AN OVERVIEW OF FAUNA AND COMMUNITY STRUCTURE OF ORIBATID MITES (*ACARI, SARCOPTIFORMES, ORIBATIDA*) IN THE MAIN ECOSYSTEM TYPES FROM THE CENTRAL MOLDAVIAN PLATEAU (ROMANIA)

Otilia IVAN[1]

e-mail: otilia.ivan@icbiasi.ro

Abstract

The present study is an overview of the fauna and structure of the oribatid communities in the main types of ecosystems from the Central Moldavian Plateau, in order to highlight the extent to which land use and habitats' peculiarities are reflected within these edaphic coenoses. Investigations have shown that in forest ecosystems oribatid fauna is richest and most diverse in terms of taxonomy, compared to other types of ecosystems, the variety of trophic resources and the multitude of ecological niches in forest soils explaining these differences. Zoogeographical spectrum analysis of oribatid fauna evidences the growing weight of cosmopolitan species, from forests and plantations to agro-ecosystems and pastures. It was also noted that species with southern distribution are less represented in forest ecosystems, while in the soil of agricultural crops and pastures their share is higher. Regarding the ecological spectrum, it was found that forest species have the highest weight in the natural forests, grassland species - in meadows, but also in forest plantations, while the proportion of eurytopic elements is the highest in agro-ecosystems and pastures. Xerophilous and meso-xerophilous species are well represented in the whole fauna, but especially in grassland ecosystems, which indicate that forest preserves a less arid microclimate with lower oscillations of temperature and humidity. Analysis of the edifying species' distribution in the considered ecosystems, based on their representativity revealed several distinct species groups in terms of preferences to a particular type of habitat, which illustrates the selectivity of oribatids in relation to bio-edaphic conditions and their bio-indicator value.

Key words: soil microarthropods, Oribatida, land use, bio-indicators.

At present is recognized that soil biodiversity is linked with soil processes, also with ecosystem functioning and services. In this respect, in the European Commission documents is highlighted the loss of soil biodiversity as a soil degradation process (European Commission, 2006). The intensive land use, beside on natural impact factors have influence, both qualitatively and quantitatively, on the soil fauna (Cluzeau D. *et al*, 2012; Jeffery S. *et al*, 2010).

Starting from these premises, interdisciplinary ecological researches were carried out during 2009-2015 in the main types of ecosystems in the Central Moldavian Plateau, aiming at assessment of the structure and functioning of the main ecosystem types, under the increasing pressure of the natural and anthropogenic impact factors. Moreover, in the study area the interference of two bioregions (continental and steppe) is noticed (Florea N., 2005), thus some habitats and species are here at the limit of their distribution area.

Oribatid mites represent a key microarthropod group that holds an important numerical share within the edaphic mesofauna assembly, backed by a remarkable richness and taxonomic diversity. Detailed analysis on fauna and communities structure in different ecosystem types were provided in previous publications (Ivan O., 2010; Călugăr A., Ivan O., 2013; Ivan O., Călugăr A., 2013; Acatrinei *et al*, 2017). In the present study, a comparative analysis and an overview is proposed, in order to highlight the extent to which land use and habitat peculiarities are reflected on these edaphic communities.

MATERIAL AND METHODS

As a result of the field observations and researches during 2009-2015, representative sampling sites were selected for the main types of ecosystems in the study area (located in Iaşi and Vaslui counties). Series of 100 cm^2 soil samples have been taken over from each site, on two levels in forest ecosystem and single level in the remaining ones. Edaphic mesofauna has been extracted from samples through the Tullgren - Berlese method (the variant proposed by Balogh) and selected by systematic groups. The faunistic

[1]Institute of Biological Research Iasi, branch of NIRDBS Bucharest

material has been submitted to microscopic study, in order to identify the taxa. Oribatid mites have been identified to species level, the abundance of each species being registered for each sample and sampling site.

Details on sampling sites, methods and data analysis of mesofauna groups in the main ecosystem types have been presented in previous publications (Ivan O., 2010; Călugăr A., Ivan. O, 2013; Ivan O., Călugăr A., 2013; Acatrinei L. *et al*, 2017).

In this overview the following ecological estimators were used: global average abundance (Ā), expressed as individuals/m^2; number of species (S); index of ecological significance (W), expressed as classes: V and IV-edifying species, III-influential species, II and I-accompanying species; specific diversity (H(s)max, H(s), H.r.), estimated by the Shannon - Wiener equation; representativity (R%) - percentage of individuals belonging to a certain species present in a habitat type, related to the individuals' number found in all analyzed habitats (Müller *et al*, 1978).

