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SOIL MICROARTHROPODS AND THEIR BIOINDICATOR VALUE REGARDING THE BIO-EDAPHIC CONDITIONS IN FOREST ECOSYSTEMS OF DANUBE DELTA

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ABSTRACT: The main objective of this study was to compare soil mesofauna communities in natural and anthropogenic forests from Danube Delta Biosphere Reserve and establish a baseline data in monitoring the disturbed sites. The abundance and diversity of edaphic microarthropods were analyzed in five plots, three of them being natural forests and two plantations (Canada poplar, and respectively willow). The mites from *Trombidiformes* and *Oribatida* were closely investigated being identified at family level. Qualitative analysis of edaphic microarthropods evidences numerical dominance of mites, excepting only one stand (Canada poplar plantation). Among mites *Oribatida* owns the biggest weight (76.6 - 94.1% of the total mites), followed by *Trombidiformes* or *Mesostigmata.* Among insects the collembolans hold higher density in the poplar plantation, and the lowest one in the willow plantation. Structure of mites communities differs between the investigated ecosystems both in quantitative and qualitative aspects depending on particular conditions of each plot.

Keywords: soil, forests, microarthropods, *Trombidiformes, Oribatida*

INTRODUCTION:

The World Resources Institute estimated that only 15%, of the Earth's surface represent protected/controlled harvesting, of aquatic or terrestrial ecosystems. Among this tiny percentage, the Danube Delta Biosphere Reserve represent an important protected wetland with international value, but its status of biosphere reserve does not exclude human activity. In consequence protection of biodiversity needs here an appropriate system of management, as well as an appropriate monitoring.

Soil biodiversity and linkages between aboveground and belowground biota are current topics not only in ecology, but also in the larger context of sustainable management of natural resources, numerous studies confirming importance of edaphic organisms that are directly involved in or facilitate many biological processes in soil. Some groups are highly sensitive to environmental factors and evidence indicator value. A modern approach of ecosystem monitoring involves bio - indication, the bio-indicators using becomes more and more important nowadays. The ecologists must paid more attention to the role of the edaphic mesofauna, a key factor in the structure and function of an ecosystem on the whole (Brussaard *et al*., 1997, Jeffery *et al*., 2010, Menta, 2012, Wardle *et al.*, 2004).

Previous studies undertaken in the forest ecosystems of the Danube Delta have watched only two groups of edaphic mesofauna - *Oribatida* and *Mesostigmata* mites so, more comprehensive, ecological studies regarding the whole edaphic mesofauna are necessary here (Ivan *et al.*, 2006). In this study soil mesofauna communities in natural and anthropogenic forests from Danube Delta Biosphere Reserve were investigated in a view to evaluate functional state and intensity of human pressure exerted on these ecosystems.

MATERIALS AND METHODS:

Sampling was performed in July 2015 in five different forest ecosystems (three natural forests and two forest plantations) placed on the D.D.B.R. territory, as follows:

1- Letea-Hăşmacul Mare (45°36′71.16″N 29°54′65.07″E), a strictly protected area of national interest corresponding IUCN category I, with *Quercus robur*, *Q. pedunculiflora*, *Populus alba* in composition; however in the last period this forest is affected by tourists and the approximatelly 2000 horses abandoned by local peoples;

2 - Chilia Veche (45°26′41″N 29°19′24″E) a natural forest with *Populus x canadensis*, *P. alba*, *Salix alba*, *Ulmus minor*, *Fraxinus excelsior* in composition;

3 - Plauru I (45°17′42″N 28°53′42″E) a natural forest with *Populus x canadensis*, *P. alba*, *Salix alba* in composition;

4 - Plauru II (45°16′31.4″N 29°39′21.8″E) - plantation of *Populus x canadensis*;

5 - Plauru II (45°16′31.4″N 29°39′21.8″E) - plantation of *Salix alba*.

