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Biological Control of the Blood-Feeding Midges during 2014 in the Middle Course of the Irtysh River

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Abstract

This article presents data about fauna and seasonal dynamics of the number of bloodsucking midges in the middle course of the Irtysh River, within the Pavlodar region of the Republic of Kazakhstan. It also contains information about the measures on disinsection against midges' larvae using a biological product based on the *Bacillus thuringiensis var. Israelensis* bacteria. The main goal of the disinsection measures in Pavlodar is not to destroy completely the midges' population, but to maintain it on a certain low level in order to create favorable sanitary and epidemiological living and working conditions for the human population of this city. The measures are taken annually in order to decrease the number of midges' larvae in the Irtysh River (mainly targeting larval stages of Simuliidae), which considerably regulates the number of bloodsuckers at a certain section of the river. Nevertheless, even after the treatment of the river by the bacterial preparation, which provokes the high percentage of larval mortality, an increase in midges' imago attacks in the city might be observed. This fact may be explained by the passive and active migration of insects from the areas not affected by treatment. Those areas are located downstream from the treated sites. And the strong winds usually transport the midges from there to the city.

Keywords

Generation; Substrate; Imago; Larva; Pupa; Pre-imago stages

Introduction

Nowadays scientists are getting more and more interested in the midges of Simuliidae family. These black flies have a great practical importance, and nevertheless they are relatively weakly studied [1].

Midges inhabit all continents except Antarctica. They are widespread except for some remote islands and deserts, devoid of rivers.

These insects have medical and veterinary importance. It is now established that they can be the vectors or intermediate hosts of pathogens provoking invasions and infections of humans and animals.

The most important disease transmitted by black flies is human and animal onchocerciasis. It was experimentally proved that midges can be the vectors of tularemia and anthrax. There is some information proving the transmission of glanders, leprosy, plague, and some other infectious diseases by these insects [1-3].

In Kazakhstan, the study of bloodsucking midges was initiated in the 60s of the 20th century, mostly in the mountainous regions (Tien Shan and south-western Altai) [4]. Nowadays 118 species of black flies in Kazakhstan have been described. They are mainly spread in the mountainous regions of south-east (Zailiysky, Jungar) and East Kazakhstan [5].

When describing the fauna of black flies in the middle course of the Irtysh River, passing through the territory of the Pavlodar region, it is important to underline the originality of the presented species. During the spring floods, the large areas of floodplain meadows get covered with water. These huge territories turn into favorable zones of midges' larvae development. A large number of organic substances that fall into the river create favorable conditions for the nutrition and development of pre-imago phases, which lead to mass breeding of midges in the territory of the Pavlodar region.

Every year the mass attacks on humans and pets by the bloodsucking midges and mosquitoes are recorded in the territory of the Pavlodar region. Therefore, it is important to conduct a study of the biological peculiarities of the local populations of black flies and mosquitoes, in order to develop and implement the measures for their reduction.

Currently, several methods of regulating the number of bloodsucking Diptera are known, but the most appropriate in terms of "efficiency and environmental safety" is a biological one. The biological method involves the use of a complex of the animals and plants, affecting the number of bloodsucking Diptera. The main purpose of this method is not the final destruction of midges, but only the effective control of their population dynamics. This group includes a variety of organisms: viruses, bacteria, fungi, algae, protozoa, helminths, arthropods, fish, birds, reptiles, *etc.*

The microorganisms are most commonly used for these purposes. According to scientific data, the microorganism, which has penetrated the body of the host, behaves as a pathogen, because of its chemical and mechanical impacts. Among the chemical impacts, the least aggressive ones are the processes of "stealing" the host food products and releasing toxic metabolites by the microorganism. It is noted that the effect of metabolites is very clearly seen for sporulating microbes during the decay of sporangia at the end of sporulation or for protozoa during cysts' disclosure. Many microorganisms (mainly bacteria) produce toxin systems. They could be endotoxins, those remaining inside the bacteria cell, or exotoxins, those getting secreted into the culture medium. A classic example of endotoxins, according to the author, can be a crystalline toxin deposited in the cells of *Bacillus thuringiensis*. The author thinks that mechanical damages combine with the chemical ones during the lysis of the infected body tissues (muscle, nerves, glands), and after their collapse, those places get filled with the parasite

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in various stages of its development. When growing up, the parasite exerts pressure on host tissues; it damages the tissue structure and its functions, and provokes tissue breaks and deformations. The extent of these destructive impacts of the parasite depends on its virulence, which enhances or reduces its properties [6].

