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Article

Ecological and faunal characteristics of nest-dwelling groups of beetles in the nests of the sand martin (*Riparia riparia* (Linnaeus, 1758)) from different biotopes of Saratov Oblast

E.N. Kondratev^{1*} , A.S. Sazhnev^{2,3} , V.V. Anikin¹ 

¹ Saratov State University, Astrakhanskaya St. 83, Saratov, 410012 Russia

² Papanin Institute for Biology of Inland Waters Russian Academy of Sciences, Borok 101, Nekouz District, Yaroslavl Oblast, 152742 Russia

³ Joint Directorate of the Mordovia State Nature Reserve and National Park "Smolny", Krasnaya St. 30, Saransk, 430005 Russia

*eugene.n.kondratyev@gmail.com

Abstract. The article reports on a study of beetles in sand martin nests in Saratov Oblast. On the basis of literature data and the authors' own research, the composition of the beetle nest fauna of *Riparia riparia* was analysed. A check-list of the beetle fauna (76 species) recorded in the sand martin nests has been compiled. The studies were conducted in 2019–2022 in the forest-steppe and steppe zones on the territory of seven districts of Saratov oblast (Russia). A total of 209 nests from 12 colonies of the sand martin were studied. On the territory of Saratov oblast, 30 species of beetles from 16 families were recorded for the *Riparia riparia* nests. In the composition of the nest fauna, three types (trophic, topical and fensive) and five variants of relationship (zoophagous, phytophagous, saprophagous, substrate-stationary, fensive) of beetles with the nest were distinguished. On the basis of these data, a heteroconcentric model of the nest was constructed. Ecological groups of beetles were identified, and a heteroconcentric model was built. The facts of change and degradation of the nest-dwelling beetle fauna with the disappearance of the edificator-species were revealed.

Keywords: botrophils, botroxenes, consortia, nest-dwelling fauna, insects, birds, Lower Volga region, European Russia

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ORCID:

E.N. Kondratev, <https://orcid.org/0000-0002-7508-4355>

A.S. Sazhnev, <https://orcid.org/0000-0002-0907-5194>

V.V. Anikin, <https://orcid.org/0000-0001-8575-5418>

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Научная статья

Эколого-фаунистические характеристики нидикольных групп жесткокрылых в гнездах береговой ласточки (*Riparia riparia* (Linnaeus, 1758)) из различных биотопов Саратовской области

Е.Н. Кондратьев^{1*} , А.С. Сажнев^{2, 3} , В.В. Аникин¹ 

¹ Саратовский государственный университет им. Н.Г. Чернышевского, 410012, Россия, г. Саратов, ул. Астраханская, д. 83

² Институт биологии внутренних вод им. И.Д. Папанина РАН, 152742, Россия, Ярославская обл., Некоузский р-н, пос. Борок, д. 101

³ Объединенная дирекция Мордовского государственного природного заповедника им. П.Г. Смидовича и национального парка «Смольный», Россия, 430005, г. Саранск, ул. Красная, д. 30

*eugene.n.kondratyev@gmail.com

Аннотация. В статье представлены результаты изучения фауны жуков в гнездах береговой ласточки Саратовской области. На основе литературных данных и собственных исследований проанализирован состав колеоптерофауны гнезд *Riparia riparia*. Составлен полный список видов жесткокрылых (76 таксонов), отмеченных в гнездах береговой ласточки. Исследования проводились в 2019–2022 гг. в лесостепной и степной зонах на территории семи административных районов Саратовской области (Россия). Изучено 209 гнезд из 12 колоний береговой ласточки. На территории Саратовской области в гнездах *Riparia riparia* обнаружено 30 видов жуков из 16 семейств. В составе гнездовой фауны выделены три типа (трофическая, топическая и фензивная) и пять вариантов связи (зоофаги, фитофаги, сапрофаги, субстратно-стациональные, фензивные) жесткокрылых с гнездом, на основе этих данных построена гетероконцентрированная модель гнезда. Выявлены факты изменения и деградации нидикольной фауны при исчезновении вида-эдификатора.

Ключевые слова: ботрофилы, ботроксены, консорция, норная фауна, насекомые, птицы, Нижнее Поволжье, Европейская часть России

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ORCID:

Е.Н. Кондратьев, <https://orcid.org/0000-0002-7508-4355>

А.С. Сажнев, <https://orcid.org/0000-0002-0907-5194>

В.В. Аникин, <https://orcid.org/0000-0001-8575-5418>

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Introduction

Bird nests are inhabited by various groups of arthropods, including Ixodida, Mesostigmata, Hemiptera, Diptera, Siphonaptera, Coleoptera, Hymenoptera, Lepidoptera, etc. (Belousova, 2011; Borisova, 1972, 1978; Hicks, 1959; Korneev et al., 2018, 2020; Krištofík et al., 1994, 1995; Nelzina, 1977; Nordberg, 1936; Tryjanowski et al., 2001; Woodroffe, 1953). Despite the high diversity of arthropods living in nests, both in Russia (Bibik et al., 2004; Butenko, 2003; Gaponov and Teuelde, 2020; Jakimenko et al., 1991; Kondratev, 2019; Kondratev et al., 2021; Korneev et al., 2020) and abroad (Gwiazdowicz, 2003; Krištofík et al., 1994, 1995, 1996, 2007; Mašan and Krištofík, 1993; Nordberg, 1936; Tomioka and Nakamura, 2002; Tryjanowski et al., 2001; Ulmanen et al., 1977; Woodroffe, 1953), historically, more attention has always been paid to parasitic groups of arthropods. Interest in non-parasitic nest-dwelling species has only increased in recent years. Nevertheless, there are only a few papers presenting data on nest-dwelling beetles in the Russian literature (Belousova, 2011; Borisova, 1978; Kirschenblatt, 1937; Korneev et al., 2020; Pushkin, 2001; Sazhnev and Kondratev, 2019, 2020; Sazhnev and Matyukhin, 2019, 2020), and foreign literature (Alonso and Garrido, 2009; Dražina and Špoljar, 2009; Krištofík et al., 1994, 1995, 2007; Krumpal et al., 1993; Lundyshev, 2008; Mašan and Krištofík, 1993; Merkl and Rozsa, 2004; Nordberg, 1936; Ryndevich and Lundyshev, 2004; Tryjanowski et al., 2001; Woodroffe, 1953). The book by E.A. Hicks (1959) and its supplement (Hicks, 1962, 1971) is still the most complete summary of the beetles living in nests.

