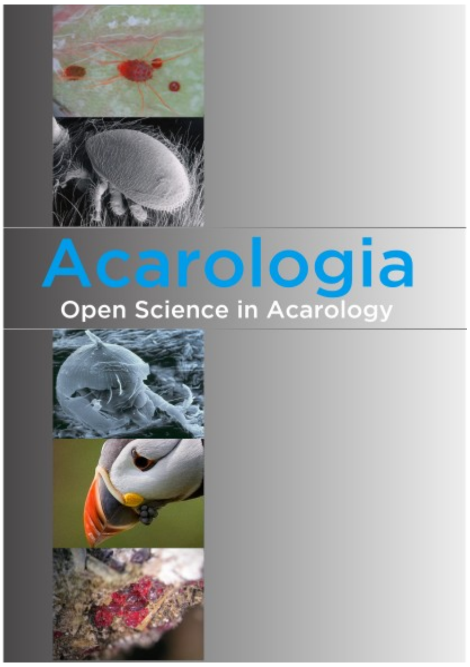

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EFFECT OF POLLUTION WITH CEMENT DUST ON THE EDAPHIC GAMASID MITE FAUNA (ACARI: GAMASINA) IN DIFFERENT FOREST ECOSYSTEMS FROM ROMANIA

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ABSTRACT — The present study analyzes the effects of pollution with cement powder on the Gamasina mite communities from soil organic horizon of some forest ecosystems. The study was carried out in two main polluted areas – one situated in Southern Romania (Cement Plant from Câmpulung Muscel – Argeş County) and the other one in the North-East (the Taşca-Bicaz Cement Plant – Neamţ County). Forest ecosystems located at different distances from the pollution sources were studied and the seasonal dynamics of both the gamasid fauna and community structures were monitored. The study focused on the suborder Gamasina Leach 1815, but the total abundance of the uropodids (Uropodina Kramer, 1882) was also considered. It was found that the percentage of Gamasina mites among all mites was higher in the control forests than in the polluted ecosystems, which was true for both polluted areas. Considering their ecological requirements, their habitat preference, vertical distribution in the soil, and seasonal population changes were investigated. In polluted biotopes, the Gamasina communities suffered from lower densities, fewer species and replacement of some species with others. The analysis of the Gamasina species distribution in the control and polluted ecosystems suggests that some species can be considered tolerant, such as certain representatives of Zerconidae, Parasitidae, Pachylaelapidae, Veigaiidae etc.

KEYWORDS — pollution; cement powder; Acari; Gamasina

INTRODUCTION

Industry is currently considered as the most important source of air, soil and water pollution. In Europe, many scientific works have been dedicated to the estimation of the effect induced by different types of industrial pollution on the edaphic microarthropods, including the mites (Seniczak *et al.* 1997, 1999, Zaitsev *et al.* 2001, Seniczak *et al.* 2002, Skubala and Kafel 2004, Khalil *et al.* 2009; Santamaria *et al.* 2012), which have even been proposed as soil quality bioindicators (Athias - Binche 1981, Karg 1989, Parisi *et al.* 2005, Gulvik 2007, Gergócs and Hufnagel 2009).

Nowadays, Romania is affected by pollutants from different sources such as cement plants, chemical industries, from smelting of iron and steel, coal mining and thermal power stations, from traffic, the use of pesticides and fertilizers. The researches carried out in some zones affected by industrial pollution were dedicated to the microartropod fauna in general and some systematic and trophic groups in

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specific, at the species level being investigated only for oribatids (Călugăr *et al.* 1983, Vasiliu and Mihăilescu 1989, Vasiliu *et al.* 1995, Vasiliu and Ivan 1995, Ivan and Vasiliu 2009, Ivan and Vasiliu 2010).

This paper aims to highlight the effect exerted by the pollution with cement powder on edaphic Gamasina mites, which is the most important group of predatory mites and most species found at the end of the food chain. At the edaphic level, the cement industry plays a major role in the pollution. The cement powder changes the habitat characteristics by water retaining and substrate alkalinisation and thus alters the living conditions for the soil mesofauna. Investigations were conducted in two areas affected by this type of pollution, Câmpulung Muscel (southern Romania) and Taşca Bicaz (North-East Romania). The researches from Taça Bicaz were performed under a 99 % reduction of dust emissions by modernizing the dedusting equipment used in the production processes, transport and storage, as well as by introducing some alternative fuels (such as tyres) in the production. The results were compared to previous researches developed at Câmpulung Muscel, focusing on oribatid mites (Ivan and Vasiliu 2010) and to similar researches concerning both Oribatida and Gamasida mites conducted in a pine forest in Poland (Seniczak *et al.* 1999).

