

# THE ETHOLOGY OF BLOOD-SUCKING MIDGES (DIPTERA: CERATOPOGONIDAE) WHILE ATTACKING ANIMALS

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## ABSTRACT

The purpose of the research was to study the ethological peculiarities of blood-sucking midges (Diptera: Ceratopogonidae) while attacking animals. The midges behaviour while attacking animals and humans was researched using an entomological net with movable bags, sticky transparent tape (0.1 0.9 m), the Monchadsky's net and observational method. The interval between the accounts was 1 hour. The intensity of the attack or the abundance index (AI) was recorded by the average and maximum indicators. Thus, in the period of massive flights of midges during the hours of their diurnal activity their massive approach to the animals was recorded. During this period they were using an active searching flight or the first way of attacking their prey. The purposeful approach of midges to the animals against the wind demonstrates that the leading stimulus to searching a prey is a scent stimulus or the animals' smell spreading with the wind. Some previous researches demonstrated the possibility of using animal waste substances such as carbon dioxide, lactic acid, octanol etc. to attract midges and the usage of these substances in traps for insects. We found out the high rate of zoophily and factorial orientation of midges while searching for an object for blood-sucking. For example, they almost do not attack humans, but the number of their attacks on animals in herds is from 8 to 10 times bigger than on a solitary animal near herds.

**Keywords:** midges, searching for prey, seasonal dynamics, diurnal activity, abundance.

## INTRODUCTION

Bloodsucking midges (Diptera, Ceratopogonidae) are the smallest bloodsucking dipterous insects and carriers of pathogens of infectious and invasive diseases of humans and animals<sup>1-5</sup>. The orientation of insects is to regulate the spatial relation of the organism with the external environment. Relation provided by a variety of sensory information coming from the receptors into the central nervous system. According to the literature review on this issue, locomotor reactions are considered as behavioral correlates of orientation. Existing ideas about the functional mechanisms of insect orientation are based on the study of taxes and optomotor reactions, morphophysiological peculiarities of sensory systems, as well as on research of route routes in the natural habitat<sup>6</sup>. According to the literature, the focus is on the orientation of the horseflies in connection with the development of biologically based complex measures aimed at reducing the number of these bloodsucking Diptera. Despite the fact that the blood-sucking midges (Diptera: Ceratopogonidae) are mass bloodsuckers in a number of regions of Siberia and the Far East, their attack on animals in Russia and in countries far abroad has not been sufficiently studied. Y.S. Balashov<sup>7</sup> classifies midges as free bloodsuckers. V.M. Glukhova<sup>8</sup> points out the antagonistic nature of the relationships between

these insects and their hosts that allows us to consider them parasites. It is known that midges have two ways of attacking a prey. The first one is the active searching flight. The second one is watching attack which is exercised by chasing a prey and crawling onto it. V.M. Glukhova<sup>8, 9</sup>. The majority of previous researches are based on watching bloodsuckers' attacks under the conditions of captivity and their artificial feeding on humans<sup>10-14</sup>. The insects' orientation consists of regulation of spatial relation of an organism with the environment which is provided by sensory information coming from receptors to the central nervous system. According to academic literature data, much attention is paid to the orientation of clegs. The purpose of the research was to study the ethological peculiarities of blood-sucking midges (Diptera: Ceratopogonidae) while attacking animals.

## Material And Methods

The research was done in the suburbs of MalyeVelizhany village which is situated in Nizhnetavdinsky district of Tyumen region (at the picture) during 2016-2017. The suburbs are located in southern taiga subzone<sup>15</sup>. The blood-sucking midges behavior while attacking animals and humans was researched using an entomological net with movable bags<sup>16,17</sup>. A net in the form of a cone

