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Ecologobiological Feature of Blood-Sucking *Simuliidae* Phenology

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***Abstract*— The researches give results on the ecology and phenology of the most basic and common types of blood-sucking midges of the Simuliidae family. This article shows dynamics of the species composition and average seasonal number of blood-sucking subfamily Simuliinae midges in water reservoirs of the Volgograd and its possible relationship with the effects of a complex of various abiotic and biotic factors. Our studies made possible to assess the effectiveness and environmental safety of measures on regulation the mass reproduction of midges. This research substantiates a list of scientifically based practical recommendations on the regulation of blood-sucking Dipteras in the conditions of large spilling rivers of the South of Russia. The research results are of great importance in the context of global warming processes, a high degree of technogenic pollution, instability of the hydrological regime and active urbanization processes.**

Keywords: larvae, blood-sucking midges, ecology, phenology, Volga river, Akhtuba river, Volgograd city

I. INTRODUCTION

Currently, more than 900 species of midges are investigated. More than 320 species inhabit the territory of Russia and neighboring countries. The Simulidae family is divided into two subfamilies *Gimnopaidinae* and *Simulliinae*. Both of them constitute an essential component in the taiga abounded by fast large and small rivers and streams. They often attack people and animals in the European part of Russia, Caucasus, on the whole territory of Siberia, the Far East and North-East.

Blood-sucking midges are dangerous parasites of humans and animals. A lot of their species carry viral and infectional diseases. At the same time, these species act as intermediate hosts of the Filarioidea nematodes. Like mosquitoes, midges have no strict confinement of bloodsucking to any one group of warm-blooded animals. However, they often attack cows and horses among other cattle. In mass attacks of *Simuliidae* when their simultaneous number can reach hundreds of thousands, the cattle production falls to 50% or more and, if protective measures are not taken. The mortality rate can reach 10% in this case. The death of animals is due to exhaustion, including bleeding, nervous and mental fatigue, as well as, importantly, the transmission of infectious diseases.

Foreign experience in the fight against Diptera, despite its long history, offers a small selection of spent funds. Conditionally they can be divided into chemical ways of reduction, land reclamation, physical elimination and biological methods. For biological methods it is possible to allocate as application of natural enemies *Simuliidae*, so use of insects' biological features.

A wealth of experience in dealing with blood-sucking *Simuliidae* was accumulated in Africa. The relevant damage is great for this region not only because of the strongest inconvenience to the inhabitants, but also because of the exhaustion and anhemia of livestock, the distribution of numerous viral, bacterial and parasitic diseases by midges.

Another region where much attention is paid to the biology of blood-sucking Diptera and methods of combating them is South America.

An ongoing problem is the abundance of midges in Southeast Asia. The greatest regional success in solving this problem has been achieved by Chinese chemical scientists.

The sanitary services of the developed countries of North America and Europe have achieved some success. Russia makes extensive use of the Soviet experience in regulating the number of midges in agricultural regions, but just develops a system for regulating the number of insects in highly urbanized areas.

Proceeding from time criteria of duration of actions it is possible to allocate direct fight against imago – destruction of adult individuals, fight at a preimaginal stage (eggs, larvae) – most often destruction or creation of unacceptable conditions for larvae of Diptera.

Chemical means of struggle are the most extensive and often applicable.

Versatile research in the field of regulation of the midges number is conducted to this day, however, due to the ubiquitous environmental trend dominated by the development of personal protection and damage reduction with the gradual abandonment of environmental impacts.

To date, the species composition, ecological and biological features and phenology of the blood-sucking midges development in the Lower Volga region and in the Volgograd region, in particular, are studied very insufficiently, represented by a few works of A.A. Denisov [2], A.A. Denisov, E.A. Ivantsova [3], M.I. Pirogovsky [6, 8], M.I. Pirogovsky, S.N. Kushnikova [7], V.D. Patrusheva [5], L.N. Andreeva [1], which used as the basis for our research.

