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Effects of Thermal Pollution on the Black Flies of the Irtysh River in Kazakhstan

[1]Akhmetov Kanat, [1]Orazbekova Aigerim, [2]Shaimardanov Zhasulan, [1]Kolpakova Valentina, [2]Shaimardanova Botagoz and [1]Ainagul Balgauovna Kaliyeva

[1]Department of Biology and Ecology, Toraighyrov University, Pavlodar, Kazakhstan
[2]Center of Competence and Technology Transfer in the Field of Water Management and Water Use, D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan

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Corresponding Authors:
Ainagul Balgauovna Kaliyeva
Department of Biology and Ecology, Toraigyrov University, Pavlodar, Kazakhstan
Email: ainanurlina80@mail.ru

Abstract: The article describes the impact of thermal pollution of water of the river Irtysh, in its middle reaches, by water used in the technological process of Aksu SRPP Teplaya tributary (Pavlodar region, Republic of Kazakhstan). The temperature of the water coming out of the Aksu SRPP is 4-6 degrees higher which accounts for 18 degrees in mid-May to 23 degrees in mid-June in 2012 and 2015 than in the main channel, which affects the ecology and species diversity of representatives of the family Simulidae (blackflies), order Diptera, whose larvae develop in the waters of the river. Increased water temperature in the Teplaya tributary affects the biology of Simuliidae, reducing the development time of their larval and adult flight summer phases. Adult imago simulid flight in the Teplaya tributary is 36-48 h ahead of adults in the main channel. The sensitive blood-sucking activity of adult Simuliidae is felt by the population from the second decade of May to the end of June. At the same time, the aggressiveness of the adult hatch from the Teplaya tributary was felt on May 13-14 during the observation years, whereas that from the main channel occurred on May 15-17. The article describes the ecological characteristics of the river section where observations were made. The observation orbit includes a section of the Irtysh River with a length of about 40 km (20 km above and below the Aksu SRPP), where there is a noticeable difference in water temperature before the SRPP and after draining the process water. The reasons for changes in biodiversity of Simuliidae and peculiarities of habitats of larval forms of Simuliidae in conditions of "regulated" flooding are discussed.

Keywords: Blood-Sucking Insects, Larval Development, Habitat and Number of Larvae

Introduction

The main purpose of this study is to study the influence of high-temperature water used in the technological process of the SRPP and its effect on the activity and biodiversity of blood-sucking diptera in the middle reaches of the Irtysh River of the Pavlodar region (Republic of Kazakhstan).

The hypothesis of the study is related to the study of the influence of the process water of the Aksu SRPP in the teplaya tributary (receiving water from the SRPP) on the biology, ecology, and biodiversity of the simuliidae compared with those above 20 km and below the power plant, where the influence is minimized in the main channel of the Irtysh River.

The influence of the anthropogenic factor, expressed in the influence of water used in the technological process of energy production on the complex of various groups of organisms, is discussed in many studies (Fedorov *et al*., 2022; Lemke and Benke, 2003; Golovanov and Smirnov, 2004; Moshchenko, *et al*., 2011; Kasyan, 2015).

The average course of the Irtysh River within the Pavlodar region is located deep in the Eurasian continent, relatively equidistant from the Atlantic, Pacific, and Arctic Oceans. In the middle course, the Irtysh River divides the region into two parts the right bank, with an area of about 41.2 thousand km2, and the left bank, with an area of about 83.6 thousand km2. The climate of the region is sharply continental, characterized by long, cold winters, long springs, and short dry, warm summers.

According in the middle reaches of the river, within the Pavlodar region, the determining factor in the formation of the riverbed and its floodplain is the sedimentary rocks of the bed for 720 km, Irtysh has no tributary. Therefore, the entire territory of the region belongs to the area of closed runoff of surface waters that collect in drainless lakes and depressions. The floodplain of the Irtysh region, on average, has a width of 15-18 km. The sedimentary rocks of the riverbed in the region were determined by the fact that many islands and sandbars were formed in certain sections of the arm, a huge number of channels, and old rivers, according to Khitsova (1981); Patrushev (2022) this situation is one of the important factors influencing the mass production of the image. The hydrological regime of the river is significantly influenced by the annual releases of water from the cascade of reservoirs in the East Kazakhstan region. The passes differ both in the volume of incoming water and in the standing time. Flood releases are a necessary condition for the life of the ecosystem of the river and the biocenoes associated with the river and its surroundings, thanks to this, a complex of coexisting organisms and their diverse relationships has evolved.

