MUZEUL JUDEŢEAN ARGEŞ, PITEŞTI, ROMÂNIA
ARGESIS *- STUDII ŞI COMUNICĂRI - seria ŞTIINŢELE NATURII*, **TOM XXIV**, 2016

ECOLOGICAL COMPARATIVE ANALYSIS BETWEEN MITE POPULATIONS FROM POLLUTED GRASSLAND ECOSYSTEMS FROM TRASCĂU MOUNTAINS

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ABSTRACT. Taking into account of the total metal load, an ecological comparative analysis between mite populations (Acari-Mesostigmata) from polluted grassland ecosystems was accomplished. In total 66 mite species were identified, grouped in 32 genera and 13 families. 15.2% from all identified mites are common species for all ecosystems. If we take into consideration the ecological requirements of the identified mite species, we observed that 21.2% were praticolous species, 21.2% were silvicolous ones and 19.7% were mixed species. The analyse of the dominance and constance classes revealed a high representation of recedent-subrecedent and accessory-accidental species. The Shannon diversity index, Simpson dominance and the equitability parameters indicated that in the ecosystems with low taxa diversity, there was a dominance of few species with individuals unequally distributed between grasslands.

Keywords: diversity, grassland, mite, soil.

REZUMAT. **Analiză ecologică comparativă între populaţiile de acarieni din ecosisteme de pajişte poluate din Munţii Trascău.** Ţinând cont de încărcătura totală de metale grele, s-a realizat o analiză ecologică comparativă între populaţiile de acarieni (Acari-Mesostigmata) din ecosisteme praticole poluate. S-au identificat, în total, 66 de specii de acarieni, grupaţi în 32 de genuri şi 13 familii. 15.2% din numărul total de taxoni îl reprezintă speciile comune pentru toate ecosistemele studiate. Dacă luăm în considerare cerinţele ecologice ale speciilor de acarieni identificate, observăm că 21.2% sunt specii praticole, 21.2% specii silvicole şi 19.7% specii mixte. Analiza claselor de dominanţă şi constanţă, a evidenţiat faptul că cea mai mare reprezentare au avut-o speciile recedente-subrecedente şi cele accesorii-accidentale. Indicii de diversitate (Shannon), de dominanţă (Simpson) şi de echitabilitate (Ewens-Caswell's V-statistic) au indicat faptul că în ecosistemele cu o diversitate specifică redusă, domină câteva specii, ai căror indivizi sunt inegal distribuiţi între pajiştile luate în analiză.

Cuvinte cheie: diversitate, pajişte, acarieni, sol.

INTRODUCTION

Research studies conducted in different types of ecosystems from Europe, as well from Romania, revealed that the soil mite populations were characterized by the characteristically structure, in correlations with environmental variables (soil temperature, humidity, pH, carbon, nitrogen, etc.) (Fenda & Ciceková, 2009; Huhta et al., 2012; Manu et al., 2013; Dirilgen et al., 2015).

In Europe ecological studies on soil invertebrates from grazed, overgrazed, natural and chemical fertilized grasslands, were made in Spain, Scotland, Switzerland, Netherland, Turkey, Austria and Germany (Cole et al., 2005; Seeber et al., 2005; Garcia et al., 2010; Onen & Koc, 2011; Wissuwa et al., 2012; Rashid et al., 2013; Vandegehuchte et al., 2015).

In Romania, studies concerning the soil fauna from grasslands, especially the predators mites (Acari - Mesostigmata) were few, highlighting the influence of fertilizers and heavy metals pollution on their structure (Huţu et al., 1991; Manu et al., 2016). Qualitative and quantitative studies upon the edaphic microarthropods fauna from some grassland ecosystems from Romania were made only in Moldavia Plain (Călugăr, 2006a, b).

Taking account of this context, the present paper wants to establish a comparative ecological analysis of the mites' populations from different levels of polluted grassland ecosystems from Trascău Mountains. The main objectives were: to establish the species diversity of each type of ecosystems, to identify the characteristically species for each investigated areas and to realize a comparative ecological analysis between structural parameter of the mite populations (numerical abundance, diversity, equitability, dominance and constance).

