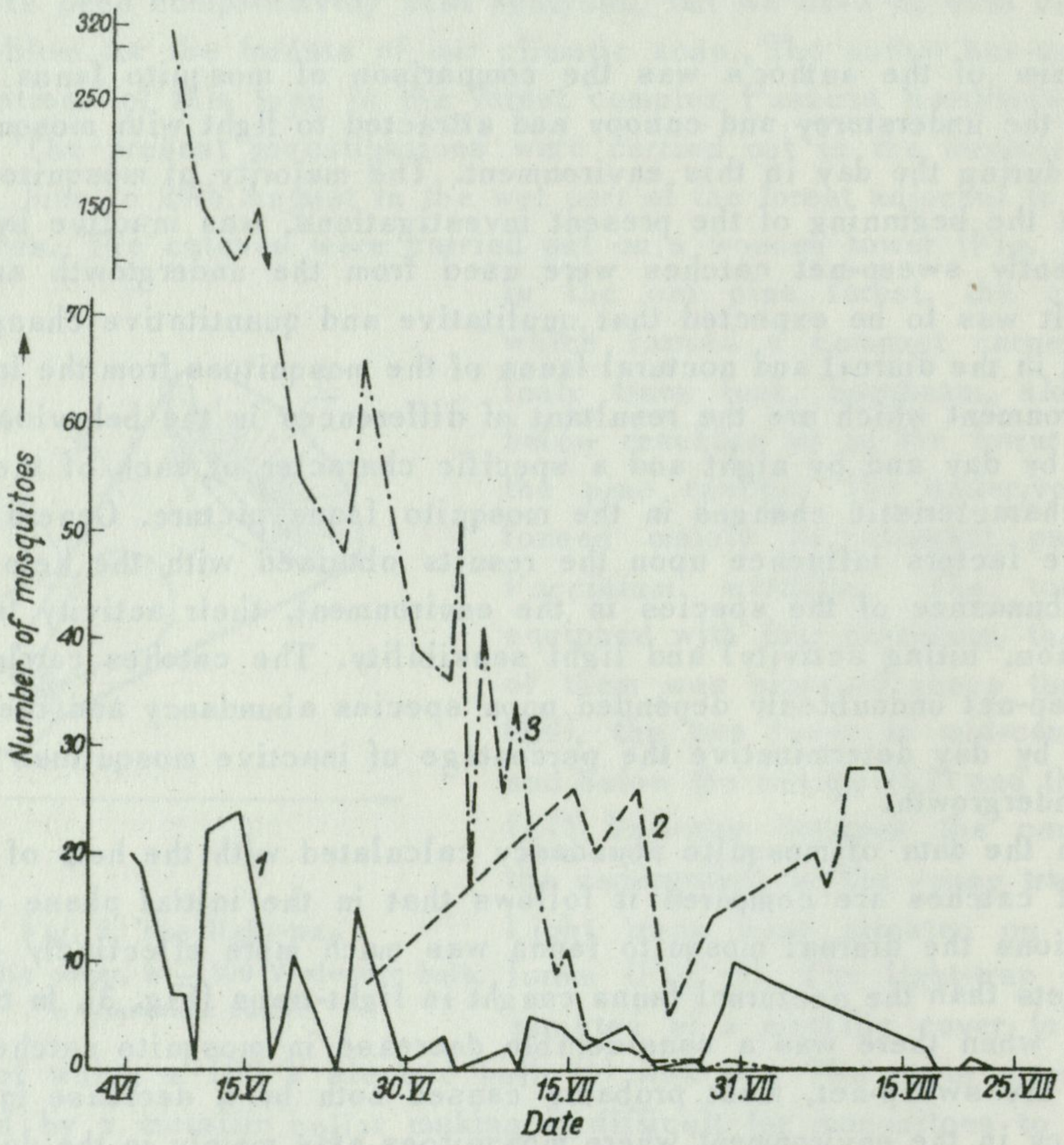

Fig. 3. Seasonal variations in numbers of mosquitoes, considered in relation to different catches

1 – nightlong light-traps, *2* – hourly light-traps, *3* – sweeping

As it was stated above nocturnal catches collected much fewer mosquitoes than sweep-net catches. The number of species caught in these two ways was evenly distributed (10 species in nocturnal catches and 9 species in diurnal catches) but only 7 species were caught with the help of both these methods. They were: *Aedes maculatus* Meig., *Aedes excrucians* Walk., *Aedes communis* De Geer, *Aedes punctor* Kirby, *Aedes cinereus* Meig., *Theobaldia ochroptera* Peus, *Culex pipiens* Linn. The remaining three species caught in this period only with the help of of light-traps (*Aedes vexans* Meig., *Theobaldia annulata* Schr.. *Theobaldia alaskaensis* Lud.) and the two species caught only by the

Abundance and percentage occurrence of different species, males and females in sweep-net catches and hourly and nightlong light-trap catches

Tab. I

			Whole of the fauna	♂ ♂	♀ ♀	*Ae. maculatus*	*Ae. excrucians*	*Ae. communis*	*Ae. cinereus*	*Ae. punctor*	*Th. ochroptera*	*Ae. vexans*	*C. pipiens*	*Th. annulata*	*Th. alaskaensis*	*A. maculipennis*	*Ae. caspius-dorsalis*	*A. claviger*
Nightlong light-trap catches	I period	percentage occurrence		66.4	33.6	41.6	22.8	12.7	12.7	4.8	2.0	1.3	0.7	0.7	0.7	0	0	0
		abundance (average per catch)	10.6	7.1	3.5	4.4	2.4	1.4	1.4	0.5	0.2	0.1	0.07	0.07	0.07	0	0	0
	II period	percentage occurrence		51.9	48.1	13.5	1.9	0	5.8	3.8	0	0	57.7	7.7	1.9	7.7	0	0
		abundance (average per catch)	3.7	1.9	1.8	0.5	0.05	0	0.2	0.1	0	0	2.2	0.3	0.05	0.3	0	0
Sweep-net catches	I period	percentage occurrence		4.4	95.6	57.3	2.0	20.9	7.6	11.7	0.1	0	0.2	0	0	0.1	0	0.1
		abundance (average per catch)	116.3	5.2	111.1	66.7	2.3	24.3	8.8	13.7	0.1	0	0.2	0	0	0.1	0	0.1
	II period	percentage occurrence		1.0	99.0	84.2	2.1	0	5.7	6.0	0	0.3	1.4	0	0	0.3	0	0
		abundance (average per catch)	19.5	0.2	19.2	16.3	0.4	0	1.1	1.2	0	0.1	0.3	0	0	0.1	0	0
Hourly light-trap catches	II period	percentage occurrence		23.8	76.2	54.9	0.8	1.2	4.0	2.1	0.4	3.6	29.8	1.2	0	1.6	0.4	0
		abundance (average per catch)	19.4	4.9	14.5	10.7	0.2	0.2	0.8	0.4	0.1	0.7	5.7	0.2	0	0.3	0.1	0

