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DIVERSITY AND COMMUNITY STRUCTURE OF ORIBATID MITES (ACARI, ORIBATEI) AT MEMORIAL COMPLEXES OF A MEGAPOLIS

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Diversity and Community Structure of Oribatid Mites (Acari, Oribatei) at Memorial Complexes of a Megapolis. Kolodochka L. A., Shevchenko O. S. — In different types of substrate (soil, litter, lichens and mosses) collected at three memorial complexes (cemeteries) of Kyiv (Ukraine), 70 species from 57 genera, 34 families of oribatid mites were found. A few eurytopic species capable of tolerance to different types of pollution make up an essential part in each species complex. The species diversity and complexity of oribatid community structure at researched areas increased with distance from the city center. There was no direct relation between the degree of dominance of most common species and the cemetery's relative remoteness from the center of the city.

Key words: oribatid mites, urban cemetery, Ukraine.

Состав и структура сообществ клещей надсемейства Oribatei в почвах мемориальных комплексов мегаполиса. Колодочка Л. А., Шевченко А. С. — Установлено, что в почвах, подстилке, мхах и лишайниках на территории трех мемориальных комплексов (кладбищ) г. Киева (Украина) обитают 70 видов 57 родов 34 семейств клещей-орибатид (Acari, Oribatei). Основу видовых комплексов составляют эвритопные виды, устойчивые к разнообразным типам загрязнения среды. Видовое разнообразие и сложность структуры сообществ клещей-орибатид обследованных территорий увеличиваются от центра города к окраине. Непосредственная связь степени доминирования наиболее массовых видов с удаленностью от центра города не установлена.

Ключевые слова: орибатидные клещи, городское кладбище, Украина.

Introduction

Oribatid mites (Sarcoptiformes) have been regarded as important part of invertebrates engaged in soil formation. Analysis of their communities is used to evaluate soils in natural and disturbed habitats (Key..., 1975). Urban anthropogenic pressure on soil cover and plant and animal communities is diverse; some territories are less disturbed and play the part of refugia where species vulnerable to different forces of extinction may still exist, while at adjacent areas they may decline or disappear. Species richness of organism communities that thrive at such refugia is, of course, higher and may later account for restoration of other more depleted habitats. Among such urban territories are parks, squares, vast and extensive lawns at recreation zones as well as zones of alienation alongside transport superhighways, islands of natural plant communities and cemeteries. It can be argued that for soil microarthropods, particularly soil mites, a cemetery is a complex web of ecotons, inside which emerges a system of species-narrow refugia. Anthropogenic pressure leads to constant fragmentation of microlandscape and alteration of natural processes of litter decomposition that influence the structure of oribatid community.

Areas, on which burial complexes are by law allowed to function, must meet such criteria as dry and breathable soils and low levels of subterranean waters. These factors form the initial soil fauna. Due to developed though spotty plant cover combined with absence of over-watered soils, a cemetery, given time, becomes the habitat for relatively rich communities of soil organisms such as oribatid mites.

Among other ecological factors should be mentioned the lower annual oscillations of temperature due to artificial surfaces covering the soil (pavements, monuments etc.) — covered soils are in average warmer then naked grounds (McIntyre et al., 2001) and thus the mites are better able to withstand the coldest winters.

There are different kinds of burial grounds in different types of settlements. Urban cemeteries are areas of spottily changed soil cover under relatively weak day-to-day anthropogenic pressure. Architecture design is traditional here (monuments, tombstones, etc.). This artificial structure climate-wise has much in common with contemporary urban architectural ensemble of stones, bricks, asphalt and islands of greenery. The spatial organization of cemetery's territory can be cautiously considered ecologically as highly reduced model of city landscape.

While researching oribatid mite communities in the megapolis we aimed to achieve new data on their structure and species diversity on urban areas under diverse anthropogenic pressure. Burial grounds were chosen on the premise that they fall under one of these categories.

We couldn't find any previous research of such kind except for the article on invertebrates (among them, mites) from burial chambers in Spain (Hidalgo-Arguello et al., 2003). Any special research of oribatid mites in soils of urban burial complexes was not carried out earlier in Ukraine.

