

The tropical preferences of carrion beetles (Coleoptera: Silphidae) of the north-eastern part of Altai

Трофические предпочтения жуков-мертвоедов (Coleoptera: Silphidae) северо-восточной части Алтая

Е.А. Еремеев

Е.А. Еремеев

The Shukshin Altai State Humanities Pedagogical University, Korolenko Str. 53, Biysk 659333 Russia.

Алтайский государственный гуманитарно-педагогический университет им. В.М. Шукшина, ул. Короленко 53, Бийск 659333 Россия. E-mail: engkent007eu@gmail.com.

Key words: insect ecology, carrion beetles, Silphidae, trophical preferences, baited pitfall traps, Altai.

Ключевые слова: экология насекомых, жуки-мертвоеды, Silphidae, трофические предпочтения, ловушки с приманками, Алтай.

Abstract. The fauna and ecology of Silphidae beetles in the territory of north-eastern part of Altai were studied for five years (2009–2013). The distribution of 17 species of carrion beetles attracted to baits composed of poikilothermic and homoeothermic animal remains in different habitats were also studied. The proximity of the habitats to water bodies and their influence on the nutritional preferences of the Coleoptera of Silphidae family were also considered. It was found that for the whole Silphidae family the corpses of warm-blooded animals have a greater degree of attractiveness (59.7 % of caught specimens), than the corpses of cold-blooded animals (40.3 %). Species showing the greatest preference for the corpses of homoeothermic organisms are *Necrodes littoralis*, *Thanatophilus latericarinatus*, *Nicrophorus vestigator* and *Nicrophorus morio*, and the lowest preference *Nicrophorus vespilloides* and *Nicrophorus fossor*.

Резюме. На протяжении 5 лет (2009–2013) проводились исследования фауны и экологии жуков-мертвоедов (сем. Silphidae) северо-восточной части Алтая. В данной статье рассматривается распределение 17 выявленных видов жуков-мертвоедов между приманками из останков пойкилотермных (холоднокровных) и гомойотермных (теплокровных) животных в различных исследуемых биотопах на территории северо-восточной части Алтая. Отдельно рассмотрена близость биотопов к водоёмам и их влияние на трофические предпочтения жуков-мертвоедов. Выяснилось, что в целом для семейства большую степень attractiveness имеют трупы теплокровных животных (59,7 % пойманных особей), чем трупы холоднокровных животных (40,3 %). Виды выказавшие наибольшее предпочтение к мортмассе гомойотермных организмов — *Necrodes littoralis*, *Thanatophilus latericarinatus*, *Nicrophorus vestigator* и *Nicrophorus morio*, наименьшее — *Nicrophorus vespilloides* и *Nicrophorus fossor*. Результаты данного исследования публикуются впервые и актуальны ввиду практически полного отсутствия работ, посвящённых этой теме.

Introduction

Despite of the big total number of the articles devoted to the studying of the fauna and the ecology

of the carrion beetles (Silphidae), there is only one article in the whole world describes the carrion beetles response to the poikilothermic (cold-blooded) and homoeothermic (warm-blooded) carrion, where Silphidae beetles did not show the clear preference for the certain type of bait [Shubeck, 1976]. The same author investigated the different aspects of Silphidae beetles behavior in the searching of corpses [Shubeck, 1968, 1969, 1971, 1975]. Other studies were connected with the succession of necrophilous insects on the carrion [Watson, 2004].

For the designated area (north-eastern part of Altai) was published data on the trophical preferences only for the species *Nicrophorus vespilloides* Herbst, 1784 preferred cold-blooded carrion [Eremeev, Psarev, 2016].

The purpose of this investigation is to reveal the trophical preferences of 17 species of detected carrion beetles between two types of bait in different habitats and for the whole studied area. Silphidae beetles are active destructors of the dead organic matter and it is very important to know which corpse (cold-blooded or warm-blooded) attracts them more to evaluate their role in the utilization of the decaying remains. The data published for the first time.