sweep-net (*Anopheles maculipennis* Meig. and *Anopheles claviger* Meig.) were not numerous and surely do not play an important role in the mosquito community (Tab. I). And so light-traps, in spite of the fact that they yielded less numerous catches, gave a full range of important, because of their abundancy, species of mosquito community staying by day in this environment.

But nocturnal catches collected a different structurally fauna from that caught by day. To start with, in the first period of these investigations there was a preponderance of males which formed only an insignificant part of the diurnal catches in spite of the fact that the sweep-net catches males and females with the same intensity. It may be caused by a strong attraction of light-traps for males. Both these methods registered *Ae. maculatus* species as dominating. It showed the same percentage occurrence in diurnal and nocturnal fauna. Both these types of catching registered also the same species as most numerous (*Ae. maculatus*, *Ae. excrucians*, *Ae. communis*, *Ae. punctor* and *Ae. cinereus*), but they had different percentage occurrence in each of the catches. And so *Ae. cinereus* and *Ae. excrucians* had a larger percentage occurrence in the fauna caught in light-traps than by the sweep-net and *Ae. punctor* and *Ae. communis* had clearly a much smaller occurrence. In the nocturnal fauna 5 species represented about 95% of the whole fauna, on the other hand in the diurnal fauna only 4 species.

In the second period of the investigations it was evident that the light-traps caught more species (8 species in the nightlong catches and 11 species in the hourly catches) than the sweep-net (7 species). Only 6 species (*Ae. maculatus*, *Ae. excrucians*, *Ae. cinereus*, *Ae. punctor*, *C. pipiens* and *A. maculipennis*) were common to all the three methods of catching. Besides the occurrence of males was more prominent in the nocturnal catches than in diurnal ones. In the diurnal catches 3 species (according to their percentage occurrence *Ae. maculatus*, *Ae. punctor*, *Ae. cinereus*) and in the nocturnal catches 5 and 6 species (hourly catches – *Ae. maculatus*, *C. pipiens*, *Ae. cinereus*, *Ae. vexans*, *Ae. punctor*; nightlong catches – *C. pipiens*, *Ae. maculatus*, *Th. annulata*, *A. maculipennis*, *Ae. cinereus*, *Ae. punctor*) represented about 95% of the whole mosquito fauna. Differences in the specific structure of the diurnal and nocturnal mosquito fauna consisted mainly in a larger percentage occurrence in the latter of *Ae. maculatus* and *Ae. punctor* species, and a significantly lesser occurrence of *C. pipiens* and the lack in the diurnal mosquito fauna of the six species caught at night.

It may follow from this that the mosquito fauna caught in light-traps is characterized by a larger occurrence of males in it and on the whole by a greater number of species. More species formed there the basic number of mosquitoes than it was observed in the fauna which stayed during the day in the undergrowth and understorey. Towards the end of the season and when the

number of mosquitoes caught with the help of the sweep-net decreased these differences became more visible. In the nocturnal fauna a much larger, than in the diurnal fauna, percentage occurrence of *Ae. excrucians* and *C. pipiens* species and much smaller of *Ae. punctor* and *Ae. communis* species was quite evident. *A. claviger* species was not caught in light-traps at all.

It is quite a surprising fact that there were also differences between the two variants of catches carried out in light-traps (Tab. I). The hourly catches provided with a larger number of mosquitoes and a larger number of species than nightlong light-traps but at the same time they showed a smaller occurrence of males in the caught mosquito fauna. The percentage occurrence of individual species was in both these types of fauna different and an analysis of their abundancy has shown that it was caused by differences in the catch of the two most numerous species: a much smaller catch of *Ae. maculatus* in the nightlong light-traps (twenty times smaller) and a larger one of *C. pipiens* than in the hourly light-traps (two and a half time larger).

The vertical distribution of mosquitoes at night in forest environment

The analysis of the vertical distribution of mosquitoes in forest was carried out on the material gained from both these types of light-traps. In spite of differences in catching both these methods illustrate some interesting general regularities in the course of this phenomenon.

Percentage occurrence of the whole mosquito fauna, males and females at four levels

Tab. II

		Levels			
		L4	*L3*	*L2*	*L1*
Nightlong light-trap catches	whole of the fauna	7.2	34.8	34.8	23.2
	♂ ♂	5.7	35.2	36.9	22.2
	♀ ♀	9.6	33.4	30.6	26.4
Hourly light-trap catches	whole of the fauna	16.0	26.3	29.9	27.8
	♂ ♂	20.6	23.8	36.5	19.1
	♀ ♀	14.4	26.6	27.6	31.4

The smallest number of mosquitoes was caught at the highest level (*L4*), i.e. above the canopy (Tab. II). In the nightlong catches the two medium levels *L2* and *L3* (below the canopy and mid-canopy) were the most attractive both

for males and females. In the hourly catches this type of vertical distribution was shown by males; for females all three levels (excepting level *L4*) were equally attractive. These results deviate from those obtained by Corbet (1961) in rain-forest of Uganda with hourly catches. He stated that common species of mosquitoes are most active in the canopy and above the canopy. On the other hand he did not state any differences in the vertical distribution of males and females with the sole exception of *Mansonia fuscopennata* species, males of which are most active above the canopy and females are equally active both at ground level and at higher levels of forest.

