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CONTRIBUTION OF SOIL INVERTEBRATES TO THE STABILITY OF ERODED SOILS IN THE SOUTH OF THE REPUBLIC OF MOLDOVA

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Abstract

The role of invertebrates and their contribution to the functioning of eroded soils is discussed. The edaphic fauna of the ordinary chernozem located in the southern zone of the Republic of Moldova has been investigated in dependence on the degree of erosion, the type of agricultural uses and the method of tillage. The highest values abundance and biomass of invertebrates were registered in the soils with a normal profile as well as in the soils with a truncated profile in conditions of the multiannual fallow under natural vegetation. The fallow soil is characterized by a greater diversity of invertebrates. In addition to the Lumbricidae family, in samples of invertebrates, there were found the species of the Arthropoda and Lucanidae classes, Chrysomelidae, Forficulidae, Formicidae, Gloremidae, Attelabidae, Tenebrionidae, Scarabaeidae families as well as other ones. The biomass of the edaphic fauna is represented predominantly by the Lumbricidae family. Their number amounts to 71.9-75.9% of the total number of invertebrates. The diversity of invertebrates in the arable and especially in the eroded soils decreases sharply. Representatives of only 2-5 families, usually Lumbricidae, Pyralidae, Scarabaeidae and Araneae families inhabit the eroded chernozems. The number of Lumbricidae family constitutes 60.5% of the total number of invertebrates in chernozem with a normal profile and 42.4-60.7% in eroded soils respectively. Research carried out during tree years show that, application of disking on eroded soils have been more efficiently for vital activity of the edaphic fauna in comparision to "no – till" technique.

Keywords**:** *diversity, eroded soils, invertebrates, tillage.*

INTRODUCTION

Soil invertebrates are an important trophic level in the ecological chain nutrition of the biocenosis. Invertebrates have a great importance for biological processes in soil, increase the fertility and humus formation by mechanical decomposition of plant residues and the formation of water-stable soil structure [4, 5, 10 and 14].

The primordial importance of the biodiversity for the environment maintaining stability and the stable development of communities is reflected in the Convention on Biological Diversity [7]. Invertebrates' diversity is one of the most important evaluation criteria of soil ecosystems, resistance to different forms of degradation [8, 10].

In some ecosystems, the local diversity of soil fauna may be more enormous, then the diversity of different groups of aboveground plants or animals [9]. 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 [4].

Soil biodiversity also can have indirect effects as to whether soil functions as a carbon sink or source. It has been demonstrated that invertebrate's biodiversity affects the erodibility of the soil due to different mechanisms.

This is important with regard to climate change as it has been shown that soil erosion can turn soil from carbon sink to a carbon source [6].

A considerable deterioration of the physical and chemical properties of eroded soils has been observed in the southern zone of the Republic of Moldova [2, 15].

Biota of eroded soils is subjected to the action of several factors that limits their vital

activity: the low organic matter content, compaction, unfavorable hydrothermal conditions. In order to survive in the extreme conditions of the eroded soil invertebrates produced specific adaptation mechanisms that facilitate the maintenance of their vitality and functioning of the soil as the ecological system.

This is manifested in the accelerating lifecycles, changing of daily and seasonal activities and the use of large quantities of the green food by phytophagus, the increase of the heat-loving species and the migration to the underlying soil horizons.

Soil biota needs an easily available carbon with a simultaneous optimization of moisture, aeration, chemical and physical parameters of habitat. This may be achieved by leaving the eroded soils to self-recover with the help of natural fallow [11, 12] and/or by environmental technologies that are based on the use of soil conservation tillage technologies.

Thus is created the basis for the resolution of the problem of creating the soil medium with the resistance to the impact of erosion processes, with the high level of biodiversity and metabolic activities and the long-dated restoration of eroded soil quality.

The purpose of this research is the evaluation of the state of invertebrates in the ordinary chernozem in dependence on the degree of erosion, the type of agricultural uses and the tillage technique to enhance of edaphic fauna contributions to the stability of eroded chernozems.

