Ecological-and-Faunistic overview (Coleoptera, Carabidae) on Reclaimed Coal Open Pit Dumps

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Abstract. In this paper, the specific features of the species and ecological composition of ground beetles on the reclaimed dumps of the Kedrovsky coal open pit mine (Kemerovo Region, Russia) are considered. It is noted that 47 species of ground beetles were found on the dumps themselves, 44 in the control; in this case, the species and ecological structure of carabidocomplexes is changing considerably as long as the dumps are restoring. 39 species of ground beetles were recorded on the young dump, most of which belong to biotopical groups of open habitats (steppe, meadow-steppe), while their overall dynamic density is the lowest compared to other sites. The lowest number of ground beetle species is 33. The control plot is characterized by the domination of species of forest biotopical preferences both in species and abundance. It is shown, that during the succession the structure of the carabidofauna varies towards establishing the community that is characteristic for a specific type of zone vegetation.

1 Introduction

Mining is one of the most powerful types of technogenesis. With its impact, almost complete degradation of natural landscape complexes takes place, on the place of which mining landscapes arise. They are mine-quarry workings and gob piles, accumulations of rock masses.

Kemerovo region, located in the south of Western Siberia (Russia), belongs to the territories where mining is actively developing. According to the official information of the regional authorities in 2017, the coal mining uplift increased by 6.2% (to 241.5 million tons) compared to 2016 (227.4 million tons). The technological process of coal mining is preferably a career (open-pit) method, as a less costly one but causing maximum damage to the environment. As a consequence of intensive development of natural resources, technogenic landscapes are being formed, the structural and dynamic organization of ecosystems is changing, and their degradation is noted. In addition, global environmental threats to such territories include destruction of ecosystems' biodiversity.

One of the ways to optimize technogenic landscapes is reclamation. From an ecological point of view, the main task in the reclamation is to create sustainable biogeocoenoses on technogenically disturbed territories that would have a powerful environment-transforming

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effect. The key biogeocoenotic part in the circulation of substances is played by a complex of soil invertebrates, which includes different functional and coenotic groups that differ in their type of nutrition (phytophagous, zoophagous, saprophagous, mixophagi), and in the form of their activity [1-3 et al.]. Ground beetles make up a major component of the zoocoenosis of soil ecosystems [4, 5]. They play an important part in the functioning of terrestrial biocoenoses, they serve as convenient model objects for eco-faunistic studies aimed at studying the processes of post-technogenic formation of anthropogenically disturbed communities [6-9].

This work makes a part of the results of a long-term study of the zoological component of coal mines rock dumps in Kemerovo region. Thus, to date, data have been published on the structure of mesogerpetobiont arthropods of the dumps being at various stages of recovery [10, 11]. The information about the species composition and diversity of ground beetles in the dumps is reflected in the paper made by S. Luzyanin et al. [12].

The purpose of this study is to study the ecological and faunal structure of the population of ground beetles of reclaimed coal mine rock dumps.

2 Materials and Methods

The research area is 25 km far to the north-east of Kemerovo (Russia) on the territory of the Kedrovsky coal open pit mine . As a research object, different-aged rock dumps, which are a mixture of fragments of mudstones, siltstones, sandstone and coal inclusions, have been selected. Within each dump sites were selected which were located on its top, and on which technical and biological reclamation was performed. The Ked1 site (55°30'39" N, 86°04'00" E) located on the dump formed 7-10 years before the time of the studies. There, the initial stages of meadow communities formation are noted. Projective cover is up to 50%, on rocky areas, below 10%. There is no turmoil. On the second site, Ked2 (55°51'39" N, 86°06'17" E; 25-30 yrs) the forb-gramineous meadow is well developed dominated by Dactylis glomerata, Taraxacum officinale, Centaurea scabiosa. At the same time, there is a tree-shrub vegetation represented by Hippophaë rhamnoides, Sorbus sibirica and Betula pendula. The turfness rate is 20-40%. Projective cover is 90-100%. As a control (Ked3, 55°55'72" N, 86°16'72" E) a thin aspen-fir forest with a small admixture of Betula pendula and Picea obovata was chosen. A large area (about 80%) of the site is covered by glades with forest tall grass. The projective cover is 95-100%, the soil is not matted.

