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SOIL MITES DIVERSITY FROM POLLUTED GRASSLAND ECOSYSTEMS IN TRASCĂU MOUNTAINS (WESTERN CARPATHIANS – ROMANIA)

Minodora MANU[1], Marilena ONETE[1], Virgil IORDACHE[2]

[1]Romanian Academy, Institute of Biology, Department of Ecology, Taxonomy and Nature Conservation, street Splaiul Independenţei, no. 296, zip code 0603100, PO-BOX 56-53, Tel. 040212219202, Fax 040212219071, Bucharest, Romania.
Email: minodora_stanescu@yahoo.com and marilena_onete@gmail.com
[2]Research Centre for Ecological Services (CESEC), Faculty of Biology, University of Bucharest, Romania.
Email: virgil.iordache@g.unibuc.ro

Corresponding author email: minodora_stanescu@yahoo.com

Abstract

The study was made in 2013 - 2014, in Trascău Mountains, situated in the south-eastern part of the Apuseni Mountains (Western Carpathians), in their southern limit, represented by the Ampoi valley. In order to determine the mite diversity, 300 soil samples were investigated from twelve grassland ecosystems, taking into account the pollution level source (an old chimney plant, which provided heavy metals pollutants: As, Cu, Zn, Pb, Mn, Ni). The altitude of grasslands varied from 464 m to 958 m, and the distance from pollution source from 975 m to 3200 m. In total, 4447 individuals were counted, belonging to the following mite orders: Trombidiformes (5.42 %), Sarcoptiformes (72.65 %) and Mesostigmata (21.92 %).
In order to assess the diversity aspects of edaphically mites, a comparative analyse was made between the natural and anthropogenic ecosystems. The highest mite diversity was recorded in natural area (grassland G12 - on 3146.52 m distance from pollution source), with 639 individuals, belonging to the 14 mite families and Shannon_H index by 1.412. On the opposite is grassland G9 (on 1311.65 m distance from pollution source), with 253 individuals from 8 families and Shannon_H index by 0.573. Dominant mites were oribatids, decomposers of the organic matter, followed by the mesostigmatids (mostly represented by Ascidae, Laelapidae and Rhodacaridae families, which are predators).
The similarity of mite presence and composition was assessed using Jaccard and respectively Bray-Curtis dendrograms. Evidence from Shannon evenness, Shannon-Weaver diversity and Simpson dominance indexes indicate that in the areas with a low taxa diversity, there is a dominance of few species with individuals unequally distributed between plots.Each investigated grassland ecosystems were characterized by characteristically mite diversity. This study represents a valuable argument for using the soil mite fauna as bioindicators.

Key words: acari, diversity, heavy metals, similarity.

INTRODUCTION

Mites are one of the most abundant edaphic fauna groups from terrestrial ecosystems that are directly or indirectly participate on the soil pedogenesis (Walter and Proctor, 2003; Krantz and Walter, 2009).
In grassland the trophic spectrum of the mites are very wide, from polyphagous to the high specialized species, parasites, herbivores, fungivores, microbivores, detritivores, scavengers and omnivores (Walter et al., 1988; Behan-Pelletier and Kanashiro, 2010).
Soil mites are very sensitive to any natural or anthropical disturbances, their being often used as bioindicators (Kardol et al., 2011; Nielsen et al., 2010, 2012).
In Romania, some qualitative and quantitative studies the edaphic microarthropods fauna from natural grassland ecosystems were made only in Moldavian Plain that is placed in the North-East of Romania (Călugăr, 2006 a, b).
Our objective is to establish a comparative diversity analysis of the soil mite fauna from twelve polluted grassland ecosystems from Romania, taking into account of the some environmental variables and heavy metals pollutants from the investigated areas (Pb, Zn, Mn, Cu, As, Ni).

MATERIALS AND METHODS

The present study was made in June, September-2013 and April-2014, in twelve grassland ecosystems situated in Ampoi Valley, from Trascău Mountains, located in the south-eastern part of the Apuseni Mountains (Western Carpathians) (Figure 1). The pollution source is represented by an old chimney plant, situated in the proximity of the Zlatna city, one of the most famous industrial centres in Romania for the extraction of copper, lead, gold and silver, mainly in the communism period (1953-1993).

