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Remarks on fauna and population of oribatid mites (Acari: Oribatida) in Priazovsky National Wildlife Sanctuary (Southern Russia)

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Abstract

This study is devoted to the faunal inventory and preliminary ecological analysis of oribatid mite communities in Priazovsky National Wildlife Sanctuary (Krasnodar Krai, Southern Russia), which is included into the Ramsar Convention 'Kuban Delta' Wetland of international importance. We sampled five major habitat types represented in the sanctuary and its environs: liman-reed beds, sandy coasts, elevated coasts, rice paddies, and a salt marsh. In total, 40 oribatid mite species were found. They belonged to 22 families. Most of the species were earlier met in the neighboring regions: Krasnodar Krai, Rostov region and Northern Caucasus. Few species however were found in Krasnodar Krai for the first time, e.g. *Ghilarovizetes obtusus* Shaldybina, 1969, which was earlier recorded only in the Central and Eastern Caucasus. The most species-rich habitats were liman-reed beds. In rice paddies, oribatid communities were rudimentary and represented only by very few species. The abundance of different oribatid ecomorphs was quite contrasting across the five habitat types. Soil-dwelling mites dominated in liman-reed beds possibly due to stable humidity of soil in this habitat type. The presence of aquatic mites in liman-reed beds was also quite peculiar. In well-drained elevated coasts, non-specialized and surface-dwelling mites were the most numerous because of their better adaptation to drought. In sandy coasts and salt marshes, surface-dwelling mites prevailed. We conclude that salinity and rice-growing seem to reduce considerably abundance and diversity of oribatid mites in the study area. We further assume that the quite high similarity of oribatid fauna in Priazovsky National Wildlife Sanctuary with that in the surrounding regions suggests much closer biogeographic relationship of Kuban lowlands with other regions of North Caucasus, than one would expect.

Keywords Oribatid community | Kuban river delta | Ramsar wetland | soil mesofauna | ecomorphs

1. Introduction

Priazovsky National Wildlife Sanctuary was founded in 1958 and since 1994 served as the part of the Ramsar Convention 'Kuban Delta' Wetland of international importance (Ramsar Convention Secretariat 2013). It is located in the southern part of the Kuban river delta at the territory of Krasnodar Krai – one of the most densely populated Russian regions with highly developed agriculture and very few relatively undisturbed landscapes. The area of the sanctuary is subject to different anthropogenic impacts including rice production, recreation, illegal fishing and poaching, oil and gas extraction and others. The impact of different anthropogenic stress types on soil biota in the wildlife sanctuary was assessed recently by Pystina et al. (2013). They showed that uncontrolled tourism and illegal fishing at the territory of the reserve have much stronger negative effects on both terrestrial and aquatic ecosystems than the others. However, background data on soil mesofauna of this territory have never been published. Despite numerous and extensive reviews on oribatid mite fauna of Northern Caucasus, Rostov Oblast and Crimea Peninsula, Kuban river delta itself and its

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environs were surprisingly disregarded in the studies of acarologists (see e.g. Karppinen et al. 1986, Krivolutsky 1995, Shtanchaeva & Subias 2010, Lebedeva & Poltavskaya 2013). The aim of this study was to perform an inventory of the oribatid mite fauna and population in major habitat types of Priazovsky National Wildlife Sanctuary and its environs and to conduct preliminary faunistic and ecological analyses of oribatid communities occurring in different edaphic and landscape conditions represented there.

