

Ethology and features of the trophic activity of blood-sucking mosquitoes (Diptera, Culicidae) in the southern taiga of the Tyumen region

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In the Tyumen region (Russia), the daily rhythm of mosquitoes' trophic activity in terms of comparing the number of individuals attacking humans and animals and the distribution of mosquitoes near cattle herds has not been studied before. The research was carried out in the sub-zone of the southern taiga forest zone of the Tyumen region in 2016-2017. The southern taiga has a high level of blood-sucking mosquitoes. In June, under the canopy of the forest, the animals are subjected to a massive round-the-clock attack, but in the daily rhythm of the trophic activity of these insects there are evening (at 23 hours) and morning (at 3-7 hours) rises in numbers. At the end of July, the daily rhythm has a high evening rise in numbers (at 21-23 hours) and a slight morning (at 5-7 hours). In open pastures, mosquito activity is less long and is characterized by one large maximum in the evening. Mosquitoes attacked animals in open areas only at night from 23 to 7 hours. The number of mosquitoes attacking calves in open areas was low and lower than the average of 2.2 ± 0.23 times per person. The nature of the daily rhythm of trophic activity of flying hematophages leaves its mark on the behavior of animals and their preference for certain biotopes on the pasture. With the number of mosquitoes observed during the day in the forest (from 2 to 32 individuals), calves preferred to graze in the open area, even with a high number of horseflies, only periodically hiding in more often shrubbery for a short time. At night, the calves are kept in the paddock, snuggling up to each other, which allows to some extent to limit the number of attacking insects. In the paddock during the night rest of the animals the largest number of mosquitoes (over 66%) flies directly near the calves at an altitude from the ground up to 1.9 meters, but single individuals are found at an altitude of more than 4 meters, a distance of 5-7 meters from calves the number of mosquitoes decreases twice, and 25-30 meters - 4 times. The high concentration of mosquitoes around the animals indicates the advisability of taking protective measures against their attack when keeping calves in open pens on pastures in the evening, when keeping animals at night in premises, treatment with repellents and insecticides should be carried out in the morning before pasture. This will allow to ensure calm and free behavior of animals during grazing and a wider coverage of various pasture biotopes.

Keywords: Culicidae, blood-sucking mosquitoes, trophic activity, southern taiga, young cattle.

Introduction

Blood-sucking mosquitoes (Diptera, Culicidae), like other representatives of Diptera blood-sucking insects, are free-living hematophages, whose females actively attack humans, animals and birds. In areas of developed livestock, their main feeder is cattle. With the high number of Diptera blood-sucking insects there is a strong concern of animals. Painful bites, blood loss, intoxication and debilitating protective movements of animals with a significant reduction in the time of both rest and eating of grass during the mouth, cause the weakening of the body and reduced resistance to various diseases. All this leads to a decrease in the productivity of animals: cows are reduced by 15-30%, the mass gain of young - by 25-40% (Pavlov, Pavlova, 2001).

All this points to the need for animal protection and insect extermination activities based on knowledge of the biological, environmental and etological characteristics of these parasites. One such point is the study of the daily rhythm of trophic activity, the distribution of mosquitoes in the pastures of cattle and the behavior of female mosquitoes when attacking the feeder.

In the Tyumen region, the daily rhythm of mosquitoes' trophic activity in terms of comparing the number of individuals attacking humans and animals and the distribution of mosquitoes near cattle herds has not been studied before. The published works to date have been devoted to the features of the daily rhythm depending on abiotic factors and changes in the species

composition of attacking mosquitoes during the day (Khlyzova, Latkin, 2015; Khlyzova, 2018). In the hardwood and birch forests located south of the sub-zone, the research of V.I. Buktinov (1962, 1966) found that at high levels of numbers, mosquito activity was observed around the clock with a slight increase of 4 hours and a slight increase in 22 hours. At a lower number, the activity curve was 2-top with maximum in the evening and morning hours and in the absence of summer at night and during the day. A similar pattern in the daily rhythm of mosquito activity is observed in the middle taiga of the Tyumen region (Ermakova, 1972), in the middle band of the European part of Russia (Skripchenko, 2000) and in other regions of the forest zone of Siberia (Kukharchuk, 1966, 1972, 1981 (Anufrieva, 1971, etc.).