Migratory bird nests can be of epizootological importance as reservoirs of arbovirus infections. In the Volga region, one of the important and accessible objects for studying the arthropod fauna of these nests is the sand martin *Riparia riparia* (Linnaeus, 1758) (Caron et al., 2017; Matrosov et al., 2013; Molchanov et al., 2021). In nest communities, beetles play an important role in regulating the number of ectoparasites (Echegaray et al., 2015; Kasheev, 1983; Zibnitskaja and Kasheev, 1995). However, data concerning beetles found in sand martin nests is limited and fragmentary (Borisova, 1978; Hicks, 1959; Korneev et al., 2020; Krištofík et al., 1994; Nordberg, 1936; Sazhnev and Kondratev, 2019, 2020; Sazhnev et al., 2018) (Table 1). Consequently, this hinders the capacity to comprehensively evaluate the species composition, distribution of ecological groups and abundance of beetles.

A total of 76 species of Coleoptera were documented in the nests of sand martins, with the most prevalent taxonomically being Staphylinidae (30 species), Cryptophagidae (7), Carabidae (7), and Histeridae (6).

The objective of the present study is to consider the distribution of ecological groups of beetles in the nests of the sand martin (*Riparia riparia*), and to establish the degree of their biotopic association with this type of nest.

Table 1. List of beetles (Coleoptera) from nests of *Riparia riparia* (based on literary data and own studies).

Taxon	Source							Authors' materials (Sazhnev and Kondratev, 2019, Sazhnev and Matyukhin, 2019, Sazhnev et al., 2018, 2020, 2020, unpublished data)
	Nordberg, 1936	Hicks, 1959, 1971	Borisova, 1978	Krištofik et al., 1994	Korneev et al., 2020			
<i>Acupalpus carus</i> (LeConte, 1863)	-	+	-	-	-	-	-	-
<i>Acupalpus meridianus</i> (Linnaeus, 1761)	-	+	-	-	-	-	-	-
<i>Bradycellus caucasicus</i> (Chaudoir, 1846)	-	-	-	+	-	-	-	-
<i>Laemostenus terricola</i> (Herbst, 1784)	-	+	-	-	-	-	-	-
<i>Syntomus foveatus</i> (Geoffroy, 1785)	-	-	-	+	-	-	-	-
<i>Syntomus obscuroguttatus</i> (Duftschmid, 1812)	-	-	-	+	-	-	-	-
<i>Trechus quadristriatus</i> (Schrank, 1781)	-	-	-	+	-	-	-	-
Fam. Carabidae								
<i>Dendrophilus punctatus</i> (Herbst, 1791)	-	-	+	-	-	-	-	-
<i>Euspilotus perrisi</i> (Marseul, 1872)	-	-	-	-	+	-	-	+
<i>Gnathoncus buyssonii</i> Auzat, 1917	-	-	-	+	-	-	-	-
<i>Saprinus planiusculus</i> Motschulsky, 1849	-	-	-	-	+	-	+	-
<i>Saprinus rugifer</i> (Paykull, 1809)	-	+	+	-	-	-	-	+
<i>Saprinus virescens</i> (Paykull, 1798)	-	+	-	-	-	-	-	-
Fam. Ptiliidae								
<i>Acrotichis intermedia</i> (Gillmeister, 1845)	-	-	-	+	-	-	-	-

Taxon	Source						Authors' materials (Sazhnev and Kondratev, 2019, Sazhnev and Matyukhin, 2019, Sazhnev et al., 2018, 2020, 2020, unpublished data)
	Nordberg, 1936	Hicks, 1959, 1971	Borisova, 1978	Krištofik et al., 1994	Korneev et al., 2020		
<i>Agrilus hyperici</i> (Creutzer, 1799)	-	-	-	-	-	-	+
<i>Cytilus sericeus</i> (Forster, 1771)	-	-	-	-	-	-	+
<i>Agriotes ustulatus</i> (Schaller, 1783)	-	-	-	-	-	-	+
<i>Lampyris noctiluca</i> (Linnaeus, 1758)	-	-	-	-	-	-	+
<i>Anthrenus pimpinellae</i> (Fabricius, 1775)	-	-	-	+	-	-	-
<i>Dermestes lanarius</i> Illiger, 1801	-	-	-	-	-	-	+
<i>Ptinus fur</i> (Linnaeus, 1758)	-	-	-	+	-	-	-
<i>Monotoma</i> sp.	-	-	-	-	+	-	-
<i>Atomaria linearis</i> Stephens, 1830	-	+	+	-	-	-	-
<i>Atomaria</i> sp.	-	-	-	+	-	-	-
<i>Cryptophagus badius</i> Sturm, 1845	-	+	-	-	-	-	-
<i>Cryptophagus cellaris</i> (Scopoli, 1763)	-	+	-	-	-	-	-
<i>Cryptophagus dentatus</i> (Herbst, 1793)	-	-	-	+	-	-	-

Taxon	Source							Authors' materials (Sazhnev and Kondratev, 2019, Sazhnev and Matyukhin, 2019, Sazhnev et al., 2018, 2020, 2020, unpublished data)
	Nordberg, 1936	Hicks, 1959, 1971	Borisova, 1978	Krištofik et al., 1994	Korneev et al., 2020			
<i>Cryptophagus distinguendus</i> Sturm, 1845	-	+	-	-	-	-	-	-
<i>Cryptophagus saginatus</i> Sturm, 1845	-	+	-	-	-	-	-	-
<i>Sericoderus lateralis</i> (Gyllenhal, 1827)	-	-	-	-	-	-	-	+
<i>Mycetaea subterranea</i> (Fabricius, 1801)	-	+	-	-	-	-	-	-
<i>Adalia bipunctata</i> (Linnaeus, 1758)	-	-	-	-	-	-	-	+
<i>Corticaria crenulata</i> (Gyllenhal, 1827)	-	-	-	-	-	-	-	+
<i>Corticaria</i> sp.	-	-	-	-	-	-	-	+
<i>Latridius minutus</i> (Linnaeus, 1767)	-	+	+	+	+	+	+	-
<i>Anaspis</i> sp.	-	-	-	-	-	-	-	+
<i>Anthelephila pedestris</i> (Rossi, 1790)	-	-	-	+	+	+	+	-
<i>Anthicus antherinus</i> (Linnaeus, 1761)	-	-	-	-	-	-	-	-
<i>Anthicus flavipes</i> (Panzer, 1796)	-	-	-	-	-	-	-	+
<i>Blaps lethifera</i> Marsham, 1802	-	-	-	+	-	-	-	+

