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OCCURRENCE OF ORIBATID MITES (*ACARI: ORIBATIDA*) ON THE SITES OF A NEW SPECIES *HIEROCHLOË REPENS* (HOST) P.B. IN BYDGOSZCZ AREA

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Abstract

The study was conducted within the Bydgoszcz limits and in the vicinity of city Bydgoszcz at seven different habitats of *Hierochloë repens* presence: city district Fordon – (1), (2), (3) and (4); city district Kapuściska – (5), and Białe Błota near Bydgoszcz – (6) and (7). Samples for acarological analyses were collected from the plots covered with *Hierochloë repens* in spring (27 May) and autumn (28 October) 2014.

The density of oribatid mites on the sites with *Hierochloë repens* was highly variable. High density of these microarthropods was characteristic of plots (2) with *Convolvulo-Brometum inermis*, (5) with *Arrhenatheretum elatioris* and (7) covered with grassy herbaceous plants growing on fertile soils. Particularly low density of oribatid mites was observed for plot (3) with *Koelerio-Corynephoretea* and *Festuco-Brometea* communities and the lowest content of carbon and nitrogen in the soil. Depending on the site and sample collection time, four to 22 species of oribatid mites were identified. Statistical analysis (Mann-Whitney *U* test) of mean number of species per sample *s* identified two groups of plots for both sample collection terms characterized by either low (1.00-3.10) or high values (3.30-7.40) of this parameter. The first group included plots (1), (3) and (6), and the second (2), (4), (5) and (7). The following species of oribatid mites dominated on the plots covered with *Hierochloë repens*:

Tectocepheus velatus – (1), (2) and (6); *Scheloribates laevigatus* – (3), *Oppiella nova* – (4), *Eupelops occultus* – (5), *Liebstadia similis* – (7).

Key words: invasive species, *Hierochloë repens*, oribatid mites, biodiversity, bioindication.

INTRODUCTION

Hierochloë repens (Host) P.B. is a wild species native to Central and Eastern Europe. It reached Poland, probably along communication routes, from the steppes of Ukraine (Gęsiński 2011). The first site of *Hierochloë repens* in Poland was reported in central part of Bydgoszcz in 1989 (Gęsiński 2003), and new sites were reported over the next years in the city itself and all around the Kuyavian-Pomeranian Province. The species is an invasive xeromesophyte (Gęsiński and Ratyńska 2011). It is usually found on sandy swards, in pine forests and on their edges, on dry meadows, bushy slopes, or along roads (Gęsiński 2007).

Oribatid mites (*Oribatida*) are the most diverse and largest group of arthropods inhabiting forest soil in the temperate zone (Olszanowski et al. 1996). Their density in this environment may be as high as several hundred thousand individuals per square meter. Oribatida are strongly associated with organic matter and can be found wherever it occurs. Most of them are saprophytic and fungiphagous organisms. Grassland ecosystems usually contain less dead organic matter than forests, which is why the density and species diversity of oribatid mites is lower there than in the forests. Pastures and meadows around Bydgoszcz were found to host different number of these mites, as they ranged from 3 500 to 59 400 individuals per m^{-2} (Chachaj and Seniczak 2005b). Due to their nature, these microarthropods are commonly treated as good bioindicators of the soil system (Behan-Pelletier 1999, 2003, Ruf and Beck 2005, Gulvik 2007).

The aim of this study was to analyze spring and autumn populations of Oribatid mites on the sites covered with *Hierochloë repens* in the Bydgoszcz and its surrounding area.

The work is first of all cognitive – we did not meet in the literature a study on the occurrence of mites in *H. repens*. In this work, we also attempted to connect the occurrence of Oribatida with locations of *H. repens*; oribatid mites are strongly associated with the soil environment – especially with the microorganisms. Their occurrence and species diversity indicate the biological activity of soils.

