THE SALINE GRASSLANDS, A SUITABLE ENVIRONMENT FOR MAINTAINING THE FUNCTIONAL RELATIONSHIPS OF THE EDAPHIC MESOFAUNA?

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Abstract

This study represents a continuation of research carried out in Danube Delta Biosphere Reserve, within the Core Program, financed by the Romanian Ministry of Research and Innovation. Communities of edaphic microarthropods in halophilic ecosystems of D.D.B.R. have been investigated to assess their vulnerability. The analysis was performed qualitatively and quantitatively, on systematic and trophic groups, in a space-time dynamic. The obtained results have shown that the structural features of edaphic mesofauna depend both on the vegetation and the biopedoclimatic conditions, in general the halophilic habitats being restrictive for most edaphic microarthropods. The highest density is observed in a salinized wet meadow, characterized by a great floral diversity. The lowest population abundance was recorded in the grassland with the poorest vegetation, where *Salicornia europaea* is the only dominant species. The analysis of the relationships between the trophic groups highlights the dominance of the detritomicrophytophages versus zoophages, a situation that is usually found in meadow ecosystems. The analysis of the seasonal dynamics of the mesofauna as a whole revealed that in most of the studied ecosystems, under summer drought conditions there was a decrease in the total number of edaphic mesofauna (1.6-4.3 times), the most significant decrease (2 -20 times) being the number of springtails that are known to be susceptible to edaphic dryness. The numerical ratio between oribatid mites and springtails (the main groups of detritomicrophytophages) is in most cases supraunitary, indicating that in the nutrient cycling the humification processes are predominant.

Key words: Danube Delta Biosphere Reserve, saline meadows, microarthropods, bioindicators

The Biodiversity Strategy of the European Union set up by 2020 requires the assessment of their ecosystems and services in order to preserve biodiversity and minimize any negative impact on biodiversity. Monitoring ecosystems plays an extremely important role in this respect.

The Danube Delta has become a biosphere reserve, precisely because of the ecosystems hosting a huge biodiversity which suffered an anthropogenic pressure over time, hence the need to protect it. A special category of DDBR ecosystems are halophilic habitats, characterized by holomorphic soils and association of plants with *Salicornia herbacea, Suaeda maritima, Puccicinellia distans, Aeluropus littoralis, Limonium gmelinii*, etc.

Mesofauna representatives, together with soil microflora, are actively involved in biodegradation processes of vegetal necromass, in the nutrient and energy circuit within the ecosystem; the density of these beings and the relationships between the various systematic and trophic groups determine the speed and course of the decomposition processes (Wallwork J. A., 1976). It is recognized that, more diverse and complex trophic relationships support a more dynamic mineralization - humification equilibrium, thus ensuring optimal conditions for the functioning of the entire ecosystem. To date fauna of microarthropods in the DDBR's saline ecosystems has not been systematically investigated, but only sporadically in some other ecological research

Considering the above-mentioned aspects, the present study proposes the assessment of the biodiversity and the vulnerability of some halophilous meadow ecosystems in DDBR through the qualitative and quantitative study of edaphic mesofauna.

This study was carried out in the context of an interdisciplinary approach within the Core Program, financed by the Romanian Ministry of Research and Innovation. An important reference point for this work is represented by previous qualitative and quantitative research on these groups of animals carried out in other wetlands, including some saline habitats (Antohe A. *et al*;

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1986; Călugăr A., 2005; Constantineanu I. *et al*, 2010).

MATERIAL AND METHOD

Four representative ecological stands (Murighiol - 1, Plopu - 2, Sarinasuf - 3 and Enisala - 4) were selected in the western DDBR, north of the Razim - Sinoe lagoon complex, between Murighiol and Enisala. In the meadow of Plopu dominates the halophyte species *Salicornia europea*, and in the rest of the meadows this species is accompanied by many other salt tolerant plants (Acatrinei L. *et al,* in press) (*table 1*). The sampling was done in June and August 2017. For each of the stands, the soil sample had a standard surface area of 100 cm^2. The mesofauna was extracted from the samples by the Tullgren – Berlese method, in the version proposed by Balogh and then it was sorted into systematic groups. The faunal material was subjected to the microscopic study; the abundance of each group was registered sample by sample. The average abundance (ā), standard deviation (σ) and Pearson's variation coefficient. (c.v.%) were calculated and also, the ratio between oribatid and astigmatid mites (O / As) and oribatid mites and collembolans (O / C) (*table 2*).