The group of products with *Bacillus thuringiensis* H-14 as an acting agent exists nowadays. One of those products is "Bakticid." It was used to regulate the number of midges in the Pavlodar region in 2014.

Materials and Methods

Starting from the second decade of April 2014, we carried out the monitoring of black flies' larvae development in the Irtysh River and the Teplaya River.

When taking measures directed toward the reduction of the number of bloodsucking midges using the bacterial preparation "Bakticid," the organized surveys of the changing number of developing midges' larvae in the treated water reservoir were conducted.

In order to conduct the studies of the "Bakticid" effects on larvae of midges, five areas were chosen:

1. River section of the Irtysh River near the village of Kenzhekol;
2. River section near the river terminal;
3. River section near the railway bridge;
4. River section near the village of Chernoyarka;
5. The Teplaya River.

The studies of fauna, phenology, and ecology of bloodsucking midges were conducted according to conventional methods [7-10].

The determination of species and production of microscopic preparations were carried out as described in the methods of I.A. Rubtsov [1].

The evaluations of the product's effectiveness against the pre-imago stages of midges were carried out before the treatment and after, during 72-96 h after the treatment.

Collection and counting of pre-imago stages of black flies were carried out at the fixed points. For this purpose, natural substrates (tree trunks fallen in water, willows covered with thickets, algae, *etc.*) were used. The number was recalculated per 1 square decimeter (dm^2) of substrate.

Results and Discussion

The studies conducted in April and May of 2014 showed that three main types of midges, *Wilhelmia eguina* (horse gnat), *Boophtora erythrocephala* (redheaded midges) *Byssodon maculata* (striped midges), were developing in the Irtysh River and in the Teplaya River. The first two species are early-spring ones, wintering in the larval stage.

The bulk of the midges' larvae in the river during the first 10 days of May were represented by the larvae of *W. equina* (horse gnat) and *B. erythrocephala* (redheaded midges). The maximum number of them was observed in collections on May 13. The dynamics of the number of midges' larvae is presented in Table 1 and on Figure 1.

Typically, these species that fly in May are intrusive, but they rarely attack humans. They feed themselves with the blood of animals.

The second decade of May saw an increase in the number of midges' larvae in the Teplaya River and the Irtysh River. The bulk of midges was represented by the first-generation larvae of *B. maculata* (striped midges), the second one of *B. erythrocephala* (redheaded midges), and early ages of *W. equina* (horse gnat) (Table 1).

With increasing air and water temperatures, larval development proceeded quite rapidly, and already on May 13th, in the Teplaya River and the Irtysh River, the maximum number of larvae of *B. maculata* (striped midges), *B. erythrocephala* (redheaded midges), and *W. equina* (horse midges) was observed in collections.

Based on the data obtained in collaboration with the Department of Consumer Protection of the region, the first tour of treatments in the Teplaya River and the Irtysh River with the bacterial preparation "Bakticid" was realized on May 16, 2014.

In 2014, the dynamics curve had several peaks. The first peak was observed in the third decade of April, when the density of larvae was 35.7 larvae per dm^2 substrate (Table 1 and Figure 1).

Such an amount is evolved through the development of the larvae of two species: *W. equina* and *B. erythrocephala*, 76.6 and 24.4%, respectively. The decline in the number during the first decade of May can be explained by the transition of larvae to pupal stage and the subsequent departure of adults.

The maximum peak of larvae quantity, 503.8 specimens per dm^2 of substrate, was observed during the third decade of May 2014. This peak is the sum of the second populations of *W. equina* and *B. erythrocephala*, as well as the first one of *B. maculata*. The following decreases in the insect number are related to desinsecting activities.

During the third decade of May an increase in the number of larvae, 667.1 specimens per dm^2 of substrate, was observed. These insects were representatives of the third-developing generation of *W. equina* and *B. erythrocephala*. The number of *B. maculata* in collections was decreasing during this period. The number of larvae was reduced to 135.2 specimens per dm^2 of substrate due to desinsecting activities.