Naturally, the whole complex of factors related to the life of the river and the “work” of regulated floods plays an important role in the biology and ecology of one of the important groups of insects of practical importance - blood-sucking diptera, the development of which is associated with the river. Abiotic factors certainly affect the situation with blood-sucking insects in the region.

A special role in this study is played by blood-sucking diptera living in the middle plain of the Irtysh River, such as Culicidae (mosquitoes), Simuliidae (black flies), and Tabania (horseflies), which are an indicator of the state of the river and an important component of its ecosystem. Culicidae (mosquitoes), Simuliidae (blackflies) and Tabania (horseflies) actively respond to abiotic factors: Floods, and temperature changes, which directly determine their impact on residents of settlements located in the immediate vicinity of the river. In the spring, with an increase in the average air temperature, as well as with a change in the hydrological regime, taxa united in the family Simulidae (blackflies) are of particular concern. Disturbing factors for the population are the massive appearance of black flies in the coastal zone of the river and settlements, characterized by blood-sucking activity aggressiveness, and concomitant "peskiness". The flight of imago forms of black flies in the spring is massive with a high number.

Specifically, technologies and special methods of animal and human protection are being developed to prevent and stabilize the aggressiveness of Simuliidae and other blood-sucking diptera (Bin *et al*., 2012; Palleria *et al*., 2013).

It should be noted that the imaginal stages of the Simuliidae are associated with the riverbed itself and its flowing branches, therefore they are an important evolutionarily developed component of the river ecosystem. According to (Malmqvist, 1994), a complex of taxa belonging to the family Simuliidae are indicators of river pollution, since they participate in ensuring the balance of components of the aquatic ecosystem between suspended particles and predators.

Materials and Methods

Blood-Sucking Bipedal Species: Culicidae (Mosquitoes), Simuliidae (Blackflies), Tabania (Horseflies). Culicidae (Mosquitoes)

The mosquito family (Culcidae) includes about 2 thousand species of blood-sucking insects, separately in the subfamilies Culicinae and Anophelinae. In CIS blood-sucking mosquitoes are represented by 68 species with subspecies belonging to the genera Aedes, Culex, Anopheles, Mansonia, Culiseta, and Uranotaenia.

Mosquitoes are small (3-4 mm) and medium-sized (up to 10 mm) insects, and have an elongated body, thin long legs, and a pair of wings Fig. (1). The head is globular. Eyes are kidney-shaped, faceted, convergent, or contiguous in the upper and lower parts of the head. Antennal antennae are 15-membered, shortly hairy, and feathery in males. The mouth apparatus is of the stinging-sucking type, its length is several times greater than the diameter of the head. The tentacles are 5-membered, and covered with scales. Thorax wider than abdomen, its segments fused, body coloration gray, black or yellow-brown, legs elongate, ending in two claws. Wings are elongate-oval, covered with scales, which are grouped in dark and light spots, which make up the wing pattern.

Simuliidae (Blackflies)

The family of black flies (Simuliidae) has more than 900 species. On the territory of the CIS 322 species are known, belonging to 2 subfamilies: Gymnopaidinae and Simuliinae.

Gnats are small (2.5-5.5 mm), dark-colored, sometimes with light spots on the back and legs, stocky insects Fig. (2). The head is round, tucked under the thorax. Proboscis of stab-sucking type. Legs short, and thick, of the usual insect structure. Wings roundish-oval, transparent, short and broad. Abdomen oblong-oval, gradually tapering to the posterior end.

