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Current state of the complex of biting black flies in the southeast of West Siberia, Novosibirskaya Oblast, Russia

Современное состояние комплекса кровососущих мошек на юго-востоке Западной Сибири в Новосибирской области

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Key words: black flies, Simuliidae, species composition, complex of biting black flies, community structure.

Ключевые слова: мошки, Simuliidae, видовой состав, комплекс кровососущих мошек, структура сообщества.

Abstract. Blood-sucking black flies are potential carriers of dangerous disease pathogens. The transformation of their communities under both the influence of anthropogenic factors and rising average annual temperatures may have a significant impact on the epidemiological significance of the group. A revision of the complex of blood-sucking black flies inhabiting the south-east of West Siberia in the Novosibirskaya Oblast was conducted. The work is based on materials obtained by the authors during a five-year monitoring of the number of blood-sucking black flies in the vicinity of Novosibirsk (2017–2021), as well as literary data from studies conducted from 1960 to 1987. The complex of blood-sucking black flies noted in the Novosibirskaya Oblast includes 19 species of the genus *Simulium* Latreille, 1802 from 7 subgenera. The basis of the blood-sucking black fly complex in the Novosibirskaya Oblast was made up of the representatives of the subgenus *Simulium (Simulium)* (10 species). The subgenus *Simulium (Schöenbaueria)* Enderlein, 1921 included 3 species, *S. (Nevermannia)* Enderlein, 1921 — 2, other subgenera *S. (Boophthora)* Enderlein, 1921, *S. (Byssodon)* Enderlein, 1925*, S. (Eusimulium)* Roubaud, 1906, *S. (Wilhelmia)* Enderlein, 1921) — 1 species each. The proportion of species with Holarctic and Palearctic distribution was 31.6% and 68.4%, respectively. The proportion of species with Pan-Holarctic, Pan-Palaearctic and Euro-Siberian chorotypes turned out to be similar, and together they account for 56.1% of the total. The most numerous and frequently attacking blood-suckers include 9 species, *Simulium maculatum* (Meigen, 1804), *S. erythrocephalum* (De Geer, 1776), *S. angustitarse* (Lundström, 1911), *S. pusillum* Fries, 1824, *S. reptans* (Linnaeus, 1758), *S. longipalpe* Beltyukova, 1955, *S. rostratum* (Lundström, 1911), *S. aemulum* Rubtsov, 1940 and *S. equinum* (Linnaeus, 1758), which in the communities studied played the role of eudominants, dominants or subdominants. The most common eudominant species was *S. maculatum*. The modern composition of the blood-sucking black fly complex of the Novosibirsk agglomeration includes 16 species of the genus *Simulium* from 7 subgenera. The species *Simulim longipes* (Rubtsov, 1956), described from materials from Eastern Kazakhstan, was first noted in West Siberia, and this is its first record for Novosibirskaya Oblast. In addition, the species *S. equinum* and *S. erythrocephalum*, typical of more southern regions, have been observed in a limited area as active blood-suckers. There is reason to believe that this is a result of rising average annual temperatures. However, this issue requires further research. Considering the possible involvement of black flies in the transmission of pathogens of transmissible zoonotic diseases of humans and animals, it is necessary to conduct monitoring studies of the blood-sucking black fly complex in the region in order to plan and carry out timely work to reduce their numbers.

Резюме. Кровососущие мошки являются потенциальными переносчиками возбудителей опасных заболеваний. Трансформация сообществ этих насекомых под влиянием антропогенных факторов и повышения среднегодовых температур могут оказывать существенное влияние на эпидемиологическое значение представителей этой группы. Проведена ревизия комплекса кровососущих мошек, обитающих на юго-востоке Западной Сибири в Новосибирской области. Основу работы составили материалы, полученные авторами в ходе пятилетнего мониторинга численности кровососущих мошек в окрестностях г. Новосибирска (2017–2021 гг.), а также литературные данные исследований, проведённых с 1960 по 1987 гг. Комплекс кровососущих мошек, отмеченных в Новосибирской области, включает 19 видов рода *Simulium* Latreille, 1802 из 7 подродов. Основу комплекса кровососущих мошек Новосибирской области составили мошки подрода *Simulium (Simulium)* (10 видов). Подрод *Simulium (Schöenbaueria)* Enderlein, 1921 включает 3 вида, *S. (Nevermannia)* Enderlein, 1921 — 2, другие подроды: *S. (Boophthora)* Enderlein, 1921, *S. (Byssodon)* Enderlein, 1925*, S. (Eusimulium)* Roubaud, 1906, *S. (Wilhelmia)* Enderlein, 1921) — по 1 виду. Доля видов с голарктическим и палеарктическим распространением составила 31,6 % и 68,4 % соответственно. Виды с пан-голарктическим, пан-палеарктическим и евро-сибирским хоротипом равнозначны и в сумме составляют 56,1 % от общего количества. К наиболее многочисленным и часто нападающим кровососам отнесены 9 видов, которые в исследованных сообществах входили в состав

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эудоминантов, доминантов или субдоминантов: *Simulium maculatum* (Meigen, 1804), *S. erythrocephalum* (De Geer, 1776), *S. angustitarse* (Lundström, 1911), *S. pusillum* Fries, 1824, *S. reptans* (Linnaeus, 1758), *S. longipalpe* Beltyukova, 1955, *S. rostratum* (Lundström, 1911), *S. aemulum* Rubtsov, 1940 и *S. equinum* (Linnaeus, 1758). В роли эудоминанта чаще других видов выступал *S. maculatum*. Современный состав комплекса кровососущих мошек Новосибирской агломерации включает 16 видов рода *Simulium* из 7 подродов. Вид *Simulim longipes* (Rubtsov, 1956), описанный по материалам из Восточного Казахстана, впервые отмечен на территории Западной Сибири и является первой находкой для Новосибирской области. Кроме того, виды *S. equinum* и *S. erythrocephalum*, типичные для более южных регионов, отмечены на исследуемой территории в роли активных кровососов. Есть основания полагать, что это результат повышения среднегодовых температур. Однако этот вопрос требует проведения дополнительных исследований. Учитывая возможное участие мошек в переносе возбудителей трансмиссивных зоонозных заболеваний человека и животных, необходимо ведение мониторинговых исследований комплекса кровососущих мошек в регионе с целью проведения работ по снижению их численности.

