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To cite this article: E A Eremeev 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **848** 012157

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Some aspects of the ecology of the species *Creophilus maxillosus* Linnaeus, 1758 and *Emus hirtus* Linnaeus, 1758 (Coleoptera: Staphylinidae) in southwestern part of the North Asia

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Abstract. The article considers some aspects of the ecology of the 2 largest species of the rove beetles of the local fauna — *C. maxillosus* and *E. hirtus*. The first species as across the whole territory, and in most of the studied habitats and localities is a subdominant species, while the second is rare everywhere — its numbers is so strongly reduced that there is a proposal to list it in the Red List of Threatened Species of the Altai Krai. Both species are quite thermophilic and prefer meadow steppes. *C. maxillosus* is found in all 3 types of investigated habitats and has a strong preference to the remains of homoeothermic organisms, which it visits together with other necrobiont Coleoptera, where it eats decaying meat and hunts larvae and imago of smaller species. *E. hirtus* tends to well-warmed areas, which are used as pastures, because its main attractant is dung, at the same time does not ignore the carrion, but practically showing no preference to a certain type of bait. Both species are experiencing a strong anthropogenic pressure and for this reason they are absent in localities in the central part of the city of Biysk (urban ecosystems).

1. Introduction

Staphylinidae is the biggest family of Coleoptera, and Animalia at all [1]. But on the territory of North Asia the fauna of the rove beetles studied incompletely and for many places there are no available data [2, 3]. For example, for the area of the plain Altai, such information is practically absent, with the exception of fairly old publications [4] or devoted to the one species (*Philonthus cyanipennis* Fabricius, 1793 or *Emus hirtus* Linnaeus, 1758), but containing quite general data, that does not reveal the peculiarities of the ecology of these species in the described region [5, 6], unlike the territory of the mountainous Altai [7, 8, 9]. Though Staphylinidae plays an important role in the communities of the terrestrial organisms, participating in the processes of the utilization of the dead organic matter, regulation of the number of invertebrate animals and being the source of food for insectivorous animals [2, 10]. Even in this experiment the share of Staphylinidae was 18.55% ($\approx 1/5$) of the total collection and inside the family the share of these both species is 9.5%. But the distribution of individuals between them is uneven — the share of *E. hirtus* is extremely low. The fact, that there is still not enough data on the distribution and ecology of these species, especially concerning the areas with the human impact



(urban ecosystems, i.e. natural communities transformed in the conditions of urban landscape into the urban communities), makes this research work actual.

2. Materials and methods

The investigation was conducted during 2 years (2017–2018) and its purpose was the studying of the fauna of necrobiont Coleoptera. For the collection of the material we used baited pitfall traps [11]. There were chosen 3 types of bait — decaying plants, meat (homoeothermic organisms) and fish (poikilothermic). The total sample size was 18 058 beetles from 11 families and 3 349 specimens belong to the family Staphylinidae.

