ORIBATID MITES FAUNA AND COMMUNITIES STRUCTURE IN HALOPHILOUS HABITATS FROM THE DANUBE DELTA BIOSPHERE RESERVE

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Abstract

The halophilous habitats, commonly found in the Danube Delta Biosphere Reserve, are restrictive habitats for most edaphic microarthropods; soil with high salt content, excess moisture and deficient aeration are the main limiting environmental factors. The present study aims to investigate, both from qualitative and quantitative points of view, the oribatid mite communities in these habitats of DDBR, less approached in previous ecological research. Following the field research, representative sampling sites were selected, located in the western DDBR, north of the Razim-Sinoe lagoon complex, between Murighiol and Enisala.

In terms of fauna, the small number of taxa was noticed (14 species, belonging to 12 genera and 9 families); poronotic oribatid mites are dominant both as number of species and individuals. *Humerobates rostrolamellatus* Grandjean, 1936, and also the genus *Humerobates* Sellnick, 1928 and the family Humerobatidae Grandjean, 1971 are recorded now for the first time in the Romanian fauna. Oribatid communities are simply structured, with a small number of species and low specific diversity, indicating a poor stability. In most of the investigated sites *Oribatula (Zygoribatula) undulata* Berlese, 1916 is the over-dominant species, holding 46-94% of all individuals. In addition, the frequency and relative abundance of the immature stages highlights the full adaptation of this species and its bio-indicator quality in relation to saline soils.

Key words: Danube Delta, saline meadows, Acari, Oribatida, bioindicators.

The Danube Delta, the second largest and the best preserved wetland in Europe, represents a wetland with international value under World Heritage Convention (1990), Man and Biosphere Programme of UNESCO (1990), Ramsar Convention (1991), Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Natura 2000 site, SCI and SPA since 2007). On the territory of Danube Delta Biosphere Reserve, 30 ecosystem types have been delimited, 23 natural or partly modified by man and seven anthropogenic ecosystems (Gâştescu P., 2009). Halophilous habitats, commonly spread within the deltaic biome, are restrictive for most plant species, but also for fauna (edaphic fauna, in particular); high soil salinity, excess moisture and deficient aeration, at least during certain periods, are the main limiting environmental factors. These habitats are populated by species that have developed adaptations, which allow them to survive in such environments and form distinct and characteristic plant and animal communities, hence a great scientific interest.

A long series of researches have been conducted on the fauna and ecology of the main edaphic microarthropod groups, including oribatid mites, in saline habitats. Most of the relevant studies concern the fauna of salt marshes in northern and western Europe (e.g., Polderman P.J.G., 1974; Weigmann G., 2008, 2013) but also in other parts of the world (New Zeeland – Luxton M., 1990). Following these studies, some species have been designated as halobiont, while other species have been shown to be halotolerant. Less numerous, investigations carried out in deltaic halophilous habitats have noticed an extremely poor fauna, dominated by surface species in relation to the edaphic ones (Zaitsev A.S., Pystina N.B., 2014).

In Romania and also in the Danube Delta oribatid mites fauna in saline habitats has been little investigated, comparative to other ecosystems; in this regard some sporadic studies may be mentioned, as part of some extensive faunistic or ecological researches, which mainly address qualitative aspects (Vasiliu N., Ivan O.,

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1995; Ivan O., 2005; Constantineanu I. *et al*, 2010).

Based on these data, the study of oribatid mites in halophilous habitats of DDBR aims at investigating the fauna, structure and seasonal dynamics of the communities, in relation to the stand conditions. This study is part of an interdisciplinary ecological research focused on assessment of conservation state and vulnerability of some natural ecosystems in DDBR, in the context of climate changes and anthropogenic pressure.

MATERIAL AND METHODS

Following the field research, four representative sampling sites were selected, located in the western DDBR, north of the Razim-Sinoe lagoon complex, between localities Murighiol and Enisala (Tulcea county), namely: 1. Murighiol (45°01′41″ N, 29°09′32″ E), halophilous grassland with *Puccinellia limosa, Juncus gerardii, Hordeum marinum, Aster tripolium, Salicornia europaea,* on the shore of Lake Saraturi; 2. Sarinasuf (45°00′51″ N, 29°04′53″ E), halophilous pasture with *Juncus gerardii, Halimione verucifera, Salicornia europaea,* on the shore of Lake Razim; 3. Plopu (45°01′23″ N, 29°06′34″ E), salt marsh with *Salicornia europaea*; 4. Enisala (44°54′34″ N, 28°49′56″ E), halophilous grassland with *Halimione verucifera, Limonium gmelinii, Salicornia europaea*. Data regarding peculiarities of soil and vegetation in the investigated sites are presented in another article (Acatrinei *et al.*, in press).