Introduction

Black flies (Diptera: Simuliidae) are ubiquitous dipterous insects, most numerous in the boreal zone of the Palearctic and Nearctic regions [Rubtsov, 1956; Yankovsky, 2002; Malmqvist et al., 2004; Currie, Adler, 2008; Adler, 2022]. The world's modern black fly fauna includes about 2,400 species, of which about 30 % (700 species) are found in the Palaearctic [Adler, 2022]. The development of the larvae and pupae of black flies occurs in watercourses, while adults live in a terrestrial-air environment. The relevance of studying this group is due to the peculiarities of the biology of black flies. Adult blood-sucking black flies seriously irritate humans and warm-blooded animals with their bites. In addition, they are potential vectors of various diseases, which explains their important medico-parasitic role [Adler, McCreadie, 2019; Cunze et al., 2024]. About 98 % of black fly species are ectoparasites that have short-term contacts with mammalian and avian hosts [Balashov, 2009]. According to current data, about 28 species can transmit pathogens through blood [Adler et al., 2010; Adler, McCreadie, 2019]. However, this figure may be an underestimated, as the association of most black fly species with arboviruses remains unexplored and the epidemiological significance of these species is still unclear [Rivera-Martínez et al., 2025].

Black flies that attack humans are generally not highly specialized and feed on the blood of various hosts, so the likelihood of transmitting some pathogens from domestic and wild animals to humans is quite high. Black flies are characterized as mammalophiles and anthropophiles [Adler, McCreadie, 2019]. It is known that black flies are carriers of the pathogens of tularemia, outbreaks of which have been registered in Russia, including in West Siberia [Budaeva et al., 2015; Kudryavtseva et al., 2021]. Epidemiological manifestations of the infection in the form of sporadic cases of tularemia in humans have been noted in the Sibirskii Federalnyi Okrug — Novosibirskaya, Kemerovaya, Tomskaya and Omskaya Oblasts, and Altaiskii Krai [Kudryavtseva et al., 2021]. In addition, according to medical experts, cases of severe allergic reactions to bites of blood-sucking black flies have recently become more frequent, which pose a serious danger to sensitized people with increased sensitivity to foreign substances contained in the saliva of black flies [Zyablitskaya et al., 2020; Sitarz et al., 2021, 2022]. Reactions can be local and systemic and include skin rash and swelling at the site of the bite, difficulty breathing caused by swelling of the throat and airways, and a sharp drop in blood pressure followed by fainting. Most often, allergic local reactions occur in children. Severe forms of general intoxication, diagnosed as simulidotoxicosis, also occur in animals when, under the influence of salivary toxins, swelling of the laryngeal mucosa occurs, leading to suffocation and death of the animal [Kaplich, Usova, 1990; Kaplich et al., 1992; Adler, McCreadie, 2019; Vasilevich et al., 2020].

In West Siberia, black flies inhabit all natural zones, from the tundra to the forest-steppe and steppe, where they represent one of the main components of the blood-sucking insect complex [Patrusheva, 1966; Mirzaeva at al., 1988; Mirzaeva, Glushchenko, 2009; Petrozhitskaya, Rodkina, 2018]. The first comprehensive data on the region's blood-sucking black flies was published in the collective monograph 'Biological Foundations of Black fly Control in the Ob River Basin' [Patrusheva, 1966]. Black flies of 96 species have been recorded in various landscapes and natural zones of the Ob-Irtysh basin [Patrusheva, 1982; Petrozhitskaya, Rodkina, 2018].

In the Novosibirskaya Oblast, studies of black flies were previously conducted in the northern and southern forest-steppe of the left bank of the Ob River [Patrusheva, 1962; Petrozhitskaya, 1992, 2010; Mirzaeva, Petrozhitskaya, 2007]. In the Priobskaya part of the right bank, information was received from the upper reaches of the Berd River [Patrusheva, 1962]. In the vicinity of Novosibirsk, studies were conducted only sporadically [Patrusheva, 1966; Darijchuk, 1972; Petrozhitskaya, 2013]. As a result, 13 species of blood-sucking black flies were recorded in the Novosibirskaya Oblast.

Changing climatic conditions in Eurasia, including southeastern West Siberia, as well as a significant increase in anthropogenic pressure, have led to significant shifts in the number and structure of black fly communities. Thus, in Russia, outbreaks of black fly numbers have been registered in the Voronezh (Don River and its tributaries) and Volgograd regions (Volga River, Volga-Akhtuba Canal) [Budaeva et al., 2015; Taratutina et al., 2023]. Unfavorable situation is also frequently recorded in the Tyumenskaya Oblast (Irtysh River basin) [Fedorova, Pavlova, 2014]. High activity of blood-sucking black flies was also noted in a number of countries — Turkey, Spain, Poland, Serbia, Lithuania, Kazakhstan, where biological methods were successfully used to control the number of black flies [Bernotienė, 2001; Gabdullin et al., 2013; Ignjatović-Ćupina et al., 2014; Sariözkan et al., 2014; Jiménez-Peydró et al., 2021; Lopez-Peña, Jiménez-Peydró, 2021; Sitarz et al., 2021, 2022].

In the context of global warming, in the south-east of West Siberia over the past 50 years, there has been a steady increase in average annual air temperature and a change in the distribution of precipitation by season [Luchitskaya et al., 2014]. This has a significant impact on the distribution of insects: in particular, a northward shift in the distribution boundary has been noted for Orthoptera (Acrididae) [Popova et al., 2022] and Odonata [Kosterin, Onishko, 2025]. In the current situation, there is every reason to expect certain changes in the species composition of the blood-sucking diptera complex as a whole, as well as in individual groups, including black-flies. Possible changes in the number, as well as the composition and structure of black fly communities in the study region, may significantly affect the epidemiological significance of this group of insects and its representatives.