Table 1

Stands characteristics

Stand	1	2	3	4
Coordinates	45°01´41.02”N, 29°09´31.99”E	45°01´23.47”N, 29°06´33.63”E	45°0.5´50.59”N, 29°04´53.34”E	44°54´33.51”N, 28°49´56.28”E
Vegetation	*Salicornia europaea, Puccinellia distans, P. limosa, Hordeum marinum, Trifolium fragiferum*	*S. europaea, Bassia hirsuta*	*Juncus gerardii, Halimione verucifera, S. europaea*	*Limonium gmelinii, H. verucifera, S. europaea*

RESULTS AND DISCUSSION

The evaluation of the biodiversity of edaphic microarthropod fauna from halophilic ecosystems of Danube Delta Biosphere Reserve (DDBR) was carried out by inventorying and analyzing the mites of the Parasitiformes supraorder (Mesostigmata order with the cohorts Gamasina and Uropodina) and Acariformes (Trombidiformes order and Sarcoptiformes order - Oribatida suborder and Astigmatina cohort) belonging to the Entognatha class (Collembola order) and insects as a whole, as well as other edaphic microarthropods, (*table 2*).

Researches have shown that both quantitative and qualitative features of soil mesofauna depend on vegetation and bio-climatic stand conditions; there were evidenced differences due to the degree of environmental anthropization (grazing), but also to some abiotic conditions (moisture, salinisation).

The highest value of the global average density of the edaphic microarthropods was recorded at the meadow ecosystem from Murighiol characterized by the highest plant biodiversity and the lowest abundance in the Plopu grassland with the poorest vegetation. Thus, the value of the mesofauna abundance in the case of soil samples collected from Murighiol grassland was higher than that observed at Plopu, about 65 times in June and 56 times in August (*figure 1, table 2*). Experimental researches carried out in the saline meadows of the Prut meadow have shown that edaphic microarthropods in the detritus trophic chain has reduced the number of taxa and the density of individuals with the salt concentration increasing at the soil surface (Antohe A. *et al*, 1986). Earlier results obtained from ecological researches carried out in mesophilous praticolous ecosystems from the middle meadow of the Prut river, partly even halophilous ones, led to the finding that the densities of the edaphic microarthropods in the halophilous grasslands of DDBR are in some cases lower and in others, similar or even higher (Călugăr A., 2005, Constantineanu I. *et al*, 2010). Thus, compared to the meadows investigated in 2005, in the intensely halophilous meadow of Plopu, the lowest population abundance (13-84 times) was registered; at Murighiol, in the case of samples taken in June, was registered the highest one (1.2-5.3 times).

The comparison with praticolous ecosystems in the lower meadow of the Prut, investigated in 2010, prospectively with a meadow in the floodplain, where the density of microarthropods was the highest in the series of ecosystems investigated at that time, revealed that in June at Murighiol the abundance of these animals was about 1.2 times higher, and in August, 1.6 times smaller. Instead, the reference to the densities of microarthropods in forest ecosystems of DDBR indicates lower values in this halophilous meadow, 1.3 times compared to the natural forests and 1.18 times to the forest plantations (Călugăr A. and Ivan O., 2016). The heavily salted grassland of Plopu is

still on the last place, here being the lowest densities of the edaphic microarthtropods (in August even 23 times lower than the lowest value recorded in 2010) (Constantineanu I. *et al*, 2010).