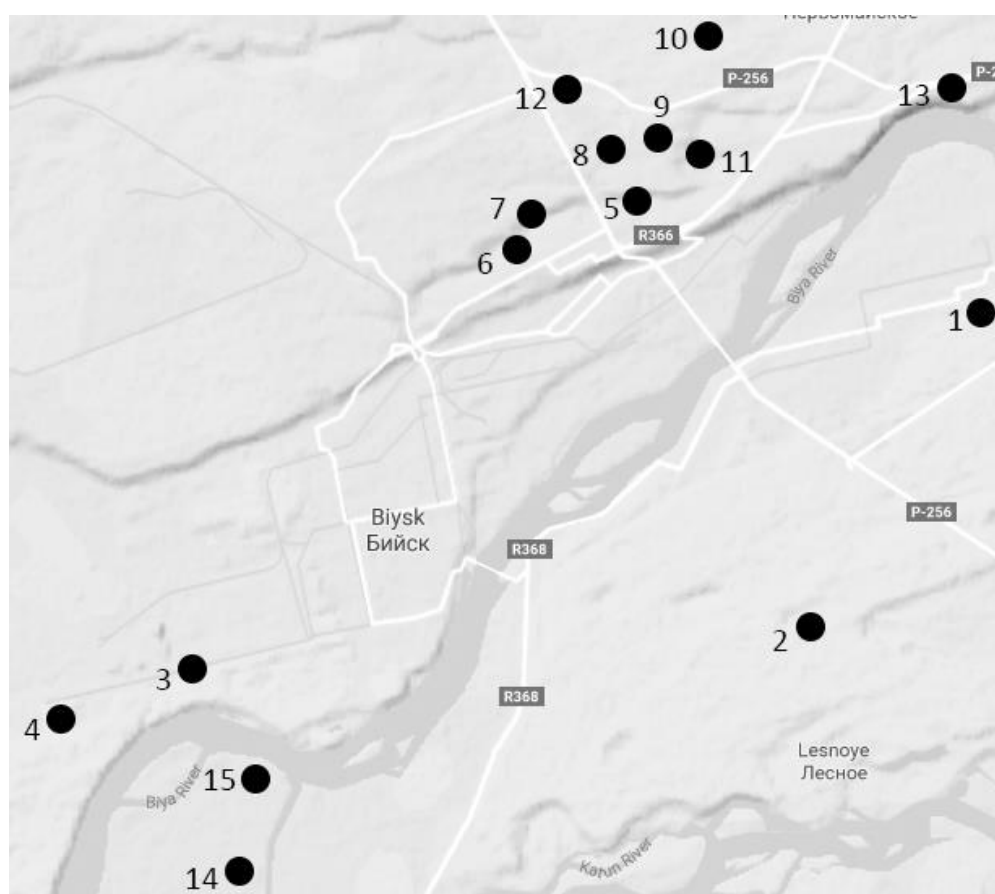


Figure 1. The map of the investigated area: *Amuro-Orlovsky Forest (AOF)*: 1 — pine forest near central city hospital, 2 — oak windbreak; *Fominsky Forest (FF)*: 3 — pine forest near thermoelectric plant, 4 — pine forest near Oleum plant; *Biya-Chumysh Upland (BCHU)*: *Dry Valley (DV)*: 5 — meadow steppe in the western part at the bottom of the valley; 6 — meadow steppe in the eastern part at the bottom of the valley, 7 — meadow steppe in the western part at the top of the slope; *Fields (F)*: 8 — meadow steppe (500 m from M-52 highway), 9 — meadow steppe (1 km from M-52 highway), 10 — meadow steppe (1 km north of city border); *Windbreaks (W)*: 11 — elm windbreak, 12 — birch windbreak; *Vth terrace of the Biya River (V)*: 13 — the top of the slope near Borovoy village; *Ikonnikov Island (IK)*: 14 — meadow steppe in the middle part of the island, 15 — willow-poplar floodplain forest in the northern part of the island.

The territory of the investigation is located in the southwestern part of the North Asia — an extensive subregion within the Palearctic realm. The area is placed in the Eastern part of the Altai Krai (Western Siberia) (figure 1). There are a few types of habitats: coniferous and deciduous forests, meadow steppes, deserted spots. Here we can distinct 4 regions. The first is *Amuro-Orlovsky Forest* (3 studied localities, in 2 localities described species were found) — coniferous forest near central city hospital (52°32'18.00'' N; 85°16'57.11'' E) with an oak windbreak outside the city's border (52°29'41.80'' N; 85°14'48.12'' E). The second is *Fominsky Forest* (2 localities) is also coniferous forest partly located in the industrial zone of Biysk — 52°29'02.58'' N; 85°05'36.43'' E (thermoelectric plant) and 52°28'41.07'' N; 85°03'27.86'' E (Oleum facility). The third is *Biya-Chumysh Upland* (13 studied localities, in 9 described species were found) — the biggest region divided into 4 subregions: *Dry Valley* (meadow steppe) — 3 localities (52°33'38.52'' N; 85°11'44.66'' E (western part) and eastern part 52°33'36.88'' N; 85°11'11.85'' E (at the bottom); 52°33'39.48'' N; 85°11'13.57'' E (at the top of the slope)), *Fields* (meadow steppe) — 3 localities (52°33'56.98'' N; 85°11'52.89'' E (550 m from the federal highway M-52); 52°34'04.23'' N; 85°12'15.10'' E (1 km from the federal highway M-52); 52°34'47.24'' N; 85°12'08.25'' E (1 km north of Biysk border)), *Windbreaks* (elm, birch, poplar, maple) — 2 localities (elm (52°34'14.37'' N; 85°12'04.14'' E) and birch windbreak (52°34'27.28'' N; 85°11'11.53'' E)), *the Vth terrace of the Biya River* — 1 locality (the top of the terrace near Borovoy village and bank of the Biya River (52°34'20.89'' N; 85°17'20.77'' E)). And the last region — *Ikonnikov Island* (protected area located at the source of the Ob River) with 3 studied localities (2 with described species): meadow steppe in the middle part of the island (52°27'17.40'' N; 85°06'29.18'' E) and deciduous floodplain forest in the northern part of the island (52°28'19.81'' N; 85°06'49.02'' E).