In all these stations there were taken series of five samples of soil divided into two suhorizons – olf (litter and fermentation layer) and ah (humification layer). Each sample had an area of 100 cm^2. The edaphic mesofauna was extracted by Tullgren – Berlese method, than it was sorted on groups. In the case of *Acariformes* mites from *Trombidiformes* and *Oribatida* the identification was performed at family level. It was calculated the average abundance ($\bar{a}$) of every identified group in each soil layer (Olf and Ah) and their sum ($\bar{A}$), expressed as individuals/m^2. Standard deviation (σ) and Pearson's coefficient of variation (cv%) of $\bar{A}$, ratio between oribatids and collembolans (O/C), radio adults/juveniles in the case of the *Oribatida* mites have been also calculated. The resemblance degree of Trombidiformes and oribatid

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communities from the 5 ecosystems were tested by Cluster analysis (UPGMA method) being used Sorensen's coefficient of similarity. All statistical calculations for this research were done in MVSP 3.2 software.

RESULTS AND DISCUSSION:

Biodiversity assessment of the edaphic mesofauna from deltaic forest ecosystems was achieved by identification and analysis of mites from two supraorders - *Parasitiformes* (*Mesostigmata*) and *Acariformes* (*Trombidiformes*, *Oribatida*, *Astigmatina*), insects from *Collembola* and overall, other insects and groups of soil microarthropods.

The highest global average density of the edaphic microarhtropods was recorded in the natural forest from Plauru, its value being about 3 times higher compared to that observed at Chilia Veche, another natural forest under study, where the the lowest density of the whole series of the plots was registered (Table 1); these values are comparable or even higher than those recorded in forest ecosystems from the middle and inferior section of the Prut riverside (Călugăr, 2006, Constantineanu *et al*., 2010).

Regarding the proportion of taxa, prevalence of mites was observed, situation generally encountered in natural forest ecosystems (Călugăr, 2006) (Table 1). However there was one exception - the case of Canadian poplar plantation Plauru II, where the colembolans through a great abundance (58% of total edaphic mesofauna) causes the reversal of this report. Among mites, the oribatids kept as usual, the majority (with 94.1% - 76.6 of total *Acari*), followed by *Trombidiformes* mites, which represents about 9-12% in natural forests from Chilia Veche and Plauru I, as well as in the plantation of *Populus* from Plauru II. In the remaining ecosystems *Mesostigmata* mites hold the second place after *Oribatida* with 6.5% at Letea and 2.7% at Plauru II - *Salix* plantation. *Astigmatina* mites which are stimulated by anaerobic environments rich in nitrogenous substances were identified in all analyzed soils, but with very low relative abundance of approximately 0.09-1.89% of total mites (Table 1). According to literature, the ratio between the main detritomicrophytophagous groups (*Oribatida* / collembolans) is a good bioindicator of the quality and stage of humification of an organic substrate (Huţu *et al.*, 1992). This ratio was subunit in two ecosystems - plantation of *Populus* from Plauru II and natural forest at Chilia Veche, in the last case the obtained value being only slightly under- unit. In the other analyzed ecosystems (natural forests from Letea and Plauru I and plantation of *Salix* from Plauru II) the ratio *Oribatida* /collembolans is supraunit (Table 1). Based on all these findings we can conclude that humification is prevalent in the majority of the studied stands; in these cases the nutrient cycling is slow. As a result, the soil quality is improved ensuring an optimal functioning of the entire ecosystem.

Table 1.
Average density of the edaphic microarthropods from the studied ecosystems

