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The Population of Carabids (Coleoptera, Carabidae) of the Dump of Solid Municipal Wastes

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Abstract. The population of carabids of the dump of solid municipal wastes (SMW) in Prokopyevsk town in Kemerovo region was studied in 2014-2016. 44 species of carabids (81.5% of specific richness of the area of researches) were found in the dump. The core population of carabids are tribes of Pterostichini, Platynini, Harpalini, Carabini and Bembidiini. In comparison with the control, the smaller number of species of tribes of Carabini, Pterostichini, Platynini, Notiophilini, Trechini and Licinini is noted in the dump. However, there are favorable conditions for the carabids of tribes of Bembidiini, Zabrini, Harpalini in the dump; the growth of specific richness of these tribes in comparison with the control zone is noted. 33 species which are common with the control and 11 original forms of carabids are noted in the dump. The core population of carabids consists of the dominant (3 species), subdominant (10 species) and rare (10 species). They share the dump and the control as well. The complex of dominant species is presented by the carabids of *Carabus regalis*, *Carabus aeruginosus*, *Pterostichus magus*. The continuously growing influence of the dump on the ecosystems leads to the decrease in dynamic density of the populations of the most part of species of carabids. However, the essential alteration of specific structure of "core" of the population of carabids is not observed; there is a change of the structure of very rare species only. Thereby, the carabids show the high ecological plasticity and an opportunity to adapt in the changing ecological conditions.

1. Introduction

The recycling of wastes and their disposal belong to one of the main environmental problems of the present. The dumps of solid municipal wastes are an influential source of the pollution of objects of the environment. The factors of dumps' negative impact on the environment are carrying out of the pollutants with the filtrational flow from the thickness of the disposed wastes to the neighbor territories, the release of biogas while waste decomposing, the emergence of fires, the pollution of soil covering by xenobiotics and microorganisms of the ground and surface waters, the influence on flora and fauna of the territories neighboring the dump [1-5]. The great risk of environmental pollution and the accumulation of toxicants in the living organisms make for burning the solid municipal wastes [6-8]. At the same time, the dumps are the habitat and feeding of different species of microorganisms, animals and plants whose studying is an important scientific task [9-11] since some of them can matter medical or quarantine.

One of the most numerous groups of organisms in the broken ecosystems, including the dump locations, is arthropods [12-13]. They possess a high biodiversity, a number, and an ecological plasticity. The important component of arthropods' surface soil zoocenosis is the ground beetles – carabids [14]. This group of insects differs in a wide range of ecological adaptations, fast reactions to the changing ecological conditions of the habitat. However, today's researches of carabids in the dumps of solid municipal wastes are small and fragmentary [12]. At the same time, the carabids are a suitable object when studying the conditions of ecosystems, a model group for the characteristic of structure of the population of the territories broken by human activity. The purpose of the research is the studying of population and structure of the domination of carabids in the changing conditions of the dump of solid municipal wastes.

2. Materials and Methods

Material collecting was carried out in Prokopyevsk town in Kemerovo region in 2014-2016 in the dump of solid municipal wastes and in the control zone. The dump is located in a natural hollow with the height difference to 30 m; approximately 1/3 part of the dump territory is filled with the municipal solid wastes to the top mark of a ditch. The municipal solid wastes are downstoked on the edge of a slope, they are further pushed off with a bulldozer on the slope boards without compaction and sorting. Nowadays, the given territory is filled up with the wastes which are constantly flattened and covered with the loam with impurity of soils from above. The age of the dump is 45 years, the area is 10–11 ha, the volume of the stoked municipal wastes is 12 million m^3.

The soil cover consists of the dark gray forest soils around the dump location. The analysis of soil condition, conducted by the healthcare budget-funded institution – "The Center of Hygiene and Epidemiology in the Kemerovo Region", showed that the examined soil belongs to the category "clean" according to the microbiological and parasitological indicators on the degree of epidemic danger. The content of oil products in the soil is admissible, the content of benzpyrene of the entire examined area does not exceed the maximum permissible concentration level.