The taxonomical ranking of species and world distribution follows Subías L.S., 2004, updated version 2018. Ecological peculiarities for each oribatid species were summarized according to Pérez-Iñigo C.,1993; Subías L.S. and Arillo A., 2001; Weigmann G., 2006; Vasiliu N. *et al.*, 1993.

RESULTS AND DISCUSSIONS

Investigations have shown that in forest ecosystems the oribatid fauna is the richest and most diversified from taxonomic viewpoint compared to the other ecosystem types (*table 1*), the variety of trophic resources and the multitude of ecological niches in forest ecosystems explaining these differences. The zoogeographical analysis of oribatid fauna reveals the growing share of cosmopolitan species from forests and plantations (13.2% and 23.7% respectively) to agro-ecosystems (41.9%) and pastures (43.7%) (*figure 1*). Also, the species with southern distribution are less represented in forest ecosystems (18.7% in forests, 17% in plantations), while in the soil of agricultural crops and grazed meadows their share is higher - 35.5% and 37.5%, respectively.

Regarding the ecological spectrum, it was found that the forest species hold the highest share in the natural forests, the praticolous species - in meadows, but also have a good representation in forest plantations, while the proportion of the eurytopic elements is highest in agro-ecosystems and pastures. The xerophilous and meso-xerophilous species are better represented in the whole fauna compared to the Moldavian Plain, for example (Ivan O., 2007), especially in grassland ecosystems (*table 2*).

The coenological analysis carried out on sampling sites and types of ecosystems, showed that in the natural ecosystems the oribatid communities are complex, with high structure heterogeneity, which gives them stability over time and the possibility to exploit the available resources of the habitat. Oribatid mites' communities in the organic horizon of natural forest ecosystems (Natura 2000 protected areas) have similarities in structural terms, noting by their complexity.

Table 1

Structural parameters of the oribatid mite communities in the investigated ecosystem types

Ecosystem types		Forest ecosystems		Grassland ecosystems		Agro-ecosystems
		natural forests	plantations	hayfields	pastures	
Number of sampled sites / number of samples		4/ 20	5/ 25	3/ 15	3/ 15	11/ 55
Average abundance*, individuals m^{-2}		11,155	6,344	4,287	8,247	1,527
Range of average abundance, individuals m^{-2} (min. – max.)		6,700-13,120	640-13,840	680-8,640	1,780-1,6240	0-4,000
Total number of taxa**	families	46	28	26	10	15
	genera	63	41	37	15	23
	species	91	59	46	16	31
Number of species / sampled site (min. – max.)		34-47	6-31	8-36	5-13	0-14
Diversity index (min. – max.)	H(s)max	5.09-5.55	2.58-4.95	2.99-5.17	2.32-3.7	1.58-3.81
	H(s)	3.9-4.24	2.28-3.85	2.2-4.37	1.13-2.62	0.83-2.98
	H.r.	76.11-93.34	58.03-88.35	73.51-84.58	48.47-70.92	48.97-85.87

Legend: * mean of global average abundance per ecosystem type; ** total number of taxa, counted for each ecosystem type; H(s)max - maximal specific diversity; H(s) - real specific diversity; H.r. – relative diversity (%).

Table 2

Ecological spectrum of the oribatid fauna by types of ecosystems

Ecosystem types / Ecological peculiarities	Forests		Grasslands		Agro-ecosystems
	natural forests	forest plantations	hayfields	pastures	
Silvicolous species	54.9*	16.95	19.56	12.5	6.45
Grassland species	-	20.34	23.91	18.75	19.35
Eurytopic species	19.78	18.64	21.74	31.25	32.25
Xerophilous and meso-xerophilous species	13.18	15.25	19.56	18.75	16.13

* all values represent percentage of the total number of species found in each ecosystem type