Dominance Index was calculated using five-point logarithmic scale for the estimation of the relative species abundance (there are 5 classes of abundance: dominant, subdominant, usual, rare and very rare). The limits of the classes are calculated for every locality, habitat or region [12, 13].

The determination of the habitat preferences was performed with the calculation of the index F_{ij} :

$$F_{ij} = \frac{n_{ij}N - n_iN_j}{n_{ij}N - n_iN_j - 2n_{ij}N_j}, \quad -1 \leq F_{ij} \leq 1,$$

where n_{ij} — the number of individuals of i species in j sample (habitat) with sample size N_j , n_i — the number of individuals of this species in the whole sample with a size equal N . This Index can take values in the range from -1 to 1 . The value range $0 < F_{ij} < 1$ means that species prefers habitat. The value range $-1 < F_{ij} < 0$ at the contrary, means that species avoids this habitat. If $F_{ij} = 0$, i species is indifferent to the habitat (neutral) — does not avoid, but does not prefer. If $F_{ij} = 1$, i species lives exceptionally in j habitat, and if $F_{ij} = -1$, correspondingly, species completely avoids it [13].

For the analysis of the trophical preferences we used Jacobs Index (D_{ij}):

$$D_{ij} = \frac{p_{ij} - p_j}{p_{ij} + p_j - 2p_{ij}p_j}, \quad -1 \leq D_{ij} \leq 1,$$

where p_{ij} is a share of this type of food in the diet of the species, p_j — the share of this type of food among all the types in the whole sample [14]. The interpretation of the results performs as F_{ij} .

Synonyms are given according to data from the website www.gbif.org [15]. Geographical coordinates of the studied localities were determined with the program *Google Earth Pro*.

3. Results

During the investigation there were totally collected 3 349 specimens of the rove beetles (Staphylinidae) and among them 319 specimens of *Creophilus maxillosus* Linnaeus, 1758 and 11 specimens of *Emus hirtus* Linnaeus, 1758. Here is a brief information about these species.

Creophilus maxillosus Linnaeus, 1758

Synonyms: *Emus maxillosus* Linnaeus, 1758; *Staphylinus maxillosus* Linnaeus, 1758.

Distribution: Across all Palearctic, North America, north of Central America, Chile, Argentina, Peru [16, 17].

Diagnosis: Hairy rove beetle is black, 14–22 mm long (figure 2A). Elytra with wide toothed transverse stripe of gray hairs and with black velvety spots on the outer corners. Abdominal tergites with spots of ash gray hairs [18].

Emus hirtus Linnaeus, 1758

Synonyms: *Staphylinus bombilius* De Geer, 1774; *Staphylinus hirtus* Linnaeus, 1758.

Distribution: From Southern, Central and South of Northern Europe in the west, to Siberia and Middle Asia to the east (westpalearctic range) [19].

Diagnosis: black beetle with blue or purple bottom, 18–28 mm long (figure 2B). Head, pronotum and back of the abdomen are covered with golden yellow hairs [20].



Figure 2. The appearance of *C. maxillosus* (A) and *E. hirtus* (B).

These 2 species are biggest among the rove beetles in the local fauna. *C. maxillosus* is usually attracts by the carrion, *E. hirtus* by the dung (but we caught it using decaying meat and fish as a bait) and it is so rare almost everywhere [19, 20] that there was a suggestion to place this species in the local Red List of Threatened Species [6].

After the calculation of the dominance index it became possible to determine the role of each species in the local communities (their status). So, *C. maxillosus* (9.53% of the collection) is a subdominant species, *E. hirtus* (0.33%) is a rare species.