MATERIAL AND METHOD

Experimental site. The experimental site is located in the southern zone of the Republic of Moldova, on the South Plains steppe area, in the district no. 13 of ordinary and calcareous chernozems of the South Bessarabian steppe plains, in the Ursoaia village of the Lebedenco district and in the Tartaul de Salchie village, Cahul region (photo 1). The experiment with the conventional and no-tillage systems was replicated three times by split-plot design. The area of plots was 1000 m^2.

Photo 1. Fragments of natural and agricultural landscapes located in the southern zone of the Republic of Moldova

Researches were carried out during the period of time between 2008 and 2012.

Soils. The soil of the site is an ordinary chernozem. Arable chernozems with different degrees of degradation caused by erosion processes (slightly, moderately and severely eroded) have been compared to the chernozem with a normal profile under arable and 55-years-old fallow land and the eroded soil which was under 58-years-old fallow.

Status of invertebrates. 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 [14]. The identification of invertebrate's diversity at the level of families and species, and also their classification according to nutrition was conducted by standard procedures [3, 13 and 14].

Soil chemical properties. The humus content was analyzed by the dichromate oxidation method and calculated using the coefficient of 1.724 [1].

Moisture of soils and the dry matter of each soil sample were determined as a weight loss of the pattern after drying at 105^0C to constant weight for 6h.

RESULTS AND DISCUSSIONS

Impact of different land management and erosion processes on soil invertebrates. Ordinary chernozems in conditions of the fallow land have the sharp differences from the arable soils according to faunal indices. Invertebrate's abundance in soils under

natural vegetation was significantly higher than in arable soils. The chernozem with the normal profile in conditions of a long-term fallow (55-yesr-old) is characterized by a higher number and biomass of soil invertebrates in comparison with eroded chernozems which are as fallow as arable (Fig. 1). The number of invertebrates is reached to 448 ex m^{-2}, *Lumbricidae* family – to 340 ex m^{-2}, and its biomass – to 84 and 74.8 g m^{-2} accordingly. The share of earthworms in the total abundance of invertebrates constitutes of 71.9-75.9 % and their biomass – 89.1-91.2 % in fallow soils.

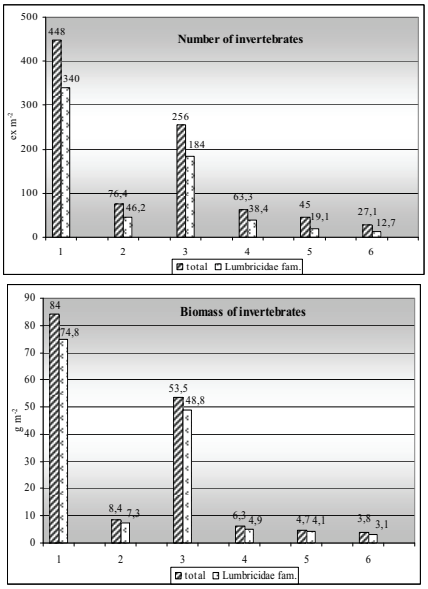

Fig. 1. The abundance of invertebrates in the ordinary chernozem in the dependence of the land uses and erosion degrees (mean values)

The weight of one exemplar of *Lumbricidae* family in fallow soils constitutes 0.22-0.27 g, in the arable chernozem with normal profile – 0.16 g, in arable eroded chernozem – 0.13-0.25 g. It should be noted that the average weight of earthworms increases with the growth of the erosion degree that indicates on the survival of big representatives of this family in eroded soils.

Indices of invertebrates' number and biomass decreased in slightly, moderately and severely chernozems by 16.9-72.5 % and 25.0-57.5 %.

Invertebrates diversity at the class level in ordinary chernozems of the southern zone of the Republic of Moldova is represented by the clases of the *Oligochaeta* – 65.7 %, *Insecta* – 17.9 %, *Miriapoda* – 15.7 % and *Arachnida* – 0.7 % (Fig. 2).