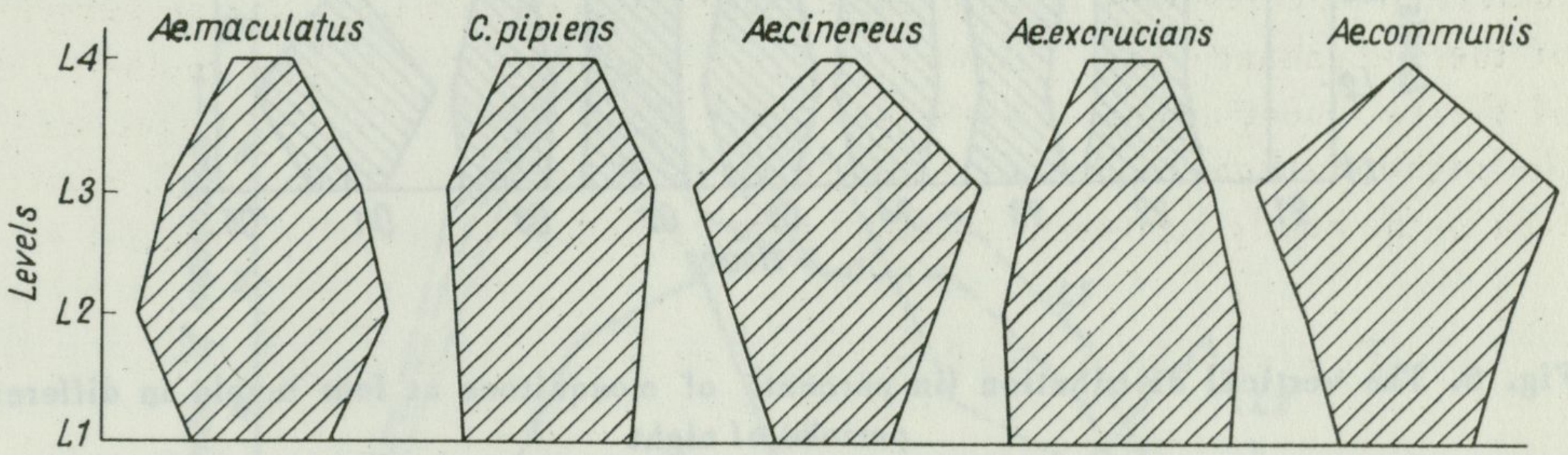

Fig. 4. The vertical distribution (in percent) of the five common species (nightlong light-trap catches)

Different species in a different degree have their preferences to individual levels (Fig. 4 and 5). *Ae. cinereus* and *Ae. communis* species quite clearly avoided level *L4* and crowded in level *L3*; and so they gladly stayed at night in mid-canopy and only in an insignificant degree flying above the canopy. Further on *Ae. maculatus* and *Ae. excrucians* were more numerous in lower levels with some preference for the sphere below the canopy. On the other hand *C. pipiens* dominated in a larger degree than any other species in the highest level *L4* and this fact was confirmed by both the types of light-trap catches.

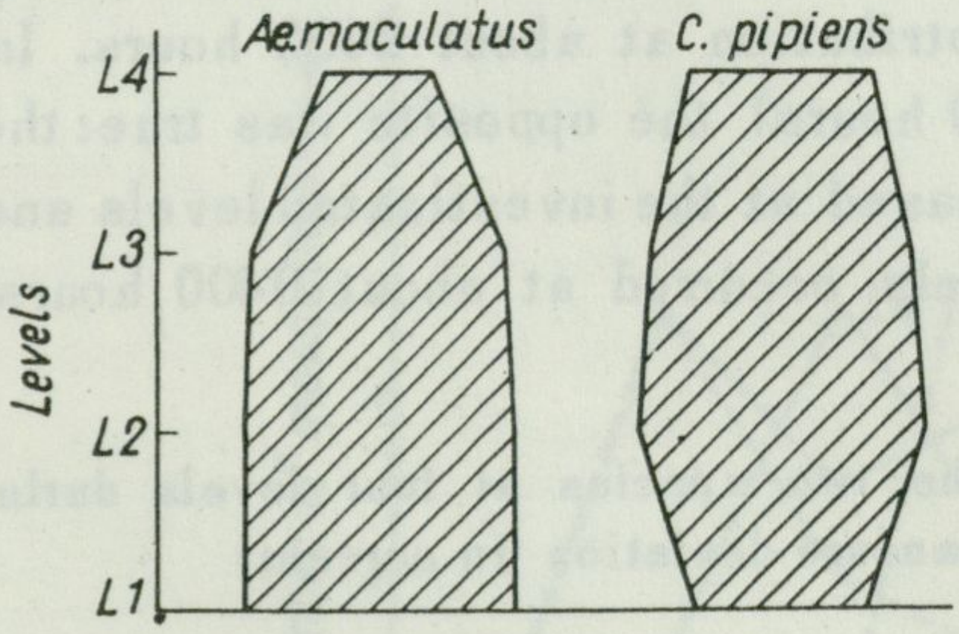

Fig. 5. The vertical distribution (in percent) of the two common species (hourly light-trap catches)

It follows from the investinvestigations that mosquito abundancy at different levels underwent regular changes at night (Fig. 6). In the first period of night when mosquitoes began to be caught in light-traps (at about 2200 hours) the majority of mosquitoes occurred at level *L1*. After this period (2300, 2400 and 0100 hours) they began to dominate

higher regions including the highest level *L4*. In the second part of night (0200 and 0300 hours) an opposite situation was observed. Mosquitoes began to move downward and at dawn (at about 0400 hours) they were dominating numerically at levels *L1* and *L2*. It is a period just before a complete movement of mosquitoes downward into the undergrowth and shrub layer to their daytime resting places.