Material and methods

Samples were taken in July–September 2012 on three cemeteries in Kyiv city: Lukianivske (plot 1), Baikove (plot 2) and Lisove (plot 3). The pine-and-oak forest adjoining the Lisove cemetery (plot 4) has been selected to compare to plot 3.

Lukianivske (opened in 1871) and Baikove (opened in 1834) cemeteries are nearer to the center of the city then the Lisove cemetery (opened in 1970). The latter lies on the border of city and forest (re-planted after the WWII). For the purpose of standardization, samples of soil (125 cm^3) and litter (near 200 cm^3) were taken under *Acer negundo* and *Picea* sp. trees that could be found on plots 1–3. Also, we collected samples of mosses, lichens and unspecified substrate (near 200 cm^3). The mites were extracted with Berlese tunnels in 70 % ethanol and mounted on slides in Hoyer liquid, species identified with keys (Key..., 1975; Pavlichenko, 1994, Sergienko, 1994).

Data on oribatid species complexes from under *Acer negundo* and *Picea* sp. are combined to observe common tendencies of a plot. Differencies in these species complexes are not discussed in this paper.

Statistical analysis was carried out in MS Excel 2003 and PAST; we used Shannon, Simpson, Sorensen indexes and Berger—Parker index (Caruso et al., 2007). We also used Paliy—Kovnatsky index (relative dominance of a species in a community): more then 10 % — dominant; from 1 to 10 % — eusubdominant; from 0.1 to 1 % — subdominant; less then 0.1 % — secondary member of community. More information on this index is given in Shitikov et al. (2003). Morphoecological types were ascertained according to Krivolutzsky (1965).

Results and discussion

There were 70 species of 57 genera from 34 families of Oribatids from soil, litter and other organic substrate on studied areas: 37 species in soil, 34 species in epiphitic mosses, lichens and unspecified organic substrate as well as 61 oribatid species in litter.

It may be concluded from table 1 that eurytopic species *T. velatus* and *O. tibialis* that belong to unspecialized morphoecological type are the dominants in most of the studied complexes of oribatid species. Other species weren't always present at all of the plots and their dominance levels are more variable.

Of the superfamily Ceratozetoidea, *P. punctum* was present in soil and litter at every plot. This species was eusubdominant on plot 3 and subdominant on plot 4. Other species of that superfamily, *X. kieviensis* and *T. novus,* were absent at plot 4, and *C. mediocris* was collected only at plots 1 and 2.

Specimens of *R. a. affinis* (Ptyctima) were common everywhere, while *E. monodactylus* and *S. personatus* were much rarer. There is evidence of eurytopic preferences of *R. a. affinis* and *S. laevigatus* (Oripodoidea) (Strenzke, 1952; Murvanidze et al., 2011).

Specimens of *E. rauschenensis* (Oripodoidea) (Seniczak et al., 1998) are considered sensitive to air nitric pollution. This case may explain the oribatid presence only in pine-oak associations on outskirts of the city (site 4). Other species, *T. velatus* and *T. novus,* have been characterized in the cited article as tolerant to all levels of nitric pollution. Our data support this conclusion as *T. novus* was more common nearer to the city center then on its edge.

It should be noted that oribatid community in pine-and-oak forest (plot 4) differs greatly in structure from other mentioned communities. Though there are no dominant species, there are 11 eusubdominant species (most of them from superfamilies Belboidea and Oppioidea). Absence of any species capable of higher dominance is a sign of more stable community in the forest than at other plots.