The aim of the study was to conduct a revision of the complex of blood-sucking black flies inhabiting the Novosibirskaya Oblast: (i) to identify the taxonomic composition and dominance structure of black flies, (ii) to establish the chorological structure of complex of these blood-sucking insects, and (iii) to assess the current state of the black fly complex in the vicinity of Novosibirsk.

Material and methods

Study area

The work is based on materials obtained by the authors during a five-year monitoring of the number of blood-sucking black flies in the vicinity of Novosibirsk, as well as the results of an analysis of all available literary data devoted to the study of these insects in the southeast of West Siberia. The literature data includes the results of studies conducted in different years, from 1960 to 1987, at 10 sites in five districts of the Novosibirskaya Oblast (Table 1, Fig. 1). Monitoring studies were carried out between 2017 and 2021 in the south-east of West Siberia, in the recreational area of Novosibirsk and its surroundings (Table 1, Fig. 1). It is known that the species composition of black flies, whose larvae develop in an aquatic environment, depends to a large extent on the characteristics of rivers [Malmqvist et al., 2007; Currie, Adler, 2008; Başören, Kazanci, 2022]. Therefore, in order to reveal the fullest possible diversity of the fauna, four sites were selected along the banks of rivers of different sizes for the collection of adult black flies: small rivers Nizhnyaya Yeltsovka and Zyryanka, and medium-sized rivers Inya and Berd (Table. 1). The size category of rivers was defined in accordance with the generally accepted standard [Hydrology of land, 1988]. Overall, the research covered 10 districts in the Novosibirskaya Oblast.



Fig. 1. Location of black fly survey sites in the Novosibirskaya Oblast. Designations: dots — the authors' data, triangles — literature data (references are listed in Table 1).

Рис. 1. Расположение участков проведения учётов мошек в Новосибирской области. Обозначения: точки — сборы авторов, треугольники — литературные данные (ссылки на литературу приведены в таблице 1).

Collection of material

During the monitoring programme, standard methods were used to collect material [Rubtsov, 1962; Khalin et al., 2021]. Counts of adult black flies were carried out every ten days from May to September. The black flies were caught using an entomological net with a hoop diameter of 30 cm, by sweeping around the collector for 3 minutes (180 sweeps), which corresponds to one count of black flies with the net. The black flies were collected near a watercourse in open areas not shaded by trees. All collections took place in the morning (from 9.00 to 11.00) under weather conditions favourable for flying insects (temperature not below +10 °C, no wind or only a light breeze not exceeding 1.0 m/s, and no precipitation).

The insects were preserved in 96 % ethanol. The specimens were prepared using Euparal [Hernández-Triana, 2007]. Species identification was carried out on the basis of morphological structures, using A.V. Yankovsky's identification guide [2002] and a Carl Zeiss Primo Star light microscope. The taxonomic composition of black flies is presented, taking into account synonyms according to the current classification system of Simuliidae [Adler, 2022].

In total, 730 surveys were conducted over 5 years, and 24,154 specimens of blood-sucking black flies were collected.

Data analysis

For a detailed analysis of the complex's structure, data obtained during monitoring from 2017 to 2021, as well as literature data for six sites where seasonal surveys were conducted, were used. Four sites were excluded: 'Novososedovo', 'Otgonka', 'Sharap' and 'Aleus' due to short-period collections (Table 1).

The characteristics of the range types of black flies are given according to the system of K.B. Gorodkov [1984, 1992] based on the longitudinal and latitudinal components, with clarifications for Simuliidae [Petrozhitskaya, Mirzaeva 2019; Jedlička et al., 2024].

The structure of the black fly community was assessed using a modified Engelmann scale [Engelmann, 1978] for rank-based traits [Petrozhitskaya, 1993; Petrozhitskaya,

Таблица 1. Основные характеристики участков сбора мошек, осуществлённого авторами и другими исследователями (литературные данные) в Новосибирской области

Table 1. Main characteristics of the sites of the black fly collection carried out by the authors and other researchers (literature data) in south-east of West Siberia, Novosibirskaya Oblast, Russia

No	Locality name	Location in Novosibirskaya Oblast	Landscape	Years	River (length) / Size category	Territory type	Data source
1	Izdrevaya	Novosibirsk district, near Izdrevaya village; 54°59′ N 83°14′ E	Forest-steppe	2017–2021	Inya (560 km) / Medium rivers	AL	authors
2	N. Eltsovka	Novosibirsk, near Nizhnyaya Eltsovka village; 54°53′ N 83°06′ E	Forest-steppe	2017–2021	Nizhnyaya Eltsovka (9.5 km) / Small rivers	C	authors
3	Botsad	Novosibirsk, Arboretum of the CSBG SB RAS; 54°49′ N 83°06′ E	Forest-steppe	2017–2021	Zyrianka (7 km) / Small rivers	RZ	authors
4	S. Iskitim	Iskitimskii district, near Staryi Iskitim village; 54°36′ N 83°25′ E	Forest-steppe	2021	Berd (363 km) / Medium rivers	RZ	authors
5	Maslyanino	Maslyaninskii district, near Maslyanino settlement	Forest-steppe	1960	Berd (363 km) / Medium rivers	AL	[Patrusheva, 1962]
6	Novososedovo	Iskitimskii district, near Novosedovo village	Forest-steppe	2013	Ik(75 km) / Small rivers	P	[Petrozhitskaya, 2013]
7	Otgonka	Toguchinskii district, near Otgonka station	Forest-steppe	2013	Inya (560 km) / Medium rivers	AL	[Petrozhitskaya, 2013]
8	Viuny	Kolyvanskii district, near Viuny village; 55°31′N 82°55′E	Northern forest-steppe	1986	Viuna (70 km) / Small rivers	AL	[Petrozhitskaya, 1992]
9	Pikhtovka	Kolyvanskii district, Pikhtovka; 55°59′ N 82°42′ E	Southern taiga, Northern forest-steppe	1986	Baksa (206 km) / Small rivers	AL	[Petrozhitskaya, 1992]
10	Zonovo	Kuibyshevskii district, near Zonovo settlement	Forest-steppe	1962	Om' (1091 km) / Medium rivers	AL	[Patrusheva, 1966]
11	Sharap	Ordynskii district, coastal area in the estuary of the Sharap River	Forest-steppe	1959	Sharap (21 km) Small rivers	AL	[Patrusheva, 1962]
12	Aleus	coastal area in the estuary of the Aleus River	Forest-steppe	1959	Aleus (23 км) Small rivers	AL	[Patrusheva, 1962]
13	Krasnoozerskoye	Krasnozerskii District, near Krasnoozerskoye settlement; 53°44′ N 78°02′ E	Southern forest-steppe	1987	Karasuk (531 km) / Medium rivers	AL	[Petrozhitskaya, 2010]
14	Karasuk	Karasuk district, near Karasuk town	Southern forest-steppe, steppe	1962	Karasuk (531 km) / Medium rivers	AL	[Patrusheva, 1966]