Materials and methods

Materials were collected during the study of the fauna and the ecology of carrion beetles in the north-eastern part of Altai (mainly the territory of the city of Biysk and its surroundings) during 5 years — since 2009 through 2013 (from May to September of each year). In designated period there were studied various landscapes and habitats with different level of anthropogenic transformation. All the 20 investigated localities are distinguished by the character of vegetation, moisture, insolation, wind, altitude, location near or far from water bodies etc. and can be divided into 5 habitats:

Amuro-Orlovsky Forest (AOF) — a wet and shadow pine forest (coniferous) with different level of mixture of deciduous trees in the area between rivers Katun and Biya near their conjunction. Humidity is high. There were studied 3 localities in the distance from the water bodies. This habitat studied for 1 year;

Industrial zone of the city of Biysk (IZ) — mixed (mostly coniferous) forest on the right bank of the Ob River. There are a lot of different industrial objects. Humidity is medium. 3 localities were placed in the distance from the water bodies. This habitat studied for 2 years;

Islands on the Biya River (ISL) — small archipelago within city's area with willow and poplar forests (deciduous) and also wet meadows. Humidity is high. 5 localities were placed near the Biya River. This habitat studied for 1 year;

Biya-Chumysh Upland (BCU) — there are 6 localities placed on the vast open space covered with meadow steppes, windbreaks (elms, birches, poplars, ashleaf maples), floodplain of the Chemrovka River and the shore of the Krasilovo Lake. Humidity is low. This habitat studied for 4 years. So long term connected with the fact that the bigger part of the studied area is located within this form of relief and it is impossible to study all the localities in 1 year;

Borovoy village (BOR) — the slope of the V-th terrace of the Biya River about 50 meters high. At the bottom of the terrace is a bank of the river with lush vegetation and humid conditions, in the middle part grasses are dominate and feels lack of moisture and at the top of the terrace is xerophytic vegetation (wormwood) growing in arid conditions. This habitat studied for 1 year

For the collection of the material we used baited pitfall traps suggested by V.K. Zinchenko [Zinchenko, 2007]. This is a plastic bottle with bait inside. The neck of the bottle is covered with organza to protect the bait from various organisms. Under the neck a plastic glass filled with preserve liquid is dug in the ground. Inside the bottles I separately put about 200 grams of decaying meat or fish (mortmass of poikilothermic or homoeothermic organisms) to reveal the preference to the certain type of bait for every species I found. The bait was not the whole but dissected corpse, but it is not critically important for the validity of the experiment. During the investigation 170 traps were used. Totally there were collected 2717 specimens of carrion beetles.

Analysis of the data was performed using paired t test and tools of the program Microsoft Office Excel 2010.

Results

On the studying area I revealed 17 species of Silphidae beetles from 2 subfamilies (Silphinae Latreille, 1807 and Nicrophorinae Kirby, 1837) and 6 genera: *Necrodes littoralis* Linnaeus, 1758; *Silpha carinata* Herbst, 1783; *Silpha obscura* Linnaeus, 1758; *Phosphuga atrata* Linnaeus, 1758; *Oiceoptoma thoracicum* Linnaeus,

1758; *Thanatophilus rugosus* Linnaeus, 1758; *Thanatophilus sinuatus* Fabricius, 1775; *Thanatophilus latericarinatus* Motschulsky, 1860; *Nicrophorus morio* Gebler, 1817; *Nicrophorus investigator* Zetterstedt, 1824; *Nicrophorus vespillo* Linnaeus, 1758; *Nicrophorus vespilloides* Herbst, 1784; *Nicrophorus fossor* Erichson, 1837; *Nicrophorus vestigator* Hershel, 1807; *Nicrophorus antennatus* Reitter, 1884; *Nicrophorus sepultor* Charpentier, 1825 and *Nicrophorus interruptus* Stephens, 1830. The conducted investigation showed that 59.7 % of carrion beetles preferred pitfall traps with the remains of homoeothermic organisms and only 40.3 % with the remains of poikilothermic organisms.

Performed paired t-test showed the preference of all the Silphinae species for the meat bait — 73.113 and for the fish bait, respectively, 26.887. Species *N. littoralis* was found only on meat bait. The other representatives of Silphinae subfamily did not show the clear preferences for the certain type of bait; however the majority of them mostly were caught on the meat baits too. The percentage ratio of the specimens caught on the bait of mortmass of poikilothermic (meat) or homoeothermic (fish) organisms is distributed as follows. Species *S. carinata* (57.6; 42.4 %), *O. thoracicum* (58.7; 41.3 %), *Th. rugosus* (63.3; 36.7 %) were found approximately in equal percentage ratio in the pitfall traps (~ 40 % on the fish baits). Species preferred homoeothermic bait even more — *Ph. atrata* (71.4; 28.6 %), *Th. sinuatus* (72.9; 27.1 %), *S. obscura* (76.4; 23.6 %). In Silphinae subfamily for the species *Th. latericarinatus* (84.6; 15.4 %), as it turned out, pitfall traps with meat bait have the highest degree of attractiveness. Thus, we can say that all the representatives of all the discovered Silphinae species on the studying territory prefer the remains of warm-blooded animals, and the last four species have a pronounced preference for them (Fig. 1).