Two series of soil samples (100 cm^2 surface, 5 cm depth) have been taken from each site, in June and August 2017; at Murighiol, a series of previously collected samples (July 2015) was also considered. Edaphic mesofauna has been extracted from samples through the Tullgren - Berlese method (the variant proposed by Balogh, 1958) and selected by systematic groups. The oribatid mites have been submitted to microscopic study, in order to identify the species. The abundance of each species was noted, on samples and localities. The primary data thus obtained have been processed using some analytic and synthetic ecological estimators: average abundance of each species (ā) and global average abundance (Ā), expressed as individuals/100cm^2 and, respectively, m^2; number of species (S); mean number of species/sample (S'); frequency (C) and relative density (D.r.) of each species; index of ecological significance (W), expressed as classes: V and IV-edifying species, III-influential species, II and I-accompanying species; species diversity (H(s)max, H(s), H.r.), estimated by the Shannon - Wiener equation; the adults/immatures ratio.

The taxonomic list of oribatid mites includes ecological requirements (according to Perez-Iñigo C., 1993; Weigmann G., 2006; Vasiliu N. *et al.*, 1993) and world distribution of each species (Subías L.S., 2004, updated version 2018). The occurrence of species in the investigated sites is indicated, as well as the relative density, as follows: +++ species with more than 5% of individuals, ++ species with 2.1-5%, + species with less than 2% of total number of specimens collected in respective habitat, except for the Plopu site where each species had a minimum abundance of only one individual, thus marked with +; * signals the first records in Romanian fauna (*table 1*).

RESULTS AND DISCUSSION

In terms of oribatid mites fauna, 14 species were identified, included in 12 genera and 9 families (*table 1*). The number of identified taxa in halophilous habitats is considerably lower than in other natural ecosystems of the Danube Delta, probably in relation to the restrictive conditions of these habitats - high saline content of soil, excess moisture and deficient aeration, at least during certain periods (Călugăr A., Ivan O., 2016; Ivan O. *et al*, 2006; Vasiliu N., Ivan O., 1995). Zoogeographical analysis of oribatid mites fauna showed that cosmopolitan and semi-cosmopolitan species hold the absolute majority (71.4%), followed by the Palaearctic elements (21.4%), the Holarctic and the European ones being less represented (7.14%) (Subías L.S., 2004, 2018). As for the ecological spectrum (Weigmann G., 2006; Vasiliu N. *et al*, 1993), the grassland species constitute the largest group (42.8%), seconded by the eurytopic species, with low requirements in relation to the living conditions (21.4%). In terms of representation of the major groups, the dominance of Poronota, both in the number of species (64.3%) and individuals (96-100%, with the exception of the less populated site Plopu) is noted.

The species *Humerobates rostrolamellatus* Grandjean, 1936, but also the genus *Humerobates* Sellnick, 1928 and the family Humerobatidae Grandjean, 1971, are recorded now for the first time in Romanian fauna. *H. rostrolamellatus* considered an arboricolous species, was commonly reported on tree bark and more rarely in forest litter, preferring wet habitats (Perez-Inigo, 1993; Weigmann, 2006); this species. According to Norton R.A. and Pelletier V.M. (2009), this species is commonly found on bark tree, feeding on fungi and algae, being virtually unknown in litter samples. On the other hand, Weigmann G. (2013) reported *H. rostrolamellatus* in the coastal region of Portugal and mentioned that it is a eurytopic species with obvious tolerance of soil salt content.

