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Maria MARKO-WORŁOWSKA[1], Anna CHRZAN[1*]
and Tomasz ŁACIAK[2]

IMPACT OF ANTHROPOPRESSURE ON MEADOW AND GROVE PEDOFAUNA IN LANDSCAPE PARK IN KRAKOW-ZAKRZOWEK

WPŁYW ANTROPOPRESJI NA PEDOFAUNĘ ŁĄKI I ZAGAJNIKA W PARKU KRAJOBRAZOWYM W KRAKOWIE ZAKRZÓWKU

Abstract: The consequence of accumulation of heavy metals (that can be detected in trace content in natural conditions) in soil is biological deactivation of environment manifesting in limitation of processes of organic substances decomposition by decreasing density, diversity and activity of the microorganisms and pedofauna.

In order to evaluate the impact of pollution of environment by heavy metals a few chosen physiochemical parameters of meadow and grove soil in Landscape Park were detected.

It was noted that soil of researched areas had slightly alkaline reaction, whereas concentration of Cd, Pb and Zn was higher in young pine forest soil, however only concentration of Cd in both areas was above the norm. In the soil of the meadow considerably higher density and diversity of groups of pedofauna analyzed was detected. In 1 m^2 of meadow soil 4928 specimen were noted, while 3264 in forest soil. In the meadow *Diptera* larvae was the most diverse group, since within its order 10 families were isolated. In forest soil specimen of 4 *Diptera* larvae families were noted. Trophic relations of dipterofaunal larvae communities biomass significantly differ from a model designed for natural meadows.

Keywords: pedofauna, density, diversity, heavy metal, *Diptera* larvae

The soil animals, due to their various relations, are very important factors in the soil formation processes, mineralization, but also in the humification of the dead organic matter. As a result of their search for the nutrition the survival and vegetative forms of bacteria and fungi spread mainly in the form of the undigested leftovers of nutrition of the soil animals. In that way, the microorganisms can settle on the new deposits of the organic matter. The fragmentation and mixing by the soil invertebrates of the organic

[1] Department of Ecology, Wildlife Research and Ecotourism, Institute of Biology, Pedagogical University of Krakow, ul. Podbrzezie 3, 31–054 Kraków, Poland, email:, mmw@ap.krakow.pl chrzan@ap.krakow.pl

[2] Department of Vertebrate Zoology and Human Biology, Institute of Biology, Pedagogical University of Krakow, ul. Podbrzezie 3, 31–054 Kraków, Poland, email: tlaciak@up.krakow.pl

* Corresponding author: annachrzn871@gmail.com

matter coming to the soil is extremely important, because it makes the organic matter available for the microorganisms [1, 2]. Due to its mobility, the pedofauna (mainly meso- and macrofauna) influences as well the aggregate structure of the soil and the size of the pores and tubules. Therefore, in this way the pedofauna determinates the absorption, maintenance and storage of the water by the soil. This capacity of the pedofauna explains the fact that many researchers call it "soil engineer". It is claimed that the matter coming to the soil passes through the alimentary canal of the soil animals at least once and that their excrements constitutes almost the entire level of the soil humus [3]. Soil fauna represents the large number of species, which play an important role in different ecosystem functions, such as the transfer of organic matter in soil or soil structure dynamics [4, 5].

The number of pedofauna specimen in m^2 of the meadow soil can reach around 260 mln (among them about 200 mln are Protozoa) with the biomass around 150 g d.m. among which the most dominant group is microfauna [6]. The number of the meso- and macrofauna is lower and can even reach 54000, whereas the biomass of meso and macrofauna is similar to those of microfauna [7]. Macrofauna are one of animals groups that occur in litter and soil in big numbers, especially big biomass, high diversity and different trophic relations. In temperate beech forest there may be as many as a 1000 species of animals, among which 200 species of arthropods in 1 m^2 of soil [8]. In the average soil of the various land ecosystems around 150 *Lumbricidae* in 1 m^2 was detected, whereas the density of the remaining macrofauna (the most of *Coleoptera* larvae and other *Insecta*, imagines *Formicidae* included , as well as *Aranea*) can reach a few hundred in 1 m^2. The density of mesofauna that is *Collembola*, *Acarina and* small *Diptera* larvae can reach several dozen thousands [3, 7]. Because of the fact that similar groups of invertebrates appear in various types of the soils in great numbers and that the borders of the groups are clearly defined, the pedofauna is frequently used in the researches on the impact of pollutions on the soils [8–10]. Monitoring studies using bioindicators provide information on the assessment of environmental pollution, the spread of contaminants and their bioavailability. Mechanisms of penetration of the analytes and the influence of abiotic factors on their accumulation in the structures of sorption in indicator organisms have not yet been sufficiently identified [11]. The various human activities influence the quality of the ecosystems, causing, for example, the changes in density, biomass, size as well as species and genetic diversity within pedofauna. Many researchers report the drastic reduction of the number and diversity of species within pedofauna as a result of the use of the pesticides and the contamination of the soil by the heavy metals [10, 12]. Soil contamination of heavy metals can have dramatic effects on soil invertebrates and therefore can lead to significant changes in the functioning of the soil [13]. It was indicated, that the most sensible to the pollutions are the *Oligochaeta* and the larvae of the most insects, because the humid surface of their bodies enables the diffusion of the pollutions, dissolved in the soil solution, to their tissues.