There is another situation in Nicrophorinae subfamily (Fig. 2). Results of paired t-test: for the meat bait — 61.233 and for the fish bait — 38.767. Species *N. vespilloides* (32.6; 67.4 %) and *N. fossor* (48.6; 51.4 %) showed the greatest preference for the substrate consists of decaying fish (these are only two species in the whole family, which preferred fish bait in more than the half cases). It is less pronounced for *N. vespillo* (55.4; 44.6 %). That is possible to say that this species does not have a clear preference for the certain type of bait, as well as *N. fossor*. The group which includes *N. investigator* (63.2; 36.8 %), *N. sepultor* (60.2; 39.8 %) and *N. interruptus* (60.7; 39.3 %) preferred fish bait in approximately 38 % of cases. For the species *N. antennatus* (72.0; 28.0 %), *N. morio* (77.8; 22.2 %) and *N. vestigator* (80.6; 19.4 %) the bait of rotten fish have had the less degree of attractiveness.

In general, in Silphinae subfamily the share of specimens attracted by the meat bait is 64.2 %, fish bait is 35.8 %. In Nicrophorinae subfamily — 54.9 % and 45.1 % respectively.

It is also worth to note the alteration of the abundance of caught specimens in each year. The reasons

of this alteration and the difference of the total number of caught specimens, probably lie in the difference of temperature conditions in various years of the investigation and also in the different natural conditions in the studying habitats where the traps have been set. As seen from Fig. 3, only in 2011 the majority of the specimens preferred the fish bait (the difference is slightly less than 2 times). In the other years the number of the specimens chose the bait with the remains of homoiothermic organisms is more than the number of specimens which were caught on the baits of poikilothermic organisms (in 2009 and 2010 insignificantly, in 2012 almost doubled and in 2013 approximately 3 times more).

The following are the results of the analysis of the distribution of the specimens of each species of the carrion beetles between the baits in different habitats.

Some carrion beetles were found only in one or two habitats. Species *N. littoralis* (100 % on the meat bait) was found only in the coniferous forest in the industrial zone of the Biysk City. As well as the species *Ph. atrata* (71.4 % of the specimens on the meat baits; 28.6 % on the fish baits) and *N. interruptus* (60.7; 39.3 %) only on the territory of the Biya-Chumysh Upland. Species *Th. latericarinatus* present in two habitats — in Amuro-Orlovsky Forest (75.0; 25.0 %) and on the Biya-Chumysh Upland (100 % on the meat baits). *N. sepultor* has also been found only in two habitats — on the Biya-Chumysh Upland (58.9; 41.1 %) and in the industrial zone (60.0; 40.0 %).

Species *S. carinata* (Fig. 4a) in two similar by the environmental conditions habitats — the Amuro-Orlovsky Forest (45.6; 54.4 %) and in the industrial zone of the city (45.9; 54.1 %) (It is densely covered with pine forest) had a slightly higher preference for the fish baits. Here its distribution between the baits was surprisingly similar. On the vast open space (Biya-Chumysh Upland) (65.1; 34.9 %) and in the habitats located close to the water bodies (islands on the Biya River, river terrace in Borovoy village) it was caught in 100 % of cases on the meat baits.

One more species from the genus *Silpha* — *S. obscura* (Fig. 4b) in all the populated habitats preferred meat baits — in the Amuro-Orlovsky Forest (68.4; 31.6 %), in the industrial zone (63.6; 36.4 %), on the Biya-Chumysh Upland (82.8; 17.2 %). In Borovoy village it was caught only in the trap with meat.

Species *Th. sinuatus* (Fig. 4c) in four of five habitats where it was found, preferred meat baits — in the Amuro-Orlovsky Forest (88.9; 11.1 %), in the industrial zone (60.0; 40.0 %), on the Biya-Chumysh Upland (73.5; 26.0,5 %), on the slope of the river terrace in Borovoy village (75.0; 25.0 %). On the islands on the Biya River this species preferred the remains of the poikilothermic organisms — all the specimens were caught only on the baits with rotten fish.