Table 1. Structure of dominance in oribatid species complexes from different substrates on studied areas (Paliy-Kovnatskiy index)

Таблица 1. Структура доминирования видов в комплексах клещей-орибатид в почвах, мхах и лишайниках на изученных участках (индекс Палия-Ковнацкого)

Species	Plot				Substrate		
	1	2	3	4	S	L	O
Hypochthoniella minutissima (Berlese, 1904)		++			•	•	
Brachychthonius immaculatus (Forsslund, 1942)			+		•		•
Liochthonius brevis (Michael, 1888)	++						•
L. propinquus Niedbala, 1972				+			•
Euphthiracarus monodactylus (Willmann, 1919)	++						•
Rhysotritia ardua affinis Sergienko, 1989	++	+	+++	+	•	•	•
Microtritia minima (Berlese, 1904)			+				•
Steganacarus personatus Niedbala, 1983	++					•	•
Phthiracarus pallidus Feider et Suciu, 1958			+	++		•	
Nothrus borussicus Sellnick, 1928	+	+				•	
N. silvestris Nicolet, 1855	+	+			•	•	
Camisia biurus (Koch, 1839)			+	++	•	•	•
Platynothrus peltifer (C. L. Koch, 1839)				+			•
Trhypochthonius conspectus Sergienko, 1991			+	++	•	•	
Hermanniella dolosa Grandjean, 1931	+					•	
Ceratozetes macromediocris Shaldybina, 1970		++			•	•	•
C. mediocris Berlese, 1908	+	+++		+	•	•	•
Micreremus gracilior (Willmann, 1931)	++		++	+	•	•	•
Cymbaeremaeus cymba (Nicolet, 1855)	+		+			•	
Tectocepheus velatus (Michael, 1880)	++++	++++	++++	+++	•	•	•
Carabodes areolatus Berlese, 1916				++		•	•
Gymnodamaeus sp.			++	++		•	•
Hypodamaeus riparius (Nicolet, 1855)		+				•	
Spatiodamaeus subverticillipes (Bulanova-Zachvatkina, 1957)		+	+		•	•	
Belba corynopus (Hermann, 1804)				++		•	
Metabelba papillipes (Nicolet, 1855)			++	+++	•	•	•
Metabelba pulverulenta (Koch, 1839)		+	++	++	•	•	
Ctenobelba tuberculata Kulijew, 1966		+				•	
Fosseremeus laciniatus (Berlese, 1905)		+				•	
Autogneta longilamellata (Michael, 1885)				+			•
Oppiella nova (Oudemans, 1902)	+++	++	+	+++	•	•	•
Multioppia sp.		+		+++	•	•	
Microppia minus (Paoli, 1908)			++	++	•		
Oppia sp. 1		+	+	+++	•	•	•
Oppia sp. 2		+	+	+++	•	•	•
Oppia sp. 3		+	+	+++	•	•	•
Oppia sp. 4				++	•	•	
Suctobelbella sp. 1		+	+	+++	•	•	•
Suctobelbella sp. 2		+		+++		•	•
Quadroppia quadricarinata (Michael, 1885)				+++		•	•
Adoristes poppei (Oudemans, 1906)		+	++			•	
Dorycranosus moraviacus (Willmann, 1954)	+		+	+	•	•	
Liacarus brevilamellatus Mihelčič, 1955			++	+	•	•	
L. subterraneus (Koch, 1844)				+		•	
Xenillus tegeocranus (Hermann, 1804)				+		•	
Cultroribula bicultrata (Berlese, 1905)				++		•	
Furcoribula furcillata (Nordenskiold, 1901)	+	+++		+	•	•	•
Protoribates capucinus Berlese, 1908			+			•	
P. longior Berlese, 1908				+		•	•

Note. ++++ — dominant; +++ — eusubdominant; ++ — subdominant; + — secondary member; • — the species is present in this type of substrate. 1–4 — numbers of studied plots. S — soil; L — litter; O — epiphitic mosses, lichens and unspecified organic substrate.

Table 1.
Окончание табл. 1.