Place of collection	Date												
	13.05	18.05	19.05	20.05	21.05	29.05	31.05	1.06	14.06	18.06	19.06	20.06	21.06
Village of Kenzhekol	322	173.8	109.5	255.3	40	573.4	385.9	227.6	479.1	271	198.6	135.6	113.7
River section near the river terminal	469.6	262.9	136.2	140	133.2	667.1	367.2	196.5	613.9	401.2	389	203	139.8
River section near the railway bridge	503.8	246.8	156.2	177.5	72.9	513.8	489.3	155.6	509.2	278.6	226.4	157.4	130.5
Village of Chernoyarka	375.2	135	131.3	163.5	5	454.05	405.6	213.8	528.4	294.5	254.7	167.9	121.5
The Teplaya river	481.6	172.7	188	150	140.4				528.3	189.4	113.4	94.6	77.3

The product's efficacy data 24, 48, 72, and 96 h after the treatment.

Table 1: The number of midges' larvae in the Irtysh River and the Teplaya River in 2014

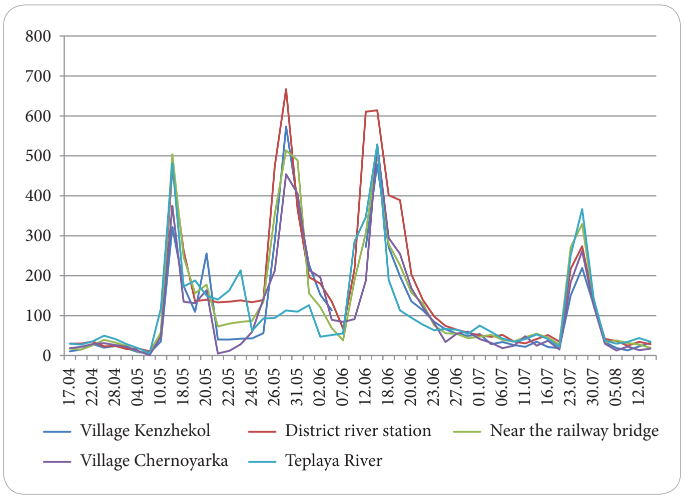

Figure 1: Dynamics of bloodsucking midges in 2014

The maximum peak, 613.9 larvae per dm^2 of substrate, was observed during the second decade of June. The high density of larvae during this period was represented by the fourth generation of *B. erythrocephala* and *W. equina*, as well as by the third one of *B. maculata*.

The next increase was recorded during the third decade of July—257.3 larvae per dm^2 of substrate. The larvae of *B. erythrocephala* dominated during this period, while the quantities of the other species were not considerable.

The biological product was used for the first time in 2002. Immediately after that, the number of midges' attacks in the city was reduced to 20 times per 20 min of observation; in 2003 the number of attacks was 14. In 2004 it was 12, in 2012 it decreased to 4-6, in 2013 there were 11 attacks, while in 2014 only 2-3 ones were recorded.

The maximum number of imago attacks in the village of Pavlodarskoe, 4-6 times per 20 min, was observed during 3 days, from the sixth to the eighth of June 2014.

Analyzing the situation on the attack of midges in Pavlodar, it should be noted that it is necessary to distinguish "molestation" of imago from their active bloodsucking aggressive attacks toward humans.

Conclusions

From 2002 to 2014, in the territory of the middle course of the Irtysh River, disinsection measures using a biological product based on the bacteria *Bacillus thuringiensis var. Israelensis* were taken.

On the basis of 12 years' research of using bacterial preparations, we have identified that the concentration of 3.0 g of product per liter is lethal to larvae of biting midges. The data obtained from the treated and untreated areas indicate a considerable decrease in the number of midges' larvae.

A high percentage of larvae deaths was caused by the use of the product during the mass development of the second-, third-, and fourth-generation of larvae. The calculating of the required product concentrations in the water was done according to the location and the technology of its submission. As a result, a considerable reduction of the number of bloodsucking midges in the middle course the Irtysh River was observed. Thus, the obtained results prove the efficiency of the bacterial product in the regulation of the number of larvae of biting midges.

We underline that the choice of the product should be determined by its environmental safety toward non-targeted objects (aquatic) and its economic advisability. When using analogical products, it is important to take into account the possibility to use larvicide in the water bodies of economic value.

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