ENVIRONMENTAL AND ECONOMIC LOSSES IN DAIRY PRODUCTION DUE TO BLOOD-SUCKING INSECTS IN COWS

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Received September 2024; Accepted October 2024; Published November 2024;

DOI: https://doi.org/10.31407/ijees14.411

ABSTRACT

This study investigates the impact of midge attacks on milk production in cows and explores effective methods to protect cattle from blood-sucking dipterans, which pose significant environmental and economic challenges to livestock farming. The research was conducted to quantify milk production loss associated with midge activity and to assess the effectiveness of an aerosol-based protective method against these pests. Standardized procedures were applied to monitor the population dynamics of blood-sucking insects during peak daily activity (12:00-16:00 and 19:00-21:00) from 2018 to 2023. Entomological surveys took place at Horobut LLC in Central Yakutia's Megino-Kangalassky district, yielding a total of 2728 mosquitoes and 4100 horseflies. Species identification was performed using morphological keys. The study revealed that the midge flight season spans over 30 days, while the grazing period for Simmental cows (n=93) in the study area lasts approximately 120 days. During this period, the cows produced an average of 1461 kg of milk with 4.05% fat and 3.10% protein content, and a daily yield of 12.1 kg. The economic impact of reduced productivity due to midge attacks was estimated at 5,097,600 rubles. A novel aerosol fogging technique was successfully tested for the first time in Central Yakutia, utilizing a 0.01% aqueous pyrethroid emulsion with 70-120 micron droplet dispersion. Applied at 10 ml per cow, this method provided up to 6 hours of protection, presenting a viable solution for reducing insect-related milk losses while minimizing environmental impact.

Keywords: agricultural regions of Yakutia, cattle, mosquitoes, horseflies, economic threshold, harmful population.

INTRODUCTION

The Republic of Sakha (Yakutia) is the largest region in Russia in terms of territory. The area of Yakutia is 3103.2 thousand square kilometers and occupies 18% or almost 1/5 of the territory of the Russian Federation. Most of Yakutia is occupied by vast mountain systems and plateaus. The territory of Yakutia can be divided into 5 parts by relief: central, western, southern, northeastern and the coastal tundra region. The latter covers the continental part of the tundra zone and the adjacent tundra and northern taiga forests. Along the sea coast, a discontinuous strip of coastal-arctic tundra subzone with widespread development of grassy swampy lowlands stretches (Matveev, 1989).
The climate of the vast territory of Yakutia is unique in the northern hemisphere due to the severity of the climate as a pole of cold and extremely sharp temperature fluctuations. Long-term average January air temperatures in

Oimyakon and Verkhoyansk are minus 49-50°C. In the Oymyakon Basin, minimum temperatures reach minus 71°C, and in Verkhoyansk up to minus 68°C. In the central regions up to minus 40-55°C. Summer is short, but relatively hot (in most of the territory plus 36-38°C, on the sea coasts +29+32°C, with prolonged sunshine (polar day)). Thermal resources of the warm season in the central and western zones are 1400-1600°C, and in the north-eastern 300-1200°C, which heralds the beginning of active vegetation of plants and the development of insects (Gavrilova, 1981).

Yakutia is a major base for traditional herd horse breeding, cattle breeding and reindeer herding in Russia. According to statistics, as of January 1, 2022, the republic's farms had 182,653 horses, 178,197 cattle, including 74,031 cows, and 162,099 reindeer (Republic of Sakha (Yakutia), 2023).

Human economic activity leads to agricultural transformation of territories, i.e. to the emergence of an agro-landscape with an abundance of biotopes for the development of arthropod larvae, the presence of large host animals (horses, deer and cattle). This is provided by information on 16 species of blood-sucking mosquitoes (Diptera, Culicidae) in the collection of dipterans of the Zoological Institute of the Russian Academy of Sciences, collected in Yakutia in the 19th and early 20th centuries (Khalin & Aibulatov, 2020; 2021).

The modern fauna of blood-sucking mosquitoes of the middle taiga subzone of Yakutia numbers 33 species and includes representatives of the genera Anopheles (1), Culiseta (3), Culex (3), Aedes (26). For the first time, 3 species are indicated as new for Yakutia - *Ae. implicatus, Ae. intermedins, Cx. vagans* (Potapova, 2015).

