Scientific Papers. Series A. Agronomy, Vol. LXV, No. 1, 2022
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EDAPHIC FAUNA AS AN INDICATOR OF DEGRADATION PROCESSES IN PODZOLIC CHERNOZEM

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Abstract

The edaphic fauna of the podzolic chernozem in the northern zone of the Republic of Moldova has been investigated. Invertebrates' testing was carried out from semi-profiles around the main profile at a distance of 5-10 m by manual sampling of soil layers to the depth of soil fauna occurrence. The highest values of invertebrates' abundance (84.8 %) were registered in the upper horizon and litter in the natural chernozem. Number of invertebrates constituted 352.0 ex m^{-2} and Lumbricidae family - 277.3 ex m^{-2}, biomass - 89.5 and 68.5 g m^{-2}, respectively. The natural chernozem contained 10 families of invertebrates and its trophic pyramids were stable. Saprophagous of Aporrectodea rosea, Aporrectodea caliginosa and Lumbricus terrestris predominate in the composition of the edaphic fauna. Species of Calosoma inquisitor, Lebia cruxmino, Carabus coriaceus, Lilioceris merdigera, Clubiona stagnatilis, Lucanus cereus, Lithobius forficatus and Melolontha melolontha have also been identified. Degradation of the faunal complex in the arable chernozem has been manifested in a decrease of abundance, biodiversity and disruption of trophic connections.

Key words*: edaphic fauna, biodiversity, podzolic chernozem, degradation, natural and agricultural ecosystem.*

INTRODUCTION

Edaphic fauna meet most of the desired criteria of soil quality indicators (Doran & Zeiss 2000; Schloter, Dilly & Munch, 2003). Soil invertebrates have been positioned as indicators of soil quality in forest and agricultural land use (Eggleton et al., 2005). Their diversity, abundance, biomass, and density have been proven to be suitable as indicators of natural or anthropogenic impacts on terrestrial ecosystems due to their correlation with physicochemical and microbiological properties and ecological changes (Paula et al., 2010). Invertebrates' diversity is one of the most important evaluation criteria of soil ecosystems, its resistance to different forms of degradation (Naeem et al., 2002; Schwartz et al., 2000). Excessive reduction of the soil biodiversity, especially the loss of keystone species and/or species with unique functions may have some cascading ecological effects, which lead to the long-term deterioration of soil fertility and the loss of agricultural productive capacity (Huhta, 2007). There is a growing interest in developing valuable and sensitive faunal indicators of soil quality, which can reflect the effects of land management and ensure a long-term sustainability of soil fertility. In this context, edaphic fauna indices can be used for evaluation of the degradation process and comparison of different land managements.

The purpose of the research was to carry out the monitoring of the edaphic fauna in the podzolic chernozem under the conditions of natural and agricultural ecosystems for assessing the processes of soil degradation, the biodiversity conservation and development of the national soil biota quality standards.

MATERIALS AND METHODS

Experimental site and soil. The experimental site 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 (Figure 1). The plot with podzolic chernozem (profile 17 under fallow; profile 18 under arable) is situated in the Shaptebani village, Ryshkani region. Invertebrate' state in the podzolic chernozem in the condition of natural ecosystems has been investigated in comparison with the long-term arable podzolic chernozem in conditions of agricultural ecosystems.

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

Invertebrates sampling was carried out from 6 soil semi-profiles to a depth of 50 cm in 2021.

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 was identified from test cuts by manually sampling the soil layers to the depth of soil fauna occurrence by Gilyarov and Striganova's method (1987). The identification of invertebrate's diversity at the level of families and species, and also their classification according to nutrition type were categorised by standard procedures (Gilyarov & Striganova, 1987; Vsevolodova-Perel, 1997, 2003).

RESULTS AND DISCUSSIONS

The number and biomass of edaphic fauna in the podzolic chernozem of natural ecosystems are characterized by higher values of these indicators in comparison with the arable chernozem (Table 1). The number of invertebrates in the natural podzolic chernozem reaches to 352.0 ex m^{-2}, *Lumbricidae* family – to 277.3 ex m^{-2}, and its biomass – to 89.5 and 68.5 g m^{-2} accordingly. Soil faunal studies of the podzolic chernozem under agricultural conditions have shown and confirmed that the long-term use of arable land leads to significant decreases in the number and biomass of invertebrates and degradation of the faunal complex as a whole. The number and biomass of invertebrates in this chernozem decreased by 66.4 and 111.9 times respectively in comparison with the natural soil, and *Lumbricidae* family reduced to zero values.