The aim of the work is to study the daily rhythm of the trophic activity of female mosquitoes attacking humans and animals, and the distribution of mosquitoes near the herd of young cattle in the southern taiga of the Tyumen region.

Research objectives:

- to study the daily rhythm of activity of female mosquitoes attacking a person in the forest and in open areas;
- to identify the features of the rhythm of the mosquito's trophic activity when attacking the calf;
- to study the patterns of mosquito distribution near a herd of young cattle, which is in an open paddock on the pasture.

Materials and methods

Studies to study the daily rhythm of trophic activity of blood-sucking mosquitoes were conducted in the sub-zone of the southern taiga forest zone of the Tyumen region (Russia) in 2017. For this purpose, two points were selected, combining several biotopes: the edge of the aspen-birch forest with a small admixture of pine and an adjacent open area of the meadow. On June 27-28, the accounting was carried out on the pasture of young cattle "Solontsy" Progress LLC, located southeast of the village of Iska, and on July 27-28 - on the pasture of PC "Moloko" near the village of Petrun'kino Nizhnetavdinsky district (fig. 1). On these pastures young cattle were kept around the clock: in the afternoon grazed in the meadow or in the forest, and on night rest was located in open paddocks.



Figure 1. Research area. (<http://www.yandex.com/maps/?ll=66.010694%2C57.625015&z=11.8>).

The number of female mosquitoes attacked was recorded by an entomological net with removable bags (Detinova et al., 1978; Rasnitsyn, Kosovskikh, 1979) during the day at intervals of 2 hours. Each account consisted of 10 swings of the "eight" around him, made in 5 replays. The intensity of the attack or the abundance index (AI) was set on average and maximum. Our research also included comparing the intensity of mosquito attacks on humans and on a calf in open areas and on a person in the forest. Therefore, every 2 hours were carried out on 3 records and thus 36 records (180 fees) were made per day.

In addition, another daily survey was carried out in July 2016, which also compared the number of mosquitoes attacking humans and animals. For research, a paddock of young cattle, located in the camp on the forest pasture "Solontsy" "Progress" LLC is used. In this case, the mosquitoes were also considered with a net, but each accounting, conducted in 2 hours, consisted of 200 swings around itself or a calf at a distance of about 20 meters from the main group of calves. This method of 200 swings in 3 minutes is widely used by the staff of the Institute of Systematics and Ecology of Animals of the Russian Academy of Sciences

(Kukharchuk, 1966, 1969, 1981; Petrozhitskaya, 1987; Mirzaeva, 1989, etc.). A total of 24 records were carried out, 363 mosquitoes were collected. When studying the daily activity of mosquitoes simultaneously, the measurements were measured by light, temperature and relative humidity. In addition, studies were conducted to study the approach of mosquitoes to the herd and distribute them at different distance from the animals, as well as the vertical distribution of the herd, for which ribbons of 10x90 centimeters wide, made of transparent polyethylene were used. One side of each tape was covered with entomological glue "Lipofix". Two series of experiments have been carried out.

The first series studied the vertical distribution of mosquitoes in the herd of calves, with sticky ribbons attached in pairs to the flight and flight at an altitude of 0.1 to 4.15 meters to the rey, nailed to a pole height of 4 meters 15 centimeters. The poles were located on both sides directly next to the herd. In the second series, the distribution of mosquitoes around the herd at a distance of 5-7 and 25-30 meters was studied. Sticky ribbons were also attached to the poles in pairs for the flight and departure at an altitude of 0.1-1.9 meters, with the use of 4 and 7 poles respectively. All experiments were conducted in the late evening from 21-01 hours with an exposure of 2 hours. At this time there was a high number of mosquitoes and wets, so the calves were kept in a dense group and did not wander around the paddock.

Results and discussion

Data on the study of the daily rhythm of trophic activity of female blood-sucking mosquitoes are presented in table 1.

Table 1. Dynamics of the daily rhythm of trophic activity of mosquitoes in the sub-zone of the southern taiga (average in the numerator, and in the denominator the maximum data of 5 re-enacts).