Table 1

List of species and their occurrence in the halophilous habitats under study

Sampling sites Taxa	1	2	3	4	Ecological requirements	World distribution
Suborder Oribatida Dugès, 1834						
HAPLOCHTHONIIDAE Hammen, 1959 *Haplochthonius (Haplochthonius)* Willmann, 1930 -*H. (H.) simplex* (Willmann, 1930)	+				recorded in various habitats: litter, caves, house dust, nests of small mammals	semi-cosmopolitan
OPPIIDAE Sellnick, 1937 *Oppia* Koch, 1836 -*O. denticulata* (G. et R. Canestrini, 1882)	+				thermo-xerophilous, mainly silvicolous	Holarctic
Multioppia (Hammeroppia) Vasiliu et Ivan, 2009 -*M. (H.) moritzi* Mahunka et Topercer, 1983	+				recorded in cultivated soils	Central Europe
Rhinoppia (Rhinoppia) Balogh, 1983 -*R. (R.) obsoleta* (Paoli, 1908)			+		eurytopic	Palaearctic, New Zealand, Hawaii
TECTOCEPHEIDAE Grandjean, 1954 *Tectocepheus* Berlese, 1896 -*T. velatus* (Michael, 1880)			+		eurytopic	cosmopolitan
PHENOPELOPIDAE Petrunkevitch, 1955 *Peloptulus* Berlese, 1908 -*P. phaenotus* (Koch, 1844)	+				eurytopic, grassland species; halotolerant	Palaearctic
HUMEROBATIDAE Grandjean, 1971* *Humerobates* Sellnick, 1928* -*H. rostrolamellatus* Grandjean, 1936*		+++	+		frequently recorded on the bark of trees, also in litter	semi-cosmopolitan
PUNCTORIBATIDAE Thor, 1937 *Punctoribates (Punctoribates)* Berlese, 1908 -*P. (P.) punctum* (Koch, 1839)			+		eurytopic, grassland species	semi-cosmopolitan
Punctoribates (Minguezetes) Subías, Kahwash y Ruiz, 1990 -*P. (M.) hexagonus* Berlese, 1908	+			++	hygrophilous, grassland species; halotolerant	Holarctic, Vietnam, Zambia
ORIBATULIDAE Thor, 1929 *Oribatula (Zygoribatula)* Berlese, 1916 -*O. (Z.) undulata* Berlese, 1916	+++	+++		+++	xerophilous halotolerant / halophilous	pantropical, subtropical
SCHELORIBATIDAE Grandjean, 1933 *Scheloribates (Scheloribates)* Berlese, 1908 -*S. (S.) fimbriatus* Thor, 1930				++	recorded in meadows, in cultivated soils	pantropical, subtropical
-*S. (S.) labyrinthicus* Jeleva, 1962	+++			+++	eurytopic, grassland species	S Palaearctic
GALUMNIDAE Jacot, 1925 *Galumna (Galumna)* Heyden, 1826 -*G. (G.) tarsipennata* Oudemans, 1914		+			not clear	S Palaearctic, Brazil
Pergalumna (Pergalumna) Grandjean, 1936 *P. (P.) obvia* (Berlese, 1914)	+++				meso-hygrophilous, prefers grassland soils	semi-cosmopolitan

Table 2

Dynamics of structural parameters of the oribatid mite communities

Sampling site / date		Ā ± c.v.		Number of taxa (F/G/S)	S'	Adults/ immatures	Specific diversity		
		total	adults				$H(s)_{max}$	H(s)	H.r.
1	24.07.2015	5860±44.7	5200±45.5	6/7/7	4	7.88	2.8073	0.7049	44.48
	6.06.2017	3520±87.6	2780±116.5	4/4/4	2	3.76	1.9999	0.484	24.2
	10.08.2017	8460±74.9	7700±78.03	4/4/4	2.4	10.13	1.9999	0.7687	38.43
2	6.06.2017	8000±69.1	7560±70.3	3/3/3	1.6	17.18	1.5849	0.7049	44.48
	10.08.2017	2360±122.5	2320±123.9	2/2/2	1	58	0.9999	0.3285	32.86
3	7.06.2017	80±145.8	60±133.3	3/3/3	0.6	3	1.5849	1.5846	99.98
	10.08.2017	40±122.5	20±200	1/1/1	0.2	1	-	-	-
4	7.06.2017	340±97.7	300±98.9	3/3/3	1.2	7.5	1.5849	1.5055	94.99
	9.08.2017	6740±124.4	5900±121.9	2/2/3	1.2	7.02	1.5849	1.0175	64.2

Legend: Ā – global average abundance (individuals/m^2); c.v.- Pearson coefficient of variation (%); number of taxa: F-families, G-genera, S-species; S'- average number of species/sample; H(S)max – maximum specific diversity; H(S) – real specific diversity; H.r. - relative diversity (%); 1-4 sampling sites (see § Material and methods)

Considering all this information, the identification of the species in halophilic habitats in Danube Delta (at Sarinasuf and Plopu, *tables 1, 3*) is consistent with the recent record from Iberian Peninsula, and also represents a novelty for DDBR and for Romanian fauna.

Analysis of the global structural parameters of the oribatid mite communities reveals great differences, especially with respect to the average global abundance, depending both on site and seasonal conditions (*table 2*). The abundance of oribatids is relatively low, comparable to that of similar habitats in DDBR and other wetlands (Vasiliu N., Ivan O., 1995; Constantineanu I. *et al*, 2010; Zaitsev A.S., Pystina N.B., 2014). Horizontal distribution, as illustrated by the high coefficient of variation, is uneven, aggregated in some sites and months. The adults / immatures ratio has high values, with large fluctuations from one season to another, which indicates the instability of the oribatid populations.