Taxon	Source						Total
	Nordberg, 1936	Hicks, 1959, 1971	Borisova, 1978	Krištofik et al., 1994	Korneev et al., 2020	Authors' materials (Sazhnev and Kondratev, 2019, Sazhnev and Matyukhin, 2019, Sazhnev et al., 2018, 2020, 2020, unpublished data)	
<i>Bruchus pisorum</i> (Linnaeus, 1758)	-	-	-	+	-	+	
<i>Chaetocnema hortensis</i> (Geoffroy, 1785)	-	-	-	-	-	+	
<i>Spermophagus sericeus</i> (Geoffroy, 1785)	-	-	-	-	+	+	
Fam. Chrysomelidae							
<i>Ceutorhynchus gallorhenanus</i> A. Hoffmann, 1955	-	-	-	-	-	+	
<i>Sitona linearis</i> (Linnaeus, 1758)	-	-	-	+	-	-	
<i>Lixus abdominalis</i> Boheman, 1835	-	-	-	-	-	+	
<i>Xyleborinus saxesenii</i> (Ratzeburg, 1837)	-	-	-	-	-	+	
Total	4	22	7	29	12	30	
Fam. Curculionidae							

Materials and methods

The study was based on entomological samples from sand martin nests in Voskresensky, Krasnoarmeysky, Lysogorsky, Rovensky, Engelssky, Khvalynsky districts and Saratovsky municipal district of Saratov Oblast in 2019–2022 (Fig. 1, Table 2). A total of 12 colonies were examined.

The main sampling sites in Saratov Oblast are visualized on the map (Fig. 2). The map was created using QGIS 3.40.3.

The colonies studied can be divided into three groups:

1. Colonies in sand quarries. The burrows of these colonies are located in a sand cliff at a height of 0.5–3.5 m. The length of such colonies varies from 1.2 to 25 m. The burrow entrances are elongated in a chain of 2–6 levels in the upper third of the cliff.

2. Colonies on the territory of Saratov and Volgograd oblasts. The colonies are located in the soil, sand and soil-sand coastal cliffs at a height of 1.2–7 m. The length of such colonies varies from 3 to 40 m. The colonies are long-lived, but in different years the location of the burrows and the number of nesting birds varies significantly due to the collapse of the shore and changes in nesting conditions. The burrow entrances are elongated in a chain of 1–5 levels in the middle or upper third of the cliff. All colonies are surrounded by ruderal vegetation.

3. Colonies on small rivers. The colonies are located in a soil cliff at a height of 1.5–2.5 m. The length of the colonies varies from 2 to 4 m. The burrow entrances are elongated in a chain of 1–4 tiers in the middle or upper third of the cliff. The burrows are often very sparse. Colonies are unstable due to shoreline collapse and changes in nesting conditions.

The total number of sand martin colonies by year of study is presented below (Table 3).

Nesting material was extracted from the burrows as they were excavated. It was then placed in an individual zip-lock bag with a label for further transport and office processing. The beetle imago and larvae were dissected using the Tullgren funnel (extraction for 2–3 hours), followed by manual

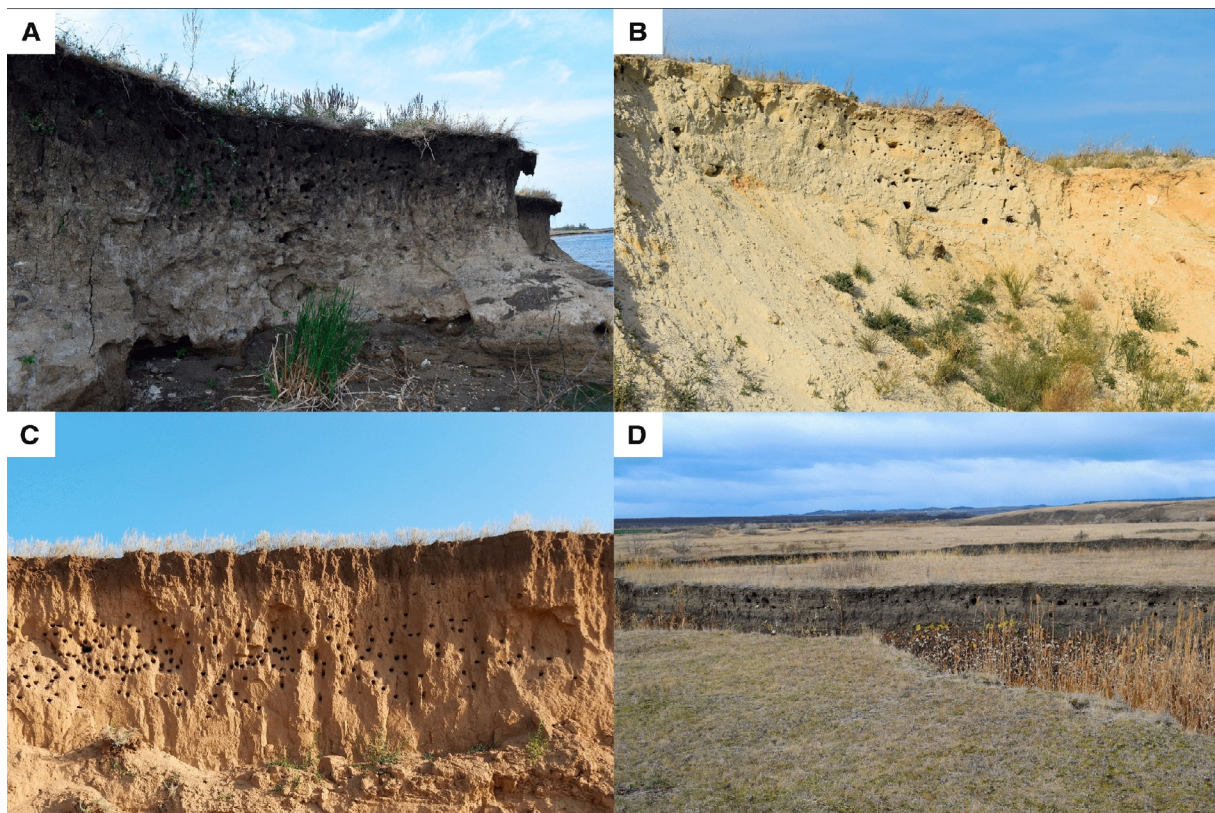


Fig. 1. Colonies of *Riparia riparia*, in the study area. **A** – Khvalynsky distr., vicinity of Ivanovka vill., shore of the Volga River; **B** – Khvalynsky distr., vicinity of Apalikha vill., sand quarry; **C** – Rovensky distr., vicinity of Beregovoe vill., shore of the Volga River; **D** – Khvalynsky distr., vicinity of Elshanka vill., pond shore.

Table 2. Data on the inhabitation of Riparia riparia colonies by year of study. I – inhabited colony, U – uninhabited colony.