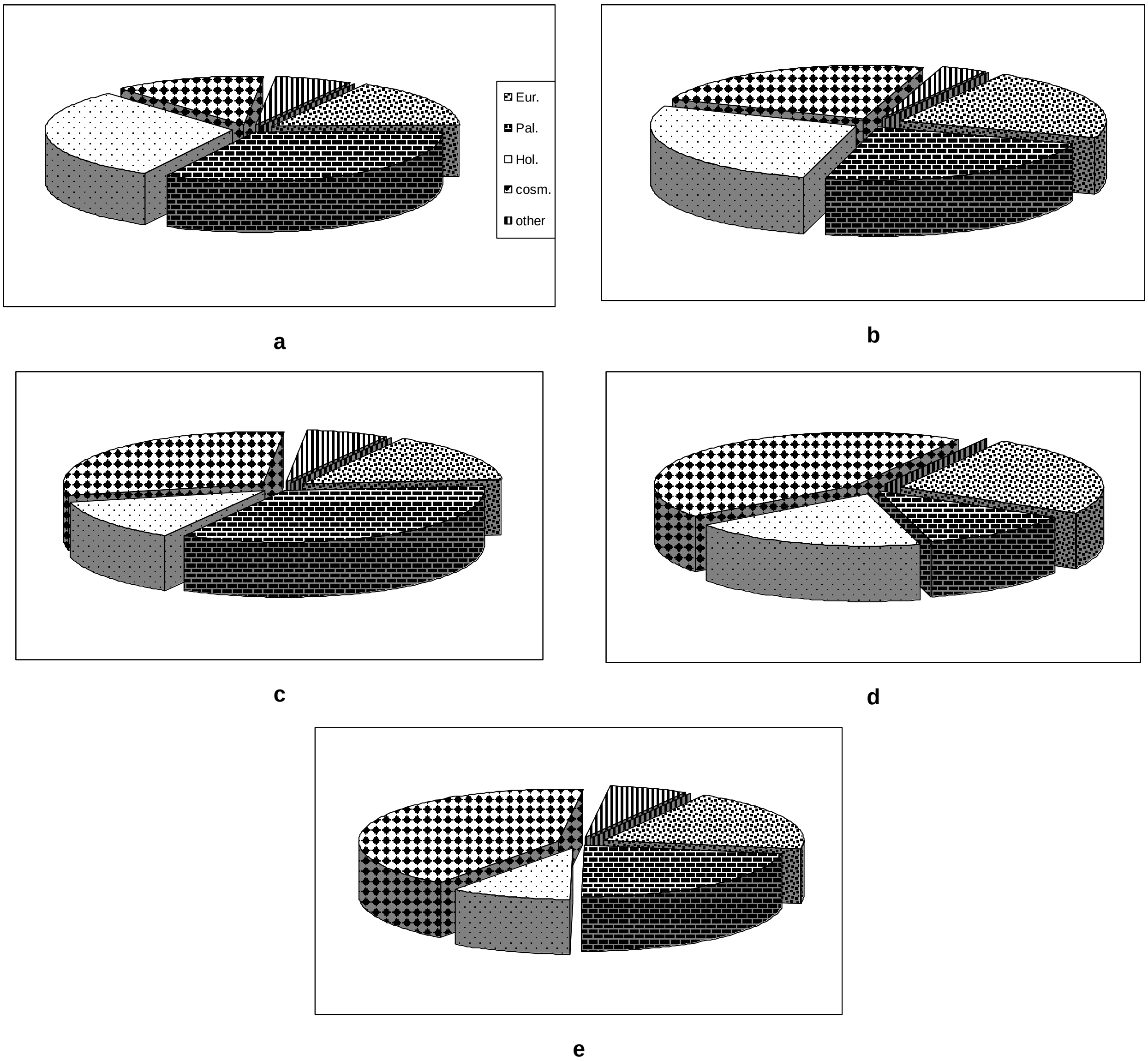

Figure 1 - **Zoogeographical spectrum of the oribatid mites in the investigated ecosystem types: a- natural forests; b- forest plantations; c- hayfields; d- pastures; e- agro-ecosystems.**

Analysis of the global structural parameters indicates generally higher values of the average global density, but especially of the species number and the specific diversity, compared to the meadows, but also with the forest plantations in this area. The balanced trophic and demographic structure, as well as the high structure heterogeneity, characterizes some functioning and stable communities. Edifying groups mainly include forest species or which prefer forest soils, and less eurytopic species (Acatrinei *et al*, 2017) (*table 3*).