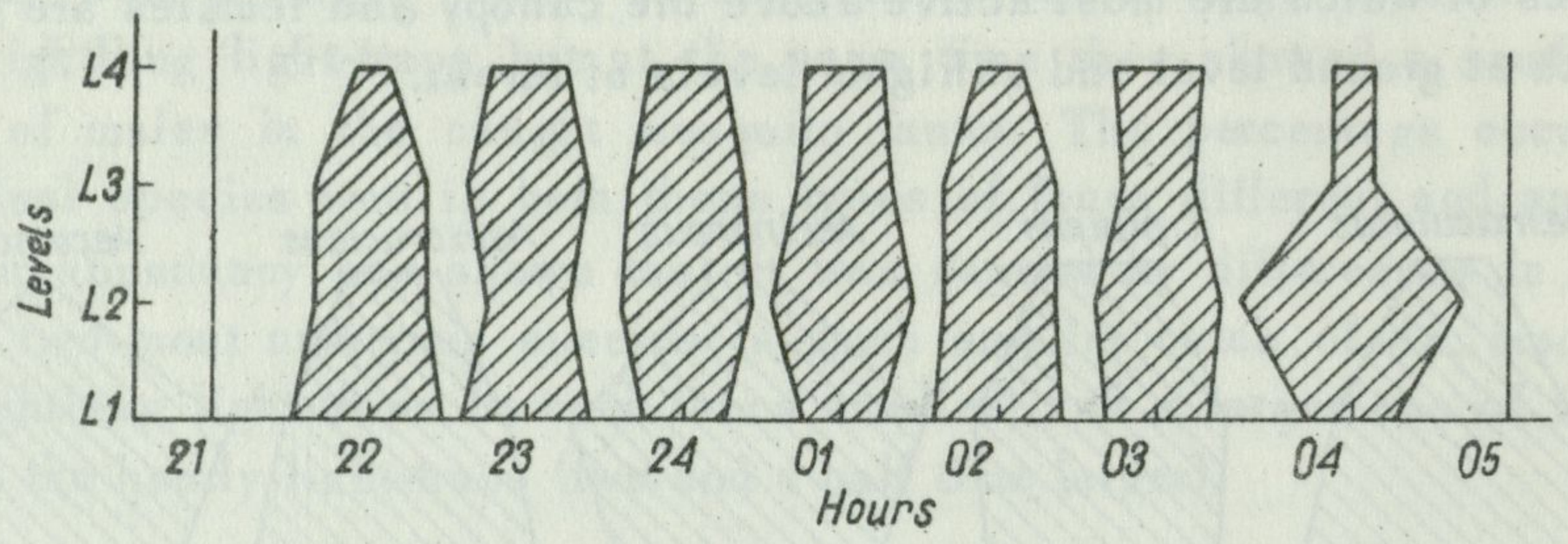

Fig. 6. The vertical distribution (in percent) of mosquitoes at four levels in different periods of night

In the hourly catches only two species. *Ae. maculatus* and *C. pipiens* were being caught in a sufficient degree to enable an analysis of the way of their vertical distribution at night. It follows from the investigations that the regularity of the vertical distribution of these species at the levels (expressed by the standard deviation) changed considerably at night (Tab. III). *Ae. maculatus* in the first part of night (2100 hours to 2300 hours) gradually increased the uniformity of its quantitive distribution at the investigated levels reaching the highest degree of uniformity of this distribution at about 2400 hours. In the second part of night (0100 hours to 0400 hours) the opposite was true: the uniformity of the distribution gradually decreased at the investigated levels and the highest degree of differentiation of levels occurred at about 0400 hours.

Uniformity of the quantitative distribution of the two species at four levels during the night, expressed by the values of standard deviation (in percent)

Tab. III

Species	Hours								
	21	22	23	24	01	02	03	04	05
Ae. maculatus	–	62.1	28.0	14.2	54.1	39.8	48.5	158.7	–
C. pipiens	–	86.0	83.2	82.4	22.8	54.8	81.7	113.0	–

C. pipiens dominated the investigated levels with a much less regularity than *Ae. maculatus*. However, like with the latter, in the first half of night the degree of distribution uniformity of *C. pipiens* increased at these levels reaching the highest degree of its uniformity later than *Ae. maculatus* because at about 0100 hours (Tab. III). After this period followed a much stronger differentiation of the levels.

The abundancy changes of these species at the levels at night (Fig. 7 and 8) indicate differences in the domination of individual layers of forest by each