The other representative of the genus *Thanatophilus* — *Th. rugosus* (Fig. 4d) in two habitats preferred meat baits — on the Biya-Chumysh Upland (65.7; 34.3 %) and in the Borovoy village, where it was caught only on

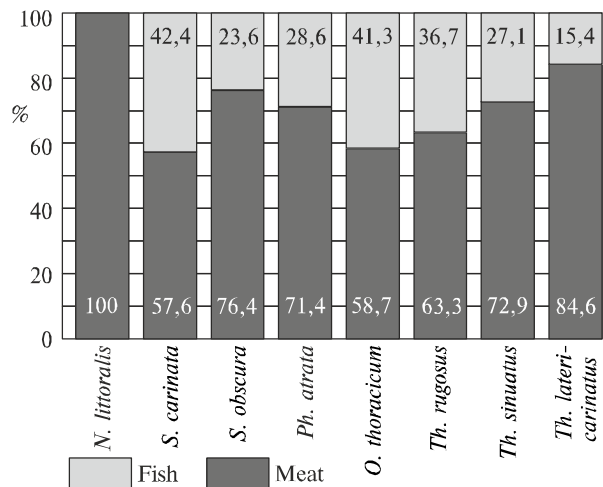


Fig. 1. Preferences for the different types of bait of the species of Silphinae subfamily, %.

Рис. 1. Преференции к различным типам приманки видов подсемейства Silphinae, %.

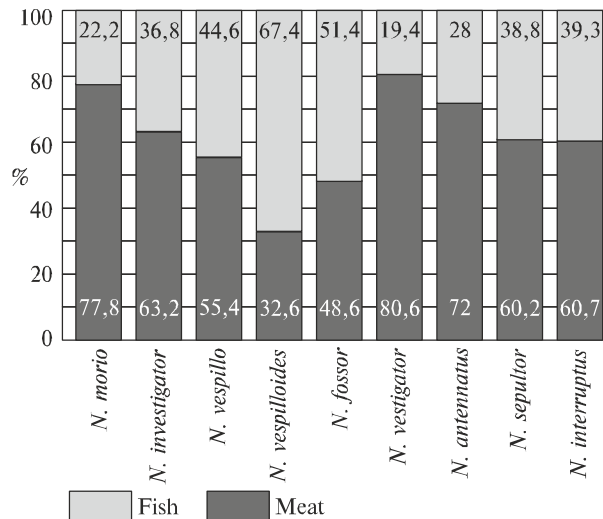


Fig. 2. Preferences for the different types of bait of the species of Nicrophorinae subfamily, %.

Рис. 2. Преференции к различным типам приманки видов подсемейства Nicrophorinae, %.

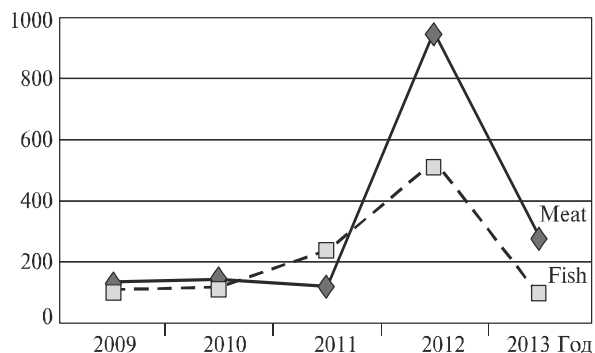


Fig. 3. Alteration of the number of specimens of carrion beetles, caught on the different types of bait in each year of the experiment.

Рис. 3. Изменение количества жуков-мертвеедов, пойманных на различных типах приманки в каждом году эксперимента.