2. Methods

The territory of Priazovsky wildlife sanctuary (coordinates of the center are: 45°35'N, 37°44'E) is mainly formed by the system of shallow lakes or 'limans' which contain both brackish and fresh water. The limans are connected with numerous natural and artificial channels. Limans and channels are separated by reed beds with marsh-meadow soils very rich in organic matter, covered with the layer of plant debris and mainly occupied by common reed (*Phragmites australis*). Elevated parts of the sanctuary are occupied by dry meadows with rare artificially planted willow trees (*Salix* sp.), but due to their rarity and severe physical disturbance by transport, these habitats were not sampled. The sandy coastal zone located in the western sector of the sanctuary is formed by relatively better drained soils on sands covered by meadows with common reed and shrubs. The eastern part is occupied by old rice paddies which were partially abandoned in the early 1990s; however, rice production has been resumed after the recovery of agriculture in the Kuban River delta in 2005–2009. These areas are occupied with rice paddy soils with either rice crops or dry steppe meadows on them. Rice paddy and liman-reed bed zones are sometimes separated by salt marshes with very little vegetation. This salt marsh was located at the place of the ancient brackish lagoon which was isolated from the sea long ago (Pogorelov & Dumit 2010). To the North of the Wildlife Sanctuary closer to Beisug liman, elevated coasts covered by chernozem soils occur. Chernozems are mainly used for crop production in the fields. Fields are separated by forest stripes with quite sharp margins formed by planted oaks, acacias and other deciduous tree species (Zinchenko et al. 2013). Oribatid mites were collected in all five habitat types described above.

Soil samples were taken in October 2011 and May 2012 with the standard cylindrical soil corers 9.5 cm in diameter. Intact soil cores contained the entire litter layer and uppermost 5 cm of the mineral soil horizon. At each sampling site, three intact soil cores were obtained. In total, samples were taken in 23 sites. The liman-reed bed and sandy coast habitats near the Azov sea were studied in 2011 and 2012 (12 sites in the former and 4 in the latter habitat type) (Tab. 1). Field margins and forest stripes at the elevated coast of Beisug liman (4 sites) and rice paddies (2 sites) were studied only in 2012 (Tab. 1). Besides that, a single sample was collected in the salt marsh in 2012. In total, 88 samples were taken.

Samples were stored in the cool box for one week at most and then transferred to the laboratory for extraction. Standard Tullgren extraction was performed into the mixture of alcohol and glycerol (19:1). Collected mites were sorted-out and counted. Then oribatid mites were identified to the species level under the light microscope using keys of Ghilarov and Krivolutsky (1975), Weigmann (2006) and original species descriptions from the literature. Species were named using the system presented in the Fauna Europaea online database (www.faunaeur.org). Immature mites were also identified to the species level using same determination sources as for adults as well as an own unpublished collection of immature oribatid mite images. During estimation of the species abundance, abundance values for immature mites were added to the abundance of the adults of the respective species. In the few cases (five individuals in total) immature oribatid mites could not be identified to the species level, they were excluded from further analyses. Allocation of oribatid mite species among ecomorphs (surface-, litter-, soil- dwellers, aquatic and non-specialized) was done following the classification proposed by Krivolutsky (1995).

Due to the quite different number of samples collected in different habitat types in the Sanctuary we had to standardize total oribatid species richness per habitat type. For this we estimated potential species richness per habitat type basing on the extrapolation of the species richness accumulation curves for each habitat type (non-linear fitting method, data not shown). This estimator proved earlier to forecast reasonable results for samples with small n's and high data variability (Toti et al. 2000). Faunistic similarity of oribatid species lists in different habitat types of Priazovsky National Wildlife Sanctuary was analyzed using cluster analysis (based on Bray-Curtis similarity index, complete link method, log-transformed abundance data). Differences in the oribatid mite mean abundance and species richness per site were tested using Tukey Unequal-N HSD test. Prior to the analysis, to account for pseudoreplication, averages from the three individual samples taken at each site were used as single data units. Those averages were considered as true replicates. Data for oribatid community in the salt marsh was not included into the statistical analysis as only the single sample was collected in this habitat type. Species

Table 1. Total abundance, mean abundance per site (±SE) and species richness of oribatid mites in five major habitat types studied in Priazovsky National Wildlife Sanctuary and its environs. Abundance and average species richness per site values marked with different letters are significantly different from each other (Tukey unequal N HSD test, P<0.05).