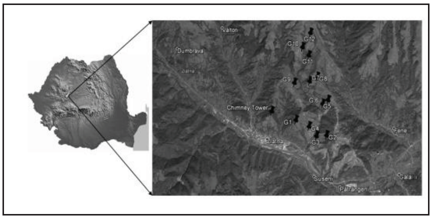


Figure 1. Geographical position of the investigated grassland ecosystems from Trascău Mountains.

The altitude of grasslands varied from 464 m to 958 m, and the distance from pollution source from 975 m (G1) to 3200 m (G12-natural ecosystem). Most of the recorded plant species were xerophytic, hemicryptophyte and perennial. Those species with the overall highest coverage percentage were *Agrostis capillaris, Nardus stricta, Rumex acetosella* and *Trifolium pratense*. The precise local coverage of these species varied greatly with respect to the anthropic impact in the area (overgrazing and pollution) and these species were not uniformly distributed in all investigated plots.

The concentration of the six heavy metals being investigated along the Ampoi valley was mapped using XRF (X-ray fluorescence spectrometer).

In one investigated area by 2500 sq.m. 25 cores were sampled for mite fauna, to a depth of 10 cm with a MacFadyen corer, by 5 cm diameter. The samples (300) were taken randomly. The mites were extracted with a modified Berlese-Tullgren funnel, in ethyl alcohol, clarified in lactic acid and identified to family level, using actual published identification keys.

4442 mites were extracted from the 300 soil cores (296 individuals from Trombidiformes order, 3185 from Sarcoptiformes order and 961 individuals from Mesostigmata).

In order to assess the diversity aspects of edaphically mites, a comparative analyse was made between the natural and anthropogenic ecosystems. Mite diversity (Shannon index), dominance (Simpson's index) and evenness (E index) were calculated using the procedures BioDiversity Pro 2.0, PAST (Hammer et al., 2001). The similarity of mite presence and composition was assessed using Jaccard (q_J) and respectively Bray-Curtis (q_{BC}) dendrograms.

RESULTS AND DISCUSSIONS

The investigated heavy metals pollutants were: arsenic (As), copper (Cu), manganese (Mn), nickel (Ni), plumb (Pb) and zinc (Zn). All values were compared with the admissible normal values of the heavy metals according to the national law (Ministry Order no. 756 from 3 November 1997 concerning the arrangement approval of the environmental pollution assessment). The arsenic concentrations exceed the normal values in all twelve grasslands, following a distance gradient, decreasing from G1 to G12. The same situation was recorded on copper, but with one exception: in G4 was identified one of the highest concentration of this heavy metal. On manganese the normal values were exceeding only in G2, G7, G8, G10 and G11, in the other ecosystems the concentrations decreased till 387.46 mk/kg^{-1}. If we take into consideration nickel and plumb concentrations these were decreasing in ecosystems situated on a high distance from the pollution source. In G5, G10, G11 and G12 the zinc concentrations are lower than the normal value, and in the remaining grasslands that heavy metal recorded increased values, with a maximum at G1 (Table 1).

If we take into consideration the mite fauna, the most abundant group was Sarcoptiformes order, mainly represented by oribatids. Oribatids are soil invertebrates that included many trophycal categories, as macrophytophagous, microphytophagous and panphytophagous species, beeing in the same time saprophagous and second consumers, decomposing the organic matter. They are involved in decomposing processes and in turnover process, making available the organic matter to plants (Walter et al., 1988; Walter and Proctor, 2003; Krantz and Walter, 2009; Nielsen et al., 2012).