Species	Plot				Substrate		
	1	2	3	4	S	L	O
Scheloribates laevigatus (Koch, 1836)	++		++	+		•	•
Eporibatula rauschenensis (Sellnick, 1908)				++	•	•	
Oribatula tibialis (Nicolet, 1855)	++++	++++	+		•	•	•
Zygoribatula frisiae Oudemans, 1900		+	++	+++	•	•	•
Protoribates lophotrichus (Berlese, 1904)		+				•	
Trichoribates novus (Sellnick, 1928)	+++	++	+	+	•	•	•
Chamobates cuspidatus (Michael, 1884)		++	+		•	•	•
Ch. subglobulus (Oudemans, 1900)	+	+				•	
Xiphobates kieviensis (Shaldybina 1980)	+	+	+			•	
Punctoribates mundus Shaldybina, 1973		+				•	
P. punctum (Koch, 1839)	+	+	+++	++	•	•	•
Eupelops nepotulus (Berlese, 1916)			++	+	•	•	
Peloptulus phaenotus (C. L. Koch, 1844)			+		•	•	
Oribatella calcarata (Koch, 1835)		+					•
Licneremaeus sp.			+			•	
Scutovertex rugosus Mihelčič, 1957			+	++	•	•	
Eremaeus silvestris Forsslund, 1957				++		•	
Acrogalumna longipluma (Berlese, 1904)		++	+		•	•	
Pilogalumna allifera (Oudemans, 1919)	++	+++		+	•	•	•
Galumna sp. 1	+	+++	++	++	•	•	
Galumna sp. 2		++	++	+		•	

Subdominant and secondary member species, which are the majority of the found mites, compose the specific species complexes in each of investigated plot.

Oribatids like the Suctobelbidae and Oppiidae families that inhabit shallow soil pores and surface-dweller mites of the Belbidae family were most numerous at the plot 4. Surface-dwellers of the Galumnidae family were most numerous at the plot 2 (Baikove cemetery). No prevalent morphoecological type of oribatids characterized other plots.

According to the increase in Shannon index values (in table 2), the studied plots can be arranged in such sequence: plot 1 —> plot 2 —> plot 3 —> plot 4. It is consistent with the common tendency of increase in biodiversity from the urban centre to its outskirts. Species richness (according to Margalef index) and evenness (Simpson index) in studied communities increases similarly from plot 1 to plot 4. Increase in evenness of species implies higher stability of community (Magurran, 1992). Thus the research of oribatid communities from several urban cemeteries of Kyiv placed in different sites of city has shown that their species complexes and community structures vary in accordance with its location in the city.

The results of Berger—Parker index don't support the aforementioned order of plots; the index values increase in the sequence of plot 4 —> plot 2 —> plot 3 —> plot

Table 2. Biodiversity indexes for studied areas
Таблица 2. Некоторые индексы биоразнообразия для изученных территорий

Index	Plot			
	1	2	3	4
Shannon	2.064	2.278	2.592	2.961
Berger—Parker	0.3892	0.2737	0.2977	0.1147
Simpson	0.7867	0.8399	0.8565	0.9336
Margalef	4.023	4.695	5.607	5.628

Note: 1—4 — numbers of studied plots.

1. It is possible that, as a result, the Berger-Parker index' value is influenced by total number of species with low population density and this determines originality and organization complexity of each community. Therefore the structure of oribatid species complex of Lukianivske cemetery appears more "simplified" in comparison with other plots because it has two dominants and the least total number of species (fig. 1–4).

The likely causes of low similarity between species lists (table 3) are differences in initial types of plant cover (coniferous forests weren't usual at Baikove and Lukianivske cemeteries) and in the history of development of each plot.

Having studied oribatid mites communities at some of the Kyiv cemeteries, we conclude that their species complexes and community structures depend on their placement in the city and history of development of plant associations. A few eurytopic species, namely *T. velatus, R. a. affinis, P. punctum, Z. frisiae, O. tibialis* and *O. nova* can be found on every plot. Mites of *T. velatus* were dominant or common on the studied cemeteries. A few subdominant species especially in mite communities at ceme-

