

ABUNDANCE AND DIVERSITY OF *Carabidae* FAMILY IN SOILS OF THE REPUBLIC OF MOLDOVA

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Abstract

The family of Carabidae in soils of natural and agricultural ecosystems located in the different zones of the Republic of Moldova has been investigated in May and August, 2021. Carabids sampling was carried out from test cuts by manual sampling of soil layers to the depth of soil fauna occurrence. Abundance of Carabidae family in natural soils is much greater compared to soils of agricultural ecosystems. Carabids were practically absent in arable soils at the time of sampling. The share of Carabidae family in the total abundance of invertebrates in forest soils of natural ecosystems constitutes of 2.1-9.6%, in chernozems - 3.0-10.2%. The base mass of Carabidae family in soils under natural vegetation is located in the litter and 0-10 cm layer. Species of the Carabus nemoralis, Carabus granulatus, Harpalus affinis, Harpalus rufipes, Calosoma inquisitor and others were identified in the faunal samples from soils in natural ecosystems.

Key words: *Carabidae family, forest soil, chernozem, natural and agricultural ecosystems.*

INTRODUCTION

The family of *Carabidae* is a part of the largest insect families, with about 40,000 species worldwide (Lövei & Sunderland, 1996; Kromp, 1999). The summary list of ground beetles (*Carabidae*) from the Republic of Moldova at the beginning of the 1990s constituted 466 species (Neculiseanu, 1991). Rare and endangered carabid's species in this area have been investigated (Neculiseanu et al., 1992; 2002; 2003). Review of the carabid's fauna "Catalogue of beetles of the Republic of Moldova", published in Bulgaria, includes 497 species belonging to 89 genera (Neculiseanu & Matalin, 2000). Later there were identified 505 species of carabids belonging to 88 genera, 15 sub-tribes, 33 tribes, 18 supra-tribes and 4 sub-families (Neculiseanu, 2003-2004).

Carabidae family plays a major role in reducing weeds and insect pests in agricultural fields. They have a wide range of nutrition. Many species are considered generalist predators, meaning they feed on a wide range of pests. For example, the species *Calosoma sycophanta* is an effective exterminator of forest pests. Species of the genera *Carabus* and *Cychrus* play a significant role as destroyers of harmful mollusks (Bagirova, 2014). In addition

to being predators, many species are omnivorous, feeding on weed seeds and can have a serious impact on weed management on the arable land (Blubaugh & Kaplan, 2016). Many species are known to have a seasonal diet shift based on food availability, allowing the predators to exploit different resources throughout the year (Symondson et al., 2002; Honek et al., 2006).

Thus, being one of the most important components of natural and anthropogenic ecosystems, ground beetles (*Carabidae*) play an important role in the natural abundance of many invertebrates.

Carabids represent one of the main groups of insects that is used for indication of character and directions of soil and vegetation changes. They play an important role in the diagnosis of soil types in deciduous forests. So, some species of the *Carabidae* family are unique and characteristic for the brown forest soils of Moldova (Gilyarov, 1965). This group of coleopterans is recommended to be used as indicator species and one of the main ones in soil monitoring studies (Baban, 2006).

The purpose of the research was to investigate the abundance and diversity of the *Carabidae* family in soils of natural and agricultural ecosystems for the biodiversity conservation

and development of the national soil quality standards.

MATERIALS AND METHODS

Experimental sites are located in central and northern zones of the Republic of Moldova (Figure 1). The content of *Carabidae* family in soils with the normal profile in the condition of the long-term use in agricultural production were investigated in comparison with the undisturbed soils in natural ecosystems (Figure 2). Six experimental sites have been tested.



Figure 1. Fragments of natural and agricultural landscapes located in the central and northern zone of the Republic of Moldova



Figure 2. Fragments of forest ecosystems

Experimental sites with typical and luvisc brown soil are located in the central zone of the Republic of Moldova, in the wooded steppe of the central - Moldovan forest province, in the district No. 8 of brown, gray forest soils and leached chernozems of the wooded steppe of hilly Kodru Forests.

The site with typical brown soil is situated in the Tuzara village and Gorodische com., Kalarash region.

The site with luvisc brown soil is located in the Dolna com., Strasheni region.

The site with mollic gray forest soil is situated near the Grozeshti village, Nisporeni region. According to pedogeographic zoning, this site is located in the Central Plateau of Kodru Forests, in the region V of Kodru' Plateau, in the district No. 8 of brown, gray forest soils and leached chernozems.

