MOSS MITE (ACARI, ORIBATIDA) COMMUNITIES IN THE APŠUCIEMS CALCAREOUS FEN, LATVIA

Uģis Kagainis, Voldemārs Spuņģis

Kagainis U., Spuņģis V. 2013. Moss mite (Acari, Oribatida) communities in the Apšuciems calcareous fen, Latvia. *Acta Biol. Univ. Daugavp., 13 (2): 39 – 53.*

Pilot study on oribatid mites in calcareous fen Apšuciems was performed on May 20th (early summer season), 2009 and results were published in 2011. By this article, new data collected on September 30th (autumn season), 2009 have been added to the discussion on fauna of oribatid mites from the Apšuciems fen. The same thirty sampling plots were chosen and sampling and extracting technique was used as previous. Vegetation cover was registered on 9th July. Present records of autumn revealed 67 species and 7 morphospecies. Ten species were recorded for the first time in the fauna of Latvia. Results from samples of the Apšuciems were compared seasonally. Adult mites sampled in autumn showed higher mean density 30,070 (10^3 ind/m^2) than adults collected in early summer – 19,496 (10^3 ind/m^2). The most dominant species were *Steganacarus (Atropocarus) striculus*, *Nanhermannia comitalis* and *Malacanothrus monodactylus*. Dominance strategies did not differ significantly among both seasons. Almost a half (43,4%) of collected 26252 Oribatida (in samples from both seasons) was juveniles, showing higher abundance in autumn. High number of subrecedent species was recorded. Adult versus juvenile ratio varied among oribatid species. Juveniles of *Platynothrus thori* showed higher dominance in May (early summer season), but juveniles of *Hypochthonius rufulus* – higher dominance in September (autumn season). Numerous oribatid indicator species were selected: *Trimalaconothrus angulatus*, *Hypochthonius rufulus*, *Nanhermannia comitalis*, *Scheloribates (Topobates) circumcarinatus*, *Oppiella (Oppiella) propinqua*, *Pilogalumna tenuiclava* indicating brown bog-rush *Schoenus ferrugineus* dominated plots and *Suctobelbella forsslundi*, *Suctobelbella palustris*, *Trhypochthoniellus longisetus* f. *longiseta* and *Scheloribates laevigatus* indicating saw tooth sedge *Cladium mariscus* dominated plots. Vegetation cover correlated with dominant oribatid species, yet it was impossible to propose statistically significant characterization of these relationships during DCA analysis. Distributional patterns of different oribatid species might be influenced by their feeding preferences. However, more diverse discussion on effects of distribution of oribatid species might have been achieved by registering additional environmental parameters e.g. amount of organic matter and calcium in soil, biomass of vegetation etc.

Key words: Oribatida, species, communities, calcareous fen, indicators, Latvia.

Uģis Kagainis. Institute of Biology, University of Latvia, 3 Miera Street, LV-2169, Salaspils, Latvia, e-mail: oribatida@inbox.lv
Voldemārs Spuņģis. Department of Zoology and Animal Ecology, Faculty of Biology, University of Latvia, 4 Kronvalda Blvd., LV-1586, Riga, Latvia; e-mail: adalia@lanet.lv

INTRODUCTION

Calcareous fens (EU Code 7210) are known by their habitat-specific moss and vegetation cover (European Commission 2013, Auniņš 2010), and high, calcium-rich groundwater table (Tabaka 1960, Kabucis 2000, Pakalne 2008). Oribatid mites (Subias 2004) are the most abundant and diverse among microarthropods in calcareous fens (Seniczak et al. 2010, after Belanger 1976). Mainly they feed on organic plant material and microscopic fungi (Schuster 1957, Luxton 1972, Anderson 1975) and play an important role in nutrient recycling (Moore et al. 1988, Weigmann 2006, Krantz & Walter 2009).

However, only few studies have been devoted to oribatid communities and their relationships to semi-aquatic ecosystems like calcareous fens or alkaline fens (Macfadyen 1952, Popp 1962, Weigmann 1982, Lebrun et al. 1989, Weigmann 1991, Kehl 1997, Weigmann 1997, Сидорчук 2008, Seniczak et al. 2010). Some of the most convincing publications have been written by G. Weigmann (1991, 1997) who investigated oribatids-indicators for fens and similar habitats. Seniczak and colleagues (2010) have described oribatid mite communities in two fens of Norway – Blamansvannet and Higher Lake – by studying both adult and immature individuals (Table 1). Variable expressions of oribatid population dynamics during different seasons also have been described and often characterized as species specific (Choudhuri & Banerjee 1975, Bhattacharya & Raychaudhuri 1977, Luxton 1983, Сидорова 1978).

In 2011, first comparable data on oribatid mites from calcareous fen in the territory of Latvia has been published (Kagainis & Spungis 2011). By gathering all available literature it has been cleared that geographically separated fens can be very diverse and slightest change in habitat structure (e.g. groundwater table, vegetation cover, density of calcium) can result in a significant difference in oribatid species composition. It appeared to be almost impossible to do any valuable faunistical and ecological comparisons between Latvian armored mites and geographically separated populations from

Table 1. Faunistic characteristics like species number, mean abundance and, abundance range and dominance (*Limnozetes ciliatus* (c), *L. rugosus* (r) and *Trimalaconothrus angulatus* (a)) of oribatid mites studied by various authors in the fens, N – absent data

Oribatid characteristics	**Reference, studied locality, date**					
	Seniczak et al. 2010 (Blamansvannet fen, June 6th)	Seniczak et al. 2010 (Higher Lake, June 6th)	Weigmann 1991 (mesotrophic fen)	Weigmann 1991 (oligotrophic fen)	Kagainis & Spungis 2011	Kagainis & Spungis (Present study)
					Apšuciems fen, May 20th	Apšuciems fen September 30th
Number of species	37	26	20	22	56	65
Mean abundance, ind*10^3/m^2	28,1	51,2	24	22	31,7	56,3
Abundance range, ind*10^3/m^2	21,3-33,8	34,3-83,3	N	N	3,8-92,2	11,5-164,0
Dominance of species	a=6%, r=3%	c=31%	N	N	c=5%, a=1%, r=0,1%	c=2,4%, a=1,2%, r=0,02%

similar ecosystems (Lebrun et al. 1989, Kehl 1997, Fisk et al. 2006, Kagainis & Spungis 2011).