Table 3

Structure and dynamcs of the oribatid mites communities

Sampling site/	1. Murighiol						2. Sarinasuf				3. Plopu				4. Enisala			
date	07.2015		06.2017		08.2017		06.2017		08.2017		06.2017		08.2017		06.2017		08.2017	
Species	ā	W	ā	W	ā	W	ā	W	ā	W	ā	W	ā	W	ā	W	ā	W
Oribatula (Z.) undulata	42.2	V	25.6	V	65.6	V	61.8	V	21.8	V	-	-	-	-	1.4	V	35.6	V
Scheloribates (S.) labyrinthicus	6.6	V	0.2	II	5.8	III	-	-	-	-	-	-	-	-	-	-	23	V
Humerobates rostrolamellatus	-	-	-	-	-	-	13.6	IV	1.4	III	0.2	IV	-	-	-	-	-	-
Punctoribates (M.) hexagonus	1.2	III	0.4	II	-	-	-	-	-	-	-	-	-	-	1	IV	-	-
Pergalumna (P.) obvia	1.2	III	1.6	III	5.4	III	-	-	-	-	-	-	-	-	-	-	-	-
Scheloribates (S.) fimbriatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	IV	0.4	II
Multioppia (H.) moritzi	0.4	II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oppia denticulata	0.2	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haplochthonius (H.) simplex	0.2	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peloptulus phaenotus	-	-	-	-	0.2	I	-	-	-	-	-	-	-	-	-	-	-	-
Galumna (G.) tarsipennata	-	-	-	-	-	-	0.2	I	-	-	-	-	-	-	-	-	-	-
Rhinoppia (R.) obsoleta	-	-	-	-	-	-	-	-	-	-	0.2	IV	-	-	-	-	-	-
Tectocepheus velatus	-	-	-	-	-	-	-	-	-	-	0.2	IV	-	-	-	-	-	-
Punctoribates (P.) punctum	-	-	-	-	-	-	-	-	-	-	-	-	0.2	V	-	-	-	-

The highest values of density, number of species and specific diversity were found in the sites with higher plant diversity (especially Murighiol, but also Sarinasuf), and the lowest in those with poor vegetation, represented almost exclusively by *Salicornia europaea* (Plopu) (*tables 2, 3*).

Oribatid communities are simply structured, with a small number of species, the best adapted being numerically dominant. Thus, distribution of individuals by species is uneven, which lead to very low values of specific diversity indicating the poor stability of oribatid communities and tendency towards structural entropy, in some cases (*tables 2, 3*). Similar peculiarities of the oribatid communities have been highlighted in other studies conducted in halophilous habitats (Ivan O., 2005; Zaitsev A.S., Pystina N.B., 2014).

In most of the investigated sites *Oribatula (Zygoribatula) undulata* Berlese, 1916 is the over-dominant species, bringing together 46-94% of all individuals (*table 3*). In addition, the frequency and relative abundance of immature stages of this species highlights its full adaptation and potential bioindicator quality in relation to saline soils. In a comparative study on the fauna and structure of the oribatid communities in the salt marshes of the southern and northern European Atlantic coasts (Portugal and Germany) Weigmann G. (2008) found *O. (Z.) undulata* with a high relative abundance in some sites in Portugal, but not also in Germany. Therefore, the species is not mentioned among the characteristic species of coastal salt marshes. At present *O. (Z.) undulata* is considered as a xerophilic species (Perez-Iñigo, C. 1993) with a pantropical / subtropical distribution (Subías L.S 2004, 2018). The results of this study, correlated with the previous records and observations on this species in Romania (Vasiliu N., Ivan O., 1995, Constantineanu I. *et al*, 2010), highlight the affinity of this species for halophilous habitats and support its bioindicator quality.

CONCLUSIONS

In the halophilous habitats under investigation suborder Oribatida Dugès, 1834 is represented by a small number of species, compared to other natural ecosystems of the Danube Delta Biosphere Reserve. The species *Humerobates rostrolamellatus* Grandjean, 1936, and also the genus *Humerobates* Sellnick, 1928 and the family Humerobatidae Grandjean, 1971 are recorded for the first time in Romanian fauna.

Regarding the ecological requirements, grassland species and eurytopic ones have the highest share in the whole fauna, while in terms of their world distribution, cosmopolitan / semi-cosmopolitan species are the most numerous.

The oribatid communities are constituted of a small number of species, having a simple structure, an unequal distribution of individuals by species and a low specific diversity, indicating increased coenotic instability and, in some cases, a state of structure entropy.

Oribatula (Zygoribatula) undulata Berlese 1916 is the over-dominant species in most investigated sites, both as adult and immature instars. These results are consistent with previous data regarding the occurrence of this species and illustrate its potential quality of bio-indicator relative to saline soils.

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