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Number and taxonomic structure of blood-sucking insects community in the forest-steppe zone of Tyumen Region

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The abundance level of blood-sucking Diptera is mainly determined by natural and climatic conditions and hydrological regime of rivers, and is subject to significant fluctuations. In order to assess the impact of meteorological conditions of the season on the abundance of blood-sucking Diptera, the abundance ratio of horseflies, mosquitoes, blackflies and midges in the forest-steppe zone of Tyumen Region for 2006, 2013-2017 was compared. Analysis of data obtained showed that of the six seasons studied the largest blood-sucking insects abundance was registered in 2014, the minimum abundance was in 2006. The abundance level and the individual components ratio of blood-sucking insect community were subject to significant changes depending on the season, in 2006 and 2014, the blackflies were mostly collected, and in 2013, 2015-2017 – mosquitoes. Meteorological and hydrological conditions of winter and spring seasons have the greatest impact on the level of insect populations of blood-sucking insects' community. Seasonal fluctuations in abundance of blackflies was 3 times, midges – 9, horseflies and mosquitoes – 10. The main limiting factors for the mass development of blood-sucking Diptera in the forest-steppe zone of Tyumen Region are hard and dry winters that cause insect death at the pre-imaginal stages of development, as well as huge temperature swings in spring and summer and small areas of breeding grounds.
Key words: horseflies, mosquitoes, blackflies, midges, abundance, meteorological conditions, Tyumen region.

Introduction

The number of blood-sucking insects (horseflies, mosquitoes, blackflies, midges), largely depends on a number of environmental factors, the main ones being temperature, relative humidity and wind speed (Rubtsov, 1956; Patrusheva, 1963; Olsufyev, 1977; Kukharchuk, 1981; Mirzaeva, 1989; Chernyshev, 1999). In addition, the abundance of blood-sucking Diptera in the habitat is affected by the presence of feeders, the main of which is cattle. In pastures where cattle are grazed, the number of blood-sucking insects was 10-12 times higher than in other lands (Pavlova, 1968). Studies performed in the forest-steppe zone of Novosibirsk Region have shown that the population level of blood-sucking Diptera is largely determined by natural and climatic conditions, hydrological regime of rivers and can vary more than tenfold in different years (Mirzaeva & Glushchenko, 2006). The population level in the previous summer season and its meteorological conditions has a significant impact for mosquitoes, blackflies and horseflies (Mirzayeva & Khodyrev, 2014). These data indicate that only systematic monitoring can fully assess the impact of meteorological conditions on blood-sucking Diptera.

The aim of our study was to compare population levels of blood-sucking Diptera in the forest-steppe zone of Tyumen Region for six years with different meteorological conditions.

Materials and methods

In summer, relatively high temperatures and moderate precipitation characterize the Tyumen Region's climate. The summer, especially June, is with periodical severe droughts (Karetin, 1990). In winter, anticyclones from Central Asia, which, largely, defines the winter season severity, influence the climate. The region is characterized by late frosts in spring until the end of the first decade of June and early autumn, and sometimes in late August.

The forest-steppe zone is located in the south of Tyumen region. The zone's climate is warm with relatively high temperatures and moderate precipitation. In the forest-steppe zone, winter usually begins in early November and lasts an average of 145 days, that is, until the end of March. Winter is severe, with frequent snowstorms. The average temperature in January is -18-20°C. Spring, on average, lasts 45 days until mid-May. The summer lasts quite long – about 125 days, from mid-May to mid-September. The average temperature in the hottest month, i.e. in July is +19-20°C. The summer is with possible storm rainfall, when up to 80 mm of rain can hit during the day. Autumn season is short – 50 days, from mid-September to early November. Autumn is characterized by huge differences in temperatures during the day. The average annual temperature is + 1°C. The annual precipitation ranges from 350-500 mm. Rivers of the forest-steppe zone are typical plain streams with a significant degree of snow-fed (Western Siberia, 1963; Agro-climatic, 1972; Physical, 1973).

The forest-steppe zone is characterized by presence of forest and steppe plant communities, marshes, solonchaks and meadows. Birch and aspen-birch forests are in the form of outliers usually limited to the topographic lows. In addition to birch and aspen-birch outliers, there are pine forests in the forest-steppe zone. The grass cover is grass-herb and grass. An integral part of the landscape is a variety of mineral composition of the lake.

The study was performed in 2006 and 2013-2017 in the surroundings of Isetskoye Village and Barkhatovo Village in Isetsky District of Tyumen Region (Fig. 1). This area belongs to the province of Tobolsk forest-steppe (Western Siberia, 1963). The study area is located on the left bank of Iset River. Small aspen-birch forests interspersing with significant areas of meadow steppes are found here, most of which are plowed and used for cultivated plants dropping.