No.	Locality	Coordinates		2019	2020	2021	2022
		N	E				
1	Khvalynsky distr., vicinity of Elshanka vill., pond shore	52.6043	47.9766	I	U	U	U
2	Khvalynsky distr., vicinity of Ivanovka vill., shore of the Volga River	52.4002	48.0906	I	I	I	I
3	Khvalynsky distr., vicinity of Demkino vill., sand quarry	52.2670	47.7965	I	I	I	I
4	Khvalynsky distr., vicinity of Apalikha vill., sand quarry	52.3171	47.6780	–	–	U	U
5	Voskresensky distr., vicinity of Komarovka vill., shore of the Tereshka River	51.9667	46.6604	–	–	U	U
6	Engelssky distr., vicinity of Malaya Topolevka vill., sand quarry	51.5566	46.2827	–	–	U	U
7	Saratov, Gagarinsky distr., vicinity of Sand Umet vill., abandoned sand quarry	51.5219	45.6280	I	U	U	U
8	Krasnoarmeysky distr., vicinity of Mordovo vill., shore of the Volga River	51.1242	45.8160	I	U	U	U
9	Rovensky distr., vicinity of Privolzhskoe vill., shore of the Volga River	51.1047	45.9356	–	–	U	U
10	Rovensky distr., vicinity of Beregovoe vill., shore of the Volga River	50.7565	46.0117	–	–	U	U
11	Lysogorsky distr., vicinity of Simonovka vill., shore of the Medveditsa River	51.3569	44.8001	–	U	U	U
12	Lysogorsky distr., vicinity of Ataevka vill., shore of the Medveditsa River	51.3100	44.8205	–	U	U	I

examination for arthropods that did not pass through the funnel (Golub et al., 2021). A total of 209 nests were examined, 3152 imagoes and larvae of Coleoptera were found in 74 nests (the proportion of samples without Coleoptera was 64.6%). The nests were divided into four groups according to Mašan (1997) (abandoned nests or the nests deserted just before finishing without eggs; completed nests with eggs; nests in nestling phase; the nests collected just after fledging of young).

An abundance index (Ab) was calculated as follows:

$$Ab = \frac{n_i}{N_r},$$

where n_i – is the total number of individuals of each species; N_r – is the total number of all nests.

A dominance index (D) was calculated as follows:

$$D = \frac{n_i \times 100}{N_c},$$

where n_i – is the total number of individuals of each species of beetles; N_c – is the total number of all individuals of beetles.

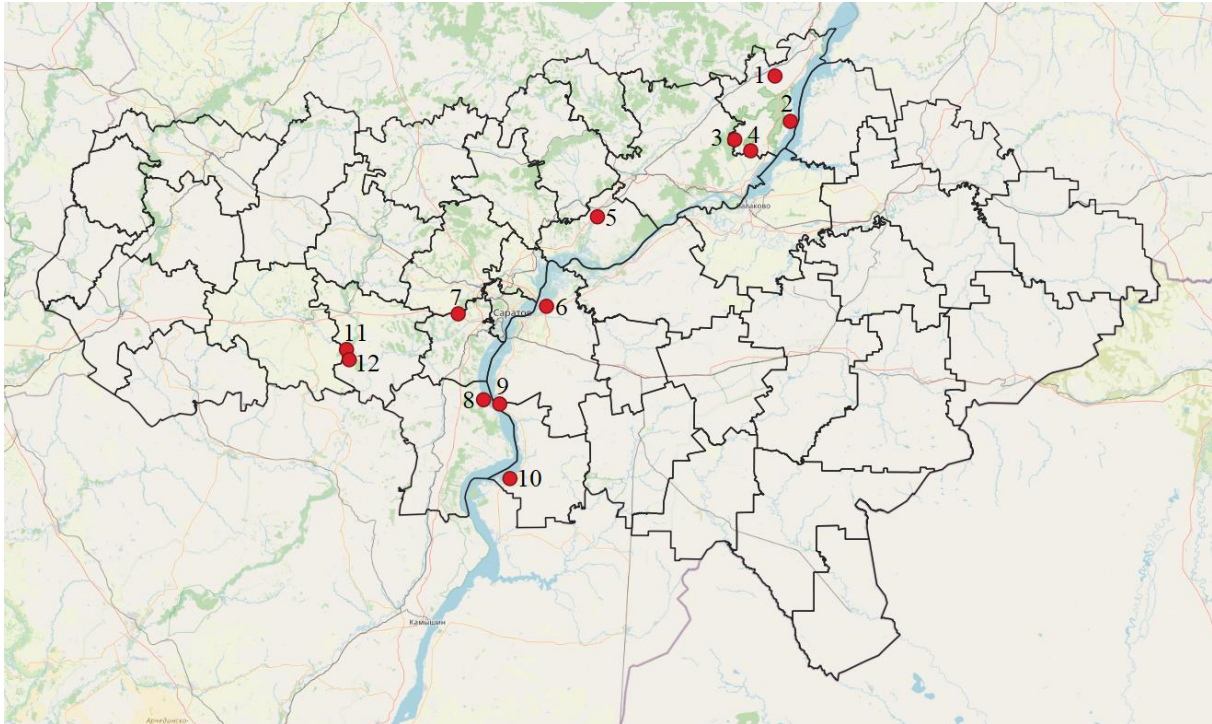


Fig. 2. Map of sampling on the territory of Saratov Oblast (numbering of localities as in Table 2).

A biotopical preferences index (BC) was calculated as follows (Beklemishev, 1961):

$$BC = \frac{Ab_i \times k_i \times 100}{\sum (Ab_i \times k_i)},$$

where k_i – is the number of nests in which individuals of each beetle species were found; Ab_i – is an abundance of individuals of each species of beetles.

Jakkard index (I_j) was calculated as follows (Potapov and Kuznetsov, 2011):

$$I_j = \frac{C}{A+B-C},$$

where A – is the number of species in the first place; B – is the number of species in the second place; C – is the number of general species in the compared places.

The Shannon–Wiener index (H') was calculated as follows (Potapov and Kuznetsov, 2011):

$$H' = - \sum p_i \times \log_2 p_i,$$

where p_i – is the ratio between the number of individuals of species i and the total number of individuals.

The dominance structure in a community was described according to the logarithmic classification of Engelmann (1978). All biological parameters were calculated using IBM SPSS Statistics 26.

After identifying and counting the material, heterocentric models of consortium were constructed, including 5 types of concentrations, based on consortial relationships (Negrobov and Khmelev, 1999, 2000). The sizes of the concentrations in the first model correspond to the number of consortia species included, while in the second model, they correspond to the number of individual consortia. The actual sizes of the concentrations (dark circles) correspond to the actual number of species/individuals included in them. The heterocentric model was constructed using Adobe Photoshop CC 2019.

The specimens are kept in 75% alcohol or dry and are deposited in the collection of the Zoological Museum, Saratov State University (SSU) and Papanin Institute for Biology of Inland Waters Russian Academy of Sciences (IBIW RAS).