was made from a mill gas with a cell size of 0.2 mm. At the top of the cone, an opening of 5 cm in diameter was left, which was reinforced with two wire rings sewn to the surface of the cone at the top at a distance of 1 cm from each other. At the base of the cone, a hole 30 cm in diameter was reinforced with a wire hoop equipped with a wooden handle. The depth of the bag was - 60 cm, the length of the handle - 40-50 cm. A removable bag with a diameter of 6 cm, length 12 cm, sewn from a kapron fabric, before fixing was fastened between the rings on the top of the net with the help of anelastic band. Previously, a label was placed in each bag. After taking into account, the bag was removed, tied and a glass jar with ether pairs. The glass jar was a capacity of 0.75 liters and had on the bottom a layer of pieces of rubber impregnated with ether, chloroform or a mixture thereof. Above, the rubber was covered with a cardboard circle that separated it from the insect chamber and served to absorb excess moisture. The jar was tightly closed with a screw cap at the top, placed in a white coarse sack, sewn according to its volume. At the time of registration, the researcher hangs this jar on himself. In addition, we used sticky transparent polyethylene tape (0.1h0.9 m), as well as visual observation. The Monchadsky bell was sewn from white coarse calico in the form of a cylinder with a diameter of 160 and a height of 150 cm, topped with a cone of 40 cm in height. Below and above, the cylinder was strengthened by hoops from thick steel wire. The bell was hung on a tree branch in such a way that the lower edge was 0.5 m above the sitting observer. After a 5-minute exposure, the bell was lowered and, on the inside, the blood-sucking midges were collected by the exhaustor. The collected insects for storage were laid out on cotton mattresses or placed in 70% alcohol for storage and subsequent determination. Species of adults were determined with the help of binocular microscopes MBS-9 and MSP-1 and determinants A.V. Gutsevich<sup>18</sup>, V.M. Glukhovoy<sup>19</sup>, A.G. Mirzaeva<sup>20</sup>. The catch of adult midges was carried out in the morning hours from 4 to 7 and evening hours from 20 to 24. sticky. The interval between the accounts was 1 hour. The intensity of the attack or the abundance index (AI) was recorded by the average and maximum indicators<sup>21, 22</sup>.

## Results

The comparative parallel counting of blood-sucking midges using the Monchadsky's net, the method of feeding the insects on a person and on a solitary calf showed the high rate of zoophily and the absence of anthropophily. For example, during the daily counting in a forest at 11 pm, 5 and 7 am on the 9<sup>th</sup> and 10<sup>th</sup> of July 2016 using the Monchadsky's net only 1 or 2 midges were caught on a person comparing to 319, 187 and 182 midges respectively that were caught with a net on a solitary

calf standing in 50 metres distance. The abundance of species by the abundance index was *Culicoides punctatus* (Meigen, 1804) - 234, *C. fascipennis* (Staeger, 1839) - 2, *C. grisescens* Edwards, 1939. - 76 individuals, respectively. During the daily counting of midges coincided with the peak of their seasonal activity we found out that their approach to the solitary calf used for the research was purposeful. We were watching that before the sunrise when the sun only started rising. From a marsh that was situated in a distance of 100-120 metres with the absence of wind, midges were flying in great numbers from a downwind side that seemed like a long endless train. The hovering of midges and their soft rustling and ringing were heard in the air. Then all the midges approached the calf. But they were not flying around the calf, they immediately sat on it and disappeared in its fur. There were so many midges, so it seemed like the calf's fur was moving. When we pressured on the animal with a hand it was completely covered with midges' blood. The massive approach of midges lasted about an hour and stopped as suddenly as it started. We were standing next to the calf, but we were not attacked by the insects. We subsequently kept some experiments in studying the way midges approach calves at a corral in a forest pastureland. As the result, we found out that the midges purposefully approached to the calves from a downwind side. The purposeful massive approach of midges was recorded in 25-50 metres distance from the calves. Their abundance considerably decreased in more remote areas (up to 100 metres), but the direction of their flight persisted. The counting of midges from the downwind side that were around us showed that in a distance of 25 metres the average number of midges was about  $254 \pm 28$  species, in a distance of 50 metres -  $115 \pm 31$  species and in a distance of 100 metres -  $53 \pm 29$  species respectively. Whereas we could not catch any midges from a windward side on a person with a net standing at the same distance from the calves. The culling of midges on a person next to the corral from different sides and during the evening and morning peaks of midges' attacks showed that from the windward side only single midges were caught compared to 616 species that were caught from the downwind side. Our examination of the sticky tapes that were put up in the calves corral from different sides to record how many midges fly into and out of the corral showed that the midges' approach was massive. From the windward side, we found out  $12 \pm 1,8$  species that were caught on a tape sized 0,1 0,9 metres and from the downwind side -  $514 \pm 59$  species respectively. Thus, in the period of massive flights of midges during the hours of their diurnal activity, their massive approach to the animals was recorded. During this period they were using an active searching flight or the first way of attacking their prey. The purposeful approach of midges to the animals against the wind