	Habitat type	**Ecomorph ***	**Distribution type****	**Liman-reed beds**	**Sandy Coast**	**Elevated Coast**	**Rice paddies**	**Salt marsh *****
	Number of sampling sites			12	4	4	2	1
	Seasons			2011-12	2011-12	2012	2012	2012
	Number of sites sampled in 2011			12	4	0	0	0
	Number of sites sampled in 2012			7	1	4	2	1
	Average number of species per site			8.75±0.96[a]	3.75±0.95[b]	7.75±1.55[a]	2.00±1.00[b]	4
	Total number of species			31	11	20	4	4
	Projected number of species based on the species accumulation curves analysis			35.2	19.0	34.8	7.2	n/a
	Total abundance			2764±759[a]	752±463[b]	4853±1413[a]	128±85[c]	2176
HYPOCHTHONIIDAE Berlese, 1910								
1	*Hypochthonius rufulus* C. L. Koch, 1836	non-sp.	C	0	0	139±84	0	0
BRACHYCHTHONIIDAE Balogh, 1943								
2	*Liochthonius sp.*****	soil	U	71±43	0	0	0	0
3	Sellnickochthonius sp.****	soil	U	5±5	0	0	0	0
EUPHTHIRACARIDAE Jacot, 1930								
4	*Rhysotritia ardua* (C. L. Koch, 1841)	litter	C	2±2	0	0	0	0
5	*Rhysotritia duplicata* (Grandjean, 1953)	litter	P	34±19	0	11±11	0	0
EPILOHMANNIIDAE Oudemans, 1923								
6	*Epilohmannia cylindrica* (Berlese, 1904)	soil	C	4±4	0	11±11	0	0
7	*Epilohmannia styriaca* Schuster, 1960	soil	M	46±34	21±21	0	0	0
NOTHRIDAE Berlese, 1896								
8	*Nothrus anauniensis* Canestrini & Fanzago, 1876	litter	C	18±18	0	0	0	0
TRHYPOCHTHONIIDAE Willmann, 1931								
9	*Mucronothrus nasalis* (Willmann, 1929)	litter	C	14±11	0	0	0	0
DAMAEIDAE Berlese, 1896								
10	*Belba corynopus* (Hermann, 1804)	surface	H	4±4	0	53±53	0	0
11	Belba sp.1****	surface	U	87±40	459±459	0	0	0
12	Belba sp.2****	surface	U	0	0	53±53	0	0
13	*Metabelba pulverulenta* (C. L. Koch, 1839)	surface	H	0	0	331±331	0	0
MICROZETIDAE Grandjean, 1936								
14	*Berlesezetes ornatissimus* (Berlese, 1913)	litter	C	0	0	32±32	0	0
DAMAEOLIDAE Grandjean, 1965								
15	*Fosseremus laciniatus* (Berlese 1905)	litter	C	0	0	32±32	0	0
TECTOCEPHEIDAE Grandjean, 1954								
16	*Tectocepheus velatus* (Michael, 1880)	non-sp.	C	226±118	0	21±21	0	0
OPPIIDAE Grandjean, 1954								
17	*Lauroppia neerlandica* (Oudemans, 1900)	soil	H	0	0	75±50	0	0
18	*Medioppia media* (Mihelcic, 1956)	soil	M	1305±500	53±20	704±379	0	128