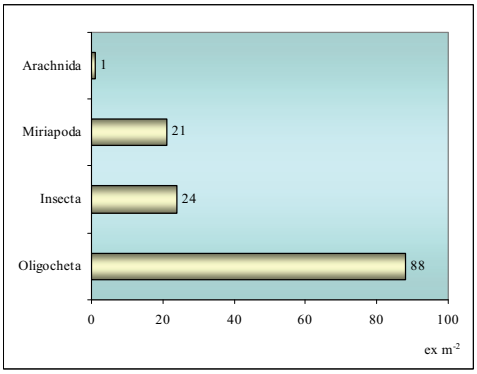

Fig. 2**.** Diversity of invertebrates (on the class level) in ordinary chernozems of the southern zone of the Republic of Moldova

Oligochaeta worms are the most abundant class among all edaphic invertebrates. Their number is the highest in the fallow soils: 422 ex m^{-2} in the chernozem with normal profile and 204 ex m^{-2} in the eroded chernozem.

Arable soils contains the class of Oligochaeta significantly less, their number are reduced in 8,3-17,6 times (Fig. 3). Significant differences in the amount of oligochaetes between soils with different degree of erosion were not observed. This may be due to the fact that number of the biodiversity samples was less than of amount and biomass samples.

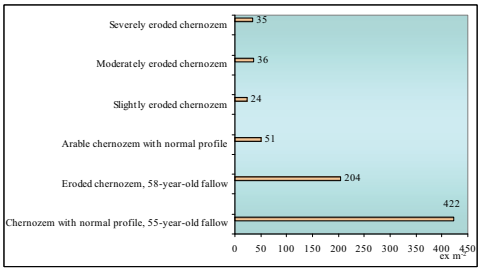

Fig. 3. Populations of the *Olighochaeta* class in the ordinary chernozem in the dependence of the land use management and erosion degrees

The diversity of invertebrates in the arable and especially in the eroded soils decreases sharply. The fallow soil is characterized by a greater diversity of invertebrates. In addition to the *Lumbricidae* family, in samples of invertebrates there were found, the species of the *Arthropoda* and *Lucanidae classes, Chrysomelidae, Forficulidae, Formicidae, Gloremidae, Attelabidae, Tenebrionidae* and *Scarabaeidae* families as well as other ones (Table 1). In general, the soil under natural vegetation contains 5-7 families of invertebrates, while eroded soils – only 2-5. The slightly eroded chernozem contains five families of the edaphic fauna, moderately and severely eroded chernozems – only two families. It should be noted that in faunal cuts of the eroded soil under 58-year-old fallow families of invertebrates, which are not met in the chernozem with normal profile, have been found. These are *Attelabidae, Tenebrionidae, Scarabaeidae* and *Siliphidae* families. But *Chrysomelidae* and *Forficulidae* families were found in the fallow chernozem with normal profile. The abundant presence of the *Formicidae* family represents is observed as in the fallow chernozems so in the eroded ones and with the normal profile.

Saprophagous predominate in the all investigated soils (Fig. 4). Their contribution to the total number of invertebrates is quite substantial and constitues 60.0-87.6 %. The share of saprophagous in the faunal complex of fallow soils constitues 79.7-87.6 % while in arable soils – 60.0-76.1 %. The contribution of phytophagous to the total number of invertebrates is significantly less and increase from fallow chernozems to arable chernozems, constituting 0.9-18.8 % and 10.1-40.0 %. Invertebrates with the mixed nutrition type in fallow soils amount to 1.6-4.9 %, in arable soils – 11.1-20.3 %. Zoophagous were found only in the chernozem with normal profile – 5.1 %, and predators in the amount of 11.1 % in the arable eroded chernozem.

Ecological pyramids in fallow chernozems are characterized by a higher stability in comparison with arable chernozems.

Lumbricus terrestris specie is the most typical representative of the *Lumbricidae* in the all soils of the southern zone. *Pyrochroa serraticornis, Ropalopus macropus, Maloë violaceus, Gnorimus nobilis, Pyransta nubilalis* and *Pieris napi* species were represented everywhere in the soils. *Lucanus cervus* was found rarely in eroded chernozem under 58-year-old fallow. Differences between the type of land management were more substantial than those between the degrees of erosion.