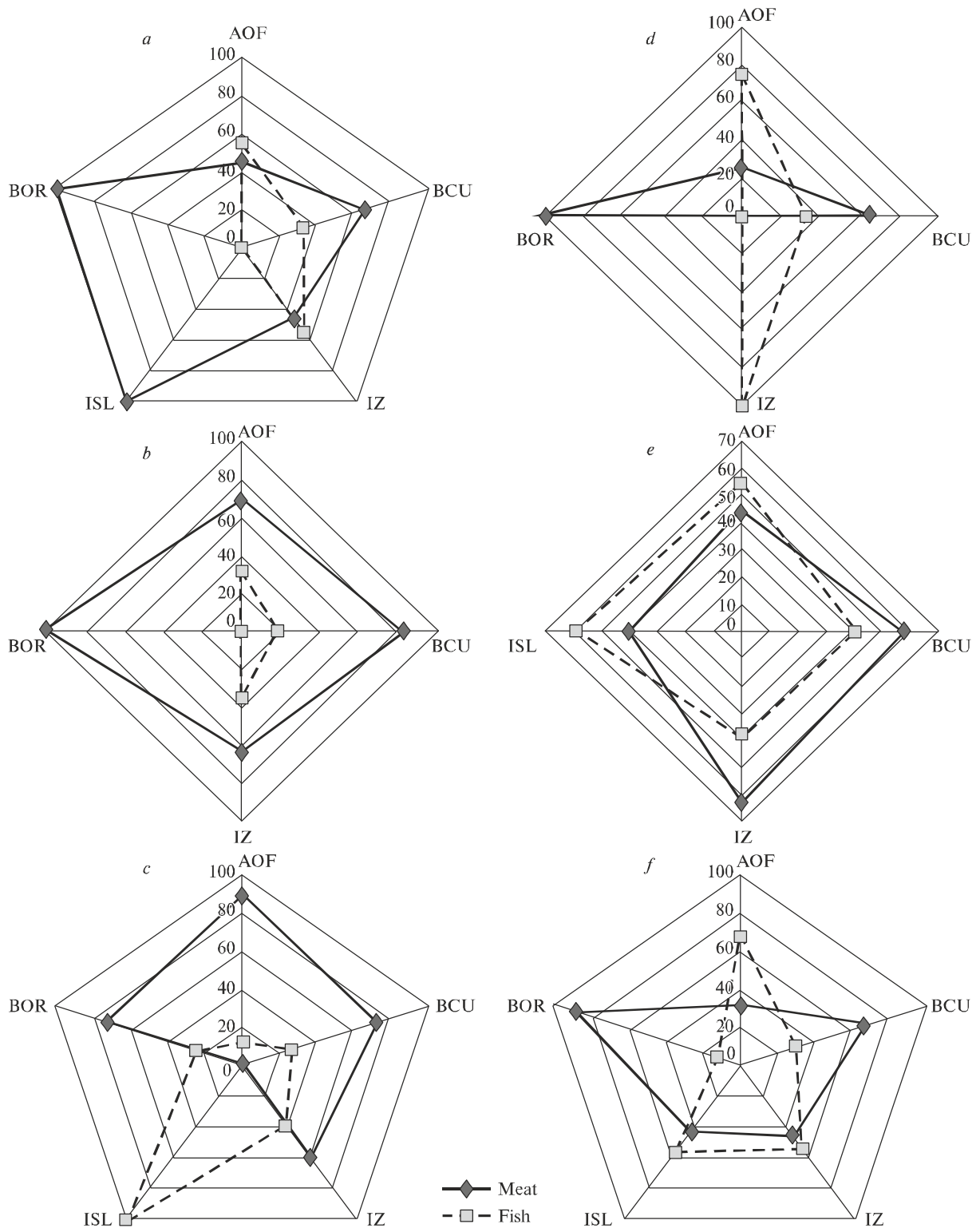


Fig. 4. The percentage ratio of the specimens of the species of Silphidae family caught in the traps with different types of bait: *S. carinata* (a), *S. obscura* (b), *Th. sinuatus* (c), *Th. rugosus* (d), *O. thoracicum* (e) and *N. vespillo* (f). Note: AOF — Amuro-Orlovsky Forest, BCU — Biya-Chumysh Upland, IZ — industrial zone, ISL — group of islands on the Biya River, BOR — the slope of the V-th terrace of the Biya River near Borovoy village.

Рис. 4. Процентное соотношение экземпляров видов семейства Silphidae, пойманных в ловушки с различными типами приманок: *S. carinata* (a), *S. obscura* (b), *Th. sinuatus* (c), *Th. rugosus* (d), *O. thoracicum* (e) и *N. vespillo* (f). Примечание: AOF — Амуро-Орловский лес, BCU — Бийско-Чумышская возвышенность, IZ — промышленная зона, ISL — группа островов на реке Бия, BOR — склон V-й террасы реки Бии в районе посёлка Боровой.

meat baits. But in the Amuro-Orlovsky Forest (25.0; 75.0 %) and in the industrial zone (in 100 % cases in the traps with fish) it preferred fish bait.