MATERIAL AND METHODS

The study was conducted in the within the Bydgoszcz limits and in the vicinity of city at seven different sites covered with *Hierochloë repens*: (1) city district Fordon (Photo 1) – 53.14615°N 18.12219°E, a degraded xeromorphic sward *Tunico-Poetum compressae* at the edge of a pine forest, soil type Mollic Technosol (IUSS Working Group WRB 2015), pH_{KCl} = 7.37, $C_{org.}$ = 28.97 g kg^{-1}, N_t = 3.03 g kg^{-1}; texture is sandy loam (68.58% sand, 27.48% silt, 3.94% clay).

(2) city district Fordon – 53.14354°N 18.12430°E, site of ruderal and meadow type that may be classified as *Convolvulo-Brometum inermis*, soil type Mollic Technosol, pH_{KCl} = 7.21, $C_{org.}$ = 27.77 g kg^{-1}, N_t = 2.83 g kg^{-1}, texture is loamy sand (79.24% sand, 19.39% silt, 1.37% clay);

(3) city district Fordon – 53.15805°N 18.12042°E, sward phytocenosis of the classes *Koelerio-Corynephoretea* and *Festuco-Brometea*, soil type Urbic Technosol, pH = 7.64_{KCl}, $C_{org.}$ = 10.03 g kg^{-1}, N_t = 1.03 g kg^{-1}, texture is loamy sand (84.09% sand, 14.00% silt, 1.01% clay);

(4) city district Fordon – 53.15799°N 18.11919°E, plants belonging to *Frangulo-Rubetum plicati* phytocenosis, soil type Mollic Technosol, pH_{KCl} = 7.30, $C_{org.}$ = 18.13 g kg^{-1}, Nt = 1.83 g kg^{-1}, texture is loam (40.13% sand, 49.45% silt, 10.42% clay);

(5) city district Kapuściska – 53.10949°N 18.04453°E, degraded fresh meadow (*Arrhenatheretum elatioris*), soil type Mollic Technosol, pH_{KCl} = 7.35, $C_{org.}$ = 21.93 g kg^{-1}, N_t = 2.27 g kg^{-1}, texture is loamy sand (72.59% sand, 25.61% silt, 1.8% clay);

(6) Białe Błota near Bydgoszcz – 53.09158°N 17.90929°E, a site occupying a roadside lawn with *Convolvulo-Brometum inermis* community, soil type Mollic Technosol, pH_{KCl} = 7.44, $C_{org.}$ = 28.53 g kg^{-1}, N_t = 2.90 g kg^{-1}, loamy sand (82.27% sand, 16.33% silt, 1.40% clay);

(7) Białe Błota near Bydgoszcz (Photo 2) – 53.09133°N 17.90919°E, grassy and herbaceous plants associated with fertile soils and elm-ash forest, soil type Gleyic Luvisol, pH_{KCl} = 7.17, $C_{org.}$ = 36.53 g kg^{-1}, Nt = 3.73 g kg^{-1}, texture is loamy sand (7.39% sand, 21.64% silt, 0.97% clay).

The samples for soil analysis were collected from the surface layer (0-20 cm). The material was dried at room temperature and sieved through a screen with 2 mm mesh. The following physical and chemical soil properties were determined with commonly used methods: soil pH in a 1M KCl solution (soil: solution ratio 1:2.5) – potentiometrically, particle size distribution (laser diffraction particle size analyzer – Mastersizer 2000), and the total content of organic carbon (C_{org}) and nitrogen (N_t) (Vario MAX CN analyzer). The results are means from three replicates.

The samples for acarological studies were collected from the plots covered with *Hierochloë repens* around Bydgoszcz in the spring (27 May) and autumn (28 October) of 2014, according to the field testing method which is widely adopted in acarology (Żbikowska-Zdun K. et al. 2006, Gulvik, M.E. 2007). Ten soil samples from the area of 17 cm^2 and 3 cm depth were collected from each site. In total, 140 soil samples were collected. The mites were extracted over 7 days using Tullergen funnels, fixed in 70% ethanol and prepared. Adult and young individuals were then classified into species or genera. The analysis covered 2707 Oribatida individuals. Mean density (*N*) of the mites was provided per 1 m^2 of soil, species dominance index (*D*) was given in %, and species diversity was described by determining the species number (*S*), mean number of species per sample for a series of 20 samples (*s*) and Shannon's diversity index (*H*).