In the case of forest plantations, oribatid communities differ structurally, especially depending on the floristic composition, which determines the quality and quantity of vegetal necromass. In mixed, 50-60 year old plantations, the average global abundance, the number of species and the specific diversity have close values to those recorded in natural forests while in the young acacia plantations parameters have lower values, with notable differences from one stand to another. It is worth mentioning the significant qualitative differences regarding the composition of the edifying and influential species groups, as it is observed that typically forest species, characteristic of forests in the area are missing or very poorly represented (representatives of Chamobatidae, Achipteriidae, Carabodidae families, also of the Ptyctima group); are present, in contrast, with high values of the ecological significance index, some grassland species (*Scheloribates labyrinthicus*, *Ramusella (I.) insculpta*), together with eurytopic ones (Călugăr A., Ivan O., 2013).

Table 3

Representativity of the edifying species (%)

	Edifying species*	Forest ecosystems		Grasslands		Agro-ecosystems	
		forests	plantations	hayfields	pastures	perennial	annual
A	*Chamobates (X.) voigtsi* (Oudemans, 1902)	100	-	-	-	-	-
A	*Steganacarus (T.) carinatus* (Koch, 1841)	100	-	-	-	-	-
A	*Zetorchestes micronychus* (Berlese, 1883)	100	-	-	-	-	-
A	*Minunthozetes pseudofusiger* (Schweizer, 1922)	100	-	-	-	-	-
A	*Atropacarus serratus* (Feider et Suciu, 1957)	100	-	-	-	-	-
A	*Achipteria (A.) nitens* (Nicolet, 1855)	100	-	-	-	-	-
A	*Metabelba (M.) pulverulenta* (Koch, 1839)	100	-	-	-	-	-
A	*Berniniella bicarinata* (Paoli, 1908)	96.8	3.2	-	-	-	-
A	*Achipteria (A.) coleoptrata* (Linnaeus,1758)	69.6	30.4	-	-	-	-
A	*Suctobelbella (S.) acutidens* (Forsslund, 1941)	42.2	57.8	-	-	-	-
A	*Suctobelbella (S.) subtrigona* (Oudemans, 1900)	29.4	70.6	-	-	-	-
A	*Damaeolus ornatissimus* Csiszár, 1962	87.4	9.7	2.8	-	-	-
A	*Scheloribates (S.) laevigatus* (Koch, 1835)	72.8	1.3	25.9	-	-	-
A	*Fosseremus laciniatus* (Berlese, 1905)	11.2	86.2	2.6	-	-	-
A	*Suctobelbella (S.) subcornigera* (Forsslund, 1941)	55	39.5	4.6	-	-	0.8
	Galumna (G.) lanceata (Oudemans, 1900)	-	100	-	-	-	-
	Punctoribates gilarovi Shaldybina, 1969	-	100	-	-	-	-
	Heminothrus (P.) peltifer (Koch, 1839)	-	100	-	-	-	-
	Protoribates (P.) lophotrichus (Berlese, 1904)	-	100	-	-	-	-
B	*Ceratozetes (C.) minutissimus* Willmann, 1951	-	65.4	34.6	-	-	-
B	*Minguezetes hexagonus* (Berlese, 1908)	-	-	1.8	98.2	-	-
B	*Oribatula (Z.) undulata* Berlese, 1916	-	-	2.5	97.5	-	-
B	*Microppia minus* (Paoli, 1908)	-	3.7	8.3	88	-	-
B	*Subiasella (L.) subiasi* (Mahunka, 1987)	-	1.6	-	98.3	-	-
B	*Scheloribates (S.) labyrinthicus* Jeleva, 1962	-	20.1	5.8	61.7	10.2	2.1
B	*Oribatula (Z.) glabra* (Michael, 1890)	-	75.8	4.6	-	19.6	-
B	*Peloptulus phaenotus* (Koch, 1844)	-	6.6	32.9	54.9	5.5	-
B	*Oribatula (O.) pannonica* Willmann, 1949	-	0.4	2.55	-	71.8	25.2
C	*Tectocepheus velatus* (Michael, 1880)	32.5	8.7	23.3	32.2	0.6	2.6
C	*Anomaloppia differens* Mahunka et Topercer, 1983	18.5	54.9	8.7	7.1	1	9.6
C	*Ramusella (I.) insculpta* (Paoli, 1908)	0.2	63.5	3.6	6.25	14.4	11.9
C	*Protoribates (P.) capucinus* Berlese, 1908	29.9	19.6	6.1	21.4	13.8	9.2
C	*Oppiella (O.) nova* (Oudemans, 1902)	28.9	46.2	5.8	-	-	19.1
D	*Scheloribates (S.) fimbriatus* Thor, 1930	-	-	-	4.1	29.2	66.7
D	*Oribatula (Z.) connexa* Berlese, 1904	-	-	-	-	92.7	7.3
D	*Zetomimus (P.) acutirostris* (Mihelcic, 1957)	-	-	-	-	16.4	83.6
D	*Ramusella (R.) sengbuschi* Hammer, 1968	-	-	-	-	-	100
D	*Graptoppia (G.) neonominata* Subias, 2004 (=*parva* Kok, 1967)	-	-	-	-	-	100