Fig. 1 Study area

Horseflies were collected and its abundance was registered stationary on the same pasture systematically once every 5-7 days during the flight period using humming-top-shaped traps. To recalculate the number of horseflies caught during the day with trap, the rate of individuals was divided by 220 (Pavlov et al., 2009).

Butterfly net with removable sacks was used when registering the abundance of mosquitoes, blackflies and midges (Detinova et al., 1978; Rasnitsyn & Kosovskikh, 1979). The abundance registrations were made during the whole flight period twice a decade. Each registration was performed as follows: 10 figure-of-eight sweeps of the butterfly net around yourself in 10 replications. The calculations used an average of 10 replications.

The average abundance of each component of blood-sucking insects was calculated by dividing the number of individuals collected during the season (according to average data of one-time registrations) by the number of registrations. The data obtained for all components were summarized to obtain average abundance of blood-sucking insects community per season.

Results and discussion

Analysis of data obtained showed that of the six seasons studied the largest blood-sucking insects (321 individuals) abundance was registered in 2014 (Flig. 2), the minimum abundance (86 individuals) was in 2006. When comparing these figures, it can be seen that the average abundance of gnats in 2014 was 3.7 times more than in 2006. The abundance level of individual components of blood-sucking insects community was subject to significant changes depending on the season, in 2006 and 2014, for instance, the blackflies were mostly collected, and in 2013, 2015-2017 – mosquitoes (Fig. 3). In 2006, blackflies accounted for 69% of collections or 59 individuals during the season on average, in 2014 - 61% or 196 individuals. Accordingly, the abundance of blackflies in 2006 and 2014 differed by 3.3 times.

The abundance of mosquitoes in 2006 was very low and amounted to 18 individuals according to the average data during the study season per registration, this corresponded to 23% of collection, in 2013 - 185 individuals or 84%. There were greater seasonal fluctuations in mosquito abundance, in 2013, for instance, the mosquito abundance was 10 times higher than in 2006. The abundance of horseflies in all six seasons of study per one-time registration was at a low level. In 2013 and 2014, the proportion of horseflies in total collections did not exceed 1% or 2 and 3 individuals according to the average data during the season, respectively. The maximum proportion of horseflies in blood-sucking insects community was registered in 2017 and was 22% or 20 individuals. Horseflies abundance during the study period significantly fluctuated, in 2017, for instance, its population was 10 times higher than in 2013.

In 2006, 2013 and 2014, the abundance of midges was exceptionally low, their proportion in total collections was less than 1% or 1, 2, and 3 individuals, respectively. The maximum population of midges was in 2016 and amounted to 19% or 9 individuals according to the average data during the season. Thus, the abundance of midges differed by 9 times in different study seasons.