demonstrates that the leading stimulus to searching a prey is a scent stimulus or the animals' smell spreading with the wind. Some previous researches<sup>11</sup> demonstrated the possibility of using animal waste substances such as carbon dioxide, lactic acid, octanol etc. to attract midges and the usage of these substances in traps for insects. The peculiarities of midges' behaviour while searching for a prey and attacking it and their high concentration among animals that were studied in our research give us to rise to confirm the relevance of using insecticides with a strong effect against midges in the period of their diurnal activity through hinged fogging, spraying and insecticide smoking. When keeping animals in corrals the peak of midges' diurnal activity coincides with the period of rest of animals in corrals, so it simplifies using the insecticides. Moreover, during the evening, night and morning hours with the absence of vertical airflows smoke and sprays spread evenly and horizontally in the direction of the wind. The massive approach of midges to a herd can be used as a way of fighting against them through arranging adhesive shields and other devices around a corral directed at midges flying into it. Studying the spread of midges in the corral next to a group of animals was undertaken with the use of nets and transparent sticky tapes that were attached to the bars at different heights. The bars were attached to a 3,5 metres high pole. We revealed that in the territory of the corral midges were concentrated directly next to the animals. The catching of midges with the net and transparent sticky tapes showed that in 5 metres distance from the animals, the concentration of midges greatly reduced, so in 10-15 metres distance, we found only single ones. The majority of midges were flying at the level of animals' height. Thus, from 700 midges that were stuck on the tapes after the four repetitions of the same experiment 479 species were at a height of 1,5 metres, 117 species were at a height from 1,5 to 2,8 metres and 44 species were at a height from 2,8 to 3,4 metres above the ground. (68,4%, 25,3% and 6,3% respectively). The comparative counting of midges in the corral on animals with the net and on a solitary calf in 10-20 metres distance from the herd also showed the great difference in midges' abundance. The abundance index in the herd was ten times higher than the abundance index on the solitary animal. Thus, on the 25-26<sup>th</sup> of July 2016 from 10 pm to 5 am 237 species of midges were caught in the herd comparing to 8 species that were caught on a solitary calf which is 30 times less. Even in the period of their high concentration, on the 7<sup>th</sup> of June 2016 at 6 am when we caught 2020 species with the net in the herd which was 15 times higher than 132 species that were caught on a solitary animal. This was probably the reason for some animals to separate from the herd in a distance and have a rest there. But it was possible only with the absence of