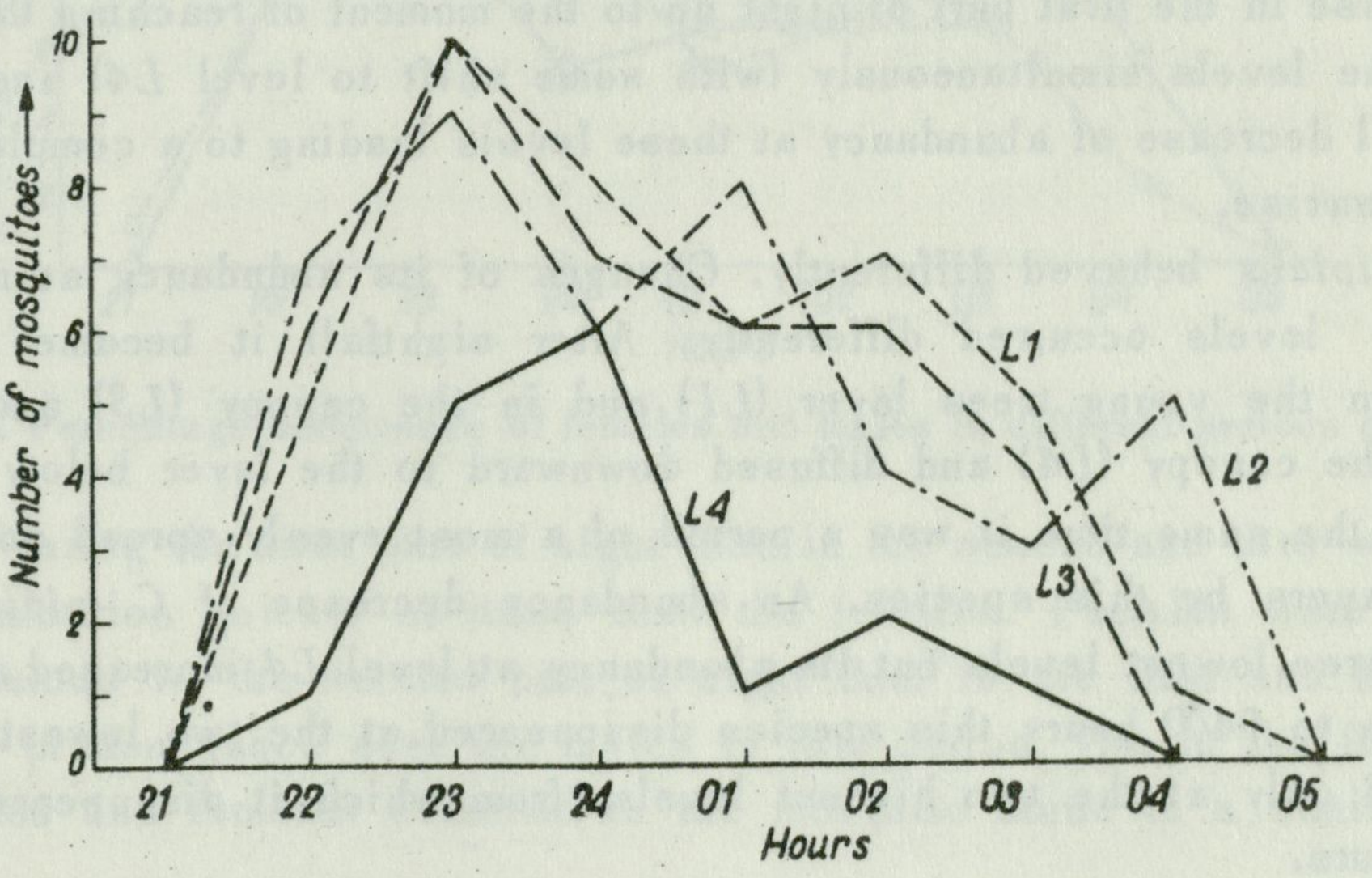

Fig. 7. Variations in number of *Ae. maculatus* at four levels at night

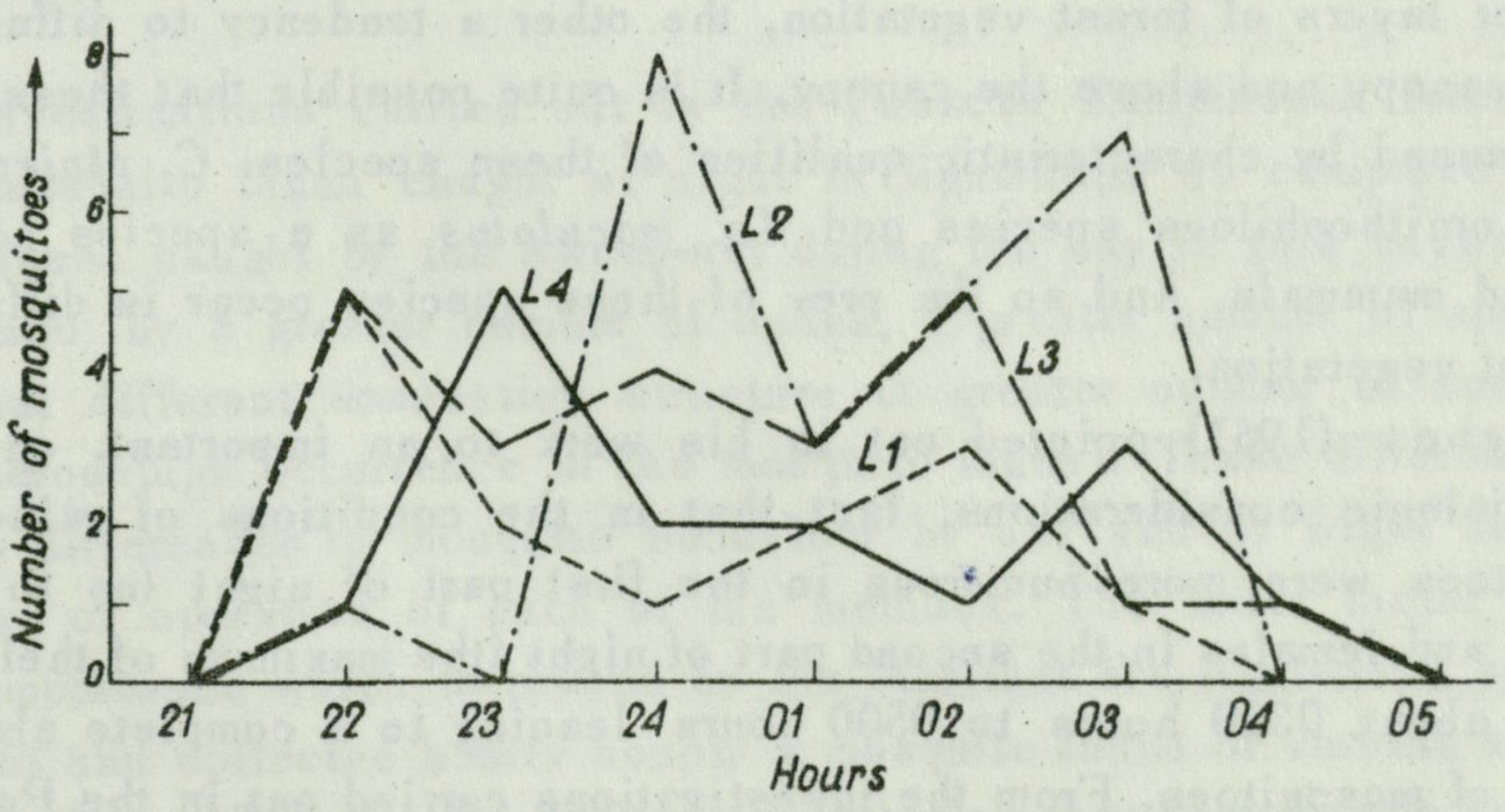

Fig. 8. Variations in number of *C. pipiens* at four levels at night

of them. *Ae. maculatus* in the first period of night quickly dominated levels *L1*, *L2* and *L3* reaching the maximum abundancy at them at about 2300 hours (Fig. 7). At the highest level above the canopy this species occurred less