Materials and methods

The study is based on faunistic material collected from soil of two types of forests: deciduous forests at Câmpulung Muscel and coniferous forests at Taşca Bicaz. For both types of forests several ecosystems situated at different distances from the pollution source were considered in this study.

At Câmpulung Muscel the investigations included the following plots:

- beech forest, about 100 years old, in the vicinity of the locality Dragoslavele at 7 km away from the cement factory (control plot) (CM-C);
- beech forest, about 100 years old, near Nămăeşti locality at 1 km away from the cement factory (CM-P1 – medium polluted);
- a grove of *Corylus avellana*, *Crataegus monogyna*, *Populus* sp. etc. at approximately 300 m from the factory (CM-P2 – highly polluted).

The investigations were carried out in the vernal and autumnal period of two successive years – 1998 and 1999. Thus, for plots CM-C and CM-P1 there were three sampling data (06/1998, 09/1998 and 06/1999) but only two for plot P2 (06/1998, 09/1998).

The investigations at Taşca Bicaz were carried out in two successive months (06/2010 respectively 07/2010) in three coniferous forests, two of them being under the influence of a cement plant, and the third one, the control, located beyond this zone:

- spruce, fir and beech forest, about 100 years old (Secu – control plot) (TB-C) (46°51'N 26°02'E);
- spruce forest, about 70-80 years old (Floarea – medium polluted) (TB-P1) (46°53'N 26°01'E);
- spruce and pine forest, about 35-40 years old (Neagra – highly polluted) (TB-P2) (46°54'N 26°02'E).

The two polluted plots were located on the opposite sides bordering the depression in which the industrial objective was nestled. Neagra was situated about 800 m away from the factory on a slope in direction of the prevailing wind.

The samples of 100 cm^2 area and a depth of 5 cm each were taken in every stand from the organic horizon of the soil at two different levels – the superficial, litter and fermentation sub-horizon (olf), and the deep, humiferous one (oh). In the case of the grove they were taken from only one level, the holorganic layer, and only at Secu they were taken from three layers, litter (ol), fermentation (of), and the humiferous layer (oh).

The fauna was extracted from the soil samples by the selective method of Tullgren – Berlese modified by Balogh (Balogh, 1958). The adult mites from Gamasina Leach, 1815 were determined to the species level, or to genera in case of juveniles or when specific characters of the adults were hard to define.

The analysis of the Gamasina communities' structure was based on the analytical ecological indices such as the average abundance of each species (ā), and their relative density (D. r.) expressed in the classes I (subrecedent under 1 %), II (recedent 1.1 – 2 %); III (subdominant 2.1 – 5 %), IV (dominant 5.1 – 10 %), and V (eudominant over 10 %) (Rajski, 1961).

The Gamasina taxocoenoses were also characterized by the following parameters: global average abundance (Ā), expressed as individuals/100 cm^2, number of species (S) and the average number of species/sample (S mean), expressing the species richness and their distribution. Additionally, the percentage of individuals out of the whole number identified in the litter and fermentation sub-horizon (olf), which reflects the vertical distribution of the individuals, and the representation (R %) (Müller *et al.* 1978), *i.e.* the percentage of individuals belonging to a certain species, found in each stand, relative to the total number of individuals recorded in a series of investigated ecosystems, were calculated.

In order to obtain more accurate and comparable data the mean (A_{mean}) of the average abundances of the sampling periods was calculated. In the Câmpulung Muscel area the mean abundance was counted for P2 from the average abundances of the two sampling periods, while for C and P1 firstly the mean of the average abundances in spring was counted, resulting in "mean spring". Then A_{mean} was calculated from the "mean spring" and the average abundance registered in autumn. In Taşca Bicaz, A_{mean} resulted from the average abundances in the two sampling periods.

To compare the similarity of the plots, the Sørensen index, also known as Sørensen's similarity coefficient, was calculated too.