According to S.D. Pavlov, R.P. Pavlova and others (2007), in veterinary entomology the concept of harmfulness of midges is expressed by assessing the impact of insects on the productivity of animals per unit of the number of parasitic arthropods. Harmfulness, expressed by the relative size of the decrease in the productivity of affected animals, is calculated depending on the average abundance of parasitic insects during periods of the highest daily activity of insects during the season of mass flight by means of one-time, 5-minute (mosquitoes) and 15-minute (horseflies) or daily counts of animals in the pasture (Pavlov, et al. 2007).

According to the results of animal counts for 15 minutes (horseflies) or 5 minutes (mosquitoes, midges, biting midges) and simultaneously during periods of maximum daily insect activity, the harmfulness of each attacking female horsefly of medium size is 0.57 and 3.68%, respectively, the largest species of horseflies - 1.23 and 8%, twin-lobed deerfly and clegs - 0.16 and 1.07%, mosquitoes - 0.058 and 0.174%, midges - 0.024 and 0.072% and biting midges - 0.0037 and 0.011% of the expected milk productivity of cows.

Using these data, economic thresholds for the harmful numbers of midge components (insects of different sizes) causing reliable (economically significant) losses in milk productivity of cows by 3% were determined. For the largest horseflies, these thresholds are 81 individuals attacking per day, 2.4 individuals in 15 minutes, and 0.4 individuals attacking at one time; for medium-sized horseflies, respectively, 176 individuals attacking per day, 5.3 individuals in 15 minutes, and 0.8 individuals attacking at one time; for twin-lobed deerfly and clegs, 612 individuals attacking per day, 18.7 individuals in 15 minutes, and 2.8 individuals at one time; for mosquitoes, 5172 individuals during the day, 52 in a 5-minute count, and 17 individuals at one time; for midges, respectively - 12,500 individuals per day, 125 individuals per 5-minute count and 42 individuals at one time; for biting midges - 81,000, 810 and 270 individuals, respectively. The given economic thresholds of harmfulness are indicators of the number of attacking insects, at which effectively applied measures begin to generate income, reduce the cost of production and increase the profitability of production. Economic thresholds of harmful mosquito numbers, causing reliable losses in milk productivity per cow by 3% are determined according to S.D. Pavlov, R.P. Pavlova and others (Pavlov, et al. 2007).

The economic damage caused by blood-sucking insects to the country's livestock industry annually consists of a shortfall in meat and dairy products, a sharp deterioration in their physiological and immune status (up to the death of animals), an increase in the incidence of invasive and infectious diseases, including especially dangerous ones common to humans and animals. It has been established that during the season of mass flight of midges, which lasts approximately 50 days, the decrease in animal productivity in farms in the south of the Tyumen region is 100 tons of milk and 12 tons of meat per 1,000 heads of cattle. Thus, annually only the Tyumen region receives less meat and milk in the amount of about 350 million rubles (Pavlov, et al. 2007).

Economic losses of meat-producing cattle from midge attacks in average is 705.5±34.0 rubles per animal. To protect Limousin cattle from midges, treatments with 0.001% (by active ingredient) delcid and 0.0125% (by active ingredient) aqueous emulsion veterin by the method of medium-volume spraying using universal horizontal spray booms (UHSB) at the rate of 250 ml per young animal and 500 ml per adult animal are highly effective. Satisfactory protection (Protection action coefficient equal to 75%) when using the preparations in these modes lasts 9.0±1.2 hours and 8.0±1.1 hours, respectively (Derkach, 2006).

Estimated losses in milk productivity of cows depending on the identified number of midges in pastures in the southern taiga subzone in average is 5.77% (from 1.22 to 13.95%), in the aspen-birch forest subzone – 4.81% (from 2.62 to 7.0%) and in the forest-steppe zone – 0.15%. However, due to large fluctuations in numbers by season, and in the forest-steppe zone midges in some years can also have economic significance in combination with other components of the midge population (Pavlov, et al. 2007).