MATERIALS AND METHODS

The study was done in twelve grassland ecosystems, situated in the Trascău Mountains, Romania (Fig. 1). Taking account of the total heavy metal load (As; Cu; Ni; Mn; Pb and Zn), the twelve grasslands were grouped, as: low (ML = 1-1.75), medium (ML = 2.92 - 3.89) and high polluted areas (ML = 5.30 - 7.28) (Manu et al., 2016).

All the investigated areas were sub-steppic calciphilous grasslands, mainly characterised by xerophytes, hemicryptophytes and other perennial species, with a heterogeneous species composition. The dominant plant species were *Agrostis capillaries* L., *Nardus stricta* L., *Rumex acetosella* L. and *Trifolium pratense* L. The grasslands were situated at altitudes between 464 and 958 m, and on slopes between 20^o - 35.48^o. The soil was mostly sandy (regosol, haplic-luvisol and eutric-cambisol), with pH from 4.52 to 5.85. (Manu et al., 2016).

The mite fauna was sampled in July and September, in 2013, by taking 25 cores to a depth of 10 cm, with a MacFadyen corer (5 cm diameter), at each of the twelve grassland sites. The 25 cores were located within a total of 2,500 sq.m. In total 300 soil samples were analysed. The samples were taken randomly. 961

Mesostigmata individuals were extracted from the 300 cores, comprising 66 species. The mites were extracted with a modified Berlese-Tullgren funnel, in ethyl alcohol clarified in lactic acid and identified to species level, using published actual identification keys. All species were deposited in the collection of the Institute of Biology-Bucharest, Romanian Academy.

After taxonomical identification, the numerical abundance (number of individuals) was the base for the quantification of some structural index as: numerical density (x/sq.m.); dominance (D %), constance (C %), Shannon diversity index (H'), Simpson dominance index (D) and diversity equitability index (Ewens-Caswell's V-statistic), using BioDiversityPro software.

The numerical density (ind./sq.m.) was calculated using the following formula (Botnariuc & Vădineanu, 1982): Ind./sq.m = (∑ no. of individuals/no. of samples) * $1m^2$/surface of the soil core; 1 m^2 = 10,000 cm^2; surface of the soil core = 20 cm^2.

The dominance was calculated using the formula: D = 100*n/N, where: n - number of individuals of one species from one sample; N - total number of individuals of all species from one sample. The dominance classes for the identified soil mites were: eudominant species with dominance over 10% (D5); dominant species with dominance between 5.1-10% (D4); subdominant species with dominance between 2.1 - 5% (D3); recedent species with dominance between 1.1 - 2% (D2) and subrecedent species with dominance under 1.1% (D1) (Engelmann, 1978).

The constancy was obtained using the formula: C = 100*pA/P, where: pA - number of samples with species A; P - total number of samples. The mite species were classified in four constancy classes: euconstant species having constancy of 75.1 - 100% (C4), constant species having constancy of 50.1 - 75% (C3), accessory species having constancy of 25.1 - 50% (C2) and accidental species having constancy of 1 - 25% (C1) (Selvin & Vacca, 2004).

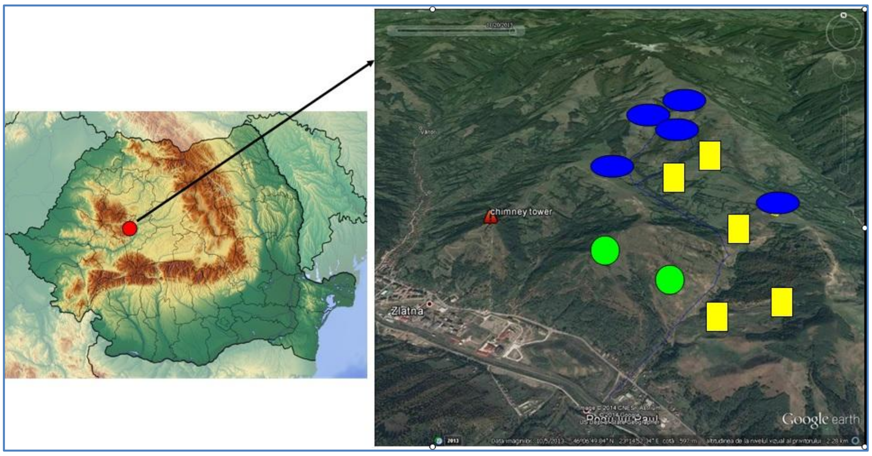

Figure 1 - Geographical characterisation of the investigated ecosystems (green circle = high polluted grasslands; yellow rectangle = medium polluted grasslands; blue oval = low polluted grasslands).