The distance from the dump to the Zhernovka River makes about 350 m, to the Elina River – 105 m. The territory of the dump does not get to the water protection zone of these water bodies.

The vegetation cover of the SMW dump territory is presented by the broken part of zone vegetation type – the birch rich-in-herbs forest. The birch rich-in-herbs forests border the dump, the aspen-and-birch forests border the valleys of the rivers.

The researches were conducted in two model sections: on the periphery of the dump (on the slope boards because of continuous movement of garbage in the dump) and in the control. The control zone is the birch rich-in-herbs forest, close to the dump, where any sorts of works were not carried out. The forest-stand of the control forest, as well as the broken birch forest on the dump location, is formed by *Betula pendula* Roth, an underbrush by *Padus avium* Miller, *Sorbus sibirica* Hedl., *Rosa majalis* Herrm., *Rosa acicularis* lindl., the species of *Spiraea* L., a soil-covering by *Dactylis glomerata* L., *Phleum pratense* L., *Plantago major* L., *Hieracium umbellatum* L., *Vicia sylvatica* L., *Vicia cracca* L., etc. The following species of weeds are typical for the examining area: *Urtica dioica* L., *U. urens* L., *Amaranthus retroflexus* L., *Sisymbrium loeselii* L., *Artemisia vulgaris* L. and others. Collecting and accounting of carabids were carried out by the standard method for collecting herpetobions by means of the soil traps placed like 10 pieces on each section. The traps were placed on the periphery of the dump in the first model section along the border line of the dump's edge. Those ones in the control forest were placed along the line leaving deep into the woods from the dump. The distance between traps is 15-20 m. The plastic tanks of 250 ml were used as traps; they were filled for 1/3 part with the 5-10% solution of acetic acid. The collecting of material from the traps was carried out by each 7–10 days. Based on the obtained data, the dynamic density of carabids was calculated: the number of specimens of bugs by 10 trap per days (spec. / 10 t.p.d.) and their relative abundance (% of the total number of individuals).

The classes of abundance of carabids were identified: over 5% of the collections are the dominant (mass) species, 1.1–5 – subdominant (usual) species, 0.3–1 – rare, less than 0.3 – very rare (single) [13].

The mathematical data processing was carried out with the use of programs Excel and Statistica 12.

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3. Results and Discussion

The results show that 54 species of carabids of 22 species, 14 tribes and 11 subfamilies (Cicindelinae, Hebriinae, Carabinae, Loricerinae, Scaritinae, Trechinae, Pterostichinae, Platyninae, Licininae, Harpalinae, Lebiinae) inhabit in the model section (tab. 1).

Table 1. Some characteristics of the population of carabids of model sections in Prokopyevsk for 2014-2016.

Tribe	**SMW dump**		**Control**		**Total**	
	Number					
	genera	**species**	**genera**	**species**	**genera**	**species**
Cicindelini	—	—	1	1	1	1
Notiophilini	1	2	1	3	1	3
Carabini	1	4	1	6	1	6
Loricerini	1	1	1	1	1	1
Clivinini	1	1	1	1	1	1
Trechini	1	1	2	2	2	2
Bembidiini	1	6	1	4	1	6
Pterostichini	2	9	2	10	2	10
Zabrini	2	5	1	2	2	5
Sphodrini	1	1	1	1	2	2
Platynini	3	6	3	7	3	7
Licinini	1	1	1	2	1	2
Harpalini	2	6	2	3	3	7
Lebiini	1	1	—	—	1	1
Total	**18**	**44**	**18**	**43**	**22**	**54**

There are 44 species of 18 genera of 13 tribes and 10 subfamilies (81.5% of the specific richness of the area of researches) in the dump of solid municipal wastes, and 43 species of 18 genera of 13 tribes and 10 subfamilies are noted in the control zone.