numerously and the increase of its abundancy was much slower. Some levelling off of the *Ae. maculatus* abundancy at the investigated levels occurred at about 2400 hours. After that a decrease of this species' abundancy followed, quicker at the highest level and slower at the other levels. For the longest time *Ae. maculatus* stayed at levels *L1* and *L2*, i.e. the layer of young trees and below the canopy. In the case of *C. pipiens* such a clear picture of abundancy changes at these levels was not obtained and a general picture of these changes at night was different from *Ae. maculatus* (Fig. 8). As for the latter a considerable similarity of its abundancy changes was observed at all levels; quick abundancy increase in the first part of night up to the moment of reaching the maximum at all the levels simultaneously (with some shift to level *L4*) and after that a gradual decrease of abundancy at these levels leading to a complete liquidation at sunrise.

C. pipiens behaved differently. Changes of its abundancy at night at individual levels occurred differently. After nightfall it became more active mainly in the young trees layer (*L1*) and in the canopy (*L3*) and then flew above the canopy (*L4*) and diffused downward to the layer below the canopy (*L2*). At the same time it was a period of a most evenly spread domination of forest layers by this species. An abundancy decrease of *C. pipiebs* started at the three lowest levels but its abundancy at level *L4* increased at the same time. Up to 0400 hours this species disappeared at the two lowest levels and remained only at the two highest levels, from which it disappeared at about 0500 hours.

And so *Ae. maculatus* and *C. pipiens* species showed different ways of distributing in forest at night. The first showed an evident tendency to staying in lower layers of forest vegetation, the other a tendency to diffusing upward to the canopy and above the canopy. It is quite possible that these differences were caused by characteristic qualities of these species. *C. pipiens* is known as an ornithophilous species and *Ae. maculatus* as a species attacking the man and mammals. And so the prey of these species occur in different layers of forest vegetation.

Corbet (1961) pointed out in his work to an important, on account of epidemiologic considerations, fact that in the conditions of rain-forest male mosquitoes were more numerous in the first part of night (up to about 2400 hours), and females in the second part of night (the maximum of their abundancy fell at about 0300 hours to 0500 hours) leading to a complete abundancy decrease of mosquitoes. From the investigations carried out in the Puszcza Kampinoska forest (Fig. 6) follows that the period of nocturnal flight activity is much shortened (from 2100 hours to 0400 hours) as compared with rain-forest (1800 hours to 0600 hours). Differences in male and female abundancy in different periods of night in the conditions of the Kampinos Forest were not very

clear. During the period of the greatest abundancy of males (from 16th July to 7th August) one could ,observe a similar distribution of the caught mosquitoes' abundancy (Fig. 9) to the one found in rain-forest. Males were more

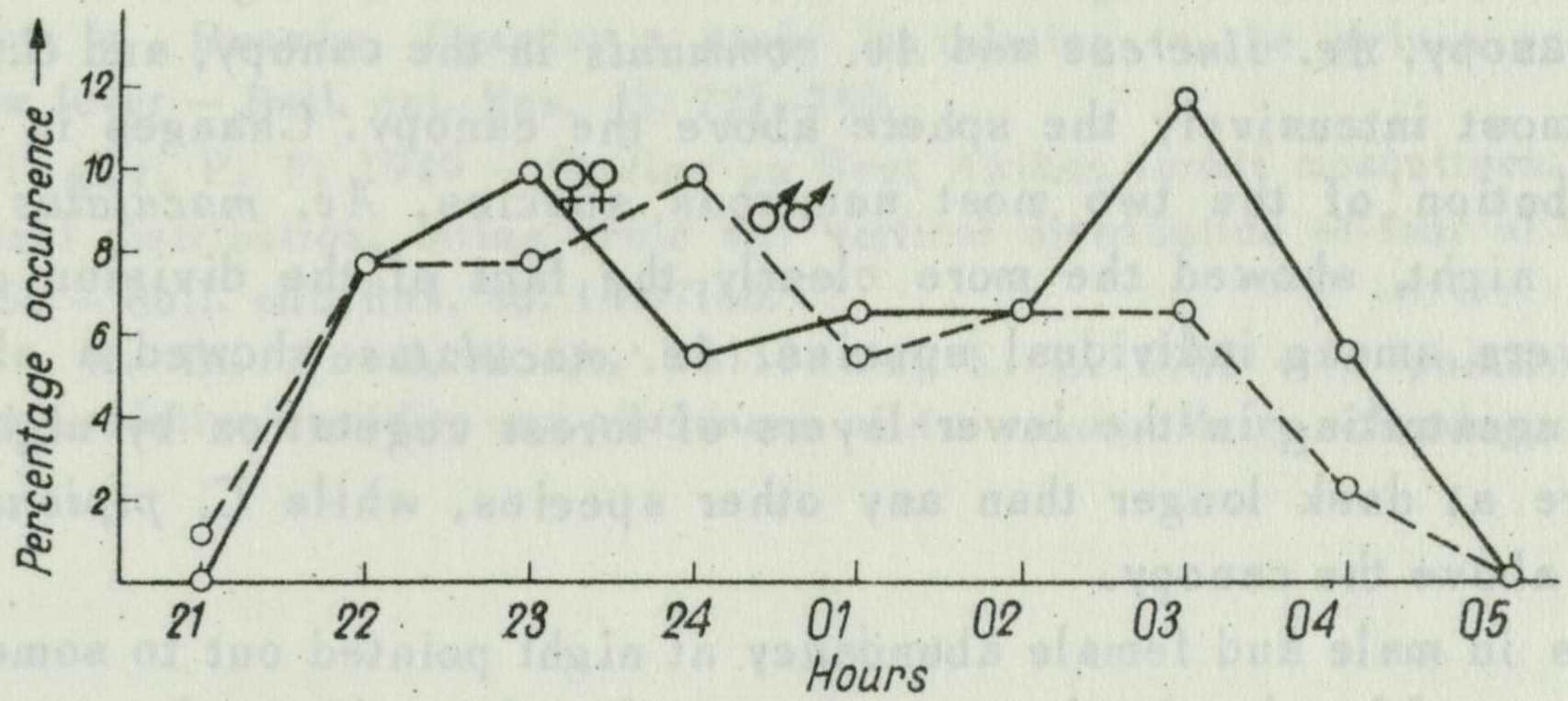

Fig. 9. Percentage occurrence of females and males in different periods of night

numerous during the first part of night than in the second and they were undergoing liquidation quicker at dawn than the females. Females were somewhat more numerous in the second part of night than in the first and hence their numerical predominance over the males in this period. But in the first part of night males and females occurred in the mosquito fauna in a similar degree.