Table 1. Average concentrations (mg/kg^{-1}) of heavy metals identified in soil from the grassland ecosystems (n.v. = normal values according to the Romanian law M.O. no.756/1997; ± = standard deviation)

Grassland	As	Cu
G1	55.31 (± 1.86)	576.3 (± 71.32)
G2	23.22 (± 2.62)	135.55 (± 61.54)
G3	24.38 (± 2.74)	147.17 (± 71.51)
G4	23.37 (± 2.95)	305.64 (± 49.16)
G5	15.68 (± 5.99)	91.49 (± 29.87)
G6	13.03 (± 5.80)	100.66 (± 64.64)
G7	21.04 (± 2.12)	156.35 (± 76.52)
G8	24.38 (± 2.62)	80.1 (± 27.54)
G9	10.04 (± 4.73)	63.63 (± 21.62)
G10	12.07 (± 3.01)	52.16 (± 16.19)
G11	10.89 (± 4.52)	46.56 (± 12.44)
G12	7.36 (± 5.57)	22.11 (± 11.36)
N.v.	5	20
Grassland	Ni	Pb
G1	34,13 (± 8.82)	421.12 (± 71.62)
G2	109.72 (± 12.52)	155.24 (± 54.27)
G3	73.74 (± 11.45)	167.23 (± 56.22)
G4	125.80 (± 22.80)	278.96 (± 36.03)
G5	109.06 (± 13.01)	102.49 (± 34.19)
G6	127.23 (± 16.37)	105.16 (± 48.22)
G7	162.82 (± 27.02)	110.68 (± 51.67)
G8	125.94 (± 19.76)	69.76 (± 16.52)
G9	105.25 (± 24.51)	71.16 (± 17.41)
G10	102.56 (± 23.04)	57.63 (± 15.40)
G11	121.83 (± 19.73)	36.88 (± 9.04)
G12	100.45 (± 18.40)	28.21 (± 4.62)
N.v.	20	20
Grassland	Mn	Zn
G1	616.34 (± 81.77)	211.69 (± 18.72)
G2	920.68 (± 95.62)	161.12 (± 15.13)
G3	896.74 (± 57.78)	204.18 (± 18.76)
G4	869 (± 51.07)	224.57 (± 19.87)
G5	387.46 (± 69.58)	99.66 (± 13.32)
G6	454.91 (± 77.03)	121.57 (± 21.02)
G7	1156.17 (± 451.65)	162.83 (± 16.12)
G8	1344.38 (± 511.34)	121.09 (± 20.98)
G9	672.78 (± 85.73)	119.4 (± 20.56)
G10	1071.34 (± 437.92)	90.83 (± 14.35)
G11	911.17 (± 137.47)	91.27 (± 13.91)
G12	854.91 (± 115.33)	74.49 (± 8.41)
N.v.	900	100

If we taking into account the numerical densities of the soil mites, the species from Mesostigmata order were on the second place, mainly represented by Ascidae, Lealapidae and Rhodacaridae families. They are predators, feeding on immature of oribatids or other soil invertebrates. These invertebrates are frequently found in anthropic ecosystems, as: urban parks, spoilt areas, industrial and derelict areas. Species from Trombidiformes order had the lowest number of individuals, being represented by predators species from Bdellidae family (feeding with arthropods eggs, nematodes), Cunaxidae family (feed on microarthropods in soil, plant debris, moss, or straw), Trombidiidae, and Tydeidae families (feeding with small mites that scavenge or feed on fungi on plant surfaces) (Walter and Proctor, 2003; Krantz and Walter, 2009) (Table 2).

In total, 4442 individuals were counted, belonging to the following soil mite orders: Trombidiformes (5.42%), Sarcoptiformes (72.65%) and Mesostigmata (21.92%).

According to other studies from the natural grasslands, the most abundant species are prostigmatids, followed by oribatids and mesostigmatids (Battigelli and McIntyre, 1999; Battigelli et al., 2003; Osler et al., 2008; Behan-Pelletier and Kanashiro, 2010). Due to the anthropic impact (heavy metal pollution), in the present study the situation is different, the dominant species being oribatids-Sarcoptiformes order, followed by mesostigmatids-Mesostigmata order and the last by the prostigmatids-Trombidiformes order.