The material was collected from May to August 2016-2017. In order to determine the species composition and take into account the dynamic density of ground beetles, the method of soil traps was used (cups 70 mm in diameter with a fixing liquid, 8-10% acetic acid solution). Traps were installed in a single line at regular intervals of 10 meters of 10 pcs. The inspection of the traps took place every 7-10 days. The dynamic density of arthropods was expressed in the number of specimens per 10 trap-days (specimens / 10 trap per days). In total, more than 1000 samples were processed.

The allocation of dominant species was carried out according to the percentage of total catchability of species. Thus, the species making up more than 5% in the collections were regarded to be dominant, 1.1-5%, subdominant, 0.3-1%, rare and under 0.3%, very rare. The mathematical processing of the data was carried out using Excel and Statistica 6.0 software.

To compare the species diversity of ground beetles in the studied areas, a cluster analysis was used, in which the Simpson index was taken as a measure of similarity. This indicator based on the relative abundance of species, takes into account both the leveling of species and species richness.

3 Results and Discussion

During the study period, the total taxonomic composition of ground beetles was 72 species of 22 genera, 47 species of carbide were recorded directly on the dumps, and 44 species were recorded in the control. There are five genera that predominate in the species ratio, accounting for 55.4% of all ground beetle fauna: Amara, 13 species (18.1%), Pterostichus, 10 species (13.8%), Harpalus, 7 species (9.7%), Bembidion and Carabus, 5 species (6.9% each).

Numerically, the representatives of the genus Carabus significantly exceed 17.8% of the total number of individuals, Harpalus, 17.1%, primarily due to the massive species in the area of the Harpalus rubripes (15.4%), as well as the genus Trechus, 14.7%.

The following massive species of land beetles are established in the research areas of the coal open pit mine and in the control: Carabus regalis, C. aeruginosis, Trechus secalis, Pterostihus magus, Amara communis, T. bakurovi, Synuchus vivalis and Poecilus versicolor, which account for 56.5% of the total number of individuals. The highest dynamic density is reached by Harpalus rubripes (17.97 ± 5.63 specimens / 10 trap per days on the site Ked2), while it was not marked in the control area), Trechus secalis (6.46 ± 5.23 specimens / 10 trap per days in the control), and also Amara aenea (2.28 ± 1.57 specimens / 10 trap per days – on the site Ked1).

To compare the structure of the ground beetle communities of the Kedrovsky coal open pit mine model sites in the context of the analysis of the effect of the change in the age stages of the restoration of the dumps, a dendrogram was constructed. As seen from Figure 1, the research sites are divided into two groups due to their degree of similarity: Group 1, the control area (Ked 3) and Group 2, plotson on the dumps themselves (Ked1, Ked2).

The first pleiad formed is characterized by a special species structure of carabides. Thus, 39 species of ground beetles were found on the Ked1 site, and only 33, on Ked2. For example, the species Bembidion gilvipes, Amara bamidunyae, A. montivaga, Curtonotus gebleri, Ophonus laticollis, Harpalus luteicornis, Microlestes minutulus, Lebia chlorocephala are noticed only on the young dump. Most of these species prefer open biotopes, so their absence on the dump, where recovery processes have been going on for more than 20 years, and in the control is quite logical. In general, low overall dynamic density of carabides is observed in comparison with other sites (Fig. 2).

It is worth of note that, despite the not very favorable microclimatic and environmental conditions available on this site (high degree of insolation, low or insufficient moisture), there are floodplain-coastal species of Bembidion gilvipes and Trechus secalis, whose average densities were 0.071 ± 0.063 specimens / 10 trap per days. The habitat of the species of this biotope group is probably due to the fact that a biological re-cultivation was carried out a few years ago in this territory with planting Pinus sylvestris and Onobrychis arenaria. By now, small areas with well-developed moss cover have formed, which retain moisture and create favorable habitat for these species of ground beetles, and which are temporary refugia for them.