Indicators	Accounting time, hour												Insects caught
	15	17	19	21	23	01	03	05	07	09	11	13	
27- 28 June 2017 (accounting with a net of 10 strokes in 5 replays)													
AI mosquitoes on humans:													
in the forest	25, 1/34	32,4/43	17,8/32	17/25	52,4/71	32,8/37	67,6/93	60,4/82	83,8/110	24,4/31	31,6/55	22,6/32	467,9/645
in an open area	3,6/8 ^x	0/0	0/0	0/0	9,4/16	5,2/14	7,4/10	3,4/8	0,2/1	0,2/1	0/0	0/0	29,4/58
AI mosquitoes on a calf													
in an open area	2,8/6 ^x	0/0	0/0	0,4/1	1,6/3	3,8/5	2/6	2/3	1,8/2	0,4/1	0/0	0,4/1	15,2/28
Air temperature, °C	23,6	23,7	23,2	21,0	15,6	14,4	13,0	12,6	16,0	19,6	21,8	22,2	-
Relative humidity, %	33	40	47	70	94	88	98	95	86	78	72	68	-
Illumination, lux	53000	48000	8500	940	2	0	0	70	8600	53000	51000	38000	-
27 – 28 July 2017 (accounting with a net 10 strokes in 5 replays)													
AI mosquitoes on humans:													
in the forest	11,8/22	25/33	14,8/27	78,8/126	130,8/160	9,4/14	7,6/12	27,4/46	40,2/67	14,2/19	2,8/6	2,4/3	365,2/535
in an open area	0,4/1	0,2/1	1/2	0,6/2	36,2/54	0,4/1	2,4/6	1/2	0,6/1	1/2	0,2/1	0/0	44,0/73
AI mosquitoes on a calf													
in an open area	0/0	0/0	0/0	0/0	9,2/19	0,6/2	1,4/2	0,8/3	2,2/6	0,2/1	0,2/1	0/0	14,6/34
Air temperature, °C	30,0	24,4	25,0	22,2	18,0	16,0	13,6	13,8	16,8	22,4	23,6	26,1	-
Relative humidity, %	48	69	72	90	100,0	100,0	100,0	97	97	74	81	49	-
Illumination, lux	53000	47000	8900	700	0	0	0	410	37000	53000	61000	61000	-
9 – 10 July 2016 (accountings with a net of 200 strokes)													
AI mosquitoes in an open area:													
on humans	0	3	3	0 ^{xx}	57	21	33	89	18	9	2	12	247
on a calf	1	1	0	0	39	17	12	26	6	8	0	6	116
Air temperature, °C	23,8	22,4	21,4	17,8	15,0	12,8	13,1	13,8	14,2	16,8	21,2	21,8	-
Relative humidity, %	56	48	53	98	94	96	96	94	94	82	55	53	-
Illumination, lux	18000	22000	9000	700	5	0	1	480	6000	13000	15000	2000	-

Note: ^{x)} accounts on the edge of the forest

^{xx)} accounts after the rain

Studies have shown that during the mass flight in June - July under the canopy of the forest mosquitoes attacked people around the clock. In June, the largest number was observed at 23 and from 3 to 7 hours, with a short-term decrease in their activity at 1 hour of the night, when it was at the level of the day. The morning rise in mosquito numbers was more intense and longer than the evening rise: AI reached 84 and 52 individuals, respectively. At the end of July, there were also 2 maximums in the 24-hour attack of mosquitoes: at 21-23 hours and at 5-7 hours. In terms of duration, both increases were the same, and the intensity of the attack evening (AI - 131) was 3.3 times higher than the morning (AI - 40). At night (from 1 to 3 hours) the number of mosquitoes remained low, amounting to 8-9 individuals on the record, during the daytime it varied from 2 to 25 individuals. However, even at this level of numbers during the day calves did not enter the forest. Due to the abundance of horseflies, they kept crowded together, in an open, wind-blown area. Sometimes, some calves, bothered by blinds, went into the forest, but after staying there for 10-15 minutes, ran out into the meadow to the main group, trying to squeeze between the animals and get to the center of the herd. you know, the intensity of mosquito attack in the center of the herd is 2 times lower than on the periphery (Konstantinov, 1990).