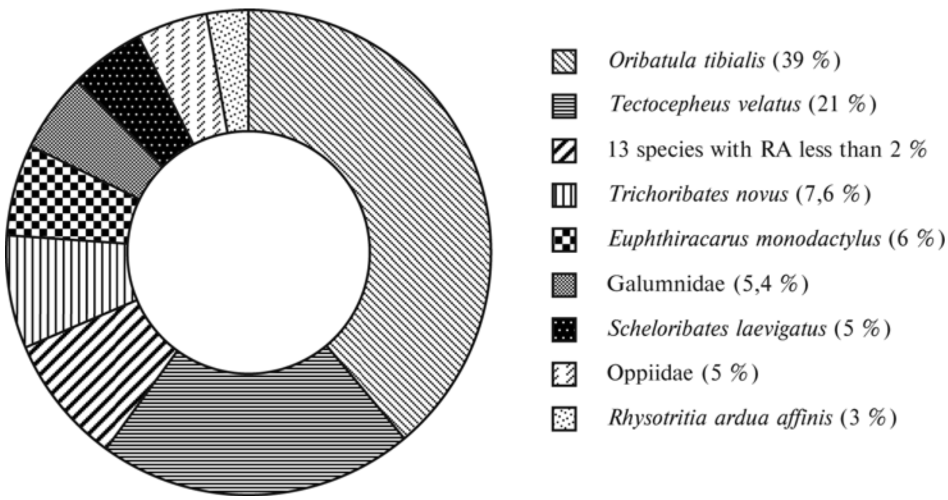

Fig. 1. Relative abundance of oribatid species in the plot 1, Lukianivske cemetery.

Рис. 1. Относительное обилие видов орибатид участка 1, Лукьяновское кладбище.

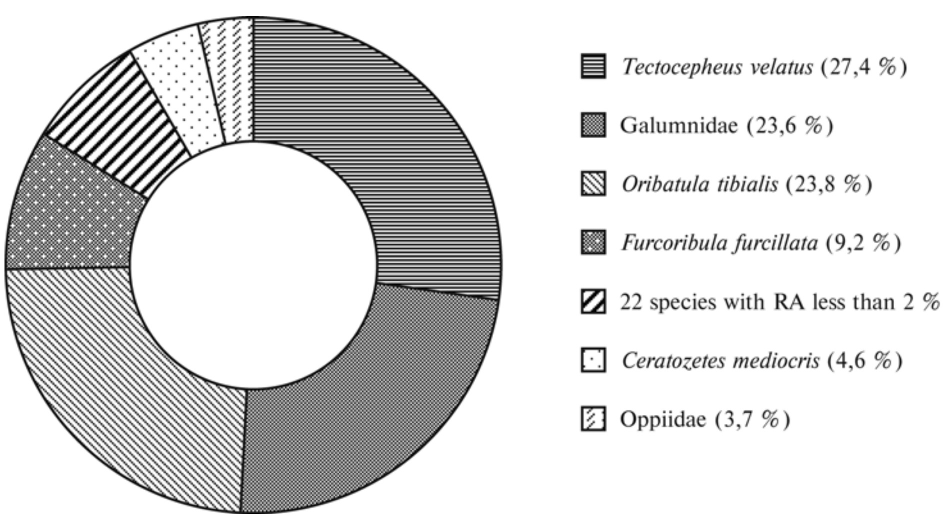

Fig. 2. Relative abundance of oribatid species in the plot 2, Baikove cemetery.

Рис. 2. Относительное обилие видов орибатид участка 2, Байковое кладбище.