Table 2

Average density (individuals/100 cm²) of the edaphic microarthropods from the studied biotopes

Taxa		Stand/ month	1		2		3		4	
4			VI	VIII	VI	VIII	VI	VIII	VI	VIII
Parasitiformes - Mesostigmata	Gamasina	ā	26.8	26.4	0.2	0.2	40.8	4.4	16.4	5
		σ	11.62	8.11	0.4	0.4	15.66	2.58	13.51	4.69
		c.v.	43.34	30.43	200	200	38.39	58.56	84.41	93.81
	Uropodina	ā	0.2	0.6	0	0	0	0	0	0
		σ	0.4	1.2	-	-	-	-	-	-
		c.v.	200	200	-	-	-	-	-	-
Acariformes - Trombidiformes		ā	11	53.4	0	2.2	136.2	22	31.8	31.4
		σ	12.08	75.91	-	2.23	60.04	24.36	31.66	46.42
		c.v.	109.84	142.15	-	101.23	44.08	110.75	99.55	147.83
Sarcoptiformes -	Oribatida	ā	35.2	84.6	0.8	0.4	80	23.6	3.4	67.4
		σ	30.85	63.41	1.17	0.49	55.29	28.86	3.32	83.82
		c.v.	87.64	74.95	145.77	122.47	69.11	122.27	97.72	124.36
	Astigmatina	ā	0.4	0.4	-	-	-	0.4	-	-
		σ	0.49	0.49	-	-	-	0.8	-	-
		c.v.	122.47	122.47	-	-	-	200	-	-
Total Acari		ā	**73.6**	**165.4**	**1**	**2.8**	**257**	**50.4**	**51.6**	**103.8**
		σ	**46.6**	**56.22**	**1.1**	**2.04**	**94.68**	**34.41**	**43.38**	**130.12**
		c.v.	**63.31**	**33.99**	**109.54**	**72.84**	**36.84**	**68.26**	**84.06**	**125.35**
Entognatha - Collembola		ā	369	61.6	0.4	0.4	20	1	7.2	3.6
		σ	282.62	21.22	0.8	0.49	18.56	1.26	9.99	5.24
		c.v.	76.59	34.44	200	122.47	92.79	126.49	138.72	145.51
Insecta		ā	37.4	19.8	6	1	24.4	17.6	10.6	5.2
		σ	14.33	14.66	4.52	1.1	19.48	7.17	5.28	2.32
		c.v.	38.32	74.04	75.27	109.54	79.83	40.75	49.78	44.52
Other groups		ā	0.2	0.4	0	0.2	0	0	5	0.2
		σ	0.4	0.8	-	0.4	-	-	5.76	0.4
		c.v.	200	200	-	200	-	-	115.24	200
Total		ā	**480.2**	**247.2**	**7.4**	**4.4**	**301.4**	**69**	**74.4**	**112.8**
		σ	**333.22**	**68.98**	**3.98**	**2.1**	**100.75**	**37.77**	**53.15**	**132.15**
		c.v.	**69.39**	**27.90**	**53.78**	**46.80**	**33.42**	**54.74**	**71.43**	**117.15**
O/As			**88.0**	**211.5**	**0**	**0**	**0**	**59.0**	**0**	**0**
O/C			**0.1**	**1.37**	**2.0**	**1.0**	**4.0**	**23.6**	**0.47**	**18.72**

Investigating the share of different groups of microartropods, the prevalence of mites (63-92%) is generally noted, as well as in other researches carried out in some meadows, but also in forests from DDBR (Călugăr A., 2005; Călugăr A. and Ivan O., 2016). Collembolans numerically dominated the mites in the constantly flooded meadows (Constantineanu I. *et al*, 2010) (*figure 1*).

Of the mites, the majority are either oribatids (31-80%) or trombidiform mites (30-79%). Oribatids, the mites with detritomicrofitophagous trophic regime (Krantz G. W. and Walter D. E., 2009), had the highest

densities, occupying the first place in June at Murighiol (48%) and Plopu (80%), and in August at Enisala (80.3%) (*table 2*, *figure 1*).