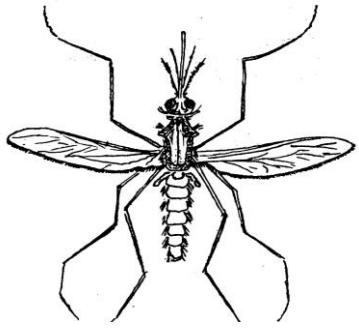

Fig. 1: Ceratopogonidae

Fig. 2: Simuliidae (blackfly)

Fig. 3: Tabania (horseflies)

Tabania (Horseflies)

Blindflies are the largest blood-sucking two-winged animals of the family Tabanidae. Tabanidae. They are widely distributed in tropical, temperate, and northern latitudes. On the territory of CIS 195 species belonging to 3 subfamilies and 12 genera are found. Blindflies are medium or large-sized insects (from 6-7 to 28-30 mm), the body of which is colored in black-gray, black-yellow, brownish-black, and yellowish-pale tones Fig. (3).

The head is large, equal to or wider than the thorax, with large, iridescent faceted eyes. Some species (Chrysops) have three simple eyes or an ocular tubercle on the vertex (Hybomitra). In males eyes are contiguous, in females they are separated by frontal stripes with shin-ing convex chitinous frontal calluses. Antennal antennae are three-membered, and attached under a frontal trian-gle.

Methods

In this study, observations on the monitoring of the species composition of simulated characteristics of the middle course of the Irtysh River, which were carried out in the period from 2003-2016, from April to October, annually, are analyzed. Studies on the distribution and density of larval stages from 2011-2014 from May to August. The collection of the material was carried out using generally accepted methods: Manual collection of substrate from watercourses with preimaginal phases of development, and collection of attacking imago females on the counter. Also, the collection of adult individuals was carried out with an entomological net, using the method of mowing through vegetation.

The larvae of the Simuliidae were collected annually on the riverbed Irtysh at a distance of 19 km and 1 km above the Aksu SRPP (a control point where there is no influence of process water) and in a Warm channel receiving water used in the technological process below the SRPP below the object at a distance of 1 km and in the main channel 19 km below (the point where the influence of technologically used water almost leveled). The larvae of the Simuliidae were collected on natural sites (on vegetation located in water at a depth from the surface of the water from 0.5-0.7 m). The selected samples were diagnosed using an MBS binocular.

The collection of water phases of development was carried out in the sections of the river with the fastest current. The river flow rate was measured using the "float" method. The time required for the cork float to cover a distance of two meters (one meter each before and after the identified substrate) was determined using a stopwatch. The determination of the flow velocity was carried out in three repetitions and after that, the average value was determined.

Larvae and pupae, as a rule, accumulate massively on the fastest rifts where the current exceeds 0.5 m/s. Subsequently, the larvae and pupae were removed from the substrates with thin forceps and placed in glass tubes containing a 70% alcohol solution. The materials collected from different substrates were stored in different ways before being transported to the laboratory for microscopic examination and identification. Only mature larvae (with dark gill spots) and pupae (with characteristic plastron gills) have been identified. Larvae and pupae were collected from all available substrates found in their habitat. The density of the preimaginal stages was calculated per square decimeters.

Imago Simuliidae were collected by trapping them around "themselves" for three minutes using a test tube and an entomological net with a hoop diameter of 15 cm and a linen bag. Ethyl acetate (acetic ether) is used to kill insects. Simuliidae is stored in a test tube with 70% alcohol or dry on a layer of cotton wool. The insects captured by the imago were collected in test tubes by lowering them in layers. The captured insect was covered with a small cotton swab, which was then pushed inside the tube, the next insect was placed on top of the cotton swab in the same tube and so on, the insects were collected in the tube before it was filled. The tubes were labeled with the year, month, day, time of collection (according to the clock), the place of collection (geographical coordinates of the place of collection, the nature of the area), meteorological conditions (air temperature, water temperature, wind speed, relative humidity, the nature of clouds).

The study of the activity of the midge was carried out by the generally accepted method of trapping oneself, for 20 min, on a bare shoulder, all types of bloodsuckers were caught.

Selection points were identified for the collection of larval stages. The identification of imago forms, larvae, and pupae was carried out using a determinant (Yankovsky, 2004). The collected materials include all phases of the development of Simuliidae. The statistical data obtained were processed according to Lakina (1990).