The consequence of the accumulation of the heavy metals in the soil (that can be detected in trace content in natural conditions) is the biological deactivation of the environment. This process is manifested, among others, in the limitations of the organic matter decomposition processes because of the reduction of the density, diversity and activity of the microorganisms and pedofauna.

In this perspective, the evaluation of the changes in the density, biomass and diversity of these animals, caused by the various human activities is an essential task. For the level of predators the highest concentration of toxic pollutants is available. Therefore the trophic structures of density and biomass of *Diptera* larvae communities, with particular attention to analysis of the predators were examined. The structure was compared with another trophic structure of biomass of *Diptera* larvae groups typical for the areas with low emission of pollutions [14].

Materials and methods

In order to evaluate the impact of the anthropopressure on the soil subsystem a few chosen physiochemical and biological parameters, that were: soil moisture [%] and pH of the soil, density and diversity of meso- and macrofauna, density and biomass as well as diversity within the *Diptera* larvae in the meadow and grove soil in the Landscape Park were detected. On the area of the Bielansko Tyniecki Landscape Park 2 types of habitats were chosen:

1. The meadow in Krakow-Zakrzowek;
2. The pine grove-around 40-year old situated near the meadow, but lower and nearer to the traffic lane.

With the use of Morris square frame (25 cm by 25 cm) a series of samples was taken on the selected sites during autumn 2008. The frame was thrust into the soil on the depth of 10 cm. In each particular site a series consisted of 16 tests on the surface of 1 m^2. Invertebrates were scampered away by employing the dynamic method in the modified Tullgren apparatus. After marking select meso- and macrofauna its density and diversity were analyzed in detail. Soil moisture and its pH and temperature as well as the content of Pb, Zn, Cd, Cu, were determined owing to the method FAAS (AAS firmy Cole-Parmer, BUCK 200A).

Diptera larvae biomass was determined by measuring their length, then the rate based on Schatz [15] and Petersen & Luxton [16] was applied. *Diptera* larvae trophic relations were indicated on the basis of Gobat et al and Brauns [17, 18].

Results and discussion

It was noted that soil of researched areas had slightly alkaline reaction, because their pH was from 7.38 to 7.78 (Table 1). Since only the low pH increases the assimilability of the heavy metals (mainly Pb and Cd) by the soil organisms, the reaction was not the increaser of the metals mobility in the researched areas [19, 20].

The soil moisture [%] of the meadow soil was on average around 8 % higher than the grove soil. It indicates that, in this case, the soil moisture causes the changes in the density and diversity of the group of pedofauna analyzed (Table 1).

Table 1

General characteristics of soil and pedofauna

Parameter	Grove	Meadow
Number meso- macrofauna [sp. N/m^2]	3264	4928
Diversity (number of taxonomic group)	17	19
Diversity *Diptera* larvae (number of families)	4	11
Biomass *Diptera* larvae [mg/m^2 d.m.]	14.77	398.33
Soil pH	7.65 (7.56–7.74)	7.57 (7.36–7.78)
Soil moisture [%]	20.95 (20.2–21.7)	28.55 (25.2–31.9)

The differences in Cd, Pb, Zn and Cu content were noted as well. In the grove soil the number of Cd, Pb and Zn was higher than in the meadow soil, whereas the number of Cu was higher in the meadow soil (Fig. 1). As the research indicates, only the number of Cd in both habitats was above the norm- that is 1 mg/kg d.m. [21]. However, in the meadow the number of Cd was slightly less than two times above the norm (1.9 mg/kg d.m.), whereas in the grove almost two and a half times higher (2.3 mg/kg d.m.).