The site with typical gray forest soil is also located in the hilly forest steppe zone of the Northern Plain (I), the forest-steppe hill of Rezina district No. 5 of gray forest soils and argillaceous chernozems near the Raspopeni village, Sholdaneshti region.

The site with albic gray forest soil falls within the hilly forest-steppe zone of the Northern Plain (I), in the forest-steppe of the Northern Plateau, in the district No. 1 of gray forest soils and clay-alluvial chernozems. Nearby is located Terebna village, Edinets region.

The site with podzolic chernozem are located in the zone of the hilly wooded steppe of the Northern Plain (1), in the district of wooded steppe of the middle Prut (2) with gray forest soils, podzolic and leached chernozems, in the Shaptebani village, Ryshkani region.

Status of invertebrates. Testing of semi-profiles in the amount of 3 units was carried out around the main test cut at a distance of 5-10 m. The state of invertebrates and *Carabidae* family was determined from test cuts by manual sampling of soil layers to the depth of soil fauna occurrence with application of Gilyarov and Striganova's method (1987).

At the same time, carabids were also selected from the litter layer and on the soil surface. Imago and larvae have been collected. Ethyl alcohol was used to immobilize (destroy) the carabids. The species identification was carried out according to the external morphological features. The taxonomic studies used during the

identification were accomplished according to Kryzhanovsky (1983). Carabids larvae were identified according to Gilyarov M.S. (1964). The studies were carried out in May and August of 2021.

RESULTS AND DISCUSSIONS

The abundance of the edaphic fauna in soils of natural ecosystems are characterized by higher values in comparison with the arable soils (Table 1). The typical brown forest soil contains invertebrates on average 376.0 ex. m⁻², luvic brown forest soil - 181.3 ex. m⁻²; molic gray forest soil - 194.7 ex. m⁻², albic gray forest soil - 192.0 ex. m⁻², typical gray forest soil - 290.7 ex. m⁻². A significant number of invertebrates was also found in the podzolic chernozem - 352.0 ex. m⁻².

The natural molic gray forest soil and natural luvic brown forest soil are characterized by the high content of carabid beetles, reaching 18.6 ex. m⁻² and 16.0 ex. m⁻². The natural albic gray forest soil, typical gray forest soil and podzolic chernozem contained species of carabids in the amount of 13.3; 10.6 and 10.7 ex. m⁻² respectively. The typical gray forest soil in a natural forest ecosystem

contained the lowest content of carabid beetles - 8.0 ex. m⁻².

The share of *Carabidae* family in the total abundance of invertebrates in forest soils of natural ecosystems in our research constitutes of 2.1-9.6%, in the podzolic chernozems - 3.0%. According to Prokhina N.A. (1968), the share of carabids in the total composition of the edaphic fauna in the calcareous chernozem was 7.1%, in the ordinary chernozem - 8.2%, in the leached chernozem - 6.7% and in the typical chernozem - 10.2%. In general, it can be assumed that the contribution of *Carabidae* family in the total amount of the edaphic fauna in natural soils does not exceed 10.0-11.0%.

The long-term use of arable land with pesticides leads to a considerable decrease in the number of invertebrates and to the degradation of the soil faunal complex in general. The number of invertebrates in arable forest soils decreased by 1.3-16.9 times, in the podzolic chernozem - by 66.4 times respectively in comparison with natural soils. *Carabidae* family reduced to zero values in soils under agricultural conditions. Only a few of the most mobile species of *Amara aenea* have been occasionally found.

Table 1. Number of invertebrates and *Carabidae* family (imago + larvae) in soils in conditions of natural and agricultural ecosystems (n = 3 for each profile)

Soil	Land use	Number, ex. m ⁻²	
		total	<i>Carabidae</i> fam.
Typical brown forest soil	forest	376.0	8.0
	arable land	93.3	0
Luvic brown forest soil	forest	181.3	16.0
	arable land	10.7	0
Molic gray forest soil	forest	194.7	18.6
	arable land	146.7	0
Albic gray forest soil	forest	192.0	13.3
	arable land	24.0	0
Typical gray forest soil	forest	290.7	10.6
	arable land	18.7	0
Podzolic chernozem	virgin land	352.0	10.7
	arable land	5.3	0
Calcareous chernozem*	virgin land	171.0	12.1
	arable land	38.0	1.4
Ordinary chernozem*	virgin land	232.0	19.0
	arable land	47.0	3.1
Leached chernozem*	virgin land	174.3	11.7
	arable land	71.0	7.8
Typical chernozem*	virgin land	166.6	17.0
	arable land	64.0	4.0

*Cited from Prokhina N.A., 1968

The base mass of edaphic fauna and carabids in the natural soils is located in the 0-10 cm layer, in the litter and in the mix of litter with soil.