The aim of this investigation is to improve knowledge on oribatid communities in the Apšuciems calcareous fen by adding new data collected during a different season.

MATERIAL AND METHODS

The fen Apšuciems is situated at Engure municipality, Latvia (coordinates 57°05'29"N, 23°31'69"E). This fen represents calcareous fens of EU importance (Habitat directive Annex I). The Apšuciems fen is also Natura 2000 site because of its specific composition of vegetation, soil structure and hydrological conditions.

Present study was curried out in autumn season on September 30, 2009. The same locality was chosen as an investigation area (Kagainis & Spungis 2011). Thirty sampling plots (area – 1 $m^{2,}$ distance between plots – 2 m) were chosen along a 60 m long transect. The same data on vegetation cover obtained on July 9^{th}, 2009 was used to characterize sampling plots (Kagainis & Spungis 2011).

Soil samples were collected in the center of the plot using a soil borer (sample area – 0,01 m^2, depth 0-10 cm). Mites were extracted on Tullgren funnels for seven days (25W light bulbs) (Dunger et al. 1997). Specimens were mounted in Hoyer's medium (Krantz & Walter 2009) and observed under the transmitted light microscope Olympus BX4. Species were identified after Weigmann's (2006) keys and correctness was confirmed when required by G. Weigmann (Germany) and R. Penttinen (Finland). Some of taxonomical elements were incorporated from H. Schatz (2003). Material is deposited in the Institute of Biology, University of Latvia.

Dominance classes followed A. D. Engelmann (1978) classification. Spearman rank correlation coefficients were calculated for dominating mite and plant species using PAST software.

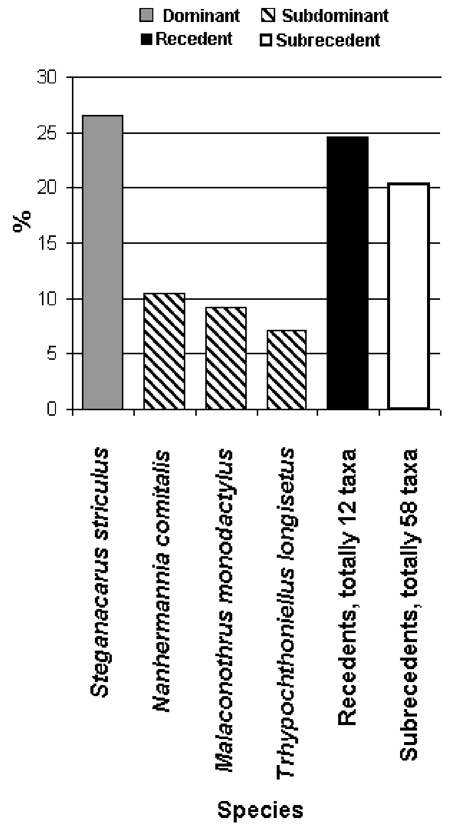

Fig. 1. Dominance (%) by A.D. Engelmann (1978) of different oribatid taxa sampled in the Apšuciems fen on September 30, 2009 (dominants – 12,5-39,9%; subdominants – 4-12,4%; recedents – 1,3-3,9%; subrecedents – < 3,9%).

Mean/average number V, dominance (D = % of total oribatid mites), constancy (C = % of samples), abundance (A, in 10^3 ind/m^2) (Seniczak et al. 2010), age structure ratio (R = division of adult and juvenile mites) were estimated. Species diversity was expressed as Shannon index (Crebs 1999). Detrended Correspondence analysis (DCA) was used to visualise distribution of sample plots depending on vegetation and oribatid species, Indicator Species Analyses – to determine indicator species for two groups of vegetation, and Cluster Analysis – to group sample plots based on Oribatid data (Zuur et al. 2007). PC ORD software was used for analyses.

RESULTS

In total, 9021 oribatid adults and 7879 juveniles representing 67 identified species (including two forms, one subspecies and one variation), 7 morphospecies and 4 unidentified taxa were recorded in the samples collected at the fen Apšuciems on September 30, 2009. Mean density of oribatid mites was calculated as ca. 56333 ind/m^2, of them ca. 30000 adult ind/m^2 and ca. 26333 juvenile ind/m^2. Shannon index (2.377) was comparatively high. More detailed characteristics of oribatid mite species is given in the table (Table 2). Ten species were registered for the first time in the fauna of Latvia, namely: *Eubrachychthonius longisetosus* Csiszar, 1961; *Liochthonius peduncularius* (Strenzke, 1951); *Sellnickochthonius cricoides* (Weis-Fogh, 1948); *Sellnickochthonius hungaricus* (Balogh, 1943); *Trhypochthonius nigricans* Willmann, 1928; *Nothrus pratensis* Sellnick, 1928; *Hermanniella punctulata* var. *septentrionalis* Berlese, 1910; *Spatiodamaeus boreus* (Bulanova-Zachvatkina, 1957); *Pergalumna willmanni* (Zachvatkin, 1953); *Oribatula interrupta* (Willmann, 1939).

Steganacarus (Atropacarus) striculus dominated and three species *Trhypochthoniellus longisetosus* f. *longiseta*, *Malacanothrus monodactylus*, *Nanhermannia comitalis* were subdominants.

The rest of the species were recedents and subrecedents (Fig. 1).