Considering the habitats, we have noticed that *E. hirtus* lives only in meadow steppes (0.56% of all the meadow steppes specimens) and is a rare species. *C. maxillosus* inhabits all the habitats: meadow steppes (subdominant; 11.38%), coniferous (subdominant; 9.07%) and deciduous forests (usual; 5.63%).

C. maxillosus is much more widely distributed than *E. hirtus*. It inhabits all the studied regions and all the 15 localities. So, in Amuro-Orlovsky Forest it is a usual species — 4.73% (13 specimens) of all the collection in this region (2 localities — in the first it is a rare species (6 specimens; 2.64%), in the

second is a usual (7; 14.58%). In Fominsky Forest it is subdominant species (40; 14.29%) (also 2 localities — subdominant (26; 14.36%) and usual (14; 14.14%)). On the Ikonnikov Island its status is subdominant species (20; 11.43%; but its role is varying too much) — here it was caught in 2 localities: in the first it is subdominant (18; 39.13%), in the second — very rare (2; 7.69%). The most abundant *C. maxillosus* on the Biya-Chumysh Upland (subdominant (246; 9.05%); it was discovered in 9 localities). Moreover, this area is so big that was divided into 4 subregions. Within the southern border of the upland — the Vth terrace of the Biya River — this species was found in the only one place where it was usual (9; 16.07%) — at the top of the terrace near Borovoy village (if we consider the collection from all the localities within the terrace — it is a rare species (9; 1.89%)). In the northern outlets of the Dry Valley (3 localities) it is usual species (72; 5.41%); in one — very rare (2; 0.43%), in the rest — usual (26; 9.35% and 44; 7.42%). In the vast open fields, it is subdominant (125; 23.41%), and known also from 3 localities (subdominant in 2 of them (51; 22.47% and 73; 24.09%)), but for 1 of them (1; 25%) it is impossible to calculate limits of the classes of abundance due to the very small sample size. And, finally, in the last subregion — windbreaks — it is subdominant species (40; 10.64%), but separately, in 2 localities where its class of abundance is usual (17; 9.04% and 23; 12.23%).

The distribution of *E. hirtus* is framed by the Biya-Chumysh Upland (rare; 0.4%) — here he was found in 4 localities: 1 specimen was collected at the top of the Vth terrace of the Biya River near Borovoy village (50 m high above river level) (very rare; 1.78% of all collection of Staphylinidae in this place and also very rare within all the terrace subregion – 0.21%), 1 in the center of the vast field covered with meadow steppe vegetation restricted by the windbreaks (very rare; 0.44% and also very rare in this subregion — 0.19%). The most abundant this species in the northern outlets of the Dry Valley (rare; 0.68%) — 4 specimens were caught at the bottom (very rare; 0.68%) and 5 (rare; 1.8%) at the top of its slope near the buckwheat field.

Habitat preferences (index F_{ij}) of these two species on the studied territory are represented in the table 1. From this data we can see that *E. hirtus* lives exceptionally in meadow-steppe habitats, while *C. maxillosus* shows the quite weak preference for meadow-steppe, almost neutral for coniferous forests and avoids deciduous forests. Thus, both of them are belong to the meadow-steppe habitat group. This data perfectly correlates with data on classes of abundance (see text above).

Table 1. Habitat preferences of *C. maxillosus* and *E. hirtus*.

Species	Habitats		
	Meadow-steppe	Coniferous forest	Deciduous forest
<i>C. maxillosus</i>	0.246591	– 0.02853	– 0.31899
<i>E. hirtus</i>	1	– 1	– 1

Both species avoids the bait made of rotten vegetation (table 2).

Analysis of resource selection for *C. maxillosus* shows that species prefers meat of homoeothermic organisms (the value for fish bait varies from habitat to habitat — the smallest difference between meat and fish in deciduous forests). There are 5 localities where species completely avoids the fish bait, in 2 localities the value is closer to 0, and in 1 locality it shows almost neutral position.

E. hirtus preferred the fish only in the meadow steppe at the top of the Vth terrace of the Biya River. In the rest cases both types of bait have almost equal high degree of attractiveness.