Results and discussions

At Câmpulung Muscel, previous investigations showed that in the control plot (Dragoslavele) the organic horizon was slightly acidic (pH 6.3 in olf, 6.16 in oh), while in the polluted forest (Nămăeşti) it was slightly alkaline (pH 7.41 in olf , 7.65 in oh) (Ivan and Vasiliu 2010). In the Taşca Bicaz area, in the Secu and Neagra plots, the same characteristics were evident, namely a slight acidity in the control plot (pH 6.3 in ol and of, and 6.4 in oh) and alkalinity in the plot influenced by the cement powder (pH 8.2 in ol, 8.3 in of and 8.6 in oh) (Vasiliu and Ivan 1995).

Within the Gamasida, the identification to the species level was only carried out for the Gamasina. Uropodid mites were considered on the whole, as part of the total mites found. In general, in the analysed ecosystems the percentage of Uropodina mites was lower than that of Gamasina mites, with only one exception in the TB-C plot in June. The disappearance of uropodid mites in the polluted ecosystems was noticed (Figure 1).

The relative proportion of the Gamasina mites among the found Acari varied both from one season to another and from one year to another, as well as in control versus polluted plots. At Câmpulung Muscel in the control plot, the share of Gamasina was higher in autumn, which is a normal situation in the case of deciduous forests, while in the polluted plots it was higher in spring (Table 1). In the Bicaz area the proportion of Gamasina mites among all mites was higher in July compared to June, both in the control and polluted plots. However, there was no clear link between pollution and the relative proportion of Gamasina mites.

The estimation of the global average density of the Gamasina mite populations at Câmpulung Muscel indicated lower densities in the polluted plots than in the control (approximately 3 to 5 times lower in June 1998, 2 to 72 times lower in September 1998 and approximately 11 times lower in June 1999). The highest abundance was found at the control plot in autumn, a normal situation for deciduous forests, while at P1 the abundance was the lowest in September. In CM-P2 the autumnal abundance was higher than the vernal abundance, which was similar to the control plot. In the Bicaz region the highest abundance was observed in the control plot in July (almost 27 times lower than in CM-P1 and 4.3 times lower than in CM-P2) (Table 1).

The number of species was lower in the polluted plots than in the control, especially when considering the average number of species per sample. We noticed an exception in the Taşca Bicaz zone in June,