Making a comparison between grasslands, the highest mite diversity was recorded in natural area G12 (situated on 3146.52 m distance from pollution source), with 639 individuals, belonging to the 14 mite families and Shannon_H index by 1.412. On the opposite is G9 (on 1311.65 m distance from pollution source), with 253 individuals from 8 families and Shannon_H index by 0.573. The highest dominance index was recorded in G10 and G12, less polluted areas. On opposite are the G3, G5 and G9 ecosystems, where the Ni, As, Pb, Cu and Zn exceed the normal values. The evenness index indicate that in the areas with a low taxa diversity, there is a dominance of few species with individuals unequally distributed between investigated areas (Figure 2).

In order to make a comparison between soil mite populations, some similarity indexes were established. If we take into consideration the numerical abundance of the all mites, the Bray-Curtis index of similarity showed us that these invertebrates were grouped as following: those from G1-G2-G10-G11; G3-G4-G6-G12 and G5-G7-G8-G9.

Table 2. Numerical abundance of the soil mite fauna from investigated grassland ecosystems.

Systematic group		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Order	Trombidiformes												
Suborder	Prostigmata												
Family	Tydeidae	62	49	24	1	4	2	29	10	5	0	4	0
	Trombidiidae	0	0	0	1	4	4	0	2	1	1	1	16
	Cunaxidae	0	0	0	1	6	0	0	0	0	2	3	4
	Bdellidae	0	0	0	0	0	2	0	0	0	0	0	0
	Total	62	49	24	3	14	8	29	12	6	3	8	20
Order	Sarcoptiformes												
Suborder	Oribatida	122	141	398	311	220	455	239	260	219	108	157	310
Family	Acaridae	0	0	0	19	0	128	0	0	0	23	27	42
	Glycyphagidae	0	0	0	0	5	0	0	0	0	1	0	0
	Total	122	141	398	330	225	583	239	260	219	132	184	352
Order	Mesostigmata												
Suborder	Gamasina												
Systematic group		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Family	Parasitidae	14	10	11	0	0	0	1	3	1	2	1	7
Family	Ascidae	7	11	7	20	4	6	33	18	3	12	7	21
Family	Phytoseiidae	1	1	0	0	0	0	1	3	0	0	3	0
Family	Macrochelidae	0	0	0	0	1	0	0	0	3	0	0	2
Family	Eviphididae	0	0	0	0	0	1	0	0	0	0	0	0
Family	Laelapidae	25	13	23	77	7	31	18	24	20	46	102	206
Family	Pachylaelapidae	5	1	4	1	0	1	0	0	0	0	0	1
Family	Zerconidae	0	0	1	0	0	3	11	0	0	0	1	0
Family	Veigaiidae	3	0	4	0	0	0	2	2	0	0	0	2
Family	Rhodacaridae	1	4	1	9	16	9	1	8	1	9	3	16
Suborder	Uropodina												
Family	Trachytidae	0	0	2	0	0	1	3	0	0	0	0	2
Family	Uropodidae	0	0	11	0	0	0	0	0	0	1	0	3
Family	Oplitidae	0	0	0	0	0	0	0	0	0	3	1	7
	Total	56	40	64	107	28	52	70	58	28	73	118	267
	Total mites	240	230	486	444	272	649	338	340	253	218	321	651