Taxa			Natural forests			Forest plantations	
			1	2	3	4	5
Mesostigmata		ā (Olf)	540	0	600	140	20
		ā (Ah)	1480	960	1720	1380	800
		Ā±cv	**2020 ± 76.59**	**960 ± 46.39**	**2320 ± 21.36**	**1520 ± 55.10**	**820 ± 84.98**
Trombidiformes		ā (Olf)	960	420	1700	460	60
		ā (Ah)	920	700	1100	1620	300
		Ā±cv	**1880 ± 83.18**	**1120 ± 69.93**	**2800 ± 39.57**	**2080 ± 79.03**	**360 ± 79.73**
Sarcoptiformes	Oribatida	ā (Olf)	6160	280	12360	2100	600
		ā (Ah)	20720	7060	15020	15460	27200
		Ā±cv	**26880 ± 51.52**	**7340 ± 54.43**	**27380 ± 40.5**	**17560 ± 15.85**	**27800 ±35.58**
	Astigmatina	ā (Olf)	240	140	0	20	0
		ā (Ah)	40	20	60	0	560
		Ā±cv	**280 ± 147.08**	**160 ± 93.54**	**60 ± 81.64**	**20 ± 200**	**560 ± 80.33**
Total Acari		ā (Olf)	**7900**	**840**	**14660**	**2720**	**680**
		ā (Ah)	**23160**	**8740**	**17900**	**18460**	**28860**
		Ā±cv	**31060 ± 50.94**	**9580 ± 53.93**	**32560 ± 37.78**	**21180 ± 21.57**	**29540 ± 35.73**
Collembola		ā (Olf)	2780	140	4640	1740	200
		ā (Ah)	9920	7920	22240	31240	5320
		Ā±cv	**12700 ± 71.66**	**8060 ± 44.88**	**26880 ± 36.88**	**32980 ± 67.95**	**5520 ± 27.26**
Other Insecta		ā (Olf)	120	260	500	220	200
		ā (Ah)	740	100	340	1380	740
		Ā±cv	**860 ± 43.25**	**360 ± 79.73**	**840 ± 53.55**	**1600 ± 75.81**	**940 ± 43.91**
Total Insecta		ā (Olf)	**2900**	**400**	**5140**	1960	**400**
		ā (Ah)	**10660**	**8020**	**22580**	32620	**6060**
		Ā±cv	**13560 ± 67.14**	**8420 ± 41.71**	**27720 ± 36.36**	**34580 ± 64.06**	**6460 ± 26.67**
Other groups		ā (Olf)	420	220	780	380	0
		ā (Ah)	1000	1480	1580	640	2280
		Ā±cv	**1420 ± 46.58**	**1700 ± 69.20**	**2360 ± 45.47**	**1020 ± 79.02**	**2280 ± 33.67**
TOTAL		ā (Olf)	11220	1460	20580	5060	1080
		ā (Ah)	34820	18240	42060	51720	37200
		Ā±cv	**46040 ± 50.32**	**19700 ± 47.03**	**62640 ± 34.40**	**56780 ± 40.36**	**38280 ± 29.01**
O/C			**2.11**	**0.91**	**1.01**	**0.53**	**5.03**

Legend: 1-5 - sampled stands (see § Material and method); O/C - Oribatida/Collembolla ratio; ā - average abundance on each group (individuals/m^2)/soil layer; Ā -global average abundance (individuals/m^2); cv- Pearson's coefficient of variation (%), Olf - litter and fermentation sub - horizon and Ah - humiferous horizon.

Another aspect analyzed in this study, the vertical distribution showed a higher population of the deeper layer Ah, 67-97% of the total number of the mesofauna being found here, both in natural ecosystems, and anthropogenic ones. The withdrawal to the depth is certainly the effect of the drought of the sampling period; sandy loam soil with a fine texture that characterizes forests in this area dries very quickly at the surface. Analysis of the horizontal distribution shows a tendency to aggregation, especially in groups or stands with lower abundance (Table 1).

Analysis of the mites fauna from *Trombidiformes,* a group with a varied food regime (Krantz & Walter, 2009) led to identification of 13 families. Among these more than a half have zoophagous food regime and the rest are microphytophages (30%) and with a diversified diet (15%). Overall, only three families - *Bdellidae, Anystidae and Scutacaridae* are common to the five forest ecosystems under study. Cluster analysis shows that natural forests at Plauru and Chilia have common characteristics in terms of *Trombidiformes* fauna spectrum, and also the two plantations from Plauru are similar. As well, the degree of similarity of natural forests and plantations is very low, being remarked distinct grouping of natural and anthropogenic ecosystems (Fig 1).