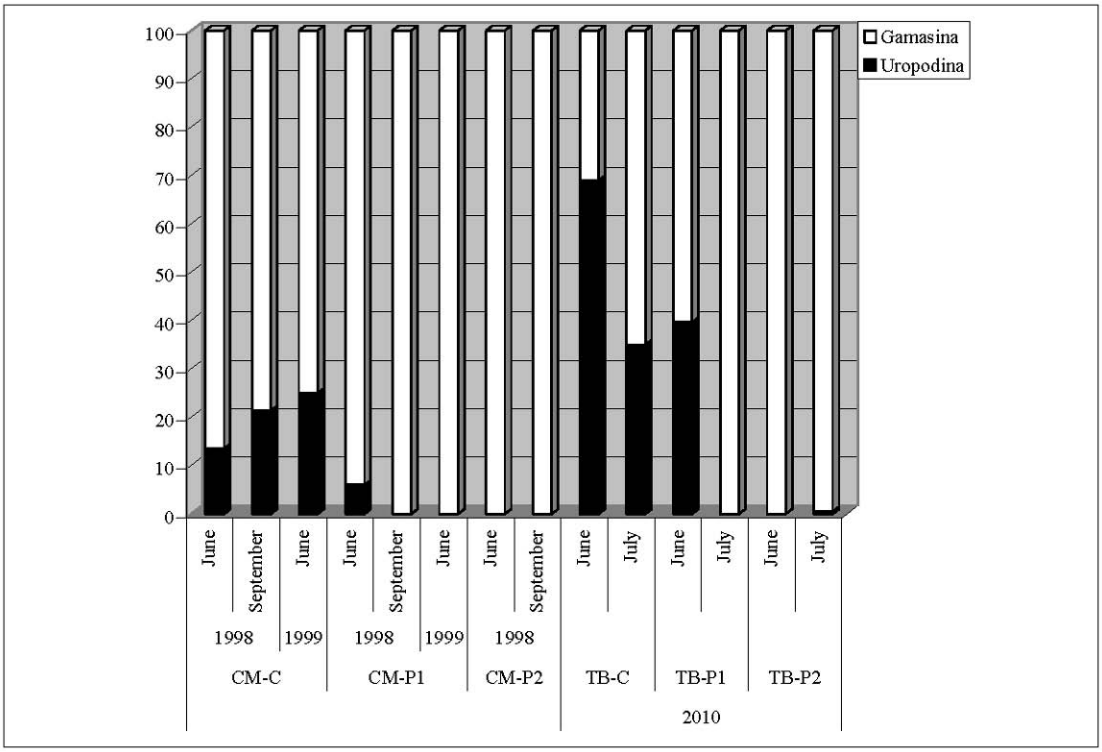

FIGURE 1: Ratio (%) Uropodina/Gamasina in the control (C) and polluted (P) forest stands at Câmpulung Muscel (CM) and Taşca Bicaz (TB).

TABLE 1: Parameters of the Gamasina mites' communities in the control and polluted forest stands (C – control, P – polluted). Ā – average abundance of the adult individuals/100 cm^2; S – number of species; S_{mean} – average of number of species; A/J – adults-immatures ratio; olf – holorganic layer; SD – standard deviation

Studied area	Date	Forest stands	Ā ± SD	S	S_{mean} ± SD	% ind. in olf	A/J	% from Acari
Câmpulung Muscel (CM)	06.1998	CM-C	33.20 ± 7.80	17	10.6 ± 3.13	84.33	3.45	5.60
		CM-P1	12.20 ± 6.50	17	6.2 ± 1.7	50.79	30.50	14.20
		CM-2	7.40 ± 8.97	7	2.4 ± 2.72	*	-	10.32
	09.1998	CM-C	43.40 ± 20.01	25	13.2 ± 2.03	78.44	3.15	9.04
		CM-P1	0.60 ± 0.80	3	0.4 ± 0.48	33.33	8.00	1.15
		CM-P2	23.00 ± 23.93	17	5.2 ± 4.6	*	9.58	8.23
	06.1999	CM-C	19.20 ± 5.70	13	8.60 ± 2.70	61.20	4.80	4.10
		CM-P1	1.80 ± 1.60	7	1.40 ± 1.20	77.77	-	2.29
Taşca Bicaz (TB)	06.2010	TB-C	2.60 ± 2.57	5	1.20 ± 0.74	92.30	4.33	3.20
		TB-P1	6.60 ± 7.45	9	2.40 ± 1.49	90.90	4.71	4.61
		TB-P2	3.80 ± 4.95	4	1.40 ± 1.35	100.00	19.00	5.89
	07.2010	TB-C	69.00 ± 38.86	25	69 ± 38.86	68.20	2.34	33.89
		TB-P1	2.60 ± 2.80	8	2.20 ± 2.30	23.07	2.60	6.29
		TB-P2	16.0 ± 20.43	11	3.80 ± 3.24	62.50	5.33	19.26

where in the medium polluted forest the number of species was approximately 2 times higher than in the control (Table 1). At Câmpulung Muscel the number of species in total, independent of the sampling periods, was approximately 1.5 to 1.7 times lower in the polluted ecosystems than in the con-

TABLE 2: List of Gamasina species with their abundances (A_{mean} = mean of the average abundances of the sampling periods) and relative densities (I-V) in the studied plots (CM – Câmpulung Muscel; TB – Taşca Bicaz; C – control, P – polluted). I – subrecedent (under 1 %), II – recedent (1.1 – 2 %), III – subdominant (2.1 – 5 %), IV – dominant (5.1 – 10 %), and V – eudominant (over 10 %).