Notes. The river size categories were defined in accordance with the generally accepted standard in Russia GOST 19179-73 1973 [Hydrology of land, 1988]. Territory type: AL — agricultural lands; C — city, RZ — recreational zone.

Примечание. Размерная категория рек определена в соответствии с общепринятым российским стандартом ГОСТ 19179-73 [Hydrology of land, 1988]. Тип территории: AL — сельскохозяйственные угодья; C — городская черта, RZ — рекреационная зона.

Rodkina, 2009]: eudominant (E; 40–100 %) — 5 points, dominant (D; 12.5–39.9 %) — 4 points, subdominant (SD; 4.0–12.4 %) — 3, recedent (R; 1.3–3.9 %) — 2, subrecedent (SR; < 1.3 %) — 1 point.

To assess the similarity of black fly species composition across different sites, cluster analysis was used (nearest neighbour clustering), with the Jaccard coefficient as a measure of similarity. Statistical data processing was performed using Past 4.13 and Microsoft Excel 2010.

The present work is registered in ZooBank (www.zoobank.org) under urn:lsid:zoobank.org:pub:C7D1878E-AF83-4376-BAA6-1FB5B4A8EBF3

Results

Taxonomic composition of the complex of blood-feeding black flies

The complex of blood-sucking black flies revealed during monitoring in the vicinity of Novosibirsk at four

sites (Izdrevaya, N. Yeltsovka, Botsad, S. Iskitim) is represented by species of the genus *Simulium* Latreille, 1802 and comprises 16 species from 7 subgenera: *S. (Simulium), S. (Schöenbaueria)* Enderlein, 1921, *S. (Nevermannia)* Enderlein, 1921, *S. (Boophthora)* Enderlein, 1921, *S. (Byssodon)* Enderlein, 1925*, S. (Eusimulium)* Roubaud, 1906 and *S. (Wilhelmia)* Enderlein, 1921) (Table 2). The greatest species richness was recorded for *S. (Simulium)* — 9 species. This group forms the basis of the blood-feeding complex (56.3 % of the total composition) (Table 2). The subgenus *S. (Schöenbaueria)* is represented by two species, the other subgenera included one species each.

Previously, based on data collected between 1960 and 1987 from various locations in the Novosibirskaya Oblast, 13 species of blood-feeding black flies belonging to six subgenera were known: *S. (Boophthora)*, *S. (Byssodon), S. (Eusimulium), S. (Nevermannia)*, *S. (Schöenbaueria)* and *S. (Simulium)* (Table 2). Three of these species were missing from our collections: *S.* (*Nevermannia*) *angustitarse* (Lundström, 1911), *S.* (*Schöenbaueria*) *rangiferinum* (Rubtsov, 1956), *S. aemulum* Rubtsov, 1940. Two more species, previously mentioned in the literature as *Simulium* sp. 1 and *Simulium* sp. 2 [Patrusheva, 1966], require clarification of their species affiliation and were therefore not taken into account in this work.

Thus, taking into account our own findings and data from the literature, the group of blood-sucking black flies recorded in the Novosibirskaya Oblast includes 19 species from 7 subgenera (Table 2). The basis of the complex was made up of representatives of *S. (Simulium)* — 10 species (52.6 % of the total composition). The subgenus *S. (Schöenbaueria)* includes 3 species (15.8 %), *S. (Nevermannia)* — 2 (10.5 %), the remaining subgenera (*S. (Boophthora)*, *S. (Byssodon), S. (Eusimulium)*, *S. (Wilhelmia)*) — 1 species each (total 21.1 %).

During our research, *Simulium longipes* (Rubtsov, 1956) was first noted in the Novosibirskaya Oblast and in Russia. Six species were first noted in the records of attacking blood-sucking black flies in the vicinity of Novosibirsk: *Simulium equinum* (Linnaeus, 1758), *S. jacuticum* Rubtsov, 1940, *S. malyschevi* Dorogostaisky, Rubtsov et Vlasenko, 1935, *S. promorsitans* Rubtsov, 1956, *S. subpusillum* Rubtsov, 1940, *S. truncatum* (Lundström, 1911). Previously, these species were known only from pre-imaginal phases and registered in single or small quantities in the region. Taken together, these six species accounted for a significant proportion (33.3 %) of the total number of blood-feeding black flies recorded in the area studied.

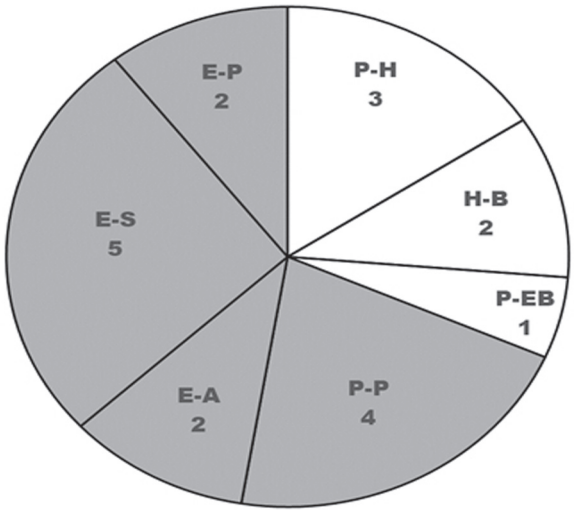


Fig. 2. Chorological structure of the blood-sucking black fly complex of the Novosibirskaya Oblast. Designations: The Palearctic (grey) and Holarctic (light) groups are highlighted in colour, chorotypes: P-H — Pan-Holarctic, H-B — Holarctic-boreal, P-EB — Palearctic-East Beringian, P-P — Pan-Palearctic, E-A — Euro-Asian, E-S — Euro-Siberian, E-P — East Palearctic, numbers indicate the number of species in individual groups.