As noted above, in the second site (Ked2) a significantly smaller number of ground beetle species (33) was recorded compared to the first site. At the same time, the dynamic density of this group of insects more than doubles on this site (Fig. 2). Forest Pterostichus melanarius (dynamic density of 0.018 ± 0.050 species / 10 trap per days), meadow Amara famelica and A. municipalis (dynamic density of 0.018 ± 0.050 and 0.016 ± 0.035 specimens / 10 trap per days) and steppe A. equestris (0.071 ± 0.151) can only be found here. The highest density in this area is achieved by Notiophilus germinyi (1.152 ± 0.810 specimens / 10 trap per days), Synuchus vivalis (1.001 ± 1.165 specimens / 10 trap per days) and Harpalus rubripes (1.095 ± 0.579 specimens / 10 trap per days).

The control plot (Ked3), which is characterized by the largest number of species, 44, stood apart as a separate branch. A number of species (mainly forest biotopic preferences) were found only in this site – Notiophilus palustris, Carabus obovatus, C. henningi, Trechus bakurovi, Clivina fossor fossor. In addition, it should be noted that 8 species of ground beetles out of 10 species of the genus Pterostichus were recorded only in the control zone: Pterostichus dilutipes, P. elmbergi, P. magus magus, P. tomensis, P. monticoloides, P. oblongopunctatus, P. maurusiacus, P. virescens. All of them belong to the forest ecological group.

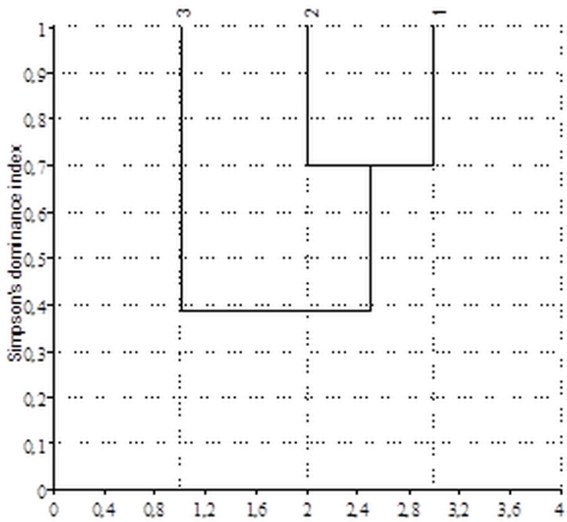

Fig. 1. Dendrogram of the similarity of the species composition of ground beetles on the sites of the Kedrovsky coal open pit mine and the control zone. Note. 1 – Ked1 site (dump aged 7-10 years), 2 – Ked2 site (dump aged 25-30 years), 3 – Ked3 site (control).

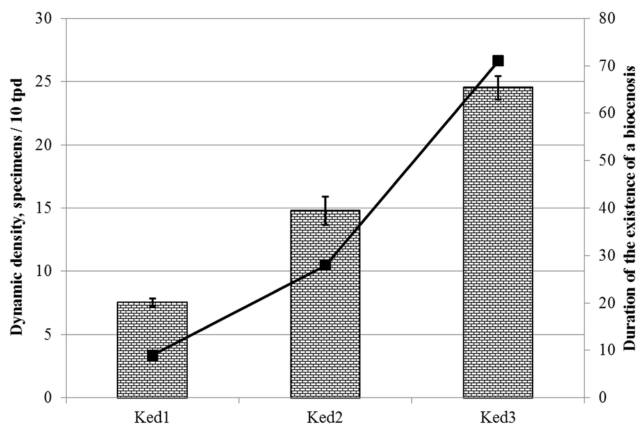

Fig. 2. The change in the dynamic density of the ground-beetles on dumps of Kedrovsky coal mines in the temporal aspect. Columns - The dynamic density of a ground-beetles, Points - Duration of the existence of a biocenosis, Lines on the columns - Standard deviation bars

Interesting enough is the discovery of the species Trechus dudkorum (0.087 ± 0.057 specimens / 10 trap per days), which is endemic to the Kuznetsk Alatau and the North-Eastern Altai. This type of South of Kuznetsk-Salair mountain area is confined to the subalpine and alpine meadows and in the North, to forest biotopes. In addition, for the first time for the Kemerovo region, the Trans-Palearctic floodplain-coastal species of Platynus assimilis (0.018 ± 0.018 specimens / 10 trap per days) is noted.