MATERIALS AND METHODS

Stationary studies on the species composition and ecology of mosquitoes and horseflies were conducted in 2018-2023 in the Megino-Kangalassky district of Central Yakutia. Collection and counting of the number of blood-sucking insects was carried out using spinning top traps and an entomological net with a diameter of 30 cm with removable bags according to T.S. Detinova during the period of their highest daily activity twice a decade at 12-16 and 19-21 p.m. In the calculations for mosquitoes and horseflies, average data for the count were used, which were taken as a one-time count on an animal in a herd. In total, about 40 counts were carried out for each studied component of the midges during the research season. 2728 mosquitoes and 4100 medium-sized horseflies were collected. During a 15-minute count, cattle were attacked by 83 to 107 horseflies of 21 species and one subspecies of two genera: Hybomitra and Chrysops, during a 5-minute count, by 136 to 220 mosquitoes. The species affiliation of dipterans was established according to the morphological keys of the identification tables. In accordance with the assignment and regulations, a patent search was carried out in the scientific and technical literature of Russia on the topic "Losses of milk productivity of cows when attacked by midges". The study of economic losses in dairy productivity of cattle was conducted at Khorobut LLC in the Megino-Kangalassky District of Central Yakutia in June - July 2018-2023. For this purpose, a herd of up to 120 cows kept in a camp was selected. Milk productivity was taken into account based on average daily milk yields 15 days before the start of the mass flight of horseflies and mosquitoes and 30 days before their mass flight. Average daily milk yields obtained from healthy cows in June–July ranged from 10 to 15 liters. Damage from reduced animal productivity due to parasitosis was calculated based on the “Methodological recommendations for determining the economic efficiency of antiparasitic measures and the results of research, inventions, and rationalization proposals” (Safiullin, 2006).

RESULTS AND DISCUSSION

Central Yakutia is located in the Subarctic zone, where there are constant long winters and permafrost. But despite the cold, the entomofauna of the republic is distinguished by high taxonomic diversity, which includes over 6,500 species from 20 orders (Vinokurov et al., 2019). In the summer, the greatest damage to dairy cattle breeding is caused by blood-sucking dipterous insects, whose mass flight is observed from the third decade of June to mid-July. At the beginning of the mass flight, the harmful effects of midges are caused mainly by attacks of mosquitoes, at the end of June and the beginning of July - horseflies, and from the first decade of July - mosquitoes and horseflies.
Taking into account the seasonality of mass attacks of midges on dairy cows in June, July and August, the average duration of observation of changes in animal productivity was 120 days.
To calculate the damage from the decrease in animal productivity due to parasitosis ($У_2$), we used the formula:

$$У_2 = М_З \times (В_З - В_Б) \times Т \times Ц_З$$

where: $М_З$ – number of sick animals, heads; $В_З$ и $В_Б$ – average daily amount of production (milk yield) obtained from healthy and sick animals, respectively, per head, kg; Т – average duration of observation of changes in animal productivity (during periods of unfavorable conditions), days; $Ц_З$ – average selling price of 1 kg of milk obtained from healthy animals, RUB.

The damage from the decrease in animal productivity due to parasitosis amounted to:

$$У_2 = 120 \times (12{,}1 - 6{,}2) \times 120 \times 60 = 5097600 \text{ rub.}$$

During the season of mass flight of midges, which is more than 30-40 days, the average daily milk yield per cow is 12.1 liters of milk. It was established that in Khorobut LLC of Megino-Kangalassky district during the pasture

period for 120 days of lactation from cows of the Simmental breed (n-93) 1461.0 kg were milked out. The fat content in milk was 4.05%, protein - 3.10%. The average daily milk yield of cows of the Simmental breed during the pasture period was 12.1 kg of milk. The number of cows by lactation periods: 3 lactation - 22 heads, 4 lactation - 24 heads, 5 lactation - 23 heads and 6 lactation - 24 heads.

The number of horseflies on each pasture was determined using spinning top traps, the collection of which corresponded to the number of these insects attacking cows in the herd during the same time. Counts were carried out once every 5-10 days on all pastures simultaneously during daylight hours. The average daily milk yield of cows was counted 10 days before the start and 48 days before the mass flight of horseflies (r=0.998). On hot days at a temperature of +28…+31 ºC, up to 980 horseflies fell into the spinning top trap per day, and up to 157 horseflies attacked the bait animal per count.