For the species *O. thoracicum* (Fig. 4e) in two of four habitats the meat bait has the greatest degree of attractiveness. In the industrial zone (62.4; 37.6 %), on the Biya-Chumysh Upland (including the floodplain of the Chemrovka River and the shore of the Krasilovo Lake where it was found only in the traps with meat bait) (58.3; 41.7 %). On the islands on the Biya River (41.5; 58.5 %) and in the Amuro-Orlovsky Forest (45.0; 55.0 %) this species preferred fish baits.

Species *N. vespillo* (Fig. 4f) in three of five habitats preferred the bait of the mortmass of poikilothermic organisms — in the Amuro-Orlovsky Forest (31.8; 68.2 %), in the industrial zone (46.3; 53.7 %) and on the islands on the Biya River (42.9; 57.1 %). On the Biya-Chumysh Upland (68.9; 31.1 %) and on the slope of the river terrace in Borovoy village (87.5; 12.5 %) it was more often found in the pitfall traps with meat baits.

Species *N. vespilloides* (Fig. 5a) in the industrial zone (31.8; 68.2 %) and on the islands of the Biya River (7.1; 92.9 %) was caught mostly in the traps with fish bait. In the Amuro-Orlovsky Forest (66.7; 33.3 %) it preferred the meat baits, and on the territory of the Biya-Chumysh Upland (50.0; 50.0 %) the percentage of the specimens caught in the traps with one or another type of bait is divided equally.

N. antennatus (Fig. 5b) only in the industrial zone had the high level of preference for the fish bait (100 %). In the rest three habitats, where it was found, the percentage of the specimens who flew on the attracted them meat bait is higher than the percentage of the specimens flew on the fish bait — in the Amuro-Orlovsky Forest (75.0; 25.0 %), on the Biya-Chumysh Upland (80.0; 20.0 %), and on the slope of the V-th terrace of the Biya River in Borovoy village (60.0; 40.0 %).

N. investigator (Fig. 5c) in one habitat preferred the meat baits (the industrial zone (51.5; 48.5 %)), in the other habitat (the islands on the Biya River (50.0; 50.0 %)) both types of baits had an equal degree of the attractiveness. On the Biya-Chumysh Upland (82.8; 17.2 %) it quite obviously preferred the decaying meat. In the Amuro-Orlovsky Forest (46.2; 53.8 %) some more of its specimens were caught in the traps with fish bait.

Species *N. fossor* (Fig. 5d) in Borovoy village was caught only in the traps with meat baits. Also the bigger share of the specimens of this species were caught in the traps with baits of meat in the industrial zone (54.8; 45.2 %) and in the Amuro-Orlovsky Forest (66.7; 33.3 %). On the Biya-Chumysh Upland this species is about two times more often preferred the bait of the carrion fish (34.6; 65.4 %).

Species *N. morio* (Fig. 5e) in the industrial zone of the city was caught only on the bait of the mortmass of homoeothermic organisms, on the slope of the V-th terrace of the Biya River in Borovoy village the quantity of the specimens is divided in half between the meat and

fish baits. On the Biya-Chumysh Upland (66.7; 33.3 %) it was more often found in the traps with meat bait.

Species *N. vestigator* (Fig. 5f) in all the habitats preferred the traps with meat bait — in the Amuro-Orlovsky Forest it was caught only on meat bait, on the territory of the Biya-Chumysh Upland (81.7; 18.3 %) and in the industrial zone (60.0; 40.0 %).

Discussion

Describing the results of the conducted experiment it is also worth to take into account the individual preferences of various species of carrion beetles. So, for example, *N. littoralis* mostly occurs on the large corpses. Set pitfall traps had small size and this fact determined in advance the less degree of the attractiveness of the baits for this species.

In addition to the eating carrion, as well as plant and fungal remains, Silphidae beetles are able to prey on the corpses eating the larvae of flies (maggots).

The distribution of the specimens of the species of the carrion beetles in different types of baits in designated habitats depends on a number of factors. So, in all the habitats always predominates the group of insects, most specimens of which preferred traps with the baits of decaying meat. The only exceptions were the islands on the Biya River. There among six species one species preferred the meat bait, the preferences of the second species are divided in half and more four species were caught mostly in the traps with fish baits. This fact is probably explained by the almost complete absence of mammals in the island natural communities. The sizes of the corpses of the birds are also not too big. The most common and available here are the corpses of marsh frog (*Pelophylax ridibundus* Pallas, 1771) and moor frog (*Rana arvalis* Nilsson, 1842), and also cast ashore fish (poikilothermic animals).