Photo 1. Site (1) city district Fordon – degraded initial xerothermic sward Tunico-Poetum compressae (photo by A. Klimek)

Prior to statistical analysis, the numerical data were subjected to a logarithmic transformation – ln (x+1) (Berthet and Gerard 1965). The statistical analysis was performed using Statistica 12 software: a compliance of the measurable parameters with the normal distribution was assessed using Kolmogorov-Smirnov test. As the normal distribution was not confirmed, a non-parametric analysis of variance (Kruskal-Wallis *H* test) was performed. For statistically significant differences ($p<0.05$) a analysis for each pair was carried out (Mann-Whitney *U* test) to identify significantly different means.

Photo 2. Site (7) Białe Błota near Bydgoszcz – grassy and herbaceous plants associated with fertile soils and elm-ash forest (photo by A. Klimek)

RESULTS AND DISCUSSION

Floristic diversity. The analyzed sites harboring *Hierochloë repens* were highly diverse in floristic terms (Gęsiński and Ratyńska 2011). The number of vascular plant species ranged from 13 to 45. They were the least abundant on site (5), and their greatest number was found on site (1). There were 32 species on the site in Białe Błota (6), and 25-26 species were identified on the other sites. The investigated phytocenoses represented different types of plant communities, such as specialized ruderal communities, fresh meadows, swards, and grassy and herbaceous communities. Their structure was highly diverse, from very simple two-layer structure in the case of ruderal vegetation to the one enriched with second growth forest on the patches near the forest. The range of sites with *Hierochloë repens* was extremely wide and characterized by high biodiversity, which indicated considerable plasticity of the species and its ability to adapt to different conditions.

Abundance and species diversity of oribatid mites. Abundance of oribatid mites within the investigated area was highly variable and ranged from 1020 to 37 500 individuals m^{-2} (Table 1). In spring, high abundance of the microarthropods was observed on two sites: (2) – 15 230 individuals m^{-2} and (5) –

18 180 individuals m^{-2}. Differences between these sites and the other ones were significant. In autumn, the number of Oribatida on these sites was even higher. They were also fairly abundant in the autumn on site (7) (16 430 individuals m^{-2}). Contrary to that, site (3) was the one with the lowest density of oribatid mites, which reached just 1020-2 050 individuals m^{-2}. This site located in the district of Fordon had also the lowest content of carbon and nitrogen in the soil. Such a low number of oribatid mites is typical for initial soils at the initial stage of succession, e.g. within a reclaimed area of a former military training area near Bydgoszcz in the first year of a forest crop (30-330 individuals m^{-2}) (Klimek et al. 2009).

Table 1. Abundance of oribatid mites (*N* in thousand individuals m^{-2}), number of species (*S*), average number of species (*s*), and Shannon *H* index on the investigated plots

Index	Season	Plots							Kruskal-Wallis test	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	*H*	*p*
N	Spring	4.33^{A}	15.23^{B}	2.05^{C}	5.96^{A}	18.18^{B}	8.73^{A}	6.56^{A}	37.96	0.000
	Autumn	8.07^{A}	37.50^{C}	1.02^{D}	7.16^{A}	22.70^{B}	9.03^{AB}	16.43^{B}	45.42	0.000
S	Spring	6	22	4	18	11	6	8	-	-
	Autumn	9	14	5	17	13	6	12	-	-
s	Spring	2.00^{A}	7.40^{D}	1.00^{C}	5.30^{B}	5.60^{B}	2.70^{A}	3.30^{B}	44.57	0.000
	Autumn	2.70^{A}	7.20^{B}	1.10^{C}	5.10^{B}	5.60^{B}	3.10^{A}	5.60^{B}	43.55	0.000
H	Spring	0.91	2.11	1.02	2.42	1.69	0.93	1.81	-	-
	Autumn	0.82	1.97	1.32	2.31	1.60	1.16	1.52	-	-

Explanations: $^{A, B, C}$ – the same letter means non-significant difference (Mann-Whitney *U* test, p<0.05)
Source: own research data

Depending on the site and sample collection time, four to 22 species of oribatid mites were identified. The highest number of species were identified in the spring on site (2) and the lowest on site (3). Statistical analysis (Mann-Whitney *U* test) of mean number of species per sample *s* identified two groups of plots for both sample collection terms characterized by either low (1.00-3.10) or high values (3.30-7.40) of this parameter. The first group included plots (1), (3) and (6), and the second (2), (4), (5) and (7). The highest values of Shannon's diversity index (*H*) (2.31-2.42) were reported on site (4) for both spring and autumn, and the lowest on site (1) (0.82-0.91).