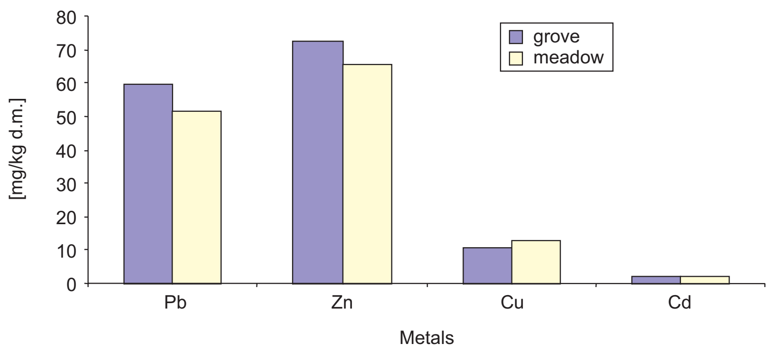

Fig. 1. Concentration of heavy metals in soil of areas analyzed [mg/kg d.m.]

Cd and Pb are the elements strongly influencing the environment, qualities of the soils and plants and health of people and animals [22]. As the research concerning fauna indicates, the considerable pollution of the soil by Cu and Pb leads to the changes in the soil qualities, biological among others [8, 9]. In the habitats analyzed, apart from the changes in the density and diversity of the meso- and macrofauna, the changes within *Diptera* larvae groups were noted as well (Table 2 and 3).

The content of the metals analyzed in the chosen habitats correlated with the number and diversity of the fauna analyzed. In the meadow soil the lower concentration of Cd, Pb and Zn was noted in comparison to the grove soil. What is more, in 1 m^2 of the meadow soil the highest density (4928 specimen) of the animals analyzed was detected. Also in the meadow soil the highest diversity of meso- and macrofauna was noted

Table 2

Density [sp. no./m^2] and indicator of domination [%] of pedofauna

Taxonomic group	Grove		Meadow	
	[sp. N/m^2]	[%]	[sp. N/m^2]	[%]
Lumbricidae	8	0.25	16	0.32
Symphyla	24	0.74		
Lithobius sp.	56	1.72	48	0.97
Geophilus sp.	48	1.47	24	0.49
Julus sp.	16	0.49		
***Coleoptera imago*:**				
Staphylinidae	8	0.25	40	0.81
Carabidae			8	0.16
Ptilidae	40	1.22		
Coleoptera larvae	72	2.21	40	0.81
Thysanoptera	56	1.72	8	0.16
Gastropoda			8	0.16
Isopoda	16	0.49	8	0.16
Diptera imago	16	0.49	16	0.32
Diptera larvae	32	0.98	**200**	4.06
Hymenoptera imago:				
Formicidae	32	0.98	56	1.14
Collembola	**1200**	**36.76**	**1920**	**38.96**
Pseudoscorpionidae	16	0.49		
Protura	24	0.74	16	0.32
Aranea			8	0.16
Acarina	**1552**	**47.55**	**2456**	**49.84**
Lepidoptera imago			8	0.16
Lepidoptera larvae			32	0.65
Dermoptera			16	0.32
Homoptera larvae	48	1.47		
Sum total	3264		4928	

(Table 2). The researches concerning *Diptera* larvae confirm clearly the results. *Diptera* larvae were analyzed in detail taking into consideration the number of the various families within their groups, and their density and biomass. The higher diversity, density and biomass of larvae in comparison to the grove soil were detected in the meadow soil (Table 3).

Moreover, according to the indicator of domination the part of *Diptera* larvae was bigger in the groups of the meadow pedofauna (Table 3). *Diptera* larvae are character-

Table 3

Density and biomass of *Diptera* larvae

Familie Name	Trophic group	Grove		Meadow	
		[N/m^2]	[mg/m^2 d.m.]	[N/m^2]	[mg/m^2 d.m.]
Cecidomyiidae	Ph	8	2.11	32	10.56
Chironomidae	S			16	7.39
Limoniidae	P			16	17.39
Syrphidae	Ph			8	4.22
Dolichopodidae	P	8	4.22	16	9.5
Ceratopogonidae	S	8	4.22	40	17.95
Phryneidae	S			8	6.34
Stratiomyiidae	S			8	89.76
Tipulidae	Ph			16	40.92
Lonchaeidae	S	8	4.22	40	194.30
Sum total		32	14.77	200	398.33

S – Saprophag; P – Predator; Ph – Phytophag; [density] = N/m^2; [biomass] = mg/m^2 d.m.

ized by wide morphological, ecological and behavioral diversity. They may use different food resources offered by the soil. Trophic relations of dipterofaunal communities were also analyzed (Fig. 2) and were compared with the model designed for natural meadows by Ciesielska [14].