Analyzing the meteorological conditions in the June accounting, it can be noted that the temperature observed during the morning rise of the population from 12.6 to 16 °C and relative humidity from 86 to 98% were favorable for summer mosquitoes. Evening maximum trophic activity of mosquitoes in June and July was observed after dark, and morning with sunrise. The decline in numbers at night and morning at the end of July was due to heavy fog, when nothing was visible at a distance of 50 meters, and the relative humidity reached 100%.

In open areas, the number of mosquitoes in comparison with the forest was much lower. Thus, if in the forest in the first accounting on the average data was caught 46.8, and in the second - 365 mosquitoes, in the open area - 29 and 44, or less in

16.1 and 8.3 times, respectively. According to the total data of the maximum accounts, this difference was multiples of 11.1 and 7.3, and on average it was 10.7 ± 1.97 times.

The daily dynamics of flying mosquitoes in the open area in June was characterized by prolonged night activity (from 23 to 5 hours) and the absence of attack during the day, with the maximum activity observed at 23 hours. In July, high activity of mosquitoes was noted only at 23 hours, and the rest of the day their number was very low, and in the records there were isolated individuals.

Data from the three daily records showed that in open areas, the number of mosquitoes attacking calves was low and lower than per person. Comparison of total accounting data showed that this difference varied from 1.93 to 2.93 times and amounted to an average of 2.2 ± 0.23 times. Records carried out on animals in open areas showed that mosquitoes attacked only at night from 23 to 7 hours with almost no daytime.

The results of studies of the characteristics of mosquitoes flying and their distribution near the herd are presented in table 2. Near animals' mosquitoes fly at different heights, sometimes rising above 4 meters. The maximum number of them is up to 1.9 meters. Thus, out of 237 caught with sticky ribbons of mosquitoes 66.2% (157 individuals) flies at altitudes up to 1.9 meters, 28.3% (67 individuals) or 2.3 times less at altitude from 1.9 to 3.25 meters and only 5.5% (13 individuals) are higher. The absence of differences in the number of hungry mosquitoes flying and leaving animals indicates a chaotic flight in the territory of the corral and the absence of visible targeted approach to animals.

Table 2. Mosquito distribution near herd of young cattle in a paddock on a forest pasture.

Height, cm	Mosquitoes sampling, distance from the calves								
	Arrival	0 m flying away	total	Arrival	5-7 m flying away	total	arrival	25-30 flying away	total
10-55	16/3 ^x	21/3 ^x	37/6 ^x	10/2 ^x	17/4 ^x	27/6 ^x	5/1 ^x	8/1 ^x	13/2 ^x
55-100	5	15	20	11/2 ^x	8/3 ^x	19/5 ^x	3/1 ^x	5/2 ^x	8/3 ^x
100-145	30	21	51	6/2 ^x	5/2 ^x	11/4 ^x	7/2 ^x	3	10/2 ^x
145-190	31	18/4 ^x	49/4 ^x	5/3 ^x	11/3 ^x	16/6 ^x	3	6	9
Total individuals	82/3 ^x	75/7 ^x	157/10 ^x	32/9 ^x	41/12 ^x	74/21 ^x	18/4 ^u	22/3 ^x	40/7 ^x
On average, on record	20,5±6,2	18,8±1,4	19,6±3,6	8±1,5	10±2,6	9,0±1,7	4,5±0,9	5,5±1	5,0±0,1
190-235	7	11/5 ^x	18/5 ^x	-	-	-	-	-	-
235-280	7	19/3 ^x	26/3 ^x	-	-	-	-	-	-
280-325	13	10	23	-	-	-	-	-	-
325-370	3	7	10	-	-	-	-	-	-
370-415	1	2	3	-	-	-	-	-	-
Individuals caught	31	49/8 ^x	80/8 ^x	-	-	-	-	-	-
On average, on record	6,2±2,1	9,8±2,3	8,0±2,1	-	-	-	-	-	-

Note: ^x) of them, mosquitoes that have been blood-stained

The average number of mosquitoes in the account of sticky tape at an altitude of 0.1 to 1.9 meters directly near the animals was 19.6 individuals. Mosquitoes are relatively smaller than animals. At a distance of 5-7 meters from the calves on the account at the same height stuck on average 9 individuals or 2 times less. At a distance of 25-30 meters from the herd of mosquitoes becomes even smaller. The average catch in the account on the tape was 5.5 individuals or almost 4 times less than about the herd. Consequently, the main number of mosquitoes in the paddock is concentrated near the animals at an altitude from the ground up to 1.9 meters.