Analysis of occurrence of selected *Oribatida* species. Oribatida populations on the sites (1), (2) and (6) were clearly dominated by *Tectocepheus velatus* (*D* = 32.9-81.3%). Its abundance there ranged from 3 070 to 12 340 individuals

m^{-2} (Table 2). This species was also common on site (5). *T. velatus* is one of the most common oribatid mite in Poland and worldwide and it is considered a good bioindicator of environmental changes (Klimek 1999, Gulvik 2007). Literature reports described it as mycophage of high reproduction rate and outstanding ability to colonize new environments (Luxton 1972, Ponge 1991).

Site (3), with soil of low carbon and nitrogen content, was dominated by *Scheloribates laevigatus* (*D* = 41.2-52.9%). However, its density was low and reached only 420-1 080 individuals m^{-2}. Similar density of this species was also observed on site (2), and it was only occasionally found on other sites. It is a species typical of meadow ecosystems (Rajski 1961).

The shrubs of *Frangulo-Rubetum plicati* community on site (4) were dominated with *Oppiella nova* (*D* = 15.2-23.5%) in both seasons. Its density was relatively low and reached 900-1 690 individuals m^{-2}. A similar density of *O. nova* was observed on site (2). It is a cosmopolitan species, with high frequency in Poland and worldwide (Olszanowski et al. 1996).

Degraded fresh meadow of the site (5) was dominated by *Eupelops occultus* (*D* = 29.5-36.1%). High density of this oribatid mite was reported for sites (2) and (5), and it reached 2 650-9 150 and 5 360-8 190 individuals m^{-2}, respectively. *E. occultus* was considerably more common in the autumn than in the spring. It is a common species of pastures and meadows, with preference for pastures (Chachaj and Seniczak 2005a).

Site (7) was covered with grassy and herbaceous plants associated with fertile soils and elm-ash forest. In both spring and autumn it was dominated by a meadow species *Liebstadia similis* (26.6-54.9%). The species was also found on two other sites covered with meadow plants: (5) and (7). Density of *L. similis* on these sites was 4 150-5 420 and 1 750-9 030 individuals m^{-2}, respectively. It is a common holarctic species, frequent all around Poland and typical of meadow ecosystems (Olszanowski et al. 1996, Chachaj and Seniczak 2005a).

Table 2. Abundance of oribatid mites (*N* in thousand individuals m^{-2}), number of species (*S*), average number of species (*s*), and Shannon *H* index on the investigated plots

	Season	Plots							Kruskal-Wallis test	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	H	p
Ceratozetella sellnicki (Rajski)	Spring	0	0	0	0.84	0	0	0	45.86	0.000
	Autumn	0	0	0	1.08	0	0	0	45.86	0.000
Eupelops occultus (C.L. Koch)	Spring	0	2.65^{A}	0.06^{B}	0.84^{B}	5.36^{C}	0	0.84^{B}	45.79	0.000
	Autumn	0.12^{A}	9.15^{B}	0	1.20^{C}	8.19^{B}	0.06^{A}	1.44^{C}	49.06	0.000