In total, 13 species of carabid beetles from 7 genera (*Bembidion*, *Calosoma*, *Carabus*, *Harpalus*, *Lebia*, *Ophonus* and *Panagaeus*), 5 tribes (*Carabini*, *Bembidiini*, *Harpalini*, *Lebiini* and *Panagaeini*) and from subfamily *Carabinae* were found and identified in the studied soils. At the time of sampling, forest soils in natural ecosystems contained 11 species from the *Carabidae* family. There are 5 species of carabid beetles in the natural luvic brown soil, 4 species - in the natural molic gray forest soil and 3 species of carabids in each - in the natural typical brown soil, albic and typical gray forest soils.

Species of *Bembidion obtusum*, *Calosoma inquisitor*, *Carabus granulatus*, *Carabus nemoralis*, *Harpalus affinis*, *Harpalus rufipes*, *Ophonus sabulicola*, have been identified in the brown forest soils of natural ecosystems (Table 2). In the natural gray forest soils species of *Bembidion obtusum*, *Calosoma auropunctatum*,

Carabus nemoralis, *Harpalus affinis*, *Harpalus griseus*, *Harpalus progrediens*, *Harpalus rufipes* and *Panagaeus cruxmajor* have been found.

Species of *Calosoma inquisitor*, *Carabus coriaceus* and *Lebia cruxminor* have been reported in the chernozem under natural vegetation.

The life form analysis of carabids indicated four life form types according to the mode of nutrition. Groups of mixo-phytophagous and zoophagous predominate in the composition of the carabid beetles (Figure 3).

Their contribution to the total number of carabids is quite significant and constitutes 36.2% and 34.7%, respectively (Figure 3). Species of carabids, which belong to phytophagous, account for 15.5% of the total abundance of *Carabidae* family. The share of predators in the total number of carabid beetles in the natural soils was not so significant in terms of the specific contribution, their share constituted 13.6%.

Table 2. Biodiversity of the *Carabidae* family (ex. m⁻²) at the species level in brown soils in natural and agricultural ecosystems

<i>Carabidae</i> family species	Typical brown forest soil	Luvic brown forest soil	Molic gray forest soil	Albic gray forest soil	Typical gray forest soil	Podzolic chernozem
	forest	forest	forest	forest	forest	virgin
<i>Bembidion obtusum</i>	2.7	0	0	2.7	0	0
<i>Calosoma auropunctatum</i>	0	0	5.3	0	0	0
<i>Calosoma inquisitor</i>	2.7	0	0	0	0	2.7
<i>Carabus coriaceus</i>	0	0	0	0	0	5.3
<i>Carabus granulatus</i>	0	2.7	0	0	0	0
<i>Carabus nemoralis</i>	0	5.2	2.7	0	0	0
<i>Harpalus affinis</i>	0	2.7	5.3	0	4.0	0
<i>Harpalus griseus</i>	0	0	0	2.6	0	0
<i>Harpalus progrediens</i>	0	0	0	8.0	0	0
<i>Harpalus rufipes</i>	0	2.7	5.3	0	4.0	0
<i>Lebia cruxminor</i>	0	0	0	0	0	2.7
<i>Ophonus sabulicola</i>	2.6	2.7	0	0	0	0
<i>Panagaeus cruxmajor</i>	0	0	0	0	2.6	0
Total	8.0	16.0	18.6	13.3	10.6	10.7

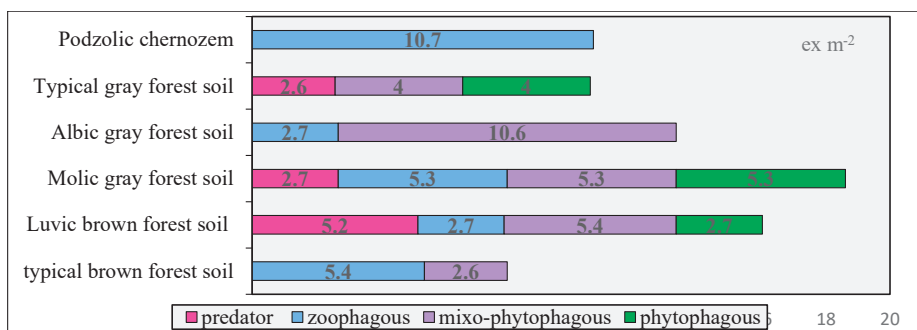


Figure 3. Composition of *Carabidae* family according to the mode of nutrition in soils in natural ecosystems

All four types of nutrition have been identified in carabid beetles living in the molic gray forest soil and luvic brown forest soil under forest.