The regression coefficient of relative deviations in milk productivity of cows during the period of mass flight of horseflies from the average daily milk yields observed before this period was 25.5% for every thousand of these insects caught in pastures by each trap or attacking during daylight hours on each animal in the herd.

The effectiveness of animal protection against midge attacks was determined by conducting production tests at Khorobut LLC in the Megino-Kangalassky district of Yakutia. The animals were divided into control and experimental groups. To protect animals from midge attacks, aerosol mist with a dispersion of 70-120 μm was sprayed over a herd of cows from a distance of 20-30 m, using a 0.05% aqueous emulsion of pyrethroid. Spraying of the animal hair was applied once every 5 days. As a result of protective spraying of cows, the damage caused to them by horseflies and mosquitoes was eliminated, which contributed to an increase in their productivity. In the experimental group of cows, the average daily milk yield increased by 4 kg, and in the control group, a decrease in milk yield by 600 g was observed. To protect animals from midge attacks, an aerosol mist with a dispersion of 70-120 μm was sprayed over a herd of cows from a distance of 20-30 m, using a 0.05% aqueous emulsion of pyrethroid by active ingredient at the rate of 15 ml per cow, providing a 6-hour duration of protective action with a CPD greater than 75%. The technology ensures the environmental friendliness of animal treatment while simultaneously increasing the insecticidal and repellent effectiveness of the preparation. Patent for invention No. 2724462 was received.

Table 1. Cost Accounting for Preventing Acute Entomosis in Cows Caused by Midge Attacks

No.	Indicators	Total	Per Cow
1	Number of cows	120	—
2	Number of cows subject to preventive treatments	120	—
3	Number of working days required to process a given number of cows	60 days	—
4	Cost of workdays for a veterinarian	1,168 RUB	—
5	Salary for staff based on workdays required for processing cows (16 min/day = 2 days)	2,336 RUB	19.5 RUB
6	Cost of the drug per season (1 bottle x 5,000 RUB)	5,000 RUB	41.7 RUB
7	Spraying apparatus	30,000 RUB	250 RUB
8	Other direct costs (e.g., communication services, equipment maintenance)	1,641.6 RUB	13.68 RUB
9	Overhead costs (19.5%)	7,600.6 RUB	63.3 RUB
10	Total cost of processing (sum of items 5, 6, 7, 8, 9)	46,578 RUB	388.2 RUB

Table 1 presents the cost accounting for the prevention of acute entomoses of cows caused by midges. The cost of processing a herd of cows is 46,578 rubles. The introduction of ultra-low-volume cow processing technology ensures the prevention of economic damage in the amount of 2,624,400 rubles per herd of cows (Tables 2-3).

Table 2. Economic Impact of Reduced Cow Productivity Due to Acute Entomosis from Midge Attacks.

No.	Indicator	Description	Value
1	M_3	Number of affected cows (heads)	120
2	B_3	Average daily milk yield from healthy cows (June–July, liters)	15
3	B_i	Average daily milk yield from affected cows with acute entomosis (June–July, liters)	6.9
4	T	Observation period for productivity changes during mass midge attacks (days)	60
5	P_3	Average selling price per liter of milk (rubles)	45
6	D_2	Total economic loss due to reduced productivity (rubles)	2,624,400 rubles

Table 3. Economic Efficiency Assessment of Cow Protection from Blood-Sucking Insects.