Table 1. Number and biomass of invertebrates in podzolic chernozem under fallow and arable land (n = 3 for each profile)

Soil (profile)	Semi-profiles	Number, ex m^{-2}		Biomass, g m^{-2}	
		total	*Lumbricidae* fam.	total	*Lumbricidae* fam.
Natural podzolic chernozem (P17)	69	280.0	192.0	54.4	49.6
	70	328.0	272.0	74.0	59.2
	71	448.0	368.0	140.0	96.8
	Media	**352.0**	**277.3**	**89.5**	**68.5**
Arable podzolic chernozem (P18)	72	16.2	0	2.4	0
	73	0	0	0	0
	74	0	0	0	0
	Media	**5.3**	**0**	**0.8**	**0**

The share of earthworms in the total abundance of invertebrates constitutes of 68.6 %, and their biomass - 91.2% in the podzolic chernozem of natural ecosystem. The weight of the one exemplar of *Lumbricidae* family in chernozems constitutes 0.26 g. The arable podzolic chernozem is characterized by a total lack of earthworms at the time of fauna sampling.

The base mass of edaphic fauna in the natural podzolic chernozem is located in the 0-10 cm layer, in the litter and mixing litter with soil. The number of invertebrates index decreases in the soil profile to a depth of 30 cm (Figure 2). *Lumbricidae* family in the natural podzolic chernozem is located in the 0-10 cm layer (87.5%).

Podzolic chernozems in the natural ecosystem are characterized by a high diversity of invertebrates compared to the arable podzolic chernozem (Table 2). There are 10 families of invertebrates in the natural podzolic chernozem, 2 families - in the arable soil.

In addition to the *Lumbricidae* family the species from the families of *Clubionidae, Hygromiidae, Carabidae, Scarabaeidae, Oniscidae, Geophilidae, Chrysomelidae, Lithobiidae* and *Lucanidae* have been identified in the natural podzolic chernozem. In this soil species from *Lumbricidae* family - *Aporrectodea rosea*, *Aporrectodea caliginosa* and *Lumbricus terrestris* were dominant. *Calosoma inquisitor, Lebia cruxmino* and *Carabus coriaceus* who are representatives of the *Carabidae* family, have been identified. Species *Lilioceris merdigera, Clubiona stagnatilis, Lithobius forficatus, Melolontha melolontha* have also been identified. It should be mentioned that specie of *Lucanus cereus* from the *Lucanidae* family, included in the Red Book of Moldova, was found.

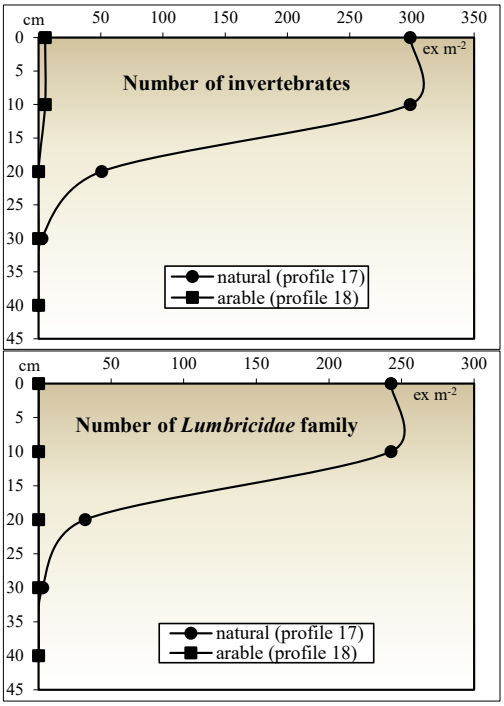

Figure 2. Composition of invertebrates according to the mode of nutrition in podzolic chernozems of natural and agricultural ecosystems (mean values, without *Formicidae* family and unidentified species)

The biodiversity of edaphic fauna in arable podzolic chernozems significantly reduced. This soil contains 2 families of invertebrates (*Clubionidae* and *Noctuidae*).

Saprophagous are present in natural podzolic chernozems (Figure 3). Their amount was quite substantial and constitutes 86.0 % from the total abundance of invertebrates. Saprophagous were absent in arable podzolic chernozems at the time of sampling.