A significant part of all 78 registered taxa (36,3%) collected in September were those that are represented with only four or less individuals.

Dominance of adults versus juveniles was estimated to six species showing a high interspecific variability (Fig.2).

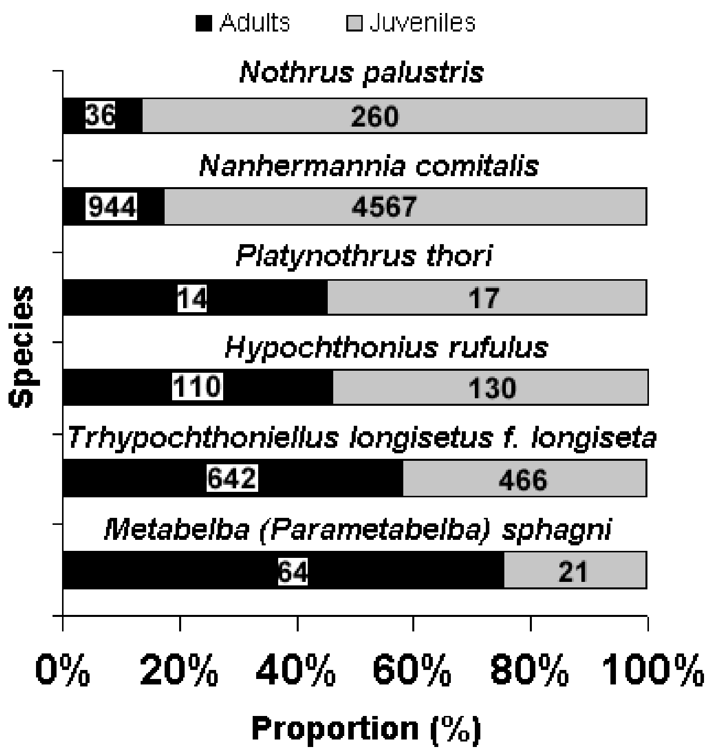

Fig. 2. Dominances (%) of juveniles against adult individuals of six oribatid mite species collected on September 30, 2009. Numbers of individuals are indicated on the bars.

Table 2. Characteristic of the material of oribatid mites from 30 samples collected in Apšuciems calcareous fen on September 30, 2009. Families are ordered accordingly to taxonomical principles (International… 1985) and species are ordered alphabetically. Numbers of morphospecies are synchronized with the list of May 20th, 2009 (Kagainis & Spungis 2011). N_{ad} – total number of adult individuals; V – mean number of adults per sample; D – dominance (% of adults); C – constancy (% populated of samples); A – population density (in 10^3 adult ind/m^2); M – max. number (in the sample); N_{juv} – total number of juvenile individuals, * - species new to the fauna of Latvia

No.	**Species**	N_{ad}	**V**	**D**	**C**	**A**	**M**	N_{juv}
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Brachiochthoniidae Thor, 1934 spp	5	0,17	0,06	6,67	0,017	4	
1.	*Eubrachychthonius longisetosus* Csiszar, 1961 *	17	0,57	0,19	33,33	0,057	5	
2.	*Liochthonius hystricinus* (Forsslund, 1942)	44	1,47	0,49	63,33	0,147	7	
3.	*Liochthonius peduncularius* (Strenzke, 1951) *	51	1,70	0,57	26,67	0,170	19	
4.	*Liochthonius tuxeni* (Forsslund, 1957)	32	1,07	0,35	63,33	0,107	5	
5.	*Sellnickochthonius cricoides* (Weis-Fogh, 1948) *	3	0,10	0,03	10,00	0,010	1	
6.	*Sellnickochthonius hungaricus* (Balogh, 1943) *	3	0,10	0,03	6,67	0,010	2	
7.	*Hypochthonius rufulus* C.L. Koch, 1835	110	3,67	1,22	76,67	0,367	16	130
8.	*Eniochthonius minutissimus* (Berlese, 1903)	1	0,03	0,01	3,33	0,003	1	
9.	*Phthiracarus ferrugineus* (C. L. Koch, 1841)	140	4,67	1,55	90,00	0,467	20	
10.	*Phthiracarus globosus* (C. L. Koch, 1841)	23	0,77	0,25	46,67	0,077	3	
	Phthiracarus Perty, 1841 sp3	2	0,07	0,02	3,33	0,007	2	
	Phthiracarus Perty, 1841 sp4	37	1,23	0,41	36,67	0,123	10	
11.	*Steganacarus (Atropacarus) striculus* (C.L. Koch, 1835)	2397	79,90	26,57	100,00	7,990	189	
12.	*Steganacarus (Tropacarus) carinatus* f. *carinata* (C.L. Koch, 1841)	101	3,37	1,12	86,67	0,337	8	
13.	*Steganacarus (Tropocarus) carinatus* f. *pulcherrima* (Berlese, 1887)	1	0,03	0,01	3,33	0,003	1	
14.	*Steganacarus spinosus* (Sellnick, 1920)	70	2,33	0,78	70,00	0,233	11	
15.	*Euphthiracarus monodactylus* (Willmann, 1919)	1	0,03	0,01	3,33	0,003	1	