Species	Forest stands					
	CM-C	CM-P1	CM-P2	TB-C	TB-P1	TB-P2
Veigaia nemorensis (C. L. Koch, 1839)	0.6/II	0.1/III	0.7/III	8.0/V	0.3/IV	0.7/IV
Prozercon trägårdhi (Halbert, 1923)	1.25/III	0.15/II	0.2/II	0.6/II	0.1/III	-
Prozercon carsticus Halaskova, 1963	3.85/V	0.05/III	4.3/V	2.9/IV	-	0.8/IV
Epicrius tauricus Bregetova, 1977	0.25/I	0.1/III	-	1.7/III	-	0.1/I
Prozercon plumosus Călugăr, 2004	3.6/IV	0.4/V	1/I	0.1/I	-	-
Olopachys suecicus Sellnick, 1950	0.35/I	0.6/IV	-	-	0.1/II	0.1/I
Asca aphidioides (Linné, 1758)	-	-	2/V	0.2/I	0.8/V	0.5/III
Pergamasus beklemischevi Sellnick, 1929	-	-	0.5/III	0.2/I	0.2/III	0.4/III
Zercon hungaricus Sellnick, 1958	3.85/V	0.1/III	0.9/IV	-	-	-
Leptogamasus sp. 2	2.8/IV	0.4/V	2.7/V	-	-	-
Veigaia exigua (Berlese, 1916)	1.0/I	0.1/III	0.4/III	-	-	-
Prozercon fimbriatus (C.L. Koch, 1839)	5.0/V	0.55/II	-	1.8/III	-	-
Hypoaspis aculeifer (Canestrini, 1883)	1.7/III	0.05/II	-	0.7/II	-	-
Leptogamasus sp. 1	2.4/III	0.35 /V	-	-	-	-
Pergamasus sp. 2	1.7/III	0.1/II	-	-	-	-
Olopachys sp. 1	0.2/I	0.2/III	-	-	-	-
Macrocheles sp.	0.25/I	0.05/II	-	-	-	-
Rhodacarus roseus Oudemans, 1902	0.3/I	0.05/II	-	-	-	-
Pseudolaelaps doderoi (Berlese, 1910)	0.1/I	-	0.5/III	-	-	-
Zercon romagniolus Sellnick, 1944	0.3/I	-	-	2.4/IV	-	-
Pergamasus sp. 3	-	0.1/III	0.2/II	-	-	-
Pachyseius humeralis Berlese, 1910	-	0.05/II	-	0.2/I	-	-
Holoparasitus calcaratus (Berlese, 1904)	-	-	0.1/I	-	0.2/III	
Paragamasus sp.	-	-	-	2.1/IV	0.1/III	4.1/V
Lysigamasus lapponicus (Trägårdh, 1910)	-	-	-	0.1/I	0.1/III	-
Leioseius bicolor (Berlese, 1948)	-	-	-	-	0.3/IV	0.1/I
Leitneria granulata (Halbert, 1923).	1.2/III	-	-	-	-	-
Pergamasus sp. 1	1.0/III	-	-	-	-	-
Veigaia sp. 1	0.2/III	-	-	-	-	-
Holoparasitus caesus Micherdzinski, 1969	0.55/II	-	-	-	-	-
Geholaspis sp.	0.6/I	-	-	-	-	-
Pachydellus ivanovi (Koroleva, 1977)	0.4/I	-	-	-	-	-
Arctoseius sp. 1	0.2/I	-	-	-	-	-
Pergamasus cf. primorellus	0.2/I	-	-	-	-	-
Rhodacarellus silesiacus Willmann, 1936	0.2/I	-	-	-	-	-
Prozercon kochi Sellnick 1943	0.1/I	-	-	-	-	-
Amblyseius sp. 1	0.1/I	-	-	-	-	-
Pergamasus cf. vagabundus	0.25/I	-	-	-	-	-
Pseudolaelaps sp.	0.15/I	-	-	-	-	-
Pachydellus furcifer (Oudemans, 1903)	0.05/I	-	-	-	-	-
Mixozercon sellnicki (Schweizer, 1948)	0.05/I	-	-	-	-	-
Parasitus sp. 1 (only juveniles)	0.05/I	-	-	-	-	-

TABLE 2: Continued.