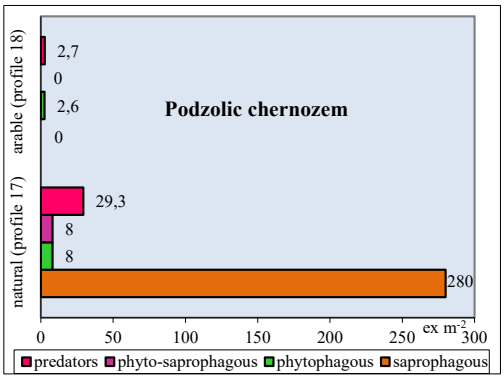

Figure 3. Composition of invertebrates according to the mode of nutrition in the podzolic chernozem in natural and agricultural ecosystems (mean values, without *Formicidae* fam. and unidentified species)

The number of phytophagous and phyto-saprophagous in the chernozem in conditions of natural ecosystems was insignificant and amounts to 2.5% each. The maximum number of phytophagous in percentage expression was recorded in the arable podzolic chernozem and rose to 49.1%.

The abundance of predators in the total number was 9.0% in the natural chernozem and 50.9% in the arable chernozem. Prolonged use of arable podzolic chernozems leads to a sudden decrease in the number of invertebrates, death of saprophagous and destruction of trophic levels and connections (Figure 3, Table 3). Research shows that the balance between invertebrate populations is upset, leading to a decrease in the quality of arable soils.

Table 2. Biodiversity of invertebrates (ex m^{-2}) at the family's level in podzolic chernozem (mean values)

Invertebrates' families	Natural podzolic chernozem (P17)	Arable podzolic chernozem (P18)
Lumbricidae	277.3	0
Scarabaeidae	5.3	0
Carabidae	10.7	0
Geophilidae	8.0	0
Chrysomelidae	2.7	0
Clubionidae	5.3	2.7
Hygromiidae	5.3	0
Noctuidae	0	2.6
Oniscidae	2.7	0
Lucanidae (larve)	2.7	0
Lithobiidae	5.3	0
Unidentified species	26.7	0
Total	**352.0**	**5.3**

Table 3. The ratio of trophic groups of invertebrates in podzolic chernozem

Soil	Profile	Saprophagous /Total	Saprophagous / Phytophagous	Phytophagous /Total
Natural podzolic chernozem	P17	0.86	35.00	0.03
Arable podzolic chernozem	P18	0	0	0.49

Trophic pyramids in podzolic chernozems of natural ecosystems are characterized by higher stability in comparison with arable podzolic chernozems. The quantitative ratio between trophic levels in natural soil is stronger compared to arable soil.

The long-term arable use of podzolic chernozems leads to the significant deterioration of the conditions needed for the vital activity of soil invertebrates, the rupture and the attenuation of relations between the components of the edaphic fauna which, in turn, contributes to the decrease in the natural stability of soils and the strengthening of degradation processes. It should be noted that similar results were obtained during monitoring studies in forest soils (Senicovscaia et al., 2021; 2021a).

CONCLUSIONS

Podzolic chernozems of the natural ecosystems in the central of the Republic of Moldova are the habitat and the source of conservation and restoration of the diversity and abundance of the edaphic fauna. The complex of invertebrates in podzolic chernozems of natural ecosystems is formed at higher level of input and content of organic matter in the soil. 10 families of invertebrates were found in podzolic chernozems. The number, biomass and biota diversity of undisturbed chernozems are considerably wider compared to arable soils. A characteristic feature of natural phytocenoses is the accumulation of basic reserves of the number of invertebrates in the horizons 0-10 cm and in the litter. Saprophagous prevail in the composition of the edaphic fauna in the natural podzolic chernozems, accounting for 86.0 % of the total abundance. The long arable utilization of podzolic chernozems has been rendered disastrous effects on the soil invertebrates. In arable chernozems only species from 2 families of edaphic fauna have been identified. There is a decrease in the number of saprophagous, especially in the *Lumbricidae* family, the destruction of levels and trophic links between invertebrates.

ACKNOWLEDGEMENTS

This research work was carried out in the framework of the institutional project "Evaluation of the soil state of the Republic of Moldova in the agrocenosis conditions, improvement of the classifier and the soil rating system, elaboration of the methodological-informational framework for monitoring and enlarged fertility reproduction" (project code 20.80009.7007.17) in 2021.

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