Data from the article of Shubeck [1976] tells that in his experiment the most of the beetles did not show clear preferences for the certain type of bait, however, for one species — *N. orbicollis* — cold-blooded carrion had a greatest degree of attractiveness. The author explain this fact by the nocturnal activity of the species, while the rest species are diurnal.

The share of the species in the other habitats preferred certain type of the bait is distributed as follows. In the Amuro-Orlovsky Forest 58.3 % of the species preferred meat bait, 41.7 % preferred fish bait. In the industrial zone 64.3 % and 35.7 % respectively. On the territory of the Biya-Chumysh Upland 6.3 % of the species did not show the preference for the certain type of bait, 6.3 % of the species were attracted in large numbers by the fish bait, and the majority of the specimens of 87.5 % of the species were collected in the traps with meat bait. On the slope of the V-th terrace of the Biya River in Borovoy village similar percentage was attracted by the traps with the remains of homoeothermic organisms and 12.5 % of the species did not show the preferences. In the floodplain of the Chemrovka

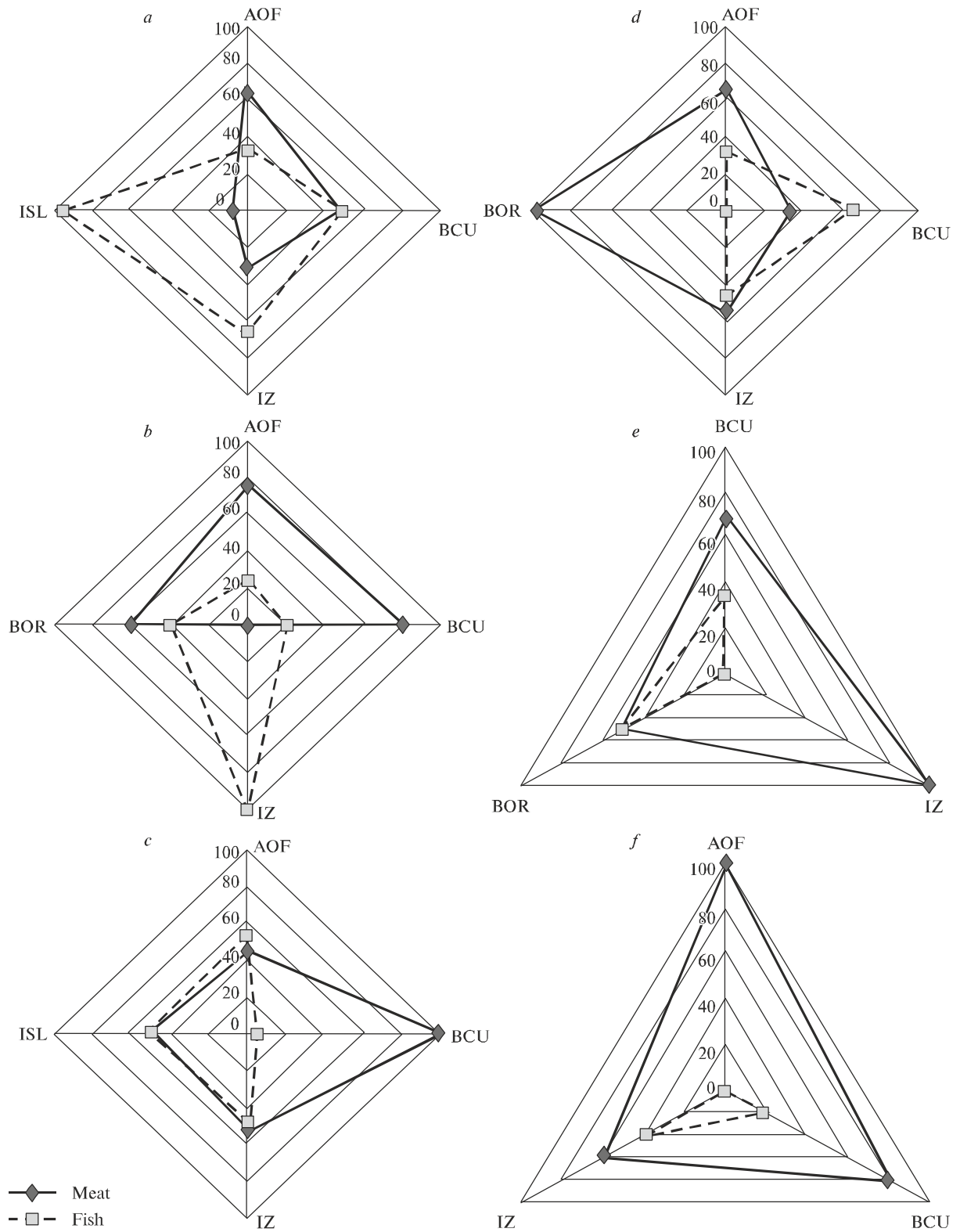


Fig. 5. The percentage ratio of the specimens of the species of Silphidae family caught in the traps with different types of bait: *N. vespilloides* (a), *N. antennatus* (b), *N. investigator* (c), *N. fossor* (d), *N. morio* (e) and *N. vestigator* (f). Note: abbreviations of the habitats names see the fig. 4.

Рис. 5. Процентное соотношение экземпляров видов семейства Silphidae, пойманных в ловушки с различными типами приманок: *N. vespilloides* (a), *N. antennatus* (b), *N. investigator* (c), *N. fossor* (d), *N. morio* (e) и *N. vestigator* (f). Примечание: сокращения названий биотопов см. рис. 4.

River and on the shore of the Krasilovo Lake all the specimens were attracted exclusively by the traps with decaying meat.

Conclusion

The conducted experiment of determination of the preferences of the Silphidae species for the certain type of bait showed that for 59.7 % of specimens the bait of the remains of homoeothermic organisms was more attractive than the bait of the remains of poikilothermic organisms (40.3 % of specimens respectively). Species which have pronounced preference for the mortmass of warm-blooded animals are *Necrodes littoralis*, *Thanatophilus latericarinatus*, *Nicrophorus vestigator* and *Nicrophorus morio*. In Silphinae