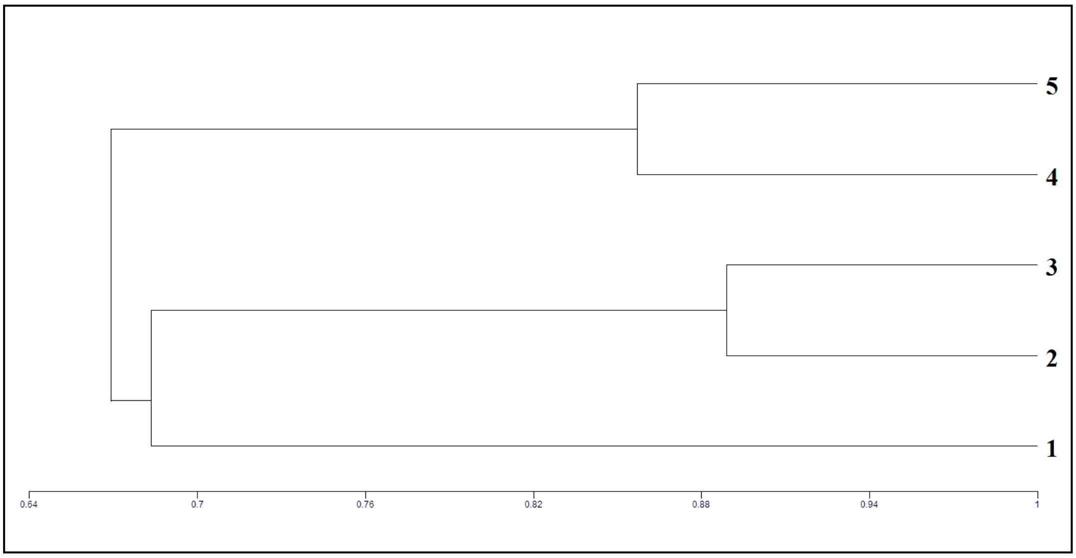

Fig. 1 Cluster analysis of *Trombidiformes* (Sørensen`s coefficient) based on families abundance

Among the edaphic microarthropods, oribatid mites are well represented in all investigated forest ecosystems, being distinguished both in abundance (hold 76.6 - 94.1% of total mites) and by taxonomic richness and diversity (Table 1, 2). Global average abundance has ample variations from one stand to another, both in the case of natural forests, and the plantations, mainly influenced by bio-edaphic conditions specific to each stand. These values of density are higher, but comparable to those found in other meadow forests, for example in the Prut lower section (Constantineanu *et al.*, 2010). Horizontal distribution illustrated by Pearson variation coefficient of abundance proves to be more uniform in plantations than in natural forests where litter is more diverse and spread mosaic-like.

Table 2

Structural parameters of oribatid mites communities

Forest type	Stand	Soil layer	Ā (adults)	Adults/ immatures	individuals in Olf (%)		Taxonomic richness*
					adult	immature	
Natural forests	1	Olf	4700	3.22			
		Ah	17680	5.81			
		O	**22380**	**4.97**	**21**	**32.4**	**21/ 28/ 32**
	2	Olf	120	0.75			
		Ah	6220	7.4			
		O	**6340**	**6.3**	**1.9**	**16**	**12/ 18/ 20**
	3	Olf	5740	0.86			
		Ah	12440	4.82			
		O	**18180**	**1.97**	**31.6**	**71.9**	**20/ 26/ 30**
Forest plantations	4	Olf	780	0.59			

	Ah	11380	2.79			
	O	**12160**	**2.25**	**6.4**	**24.4**	**19/ 25/ 26**
5	Olf	160	0.36			
	Ah	18460	2.11			
	O	**18620**	**2.03**	**0.9**	**4.8**	**18/ 22/ 24**

Legend: Ā – global average abundance (individuals/m^2); * - number of families/ genera/ species; O - organic layer (global); Olf – litter and fermentation sub-horizon; Ah – humiferous horizon; 1, 2…5 - forest stands (see Material & method)

Demographic structure of the oribatid communities was analyzed using numerical ratio adults / immatures. The values of this ratio range between 1.97 and 6.34, indicating a normal dynamic of coenoses and their relative stability. In all investigated ecosystems adults / immatures ratio is lower in the superficial sub-horizon (Olf) than in the deep humiferous layer (Ah) Vertical distribution of oribatid mites was analyzed using the percentage of individuals identified in surface sub-horizon. As mentioned above for other groups of microarthropods, also in the case of oribatids a massive migration into deep layer is observed, 54.8 - 97.8% of individuals being found here, as a response to limiting conditions (high temperatures, dryness) reported in the sampling period. In all investigated stands percentage of immatures identified in Olf is higher than that of adults, so juvenile stages that withdraw in a lower proportion to the deep layer, are proving more resilient than adults to the unfavorable conditions (Table 2).