RESULTS AND DISCUSSIONS

In total 66 mite species were identified, with 19,220 individuals/square meter (ind./sq.m). These species were grouped in 32 genera and 13 families, with different percentage of representation: Parasitidae (9.09%), Ascidae (25.8%), Phytoseiidae (1.52%), Macrochelidae (3.04%), Eviphididae (1.52%), Laelapidae (25.8%), Pachylaelapidae (4.55%), Zerconidae (9.1%), Veigaidae (3.04%), Rhodacaridae (7.58%), Trachytidae (4.55%), Uropodidae (3.04%) and Oplitidae (1.52%) (Fig. 2).

The highest numerical abundance was obtained in low polluted grasslands (10,300 ind./sq.m), in comparison with high polluted areas (326 ind./sq.m.) or with medium polluted ecosystems (5,660 ind./sq.m.). Ten from identified mites are common species for all ecosystems, which represent 15.2% from the total number: *Lysigamasus misellus*, *Asca bicornis*, *Amblyseius* sp.; *Hypoaspis aculeifer*, *Hypoaspis karawaiewi*, *Hypoaspis vacua*, *Hypoaspis oblonga*, *Hypoaspis preasternalis*, *Rhodacarellus perspicuus* and *Rhodacarellus silesiacus* (Tab. 1).

The high polluted grasslands were characterized by the lowest species diversity (21 species) and by the highest dominance index (Tab. 2). Only three species were eudominant (*Asca bicornis*, *Hypoaspis aculeifer* and *Hypoaspis preasternalis*) and two were dominant (*Lysigamasus misellus* and *Rhodacarellus silesiacus*). The rest of them were recedent - subrecedent and accessory - accidental species (Tab. 1). Characteristically species for this group of ecosystems were: *Proctolaelaps pygmaeus*, *Hypoaspis angusta*, *Hypoaspis gracilis* and *Pachylaelaspis troglophilus* (Tab. 1).

In the medium polluted grasslands were obtained the highest diversity and equitability, being identified 44 mite species (Tab. 2). Only two eudominant mites and two euconstant were identified (*Asca bicornis* and *Hypoaspis preasternalis*). The characteristic species for this group of ecosystems were the majority from Ascidae, Zerconidae, Eviphididae and Trachytidae families, together with two species from Parasitidae (*Holoparasitus calcaratus* and *Pergamasus crassipes*), which represent 28.8% from the total number of identified mites (Tab. 1).

The low polluted grassland were identified 39 species from Mesostigmata order, from which three species were eudominant-euconstant (*Hypoaspis aculeifer*, *Hypoaspis oblonga* and *Hypoaspis preasternalis*) and two were dominant-constant (*Asca bicornis* and *Hypoaspis vacua*). 24.2 % from mite species were identified only in low polluted areas (Tab. 1). In the same time the lowest values of the equitability diversity index and the medium values of Shannon and Simpson dominance index were obtained (Tab. 2).

Making a comparison with the same type of ecosystems from Romania (meadows and pastures), where were identified 38 Mesostigmata species, we observed that our results from the medium and low polluted grasslands were similar with those (Călugăr, 2006b). The impact of heavy metal pollution affected the species diversity from the high polluted areas, where the value of this parameter was much lower.