Results

Our systematic observations of the biodiversity of representatives of the Simuliidae family in the middle reaches of the Irtysh River began in 2000 and covered the segment from the beginning 40 km, above the city of Pavlodar and ended 40 km downstream. 5 species of black flies were diagnosed on the studied section of the river: Wilhelmina equina, Byssodon maculate, Eusimulium aureum, Boophthora erythrocephala, Simulium longipalpe. The population data is shown in Fig. (4).

The fauna of the Simuliidae, on the section of the river adjacent to the city of Pavlodar, covered by annual observations, has undergone changes. Since 2005, representatives of the species Eusimulium aureum have been absent from the collections of May-June every year, and since 2007, the species Simulium longipalpe has not been registered in the collections. Single specimens of S. longipalpe were collected in the mainstream, but only in 2002-2004.

The water used in the energy production of the enterprise is discharged into the Teply duct, and the temperature of the discharged water is higher than in the riverbed. The consequence of this is that in winter there is no ice formation on the Ertis River below Aksu and Pavlodar, for 25-30 km. That is, there is a fact of temperature contamination of the riverbed. The Teply Duct near Pavlodar connects to the main riverbed. The temperature of the water in the channel is usually 4-5 degrees Celsius higher than the temperature of the water in the main channel near the city of Pavlodar. Table (1) shows an example of accounting for the water temperature in the Teply duct and the main river erbed near Pavlodar on a specific accounting date and the total number of larvae per dm2 of the plant substrate.

Table (1) indicates the dependence of Simuliidae larval emergence dates on water temperature, the number of larvae in the Teplaya channel, which "receives" water used in the technological process of the state regional power plant of Aksu (hereinafter SRPP), and the number of larvae per 1 dm sq. m. at the stations in the main channel, before SRPP and near Pavlodar. Analyzing the comparative brooding of preimaginal stages of Simuliidae in the above-described streams we come to the following conclusion. The temperature impact of water used in the technological process of SDPP actively affects the ecosystem of the channel, in particular, the biocenosis. The proof of this influence is that the period of maturation and change of preimaginal ages in the development of Simuliidae is shortened, which leads to a reduction in the time of adult phase departure. The table shows the actual counts of larval stages of Simuliidae in the streams of the Irtysh River, differing in water temperature at each site. According to the observations, the departure of adult Simuliidae in the Teplaya channel starts 36-48 h earlier than the departure of adult Simuliidae in the main channel of the Irtysh River near Pavlodar. The exception is the generative season of 2020 when the development of Simuliidae in the Teplaya channel was absent.

The indicator of dominant Simulidae species at the observation site did not remain a constant value. Figure (4) illustrates substrate occupancy per square decimetre by Simulidae larvae in 2003 and 2016.

In the period from 2011-2014, studies on the dynamics of Simuliidae larval abundance were conducted. Sites with mass flight of adult forms were selected. The data shown in Table (2) show the average number of larvae per 1 dm^2 of substrate for several years of observation.

Table 1: Comparative water temperature and average number of larvae per square decimeter of substrate

River bed	Date of collection	Water t°C	Larvae hatch per dm^2	Date of collection	Water t°C	Larvae hatch per dm^2	Date of collection	Water t°C	Larvae hatch per dm^2
Teplaya tributary	14.05.2011	22°C	159	18.05.2012	23°C	382,2	14.05.2013	22°C	221,8
Riverbed near Pavlodar	14.05.2011	18°C	487,0	18.05.2012	18°C	900	14.05.2013	17,5°C	307

Table 2: Comparative water temperature and average number of larvae per square decimeter of substrate

River bed	Date of collection	Water t°C	Larvae hatch per dm^2	Date of collection	Water t°C	Larvae hatch per dm^2	Date of collection	Water t°C	Larvae hatch per dm^2
Teplaya tributary	12.05.2014	23,5°C	219,6	13.05.2015	22°C	301	14.05.2016	23°C	386,0
Riverbed near Pavlodar	12.05.2014	018°C	0220	13.05.2015	18°C	782	14.05.2016	18°C	596,2