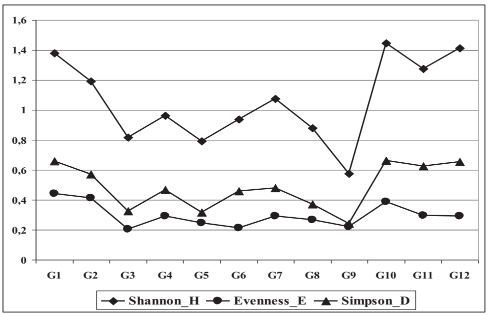
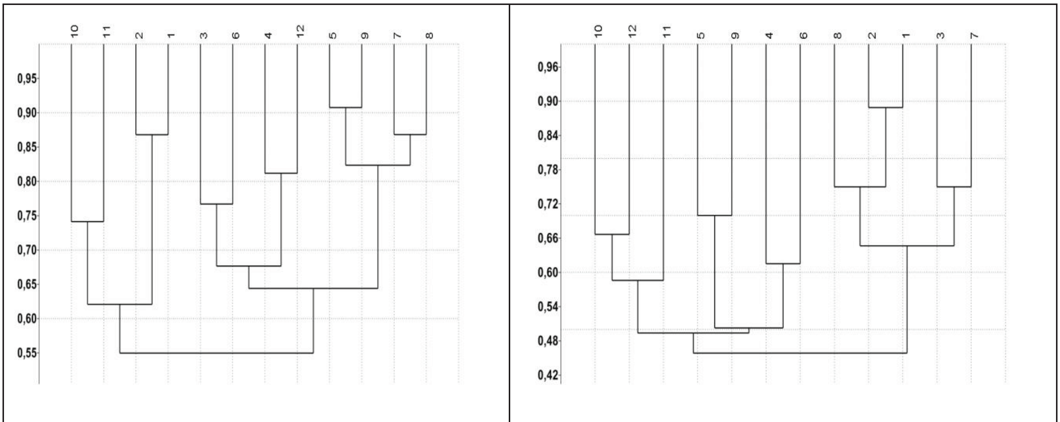


Figure 2. The diversity (Shannon_H index), the dominance (Simpson_D index) and the eveness (E) of the soil mite populations from investigated grassland ecosystems.

The highest Bray-Curtis similarity index was obtained between populations from G1-G2 (q_{BC} = 0.94); G5-G9 (q_{BC} = 0.82), G7-G8 (q_{BC} = 0.84), G4-G12 (q_{BC} = 0.69) and G10-G11 (q_{BC} = 0.78) (Figure 3A). The increased similarities between less and most polluted grasslands, could be explained through the abundance of the prostigmatids – order Trombidiformes, especially of mites from Tydeidae family (predatory, fungivorous and scavenging invertebrates). It is possible that the presence of the high heavy metals concentrations to determine increasing of the soil acidity, favorable environment for fungi development or other parasites invertebrates development, that constitute the trophic reservoir for these mites.

Taking into discussion the presence/absence of the mite systematic groups, there were classified in three groups: invertebrates from G10-G11-G12, from G4-G5-G6-G9 and G1-G2-G3-G7-G8. The highest value of the

Jaccard similarity index where obtain between populations from G1-G2 (q_J = 0.88), G5-G9 (q_J = 0.70) and G10-G12 (q_J = 0.68) (Figure 3B). These groupings demonstrated that heavy metals influence the soil mite composition, on distance gradient. Mites systematic groups from the grasslands situated closed to the pollution source (G1, G2, G3, G4) are characterized by a lower representation in comparison with those from ecosystems situated on a distance from chimney tower (as G10, G11, G12).



A. Bray-Curtis similarity B. Jaccard similarity

Figure 3. Similarity dendrograms of the investigated systematic mite groups from investigated grassland ecosystems.

CONCLUSIONS

Each investigated grassland ecosystems were characterized by specifically heavy metals concentrations and by characteristically mite taxa diversity. The concentrations of heavy metals are much higher in soil of ecosystems near to the pollution source and lower on the distance. All heavy metals exceed the admissible legal values concentrations in all investigated ecosystems, except the natural grassland.

The most abundant group was Sarcoptiformes order, mainly represented by oribatids, follwed by Mesostigmata and Trombidiformes orders.

Evidence from Shannon evenness, Shannon diversity and Simpson dominance indexes indicated that in the areas with a low taxa diversity, there is a dominance of few taxa with individuals unequally distributed between plots. The mite diversity increased in grasslands situated on a higher distance from the pollution sourse. The influence of the heavy metal pollution is highlighted by the affinity between mites groups from different ecosystems. Mites systematic groups from the grasslands situated closed to the pollution source are characterized by a lower representation in comparison with those from ecosystems situated on a distance from chimney tower.

Modifications of the structural parameters of the mite populations and their composition represent useful arguments for their usage as bioindicators.

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