	Season	Plots							Kruskal-Wallis test	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	H	p
Eupelops torulosus (C.L. Koch)	Spring	0	0.54	0	0.06	0	0	0	5.07	0.534
	Autumn	0	3.37	0	0	0	0	0	6.00	0.423
Galumna lanceata (Oudemans)	Spring	0	0.06^{A}	0	0	1.44^{B}	0	0	40.44	0.000
	Autumn	0	0	0	0	0.36	0	0	25.07	0.000
Liebstadia similis (Michael)	Spring	0	0	0	0	4.15^{A}	0	1.75^{B}	55.27	0.000
	Autumn	0	0	0	0	5.42^{A}	0	9.03^{A}	62.24	0.000
Nothrus anauniensis Canestrini & Fanzago	Spring	0	0.42^{A}	0	0.48^{A}	0	0	0.90^{A}	23.23	0.000
	Autumn	0	4.52^{A}	0	0.12^{B}	0	0	1.75^{A}	50.00	0.000
Oppiella nova (Oudemans)	Spring	0	0.36^{A}	0	0.90^{A}	0	0	0	34.86	0.000
	Autumn	0.18^{A}	1.44^{B}	0	1.69^{B}	0	0	0	36.38	0.000
Punctoribates punctum (C.L. Koch)	Spring	0	0.54^{A}	0	0.60^{A}	0.48^{A}	1.75^{A}	0.84^{A}	18.00	0.006
	Autumn	0	0.78^{A}	0	0.24^{A}	0.90^{A}	1.08^{A}	1.02^{A}	20.44	0.002
Scheloribates laevigatus (C.L. Koch)	Spring	0	0.54^{A}	1.08^{A}	0.06^{B}	0.06^{B}	0	0.30^{A}	21.76	0.001
	Autumn	0	1.20^{A}	0.42^{AB}	0.54^{AB}	0.12^{B}	0	0.90^{A}	27.95	0.000
Scutovertex sculptus Michael	Spring	0.06^{A}	0.12^{A}	0.18^{A}	0	0	0.78^{B}	0.18^{A}	26.55	0.000
	Autumn	0	0	0.36^{A}	0.06^{A}	0.66^{A}	2.83^{B}	0	37.26	0.000
Suctobelba sp.	Spring	0.06^{A}	0.66^{A}	0	0.06^{A}	0.36^{A}	0.06^{A}	0	13.87	0.031
	Autumn	0.60^{AB}	1.99^{B}	0	0.30^{AB}	0.54^{AB}	0	0.06^{A}	21.93	0.001
Tectocepheus velatus (Michael)	Spring	3.07^{A}	6.68^{B}	0.72^{C}	0.84^{C}	5.12^{A}	5.96^{A}	1.63^{AC}	34.55	0.000
	Autumn	6.56^{A}	12.34^{A}	0.12^{B}	0.78^{B}	5.90^{AC}	4.64^{AC}	1.75^{C}	38.46	0.000
Other oribatid mites*	Spring	1.14	2.65	0.00	1.26	1.20	0.18	0.12	-	-
	Autumn	0.60	2.71	0.12	1.14	0.60	0.42	0.48	-	-

*$N < 1\,000$ individuals per m^{-2}: *Adoristes ovatus* (C.L. Koch) – spring: (4); autumn: (1),(3),(4). *Brachychthonius* sp. autumn: (2), (6). *Paradamaeus clavipes* (Hermann) – spring: (2), (3); autumn: (4). *Fosseremus laciniatus* (Berlese) – spring: (2); autumn: (2). *Galumna obvia* (Berlese) – spring: (2), (4); autumn: (4). *Gymnodamaeus bicostatus* (C.L. Koch) – spring: (2); autumn: (2). *Heminothrus peltifer* (C.L. Koch) – spring: 4. *Trichoribates incisellus* (Kramer) – spring: 2, 5; autumn: (1), 5. *Liochthonius* sp. – spring: (1); autumn: (1), (2), (7). *Metabelba pulverulenta* (C.L. Koch) – spring: (4); autumn: (4). *Microppia minus* (Paoli) – spring: (5); autumn: (5). *Microzetorchestes emeryi* (Coggi) – spring: (2); autumn: (1), (2). *Oppia denticulata* (Canestrini) – autumn: (5). *Oribatella calcarata* (C.L. Koch) – spring: (7); autumn: (7). *Oribatula tibialis* (Nicolet) – spring: (2). *Peloptulus phaenotus* (C.L. Koch) – spring: (1), (6); autumn: (3), (6). *Pilogalumna allifera* (Oudemans) – spring: (2), (4), (6); autumn: (2), (4). *Pilogalumna tenuiclava* (Berlese) – autumn: (7). *Protoribates capucinus* Berlese – spring: (4); autumn: (4). *Quadroppia quadricarinata* (Michael) – spring: (2), (5); autumn: (1), (5). *Ramusella mihelcici* (Pérez-Íñigo) □ spring: (2). *Rhysotritia duplicata* (Grandjean) – spring: (1), (2). *Scheloribates latipes* (C.L. Koch) – spring: (2), (4); autumn: (4), (7). *Trichoribates novus* (Sellnick) – spring: (5); autumn: (5). *Xenillus tegeocranus* (Hermann) – spring: (4); autumn: (4).
Explanations: see Table 1.
Source: own research data