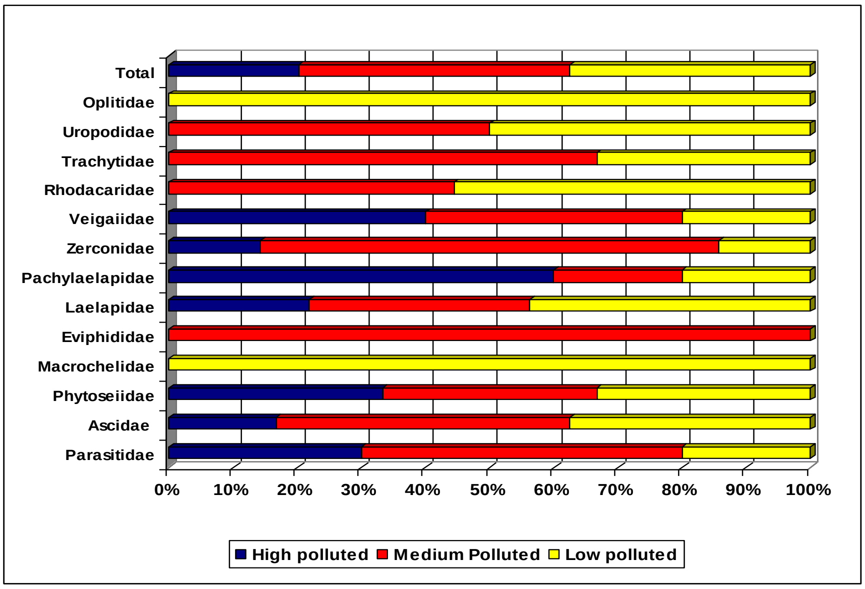

Figure 2 - The taxonomical spectrum of the soil mites from investigated grasslands.

Table 1- The structure parameters for soil mites populations (Acari-Mesostigmata) from investigated polluted grasslands (numerical abundance - ind./sq.m ± standard deviation; dominance - A% and constance - C %).

Taxa	**High polluted grasslands**			**Medium polluted grasslands**			**Low polluted grasslands**		
	ind/sq.m	**A**	**C**	**ind/sq.m**	**A**	**C**	**ind/sq.m**	**A**	**C**
Family Parasitidae									
Holoparasitus calcaratus (C. L.Koch, 1839)				100±0.57	1.76	12			
Lysigamasus misellus (Berlese, 1904)	180±1.25	5.52	8	200±1.4	2.46	20	200±0.7	1.94	28
Lysigamasus sp.	80± 0.62	2.45	8	40±0.23	0.70	4			
Pergamasus crassipes Berlese, 1906				600±43	1.06	8			
Vulgarogamasus kraepelini (Berlese, 1905)							20±0.2	0.19	4
Parasitus fimetorum (Berlese, 1904)	20±0.2	0.61	4	80±0.47	1.41	12			
Family Ascidae									
Antennoseius avius Karg, 1976				20±0.2	0.35	4			

Taxa	High polluted grasslands			Medium polluted grasslands			Low polluted grasslands		
	ind/sq.m	**A**	**C**	**ind/sq.m**	**A**	**C**	**ind/sq.m**	**A**	**C**
Antennoseius bacatus Athias-Henriot, 1961				60±0.33	1.06	12			
Arctoseius semiscissus (Berlese, 1892)				20±0.2	0.35	4	20±0.2	0.19	4
Asca bicornis (Canestrini and Fanzago, 1887)	440±3.39	13.50	20	900±2.25	15.85	76	540±1.03	5.24	64
Cheiroseius borealis (Berlese, 1904)				100±0.40	1.76	20			
Cheiroseius bryophilus Karg, 1969	40±0.27	1.23	8				100±0.5	0.97	16
Iphidonopsis pulvisculus (Berlese, 1921)							40±0.27	0.39	8
Iphidonopsis sp.							20±0.2	0.19	4
Iphidozercon gibbus Berlese, 1903				100±0.5	1.76	16			
Lasioseius berlesei (Oudemans, 1938)							20±0.2	0.19	4
Lasioseius sp.				20±0.2	0.35	4	120±0.43	1.17	24
Lasioseius youcefi Athais-Henriot, 1959				60±0.33	1.06	12			
Leioseius insignitis (Hirschmann, 1963)							40±0.27	0.39	8
Zerconopsis remiger (Kramer, 1876)				60±0.43	1.06	8	60±0.33	0.58	12
Gamasellodes bicolor (Berlese, 1918)	40±0.4	1.23	4	40±0.27	0.70	8			
Protogamasellus mica (Athias-Henriot, 1961)				120±1.2	2.11	4			
Proctolaelaps pygmaeus (Muller, 1860)	20±0.2	0.61	4						
Family Phytoseiidae									
Amblyseius sp.	20±0.2	0.61	4	100±0.5	1.76	16	60±0.33	0.58	12
Family Macrochelidae									
Geholaspis longispinosus Kramer, 1876							40±0.27	0.39	8
Macrocheles recki Bregetova & Koroleva 1960							80±0.37	0.78	16