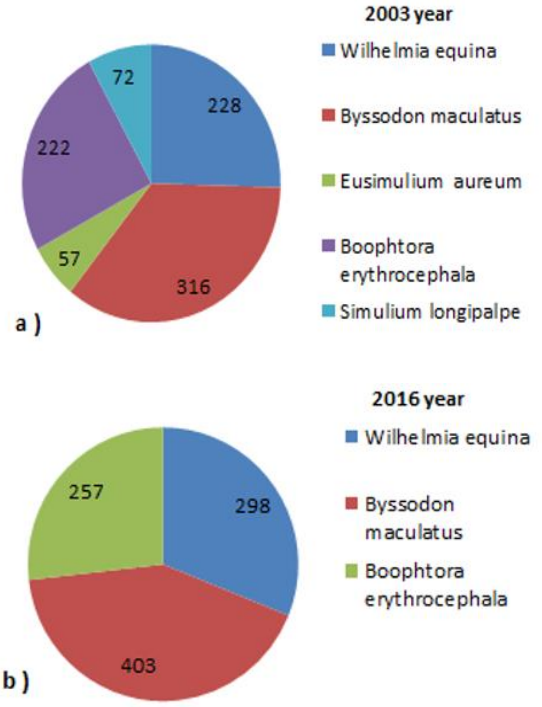

Fig. 4: Species composition and number of adult Simuliidae (units) per 1 dm^2 of substrate in the middle reaches of the Irtysh River as of (a) 2003-2007 and (b) from 2016-2022

Discussion

The study reflects the influence of high air temperatures on the water temperature in the coastal part of the riverbed, including the coastal part of its various channels and shallow rifts (especially with reduced flow velocity), which cause activation of the development of preimagic stages and flight of imago Simuliidae, as well as the influence of elevated water temperature used in the technological process of the Aksu SRPP. This circumstance is important, given that in the middle reaches of the Irtysh River, including the area discussed in this study, very plastic species of Simuliidae live, that is, taxa of blackflies capable of living in conditions of increased turbidity, reduced percentages of oxygen saturation in water and other not entirely favorable conditions.

The modern world fauna of Simuliidae includes 2415 species, 17 of which are considered fossils (Adler and Grosskey, 2022). According to the analysis of studies of Simuliidae biodiversity in the territory of Kazakhstan, 88 species are registered, 16 species of which are endemics. Regarding the fauna of Simuliidae in the middle reaches of the Irtysh River within the Pavlodar Priirtyshye, there is no consensus. Thus, some researchers (Makatov, 2009) the fauna of the Irtysh River Simuliidae in the region counts 21 species. However, the analysis of literature that discusses the problems of ecology and biology of Simuliidae says that large plain parts of rivers are not characterized by high biodiversity, this is because of the presence of some factors: Relatively calm current (low flow velocity), mineralization and mechanical particles (Alshin *et al*., 2018; Ubaskin *et al*., 2022). The above suggests that only plastic species of Simuliidae can occur on large plain rivers. The peculiarity of the distribution and ecology of black flies is that lotic conditions characterize their habitats, i.e., the oscillatory character of water flow is present. The plain part of the river Irtysh in the middle reaches is not rich in this sense and the habitats with which the emergence of aquatic stages of Simuliidae is associated are confined to crevices in the coastal zones of the main channel and channels. Previously, researchers have noted the aforementioned timing of Simuliidae clutches and brood ecology of pre-mammalian stages, noting that the higher the water "disturbance", the greater the likelihood of rich species diversity (Hemphill and Cooper, 1983; Gallardo-Mayenco and Toja, 2002). The rich biodiversity of Simuliidae is characteristic of turbulent streams, which are mountain rivers and headwaters of large channels. The main reason for this distribution of Simuliidae is that there is less competition among larval stages for oxygen and food resources in swift streams, with the depleted predator fauna also being an important factor (Yixin *et al*., 1998). An important concomitant factor explaining the significant biodiversity of Simuliidae in mountain streams is the absence or lower content of mechanical impurities, which settles faster and does not form an additional limiting factor for larval development (Kenzhebaev, 1985).

Changes in the fauna of the Simuliidae associated with the extinction of the species Eusimulium aureum and Simulium longipalpe, in the collections of 205-2007, are due to the fact that both species belong to the Palearctic complex of European-Asian species. The localities of these species were mainly confined to the Teplaya tributary, which is associated with the technological process of the Aksu SRPP. We attribute the reason for this localization to the fact that these are more heat-loving species confined to beds with higher water temperatures in the area from 18-26 degrees Celsius according to Kaplich and Skulovets (2000).