No.	Indicators	Unit of measurement	Value
1	Economic loss from reduced cow productivity due to acute entomosis caused by midge attacks	Rubles	2,937,600
2	Cost of processing a herd of cows (based on prices from one year)	Rubles	46,578
3	Duration of protective action (protective action coefficient = 75%)	Hours	6 hours
4	Economic return per ruble spent	Rubles	31.92

The species composition of horseflies in horse pastures of the flat territories of Central Yakutia is represented by 21 species and one subspecies: *Chrysops nigripes Ztt., Chr. divaricatus Lw., Chr. validus Lw., Chr. relictus Mg., Chr. ricardoae jakutensis Ols., Chr. (H.) vanderwulpi Krob.* and *Hybomitra sexfasciata Hine., H. olsoi Takah., H. arpadi Szil., H. pavlovskii Ols., H. tarandina L., H. aequetincta Beck., H. lurida Flln., H. nitidifrons nitidifrons Szil., H. distinguenda contigua Ols., H. ciureai Seg., H. muehlfeldi Br., H. bimaculata var. bisignata Jaenn., H. nigricornis Ztt., H. lundbecki lundbecki Lyn., H. lundbecki sibiriensis Ols., H. montana montana Mg., H. montana var. flaviceps Zett.* Yakutia horseflies are characterized by the phenomenon of melanization of the integument, sometimes leading to the complete disappearance of brown spots on the abdomen. We have identified dark forms: *H. bimaculata var. bisignata Jaenn.* and *H. montana var. flaviceps Zett.*

The species composition of blood-sucking mosquitoes in the agrocenoses of Central Yakutia is represented by 14 species: *Anopheles messeae, Culiseta bergrothi, Aedes (Ochlerotatus) dorsalis, Ae. (Och.) mercurator, Ae. (Och.) excrucians, Ae. (Och.) euedes, Ae. (Och.) flavescens, Ae. (Och.) cyprius, Ae. (Och.) communis, Ae. (Och.) punctor, Ae. (Och.) hexodontus, Ae. (Och.) diantaeus, Ae. (Och.) pullatus, Ae. (Och.) cataphylla.*

On average, over 4 years of observations, the number of midges was 5.57 conventional units per season. When comparing the number of different components of midges in conventional units, it was found that horseflies cause the greatest harm, amounting to an average of 4 conventional units per season. Mosquitoes are in second place in this indicator (1.57 conventional units).

Breeding places of horseflies (permanent reservoirs and lowland swamps) are less susceptible to drying out, which ensures, along with the high plasticity of these insects, a more stable nature of their numbers.

In the agrocenoses of Central Yakutia, we identified three types of mosquito biotopes: forest pastures, dry pastures and farm territories of summer pastures for cattle. The population density of larvae in the biotope of early spring species of the genus Aedes is 74-126 specimens/m^2.

A high number of horseflies and mosquitoes attacking cows has been established in Central Yakutia. Horseflies inflict painful bites on cattle with their piercing-cutting mouth apparatus, literally cutting the skin of cows, thereby causing a serious disease such as cutaneous myiasis. In the morning and evening peaks, the number of mosquitoes in a 5-minute count was 397-456 specimens, including 15 species of mosquitoes of three genera: Aedes (Ochlerotatus), Culiseta and Anopheles. During a 15-minute count, cattle were attacked by 83 to 107 medium-sized horseflies of 21 species and one subspecies of two genera: Hybomitra and Chrysops. When studying the daily dynamics of horsefly flight, it was found that at the beginning of the season, the flight of adult horseflies lasts from 8 a.m. to 8 p.m. (12 p.m.), in the middle of the period from 7 a.m. to 10 p.m. (15 p.m.), and at the end of the period from 8 a.m. to 7-8 p.m. (11-12 p.m.). Due to the mass attack of midges, mainly horseflies, the milk yield of cows in Yakutia is significantly reduced.

CONCLUSION

- Ensuring food security in the dairy market is one of Russia's strategic objectives. The vast territory of Yakutia is a region with a unique tradition of dairy farming, home to more than 190,000 cattle. However, despite the efforts of livestock workers, cow milk yields significantly decrease during the summer due to mass attacks by harmful blood-sucking insects, including mosquitoes and horseflies. In the agrocenoses of Central Yakutia, we identified three types of mosquito biotopes: forest pastures, dry pastures, and farm territories of summer pastures for cattle. The population density of larvae in the biotope of early spring species of the genus *Aedes* is 74-126 specimens/m^2.