No.	Species	N_{ad}	V	D	C	A	M	N_{juv}
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
16.	*Malaconothrus monodactylus* (Michael, 1888)	831	27,70	9,21	93,33	2,770	86	
17.	*Trimalaconothrus angulatus* Willmann, 1931	111	3,70	1,23	73,33	0,370	17	127
18.	*Trimalaconothrus maior* (Berlese, 1910)	11	0,37	0,12	3,33	0,037	11	
19.	*Trhypochthonius nigricans* Willmann, 1928 *	2	0,07	0,02	6,67	0,007	1	
20.	*Trhypochthoniellus longisetus* f. *longiseta* (Berlese, 1904)	642	21,40	7,12	93,33	2,140	53	466
21.	*Nothrus palustris C.L. Koch, 1839*	36	1,20	0,40	43,33	0,120	8	230
22.	*Nothrus pratensis Sellnick, 1928 **	1	0,03	0,01	3,33	0,003	1	11
23.	*Camisia spinifer (C.L. Koch, 1835)*	1	0,03	0,01	3,33	0,003	1	1
24.	*Platynothrus peltifer (C.L. Koch, 1839)*	14	0,47	0,16	6,67	0,047	13	17
25.	*Platynothrus thori (Berlese, 1904)*	18	0,60	0,20	26,67	0,060	4	127
26.	*Nanhermannia comitalis Berlese, 1916*	944	31,47	10,46	93,33	3,147	90	4567
27.	*Hermanniella dolosa Grandjean, 1931*	169	5,63	1,87	66,67	0,563	31	
28.	*Hermanniella punctulata var. septentrionalis Berlese, 1910 **	1	0,03	0,01	3,33	0,003	1	
29.	*Damaeus riparius Nicolet, 1855*	1	0,03	0,01	3,33	0,003	1	1
30.	*Metabelba (Parametabelba) sphagni Strenzke, 1950*	64	2,13	0,71	60,00	0,213	11	21
31.	*Spatiodamaeus boreus (Bulanova-Zachvatkina, 1957) **	2	0,07	0,02	6,67	0,007	1	
32.	*Gustavia microcephala (Nicolet, 1855)*	5	0,17	0,06	6,67	0,017	4	
33.	*Xenillus tegeocranus (Hermann, 1804)*	15	0,50	0,17	30,00	0,050	5	
34.	*Ceratoppia quadridentata (Haller, 1882)*	5	0,17	0,06	13,33	0,017	2	
35.	*Carabodes willmanni Bernini, 1975*	1	0,03	0,01	3,33	0,003	1	
36.	*Tectocepheus velatus velatus (Michael, 1880)*	191	6,37	2,12	66,67	0,637	62	

No.	**Species**	**N_{ad}**	**V**	**D**	**C**	**A**	**M**	**N_{juv}**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
37.	*Quadroppia hammerae Minguez et al., 1985*	184	6,13	2,04	36,67	0,613	88	
38.	*Quadroppia quadricarinata Michael, 1885*	14	0,47	0,16	10,00	0,047	9	
	Quadroppia Jacot, 1939 spp	1	0,03	0,01	3,33	0,003	1	
39.	*Micropia minus (Paoli, 1987)*	2	0,07	0,02	6,67	0,007	1	
40.	*Oppiella (Moritzoppia) neerlandica (Oudemans, 1900)*	2	0,07	0,02	6,67	0,007	1	
41.	*Oppiella (Oppiella) nova (Oudemans, 1902)*	69	2,30	0,76	40,00	0,230	16	
42.	*Oppiella (Oppiella) propinqua Mahunka & Mahunka, 2000*	282	9,47	3,13	43,33	0,940	97	
43.	*Oppiella (Rhinoppia) hygrophila (Mahunka, 1987)*	28	0,93	0,31	36,67	0,093	7	
44.	*Oppiella (Rhinoppia) subpectinata (Oudemans, 1900)*	2	0,07	0,02	6,67	0,007	1	
	Oppiella Jacot, 1937 sp1	1	0,03	0,01	3,33	0,003	1	
	Suctobelba Jacot, 1937 sp1	105	3,50	1,16	33,33	0,350	52	
45.	*Suctobelbella falcata (Forsslund, 1941)*	1	0,03	0,01	3,33	0,003	1	
46.	*Suctobelbella forsslundi (Strenzke, 1950)*	189	6,30	2,10	83,33	0,630	22	
47.	*Suctobelbella palustris (Forsslund, 1953)*	145	4,83	1,61	73,33	0,483	19	
48.	*Suctobelbella subcornigera (Forsslund, 1941)*	248	8,27	2,75	80,00	0,827	73	
	Suctobelbella Jacot, 1937 sp1	2	0,07	0,02	3,33	0,007	2	
	Suctobelbella Jacot, 1937 sp2	29	0,97	0,32	40,00	0,097	7	
	Suctobelbella Jacot, 1937 sp3	3	0,10	0,03	10,00	0,010	1	
	Suctobelbella Jacot, 1937 spp	111	3,70	1,23	66,67	0,370	24	
	Oppioidea Grandjean, 1951 spp	187	6,23	2,07	40,00	0,623	60	
49.	*Bankinosoma lanceolata (Michael, 1885)*	23	0,77	0,25	3,33	0,077	23	

No.	Species	N_{ad}	V	D	C	A	M	N_{juv}
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
50.	*Limnozetes ciliatus (Schrank, 1803)*	214	7,13	2,37	60,00	0,713	74	
51.	*Limnozetes rugosus (Sellnick, 1923)*	2	0,07	0,02	3,33	0,007	2	
52.	*Eupelops plicatus (C.L. Koch, 1835)*	4	0,13	0,04	13,33	0,013	1	14
53.	*Anachipteria deficiens Grandjean, 1932*	106	3,53	1,18	86,67	0,353	15	
54.	*Parachipteria punctata (Nicolet, 1855)*	47	1,57	0,52	53,33	0,157	13	
55.	*Galumna obvia (Berlese, 1915)*	270	9,00	2,99	96,67	0,900	57	
56.	*Pergalumna willmanni (Zachvatkin, 1953)* *	3	0,10	0,03	3,33	0,010	3	
57.	*Pilogalumna tenuiclava (Berlese, 1908)*	62	2,07	0,69	60,00	0,207	10	
58.	*Ceratozetes peritus Grandjean, 1951*	49	1,63	0,54	20,00	0,163	20	
59.	*Fuscozetes fuscipes (C.L. Koch, 1844)*	146	4,87	1,62	86,67	0,487	14	
60.	*Trichoribates incisellus (Kramer, 1897)*	1	0,03	0,01	3,33	0,003	1	
61.	*Trichoribates novus (Sellnick, 1928)*	3	0,10	0,03	3,33	0,010	3	
62.	*Minunthozetes pseudofusiger (Schweizer, 1922)*	13	0,43	0,14	23,33	0,043	4	
63.	*Punctoribates sellnicki Willmann, 1928*	24	0,80	0,27	13,33	0,080	15	
64.	*Podoribates longipes Berlese, 1887*	30	1,00	0,33	10,00	0,100	28	
65.	*Scheloribates (Topobates) circumcarinatus Weigmann & Miko, 1998*	153	5,10	1,70	86,67	0,510	18	
66.	*Scheloribates laevigatus (C.L. Koch, 1836)*	162	5,40	1,80	86,67	0,540	21	
67.	*Oribatula interrupta (Willmann, 1939)* *	1	0,03	0,01	3,33	0,003	1	
	juvenile ind. spp		70,53	24,02	100	7,223	213	2167
	Total number	9021	300,77	100	100	30,070	968	7879