In the following article the system of Coleoptera is used according to the Catalogue of Palaearctic Coleoptera (Alonso-Zarazaga et al., 2022; Catalogue ..., 2007, 2010, 2015–2017, 2020).

Table 3. Sampling locations and number of collected nests. Explanations: N – total number of burrows examined in the colony, s – number of nests collected.

Date	Locality	N (s)
2019		
23–24.06; 5–7.07	Khvalynsky distr., vicinity of Ivanovka vill., shore of the Volga River	52 (25)
20.07	Krasnoarmeysky discr., vicinity of Mordovo vill., shore of the Volga River	19 (8)
25.07	CSaratov, Gagarinsky distr., vicinity of Peschanyj Umet vill., abandoned sand quarry	13 (9)
2020		
25.06; 29.07; 7.11	Khvalynsky distr., vicinity of Ivanovka vill., shore of the Volga River	53 (31)
25.06; 30.07	Khvalynsky distr., vicinity of Demkino vill., sand quarry	22 (11)
26.06; 30.07; 7.11	Khvalynsky distr., vicinity of Elshanka vill., pond shore	23 (16)
26.07	Lysogorsky distr., vicinity of Simonovka vill., shore of the Medveditsa River	25 (1)
	Lysogorsky distr., vicinity of Ataevka vill., shore of the Medveditsa River	13 (4)
27.07	Saratov, Gagarinsky distr., vicinity of Peschanyj Umet vill., abandoned sand quarry	12 (3)
2021		
8.05; 27.06	Khvalynsky distr., vicinity of Elshanka vill., pond shore	16 (5)
27.06; 8.07; 11.07; 5.77	Khvalynsky distr., vicinity of Ivanovka vill., shore of the Volga River	49 (24)
	Khvalynsky distr., vicinity of Apalikha vill., sand quarry	24 (7)
8.07; 4.11	Khvalynsky distr., vicinity of Demkino vill., sand quarry	19 (9)
	Rovensky distr., vicinity of Beregovoe vill., shore of the Volga River	16 (4)
3.11	Engelssky distr., vicinity of Malaya Topolevka vill., sand quarry	22 (8)
6.11	Voskresensky distr., vicinity of Komarovka vill., shore of the Tereshka River	9 (2)

Date	Locality	N (s)
2022		
26.06	Krasnoarmeysky discr., vicinity of Mordovo vill., shore of the Volga River	12 (1)
28.06; 4.11	Khvalynsky distr., vicinity of Apalikha vill., sand quarry	20 (9)
	Khvalynsky distr., vicinity of Demkino vill., sand quarry	18 (9)
3.07	Khvalynsky distr., vicinity of Ivanovka vill., shore of the Volga River	13 (2)
20.08	Engelssky distr., vicinity of Malaya Topolevka vill., sand quarry	14 (3)
5.09	Rovensky distr., vicinity of Beregovoe vill., shore of the Volga River	14 (5)
15.12	Rovensky distr., vicinity of Privolzhskoe vill., shore of the Volga River	12 (4)
3.11	Voskresensky distr., vicinity of Komarovka vill., shore of the Tereshka River	5 (1)
6.12	Lysogorsky distr., vicinity of Ataevka vill., shore of the Medveditsa River	18 (8)

Results and discussion

Coleoptera are relatively common in *Riparia riparia* nests (the proportion of samples with beetles is 35.40%). Over the four years of the study, Coleoptera represented 14.87% of the total number of arthropods found in nests. The most abundant groups are the order Mesostigmata (65.24%) and the class Collembola (9.61%), all other taxa are not abundant (0.05–2.06%).

The total number of samples during the study and the ratio of residential and non-residential burrows of *Riparia riparia* by year are presented in the graph (Fig. 3). There was no linear relationship between the number of samples taken and the number of beetles in them during the study ($R^2 = 0.4597$). From 2019 to 2022, a downward trend was observed in the number of residential burrows of sand martins among the colonies. This decline may be attributed to the search for new colony sites, a consequence of the diminished suitability of existing colonies for the construction of new burrows.

A total of 19 species of Coleoptera belonging to 14 different families were documented within the nests of sand martins (Table 4). The family Staphylinidae exhibited the highest level of diversity, with five species recorded (a figure that is generally comparable with data reported in the extant literature).

Within the order Coleoptera, the family Staphylinidae exhibits the greatest abundance, accounting for 96.91% of the total, a proportion largely attributed to the predominance of the species *Haploglossa nidicola*. The family Histeridae follows, accounting for 1.62%, while other families are present in minimal numbers, ranging from 0.08% to 0.155%.

The mean number of beetles (Fig. 4) recorded in residential (281) and non-residential (49) burrows over a four year period did not exhibit significant differences ($t = 0.205$; $p = 0.05$). The differences in the number of species are also insignificant: 11 species in residential burrows and 9 in non-residential ones. The differences in the number of species are not significant either: 11 species in residential burrows, and 9 in non-residential ones. However, in the latter, the beetles present are mostly random species from nearby

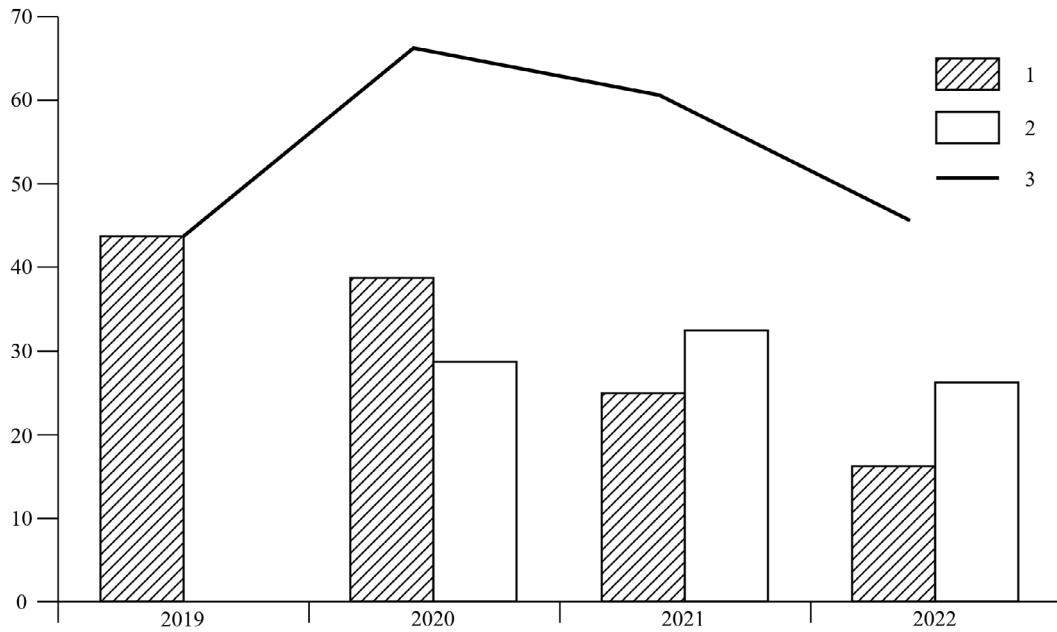


Fig. 3. Ratio of residential and non-residential burrows of *Riparia riparia* by year of study. 1 – residential burrows, 2 – non-residential burrows, 3 – total number of samples.