Рис. 2 Хорологическая структура комплекса кровососущих мошек Новосибирской области. Обозначения: цветом выделены Палеарктическая (серый) и Голарктическая (светлый) группы, хоротипы: P-H — пан-голарктический, H-B — голарктический-бореальный, P-EB — палеарктический-восточно-берингийский, P-P — пан-палеарктический, E-A — европейско-азиатский, E-S — европейско-сибирский, E-P — восточно-палеарктический, цифры — число видов отдельных групп.

Chorological structure of the black fly complex

In terms of their distribution patterns, taking into account latitudinal and longitudinal components, the black fly species recorded in the Novosibirskaya Oblast were classified into 2 groups and 7 chorotypes (Table 2, Fig. 2). Black flies with a Holarctic and Palaearctic distribution accounted for 31.6 % and 68.4 % respectively. In the Palearctic group, species with Pan-Palaearctic and Euro-Siberian chorotypes prevailed (21.1 % and 26.3 % of the total composition, respectively). The East Palaearctic and Eurasian chorotypes together accounted for 21.0 %. Among the Holarctic species, black flies with a pan-Holarctic range predominated (Fig. 2).

The structure of black fly communities in the studied areas

The composition and dominance structure of the blood-sucking black fly communities varied significantly across sites studied (Table 2, Fig. 3). Their main characteristics are presented below.

Izdrevaya. A total of 15 species were recorded at the site. The eudominant: *Simulium maculatum*. Subdominants: *S. erythrocephalum*, *S. longipalpe* and *S. equinum*. Few and rarely attacking black flies (recedents —1 species, subrecedents — 10 species) made up 3.1 % of the community structure (for abundance). Dominants were absent.

Nizhnyaya Yeltsovka (N. Yeltsovka). Twelve species were recorded in this area. The eudominant: *S. maculatum*. Subdominant: *S. longipalpe*. Few and rarely attacking black flies (recedents —1 species, subrecedents — 9 species) made up 1.5 % of the community structure. Dominants were absent.

Botsad. A total of 13 species were recorded. The eudominant: *S. maculatum*. The other 12 species were

few in number and rarely attacked (recedents — 2 species, subrecedents — 10 species) with a total share in the complex structure of 3.2 % of the community structure. Dominants and subdominants were absent.

Starii Iskitim (S. Iskitim). Ten species were recorded. The eudominant: *S. maculatum*. Dominant: *S. erythrocephalum*. Few and rarely attacking black flies (recedents — 2 species, subrecedents — 6) made up 8.8 % of the community structure. Subdominants were absent.

Maslyanino. Four species were identified. The eudominant: *S. maculatum*. Dominant: *S. longipalpe*. Subdominants: *S. reptans* и *S. aemulum.* Few and rarely attacking black flies (recedents and subrecedents) were absent.

Viuny. Three species were recorded. The eudominant: *S. maculatum.* Dominants: *S. pusillum* and *S. longipalpe*. Subdominants, and also the few and rarely attacking black flies (recedents and subrecedents) were absent.

Table 2. Taxonomic composition, species distribution and structure of the blood-sucking black fly complex (in points on the Engelmann scale) in the studied sites in the vicinity of Novosibirsk (2017–2021) and other regions of Novosibirskaya Oblast (1960–1987)

Таблица 2. Таксономический состав, распространение видов и структура комплекса кровососущих мошек (в баллах) на исследованных участках в окрестностях г. Новосибирск (2017–2021 гг.) и других районов Новосибирской области (1960–1987 гг.)

№	Species	Distribution	Izdrevaya	N. Eltsovka	Botsad	S. Iskitim	Maslyanino[1]	V'iu-ny[3, 4]	Pikhtovka[3, 4]	Zonovo[2]	Krasnoserskoe[4]	Karasuk[2]
1	*Simulium (Boophthora) erythrocephalum* (De Geer, 1776)	E-A	3	1	1	4	0	0	0	2	5	4
2	*Simulium (Byssodon) maculatum* (Meigen, 1804)	P-EB	5	5	5	5	5	5	4	1	0	0
3	*Simulium (Eusimulium) aureum* Fries, 1824	E-A	1	1	1	0	0	0	0	1	0	1
4	*Simulium* (*Nevermannia) longipes* (Rubtsov, 1956)	E-P	2	2	2	0	0	0	0	0	0	0
5	*S. (Nevermannia) angustitarse* (Lundström, 1911)	P-P	0	0	0	0	0	0	0	0	4	5
6	*Simulium (Schöenbaueria) pusillum* Fries, 1824	E-S	1	1	1	1	0	4	4	1	0	0
7	*S. (Schöenbaueria) subpusillum* Rubtsov, 1940	H-B	1	1	1	1	0	0	0	0	0	0
8	*S. (Schöenbaueria) rangiferinum* (Rubtsov, 1956)	E-S	0	0	0	0	0	0	2	0	0	0
9	*Simulium* (*Simulium*) *aemulum* Rubtsov, 1940	E-S	0	0	0	0	3	0	0	0	0	0
10	*Simulium* (*Simulium*) *jacuticum* Rubtsov, 1940	E-P	1	0	0	0	0	0	0	0	0	0
11	*Simulium* (*Simulium*) *longipalpe* Beltyukova, 1955	E-S	3	3	2	2	4	4	4	5	3	3
12	*Simulium* (*Simulium*) *malyschevi* Dorogostaisky, Rubtsov, Vlasenko, 1935	H-B	0	0	1	0	0	0	0	0	0	0
13	*Simulium* (*Simulium*) *noelleri* Friederichs, 1920	P-H	1	0	0	1	0	0	0	0	1	0
14	*Simulium* (*Simulium*) *ornatum* Meigen, 1818	P-P	1	0	0	1	0	0	0	0	0	0
15	*Simulium* (*Simulium*) *promorsitans* Rubtsov, 1956	E-S	1	1	1	1	0	0	0	0	0	0
16	*Simulium* (*Simulium*) *reptans* (Linnaeus, 1758)	P-P	1	1	1	2	3	0	1	0	0	0
17	*Simulium* (*Simulium*) *rostratum* (Lundström, 1911)	P-H	1	1	1	0	0	0	3	4	4	2
18	*Simulium* (*Simulium*) *truncatum* (Lundström, 1911)	P-H	1	1	1	0	0	0	0	0	0	0
19	*S. (Wilhelmia) equinum* (Linnaeus, 1758)	P-P	3	1	1	1	0	0	0	0	0	0
20	*Simulium* sp.1	?	0	0	0	0	0	0	0	0	0	2
21	*Simulium* sp.2	?	0	0	0	0	0	0	0	2	0	0
Всего видов			15	12	13	10	4	3	6	7	5	6