Taxa	**High polluted grasslands**			**Medium polluted grasslands**			**Low polluted grasslands**		
	ind/sq.m	**A**	**C**	**ind/sq.m**	**A**	**C**	**ind/sq.m**	**A**	**C**
Family Eviphididae									
Eviphis ostrinus (C. L. Koch, 1836)				20±0.2	0.35	4			
Family Laelapidae									
Hypoaspis angusta Karg, 1965	40±0.4	1.23	4						
Hypoaspis claviger (Berlese, 1882)							60±0.3	0.58	12
Hypoaspis aculeifer (Canestrini, 1883)	1,160± 6.63	35.58	40	160±0.62	2.82	24	1,280± 8.67	12.43	24
Hypoaspis astronomica (C. L. Koch, 1839)				40±0.27	0.70	8	40±0.27	0.39	8
Hypoaspis austriaca (Sellnick, 1935)							20±0.2	0.19	4
Hypoaspis gracilis Meledjaeva,1963	60±0.33	1.84	12						
Hypoaspis karawaiewi (Berlese, 1903)	80±0.37	2.45	16	20±0.2	0.35	4	140±0.84	1.36	12
Hypoaspis miles (Berlese, 1882)				180±0.7	3.17	24	20±0.2	0.19	4
Hypospis sp. 1				80±0.37	1.41	16	180±0.49	1.75	32
Hypospis sp. 2				120±0.66	2.11	16	60±0.33	0.58	12
Hypoaspis vacua (Michael, 1891)	80±0.37	2.45	16	180±1.11	3.17	12	940±2.83	9.13	64
Hypoaspis oblonga (Halbert, 1915)	20±0.2	0.61	4	240±0.96	4.23	20	1,180± 2.30	11.46	80
Hypoaspis preasternalis (Wilmann, 1949)	600±1.63	18.40	44	1,000± 1.77	17.61	92	3,560± 3.06	34.56	100
Ololaelaps placentula (Berlese, 1887)				40±0.4	0.70	4	40±0.27	0.39	8
Ololaelaps veneta (Berlese, 1904)				120±0.72	2.11	12			
Ololealaps sellnicki Bregetova and Koroleva 1964							80±0.37	0.78	16
Androlaelaps casalis (Berlese, 1887)							20±0.2	0.19	4
Family Pachylaelapidae									
Pachylaelaps furcifer Oudemans, 1903	60±0.43	1.84	8	120±0.52	2.11	20			

Taxa	**High polluted grasslands**			**Medium polluted grasslands**			**Low polluted grasslands**		
	ind/sq.m	**A**	**C**	**ind/sq.m**	**A**	**C**	**ind/sq.m**	**A**	**C**
Pachylaelaps pectinifer (G. & R. Canestrini, 1881)	20±0.2	0.61	4				20±0,2	0.19	4
Pachylaelaspis troglophilus Halbert, 1915	40±0.27	1.23	8						
Family Zerconidae									
Parazercon radiatus (Berlese, 1910)							20±0.2	0.19	4
Prozercon kochi Sellnick, 1943				20±0.2	0.35	4			
Prozercon sellnicki Halaskova, 1963				100±0.57	1.76	12			
Zercon berlesei Sellnick, 1958				120±0.83	2.11	12			
Zercon hungaricus Sellnick, 1958				20±0.2	0.35	4			
Zercon triangularis (C. L. Koch, 1836)				40±0.4	0.70	4			
Family Veigaidae									
Veigaia exigua (Berlese, 1916)				100±0.57	1.76	12	40±0.4	0.39	4
Veigaia nemorensis (C. L. Koch, 1839)	60±0.43	1.84	8	60±0.33	1.06	12			
Family Rhodacaridae									
Rhodacarellus perspicuus Halaskova, 1958	20±0.2	0.61	4	80±0.36	1.41	16	160±0.62	1.55	24
Rhodacarellus silesiacus Willmann, 1953	180±0.9	5.52	20	100±0.5	1.76	16	380±1.05	3.69	48
Rhodacarus coronatus Berlese, 1921							40±0.27	0.39	8
Rhodacarus denticulatus Berlese, 1921				140±0.89	2.46	12	300±1.47	2.91	20
Rhodacarus roseus Oudemans, 1902				140±0.67	2.46	20	20±0.2	0.19	4
Family Trachytidae									
Trachytes aegrota (C. L. Koch, 1841)				100±0.57	1.76	12			