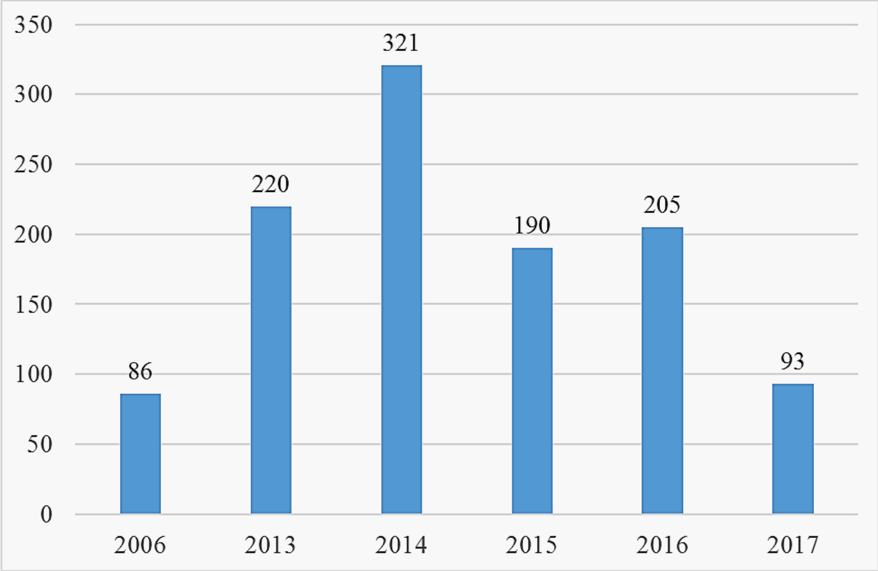

Fig. 2 The average insects abundance from blood-sucking insects community

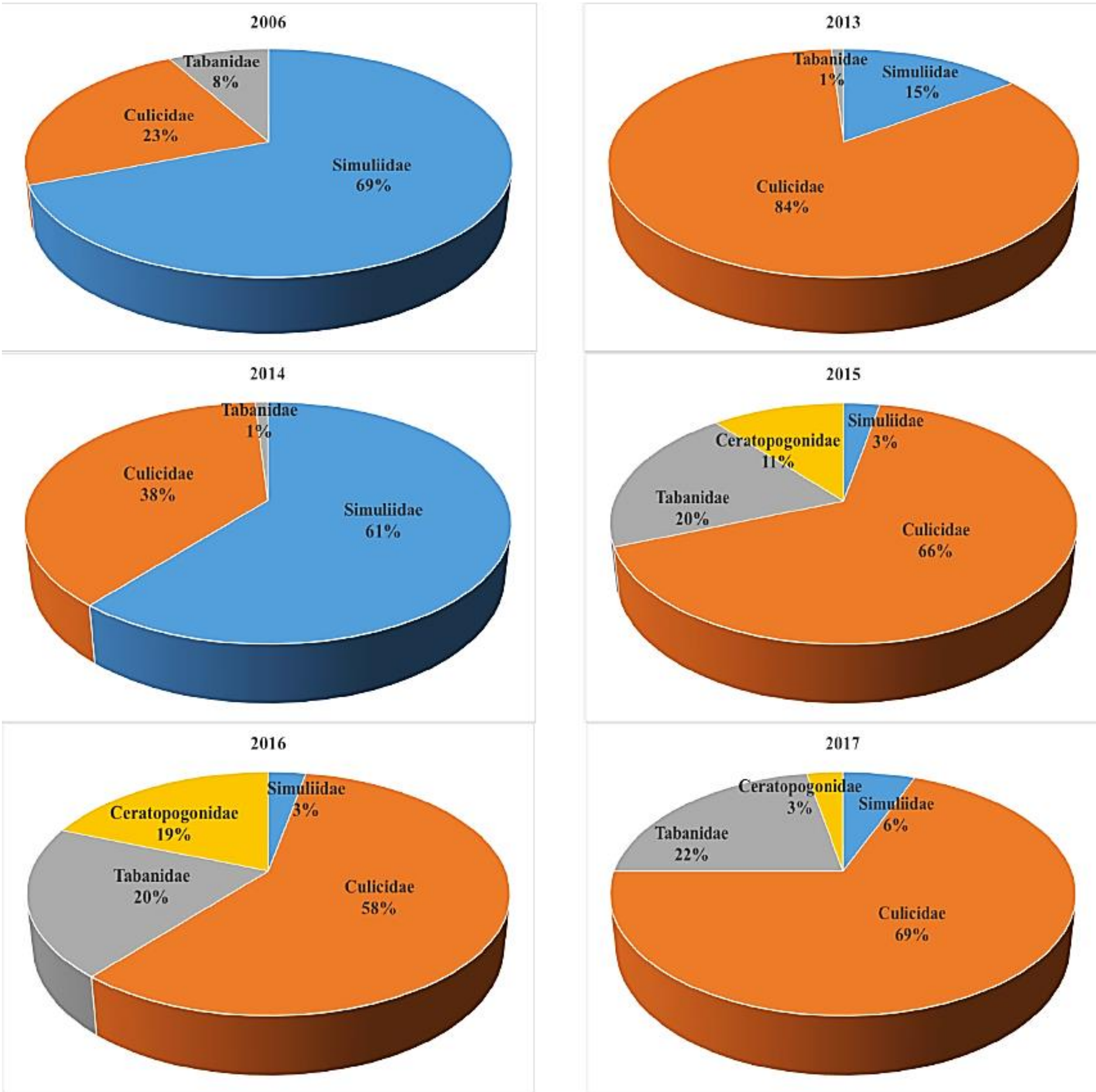

Fig. 3 The components ratio of blood-sucking insects community

Fluctuations in the number of both blood-sucking insects community and its individual components were caused by the prevailing weather conditions in study period. In 2005-2006, the winter was cold and dry. It was freezing cold in January (up to -40ºC) and the ground was deeply frozen. Because of the dry winter, in spring, the rivers did not overflow, most of the floodplain remained dry and there were practically no intermittent water bodies. Thin snow cover and low air temperatures led to severe freezing of the coastal water bodies, which negatively affected the larvae of horseflies and midges living in them (Fiodorova et al., 2018). The lack of large areas of intermittent water bodies in summer and early summer, which is the main breeding places for blood-sucking mosquitoes (Khlyzova & Fiodorova, 2018), prevented the development of most eggs laid in the previous season.

The winter of 2012-2013 was not so severe, the land was covered with a thick snow layer, which prevented the land from deep freezing, and provided enough water to wet the soil cover and form large areas of intermittent water bodies in spring, but there was no flooding of rivers. In 2013, spring came late and lagged behind the long-term annual average by 10-14 days. April and May were cool with frequent precipitation. Summer was characterized by frequent changes in temperature, alternating hot and cool, rainy periods. The lack of spring flooding of the rivers affected the relatively low population of blackflies. The large number of intermittent water bodies in spring was good for the abundance of mosquitoes, in addition, frequent summer rains allowed summer and late summer mosquitoes to develop, which kept the abundance of mosquitoes at a high level almost until the end of summer.