Species	Forest stands					
	CM-C	CM-P1	CM-P2	TB-C	TB-P1	TB-P2
Olopachys sp. 2		0.15 /III	0.3/III	-	-	-
Arctoseius sp. 2	-	0.05/II	0.4/III	-	-	-
Dendrolelaps sp.	-	0.05/II	-	-	-	-
Zercon cf. peltatus pelatatoides	-	0.05/II	-	-	-	-
Veigaia sp. 2	-	-	0.26 /II	-	-	-
Eviphis sp.	-	-	0.2 /II	-	-	-
Amblyseius sp. 2	-	-	0.1/II	-	-	-
Pachydellus sp. 1	-	-	0.2/II	-	-	-
Cheiroseius sp.	-	-	0.1/I	-	-	-
Amblyseius sp. 3	-	-	0.1/I	-	-	-
Prozercon trägärdhisimilis Solomon, 1984	-	-	-	6.4/V	-	-
Zercon montigenus Blaszak, 1972	-	-	-	1.9/IV	-	-
Olopachys vysotskajae Koroleva, 1976	-	-	-	1.9/IV	-	-
Zercon moldavicus Călugăr, 1987	-	-	-	1.7/III	-	-
Leptogamasus sp. 3	-	-	-	1.0/III	-	-
Macrocheles sp. 2	-	-	-	0.5/II	-	-
Epicrius canestrinii (Haller, 1881)	-	-	-	0.4/II	-	-
Punctodendrolaelaps sp.	-	-	-	0.4/II	-	-
Leptogamasus sp. 4	-	-	-	0.4/I	-	-
Holoparasitus sp.	-	-	-	0.2/I	-	-
Pachydellus sculptus Berlese, 1920.	-	-	-	0.1/I	-	-
Zercon sp.	-	-	-	0.1/I	-	-
Leioseius montanulus Hirschmann, 1963	-	-	-	-	1.5/V	-
Parasitus sp. 2 (only juveniles)	-	-	-	-	0.3/IV	-
Hypoaspis vacua (Michael, 1891)	-	-	-	-	0.2/III	-
Paragarmania dendriticus (Berlese, 1918)	-	-	-	-	0.1/III	-
Ololaelaps sellnicki Bregetova et Koroleva, 1964	-	-	-	-	0.1/III	-
Ololaelaps placentula (Berlese, 1887)	-	-	-	-	0.1/III	-
Hypoaspis procera Karg, 1965	-	-	-	-	0.1/III	-
Amblyseius sp. 4	-	-	-	-	-	1.2/V
Veigaia cervus (Kramer, 1876)	-	-	-	-	-	0.6/IV
Leptogamasus sp. 5	-	-	-	-	-	0.4/III
Pachydaellus sp. 2	-	-	-	-	-	0.2/II
Leptogamasus cf. calicrus	-	-	-	-	-	0.1/I
Hypoaspis austriacus (Sellnick, 1935).	-	-	-	-	-	0.1/I
Species number	34	22	20	25	16	14
A_{mean} total	34.8	3.8	15.16	35.8	4.6	9.9

TABLE 3: Share (%) of dominance groups in studied plots (CM – Câmpulung Muscel; TB – Taşca Bicaz; C – control, P – polluted). I – subrecedent (under 1 %), II – recedent (1.1 – 2 %), III – subdominant (2.1 – 5 %), IV – dominant (5.1 – 10%), and V – eudominant (over 10 %).

AREA-PLOT	I + II	III	IV + V
CM-C	65	21	15
CM-P1	46	36	18
CM-P2	50	30	20
TB-C	56	16	28
TB-P1	6	63	31
TB-P2	43	21	36

TABLE 4: The Sørensen's similarity coefficients of the studied plots (CM – Câmpulung Muscel; TB – Taşca Bicaz; C – control, P – polluted).

Plots	CM-C	CM-P1	CM-P2	TB-C	TB-P1	TB-P2
CM-C	100	57.14	29.62	27.11	12	12.5
CM-P1	57.14	100	47.61	34.04	15.78	22.22
CM-P2	29.62	47.61	100	26.66	27.77	23.52
TB-C	27.11	34.04	26.66	100	29.26	30.76
TB-P1	12	15.78	27.77	29.26	100	40
TB-P2	12.5	22.22	23.52	30.76	40	100

trol. A similar situation was found at Taşca Bicaz, where the number of species in the polluted plots was approximately 1.5 to 1.7 times lower than that in the control plot (Table 2).

Analysis of the vertical distribution of the mites revealed that Gamasina mites mainly populated the superficial sub-horizon, which is the usual habitat for these hemi-edaphic mites. However, there were two exceptions in CM-P1 plot in September and TB-P2 in July, when 67 % and 77 %, respectively, were found in the deep humiferous sub- horizon (Table 1). Regarding the life-stage structure, the ratio of adults to juveniles was higher in the polluted ecosystems than in the control plot (Table 1).