*see Material and methods

The oribatid communities in the (semi)natural grasslands (hayfields) have similarities in structural terms, despite the fact that global density is highly varied depending on the stand conditions (*table 1*). Analysis of the global structural parameters indicates that values of global average density, number of species and specific diversity are comparable to other grassland ecosystems in the northeastern region of the country (Ivan O., 2007, 2010). As regards the grazed meadows, the oribatid communities are very different both qualitatively and quantitatively, depending on the stand bio-edaphic conditions, but especially in relation to the pressure of the anthropogenic factor. In these sites there is a significant decrease in species richness and specific diversity, despite the fact that the average global abundance can reach higher values than those in the hayfields, therefore these oribatid communities are less complex and less stable. In the sites where an ecological factor becomes limiting (excess moisture, soil salt content), the number of species is relatively low, and the best adapted ones, few in number, reach high abundances.

In the soil of agricultural crops the oribatid mites' abundance and specific diversity are reduced or even extremely low, until the destruction of their communities. It is noted the large differences in structural parameters from one site to another, but especially from one crop to another (*table 1*). Annual crops, because of the specific agro-technical works, offer less favorable conditions, being populated by a small number of species, with lower requirements and demographic strategies that allow them to increase population in a short time. Among the edifying species are typical grassland species and eurytopic ones, among which some species recorded frequently or especially in cultivated soils (*Scheloribates fimbriatus, Zetomimus (P.) acutirostris, Oribatula (Z.) connexa*) (*table 3*) (Ivan O., 2008; Ivan O., Călugăr A., 2013).

Analysis of distribution of the edifying species (with values of the ecological significance index above 5.1, corresponding to the classes IV and V) reveals several distinct groups of species, as follows (*table 3*):

A - forest and preferential forest species, with high representativity values exclusively or especially in forest ecosystems; the most demanding species in this group are present only in natural forests;

B - praticolous and preferentially grassland species, with high representativity values especially in meadows, some of them having comparable values in forest plantations and / or agroecosystems;

C- eurytopic species, indifferent to vegetation, with low exigencies, being recorded in all types of ecosystems;

D - species only recorded in the soil of agroecosystems.

CONCLUSIONS

Oribatid communities in the soil organic horizon of natural forest ecosystems (Natura 2000 sites) are distinguished by their complexity with generally higher values of the average global density, but especially of the number of species and the specific diversity, compared to meadows, but also with forest plantations in the area. The balanced trophic and demographic structure and high structure heterogeneity characterize these communities as functional and stable over time.

In the case of forest plantations, oribatid communities are structurally differentiated, depending on the particular floristic composition, which determine the quality and quantity of plant necromass. Compared with the natural forests, significant qualitative differences were revealed regarding the composition of edifying and influential species groups. It has been noticed that a number of forest species, characteristic of the *Quercus* spp. forests in the area, are missing or very poorly represented, while some grassland species, together with eurytopic ones are present, with high values of the ecological significance index.

In grassland ecosystems, especially, the anthropogenic impact exerted by grazing, agriculture, construction, tourism etc. is reflected in oribatid communities by the increased proportion of eurytopic species, which become edifying elements, by the large number of species with accidental frequency and by diminishing of both density and specific diversity.

In the soil of agricultural crops, the values of oribatid mites' abundance and of specific diversity are comparatively lower or even extremely low, until the destruction of their communities, with remarkable differences in the structural parameters from one site to another, but especially from one crop to another.

Analysis of the edifying species' distribution in the considered ecosystems revealed several distinct species groups in terms of preferences to a particular type of habitat, which illustrates the selectivity of oribatids in relation to the bio-edaphic conditions and their bio-indicator value.

ACKNOWLEGMENTS

This study was partly supported by BIODIVERS 2 Research Programme developed under coordination of National Institute of Research and Development for Biological Sciences Bucharest and funded by the Romanian Ministry of Research and Innovation.