The winter of 2013-2014 was similar to the winter of 2012-2013 in terms of climatic conditions. Spring of 2014 came early, but was lengthy. March was warm and with a lot of precipitation. The first half of April was very warm, but in the second half of April, there was a cold snap that significantly delayed snow melt and, accordingly, the development of pre-imaginal stages of blood-sucking Diptera. Warm May with frequent rains created favorable conditions for the rapid development of blood-sucking mosquitoes and midges. June was hot and in combination with large amounts of precipitation in previous months, there were optimal conditions for mass breeding of mosquitoes and blackflies. The cold snap in July had a negative effect on the abundance of blood-sucking insects: the abundance of mosquitoes and horseflies declined sharply, and blackflies almost stopped flying. Hot weather in August contributed to breeding of the second generation of some species of blood-sucking mosquitoes and partial reactivation of horseflies. Wide fluctuations in temperature in spring and summer had an overall negative effect on the population level of blood-sucking Diptera, but despite this, of the six seasons of study, 2014 was characterized by the highest abundance of blood-sucking insects.

The beginning of winter 2014-2015 was severe, freezing weather hit in November – first half of December (up to -29°C), which led to a deep freezing of soil and coastal part of water bodies. The spring of 2015 was lengthy with cold weather coming back, snow cover melted gradually, which caused the lack of large areas of intermittent water bodies and a slight increase in river levels. At the end of May, there was a sudden warming up to +30°C, this caused the intermittent water bodies to overheat and the death of mosquito larvae and pupae that did not have time to complete their development. The predominance of blackflies in this season, in comparison with other blood-sucking insect components, is due to the relatively stable level of the rivers throughout the summer season, ensuring that these insects breed steadily.

The winter of 2015-2016 and the spring of 2016 were characterized by frequent changes in temperature– cold waves were replaced by heat waves. In November, the temperature ranged from -25 °C in the middle of the month to +4°C at the end of the month. By the end of December, cold weather up to -31 °C settled over, in January the air temperature dropped to -35°C. At the end of February, there was a sudden warming up to +4°C and snowmelt. The first half of spring was with a large amount of precipitation, by mid-April the snow cover was completely gone, and the air warmed up to +20°C. The cold snap that hit in May with heavy night frosts led to a delay in the development of pre-imaginal stages of mosquitoes and blackflies. The lack of spring flooding and dry summer had a negative effect on the abundance of blackflies throughout the summer season.

The winter of 2016-2017 was severe. The first half of winter was cold and dry, in November, the air temperature dropped to -34°C, in December, frosts reached a temperature of -41°C. Low temperatures and thin snow cover provided soil freezing and coastal part of water bodies. Heavy snowfalls arrived in late December and continued in January. At the end of February, there was a sudden warming up to +5°C and a serious snowmelt. Spring was lengthy with temperature drops. Snow was all gone in the second decade of April. In early May, the warming that was in late April changed to a cold snap with night frosts. There was no spring flooding of the rivers, the summer was dry, which caused a low abundance of blackflies throughout the summer season. The predominance of mosquitoes among other components of gnats was due to the warm and rainy second half of May and, consequently, a large number of intermittent water bodies.

Thus, the meteorological conditions in the study area throughout the year and mainly in the spring-summer season, affect both the abundance of insects from blood-sucking insects community and its components ratio, depending on the prevailing weather conditions, the abundance of blood-sucking Diptera can vary 10 times.

Conclusions

The assessment of main environmental factors on the abundance level and dynamics of blood-sucking Diptera has shown that the meteorological conditions of winter and spring seasons have the greatest effect on the abundance level of insects of «blood-sucking insects» community. A comparative abundance analysis of horseflies, mosquitoes and blackflies in the summer seasons of 2006, and 2013-2017 in the forest-steppe zone of Tyumen Region identified the dependence of this indicator on meteorological and hydrological conditions. At the same time, the identified fluctuations in the abundance of blackflies was 3 times, midges - 9, horseflies and mosquitoes - 10. The main limiting factors for the development of blood-sucking Diptera in the forest-steppe zone of Tyumen Region are hard and dry winters that cause insect death at the preimaginal stages of development, as well as huge temperature swings in spring and summer and small areas of breeding grounds. Smaller fluctuations in the abundance of blackflies in comparison with other components of blood-sucking insects community are because the region's lowland rivers are not characterized by sharp changes in water level during the summer season; in addition, during all six seasons of the study, there was no high spring flooding.

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