subfamily species *Silpha carinata* and *Oiceoptoma thoracicum* have the greatest per cent of specimens attracted by the mortmass of cold-blooded animals among the other Silphinae species (about 42.0 % of the specimens of each species). In Nicrophorinae subfamily the representatives of the species *Nicrophorus vespillo* (44.6 % of specimens) and especially *Nicrophorus fossor* (51.4 %) and *Nicrophorus vespilloides* (67.4 %) have the greatest number of species attracted by the bait of the corpses of poikilothermic animals. All these species of carrion beetles are widely distributed and quite common in the habitats located near the water bodies, where how it turned out, most of the specimens preferred fish bait. This is connected with the fact that in such localities the anuran and fish corpses (cold-blooded) are more

common and available than the avian and mammalian corpses.

Acknowledgements

This investigation was partially supported by the RFBR grant No.14-04-98003.

References

- Eremeev E.A., Psarev A.M. 2016. [Some aspects of the ecology of the species *Nicrophorus vespilloides* Herbst, 1784] // *Sovremennye problem nauki i obrazovaniya*. Vol.5. URL: <http://www.science-education.ru/article/view?id=25156> (дата обращения: 16.09.2016). [In Russian]
- Shubeck P.P. 1968. Orientation of carrion beetles to carrion: random or non-random? // *Journal of the New York Entomological Society*. Vol.76. P.253–265.
- Shubeck P.P. 1969. Ecological studies of carrion beetles in Hutcheson Memorial Forest // *Journal of the New York Entomological Society*. No.77. P.138–151.
- Shubeck P.P. 1971. Diel periodicities of certain carrion beetles (Coleoptera, Silphidae) // *The Coleopterists Bulletin*. Vol.25. No.2. P.41–46.
- Shubeck P.P. 1975. Do diurnal carrion beetles use sight, as an aid to olfaction, in locating carrion? // *Hutcheson Memorial Forest Bulletin*. Vol.3. No.2. P.36–39.
- Shubeck P.P. 1976. Carrion beetle responses to poikilotherm and homoiotherm carrion (Coleoptera: Silphidae) // *Entomological News*. Vol.87. No.9–10. P.265–269.
- Watson E.J.G. 2004. Faunal succession of necrophilous insects associated with high-profile wildlife carcasses in Louisiana // A dissertation for the degree of Doctor of Philosophy. 219 p.
- Zinchenko V.K. 2007. [A simple and effective trap for catching necrophagous beetles] // *Evrasiatskii Entomologicheskii Zhurnal (Eurasian Entomological Journal)*. Vol.6. No.4. P.410. [In Russian].

Поступила в редакцию 2.08.2017