Three groups of carabids (predators, mixo-phytophagous and zoophagous) were registered in the natural typical gray forest soil.

The typical brown forest soil and albic gray forest soil had two groups of representatives from the *Carabidae* family.

Only one group of zoophagous has been registered in the podzolic chernozem under virgin land.

According to zoogeographical analyses, carabids species belong to 7 zoogeographic elements with a predominance of Trans Palearctic (19.8%), followed by Palearctic (17.4%), European elements (13.3%), which is 65.4% of the collected species (Figure 4).

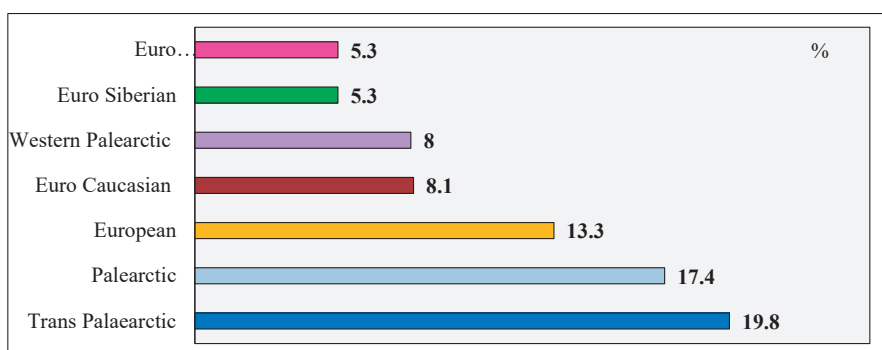


Figure 4. Geographical distribution of carabids selected from the studied soils

A smaller number of species are represented by Euro Caucasian (8.1%), Western Palearctic elements (8.0%), Euro-Siberian (5.3%) and Euro Mediterranean elements (5.3%).

CONCLUSIONS

Ground beetles (*Carabidae* family) are one of the most important components of the edaphic fauna of natural and anthropogenic ecosystems. The practical importance of carabids is due to their biodiversity and variety of mode of nutrition. Carabids, as a good indicator, may become one of the main objects in solving cadastral problems, conducting soil-ecological

monitoring and developing soil quality standards.

Abundance of the edaphic fauna and *Carabidae* family in natural soils is much greater compared to soils of agricultural ecosystems. Their number is 8.0-18.6 ex. m⁻². The share of *Carabidae* family in the total abundance of invertebrates in forest soils of natural ecosystems constitutes of 2.1-9.6%, in chernozems - 3.0-10.2%. The base mass of *Carabidae* family in soils under natural vegetation is located in the litter and 0-10 cm layer.

13 species of carabid beetles from 7 genera, 5 tribes and 1 subfamily *Carabinae* were found

and identified in the studied soils. Species of the *Carabus nemoralis*, *Carabus granulatus*, *Harpalus affinis*, *Harpalus rufipes*, *Calosoma inquisitor* and others have been detected in the faunal samples from soils in natural ecosystems. Groups of mixo-phytophagous and zoophagous predominate in the composition of the carabid beetles. Trans Palearctic, Palearctic and European species predominate in the range, accounting for 65.4% of the total number of carabids.

A characteristic consequence of the long-term use of soils for arable land is the destruction of the population of carabids beetles. The negative effect on the edaphic fauna and *Carabidae* family is observed as a result of long-term land management practices with the non-standard application of chemicals. The state of carabids fauna in the old-arable soil is characterized by the significant reduction in the number and diversity in comparison with the level of the 1960s and with soil's standards that are in conditions of natural ecosystems. Carabids were practically absent in arable soils at the time of sampling.

The problem of impoverishment and destruction of the *Carabidae* fauna is caused by the fragmentation and degradation of biocenoses, violation of the rules for the application of pesticides and environmental pollution.

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