We associate the disappearance of the mentioned species in the collections of subsequent years with two reasons: The first perhaps a small population of species was eliminated by disinsection measures on the bayou and riverbed near Pavlodar; the second possible reason is due to the fact that from the mid-2000s to the present day, the number of wild bird populations (near-aquatic and other groups of birds) that nested in the floodplain of the river and in the region as a whole, which led to the disappearance of E. aureum and S. longipalpe. These taxa of Simuliidae, according to Mironenko (2020), belong to the group of ornithophilic bloodsuckers. We also agree with

(Sidorenko 2022) that warm water flows reduce the indicators of retained oxygen compared to cold water. The requirement for oxygen parameters of the S. longipalpe species was noted earlier by Yankovsky (2004). Complementing the reasoning of the data shown in Fig. (4), we consider it necessary to note the influence of air temperature, which causes temperature rise in the coastal part of the river channel, both its main streams and channels. It is in the riparian zone that the vegetation substrate is inhabited by simulid larvae, up to a depth of no more than 50-60 cm. Water temperature, warmed by high air temperatures, is one of the important factors affecting the brood-rearing, development, and maturation activity of larvae and adult Simulidae. High air temperatures directly affect shallow riparian portions of the river channel and shallow stream crossings. Years with the highest air temperatures in the region were recorded, according to Kazhydromet data for the period from 2011-2014.

The influence of high air temperatures on water temperature in the coastal part of the channel, including the coastal part of its various channels and shallow channels (especially with reduced flow velocity) causes activation of development of preimagial stages and flight of adult Simulidae. This fact is important considering that the middle reaches of the Irtysh River, including the section discussed in this study, are inhabited by very plastic Simuliidae species, i.e., taxa of blackflies capable of living in conditions of increased turbidity, reduced oxygen saturation percentages in water and other not quite favorable conditions.

Under conditions of the Pavlodar region, the periods of mass, most many adults of Simull phases are limited to the periods from the middle of May to the end of the second, rarely the third decade of June. Researchers note that in years with abundant floodwaters, a high abundance of both larval stages and adult phases of Simuliidae is observed on the floodplains of rivers (Alshin *et al*., 2018).

From the data in Table (1), the increased water temperature does not have a significant effect on the larval emergence of Simuliidae per unit area. This can be judged by the number of larvae per unit area of the plant substrate in the Teplaya tributary and the main channel of the Irtysh River near Pavlodar. Substrate occupancy by pre-imaginal stages of Simuliidae is always higher in the main channel, except for observations conducted in 2014.

In our opinion, the reason for the more abundant emergence of pre-mammalian stages of Simuliidae on the stages in the main channel of the river Irtysh than in the Teplaya tributary is related to the qualitative indicators of water composition. The discharge of water used in the SRPP technology impacts the biota, in particular, by reducing the optimal indicators of the aquatic environment in the channel. This can be judged because, in May-June 2020, no pre-imaginal stages of Simulidae were found in the Teplaya channel, while in the main channel, the vegetation substrate was populated.

Analyzing observations on the biodiversity of Simuliidae species near Pavlodar in the period from 2003-2007 and from 2016-2022, we note that the species composition has decreased to three species, all of them belong to the group of mammalophilic species, their females feed on the blood of mammals, including humans (Gryaznov, 1984).

The fauna of Simuliidae since 2016 in the river section near Pavlodar includes 3 species: Wilhelmina equina, Byssodon maculate, Boophthora erythrocephala. The same species inhabit the Teplaya channel. In our opinion, the above taxa belong to the most plastic groups of Simuliidae, which are quite well tolerant of various changes in the composition of the environment, in this case, the aquatic ecosystem. However, the case absence in 2020 of the emergence of preimaginal stages of the mentioned species in the Teplaya tributary suggests that there is a threshold or type of pollution that cannot be overcome. The answer to this question can be given only after a scrupulous study of changes in the chemical characteristics of "discharged" water used in the technology of the Aksu SRPP.