REFERENCES

Acatrinei L., Huţanu M., Ivan O., Călugăr A., 2017 - *Functional diversity and ecosystem resilience in some forests "Natura 2000" sites in Northeastern Romania*. Proceedings of the 15th International Conference on Environmental Science and Technology, https://cest.gnest.org/sites/default/files/presentation_file_list/cest2017_00963_poster_paper.pdf

Călugăr A., Ivan O., 2013 - *Diversity and distribution of the edaphic mites (Acari: Gamasina, Oribatida) in* *some forest plantations from the Central Moldavian Plateau*, Lucrări Ştiinţifice, Seria Agronomie, 56 (2): 97-103

Cluzeau D., Guernion M., Chaussod R., Martin-Laurent F., Villenave C., Cortet J., Ruiz-Camacho N., Pernin C., Mateille T., Philippot L., Bellido A., Rougé L., Arrouays D., Bispo A. and Pérès G., 2012 - *Integration of biodiversity in soil quality monitoring: Baselines for microbial and soil fauna parameters for different land-use types*, *European Journal of Soil Biology*, **49**: 63-72.

European Commission, 2006 - *Thematic Strategy for the Protection of Soil* - http://ec.europa.eu/environment/soil/index.htm

Florea N., 2005 - *Map of ecological units in Romania*. Factors and Pedogenetic Processes under Temperate Zone, 4 S. noua: 109-116 (in Romanian)

Ivan O., 2007 - *Diversity and distribution of the oribatid mites (Acari, Oribatida) in some lawn ecosystems from Moldavian Plain (Romania)*, Studii şi comunicări, Compl. Muz. St. Nat. "Ion Borcea" Bacău, 21: 236-243.

Ivan, O., 2008 - *Density, diversity and distribution of the oribatid mites (Acari, Oribatida) in some cultivated soils from North-Eastern Romania*, USAMV Iasi, Lucrări ştiinţifice, ser. Agronomie, vol. 51 (CD – ROM).

Ivan O., 2010 - *Fauna and structure of the oribatid communities (Acari, Oribatida) in some hayfield protected areas from Eastern Romania*, Scientific Annals of „Al. I. Cuza" University of Iasi. (New Series), Section 1, Animal Biology, LVI: 53-61.

Ivan O., Călugăr A., 2013 - *Peculiarities of the edaphic mesofauna in some cultivated soils from the Central Moldavian Plateau*, Lucrări Ştiinţifice, Seria Agronomie, 56 (2): 125-131.

Jeffery S., Gardi, C., Jones A., Montanarella L., Marmo L., Miko L., Ritz K., Peres G.J., Römbke J., van der Putten W. H. (eds.), 2010 - *European Atlas of Soil Biodiversity*. European Commission, Publications Office of the European Union, Luxembourg, pp. 128.

Müller H.J., Bahrmann R., Heinrich W., Marstaller R., Schaller G., Witsack W., 1978 - *Zur structuranalyse der epigaischen Artropodenfauna einer Rasen-Katena durch Kescherfange*. Zool. Jb. Syst., 105: 131-184.

Pérez-Iñigo C., 1993 - *Acari, Oribatei, Poronota.* In: Ramos M.A. et al., (eds.), *Fauna Ibérica*, vol.3, Museo Nacional de Ciencias Naturales, CSIC, Madrid, pp. 320.

Subías L.-S., 2004 – *Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes, Oribatida) del mundo (1758-2002)* – Graellsia, 60: 3- 305. Updated version January 2018 [Internet] available from: http://bba.bioucm.es/cont/docs/RO_1.pdf, pp. 605.

Subías L.S., Arillo A. 2001 - *Acari, Oribatei, Gymnonota II*. In: Ramos M.A. et al., (eds.), *Fauna Ibérica*, vol. 15, Museo Nacional de Ciencias Naturales, CSIC, Madrid, pp.289.

Vasiliu N., Ivan O., Vasiliu M., 1993 - *Faunistic synopsis of the oribatid mites (Acarina, Oribatida) from Romania.* Anuarul Muz. Naţ. al Bucovinei, Suceava, fasc. Şt. nat., XII: 3-82 [in Romanian].

Weigmann G., 2006 – *Acari, Actinochaetida. Hornmilben (Oribatida)*, Goecke&Evers, Keltern: pp. 520.