Distribution of Oribatida in the samples was influenced by vegetation (Fig. 3). Axis 1 might be explained as changes from saw tooth sedge *Cladium mariscus* dominated sample plots to brown bog-rush *Schoenus ferrugineus* dominated, Axis 2 – might be changes in height of vegetation from tall at bottom to short at top or from monodominant plant cover to polydominant one. Among dominating oribatids *Steganacarus (Atropacarus) striculus*, *Malacanothrus monodactylus* and *Nanhermannia comitalis* negatively correlated with the Axis 1 (-0,677; -0,728; -0.557 respectively, n=30; p<0,01), while *Trhypochthoniellus longisetosus* f. *longiseta* – positively (0,631; n=30; p<0,01).

Cluster analysis (Fig .4) showed that sample plots did not form definite groups according to vegetation.

At sample plots No 1-15 brown bog-rush *Schoenus ferrugineus* dominated while at sample plots No 15-30 – saw tooth sedge *Cladium mariscus* was the dominating plant species. Indicator Species Analyses of oribatid species showed that numerous species might be regarded as indicators in these groups. Of 56 species *Trimalaconothrus angulatus*, *Hypochthonius rufulus*, *Nanhermannia comitalis*, *Scheloribates (Topobates) circumcarinatus*, *Oppiella (Oppiella) propinqua*, *Pilogalumna tenuiclava* had the highest indicator values for brown bog-rush *Schoenus ferrugineus* dominated plots, while of 16 species *Suctobelbella forsslundi*, *Suctobelbella palustris*, *Trhypochthoniellus longisetus* f. *longiseta* and *Scheloribates laevigatus* – in saw tooth sedge *Cladium mariscus* dominated plots.

Spearman rank correlations (Table 3) among dominant oribatid mite and plant species showed that dominating plant species weakly influence the distribution of mites in the Apšuciems fen.

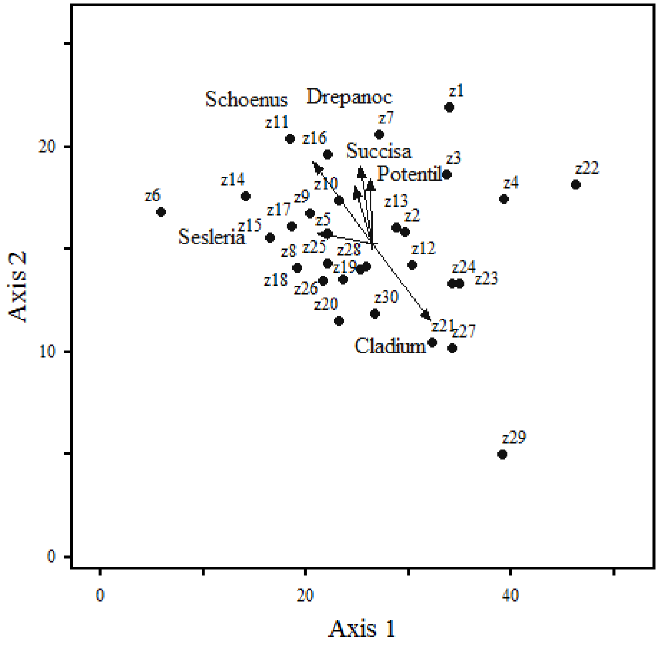

Fig. 3. DCA ordination of sample plots based on Oribatid data on September 30th, 2009 at the Apšuciems fen. Axis 1 eigenvalue 0.310, Axis 2 – 0.099. Abbreviations: Schoenus – *Schoenus ferrugineus*, Drepanocl – *Drepanocladus revolvens*; Succisa – *Succisa pratensis*; Sesleria – *Sesleria coerulea*; Potentil – *Potentilla erecta*; Cladium – *Cladium mariscus*.

DISCUSSION

In the present study, ten species have been registered for the first time in the fauna of Latvia. From now 209 oribatid species are known for the fauna of Latvia.

Adult mites sampled in September (autumn season) showed higher mean density ca. 30070 ind/m^2 than adults collected in May (early summer season) – ca. 19496 ind/m^2 (Kagainis & Spungis 2011). Oribatid mites mostly feed on dead organic vegetation material and microscopic fungi. Northern European vegetation is less abundant in spring and keeps developing throughout the next season. Oribatid mites quite often reach their density peaks only in late autumn (Luxton 1983, Jordana et al. 1987, Donaldson 1996) by constantly feeding and adjusting their life cycles appropriately to food conditions (Schuster 1957, Luxton 1927, Anderson 1975, Moore et al. 1988, Гришина 1991, Belozerov 2009). Still, there have been published articles proving dominance of oribatid numbers also in May, yet these mites being collected from relatively far related ecosystems to fens (Сидорова 1978, Luxton 1983). However, it is also proved that water content and temperature of soil as well as altitude can positively affect the mean density of oribatid mites (Sanyal & Bhaduri 1982).