It should be noted that species that were not found in collections after 2007 in the riverbed's section near Pavlodar constituted an insignificant part of the biodiversity of Simuliidae in the middle reaches of the Irtysh River in the Pavlodar region. Data on the species diversity of black flies before 2003 in the middle reaches of the river are scarce, if not absent, so it is difficult to establish at the moment what was the situation of the fauna before the 2000s. The probable reasons for the disappearance of simulid species near Pavlodar are discussed above. According to some researchers (Patrushev, 1967), the species composition of large plain rivers, such as the middle course of the river Irtysh, is not rich in biodiversity. The reason for this is strong water salinity and reduced flow velocity. The latter causes a decrease in dissolved oxygen in water, which is one of the important limiting factors.

As shown by the studies, which are illustrated in Fig. (5), the peak in larval counts at the sampling points occurs between the months of May and June. The years 2011, and 2013,2014 are characterized by active flooding. In 2012, there was no flooding. High aggressiveness of Simuliidae was observed. The aggressiveness of Simuliidae is understood as their active feeding and "attacks" on the population. The number of larval stages of black flies per unit area varies during each month. High air temperatures lead to rapid warming of the water, which leads to a rapid accumulation of positive temperatures, shortening the development time and departure of adult forms. For example, in 2011-2014, the average air temperature was high and reached +27-+30C. This had a positive effect on the number of frolicking larvae. Our observations are consistent with the opinion of European scientists (Lopez-Pena and Jimenes-Peydro, 2020) showing that river water quality

and temperature increase a factor affecting the change in biodiversity of Simuliidae.

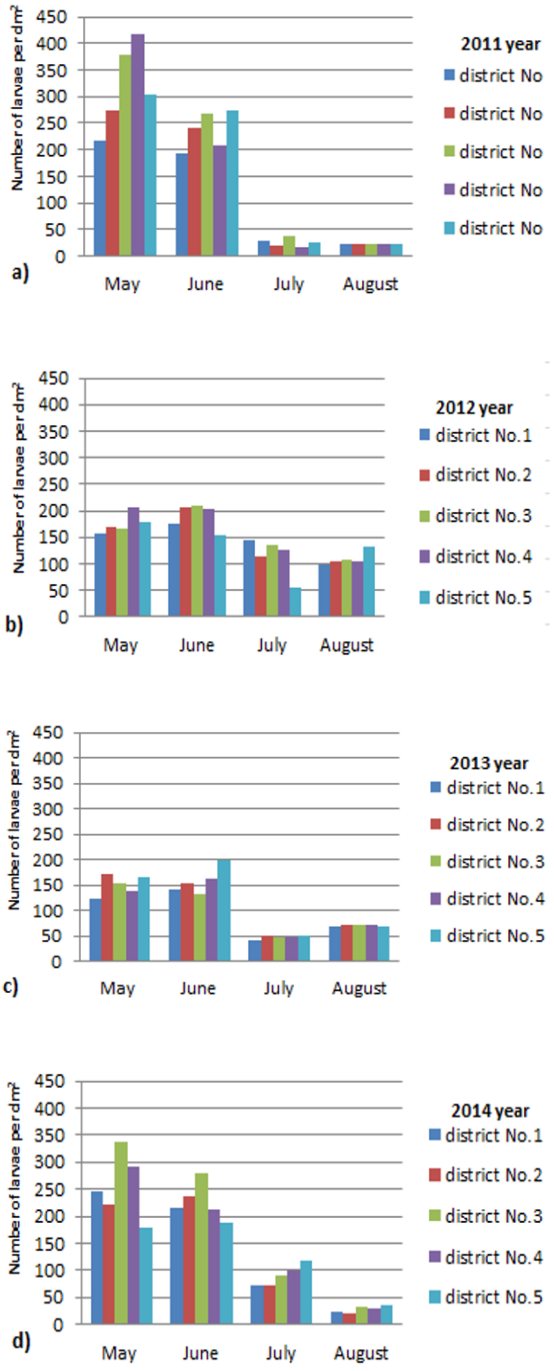

Fig. 5: Average number of midge larvae in the Irtysh River per dm2, from 2011-2014 (Lot No. 1-520 10' 41" N. 0760 58' 55" E., Lot No. 2-520 31' 18" N. 0760 48' 44" E., Lot No. 3-520 15' 58" N. 0760 56' 09" E., Lot No. 4-520 19' 17" N. 0760 53' 25" E., Lot No. 5-520 11' 39" N. 0760 59' 12" E.)