	(Tab. 1 continued) **Habitat type**	**Ecomorph ***	**Distribution type****	**Liman-reed beds**	**Sandy Coast**	**Elevated Coast**	**Rice paddies**	**Salt marsh *****
19	*Microppia minus* (Paoli, 1908)	litter	C	2±2	0	0	0	0
20	*Oppiella nova* (Oudemans, 1902)	soil	C	116±39	11±11	21±21	64±64	0
SUCTOBELBIDAE Jacot, 1938								
21	*Suctobelbella trigona* (Michael, 1888)	soil	P	37±17	11±11	53±53	0	0
THYRISOMIDAE Grandjean, 1954								
22	*Banksinoma lanceolata* (Michael, 1885)	soil	H	2±2	0	0	0	0
HYDROZETIDAE Grandjean, 1954								
23	*Hydrozetes lacustris* (Michael, 1882)	water	H	28±22	0	0	0	0
MOCHLOZETIDAE Grandjean, 1960								
24	*Podoribates longipes* (Berlese, 1887)	surface	H	2±2	0	0	0	0
ORIBATULIDAE Thor, 1929								
25	*Hemileius initialis* (Berlese, 1908)	non-sp.	C	71±41	0	85±85	0	0
26	*Oribatula tibialis* (Nicolet, 1855)	non-sp.	H	16±12	0	0	0	0
27	*Zygoribatula frisiae* (Oudemans, 1900)	non-sp.	H	5±5	0	1941±545	21±21	0
PROTORIBATIDAE J. Balogh et P. Balogh, 1984								
28	*Protoribates capucinus* Berlese, 1908	non-sp.	C	123±57	0	128±76	0	0
SCHELORIBATIDAE Grandjean, 1953								
29	*Scheloribates laevigatus* (C. L. Koch, 1836)	non-sp.	C	137±56	0	0	21±21	0
CERATOZETIDAE Jacot, 1925								
30	*Ceratozetes mediocris* Berlese, 1908	surface	C	36±28	0	203±175	0	0
31	*Diapterobates humeralis* (Hermann, 1804)	surface	H	21±18	0	21±21	0	0
32	*Ghilarovizetes obtusus* Shaldybina, 1969	surface	Ca	0	0	0	0	640
33	*Latilamellobates incisellus* (Kramer, 1897)	surface	H	4±4	11±11	0	0	0
34	*Latilamellobates naltschicki* Shaldybina, 1971	surface	M	4±4	5±5	0	0	0
35	*Trichoribates berlesei* (Jacot, 1929)	surface	H	78±37	128±102	0	0	640
MYCOBATIDAE Grandjean, 1954								
36	*Mycobates parmeliae* (Michael, 1884)	surface	H	0	0	0	21±21	768
37	*Punctoribates hexagonus* Berlese, 1908	soil	C	0	21±21	0	0	0
ORIBATELLIDAE Jacot, 1925								
38	*Oribatella calcarata* (C. L. Koch, 1836)	surface	H	44±29	11±11	43±43	0	0
GALUMNIDAE Jacot, 1925								
39	*Galumna obvia* (Berlese, 1914)	surface	C	185±55	21±12	0	0	0
40	Psammogalumna sp.****	surface	U	39±26	0	896±711	0	0
GAMASIDA			U	930±135	960±605	192±123	0	3072
OTHER MITES			U	460±296	128±46	0	0	0

* Oribatid mite ecomorphs are abbreviated as follows: **non-sp.** – non-specialized, **soil** – soil-dwellers, **litter** – litter-dwellers, **surface** – surface-dwellers, **water** – aquatic mites.

** Distribution types are provided according to Subias (2014) with simplifications. Acronyms are as follows: **C** – Cosmopolitan and semicosmopolitan, **H** – Holarctic, **P** – Palearctic, **M** – Mediterranean and Middle Eastern, **Ca** – Caucasian, **U** – unknown.

*** Due to the single site where this type of habitats was studies calculation of SEs, potential species richness and comparison of means were not possible.

**** taxonomic status of this species requires further examination.

accumulation curves calculation and cluster analysis were done using BioDiversity Pro software (McAleece et al. 1997), and Tukey test was performed using STATISTICA 7.0 package (Statsoft 2007).

3. Results

In total, 40 oribatid mite species were found in the wildlife sanctuary and its environs (Tab. 1). They belonged to 22 families. The highest average species richness per site (8.75) was observed in the liman-reed beds. Here also the highest total observed (31) and estimated (35.2) number of species was recorded (Tab. 1). Second most species-rich habitat type was the elevated coast with 7.75 species per site on average and the total estimated number of species equaling to 34.8. Average species richness per site in these two habitat types was not significantly different from each other (Tukey test, $p > 0.05$). Sandy coasts hosted significantly lower number of species, 3.75 on average per site (Tukey test, $p < 0.05$), and potentially 19.0 species in total (Tab. 1). In the rice paddies we found the lowest number of species – only 2.0 on average per site. Estimated species richness for this habitat type was equal to 7.75 species (Tab. 1). Salt marshes hosted four species in total (Tab. 1). Due to lack of replication estimated species richness was not assessed for this habitat type.