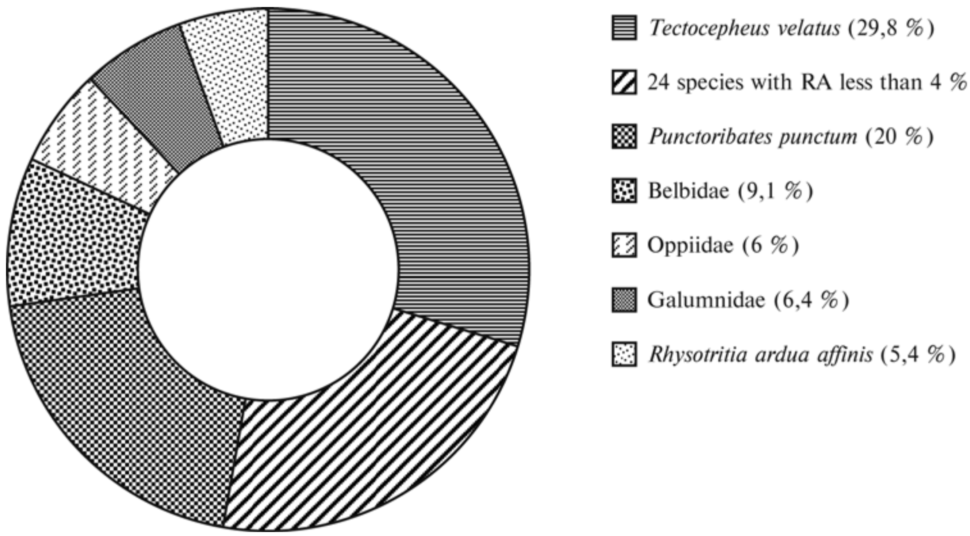

Fig. 3. Relative abundance of oribatid species in the plot 3, Lisove cemetery.
Рис. 3. Относительное обилие видов орибатид участка 3, Лесное кладбище.

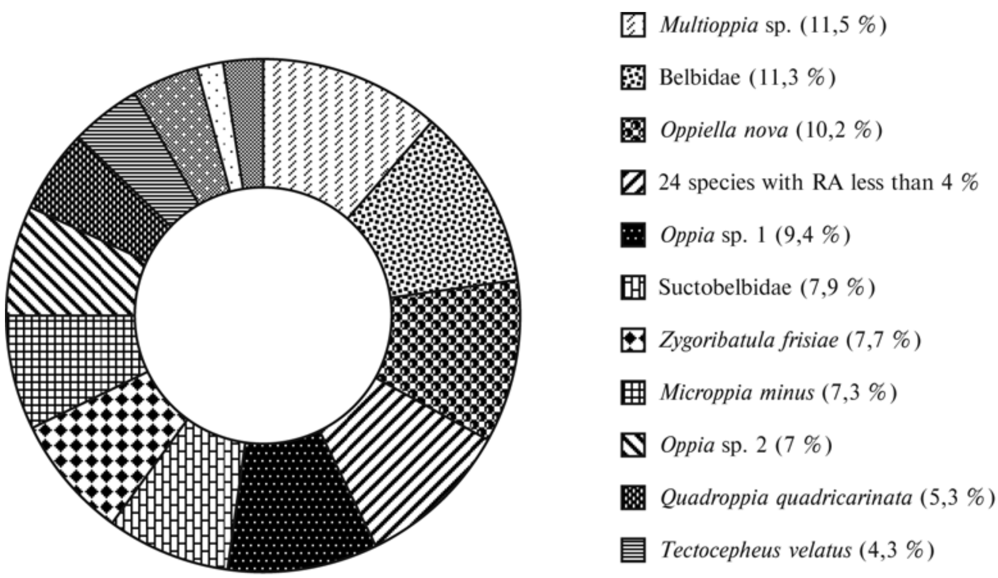

Fig. 4. Relative abundance of oribatid species in the plot 4, pine-and-oak forest.
Рис. 4. Относительное обилие видов орибатид участка 4, сосново-дубовый лес.

teries in the central part of city are known to be tolerant of various types of pollution. Other species were less numerous.

The "urban center—outskirts" gradient reflects the increase of diversity (Shannon index) as well as the evenness of species (Simpson index). According to Margalef index species richness increases in likewise direction. And yet as shown by Berger—Parker index the highest degree of dominance of the most common species doesn't necessarily correlate with distance from the city centre.

Table 3. Similarity of species lists at studied plots (Sorensen index)

Таблица 3. Сходство видового состава орибатид на исследованных участках (индекс Съёренсена)

Plot	Plot			
	1	2	3	4
1				
2	0.1786			
3	0.147	0.2571		
4	0.1746	0.213	0.2987	

Management and microclimate conditions influence the mosaic patterns of presence and dominance of mite species at the cemetery. Some of the microbiotope borders are elements of sepulchral architecture restricting the movement of arthropods and some are natural limits of synusia. In turn, mosaic relief allows for diversity of ecological niches that conducts to occurrence of complicated system of ecotones.

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