Notes. Species distribution: P-H — Pan-Holarctic, H-B — Holarctic-boreal, P-EB — Palearctic-East Beringian, P-P — Pan-Palearctic, E-A — European-Asian, E-S — European-Siberian, E-P — East Palearctic. The structure of the black fly complex (rank indicator) according to the scale of Engelmann [1978] for rank features [Petrozhitskaya, 1993; Petrozhitskaya, Rodkina, 2002]. The sites marked with digital indices are literary data: 1 — Patrusheva [1962], 2 — Patrusheva [1966], 3 — Petrozhitskaya [1992]; 4 — Petrozhitskaya [2010].

Примечание. Тип ареала: P-H — пан-голарктический, H-B — голарктический-бореальный, P-EB — палеарктический-восточно-беринги йский, P-P — пан-палеарктический, E-A — европейско-азиатский, E-S — европейско-сибирский, E-P — восточно-палеарктический. Структура комплекса мошек (ранговый индикатор) по шкале Энгельмана [Engelmann, 1978] для ранговых признаков [Petrozhitskaya, 1993; Petrozhitskaya, Rodkina, 2002]. Участки, отмеченные цифровыми индексами даны по литературным данным: 1 — Patrusheva [1962], 2 — Patrusheva [1966], 3 — Petrozhitskaya [1992]; 4 — Petrozhitskaya [2010].

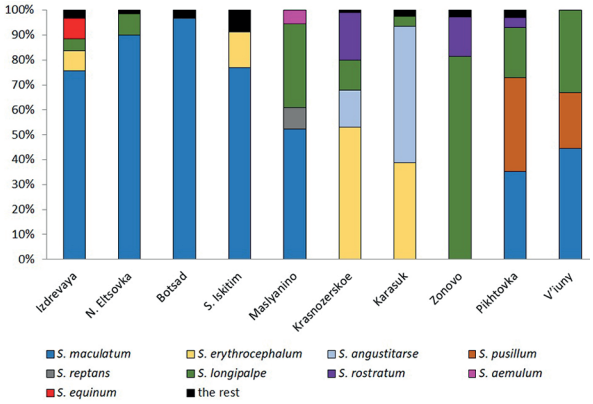


Fig. 3. The predominant species in the structure of the complex of blood-sucking black flies in the studied sites in the Novosibirskaya Oblast. Designations: 'the rest' — species with a share of less than 3.9 %.

Рис. 3. Преобладающие виды в структуре комплекса кровососущих мошек на исследуемых участках в Новосибирской области. Обозначения: "the rest" — виды с долей ≤ 3,9 %.

Pikhtovka. Six species were noted in the area. Dominant: *S. maculatum*, *S. pusillum* and *S. longipalpe*. Subdominant: *S. rostratum*. Few and rarely attacking black flies (recedents and subrecedents — 1 species each) made up 7,1 % of the community structure. Eudominants were absent.

Zonovo. Six species were recorded (excluding *Simulium* sp. 2). The eudominant: *S. longipalpe*. Dominant: *S. rostratum*. Subdominant: *S. erythrocephalum*. Few and rarely attacking black flies (recedents — 1 species, subrecedents — 3 species) made up 2.1 % of the community structure.

Krasnozerskoye. Five species were recorded. The eudominant: *S. erythrocephalum*. Dominants: *S. angustitarse* и *S. rostratum*. Subdominant: *S. longipalpe*. Few and rarely attacking black flies (subrecedent — 1 species), accounted for only 1 % of the community structure. Recedents were absent.

Karasuk. Five species were recorded (excluding *Simulium* sp.1). The eudominant: *S. angustitarse*. Dominant: *S. erythrocephalum*. Subdominant: *S. longipalpe*. Few and rarely attacking black flies (recedents and subrecedents — 1 species each) made up 2.4 % of the community structure.

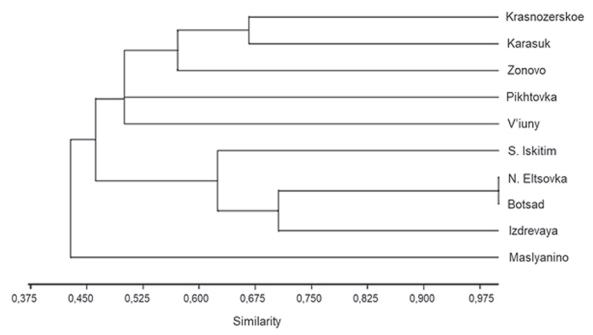


Fig. 4. Dendrogram of similarity of black fly species composition in the Novosibirskaya Oblast based on the Jaccard index (nearest neighbor method).

Рис. 4. Дендрограмма сходства видового состава мошек Новосибирской области на основе индекса Жаккара (метод ближайшего соседа).