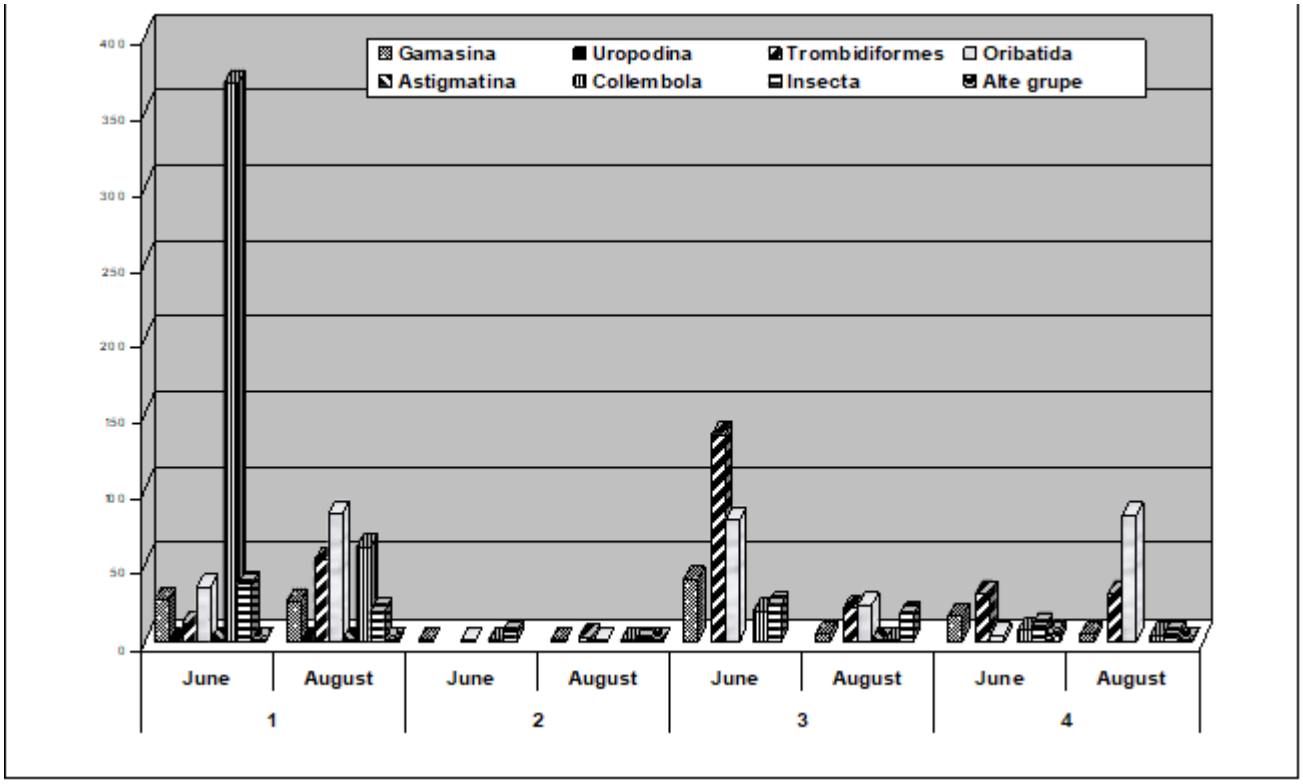

Figure 1 **The average density and dynamics of the main edaphic microarthropod groups**

The mites of the Mesostigmata order are predominantly represented by gamasid mites with predominantly predator trophic regime (Krantz, 2009). These are found in all the meadows analyzed, ranging between 4.8% (Enisala - August) and 36.4% (Murighiol - June). High percentages are also observed in these mites, in June at Enisala (about 32%) and Plopu (20%), and in August, with 16% of all mites, at Murighiol and Sarinasuf. Among mesostigmatids, uropodid mites, characterized by a varied diet (Krantz G. W. and Walter D. E., 2009), were represented by a small number of individuals (0.27-0.42% of total mites) and were identified only at Murighiol (*table 2, figure 1*).

Trombidiformes, a group whose representatives have a diverse diet (Krantz G. W. and Walter D. E., 2009), dominated numerically in June at Sarinasuf and Enisala meadows (53% and 62% respectively) and in August, at Plopu (79%) (*table 2, figure 1*).