SUMMARY

The investigations carried out in the Puszcza Kampinoska forest proved that the mosquito fauna caught at night in light-traps as compared with the mosquito fauna caught by the sweep-net during the day in this environment is characterized by a greater number of males, a greater number of species and a somewhat different domination structure (a greater number of species had a larger percentage occurrence in the mosquito fauna). These differences were caused by differences in mosquito behaviour by day and by night and by the specificity of operation of each of the methods. The latter factor may have quite an importance which is proved by the fact that the light-traps set for the whole night and collected hourly supply a mosquito fauna of varying abundancy, species number and structure. It is an interesting fact that hourly collections of catches from light-traps increased significantly the occurrence of *Ae. maculatus* species in the mosquito fauna and increased the occurrence of *C. pipiens*.

The investigated forest layers differed both in the abundancy of mosquitoes and in the degree of preference showed by individual species. The

smallest results in catching mosquitoes were achieved at the highest of the investigated levels, i.e. above the canopy. The most numerous males were found in the sphere above the canopy and in mid-canopy and the females were equally numerous also in the young trees layer. Some differences in the degree of domination of the forest layers by individual species were stated. *Ae. maculatus* and *Ae. excrucians* were most numerous in the young trees layer and below the canopy, *Ae. cinereus* and *Ae. communis* in the canopy, and *C. pipiens* dominated most intensively the sphere above the canopy. Changes in the vertical distribution of the two most numerous species, *Ae. maculatus* and *C. pipiens*, at night, showed the more clearly the fact of the division of forest vertical layers among individual species. *Ae. maculatus* showed a clear tendency to concentrating in the lower layers of forest vegetation by night and it stayed there at dusk longer than any other species, while *C. pipiens* in the canopy and above the canopy.

Changes in male and female abundancy at night pointed out to some quantitive advantage of females in the second part of night and to a longer, than the males, stay in the environment during the morning hours.

REFERENCES

1. Bates, M. 1944 – Observation on the distribution of diurnal mosquitoes in a tropical forest – Ecology 25: 159–170.
2. Beklemišev, V.N. 1934 – Sutočnye migracii bezpozwonočnych w komplekse nazemnych biocenozov – Trudy Perm. Inst. 6.
3. Corbet, P.S. 1961 – Nocturnal flight activity of *Culicidae* and *Tabanidae* as indicated by light-traps – Trans. R. ent. Soc. London 113: 301–314.
4. Corbet, P.S. 1964 – Nocturnal flight activity of sylvan *Culicidae* and *Tabanidae* (*Diptera*) as indicated by light-traps: a further study – Proc. R. ent. Soc. London, A 39: 53–67.
5. Corbet, P.S., Haddow, A.J. 1961 – Observations on nocturnal flight activity in some African *Culicidae* (*Diptera*) – Proc. R. ent. Soc. London A, 36: 113–118.
6. Dąbrowska-Prot, E. 1964 – Communities of mosquitoes in three types of forest land – Ekol. Pol. A 12: 737–783.
7. Elton, Ch., Miller, R. 1954 – The ecological survey of animal communities with a practical system of classifying habitats by structural characteres – J. Ecology 42: 460–496.
8. Haddow, A.J. 1945 – The mosquitoes of Bwama County, Uganda. III. The vertical distribution of mosquitoes in a banana planation and the biting cycle of *Aedes* (Stegomyia) *simpsoni* Theo. – Bull. ent. Res. 36: 297–304.
9. Haddow, A.J. 1954 – Studies of the biting-habits of African mosquitoes. An appraisal of methods employed, with special reference to the twenty-four-hour catch – Bull. ent. Res. 45: 199–242.
10. Haddow, A.J. 1961 – The biting behaviour of mosquitoes and tabanids – Trans. R. ent. Soc. London 113: 315–335.

11. Haddow, A. J., Gillett, J. D., Highton, R. B. 1947 – The mosquitoes of Bwamba County, Uganda. V. The vertical distribution and biting cycle of mosquitoes in rain-forest, with further observation of microclimate – Bull. ent. Res. 37: 301–330.
12. Haddow, A. J., Mahaffy, A. F. 1949 – The mosquitoes of Bwamba County, Uganda. VII. Intensive catching on tree-platforms with further observation on *Aedes africanus* (Theob.) – Bull. ent. Res. 40.
13. Lumsden, W. H. R. 1952 – The crepuscular biting-activity of insects in the forest canopy in Bwamba, Uganda; a study in relation to the sylvan epidemiology of yellow fever – Bull. ent. Res. 42: 721–760.
14. Mattingly, P. F. 1949 – Studies on West Afrikan forest mosquitoes. Part I. The seasonal distribution, biting cycle and vertical distribution of four of the principal species – Bull. ent. Res. 40: 149–168.
15. Platt, R. B., Love, G. J., Williams, E. L. 1958 – A positive correlation between relative humidity and abundance of *Ae. vexans* Meig. – Ecology 39:167–169.

ZMIANY PIONOWEGO ROZKŁADU KOMARÓW W ŚRODOWISKU LEŚNYM

Streszczenie

Badania prowadzono od czerwca do września 1964 r. w Puszczy Kampinoskiej. Połowy nocne komarów pułapkami świetlnymi dokonywano na 14 metrowej wieży na czterech poziomach: ponad koronami drzew (poziom *L4*), w koronach drzew (*L3*), tuż pod koronami drzew (*L2*) oraz w warstwie młodych drzewek (*L1*). Zastosowano dwa warianty połowów pułapkami świetlnymi: wybierano je po skończonym połowie o świcie lub co godzinę w ciągu całej nocy.