Table 2. Resource selection of *C. maxillosus* and *E. hirtus*.

total	<i>C. maxillosus</i>			<i>E. hirtus</i>		
	plant	meat	Fish	plant	meat	fish
	– 1	0.959816	0.298217	– 1	0.992122	0.994523
<i>Habitats</i>						
ms	– 1	0.956581	0.147185	– 1	0.9866	0.990676
cf	– 1	0.964811	0.285401	–	–	–
df	– 1	0.962067	0.689475	–	–	–

<i>Regions and localities</i>						
BCHU	– 1	0.963206	0.308918	– 1	0.990298	0.993253
DV	– 1	0.987768	0.306667	– 1	0.983137	0.989175
1	– 1	1	– 1	–	–	–
2	– 1	0.963173	0.275949	– 1	0.863481	0.990884
3	– 1	0.98834	– 0.04549	– 1	0.995483	0.960067
F	– 1	0.851398	– 0.07567	– 1	1	– 1
4	– 1	0.615473	0.478451	– 1	1	– 1
5	– 1	0.97316	– 0.76207	–	–	–
6	– 1	1	– 1	–	–	–
W	– 1	0.958848	0.194313	–	–	–
7	– 1	0.958282	0.366178	–	–	–
8	– 1	0.959038	0.036649	–	–	–
V	– 1	1	– 1	– 1	– 1	1
9	– 1	1	– 1	– 1	– 1	1
AOF	– 1	0.956846	0.799142	–	–	–
10	– 1	1	– 1	–	–	–
11	– 1	0.629139	0.772973	–	–	–
FF	– 1	0.931707	0.12	–	–	–
12	– 1	0.972428	– 0.33619	–	–	–
13	– 1	0.832335	0.54265	–	–	–
IK	– 1	0.92233	– 0.53191	–	–	–
14	– 1	1	– 1	–	–	–
15	– 1	– 1	1	–	–	–

4. Discussion

Using obtained data, we can say that both species are quite thermophilic due to their likeliness to meadow steppe habitat (well warmed by the sun arid environment). Also both species avoid the localities placed within city area unlike the other species of Staphylinidae or, for example, Silphidae (but the species composition of these families is also reduced). *C. maxillosus* is absent or rare in such localities where a lot of houses and illegal dumps of domestic waste nearby (Amuro-Orlovsky Forest, Dry Valley), but quite tolerant to the presence of big industrial objects even in coniferous forests (the habitat it avoids). So, the anthropogenic impact has an indirect negative influence on this species. The explanation may be as follows. Like it was revealed before [21] illegal dumps contain a lot of edible waste and it creates an additional feed source for many other species that leads to the rise of competition (for example with *Nicrophorus*). *E. hirtus* is rare or very rare is everywhere. It inhabits the only one region and type of habitats — meadow steppes in the Biya-Chumysh Upland due to its likeliness to the dung (this region has quite well developed agriculture and some fields are used as pastures). It seems that species sometimes can be attracted by the decaying flesh. And, undoubtedly that the species is endangered due to the destruction of natural habitats, activity of collectors (this beetle has a pretty appearance and many people want to obtain it for a certain price, luckily in the studied area this business is not developed). Its rarity can be traced across its entire range [6, 19, 20].

It seems that anthropogenic impact has a strong influence on these species as we have failed to catch any specimen on the areas located close to the center of the city, despite the big extensive parts of different urban communities. Another deterrent may be the competition for the food with burying beetles, but other investigations did not confirm this [22, 23]. Both species avoids large water bodies that might be connected with their cooling effect, insofar as *C. maxillosus* and *E. hirtus* are thermophilic.

5. Conclusion

Studied species of the rove beetles are biggest in the local fauna of Staphylinidae. *C. maxillosus* is subdominant species and closely connected with carrion, while *E. hirtus* is rare (or very rare — the class

of abundance of every species varies from place to place) and its cycle has more common with dung. Both species are thermophilic and prefer meadow steppe habitats (*E. hirtus* lives exceptionally there, *C. maxillosus* inhabits both meadow steppes and various types of forests), avoiding zones located close to the water bodies. *C. maxillosus* has clear attraction to the meat, while for *E. hirtus* there is no difference between the baits we suggested except the one place, where it chose the bait with fish. The anthropogenic activity seems have a negative impact on these rove beetles as we could not found them in the populated parts of the city. And if *C. maxillosus* is common in the suburbs, *E. hirtus* is rare in all the studied localities and apparently it is endangered.

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