Overall, in the Novosibirskaya Oblast, of the 19 species recorded in the study area, only 9 acted as eudominants, dominants or subdominants in at least one of the study sites and can be classified as numerous and frequently attacking species: *S. maculatum*, *S. erythrocephalum*, *S. angustitarse*, *S. pusillum*, *S. reptans*, *S. longipalpe*, *S. rostratum*, *S. aemulum*, *S. equinum*. Seven species of black flies were classified as the recedents and subrecedents, with their numbers varied across sites from 0 to 12. Within the attacking black fly complex, the proportion of these few and rarely attacking species ranged from 0 to 8.8 %.

Simulium maculatum was the most common eudominant species, occurring at six sites, five of which were on the right bank of the Ob River, and only one (Viuny) on the left bank north of Novosibirsk. Three species (*S. erythrocephalum*, *S. angustitarse* и *S. longipalpe*) were found as eudominants only at isolated sites on the left bank part of the region.

An analysis of the similarity in the species composition of black fliers across different sites in the Novosibirskaya Oblast, based on the Jaccard coefficient, revealed two main clusters with a similarity level of $J \geq 0.5$ (Fig. 4). One of these groups comprised all the west sites, whilst the other included all the east sites, with the exception of Maslyanino, which showed the lowest level of similarity to all the other sites ($J \geq 0.425$). Within the 'west sites' cluster, two areas were isolated: Viuny (northern forest-steppe) and Pikhtovka (subtaiga zone of the southern taiga), with a level of similarity in species composition between them of $J = 0.5$. Another group consisted of the southern forest-steppe areas of Zonovo, Karasuk and Krasnozerskoye ($J = 0.38 – 0.67$), with the latter two being the most similar ($J = 0.67$). In the 'right bank' cluster, the lowest level of similarity with other sites in the group was demonstrated by S. Iskitim ($J \geq 0.625$), and the highest ($J = 1$) was found between relatively closely located forest-steppe areas near the small rivers Zyryanka (Botsad) and Nizhnyaya Eltsovka (N. Eltsovka).

Discussion

The forest-steppe landscapes of the Novosibirskaya Oblast are divided into subzones from north to south (latitudinal component) and depending on the orientation in relation to the Ob River (longitudinal). Black fly communities on the left bank of the Novosibirskaya Oblast varied in composition and structure. In the northern forest-steppe (Viuny), communities were similar to the subtaiga zone of the southern taiga (Pikhtovka). The communities that form this cluster were dominated by *S. maculatum* (44.5 %), with a significant proportion of *S. longipalpe* (33 %) and species of the subgenus *Shöenbaueria* (22.5 %). In the southern forest-steppe (Krasnozerskoye and Karasuk), blood-sucking black fly communities included 5 species; *Shöenbaueria* black

flies were absent, but *S. erythrocephalum* dominates (53 %), with a significant proportion of the species *S. rostratum* (Lundström, 1911), *S. angustitarse* and *S. longipalpe* (19 %, 15 % and 12 % of the total, respectively); *S. noelleri* Friederichs, 1920 were noted singly [Petrozhitskaya, 1992, 2010; Petrozhitskaya, Rodkina, 2018]. The warmer, drier climate and sparse river network of the southern part of the Novosibirskaya Oblast contribute to the depletion of black fly communities and their isolation into a separate cluster. The forest-steppe in the right bank of Ob River has a pronounced differentiation in relief, which is reflected in the dense river network, hydrodynamic indicators and general climatic characteristics. Thus, in the Maslyanino in the upper reaches of the Berd, where the forest-steppe adjoins mountain-taiga landscapes, the blood-sucking complex is not distinguished by diversity, with only 4 species of blood-suckers: *S. maculatum* dominate (52.3 %), *S. longipalpe* are numerous (33.5 %), *S. pusillum* and *S. aemulum* Rubtsov, 1940 complete the complex (8.6 % and 5.6 %, respectively) [Patrusheva, 1962]. In the 1960s, *S. longipalpe* black flies in the study region at the beginning of the summer season could account for more than 80 %, and on average for the season 33 % of the total number of attacking black flies [Patrusheva, 1966]. According to monitoring data in the Novosibirskaya Oblast, this species may account for 1.7–12.8 % of the total population. Within the blood-sucker complex, they occupy borderline positions between subdominants and recedents, with a trend toward a decreasing overall share.

At four monitoring sites in the vicinity of Novosibirsk, the main component of the blood-sucking complex included *S. equinum*, first mentioned for this area in single numbers among blood-suckers in the early 2000s [Petrozhitskaya, 2013]. This species had not previously been recorded among blood-suckers in the study area [Patrusheva, 1966, 1982; Dariychuk, 1972]. According to our data, since the beginning of the XXI century, the number of imagos of this species among attacking humans black flies increased from single individuals to 70 or more specimens during one count with the net (unpublished data). Apparently, at present, conditions in the region studied are fairly favourable for the development of *S. equinum*. As a result this species has expanded significantly northwards compared with the end of the last century. Considering certain difficulties in identification of species of the subgenus *S. (Wilhelmia)*, the affiliation of the material collected in the vicinity of Novosibirsk to the species *S.* (*Wilhelmia*) *equinum* was confirmed using molecular genetic methods. [Vaulin et al., 2022].

Black fly *S. equinum* is widespread throughout the Palearctic region (Pan-Palearctic holotype), predominantly in areas with a warm climate [Şirin et al., 2015; López-Peña et al., 2022; Cunze et al., 2024]. The medical-parasitic situation with species of the *S.* (*Wilhelmia*) *equinum* complex is complicated by the fact that it has recently become known that representatives of the subgenus *S. (Wilhelmia)* (e.g. *Simulium turgaicum* Rubtsov, 1940) are involved in the transmission of helminths dirofilaria that is very dangerous for people and domestic animals, including dogs, cows and birds [Khanzadeh et al., 2020].