The greatest part of species in carabids' fauna of the area of researches comprises such tribes as Pterostichini (10 species, 18.52% of the total number of species), Platynini and Harpalini (7 species of each, 12.96%), Carabini and Bembidiini (6 species of each, 11.11%). However, the representation of tribes and genera in the SMW dump differs from the control zone. The species of the subfamily of Cicindelinae (Cicindelini tribe) are not found in the dump and Lebiinae subfamilies (Lebiini tribe) is not found in the control. The tribe of Trechini is presented by one genus in the dump, and two in the control. There are less species of Carabini tribe (4 species while 6 in the control), Pterostichini (9 and 10 species respectively), Platynini (6 and 7 species), Notiophilini (2 and 3 species), Trechini and Licinini (1 and 2 species of each) in the dump. At the same time, the carabids of the certain tribes (Bembidiini, Zabrini, Harpalini) have favorable conditions for their habitation in the dump; the growth of specific richness is noted in comparison with the control. Therefore, the carabids of Harpalini tribe comprises 6 species in the dump and 3 in the control zone, the species of Bembidiini tribe comprises 6 and 4 respectively. The carabids of Zabrini tribe in the conditions of the dump show not only bigger specific but also generic richness in comparison with the control: there are 5 species of 2 genera in the dump, and 2 species of one genus in the control zone.

The carabids of such tribes as Carabini (63.62% of the total number of collected carabids), Pterostichini (20.64%), Platynini (5.95%) prevail on their numerical abundance.

The found species of carabids were divided into four classes of abundance (tab. 2). 3 species (5.6% of the total number of species) are carried to the dominant (mass) species, 10 species (18.5%) to the subdominant (usual), 10 (18.5) to the rare, 31 (57.4) to the very rare species.

The model sections of the mass, usual and rare species of carabids do not differ on their species composition, all these species are common for both model sections and make a basis of their population.

Table 2. Specific richness and abundance (%) of the population of carabids of SMW dump and the control zone in Prokopyevsk town.

Class of abundance	SMW dump		Control	
	Number of species	Specific abundance	Number of species	Specific abundance
Mass	3	6.8	3	7.0
Usual	10	22.7	10	23.3
Rare	10	22,7	10	23.3
Very rare	21	47.8	20	46.5
Total	**44**	**100**	**43**	**100**

The complex of dominant species is made of 3 mass species of carabids (in decreasing order): *Carabus regalis* Fisch. (45.23% of the general colecting of carabids), *Carabus aeruginosus* Fisch. (15.73%), *Pterostichus magus* Mnnh. (10.48%). They collectively account 71.44% of the general collecting of carabids. However, the average dynamic density of the dominant species of carabids in the dump is 2.5 times lower in comparison with the control forest (fig.1).