Observations of the emergence period of Simuliidae show that adult forms are not limited only to the period from May to June. The adult flight of Simuliidae usually starts from the third decade of April - this is Wilhelmina equina and lasts until the second decade of October. During the period from July to October, the black flies do not show aggression towards humans and animals. This suggests that there are factors that promote or create conditions for the bloodsucking activity of Simuliidae. Such factors include regulated artificial floods on the river Irtysh, which especially strongly affect the components of the river biocenosis in the middle plain stream. In particular, river floods, which on average reach a width of 15-17 km, characterize the territory of the Pavlodar region. The area of the river floodplain is quickly flooded (within 2-3 days) and with the cessation of floods, water quickly enters the channel. The large volume of water released, and its speed provide a sharp rise in water mineralization, and the removal of mechanical impurities (sand grains and other materials) worsens the optimal indicators for the development of biocenosis components of the river ecosystem, one of which are Simuliidae. Environmental factors are determinants in the development of Simuliidae (Carlsson, 1967).

Organized, regulated water release from upstream reservoirs changed the natural processes of the development of organisms associated with the aquatic environment. Prior to the anthropogenic regulation factor, the Irtysh River spill was quite slow (Beisembayeva *et al*., 2015) and this did not lead to the stressful development of individual hydro points, in particular, pre-imaginal phases of Simuliidae. In water, their development took place according to the conditions of "soft" floods established in adaptive evolution without a sharp rise in salinity, introduction of mechanical impurities, and rise in turbidity indicators, i.e., without special harsh conditions. The above described for most larval phases of Simuliidae are optimal environmental parameters, under which the reserves of substances necessary for the formation of adult forms, eggs after flight and fertilization are formed.

The need for a high-protein diet is related to the peculiarities of the biology of black flies. Protein is necessary for adult forms for the initial processes of reproduction - egg formation. In unregulated river conditions, larvae develop in a constant natural unchanged environment. In the period of sharply coming artificial floods, larvae develop in conditions sharply different from normal, formed over many millennia. The adults that have fledged from larvae that survived the artificial floods seek a high-protein diet, the suppliers of which are warm-blooded animals and humans. This may explain high gnat aggression in the immediate vicinity of the river flood. In periods after floods, larvae develop in conditions close to natural conditions. Apparently, this is the main reason for the lack of aggression among adults.

Conclusion

The results obtained during the study provide information on the distribution, timing of development, and factors affecting the biology of Simuliidae in the middle plain of the Irtysh River in the Pavlodar region.

In the zone of influence of the water used in the technological process of the Aksu SRPP and the increased water temperature by 2-4 degrees Celsius, a complex of three species W.eqina, B.maculatus, and B. erythrocephala was established, which turned out to be the least demanding for water quality indicators.

Simuliidae form ecological complexes, the selection factors in the zone of influence of the water used in the technological process are the temperature in the Warm duct increased by 2-4 degrees Celsius and the regulation of effluents. Artificial floods have changed the natural course of rising water levels and flooding of the floodplain, which was the reason that the studied section of the Irtysh River contains only ecological plastic species adapted to increased mineralization, turbidity, and factors related to production affecting the indicators and composition of water.

Thus, the biodiversity, breeding, and abundance of Simuliidae in the middle reaches of the Irtysh River depends on a variety of biotic and abiotic factors, such as water and air temperature and annual pest control operations reduce the number of taxon populations.

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Author's Contributions

Akhmetov Kanat: Supervised the study, conducted the literature review, and drafted the manuscript.

Orazbekova Aigerim and Kolpakova Valentina: performed comparative analysis of the data obtained.

Shaimardanov Zhasulan, Shaimardanova Botagoz and Ainagul Balgauovna Kaliyeva: Conducted field-work, also contributed to manuscript writing.

Ethics

This article contains original, unpublished material. The corresponding author acknowledges that other authors have reviewed and approved this manuscript; no ethical issues are involved.

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