Results of the cluster analysis of the faunistic similarity (Bray Curtis similarity index between species lists in each habitat type) of oribatid mite assemblages in different habitat types are shown in Figure 1. Overall Bray-Curtis faunistic similarity between different habitat types was quite low. However, there was higher faunistic resemblance of the oribatid communities between liman-reed beds and elevated coasts relative to the other habitat types. A second but not so prominent cluster was formed by the oribatid communities in the salt marshes and sandy coasts. Rice paddies with their rudimentary mite community remained separate and least similar to the other habitat types.

Abundance distribution across the habitats generally resembled the trend which was revealed for the species richness. The highest value was found in the elevated coasts (4853 ind. m^{-2}), but it was not significantly different from that of the liman-reed bed area (2764 ind. m^{-2}) (Tab. 1). Significantly lower abundance of oribatids was discovered in the sandy coasts – about 750 individuals per square meter. Few individuals were extracted in the rice paddies and the average abundance per site was extremely low – about 125 individuals per square meter (Tab. 1).

Abundance of different oribatid mite ecomorphs in the five habitats is shown in Figure 2. Liman-reed bed habitats are dominated by soil-dwelling oribatids, while in the elevated coasts non-specialized mites prevail. In the latter habitat the relative abundance of surface-dwelling mites is also quite high. In sandy coasts and salt marshes, surface-dwelling mites are dominating. In the rice paddies the dominance structure is unclear due to the extremely low abundance of oribatid mites, however, soil-dwelling oribatids tend to be more numerous. Presence of aquatic mites in the liman-reed bed sites is also notable.

4. Discussion

The oribatid mite fauna of Priazovsky wildlife sanctuary seems to consist mainly of species, which have been already recorded in the North Caucasus region (Karppinen et al. 1986, Krivolutsky 1995,

Figure 1. Results of the cluster analysis (Bray-Curtis index, complete-link clustering, log-transformed abundance data) of oribatid mite community species composition in the five habitat types studied in the Priazovsky Wildlife Sanctuary and its environs.

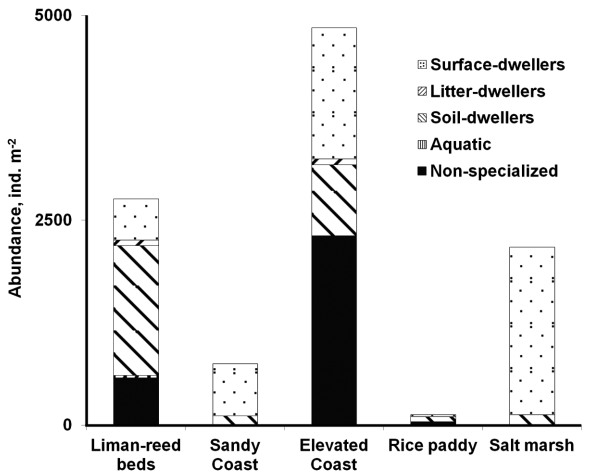

Figure 2. Abundance of different oribatid mite ecomorphs in the five habitat types studied in the Priazovsky Wildlife Sanctuary and its environs.

Shtanchaeva & Subias 2010, Lebedeva & Poltavskaya 2013). However, several species like *Belba corynopus* or *Mucronothrus nasalis* were found earlier only in more humid conditions in forests located to the north and south from the described area. In our study, in the environs of the Wildlife Sanctuary they were recorded predominantly in the liman-reed bed zone and in the elevated coasts. However, we initially expected to find many other globally distributed species which were earlier recorded in the Northeastern or Central Caucauses but not yet in the Sanctuary. This may still be the result of the limited sampling effort in our study (Subias 2014). We only found a few globally distributed species, for example, *Diapterobates humeralis* and *Trichoribates berlesei*. From the literature we know that the two species mentioned above occur predominantly in the upper-stream parts of Kuban river catchment, to the east from the Sanctuary in the central part of North Caucasus (Shtanchaeva & Subias 2010, Lebedeva & Poltavskaya 2013). Further investigations on the ways of oribatid fauna enrichment in the Kuban river delta which may include mechanisms like transfer with migrating birds and river flowing water will help to better understand the history and biogeographic relationships of the study area with the neighboring regions (Krivolutsky & Lebedeva 2004, Larsen et al. 2006, Lebedeva 2012).