Total numbers of registered species and densities of oribatids have been registered in a grater amount if compared to similar studies (Table 1). Thirty samples were collected in each expedition in the Apšuciems fen, while only five samples were collected in fens of Norway and six samples in fens of Germany (Weigmann 1991, Senizcak et al. 2010). A relatively large area of soil (0,3 m^2) has been investigated in the Apšuciems fen. Despite that published data on fens of Norway and Germany do not clarify the exact values of total area. It is possible that total area of investigated territory showed an effect on success of finding more species and collecting larger total number of individuals (Weigmann 1991, Seniczak et al. 2010).

When similar studies were compared with the Apšuciems fen, significantly different values of mean abundance and abundance range have been found registered in semi-aquatic habitats (Table 1). This could be explained by differences in biological factors like vegetation cover among

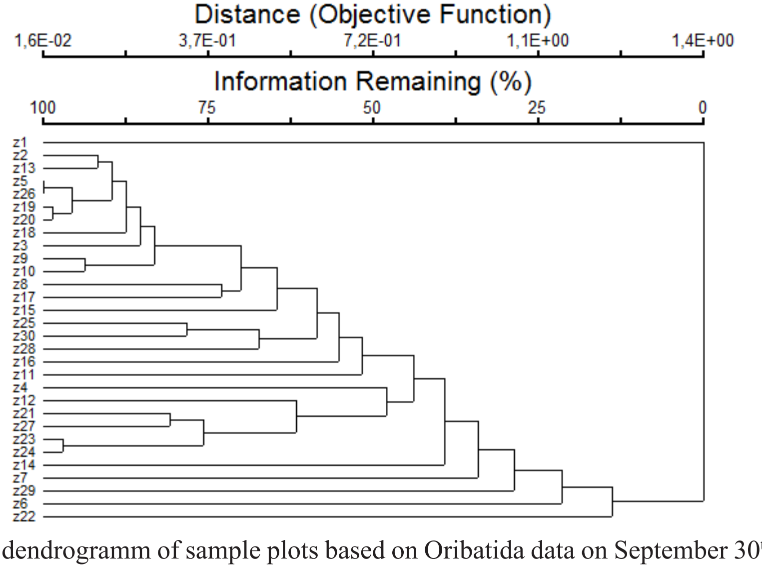

Fig. 4. Cluster dendrogramm of sample plots based on Oribatida data on September 30th, 2009 at the Apšuciems fen.

Table 3. Spearman rank correlations among dominant oribatid and plant species in samples collected on September 30th, 2009; in the Apšuciems fen. Explanations: * – p<0,05; ** – p<0,01; n.s. – absent statisticaly significant correlation

Plant species	Oribatid species			
	Steganacarus (Atropacarus) striculus	*Malacanothrus monodactylus*	*Trhypochthoniellus longisetosus* f. *longiseta*	*Nanhermannia comitalis*
Drepanocladus revolvens	n.s	n.s	n.s	n.s
Campylium stellatum	-0,375*	-0,429*	n.s	n.s
Schoenus ferrugineus	0,380*	n.s	-0,415*	0,438*
Carex panicea	0,374*	n.s	n.s	0,381*
Potentilla erecta	n.s	n.s	n.s	0,377*
Molinia caerulea	0,519**	n.s	n.s	0,447*
Succisa pratensis	n.s	n.s	n.s	n.s
Parnassia palustris	n.s	n.s	n.s	n.s
Cladium mariscus	n.s	n.s	n.s	-0,457*

localities (Weigmann 1991, Seniczak et al. 2010, Kagainis & Spungis 2011) that can also affect the oribatid species composition (Lebrun et al. 1989).

Seniczak and colleagues (2010) registered the majority of taxa (89 %) that were represented by a single specimen (density lower than 2000 ind/m^2) at the fen Blamannsvannet. In the fen Apšuciems 94 % of taxa were registered with density < 2000 ind/m^2. Obtained data already have been explained previously by high abundances of habitat tolerant species usually found in wet ecosystems (Borcard 1991, Donaldson 1996, Seniczak et al. 2006).

In both seasons identified juveniles showed species-specific dominance strategies (Fig. 2, Kagainis & Spungis 2011). Numerous works have been written comparing dominance strategies among different oribatid species. However, dominance strategies among juvenile stages and different oribatid taxa have been compared by few authors (Luxton 1983, Seniczak et al. 2010). Results in dominance of different juvenile taxa strongly varied between the present study and previous investigations. This might be due to the different habitats with specific biological conditions rounded in each investigation that might influence oribatid species (Lebrun et al. 1989, Kehl 1997).

Proportion between juveniles and adults among the selected species remained rather stable during the season, with exception of *Platynothrus thori* and *Hupochthonius rufulus* (Figure 2). Juveniles of *Platynothrus thori* showed higher dominance in May (early summer season), but juveniles of *Hypochthonius rufulus* – higher dominance in September (autumn season) (Kagainis & Spungis 2011). Results could be explained by similar trophical needs for both species and non-overlapping feeding strategies. However, there are no similar data published previously to be used in comparisons with the presented results. More extensive discussion could be possible if changes in vegetation cover would be estimated. G. W. Krantz & D. E. Walter (2009) mentioned that the different extracting methods can differently affect the results of immature individuals and always should be taken into consideration when similar data are compared.

By using Spearman rank correlation test both positive and negative relationships have been calculated (Table 3) and might be explained by feeding preferences of selected oribatid species

(Schuster 1957, Luxton 1927, Anderson 1975, Moore et al. 1988, Гришина 1991, Belozerov 2009). Still, when analysed with Detrended Correspondence analysis, vegetation cover did not explaine distribution of oribatid species. This might mean that additional parameters (e.g. height of vegetation, microbial communities, decomposition rate, biomass of vegetation, abundance of organic matter in soil, temperature of soil, water and calcium content in soil, altitude etc.) should be collected during the field study for more diverse discussion (Sanyal & Bhaduri 1982, Fisk et al. 2006, Seniczak et al. 2010).