The study of oribatid fauna as a whole led to a checklist of 31 families, 46 genera and 58 species (Krantz & Walter, 2009, Weigmann, 2006), more detailed analysis being in preparation for another article. Number of taxa recorded in natural forests, excepting Chilia Veche stand, is slightly higher than in forest plantations, with no proportional relationship with the global average abundance (Table 2). Within the taxonomic spectrum dominance of family *Oppiidae* Sellnick 1937 was noted, both in number of taxa, and the relative abundance. This family comprising microphytophagous oribatid mites is represented by 10 genera and 11 species that hold, from one forest stand to another 31.8 - 64.7% of total oribatids. The second family as representativity, missing only at Chilia Veche is *Brachychthoniidae* Thor, 1934 with 3 genera and 5 species that comprise 2.95-22.33% of oribatid individuals.

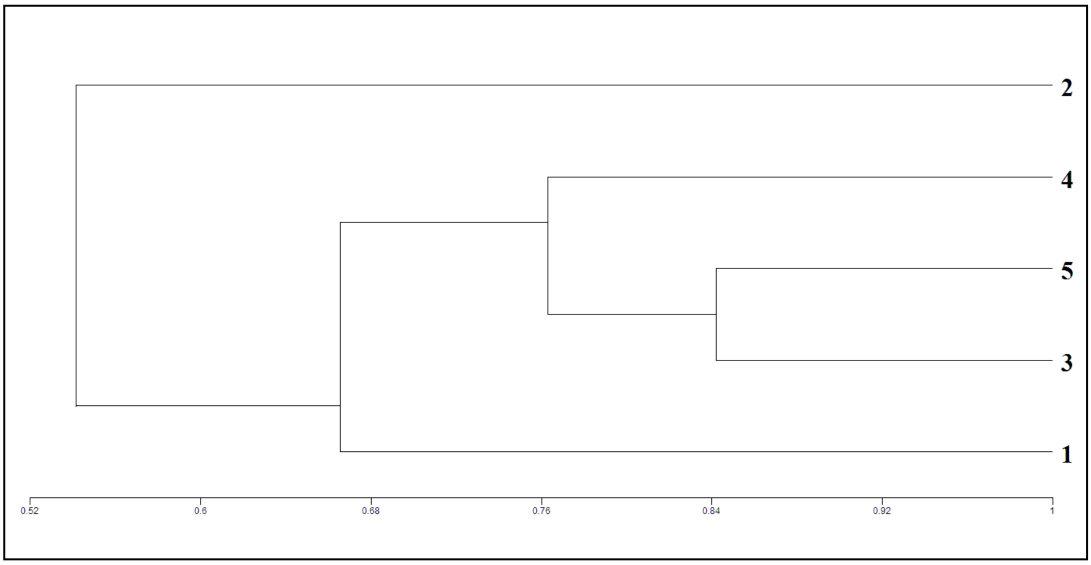

Fig. 2 Cluster analysis of oribatid mites (Sørensen`s coefficient), based on families abundance

The similarity and cluster analysis of oribatids based on families' abundance shows a higher similarity of oribatid communities depending on stand location (3, 5 and 4 stands – Plauru I and II) while the community from Letea forest and especially that in Chilia Veche are more distant (Fig. 2). It is probable that in the case of Danube Delta forests soil type and other local conditions be prevalent beside the forest type, composition and litter quality as main factors with influence on oribatid communities' structure. Nevertheless, further investigation based on species composition and abundance are needed, taking into account the seasonal dynamics of these ecosystems.

CONCLUSIONS:

Our investigation showed that the qualitative and the quantitative features of the edaphic mesofauna communities depend on the particular bio-edaphic conditions of each stand, the global abundance being higher or comparable with values registered in another meadow forests.

The ratio between the main detritomicrophytophagous groups (oribatids and collembolans – O/C) with supraunit values in most investigated ecosystems indicates prevalence of humification process with accumulation of humic substances, thus favorable conditions for the components of the edaphic subsystem, and for the ecosystem as a whole.

The similarity and cluster analysis of *Trombidiformes* and *Oribatida* based on families abundance highlighted bio-indicator valence of these groups, that should be thoroughly investigated in the next project stages.

Results of this study indicated that climatic conditions that occur in the sampling period significantly influenced the communities of edaphic mesofauna, however for an adequate data interpretation, further analysis should be done; a study based on population dynamics of edaphic mesofauna will led to the understanding of ecosystem functioning under the impact of natural and anthropogenic factors.

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