Total and site-specific oribatid species richness found in elevated coasts and liman-reed bed habitats of the wildlife sanctuary were similar to the respective values typical for undisturbed dry steppes which surround the study area (Zaitsev 2001). Within the sanctuary, relatively high species richness in liman-reed bed habitats and in elevated coasts in comparison with sandy coasts indicates optimal conditions for oribatid mites in the former habitats from the biogeochemical and microclimatic points of view (Krivolutsky 1995). Forested areas as well as reed beds tend to sustain more stable moisture regime over time due to more dense vegetation and also bear thicker litter layer than sandy coasts or salt marshes, where vegetation is less dense (Pystina et al. 2013). Conditions in the former two habitats were proven to provide more ecologically stable microclimatic conditions and a wider range of ecological niches and thus potentially sustain a higher abundance and diversity of soil microarthropods (Battigelli et al. 2004).

The high differences in the mite abundances and the species richness between the five studied habitats can at least in part be explained by the anthropogenic stress, which is highest in the rice paddy soils (Sidorenko 2006), and in the sandy coasts where the combination of high soil salinity and recreational press has been observed (Pystina et al. 2013). The latter force results in degradation of the vegetation and hence the litter layer and in physical disturbance of quite weak soils by car tires (Pystina et al. 2013). Possibly these are the reasons for the quite low observed oribatid abundances in these habitat types being lower than the expected densities of ca 5–10 thousand individuals per square meter that are typical for temperate grasslands zone at these latitudes (Krivolutsky 1995).

Low Bray-Curtis faunistic similarity between oribatid species lists in habitats of the liman-reed beds from one side and sandy coasts and rice paddies from another side indicates a high level of degradation of the mite assemblages in the recreational and intensive agriculture landscapes. In the salt marshes we found the species *Ghilarovizetes obtusus*, which is not typical for this habitat type, but is rather common in the dryer conditions of Central Caucasus (Shtanchaeva & Subias 2010). Like found in other parts of the world, the paddy rice soils of this study host an extremely scarce oribatid mite fauna, which is mainly represented by opportunistic parthenogenetic species like *Scheloribates laevigatus* and *Oppiella nova* (Nakamura 1988, Cancela de Fonseca & Sarkar 1998, Widyastuti 2002). Probably, mainly parthenogenetic species are favored to survive and form more or less sustainable populations in the conditions of extremely low population densities and negligible chances of meeting a mating partner (Cianciolo & Norton 2006, Smelansky 2006).

Unlike in all other habitat types, soil-dwelling mites dominated in liman-reed beds possibly indicating the highest stability of the moisture regime in this habitat type (Pystina et al. 2013). In contrast, much dryer conditions in combination with the presence of a litter layer in the forest stripes located on the elevated coasts explain the predominance of non-specialized and surface-dwelling mites being the most drought-resistant (Zaitsev & Wolters 2006). In salt marshes with partially anaerobic mineral soil horizon which is not favorable for soil-dwelling oribatid mites, surface-dwellers clearly prevail (Princz et al. 2012).

We can assume that the territory of Priazovsky National Wildlife Sanctuary may be the area of contact between the acarofauna of natural grasslands (steppes) and deciduous forests located to the east and north from it, respectively, and fauna of Caucasian montane forests located to the south. The close neighborhood of the Wildlife Sanctuary with Caucasus mountains which are known to have an extremely rich oribatid fauna supports the quite high local species diversity in the study area in comparison with the other adjacent territories (Shtanchaeva & Subias 2010, Lebedeva & Poltavskaya 2013). Intensive rice production results in the complete disruption of oribatid mite communities and can be considered the major risk for soil biodiversity in the Sanctuary landscapes.

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