G. Weigmann (1991, 1997) proposed oribatid indicators to the fens – *Punctoribates sellnicki*, *Scheloribates (Topobates) circumcarinatus*, *Zetomimus furcatus*, *Suctobelbella palustris* and *Malaconothrus monodactylus*. Only *Suctobelbella palustris* is confirmed in our study as indicator for *Cladium mariscus* dominated fen. Proposed indicator species *Trimalaconothrus angulatus* and *Scheloribates (Topobates) circumcarinatus* are considered to be reliable indicators for purple moor grass *Molinia caerulea* fens (Macfadyen 1952). These two species are included as potential indicators for *Schoenus ferrugineus* dominated vegetation together with some more species, but *Molinia coerulea* dominating fen was not studied. The potential indicator species for *Cladium mariscus* dominated vegetation in our study are quite different. The proposed indicators for two dominating vegetation types were not clearly supported by other analysis (DCA and Cluster Analysis). Our investigations showed heterogeneity of the particular fen. Actually much more studies are needed to develop indicator species for definite plant associations not for fens as such. It seems also that dominance/polydominance of plants could influence Oribatida communities. Additionally, indicators might differ among biogeographical regions (Lebrun et al. 1989, Weigmann 1991, Kehl 1997).

CONCLUSIONS

Vegetation cover correlated with dominant oribatid species, yet it was impossible to propose statistically significant characterization of these relationships during DCA analysis. More diverse discussion on effects of distribution of oribatid species might have been achieved by registering additional environmental parameters e.g. amount of organic matter and calcium in soil, microbial communities, decomposition rate, biomass of vegetation etc. By developing collecting techniques and identification of immature individuals, better illustration of oribatid ecological traits in future studies might be obtained. Many uncertainties faced in the present study, and the lack of faunistical and ecological investigations in calcareous fens are the main reasons why similar research should be further continued and developed.

ACKNOWLEDGMENT

Author is grateful to Gerd Weigmann (Institute of Zoology, University of Berlin, Germany) and Ritva Penttinen (Zoological Museum, University of Turku, Finland) for checking correctness of identification of oribatid species and providing with useful literature. Author is grateful to Māra Pakalne for her assistance with the identification of vegetation and mosses. Author also wants to thank Ineta Salmane (Institute of Biology, University of Latvia) for valuable consultations and Guntis Brūmelis (Faculty of Biology, University of Latvia) for the provided help and comments on English.

Current study was performed as a part of the project "Influence of climatic changes on nature of Latvia" in the framework of the National Long Term ecological research and "An investigation of invertebrate species and communities and limiting factors in the subboreal fens".

REFERENCES

Anderson J.M. 1975. Succession, diversity and trophic relationships of some soil animals in decomposing leaf litter. *Animal Ecology*, 44:475-495.

Auniņš A. 2010. Eiropas Savienības aizsargājamie biotopi Latvijā. Noteikšanas rokasgrāmata (Protected habitats of importance of European Union in Latvia. Handbook of determination). Latvijas Dabas fonds, Rīga. Pp. 319. (In Latvian).

Belanger S.D. 1976. The Microarthropod community of Sphagnum moss with emphasis on the Oribatei. Unpublished M. Sc. thesis. State University of New York, Syracuse, New York. Pp. 80.

Belozerov V.N. 2010. Seasonal adaptations in the life cycles of mites and ticks: comparative and evolutionary aspects. In: Sabelis M.W. & Bruin J. (eds.): Trends in Acarology: Proceedings of the 12th International Congress. Dordrecht, Pp. 319-326.

Bhattacharya T., Raychaudhuri D.N. 1977. Monthly variation in the density of soil microarthropods in wasteland of Santiniketan in relations to soil climate and edaphic factors (Abstract). *Proc 2nd. Orient. Entomol. Symp.*, Pp 57.

Borcard D. 1991. Les Oribates des tourbiéres du Jura suisse (Acari, Oribatei): Ecologie I. Quelques aspects de la communauté d'Oribates des sphaignes de la tourbiére du Cachot (Oribatida of the bogs of the Swiss Jura (Acari, Oribatei): Ecology I. Some aspects of the oribatid community of peat bogs in Cachot). *Rev. Suisse Zool.*, 98:303-317. (In French, English abstract).

Choudhuri D.K., Banerjee S. 1975. Qualitative and quantitative composition of Acari and collembolan relation to soil organic matter-microbes complex. Orient. Insects, 9(3):313-316.

Crebs Ch., J. 1999. Ecological Methodology. 2nd ed. Benjamin Cummings, New York. Pp. 620.

Сидорова Л. Е. 1978. Фауна и сезоналъная динамика орибатидных клещей сукходолного луга Уренского района Горковсков областъи (Fauna and seasonal dynamics of oribatid mites in a dry valley meadow of the Uren District in the Gorky Region). In: Gauna, systematics, biology and ecology of helminths and their intermediate hosts, Ninzny Novgorod, Gorkij. C. 69-77. (In Russian).

Donaldson G.M. 1996. Oribatida (Acari) associated with three species of Sphagnum at Spruce Hole Bog, New Hampshire, U.S.A. *Can. J. Zool.*, 74:1706-1712.

Dunger W., Fiedler G., Fiedler H.J. 1997. Methoden der Bodenbiologie. Gustav Fischer Verlag, Jena. S. 539. (In German).

Engelmann A.D. 1978. Dominant Klassifizierung von Bodenarthropoden. *Pedobiologia*, 18: 378-380.