II. Materials and Methods (Model)

The territory of the Lower Volga region is located in the dry steppes and semi-desert zone and is among the arid, crossed by two major rivers - the Volga and the Don - with a large number of floodplain lakes, Volgogradsky and Tsimlyansky reservoirs, a number of smaller rivers, a system of reservoirs on the Volga-don shipping channel. Smaller the same as Hoper, Medveditsa, Buzuluk have their own floodplains with passing through them strongly meandering beds, forming a large number of backwaters, favorable for bloodsucking insects breeding. Some small steppe rivers, originating from springs, disappearing often lost in the steppe, dry up, others turn into a chain of closed reservoirs (rivers Ilovlya, Aksai, Elan', Tersa et al.).

Breeding sites of blood-sucking midges in the city of Volgograd are various flowing water bodies: the entire length of the coastal zone of the Volga river of Volgograd city, the Akhtuba river, the waters of the Volga-Akhtuba floodplain, the Volga-Don channel. The distribution of midge species in the study area is closely related to river systems. Most species of black flies are confined to certain streams, where the development of their preimaginal stages. Preimaginal stages of black flies do not develop in ponds formed by snowmelt and heavy rains in different types of natural habitats, agroecosystems and urban ecosystems. In the vast majority, midges tend to objects with running water for laying eggs. Those who reach the ponds in oviposition period (July-August) are faced with the hot climate situation, when the steppe ponds and small urban ones dry up and then refilling elsewhere.

The Volga-Akhtuba floodplain is the water space between the Volga and Akhtuba rivers, which is crossed by numerous rivers and channels. The Volga-Akhtuba floodplain begins just behind the Volzhskaya Hydroelectric power station (HPP). A little further from the Volga separates Akhtuba and it turns out that on the one hand the floodplain is limited by Volga, and on the opposite Akhtuba. The width of the floodplain reaches 30 km, and its length is about 450 km. The Volga-Akhtuba floodplain stretches immediately on the territory of three subjects of the Russian Federation. These are the Volgograd region, Astrakhan region and the Republic of Kalmykia.

The floodplain lies below the ocean level with an inclination to the South. Its height ranges from - 5 meters in the North and -9 meters in the South. The climate is quite mild, because of the humidity is more even than in the surrounding vast steppes and with lesser temperature fluctuations. The importance of the floodplain is to regulate the humidity and composition of the atmospheric air of the cities of Volgograd and Volga.

The unique value of the floodplain — wetlands and key ornithological areas of international importance-places of nesting and recreation of birds, water meadows with maximum productivity, spawning grounds, fertile floodplain lands, floodplain oak forests. There are about 800 species of higher vascular plants and 300 species of vertebrates. More than 70 species of plants and animals are listed In the red book of the Volgograd region [1].

In 2000, within the Volgograd region in the Northern part of the Volga-Akhtuba floodplain, in order to preserve the unique ecosystem, the Natural Park "Volga-Akhtuba floodplain" was created. Volga-Akhtuba floodplain is the only part of the Volga that has preserved its natural structure. The wetlands of the floodplain are unique natural formations of international importance and are an example of a reference type of land for the southern region of the European part of our country. Nature Park was created in order to preserve this unique corner of nature.

Implementation of entomological surveys and phenological observations in places (fixing-ranges) of water bodies and adjacent territories, sampling in places (fixing-ranges) on each water object were carried out in the spring-summer period from March to August 2018-2019.

The selection of material was carried out by the water edge from a depth of 0.5-1.0 m on the river with water standing up to 1.5 m from the water edge in the reservoir and the Volga and Akhtuba rivers. For the coastal line, the material was selected with the previously established intervals in the 1-3 m band. Preference in the selecting material in the water edge and in that reservoirs was given to aquatic vegetation, branches, submerged in the water or submerged - nailed by the waves to the water edge plant residues, mainly the last year's shoots of reeds and branches. We used stones, fragments of bricks, etc. as the main material for select in reservoirs, in the absence of plants. Preimaginal steps (larvae, pupae) of biting *Simuliidae* we collected and dissolved in vials with 70 % alcohol for further study and consideration.