Total number of oribatid mites, abundance of individual species, number of species *S*, mean number of species per sample (*s*) and Shannon's diversity index (*H*) were used to carry out a cluster analysis using Ward's method that may be applied to compare research plots (Grajewski 2006). Clustering dendrogram yielded by Ward's method for the linkage distance of 10 for spring and 20 for autumn identified two groups of plots (Figure 1). In the spring, the first group included plots (2), (4) and (5), and the second (1), (3), (6) and (7). The pattern was similar in the autumn but the site (7) was classified into the first group and the site (4) into the second.

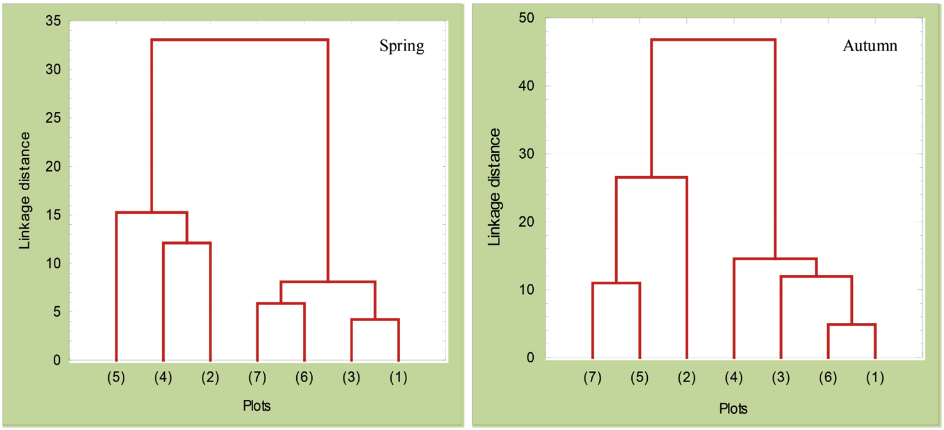

Figure 1. Clustering according to Ward's method, including the abundance of oribatid mites (N total and N of species), number of species (S), average number of species (s), and Shannon's diversity index H index on the investigated plots

SUMMARY

The density of oribatid mites on the sites with *Hierochloë repens* around Bydgoszcz was highly variable. High density of these microarthropods was characteristic of plots (2) with *Convolvulo-Brometum inermis*, (5) with *Arrhenatheretum elatioris* and (7) covered with grassy herbaceous plants growing on fertile soils. Particularly low density of oribatid mites was observed for plot (3) with *Koelerio-Corynephoretea* and *Festuco-Brometea* communities and the lowest content of carbon and nitrogen in the soil.

Depending on the site and sample collection time, four to 22 species of oribatid mites were identified. Statistical analysis (Mann-Whitney *U* test) of mean number of species per sample *s* identified two groups of plots for both sample collection terms characterized by either low (1.00-3.10) or high values

(3.30-7.40) of this parameter. The first group included plots (1), (3) and (6), and the second (2), (4), (5) and (7).

The sites covered with *Hierochloë repens* were dominated by the following species of oribatid mites: *Tectocepheus velatus* – (1), (2) and (6); *Scheloribates laevigatus* – (3), *Oppiella nova* – (4), *Eupelops occultus* – (5), *Liebstadia similis* – (7).

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