Within the fauna of mites, it is noteworthy the poor representation of the mites from Astigmatina cohort, a microphytophagous group (Krantz G. W. and Walter D. E., 2009), stimulated by wet and rich in organic matter (Călugăr M. *et al*, 1989). These mites were identified only in the samples from Murighiol and Sarinasuf meadows, but only in August; the fact may be related to the grazing activity observed here. With regard to their relative abundance, it is extremely small, below 1% of all mites (*table 2, figure 1*). Therefore, astigmatines are absent in the highly saline meadows (Plopu, Enisala), this being contrary to that found in previous research which indicates that their densities grow in saline surfaces (Antohe A. *et al*, 1986).

Similar results namely the dominance of Prostigmata, Oribatida and Gamasida (Mesostigmata) were found in an extensive study on distribution and diversity patterns of soil fauna in different salinization habitats of China. Also, as a conclusion it is highlighted that habitat salinization affected the diversity and composition of soil fauna (Yin X. *et al*, 2018).

The study of the seasonal dynamics of mesofauna, as a whole, revealed, in accordance with the research in the saline experimental field (Antohe *et al*, 1986), that in the summer drought there is a decrease in the total number of edaphic mesofauna (1.6-4.3 times). The most significant decrease (2-20 times) in density in August compared to June, and the one that actually draws the general trend, is that of collembolans, which are known to be sensitive to edaphic dryness, and possibly, also to increased salinity. Seasonal dynamics showed that some of the microarthropods increase in their number in

August compared with June. This increase is quite important, such as about 22 times in the case of Oribatida in Enisala and 5 times for Trombidiformes at Murighiol (*table 2, figure 1*). The analysis of the relationships between the trophic groups highlights the dominance of the detritomicrophytophagous group compared to the zoophagous, which is usually found in praticolous ecosystems (Antohe A. *et al*, 1986, Călugăr A., 2005, Constantineanu I. *et al*, 2010).

The numerical ratio between the two categories of sarcoptiforms - oribatids / astigmatines reflects the prevalence of aerobic and anaerobic processes during the biodegradation of some organic substances. Examination of this ratio indicates very high values, astigmatines having sporadic presence and densities much lower than those of the oribatids, a result that shows the tendency towards intense humification.

Unlike the Astigmatina mites, which develop in nitrogen-rich environments, favoring anaerobic decomposition processes, Oribatida suborder prefers the environments where aerobic decomposition processes predominate, which has the effect of humification of the organic residues. The values of the numerical ratio between oribatids and collembolans (the major detritomicrophytophagous groups) are in most cases superunit, indicating the the predominance of humification processes, as occur in the most praticolous ecosystems (Huţu *et al*, 1992).

Horizontal distribution is mainly based on trophic resources of different groups. Gamasids have a more uniform spread at Murighiol and Sarinasuf (June), here the coefficient of variation has lower values than those calculated for the rest of the meadows. It can be seen that Trombidiformes and collembolans, which are the prey for the gamasid mites, are more abundant and even distributed, at least in some months, thus providing a plenty source of food necessary for gamasids (*table 2*). Of the detritomicrophytophages, the oribatids and collembolans are distinguished by a non-uniform, agglomerated distribution in most of the investigated meadows and time sequences, which is evidenced by a high coefficient of variation (*table 2*).

CONCLUSIONS

Taking into account the results obtained with edaphic mesofauna one can assert that edaphic mesofauna has a bioindicator value, both at group and ratio level.

The edaphic microarthropods are characterized by high densities in meadow with high floristic diversity, and low density in those poor in plant species and higher soil salinity. In summer drought conditions, in most of the studied praticolous ecosystems a diminution of the mesofauna density was found, the most noticeable being in collembolans, which are recognized as susceptible to edaphic dryness, thus possibly also to salinity.

Among the mites, there were noted with an increased weight, either oribatids or Trombidiformes. Mesostigmatid mites occupied the third place and the astigmatines had low densities or were absent in most of the stands / time sequences analyzed.

Analysis of the relationships between trophic groups highlights the dominance of detritomicrophytophagous microarthropods, compared to zoophagous ones, a situation commonly encountered in praticolous ecosystems. Based on oribatid / astigmatine (O / As) ratio, as well as oribatid / collembolans (O / C) with supraunit values, it can be appreciated that humification predominates in the analyzed halophilous meadows.

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