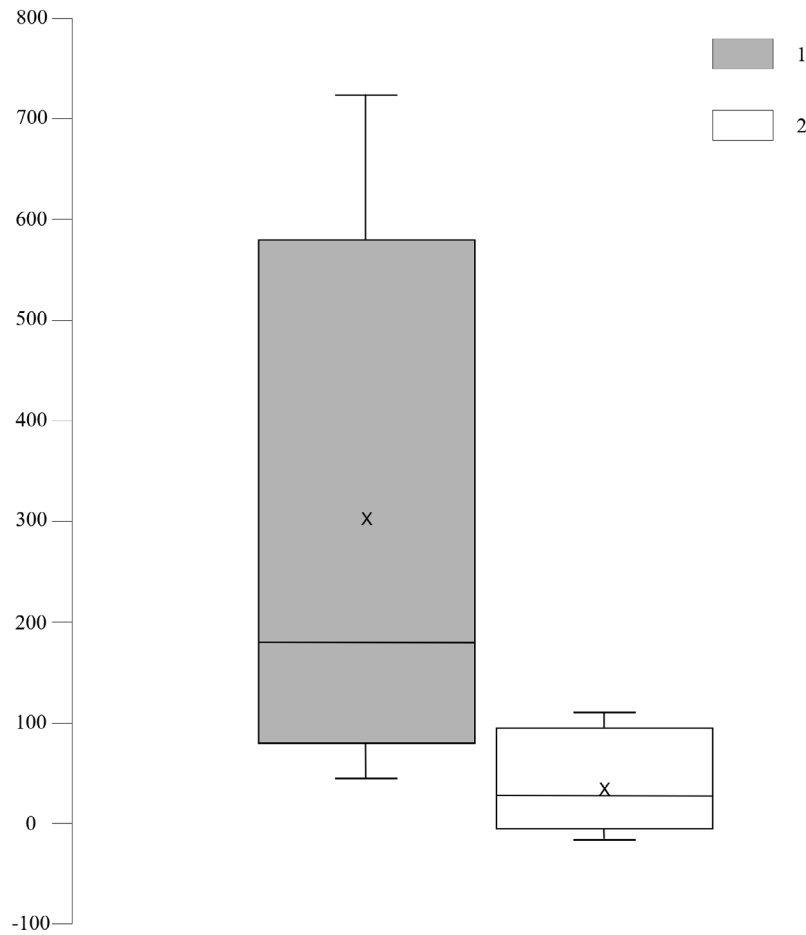


Fig. 4. Quantitative ratio of Coleoptera in residential and non-residential burrows of sand martins (1 – inhabited, 2 – uninhabited). Mustache – max and min values, middle line – median, cross – sample mean.

Table 4. Ecological groups, indexes and classes of dominance of Coleoptera in the nests of sand martins (based on materials from the Saratov oblast). EC – ecological characteristics; D – dominance index; Ab – abundance index; BC – biotopical preferences index by Beklemishev (1961); Dominance classes are identified according to Engelman (1978). Ecological characteristics: Z – zoophagous; P – phytophagous; S – saprophagous. Eudominants and dominants are highlighted in bold.

№	Таксон	EC	D, %	Ab, ind./nest	BP, %	Dominance class
Fam. Histeridae						
1	<i>Saprinus rugifer</i>	Z	1.62	0.77	0.330	Recedent
Fam. Staphylinidae						
2	<i>Falagrioma thoracica</i>	Z	0.08	0.04	0.001	Subrecedent
3	<i>Haploglossa nidicola</i>	Z	96.30	45.85	99.629	Eudominant
4	<i>Haploglossa picipennis</i>	Z	0.23	0.11	0.004	Subrecedent
5	<i>Leptacinus sulcifrons</i>	Z	0.23	0.11	0.008	Subrecedent
6	<i>Sepedophilus obtusus</i>	Z	0.08	0.04	0.001	Subrecedent
Fam. Scarabaeidae						
7	<i>Plagiogonus arenarius</i>	S	0.08	0.04	0.001	Subrecedent
8	<i>Pleurophorus caesus</i>	S	0.15	0,07	0.001	Subrecedent
Fam. Buprestidae						
9	<i>Agrilus hyperici</i>	P	0.08	0.04	0.001	Subrecedent
Fam. Byrrhidae						
10	<i>Cytilus sericeus</i>	P	0.08	0.04	0.001	Subrecedent
Fam. Lampyridae						
11	<i>Lampyris noctiluca</i>	Z	0.08	0.04	0.001	Subrecedent
Fam. Dermestidae						
12	<i>Dermestes lanarius</i>	S	0.08	0.04	0.001	Subrecedent
Fam. Corylophidae						
13	<i>Sericoderus lateralis</i>	S	0.15	0.07	0.005	Subrecedent
Fam. Latridiidae						
14	<i>Corticaria crenulata</i>	S	0.15	0.07	0.005	Subrecedent
15	<i>Corticaria</i> sp.	S	0.15	0.07	0.005	Subrecedent
Fam. Tenebrionidae						
16	<i>Blaps lethifera</i>	S	0.08	0,04	0.001	Subrecedent
Fam. Anthicidae						
17	<i>Anthicus flavipes</i>	S	0.08	0.04	0.001	Subrecedent
Fam. Chrysomelidae						
18	<i>Chaetocnema hortensis</i>	P	0.08	0.04	0.001	Subrecedent
Fam. Curculionidae						
19	<i>Xyleborinus saxeseni</i>	S	0.15	0.07	0.002	Subrecedent
20	<i>Lixus abdominalis</i>	S	0.07	0.04	0.001	Subrecedent

biotopes (e.g., *Agrilus hyperici* and *Chaetocnema hortensis*) rather than those associated with burrow communities. *Haploglossa nidicola* also predominates in numbers in uninhabited swallow burrows.