Taxa	**High polluted grasslands**			**Medium polluted grasslands**			**Low polluted grasslands**		
	ind/sq.m	**A**	**C**	**ind/sq.m**	**A**	**C**	**ind/sq.m**	**A**	**C**
Trachytes irenae Pecina, 1969				20±0.2	0.35	4			
Trachytes pauperior Berlese, 1914							40±0.27	0.39	8
Family Uropodidae									
Uropoda orbicularis (O. F. Muller, 1776)							80±0.37	0.78	16
Uropoda sp.				220±1.41	3.87	12			
Family Oplitidae									
Oplitis minutissima (Berlese, 1903)							220±0.86	2.14	28

If we take into consideration the ecological requirements of the identified mite species, we observed that 21.2% were praticolous species (*Lysigamasus misellus*, *Anntenoseius avius*, *Arctoseius semiscisus*, *Cheroseius borealis*, *Lasioseius berlesei*, *Zerconopsis remiger*, *Protogamasellus mica*, *Hypoaspis claviger*, *Hypoaspis miles*, *Hypoaspis vacua*, *Hypoaspis praesternalis* and *Rhodacarellus silesiacus*); 21.2% were silvicolous ones (as the species from Zerconidae, Trachytidae, Oplitidae families, as well as *Holoparasitus calcaratus*, *Cheroseius bryophilus*, *Macrocheles recki*, *Rhodacarus roseus*) and 19.7% were mixed species (identified in grasslands and forests as well) (Masan, 2003; Masan & Fenda, 2004; Gwiazdowicz, 2007; Salmane & Brumelis, 2010). It must be highlighted that were signalled species characteristically for impacted areas (as mine areas or derelict industrial lands), as: *Antennoseius bacatus*, *Iphidozercon gibbus*, *Lasioseius youcefi*, *Gamasellodes bicolor*, *Proctolaelaps pygmaeus*, *Rhodacarellus perspicuus* and *Rhodacarus denticulatus* (Gwiazdowicz, 2007; Kaczmarek et al., 2012).

Table 2 - The ecological index for mites' populations from investigated grasslands.

Index	**High polluted grasslands**	**Medium polluted grasslands**	**Low polluted grasslands**
Shannon diversity (H')	0.66	0.844	0.68
Simpson dominance (D)	0.21	0.07	0.17
Ewens-Caswell's V-statistic equitability	0.87	2.89	0.47

The presence of a high number of forestry species and of accessory-accidental ones in all three types of investigated areas showed us that on one hand the mesostigmatids were very mobile invertebrates, which migrated from the adjacent areas (deciduous forest ecosystems) and on the other hand that influence of the unfavourable environmental conditions from the grasslands (dryness, soil pollution, etc.) on mites populations.

CONCLUSIONS

The study of the soil fauna (Acari - Mesostigmata) from the polluted grassland ecosystems, revealed a taxonomical spectrum formed by the 66 species belonging to 32 genera and 13 families. The abundance of the soil mites and also the number of the species was variable from a type of ecosystem to another in accordance with the total metal load.

In the taxonomic spectrum in all investigated ecosystems the Ascidae and Laelapidae families were best represented. The Shannon diversity index, Simpson dominance and the equitability parameters indicated that in the areas with low taxa diversity, there is a dominance of few taxa with individuals unequally distributed between plots.

As to the species autecological peculiarities, the faunistic list includes praticolous, forestry, as well as indicator mites for anthropic ecosystems. The analyse of the dominance and constance classes revealed a high representation of recedent-subrecedent and accessory-accidental species, especially in high polluted ecosystems. The lowest and medium polluted areas offered the better conditions of invertebrates' populations, in comparison with high polluted grasslands.

ACKNOWLEDGMENT

This study was carried out in the framework of the projects: RO1567-IBB01/2016 from Institute of Biology-Bucharest, Romanian Academy and no. 50/2012 (ASPABIR) - Priority Uefiscdi Partnerships. We thank to Simona Plumb and Rodica Iosif for their assistance in the lab and the field.

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