Table 1. Diversity of soil invertebrates (on the family's level) in ordinary chernozems of the southern zone of the Republic of Moldova, ex m^{-2}

Nr.	Family	Chernozem with normal profile, 55-year-old fallow	Eroded chernozem, 58-year-old fallow	Arable chernozem with normal profile	Slightly eroded chernozem	Moderately eroded chernozem	Severely eroded chernozem
1	Lumbricidae	338	184	35	20	36	35
2	Glomeridae	84	20	16	4	0	0
3	Attelabidae	0	36	0	0	0	0
4	Tenebrionidae	0	8	0	0	0	0
5	Scarabaeidae	0	4	0	4	0	5
6	Siliphidae	0	4	0	0	0	0
7	Elateridae	0	0	8	0	0	0
8	Pyralidae	0	0	16	4	24	6
9	Carabidae	0	0	4	0	0	0
10	Araneae	0	0	0	4	0	0
11	Chrysomelidae	4	0	0	0	0	0
12	Forficulidae	22	0	0	0	0	0
13	Formicidae	+	+	0	0	0	0
Total		448	256	79	36	60	46

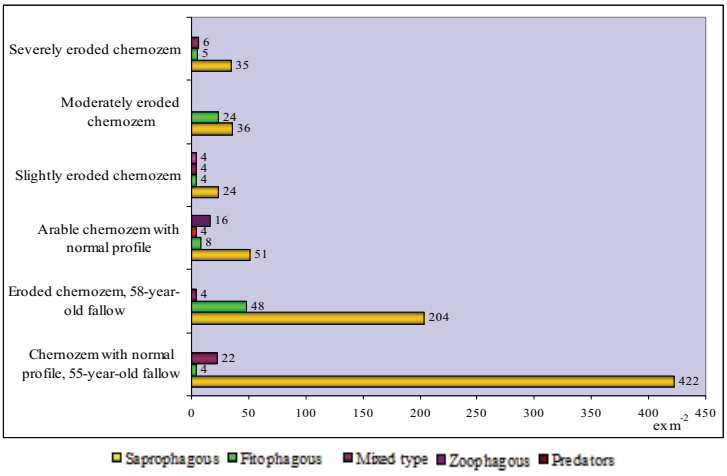

Fig. 4. The composition of invertebrates on the mode of nutrition

Influence of the different soil tillage on invertebrates in the slightly eroded chernozem. The tillage system for the eroded soil has represented one of the main elements of reclamation technology, which, as was supposed, will be restored the invertebrates abundance.

The number and biomass of total invertebrates and *Lumbricidae* family varied in the wide limits in the dependence of the selection dates, the moistness and the organic matter content (Fig. 5). The maximum values of indices were fixed in the spring, when the moisture content constituted 19.0-20.9 %. The minimum values were registered in the autumn. The content of moisture during some periods constituted 11.2 %.

Differences between treatments manifested to the third year of the research. The conventional tillage (arable on 20-25 cm) and disking 15 cm contributed to the improvement of the vital activity of earthworms. Their number constituted 78-88 ex m^{-2}, while the variant with the no-tillage system contained 24 ex m^{-2}. The application of disking on eroded soils have been more efficiently for the edaphic fauna as compared to "no – till" technique during the three years of investigations.

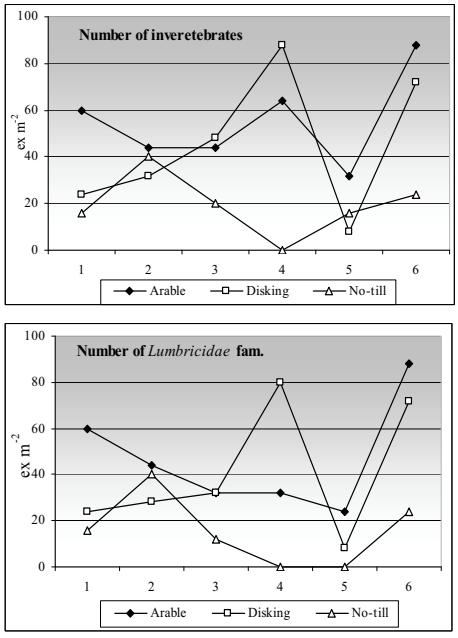

Fig. 5**.** The effect of different methods of tillage of the slighyly eroded chernozem on the number and biomass of invertebrates: 1-6 – selection dates (2010-2012)

The humus content did not differ significantly depending on the type of treatment.