We estimated the intensity of imago takeoff by taking into account the number of attacks per 15-20 minutes "on ourselves" for all fixing-ranges during the presence of the imaginal stage of development. For this purpose calculation of all sat down on the chosen object (collector) in a certain period of time for feeding of midges was made. To avoid re-counting of the same individuals repeatedly returning to the feeding place, the settled midges were collected in a cloth bag using an impromptu vacuum cleaner for counting. Then abusive insects were counted and then immobilized.

We used an entomological net with edible sacs to collect and count imagoes. Collected insects have been stored on cotton mattresses or placed in 70 percent alcohol for subsequent identification. Also, the accounting of attacking midges was carried out with the test tube, from the forearm of the hand or the shin of the leg per 20 minutes

Taxonomic identification was carried out according to a number of broad-used entomological keys [4, 9-11].

III. Results and Discussion

In the spring-summer period of 2018, several mass species of the *Simuliidae* family, including *Simulium morsitans* Edw., *Schonbaueria matthiesseni* End., *Titanopteryx maculata* Mg. were recorded.

The average seasonal indices of the number of blood-sucking midges of *Simuliinae* family ranged from 50 to 179.0 ind. registration, in all places of observation. Peak abundance of adults was recorded from the third decade of May to the first decade of June (Table 1).

TABLE I. Entomological and phenological observation of blood-sucking midges in 2018.

Phenomena	**Places of observation and material collection**		
	Volga river	***Bayou of the Akhtuba river***	***Volga-Akhtuba channel***
Larvaes' amount peak	21.05	16.05	16.05
1st generation takeoff	28.05	21.05	23.05
Imagoes' amount peak	1st decade.06	3rd decade.05	3rd decades.05
Last time registration	3rd decade. 07	3rd decade.07	3rd decade.07

It shows typical regional statistics.

In 2019 the number of midges rates declined in all sites of investigation. As the mass species marked, same in the previous year, representatives of the Simu-liidae family, such as Simulium morsitans Edw., Schonbaueria matthiesseni End., Titanopteryx maculata Mg. The first generation takeoff was observed from about the second decade to the third decade of May. The average seasonal abundance ranged from 27 to 59 ind. on the account. The peak number of imagoes was marked in 1st decade – 3rd decade of June (Table. 2).

Observations in 2019 did not reveal significant phenological differences from indicators of midge development in the previous year.

TABLE II. Phenological observations of blood-sucking midges in a 2019 season.

Phenomena	**Places of observation and material collection**		
	Volga river	***Bayou of the Akhtuba river***	***Volga-Akhtuba channel***
Larvaes' amount peak	19.05	12.05	12.05
1st generation takeoff	22.05	18.05	18.05
Imagoes' amount peak	2nd decade .06	1st decade .06	1st decades .06
Last time registration	3rd decade . 06	3rd decade .06	3rd decade .06

The data on the territorial distribution of the activity of the main stages of development of midges, that were collected during the two-year studies, were summarized and presented in table 3.

TABLE III. Average seasonal numbers of blood-sucking midges of the Simuliinae subfamily in the sites of observation and sampling in 2018-19.

Accounting method	**Year**	**Places of observation and material collection**		
		Volga river	***Bayou of the Akhtuba river***	***Volga-Akhtuba channel***
Imago / "on ourselves" / ind.	50	125	179	50
	27	39	59	27
Larvae / in substrate / ind.	31.3	40.2	61.4	31.3
	11.9	18.7	28.7	11.9

Table 3 shows a reduce by half the number of blood-sucking Simuliidae gnats of all places of observation in 2019th to the previous year. The reduction of blood-sucking midges larvae in all places of observation for 2019th year was also marked.