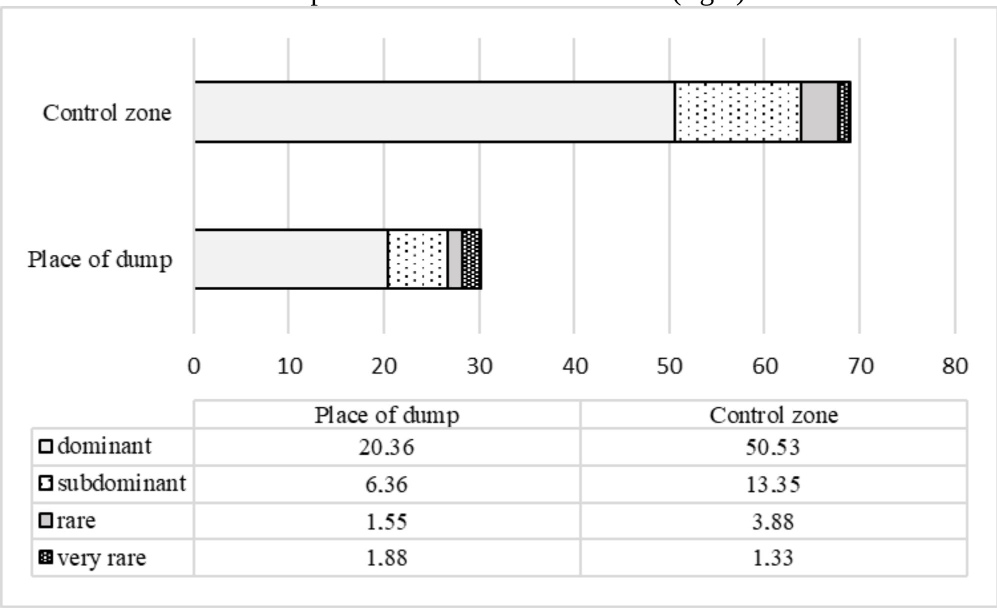

Figure 1. The average dynamic density of carabids of different classes of abundance in the dump of solid municipal wastes and in the control zone in Prokopyevsk town in 2014-2016, spec. / 10 t.p.d.

The lower dynamic density of dominating carabids of the dump is noted in different years of researches (tab. 3). The exception is *Carabus regalis*'s data when the population density of this species in the dump was higher than in the control in 2014.

Table 3. The dynamic density of dominating species of carabids in the model sections in Prokopyevsk in 2014-2016, spec./10 t.p.d.

Species	2014		2015		2016	
	Dump	**Control**	**Dump**	**Control**	**Dump**	**Control**
Carabus regalis Fisch.	9.99±0.58	7.78±0.58	3.81±0.38	15.13±1.56	0.04±0.01	8.12±0.53
Carabus aeruginosus Fisch.	1.73±0.12	3.57±0.28	1.03±0.20	6.10±0.69	—	3.17±0.51
Pterostichus magus Mnnh.	2.15±0.19	2.63±0.40	1.10±0.13	2.25±0.23	0.51±0.04	1.77±0.20

One should pay attention to the data obtained in 2016 when the dynamic density of two dominant species (Carabus regalis and *Pterostichus magus*) of the dump sharply decreased, and *Carabus aeruginosus* was not found at all. It is connected with carrying out the work on maintaining a special SMW polygon in the dump in 2016. Dredging and compressed garbage excavation were carried out, the ditch and an entrance trench were formed.

The usual (subdominant) species of the dump and of the control forest are presented by carabids: *Carabus henningi* Fisch., *Clivina fossor* (L.), *Trechus secalis* (Pk.), *Pterostichus strenuus* (Pz.)., *Pt. monticoloides* Shil., *Pt. oblongopunctatus* (F.), *Amara communis* (Pz.), *Agonum bellicum* Lutshn., *Platynus krynickii* Sperk, *Harpalus latus* (L.). The average dynamic density of the populations of the subdominant species of carabids of the dump is by 2.1 times lower in comparison with the control (fig. 1). The most part of subdominants (7 species) decrease in their number in the dump. At the same time, the species of *Clivina fossor*, *Harpalus latus*, *Agonum bellicum* show the growth of number of individuals by 1.3, 1.5, 1.9 times, respectively, in comparison with the control forest.

Carabus schoenherri Fisch., *Loricera pilicornis* (F.), *Poecilus versicolor* (Sturm), *Pterostichus melanarius* (Ill.), *Pt. dilutipes* (Mots.), *Pt. maurusiacus* Mnnh., *Amara nitida* Sturm, *Agonum bicolor* Dej., *A. gracilipes* (Duft.), *Platynus assimile* (Pk.) are taken as rare species. The average dynamic density of populations of rare species of carabids of the dump is by 2.5 times lower in comparison with the control forest (fig. 1). Two rare species (*Pterostichus melanarius*, *Poecilus versicolor*) are notable for their growth by number in the dump by 1.1 and 4.8 times, respectively. All other rare species have the decreasing number in the dump.

The distinctions of species composition of the examining sections are only connected with the specific richness of very rare species of carabids (tab. 4). The model sections comprise 31 very rare species of carabids totally. There are 21 very rare species in the dump and 20 very rare species inhabit in the control forest. 10 species of them are common for both model sections, 11 species are only found in the SMW dump, and 10 species are only in the control zone. The species of *Notiophilus jakowlewi* Tschit., *Notiophilus palustris* (Duft.), *Bembidion lampros* (Hbst.), *Bembidion properans* (Steph.), *Poecilus versicolor* (Sturm), *Badister bullatus* (Schrank) are notable for their immense numerical abundance in comparison with the control.