As for black fly *S. erythrocephalum*, the data obtained suggest that relative abundance of this species may increase during hot seasons with elevated temperatures and even low summer precipitation. High numbers of *S. erythrocephalum* are currently observed in arid regions of the Palearctic — Turkey and Spain [Şirin et al., 2015; López-Peña et al., 2022]. Despite the rather harsh conditions for black fly larvae in the watercourses of the Barabinskaya forest-steppe in West Siberia, they develop successfully over several generations [Petrozhitskaya, 2010]. Representatives of this species, as well as *S. equinum*, are characterized by a wide adaptive potential of preimaginal phases, capable of withstanding significant anthropogenic loads on hydrocenoses, including the after-effects of agricultural use of surrounding lands [Cunze et al., 2024].

It appears that climate warming in the southeast of West Siberia and increased tolerance of black flies in flat landscapes to higher temperatures, organic and pollutant loads in large and medium-sized watercourses contribute to the expansion of the range of *S.* (*Wilhelmia*) *equinum* and an increase in the numbers of *S.* (*Boophthora*) *erythrocephalum*. As a result, the parasitological situation in this region is becoming more acute: an expansion of the composition and a change in the structure of the blood-sucking black fly complex is observed, with a constant eudominant and a pulsating number of subdominants. Considering the possible involvement of black flies in the transmission of pathogens of transmissible zoonotic diseases of humans and animals, it is necessary to conduct monitoring studies of the complex of blood-sucking black flies in the region in order to control their numbers. The experience of other countries shows good results in controlling and limiting the number of common species of black flies in certain areas, taking into account regional specifics in the composition and biology of blood-suckers [Bernotienė, 2001; Petrić et al., 2006; Akhmetov, 2019; Jiménez-Peydró et al., 2021].

Black fly *S. reptans*, as well as *S. equinum*, is widespread in the Palearctic (Pan-Palearctic chorotype), but females of this species are not particularly aggressive. They are common in the blood-sucker complex of boreal and temperate latitudes. [Day et al. 2008; Kúdela et al., 2014; Başören, Kazanci, 2016; Đuknić et al., 2020; López-Peña, 2022; Vaulin et al., 2024]. A comparative molecular genetic study of *S. reptans* from the vicinity of Novosibirsk and other regions of Russia (Murmansk, Irkutsk, Krasnoyarsk regions) and Northern Kazakhstan (Pavlodar region) with data from European countries (from the Genbank) showed the presence of two molecular forms — *S. reptans* A and *S. reptans* B, which have differences in geographic, zonal-latitudinal and ecological characteristics [Vaulin et al., 2024].

Among 12 species of the identified complex of blood-sucking black flies that are not common, black flies of the subgenus *Shöenbaueria* should be noted separately: *S. pusillum* (European-Siberian chorotype) and

Simulium (Schöenbaueria) subpusillum Rubtsov, 1940 (Holarctic-boreal chorotype), which are widespread in the boreal zone of the Palearctic and Nearctic. In the middle of the last century, in the forest-steppe landscapes of West Siberia, the proportion of these species was more significant, and they were always noted in the black fly complex [Patrusheva, 1982]. Black flies of the subgenus *S. (Schöenbaueria)* are characteristic of the taiga zone and northern forest-steppe [Patrusheva, 1966; 1982; Petrozhitskaya, 1992]. Currently, in the forest-steppe landscapes of the southeast of West Siberia, their number has significantly decreased to several individuals in the first half of June. One can note a trend toward a decrease in their share in the overall structure of black flies; they are assessed as recedents.

As for medical and parasitological perspective, the situation is becoming increasingly critical as the populations of the black flies *S. equinum* and *S. erythrocephalum* — which produce two generations a year — are growing, and the abundance of *S. maculatum*, which is the main blood-feeding species in the south-eastern part of West Siberia, remains high. Considering the persistent foci of tularemia in the Novosibirskaya Oblast, these species may be involved in the transmission of the pathogen from small rodents to humans, especially in recreational areas and agricultural lands during years of increased small mammal populations.

Conclusions

To date, the complex of active blood-sucking black flies recorded in the Novosibirskaya Oblast includes 19 species from 7 subgenera of the genus *Simulium* Latreille. The species *S. longipes* was first noted in West Siberia, and this is its first record for Novosibirskaya Oblast. The complex of black flies attacking humans for blood-sucking increased: in addition to the previous composition, 6 species, *Simulium equinum*, *S. jacuticum*, *S. malyschevi*, *S. promorsitans*, *S. subpusillum* and *S. truncatum,* were noted that were earlier recorded only in the pre-imaginal stages of development. The basis of the blood-sucking black fly complex in the Novosibirskaya Oblast was made up of the representatives of the subgenus *S. (Simulium)* — 10 species. The subgenus *S. (Schöenbaueria)* included 3 species, *S. (Nevermannia)* — 2, other subgenera, *S. (Boophthora)*, *S. (Byssodon), S. (Eusimulium)* and *S. (Wilhelmia)* — 1 species each.

The proportion of species with Holarctic and Palearctic distribution was 31.6 % and 68.4 %, respectively. The proportion of species with Pan-Holarctic, Pan-Palaearctic and Euro-Siberian chorotypes turned out to be similar, and together they account for 56.1% of the total.

The most numerous and frequently attacking bloodsuckers include 9 species, *S. maculatum*, *S. erythrocephalum*, *S. angustitarse*, *S. pusillum*, *S. reptans*, *S. longipalpe*, *S. rostratum*, *S. aemulum* and *S. equinum,* which in the communities studied played the role of eudominants, dominants or subdominants. The most common eudominant species was *S. maculatum*.

The modern composition of the blood-sucking black fly complex of the Novosibirsk agglomeration includes 16 species of the genus *Simulium* from 7 subgenera. In addition, the species *S. equinum* and *S. erythrocephalum*, typical of more southern regions, have been observed in a limited area as active blood-suckers. There is reason to believe that this is a result of rising average annual temperatures. However, this issue requires further research and more in-depth study.

Considering the possible involvement of black flies in the transmission of pathogens of transmissible zoonotic diseases of humans and animals, it is necessary to conduct monitoring studies of the blood-sucking black fly complex in the region in order to plan and carry out timely work to control their numbers.

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