Analysis of the distribution of female mosquitoes, drunk with blood, in the records of sticky tapes showed that they occur at an altitude of up to 2.8 meters. Among the mosquitoes caught in all experiments at an altitude of 0.1 to 1.9 meters, the number of which was 270, with blood was 38 individuals or 14.1%. At the same time, there were 6.4% of them directly near the animals, 28.8% at a distance of 5-7 meters, and 17.5% in 25-30 meters compared to the total number of mosquitoes caught at these distances from the herd. The results indicate that the blood-pumping mosquitoes near the animals do not linger and gradually dissipate. Installation of sticky ribbons on the flight (glue on the opposite side of the animals) and departure (glue directed to animals) in relation to the herd of calves showed that directly near the herd on departure stuck mosquitoes with blood twice more than on the fly. At a distance of 5-7 meters this difference was 1.3 times, and the number of them was equalized at a distance of 25-30 meters. Thus, with general chaotic movement, the flight of the pumped blood of mosquitoes is directed away from the animals.

Conclusion

In the sub-zone of the southern taiga of the Tyumen region, there is a high level of blood-sucking mosquitoes actively attacking humans and cattle. During the mass flight in June under the canopy of the forest, the animals are subjected to their mass attack during the round of the day, but in the daily rhythm of trophic activity these insects are observed in the evening (at 23 hours)

and morning (at 3-7 hours) rises in numbers. In the second half of July in the daily rhythm there is a high evening rise in numbers (at 21-23 hours) and a slight morning (at 5-7 hours).

In open areas where mosquito numbers are 10 times lower, trophic activity is less long and is characterized by one large maximum in the evening with prolonged night activity and almost complete absence of flying during the daytime.

Our dependence on the duration of the trophic activity of mosquitoes on numbers is reflected in the works of V.I. Buxhtinov (1962, 1966), G.N. Volik (1967), R.M. Ermakova (1972) and other researchers, namely, the higher the number, the longer the activity of females during the day.

The activity of mosquitoes, as well as other insects, changes throughout the day and due to the continuous influence of periodically changing external factors and mainly, light and temperature. At relatively high night temperatures (not below 13 °C, the main factor limiting the intensity and duration of activity at this time is heavy fogs with an increase in relative humidity of up to 100%. There was no negative effect of the temperature from 12.6 to 30 °C, recorded during the recordings, on the flight of mosquitoes, was not revealed. V.B. Chernyshev (1981) notes that in the daily rhythm of twilight flying insects the most pronounced dependence on light, with which our research is quite consistent. According to A.S. Monchadsky (1946a, 1950, 1956, 1958), periodic changes in light during the day determine the occurrence and basic patterns of daily rhythm of activity, namely its qualitative side, and changes in temperature within the optimum and transition zones affect only its quantitative side.

The nature of the daily rhythm of trophic activity of flying hematophages leaves its mark on the behavior of animals and their preference for certain biotopes on pasture. With the number of mosquitoes observed during the day in the forest (from 2 to 32 individuals on the record), calves preferred to graze in the open area, even with a high number of blind, only periodically hiding in more often shrubbery for a short time. At night, the calves are kept in the paddock, snuggling up to each other, which allows to some extent to limit the number of attacking insects. Mosquitoes fly in the largest number (over 66%) in the paddock during the night rest of the animals. directly near the calves at an altitude of up to 1.9 meters from the ground, but single individuals are also found at an altitude of more than 4 meters. At a distance of 5-7 meters from calves the number of mosquitoes decreases twice, and 25-30 meters - 4 times.

The high concentration of mosquitoes around the animals and the nature of their daily rhythm indicate the expediency of carrying out protective measures against their attack during the mass flight when keeping calves in open paddocks in the pastures in the evening. This applies to both ultra-low-volume spraying of animals with insecticides or insecticide smoke during the mass summer during maximum daily activity, as well as treatment of animals with repellents, and insecticides designed for residual action on the hairline. When keeping livestock at night in livestock treatment facilities with repellents and insecticides should be carried out in the morning before pasture. This allows for the calm and free behavior of animals when grazing and wider coverage of various biotopes of pasture.

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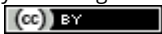
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