Table 4. Species composition and numerical abundance (%) of very rare species of carabids of model sections in Prokopyevsk town

Species	SMW dump	Control
Cylindera germanica L.	—	0.03
Notiophilus aquaticus (L.)	—	0.03
Notiophilus jakowlewi Tschit.	0.13	0.07
Notiophilus palustris (Duft.)	0.30	0.22
Carabus granulatus L.	—	0.07
Carabus obovatus Fisch.	—	0.06
Trechoblemus micros (Herbst, 1784)	—	0.03
Bembidion lampros (Hbst.)	0.33	0.06
Bembidion properans (Steph.)	0.23	0.16
Bembidion gilvipes Sturm	0.20	—
Bembidion guttula (F.)	0.07	—
Bembidion mannerheimii C.R.Sahlb.	0.10	0.36
Bembidion quadrimaculatum(L.)	0.07	0.03
Pterostihus niger (Schall.)	0.13	0.17
Pterostihus nigrita (Pk.)	—	0.03
Amara eurynota (Pz.)	0.13	—
Amara similata (Gyll.)	0.07	—
Curtonotus aulicus (Pz.)	0.13	—
Calathus melanocephalus (L.)	—	0.06
Synuchus vivalis Ill.	0.27	—
Agonum fuliginosum (Pz.)	—	0.26
Oxypselaphus obscurum (Hbst.)	0.03	0.12
Badister bullatus (Schrank)	0.07	0.03
Badister lacertosus Sturm	—	0.03
Bradycellus glabratus (Rtt.)	—	0.06
Harpalus rufipes (Deg.)	0.03	0.03
Harpalus smaragdinus (Duft.)	0.03	—
Harpalus tardus (Pz.)	0.07	—
Ophonus laticollis Mnnh.	0.03	—
Ophonus rufibarbis (F.)	0.13	—
Paradromius ruficollis Motsch.	0.23	—

4. Conclusions

54 species of carabids are found in the area of researches. 44 of them inhabit the dump of solid municipal wastes (81.5% of specific richness of the area of researches): 33 species share the control zone as well and 11 species are original ones.

The leading role belongs to the tribes of Pterostichini, Platynini, Harpalini, Carabini and Bembidiini in forming the population of carabids of the area of researches. However, the smaller specific richness in the conditions of the dump in comparison with the control is revealed by the example of the tribes of Carabini, Pterostichini, Platynini, Notiophilini, Trechini and Licinini, and species of the subfamily of Cicindelinae (Cicindelini tribe) are not found. At the same time, the carabids of some tribes (Bembidiini, Zabrini, Harpalini) have favorable conditions for their inhabitation in the dump. The growth of specific richness is noted in comparison with the control zone.

The "core" of the population of carabids consists of dominant (3 species), subdominant (10) and rare (10) species which are common for both model sections. The complex of dominant species is presented by the carabids of *Carabus regalis*, *Carabus aeruginosus*, *Pterostichus magus* whose dynamic density of populations in the dump is by 2.5 times lower in comparison with the control. Similarly, the most part of subdominant and rare species of the dump have decreasing dynamic density. The exception is the subdominants of *Clivina fossor*, *Harpalus latus*, *Agonum bellicum* and rare species of *Pterostichus melanarius*, *Poecilus versicolor* having high numerical indicators in the dump.

The distinctions of species composition of the model sections are only connected with the specific richness of the very rare species of carabids. 31 species are totally noted (21 in the dump and 20 in the control), i.e. 10 species are common in both cases and the rest ones are original (11 and 10 species respectively).

Thus, the decrease of dynamic density of the populations of the most part of species of carabids is observed because of continuously growing influence of SMW dump on the natural ecosystems. However, the essential transformation of specific structure of "core" of the population of carabids is not observed; there is a change of composition of very rare species only. Thereby, this significant herpetobium group shows the high ecological plasticity and an opportunity to adapt in the changing ecological conditions.

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