mosquitoes which attack a solitary animal in bigger numbers than animals in a herd. It was pointed out in our study and by Konstantinov<sup>17</sup> in 1990. Further watching the midges' behaviour and their counting with the sticky tapes showed that the hungry or full of blood midges did not fly out of the corral massively during the peak of their diurnal activity and after its decline or after the calves were taken to a pasture. After the thorough examination of the corral with single trees and no grass, it was revealed that the full of blood midges hid in great numbers in different covers like soil litter especially from the downwind and sunlit surface roughness and also inside of loose and dry dung and soil substrate. Moreover, single midges were noticed on the tree trunks and on the fence. It gave us to rise to assume that midges that flew into the corral but did not suck animals' blood did not leave the corral. They probably stayed on its territory. We observed the confirming situation in conditions of cloud after the rain in the afternoon when the massive attack of midges on cows in the corral was recorded. Midges were flying around the animals or crawling onto them which was clearly seen on the lying animals with a black colouring. This way of midges' attacks was classified by V.M. Glukhova as a stalking type. We classified an active chasing (accompanying) of moving animals by a midges' swarm which we repeatedly observed while cattle was coming back from the pasture as the same type of attacks. While attacking cattle midges sat mostly on the parts of animals' bodies with shorter fur such as heads, necks, chests, bellies and limbs. In conditions of the high midges' abundance they were massively crawling on cattle's sides, backbones and the other body parts. They also were flying around the animals at the level of their height, so it seemed like the animals were in the cloud of midges. Midges attacking animals did not get full of blood immediately. This became clear by the fact that special devices attached to a calf and covered with plastic wraps with an adhesive layer that were designed to midges flying out of animals' fur contained a small number of midges full of blood (about 15%). It followed that midges do not always start sucking blood as soon as they sit on an animal. According to V.I. Bukshtynov<sup>18</sup>[18] the period of time midges crawl on animals' fur is from 10 seconds to 10 minutes. The bloodsucking usually lasts from 1 to 5 minutes. However, S.M. Jafarov<sup>23</sup> and V.A. Isaev<sup>24</sup> pointed out that the full portion of blood midges get in 10 minutes. V.M. Glukhova<sup>25</sup> believed that the process of blood-sucking lasts from 3 to 6 minutes on average. A long and repeated contact between midges and animals while searching a place for blood-sucking and a stalking type of attack in crawling and chasing forms give us rise to assume the relevance of reduction the insects in the period of their massive flights through systematic treats of animals' fur with long-acting insecticides with a residual effect during any time of a day while

spraying animals against blood-sucking midges and zoophily flies before taking them to a pasture. Searching for female midges full of blood showed that after sucking blood they do not fly out of the corral immediately. The big amount of them was found in the morning on the birch tree trunks in the corral at the height of 2,5 metres above the ground. Our counting them with a transparent sticky tape encircling trees in different height with adhesive layer directed to a trunk showed that there were  $13 \pm 1,7$  female species full of bright red blood by square decimeter. In that regard, it is probably relevant to use long-acting insecticides with a residual effect for spraying tree trunks, poles and fences which are the places of rest for insects to reduce midges in the territory of a corral.

### Discussion

When studying the behavior of slimy in attacking cattle, the established by V.M. Glukhova<sup>8-10</sup> types of the reaction of these insects: in the form of search flight and an oncoming attack. The observed high degree of zoophilia of Culicoides midges animals in pastures and cattle farms established by us determines trophic connections of the dominant *C. punctatus* and subdominant *C. grisescens* and *C. fascipennis* species. The last two species prefer feeding on large animals according to the data of other researchers<sup>9, 12, 26-28</sup>. In relation to *C. punctatus* there is evidence that females of this species are equally attacking both humans and animals<sup>29, 30</sup>. For *C. punctatus* zoophilia in the south of the Tyumen region can apparently be explained by the influence of the anthropogenic factor, since the studies were carried out on farms and pastures of cattle in the conditions of developed cattle breeding. With the objects of bloodsucking, it is obvious that the leading one of the midges is the olfactory orientation, unlike the flies, mosquitoes and midges, which are more visually oriented. We noted that only the midges purposefully flew to the herd of animals from the leeward side. In a large number of concentrated slugs in the herd directly near the animals, with the bulk of them kept at a height of 1.5 m. When attacking animals, they longly circle around them or crawl on the surface and under the cover of the hairline. Only 15% of the female Culicoides midges animals on the animal are sucked up by blood, indicating multiple contacts with the hair covering when searching for a bloodsucking place. The high degree of zoophilia of the Culicoides midges, expressed by the purposeful approach to the flock for the smell of animals on the leeward side and the mass accumulation near the animals, the nature of parasitization, active flying and attack in the premises, indicate the expediency of using high-speed contact insecticides against them, through systematic treatments of the protected animals.

### Conclusion

We found out the high rate of zoophily and factorial orientation of midges while searching for the object for blood-sucking. For example, they almost do not attack humans, but the number of their attacks on animals in herds is from 8 to 10 times bigger than on a solitary animal near herds. The midges' approach to animals usually occurs from the downwind side. The majority of midges fly at the level of animals' height. The female midges full of blood do not fly out of a corral after the decline of their activity. They hide near animals and then stalk animals and crawl onto them or chase and attack them.

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