CONCLUSIONS

The long arable utilization of soils and erosion processes has been rendered disastrous effects on the soil invertebrates of the southern zone of the Republic of Moldova. The highest values abundance and biomass of invertebrates were registered in the soils with a normal profile as well as in the soils with a truncated profile in conditions of the multiannual fallow under natural vegetation. The fallow soil is characterized by a greater diversity of invertebrates. Ecological pyramids in fallow chernozems are characterized by a high stability in comparison with arable chernozems.

The catastrophic loss of biomass, of the edaphic fauna diversity represents a particularity of arable eroded chernozems. Differences between the types of the land management were more substantial than those between the degrees of erosion.

The application of disking on the eroded soils has been more efficient for vital activity of the edaphic fauna in comparison to the no-till technique.

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REFERENCES

[1] Arinushkina, E.V., 1970. *Guide for chemical analysis of soils*. MGU, Moscow, 487 p.

[2] Boaghe, L., 2010. *Properties and regimes of eroded ordinary chernozemus in the Southern Zone of Moldova and measures for preventing accelerated degradation*. PhD thesis in biology. USM, Chişinău, 30 p.

[3] Cozari, T., 2010. *Insectele*: Mică enciclopedie. Arc: Î.E.-P. Ştiinţa, Chişinău, 176 p.

[4] Huhta, V., 2007. *The role of soil fauna in ecosystems: A historical review*, Pedobiologia, Volume 50, Issue 6: 489- 495.

[5] Jouquet, P. Dauber, J, Lagerlof, J.P. Lavelle, M. Lepage, 2006. *Soil invertebrates as ecosystem engineers: intended and accidental effects on soil and feedback loops*, Appl. Soil Ecol., 32:153-164.

[6] Lal, R., Pimentel, D., and oth., 2008. *Soil Erosion: A Carbon Sink or Source,* Science, 319: 1040 – 1042.

[7] *Millennium Ecosystem Assessment. Ecosystems and Human Wellbeing: Synthesis. sland Press*, Washington,DC.2005,(http://www.maweb.org/en/Reports.aspx#;http://www.millenniumassessment.org/en/Reports.aspx#).

[8] Naeem, S., Loreau, M., Inchausti, P., 2002. *Biodiversity and ecosystem functioning: the emergence of a sysnthetic ecological framework, in: Loreau*, M., Naeem, S., Inhausti, P. (ed.), Biodiversity and ecosystem functioning: synthesis and perspectives. – Oxford University Press, 3-11.

[9] Schaefer, M., Schauermann, J., 1990, *The soil fauna of beech forests: comparison between a mull and a moder soil,* Pedobiologia (Jena), 34: 299–314.

[10] Schwartz, M.W., Brigham, C.A., Hoeksema, J.D., Lyons, K.G., Mills, M.H., van Mantgem, P.J., *Linking biodiversity to ecosystem function: implications for conservation biology*. Ecologia, 2000, 122: 297-305.

[11] Senicovscaia, I., 2012. *Degradation and Recovery of Biota in Eroded Chernozems of the Republic of Moldova*. Scientific Papers Series “Management, Economic Engineering in Agriculture and Rural Development”, Vol. 12, Issue 1, Bucureşti, 225-230.

[12] Senicovscaia, I., Marinescu, C. and oth., 2012. *Instrucţiuni metodice privind evaluarea şi sporirea rezistenţei biotei solurilor în condiţiile intensificării proceselor de degradare*. Pontos, Chişinău, 76 p.

[13] Toderaş, I., Vladimirov, M., Neculiseanu, Z., 2007. *Lumea animală a Moldovei*. Arc: Î.E.-P. Ştiinţa, Chişinau, 195 p.

[14] ****Quantitative Methods in Soil Zoology*, 1987, Ed. Gilyarov M.S., Striganova B.R., Nauka, Moscow, 228 p.

[15] *****The complex program of recovery of degraded lands and increase of soil fertility*. Part I, 2004. R. resp. S.Andries, Pontos, Chisinau, 212 p.