The major environmental factors which influence on the Simuliidae immature development stages are spring flood level, water temperature, flow rate. For the sections of the Volga river, bayou of the Akhtuba river, Volga-Akhtuba channel, the most significant change in water level due to the functioning of the Volga hydroelectric during the spring flood. The mode of operation of the Volga HPP is carried out according to the approved schedule of special spring release, as this is a necessary condition for creating favorable conditions for fish spawning and farming in the Volga-Akhtuba floodplain, and in general, should not lead to deterioration of the sanitary and epidemiological situation in the region. The regulation of the Volgograd hydroelectric plant operation is implemented on the basis of the Interdepartmental working group (IWG) recommendations on the Volga-Kama reservoirs cascade operative regulation and is determined by the Federal water resources Agency depending on the current hydrological and water management situation. Taking into account changes in the hydrological situation of the surveyed territory, in accordance with the instructions of the Federal water

resources Agency, the volume of average daily water release through the Volgograd HPP for 2018 amounted to 15,000±500 m^3/s, on the Volga river. The flow rate ranged from 0.8 to 0.9 m/s. The Akhtuba flow rate growth trends were 0.3-0.5 m/s in this period. For the 2019th period, the volume of the average daily release of water through the Volgograd hydroelectric Volzhskaya HPP on the Volga river amounted to 9000±500 m^3/s.

It is difficult to overestimate the importance of the hydrological factor in the life of this ordo. Many researchers pointed to the decisive phenology and abundance of the effects of the onset and duration of floods, the height of water level, the bulk of the water temperature, intermediate floods, the sharpness of the decline in the bulk of the water. Not without reason, in many countries of Europe, Africa, North and South America, one of the main instruments for regulating the number of bloodsucking diptera is the management of the hydrological characteristics of rivers (most often by controlling the release regime on dams) [1-3].

In addition to the influence of the hydrological regime of the Volzhskaya HPP's Volgograd Hydraulic Hub, the ecological and biological features of blood-sucking midges in the Volgograd region in 2018 were taken into account. Larviciding destructive measures are also effective. When treating water bodies to eliminate the negative effect of insecticide on non-target objects, a selective microbiological preparation based on Bacillus thuringiensis was used, because its maximum effect is achieved against larvae. The measures taken against the blood-sucking midges of Simuliidae in 2018 had a positive effect in 2019. This data can be observed in tables 1, 2, 3.

The management of adjacent agricultural territories by influencing the processes determining the metabolomics of a community allows influencing massive changes in ecosystems. Experimental measures to reduce the anthropogenic load and increase the sustainability of anthropogenically modified communities lead to changes in the mass productivity of Diptera.

A promising direction should also be considered the management of the phenological changes in the studied insects, which will violate the timeliness and mass production. The use of powerful insecticides and microbiological insemination of the river carry a certain environmental danger, which is of particular importance given the location of Volgograd in the immediate vicinity of the protected nature area – the Volga-Akhtuba floodplain. The use of substances that regulate the pupation and release of adults can be combined with generally accepted chemical, biological, and hydraulic control means. The quasihormonal compounds of synthetic and plant origin, ecdysterones, can act as such regulatory substances. They often stimulate molting larvae, pupation and imago releasing. Untimely (sooner or later) exit of adults will lead to death of imago in cold spring conditions, drowning of the main mass in high water, drying of measured pupas when the water level falls. Also, males that fly too early die from starvation under conditions of a lack of plant food, which leads to the non-fertilization of females and their lack of need for bloodsucking.

IV. Conclusion

Thus during the period of our research, entomological and scientific situations on blood-sucking *Simuliidae* in Volgograd we have established the most massive and common species, among which are *Simulium morsitans* Edw., *Schonbaueria matthiesseni* End., *Titanopteryx maculata* Mg.

We have also identified the timing of the peaks of the blood-sucking *Simuliidae* larval stage and imago takeoff in the water bodies of the city of Volgograd, which depend on the hydrological regime of the Volgograd Hydraulic Plant of the Volga Hydroelectric Power Plant on the Volga River.

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