Ponadto w ciągu dnia dokonywano wokół wieży połowów czerpakowych, wyławiając w ten sposób komary z ich kryjówek dziennych w runie i krzakach.

W wyniku przeprowadzonych badań stwierdzono, że:

1. Fauna komarów łowiona nocą pułapkami świetlnymi, w porównaniu z fauną dzienną łowioną czerpakiem, charakteryzowała się większą liczbą gatunków i wiekszą ilością samców; więcej gatunków tworzyło podstawową masę komarów (około 95% całej ilości fauny).

2. Fauna komarów łowiona pułapkami świetlnymi wybieranymi co godzinę różniła się od fauny wybieranej o świcie większą liczebnością komarów, większą liczbą gatunków, ale równocześnie mniejszym udziałem samców. Procentowe udziały poszczególnych gatunków były w obu typach połowów różne, a wynikało to głównie z powodu 20-krotnie mniejszego połowu *Ae. maculatus*, a 2,5-krotnie liczniejszego połowu *C. pipiens*, w pułapki całonocne.

3. Poszczególne poziomy były w różnym stopniu atrakcyjne dla komarów. Najsłabiej były łowione komary na najwyższym poziomie ponad koronami drzew (*L4*). Dla samców najatrakcyjniejsza była strefa pod koronami drzew i w koronach drzew (*L2*, *L3*), dla samic wszystkie trzy poziomy, poza najwyższym, były również atrakcyjne (*L1*, *L2*, *L3*).

4. Różne gatunki związane były w różnym stopniu z poszczególnymi poziomami. *Ae. maculatus* i *Ae. excrucians* wybierały wyraźnie dolne poziomy (*L1*, *L2*), *Ae. cine-*

reus i *Ae. communis* chętniej przebywały w ciągu nocy w koronach drzew (*L 3*), natomiast *C. pipiens* w największym ze wszystkich gatunków stopniu uprzywilejowywał strefę ponad koronami drzew (*L 4*).

5. Liczebność komarów na poziomach ulegała prawidłowym zmianom w ciągu nocy. W pierwszym okresie nocy najwięcej komarów występowało w najniższym poziomie (*L 1*). Następnie (godziny 23, 24, 1^{oo}) przechodziły do wyższych poziomów. W drugiej połowie nocy (godzina 2, 3^{oo}) zaczynały skupiać się na niższych poziomach i nad ranem ograniczały swoje występowanie głównie do poziomu *L 1* i *L 2*.

6. Dwa najliczniejsze w połowach cogodzinnych gatunki *Ae. maculatus* i *C. pipiens* w różny sposób zmieniały w ciągu nocy pionowy rozkład. *Ae. maculatus* znacznie równomierniej niż *C. pipiens* opanowywał badane poziomy. Oba gatunki w pierwszej połowie nocy stopniowo zwiększały równomierność rozkładu pionowego (mierzoną odchyleniem standardowym), przy czym *Ae. maculatus* osiągał maksymalną równomierność tego rozkładu około godziny 24^{oo} a *C. pipiens* nieco później bo około 1^{oo}. W drugiej połowie nocy zachodziło zjawisko odwrotne: stopniowo zwiększały nierównomierność rozkładu, skupiając się na pewnych poziomach.

Szczegółowa analiza zmian liczebności tych gatunków na poszczególnych poziomach wykazała, że *Ae. maculatus* w pierwszej połowie nocy szybko opanował poziomy *L 1*, *L 2*, *L 3*, osiągając na nich maksymalną liczebność. Na najwyższym poziomie gatunek ten występował mniej licznie i znacznie powolniej wzrastała tam jego liczebność. Pewne wyrównanie jego liczebności na poziomach następowało około godziny 24^{oo}, a następnie obserwowano stopniowy spadek liczebności tego gatunku, szybszy na najwyższym poziomie, słabszy na pozostałych. Najdłużej utrzymywał się na poziomach *L 1* i *L 2* czyli w warstwie młodych drzewek i pod koronami drzew.

Ogólny obraz zmian liczebności *C. pipiens* na poziomach w ciągu nocy był inny niż u *Ae. maculatus*. Po zapadnięciu zmroku gatunek ten uaktywniał się przede wszystkim w warstwie młodych drzewek (*L 1*) i w koronach drzew (*L 3*), a dopiero później opanowywał pozostałe poziomy. Maksymalną liczebność osiągał na poszczególnych poziomach w różnych okresach nocy, natomiast *Ae. maculatus* równocześnie na wszystkich poziomach. Spadek jego liczebności w drugiej połowie nocy zaczynał się na trzech niższych poziomach i w tym samym czasie wzrastała jego liczebność na najwyższym poziomie. Najdłużej utrzymywał się na dwóch wyższych poziomach (*L 3* i *L 4*), skąd znikał dopiero około godziny 5^{oo}.

Tak więc *Ae. maculatus* wykazywał wyraźną tendencję do przebywania w ciągu nocy w niższych warstwach roślinności lasu, a *C. pipiens* do wylatywania w górę w korony drzew i ponad nie. Możliwe, że przyczyną takiego rozkładu pionowego tych gatunków w ciągu nocy jest występowanie w różnych warstwach roślinności lasu najczęstszych ich ofiar – *C. pipiens* znany jest jako gatunek ornitofilny a *Ae. maculatus* jako gatunek napadający na człowieka i ssaki.

7. Zmiany liczebności samic i samców w ciągu nocy wskazywały na pewną ilościową przewagę samic w drugiej połowie nocy. Ponadto samice dłużej niż samce utrzymywały się w wyższych warstwach roślinności lasu w godzinach rannych.

AUTHOR'S ADRESS:
Dr. Eliza Dąbrowska-Prot,
Institute of Ecology, Warszawa, ul. Nowy Świat 72, Poland.