European Commission 2013. Interpretation Manual of European Union Habitats. EUR 28, May European Commission; Nature and biodiversity. DG Environment, Brussels. Pp. 148.

Fisk M.C., Kessler W.R., Goodale A., Fahey T.J., Groffman P.M., Driscoll C.T. 2006. Landscape variation in microarthropod response to calcium addition in a Northern hardwood forest ecosystem. *Pedobiologia*, 50:69-78.

International Code of Zoological Nomenclature. 1985. 3rd ed., Trust Zool. Nomencl., London. Pp. 1 – 3.

Jordana R., Arbea J.I., Moraza L., Montenegro E., Mateo M.D., Hernandez M.A., Herrera L. 1987. Effect of reafforestation by conifers in natural biotopes of middle and South Navarra (Northern Spain). *Revue Suisse Zool.*, 94(3):491-502.

Kabucis I. Biotopu rokasgrāmata (The handbook of habitats). Latvijas Dabas fonds,, Rīga. 160 lpp. (In Latvian).

Kagainis U., Spungis V. 2011. First data on moss mite (Acari: Oribatida) communities in the calcareous fen Apšuciems, Latvia. *Acta Biologica Universitatis Daugavpiliensis*, 11(2):248-258.

Kehl C. 1997. Ecology of Malaconothridae (Acari, Oribatida) in northeast German mires. *Abhandlungen und Berichte des Naturkundemuseums Görlitz*, 69:11-18.

Krantz G.W., Walter D.E. 2009. A manual of acarology. Texas Tech University Press, Lubbock. Pp. 807.

Lebrun P., Wauthy G., Dufrêne M. 1989. Soil mites in Belgium: a review. Comptes rendus du symposium "Invertebres de Belgique". Pp. 203-210.

Luxton M. 1972. Studies on the oribatid mites of a Danish beech wood soil. Pedobiologia, 12:434-463.

Luxton M. 1983. Studies on the invertebrate fauna of New Zeland peat soils, III. – Fern peats. *Rev. Ecol. Biol.*, 20(1):87-109.

Macfadyen A. 1952. The small arthropods of a Mollina fen at Cothil. *The Journal of Animal Ecology,* 21:87-117.

Moore J.C., Walter D.E., Hunt H.W. 1988. Arthropod regulation of micro- and mesobiota in below-ground detrital food webs. *Ann. Rev. Entomol.*, 33:419-439.

Pakalne M. 2008. Purvu biotopi un to aizsardzība. Purvu aizsardzība un apsaimniekošana īpaši aizsargājamās dabas teritorijās Latvijā (Bog-type habitats and their protection. Protection and management of bogs in protected nature territories of Latvia). Jelgavas tipogrāfija, Rīga. Pp. 8 – 19.

Popp E. 1962. Semiaquatile Lebensträume (Bülten) in Hoch- und Niedermooren. II Die Milbenfauna. Int. Revue ges. *Hydrobiol.*, 47:533-579. (In German).

Sanyal A.K., Bhaduri A.K. 1982. Oribatid mites in relation to temperature and water content of soil. *Proc. Symp. Ecol. Anim. Populo. Zool. Surv. India*, 3:119-126.

Schatz H. 2003. Oribatida – List of Species. www.zoology.ubc.ca/~srivast/mites/extras/Schatz.xls (Last accessed: 20.08.2013)

Schuster R. 1957. Die terrestrische Kleinarthropodrnfauna in der *Tenarea*-Troittoirs des Westmediterranean Litorals. *Kierer Meeresforsch.* 13(2):244-262.

Seniczak A., Solhøy T., Sejniczak S., Riva-Caballero A. 2010. Species composition and abundance of the oribatid fauna (Acari, Oribatida) at two lakes in the Føyen area, Bergen, Norway. *Biological Lett*. 47:11-19.

Seniczak S., Bukowski G., Seniczak A., Bukowska H. 2006. The soil Oribatida (Acari) of the ecotones between the Scots pine forest and lakes in the National Park Bory Tucholskie. *Biological Lett.*, 43: 21–225.

Subías L.S. 2004. Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes, Oribatida) del mundo (excepto fosiles). 60 (número extraordinario), Graellsia. Pp. 3-305. Available from: www.ucm.es/info/zoo/Artropodos/Catalogo.pdf. (Last accessed: 20.08.2013).

Tabaka L. 1960. Kurzemes zāļu purvu veģetācija. (Characteristics of vegetation of bogs and fens of Kurzeme) In: Latvijas PSR veģetācija, III daļa, Publishing House of Academy of Sciences of Latvian SSR, Pp. 13-19 (In Latvian).

Weigmann G. 1982. The beetle mite fauna (Acari, Oribatei) of Berlin. *On the question of the protection of soil animal species*, 11:311-326.

Weigmann G. 1991. Oribatid communities in transects from bogs to forests in Berlin indicating the biotope qualities. M*odern*

Acarology, 1:359-364.

Weigmann G. 1997. Bioindication by means of isovalent species groups. Abhandlungen und *Berichte des Naturkundemuseums Görlitz*, 62:59-65.

Weigmann G. 2006. Hornmilben (Oribatida). Die Tierwelt Deutschlands. Goecke & Evers, Keltern: S. 520. (In German).

Zuur A.F., Leno E.N., Smith G.M. 2007. Statistics for Biology and Health: Analyzing Ecological Data. Springer, New York. Pp. 672.

Гришина Л. Г. 1991. Продолжительность жизненного цикла панцириых клещей (Sarcoptiformes: Oribatei) (The duration of oribatids (Sarcoptiformes: Oribatei) life cycle). Сибирский биологический Журнал, 3:38-47. (In Russian).

Сидорчук Е.А. 2008. Панцирные клещи (Acari, Oribatei) трех нтзинных болот Европейского Севера Россий. *Зоологический Журнал*, 84:485-490. (In Russian).

Received:15.08.2013.
Accepted: 10.10.2013.