In the two investigated areas 77 species were identified in total, of which approximately 64 % occurred in the Câmpulung Muscel area and about 53 % occurred in the Taşca Bicaz area. About 17 % of species were found to be common in the two studied areas and among these, only one species, *i.e.* the ubiquitous *Veigaia nemorensis*, was common in all analyzed plots (Table 2). In both studied areas, some species were recorded in both the control and polluted plots. Other species were exclusively found either in the control or in the polluted plots. At Câmpulung Muscel, 35 % of the species were identified in both the control and polluted plots, 35 % were only present in the control and 30 % only in the polluted plots. At Bicaz, 20 % of the species were common at both control and polluted plots, 41 % were only recorded in the control plot and 39 % only in the polluted plots (Table 2).

The general dominance structure of the Gamasina mite communities in the Câmpulung Muscel area was similar in all plots (Table 3). Recedent and subrecedent species were the most numerous followed by subdominant, dominant and eudominant species. On the other hand, in the control plot of Taşca Bicaz there was a predominance of subrecedent and recedent species, followed by the dominant, eudominant and subdominant ones. In the highly polluted ecosystem of Neagra the situation was similar: the subrecedent and recedent species were in the first place, followed by the dominant, eudominant and subdominant species. At the medium polluted plot of Floarea, subdominant species were followed by dominant, eudominant and then by recedent and subrecedent species (Tables 2, 3).

The specific composition of the Gamasina mite communities from the six plots was compared by the Sorensen similarity index (Table 4). The high-

TABLE 5: Representation (%) of the dominant and eudominant species in the control and affected forest ecosystems at Câmpulung Muscel (CM) zone (C – control, P – polluted).

Species	CM-C	CM-P1	CM-P2
Prozercon fimbriatus	88	12	-
Zercon hungaricus	82	2	16
Prozercon plumosus	74	14	13
Leptogamasus sp. 1	78	22	-
Prozercon carsticus	47	2	51
Leptogamasus sp. 2	45	9	46
Olopachys suecicus	45	55	-
Asca aphidioides	-	-	100
Zercon romagnolus	11	-	

TABLE 6: Representation (%) of the dominant and eudominant species in the control and affected forest ecosystems at Taşca Bicaz (TB) zone (C – control, P – polluted).

Species	TB-C	TB-P1	TB-P2
Zercon montigenus	100	-	-
Zercon romagnolus	100	-	-
Olopachys vysotskajae	100	-	-
Prozercon trägärdhisimilis	100	-	-
Veigaia nemorensis	88.9	3.33	7.77
Prozercon carsticus	78.37	-	21.63
Paragamasus sp.	33.33	1.58	65.07
Asca aphidioides	13.33	53.33	33.33
Leioseius montanulus	-	100	-
Leioseius bicolor	-	75	25
Veigaia cervus	-	-	100
Amblyseius sp. 4	-	-	100

est similarity (57 %) was found between forests of the same type from the same geographic area (beech control forest from Dragoslavele and polluted beech forest from Nămăeşti). A relatively high similarity (40 %) was also found in the polluted forests at Taşca Bicaz. The similarity index was lower (<30 %) between the control forests of different geographic areas (Dragoslavele and Secu), although both were secular forests with *Fagus silvatica* as main component. Less than 30 % similarity was also determined for the polluted forests from the two zones Câmpulung Muscel and Taşca Bicaz. Thus, these results suggest that the composition of the Gamasina mite communities is more strongly influenced by the complex bio-pedo-climatic zonal or stationary factors such as vegetation, type of soil, pH values, exposure etc. than the degree of pollution.

The representation analysis of the dominant and eudominant species revealed three categories of species: (1) species with high or exclusive representation in control plots (over 80 % of the total number of individuals found here), (2) tolerant species found in both control and polluted plots with similar representation or with lower representation in polluted plots, and (3) species that are possible bio-indicators, preponderantly or exclusively found in polluted plots (Tables 5, 6). For the first category, we found in the Câmpulung Muscel area two species with the highest representation in the control plot (*Prozercon fimbriatus*, *Zercon hungaricus*), which could be considered exigent species, *i.e.* species sensitive to changes in the edaphic environment (especially toward pH). In the category of tolerant species, *Prozercon plumosus*, *Leptogamasus* sp. 1, *Prozercon carsticus*, *Leptogamasus* sp. 2 and *Olopachys suecicus* could be included. *Asca aphidioides* could be considered as a bio-indicator because it was found with 100 % representation in CM-P2. It was also found in all plots of the Bicaz area but with the highest representation in the polluted plots (Tables 5, 6). According to the results obtained for the Taşca-Bicaz area, the species that are very sensitive to environmental changes are *Zercon montigenus*, *Zercon romagniolus*, *Prozercon trägärdhisimilis* and *Olopachys vysotskajae* with 100 % representation in TB-C. *Veigaia nemorensis*, albeit highly represented in the control plot, is considered an ubiquitous species (Bregetova 1977, Karg 1993, Salmane and Brumelis 2010). *Paragamasus* sp. and *Prozercon carsticus* could be considered as tolerant species. In the third category, the presumed bio-indicators, we found *Leioseius montanulus*, *Leioseius bicolor*, *Veigaia cervus* and *Amblyseius* sp. 4.