- In total, 40 counts were conducted for each studied component of the midges during the research season, collecting 2,728 mosquitoes and 4,100 medium-sized horseflies. During a 15-minute count, cattle were attacked by 83 to 107 horseflies from 21 species and one subspecies across two genera (*Hybomitra* and *Chrysops*), while during a 5-minute count, 136 to 220 mosquitoes attacked the cattle. The productivity loss for a herd of cows due to acute entomoses caused by midge attacks amounts to 5,097,600 rubles. The economic return per 1 ruble spent is 31.92 rubles, with the cost of processing a herd of cows, based on 2014 prices, at 46,578 rubles.
- Implementing protective measures against midges through systematic ultra-low-volume spraying of cows with synthetic pyrethroid-based preparations prevents more than half of the expected decrease in milk productivity due to midge attacks. The expected annual economic benefit of using the ultra-low-volume spraying technology for cows is 1,486,590 rubles. This technology provides a 6-hour duration of protective action with a protection coefficient greater than 75%.
- The aerosol technology for protecting animals from mass attacks by dangerous blood-sucking insects differs from traditional methods in its low labor intensity and high effectiveness against midges.

Acknowledgements. The work was supported by the Ministry of Education and Science of the Russian Federation on the scientific topic FWRS-2024-0024. We express our gratitude to the director of LLC "Khorobut" of the Republic of Sakha (Yakutia) Kolosov V.A. and the chief livestock specialist Vasilyeva N.A. for help with research.

REFERENCES

1. Derkach, S. V. (2006). Monitoring the formation of the helminth fauna of beef cattle of the Limousin breed imported from France. Proceedings of the All-Russian Research Institute of Veterinary Entomology and Arachnology: Collection of scientific papers (Vol. 48, pp. 53–55). Tyumen. (In Russian);
2. Gavrilova, M. K. (1981). Modern climate and permafrost on continents. Moscow: Publishing House Nauka. (In Russian);
3. Khalin, A.V., Aibulatov, S.V. (2020). Fauna of Blood-Sucking Insects of the Gnus Complex in the Northwestern Region of Russia. III. Mosquitoes (Culicidae). *Entmol. Rev.* 100, 58–82,
4. https://doi.org/10.1134/S0013873820010066;
5. Khalin, A.V. & Aibulatov, S.V. (2021). Northernmost records of mosquito species (Diptera: Culicidae) in northwestern Russia. Zoosystematica Rossica, 2021, 30(1): 46-63, https://doi.org/10.31610/zsr/2021.30.1.46;
6. Matveev, I. A. (Ed.). (1989). Atlas of agriculture of the Yakut Autonomous Soviet Socialist Republic. Moscow: Publishing House Main Directorate of Geodesy and Cartography GUGK MIA USSR. (In Russian);
7. Pavlov, S. D., Pavlova, R. P., Khlyzova, T. A., & Fedorova, O. A. (2007). Decrease in milk productivity of cows depending on the number of midges on pastures and the effectiveness of protective measures. Proceedings of the All-Russian Research Institute of Veterinary Entomology and Arachnology: Collection of scientific papers (Vol. 49, pp. 160–174). Tyumen. (In Russian);
8. Potapova, N. K. (2015). Fauna of blood-sucking mosquitoes (Diptera, Culicidae) and features of their distribution in the regions of Yakutia. Eurasian Entomological Journal, 14(2), 162–170. (In Russian);
9. Republic of Sakha (Yakutia). (2023). Republic of Sakha (Yakutia) in numbers: Brief statistics collection. Yakutsk. (In Russian);
10. Safiullin, R.T. (2006). *Metodicheskiye rekomendatsii po opredeleniyu ekonomicheskoy effektivnosti protivoparazitarnykh meropriyatiy i rezul'tatov nauchnykh issledovaniy, izobreteniy i ratsionalizatorskikh predlozheniy* [Methodological recommendations for determining the economic efficiency of antiparasitic measures and the results of research, inventions, and rationalization proposals]. Moscow;
11. Vinokurov, N. N. (Ed.). (2019). *Krasnaya kniga Respubliki Sakha (Yakutiya). T. 2: Redkie i nakhodyashchiesya pod ugrozoy ischeznoveniya vidy zhivotnykh* [Red Data Book of the Republic of Sakha (Yakutia). Vol. 2: Rare and endangered animal species]. Moscow: Nauka. (In Russian);