According to the Jaccard index (Ij), the greatest similarity in the composition of the beetle fauna is found in colonies located on sandy soils (0.50) or in old colonies where birds are not/have not settled (colonies in the villages of Privolzhskoe, Peschany Umet, Mordovo, Apalikha, Malaya Topolevka, Beregovoe). The greatest similarity (Ij = 0.67) was found in the communities of the Mordovo–Apalikha colonies (mainly *Haploglossa nidicola* and *Saprinus rugifer* were found in the collections; in the village of Apalikha, *Pleurophorus caesus* was also found). In most cases, the Jaccard index was 0.50 in colonies on sandy soils. For some colonies on sandy soil, the index value was 0.3. For the colonies Apalikha–Malaya Topolevka, Apalikha–Beregovoe, Apalikha–Privolzhskoye and Demkino–Mordovo the index was 0.25. The similarity of communities in other colonies is not high (Ij = 0.22–0.10). The lowest similarity is observed between the colonies of Elshanka and Demkino (Ij = 0.08).

The Shannon index (H') in two colonies, whose communities consist only of *Haploglossa nidicola*, is equal to 0 (Peschany Umet). In other colonies, the diversity of Coleoptera species is low (average = 0.368): from the minimum in the colony of Elshanka (0.184) to the maximum in the colony of Beregovoe (0.736).

Based on the analysis of the collected material, trophic groups of Coleoptera were identified. According to the type of feeding in the nests of *Riparia riparia*, zoophages (representatives of the families Carabidae, Staphylinidae, Histeridae, Lampyridae) dominate with a share of 98.69%; other groups are much more modestly represented: saprophages – 1.08% and phytophages – 0.23%.

In the presented heteroconsort model, in terms of number of species, the system-forming types of compounds are trophic, topical (substrate-stationary) and fundamental compounds (Fig. 5). At the trophic level, beetles are dominated by saprophages (*Dermestes lanarius*, *Sericoderus lateralis*, *Corticaria* sp., *Corticaria crenulata*, *Plagiogonus arenarius*, *Pleurophorus caesus*, *Blaps lethifera* and *Anthicus flavipes*), which feed on decaying remains of both plant and animal origin. Second in number of species are the zoophages (*Haploglossa nidicola*, *H. picipennis*, *Falagrioma thoracica*, *Leptacinus sulcifrons*, *Sepedophilus obtusus*, *Saprinus rugifer*), which feed mainly on ectoparasites but also on other arthropods. There are few phytophages (*Agrilus hyperici*, *Cytilus sericeus*, *Chaetocnema hortensis* and *Xyleborinus saxesenii*). These are mainly accidental species from the nearest open biotopes or species that feed on plant parts of the nest.

The nest can be considered as a consortium, where the consorts are connected by substrate-stationary connections (*Haploglossa nidicola*, *H. picipennis*, *Saprinus rugifer*, *Dermestes lanarius*) and the determinant acts as an environment-forming element.

The species *Haploglossa nidicola*, a typical inhabitant of shorebird nests, was classified as an obligate nest beetle in our collections. It is present in nests, including larval stages. Quite often (1.62%) *Saprinus rugifer* was present in nests, considered by some authors to be a nest beetle (Kryzhanovsky and Reichardt, 1976).

Two colonies (Elshanka and Beregovoye) with different soil types and the longest observation period were selected as model colonies to monitor the dynamics of the number and composition of nesting beetles in these colonies. Data for 2012 have already been published (Korneev et al., 2020).

In both cases, after the birds left the colony in 2019–2020 (Figs. 6, 7), a decrease in the number of bothrobionts and an increase in bothroxenes in the nest were observed. Then, in the Elshanka colony, there was a complete degradation of the nest-dwelling fauna, which is clearly visible in the change of ecological groups of nest-dwelling beetles. The true burrow fauna is replaced by more eurytopic species from surrounding habitats and stenotopic bothrobiont species disappear as the edificator species disappear. As a result, the taxonomic structure of the community changes dramatically. Similar observations in Saratov Oblast were previously made for burrowing mammals (Sazhnev et al., 2016). All this emphasises the close association of bothrobionts with burrow complexes and host species.

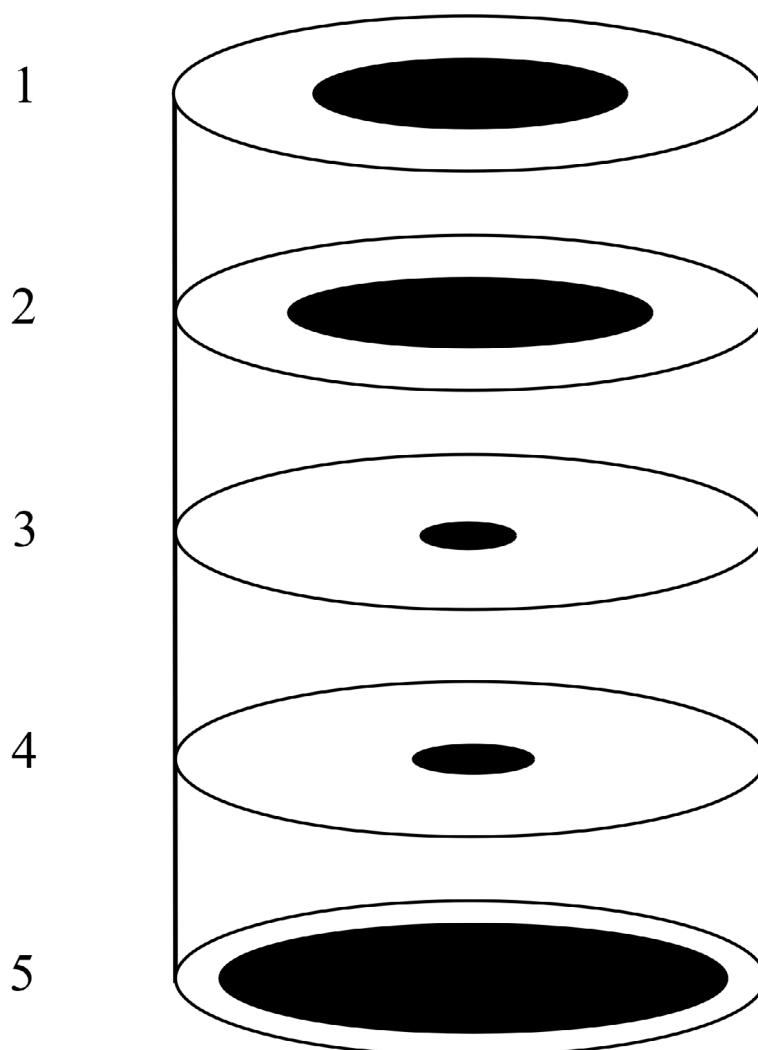


Fig. 5. Heterocentric model of consortium of beetles and nest of *Riparia riparia*. 1 – trophic (zoophagous), 2 – trophic (saprophagous), 3 – trophic (phytophagous), 4 – topical (substrate-stational), 5 – fensive.