The overall ecological structure of the ground beetle population of the sites under consideration is characterized by a significant preponderance with regqard of the species (39% of the total number of species) and numerically (47.7% of the total number of individuals) of the forest biotope group. This trend is quite natural, because the coal enterprise under consideration is on the border of the northern forest-steppe of the Kuznetsk Basin and northwestern sub-taiga of the Kuznetsky Alatau, in connection with which the forest habitats of the area are common. At the same time the share of the species preferring xerophytic habitats and pertinent to meadow-steppe and steppe groups is significantly lower.

While considering the biotopical preferendum of ground beetles separately on dumps and in the control, it can be noted that on the sites located on dumps, regarding to species and numerically, the groups of ground beetles that prefer open habitats dominate. In the control, as noted above, the forest group predominates (Fig. 3). In addition there is a clear trend of decreasing species diversity of ground beetles of meadow-steppe and steppe groups while the dump rate of the sites increases. Thus, in the sites under consideration, the largest number (5) of steppe species is recorded in the site Ked1, which is characterized by a high degree of aridity. Typical steppe species include: Amara bamidunyae, A. equestris, the massive Harpalus rubripes, H. tardus, Cymindis angularis and Microlestes maurus. In the control no species of this biotopic preference were observed.

The species of meadow and steppe groups have a similar trend, while in the control only two meadow steppe species: Agonum gracilipes and Amara plebeja with very low dynamic density, at 0.018 ± 0.050 specimens / 10 trap per days were registered.

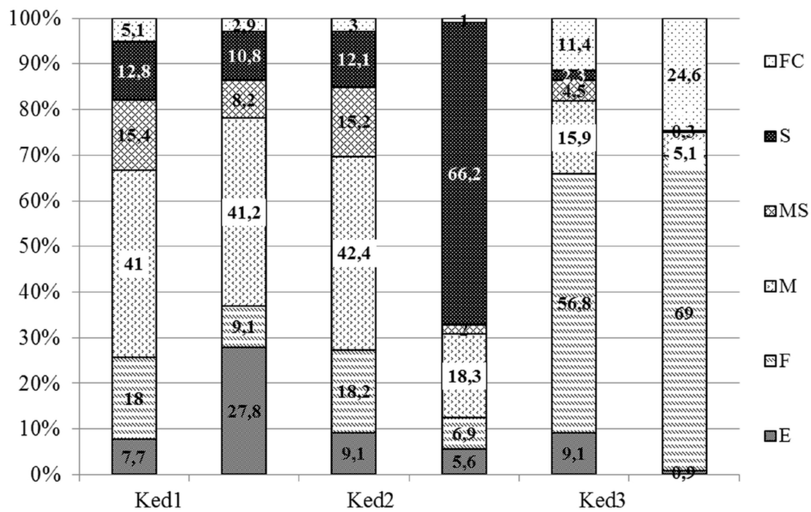

Fig. 3. Species (column 1) and numerical (column 2) abundance of ecological groups of ground beetles in the areas studied. Note. FC – floodplain-coastal species, E – forest species, S – steppe species, MS – meadow and steppe species, M – meadow species, E – eurytopic species

The floodplain-coastal group consists of species that prefer high- or medium-humid areas, such as banks of water reservoirs, small rivers, streams, etc. Therefore, it is quite natural that the largest species (11.4%) and numerical (24.6%) abundance of this group is registered in the control (Ked3 site). At the same time, as it was noted above, it is interesting to find only the floodplain-coastal species on the Ked1 site, Bembidion gilvipes (0.024 ± 0.021 specimens / 10 trap per days), which, probably, migrated from the sites adjacent to the dump with the presence of small streams.

4 Conclusion

A detailed study of the carabidofauna of the anthropogenically transformed areas in question showed that ground beetles quickly develop new ecological niches and, first of all, this is due to the migration of species from adjacent natural and little disturbed ecosystems to these areas.

The establishment of a microclimate on the dumps formed different from the initial one affects the subsequent formation of carabidofauna mainly consisting of species preferring open habitats. Subsequently, during the succession, the structure of the carabidofauna changes towards establishing a community that is characteristic of a particular zonal type of vegetation.

Further studies of the structure and mechanisms of the formation of animal communities on degraded landscapes will allow monitoring of the restoration of such areas, and further optimize the reclamation methods used for their rational and effective use.

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