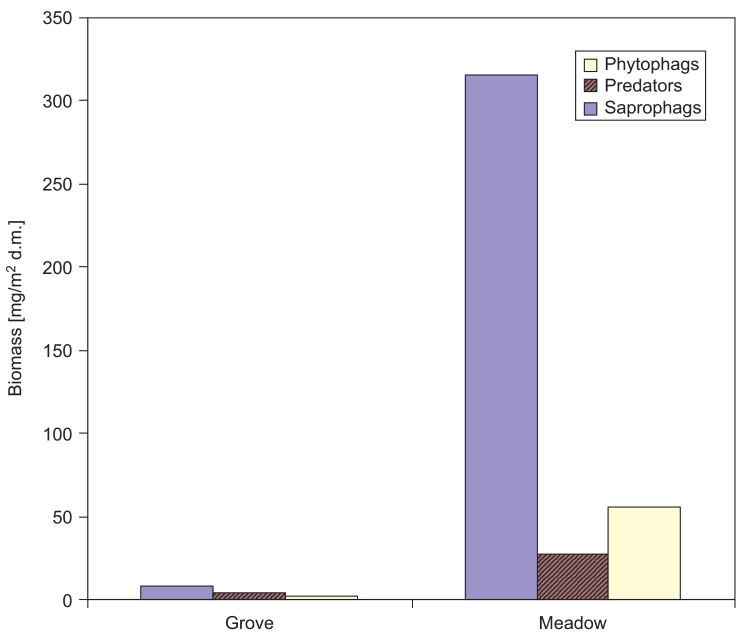

Fig. 2. Trophic relations of *Diptera* larvae communities biomass

Trophic relations of dipterofaunal larvae communities biomass significantly differ from a model. These differences depend on very small participation of saprophags against phytophags and predators, and may point at disturbances in the soil subsystem on studied localities caused by anthropogenic pressure. At the same time very high biomass of predators and saprophags larvae in the meadow shows smaller human impact than in the grove.

Dusts emitted by the non-ferrous foundries, carbon burning and traffic pollutions are the main sources of the spot and area pollutions of the soils by the heavy metals. The amount of the pollutions emitted by the motor vehicles apart from the size of the traffic intensity is determined mainly by the distance from the road and landform features. The danger increases accordingly to the traffic intensity and is generally limited to the width of 150–200 m at each side of the road [23]. In the conducted research, apart from the industry and carbon burning, the traffic is one of the main sources of the pollutions. The traffic is probably one of the sources of the higher concentration of Cd, Pb and Zn in the grove soil – situated lower than the meadow and nearer to the busy Tyniecka street.

Conclusions

In the grove soil the content of Cd, Pb and Zn was higher than in the meadow soil, whereas the content of Cu was higher in the meadow soil.

The content of heavy metals in the chosen habitats correlated with the number and diversity of the soil fauna.

The higher diversity, density of pedofauna and biomass of *Diptera* larvae in comparison to the grove soil were detected in the meadow soil.

Trophic relations of dipterofaunal larvae communities biomass may point at disturbances in the soil subsystem on studied localities caused by anthropogenic pressure.

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WPŁYW ANTROPOPRESJI NA PEDOFAUNĘ ŁĄKI I ZAGAJNIKA W PARKU KRAJOBRAZOWYM W KRAKOWIE ZAKRZÓWKU

Instytut Biologii
Uniwersytet Pedagogiczny w Krakowie

Abstrakt: Konsekwencją kumulacji metali ciężkich w glebie (występujących w warunkach naturalnych w ilościach śladowych) jest dezaktywacja biologiczna środowiska przejawiająca się m.in. ograniczeniem procesów rozkładu substancji organicznych poprzez zmniejszenie zagęszczenia, różnorodności i aktywności mikroorganizmów oraz pedofauny.

W celu oceny wpływu zanieczyszczenia środowiska metalami ciężkimi zbadano wybrane parametry fizykochemiczne w glebie zagajnika i łąki w Parku Krajobrazowym w Zakrzówku.

Stwierdzono, że gleba badanych siedlisk wykazywały odczyn lekko zasadowy, natomiast stężenie Cd, Pb i Zn było wyższe w glebie młodego zagajnika sosnowego, ale tylko w przypadku kadmu w obydwu siedliskach przekraczało normę. W glebie łąki wykryto znacznie większą liczebność i różnorodność pedofauny. W 1 m^2 gleby łąkowej odnotowano 4928 osobniki, a w glebie leśnej 3264. Na łące larwy *Diptera* były najbardziej zróżnicowaną grupą, bowiem w ich obrębie wyodrębniono przedstawicieli 10 rodzin. W glebie leśnej odnotowano tylko 4 rodziny larw *Diptera*. Struktura troficzna larw *Diptera* w biomasie znacznie różni się od modelu stwierdzonego dla naturalnych łąk.

Słowa kluczowe: pedofauna, zagęszczenie, różnorodność, metale ciężkie, larwy *Diptera*