Conclusion

As a result of the research in the forest-steppe and steppe zones of Saratov Oblast 30 species of beetles from 16 families were found in the nests of *Riparia riparia* (Histeridae – 2 species, Staphylinidae – 8, Buprestidae – 1, Scarabaeidae – 3, Byrrhidae – 1, Lampyridae – 1, Elateridae – 1, Dermestidae – 1, Coccinellidae – 1, Scaptiidae – 1, Corylophidae – 1, Latridiidae – 2, Tenebrionidae – 1, Anthicidae – 1, Chrysomelidae – 3 and Curculionidae – 2). The largest diversity of species was recorded in the colonies of Demkino and Ivanovka – 9 species each, the smallest – in the colony of Peschany Umet – 1 species. The composition of the beetle fauna is most similar in colonies located on sandy soils or in old colonies, where the birds have stopped settling, according to the Jaccard index (0.25–0.67). The similarity is much lower (0.08–0.22) in colonies located on soil. A monospecific community was observed in the colony of Peschany Umet. Zoophages (species of the families Carabidae, Staphylinidae and Histeridae) dominate in the nests; saprophages and phytophages are much less represented. The dominant group in most colonies is *Haploglossa nidicola*. Other nest beetles (including facultative beetles) include *Haploglossa picipennis* and *Saprinus rugifer*. The species *Dermestes lanarius*, *Sericoderus lateralis* and *Corticaria crenulata* have a significant proportion of nest beetles. The analysis of the quantitative composition of the beetles in the study areas showed a rather rapid (1–2 years) degradation of the nest communities with the disappearance of the idifactor species and organiser of the consortium, the sand martin.

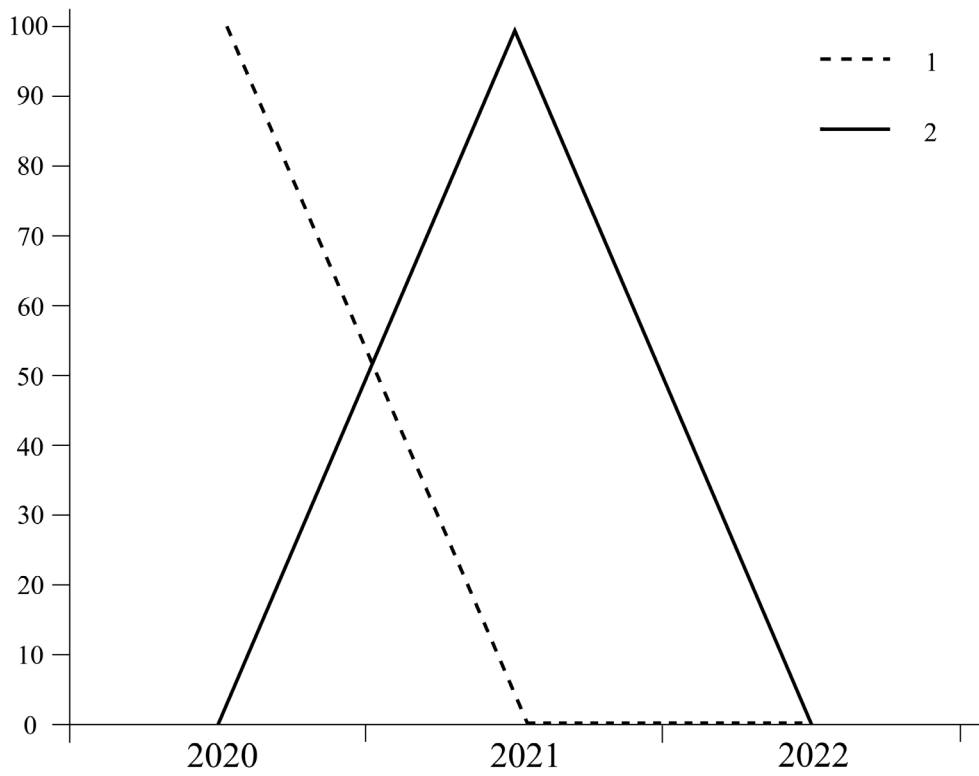


Fig. 6. Changes in the number of beetles (in%) from the nests of *Riparia riparia* over the years in the colony in the village of Elshanka (1 – bothrobionts, 2 – botroxenes).

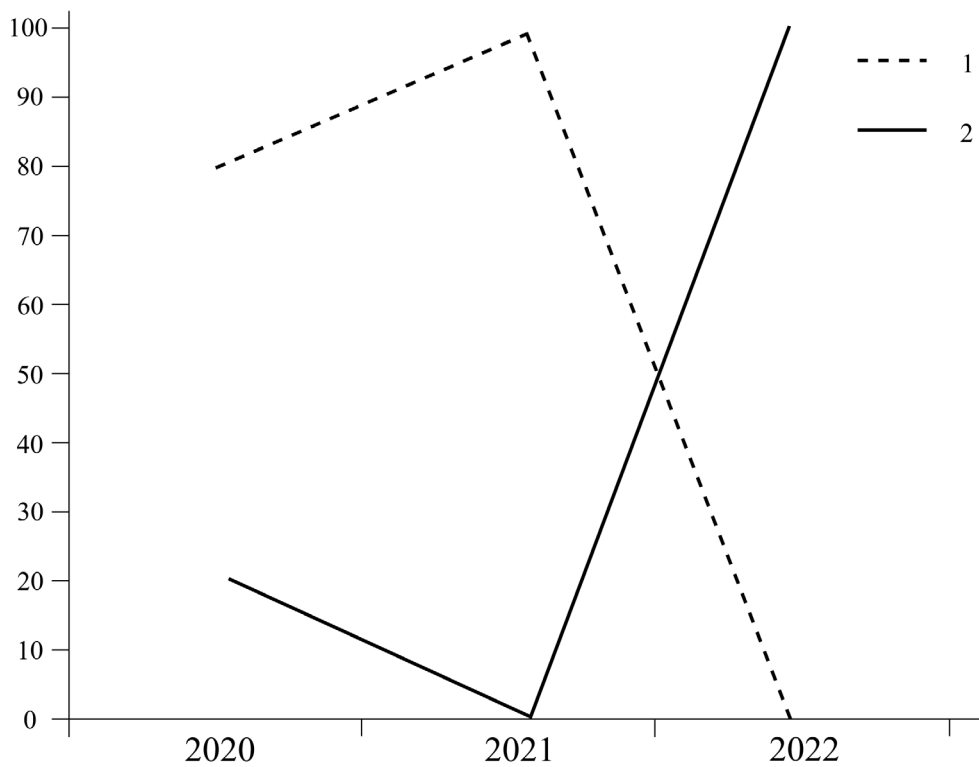


Fig. 7. Changes in the number of beetles (in%) from the nests of *Riparia riparia* over the years in the colony in the village of Beregovoe (1 – bothrobionts, 2 – botroxenes).

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