Seniczak *et al.* (1999), also quoted by Ivan and Vasiliu (2010), evidenced in their work concerning soil pollution with cement powder that an increasing soil pH influences the functional relations amongst the groups of organisms involved in the decomposition of the organic matter. They found that the density of soil Acari – Oribatida and Gamasida – was significantly lower in the highly contaminated plot than in the control plot. These results are consistent with the results obtained at Câmpulung Muscel and Taşca Bicaz areas by Vasiliu and Ivan (1995) and Ivan and Vasiliu (2010) and partly with the results from our study. Thus, previous investigations showed that the densities of edaphic microarthropods decrease in polluted forests. Within the edaphic mesofauna, oribatid mites showed a special response to soil polluted by cement dust. In the affected forests, their population densities, species number and diversity significantly decreased. Similarly, Vasiliu and Ivan (1995) found that Gamasida mites were less abundant in polluted plots than in the control.

Concerning Gamasina mites from Câmpulung Muscel area studied in 1998 and 1999 we noticed that the mean abundances and the number of species in the polluted plots were lower than in the control plot. However, an unexpected situation was found in the autumn season in the case of the communities from the plot closest to the factory. The grove located in the vicinity of the plant, CM-P2, was exposed to the highest pollution but the pollution effects on the species number and abundance were less evident, being only about 1.5 to 2 times lower in the polluted plot than in the control plot. Compared to the less polluted forest from Nămăeşti (CM-P1), the number of species and the density were approximately 6 and 38 times, respectively, higher. Also, at Taşca Bicaz in June, an unexpected situation was found: the abundance and the number of species of the gamasid mites was higher in the polluted forests than in the control plot. Regarding the mites in young Scots pine forests affected by pollution of cement dust, Seniczak *et al.* (1999) observed higher population densities in the most polluted plots as compared to the medium polluted ones, which was similar to the situation in autumn at Câmpulung Muscel of our study. These authors suggested that, to a certain degree, the soil protects the mites against alkaline deposition. Additionally, they found that in the contaminated plots the number of species of soil Oribatida and Gamasida was lower than in the control plot, except in the least contaminated plot where the number of gamasid species was higher than in the control plot, as we observed at Taşca Bicaz in June. It could be that a slight contamination stimulates, to a certain degree, some characteristics of mite communities, but this needs further verification.

In the Bicaz area, the present study and that by Vasiliu and Ivan (1995) revealed that in control forests uropodid mites were represented with a higher proportion than in polluted plots. At Secu, uropodid mites made up 35 % from the total of Gamasida mites but only 0,038 % in the polluted plot from Neagra. Uropodid mites are considered particularly sensitive and thus good bioindicators of environmental changes (Athias-Binche

1981, Karg 1989, Gulvik 2007). This was also evident in our results and those of Vasiliu and Ivan (1995). In our study, uropodid mites were constantly present in the control plots, where they represented 69 % from the Gamasida mites, while they represented only 0.53 % at the highly polluted plot Neagra. In the medium polluted Floarea plot, large fluctuations from one season to another were noticed. Here, the uropodid mites were well represented in June (almost 40 % from Gamasida) but were absent from the samples in July, suggesting poor stability of their communities. Additionally, the presence of uropodid mites in the polluted plots could reflect the improvement of the conditions in the edaphic environment following the measures against pollution during the last decade, *i.e.* being in an incipient stage of the soil recovery process. However, it is impossible to interpret the development of the polluted ecosystems only on the base of the presented data. This study needs to be followed by further researches yielding more and more complete data with respect to the abiotic and biotic conditions, and if possible also from other zones or ecosystems under similar pollution conditions.

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