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MICROGEOGRAPHIC DIVERSITY OF UROPODINA (ACARI MESOSTIGMATA) COMMUNITIES IN DEAD WOOD AND TREE HOLLOWS

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Błoszyk J., Markowicz M., Labijak B., Skwierczyński F., Napierała A. – Microgeographic diversity of Uropodina (Acari Mesostigmata) communities in dead wood and tree hollows.

The current study is aimed at establishing species composition of Uropodina mite fauna in dead wood habitats in a selected forest complex in western Poland. In this case the study focuses on three natural reserves of Wielkopolska. In 278 samples of dead wood and 71 from tree hollows collected between 2002-2004, 27 species of Uropodina were found. The material collected from the tree hollows contained only 12 species. The two species that were most numerous in the analysed material were *Oodinychus ovalis* and *Olodiscus minima*. The lower number of species inhabiting the tree hollows stems from the fact that such microhabitats are isolated inaccessible places. The main factor that is responsible for the difference in the abundance of uropodine mites in both microhabitats are seasonal changes in temperature. Moreover, the results of the analyses show that species composition of Uropodina communities in dead wood and tree hollows can be different even within one forest complex, which suggests that the process of diversification in Uropodina communities inhabiting dead wood merocoenoses probably takes place at the microgeographic level.

KEY WORDS: lignicolous mites, Uropodina, dead wood microhabitat, decomposition, biodiversity, Poland.

INTRODUCTION

As has been already shown in many previous studies, dead wood can form a basis of various microhabitats in forest ecosystems, frequently inhabited by different groups of organisms (BŁOSZYK, 1990, 1999; BUCHHOLZ, 1991; MICHALSKI *et al.*, 1992a, 1992b; ZABRANSKY, 1998; SKORUPSKI, 2001; GUTOWSKI *et al.,* 2002; STACHOWIAK *et al.,* 2008; GWIAZDOWICZ *et al.*, 2011; STOKLAND *et al.,* 2012; PYLE and BROWN, 2002; SIIRA-PIETIKÄINEN *et al.,* 2008). One group of mites which inhabit merocoenoses consisting of dead wood are Uropodina (Acari: Mesostigmata) (BŁOSZYK, 1990, 1999; BŁOSZYK *et al.,* 2003a, 2003b; NAPIERAŁA *et al.,* 2009; NAPIERAŁA and BŁOSZYK, 2013). Little is known about the mechanisms responsible for formation of uropodine communities in dead wood. However, results of previous research show that uropodine mites inhabiting dead wood are both ubiquitous edaphic species and specialized lignicoles (see BŁOSZYK, 1990, 1999; BŁOSZYK *et al.,* 2003a, 2003b; NAPIERAŁA and BŁOSZYK, 2013). In such microhabitats uropodine mites probably feed on fungi and fungus spores, however, the exact eating habits of most uropodine species are still unknown (FAASCH 1967).

In one of his studies BŁOSZYK (1990) adduces interesting evidence, which shows that communities of uropodine mites living in tree hollows are different in terms of the species composition and number from communities found in soil and those in temporary microhabitats (e.g. in nests of birds, small mammals, and anthills, etc.). The results of further research (NAPIERAŁA and BŁOSZYK, 2013) corroborate the earlier observations as they clearly show that Uropodina communities inhabiting tree hollows are both faunistically and structurally different from those found in other dead wood merocoenoses such as rotten stumps, lying logs, and fallen branches. The evidence from different regions of Poland presented in the studies mentioned above shows that the Uropodina communities found in tree hollows were usually dominated by *Oodinychus ovalis* and *Uroobovella pyriformis*. Be it noted that, in contrast to soil communities, strong dominance of one or two species is characteristic of communities inhabiting all types of unstable merocoenoses (BŁOSZYK, 1999; BŁOSZYK and GWIAZDOWICZ, 2006; BŁOSZYK and OLSZANOWSKI, 1985; BŁOSZYK *et al.*, 2003b; NAPIERAŁA and BŁOSZYK, 2013). In such cases the dominant species can constitute over 50% of the whole community. Good examples of such dominant species, which often occur only in one specific type of merocoenoses, are *Phaulotrachytes borealis* (SELLNICK, 1940) found in nests of mammals, *Leiodinychus orbicularis* in bird nests, and *O. spatulifera* (MONIEZ, 1892) in anthills (BŁOSZYK, 1983, 1999; BŁOSZYK and GWIAZDOWICZ, 2006; BŁOSZYK and OLSZANOWSKI, 1985; BŁOSZYK *et al.*, 2003b, 2006; NAPIERAŁA and BŁOSZYK, 2013; LESZCZYŃSKA-DEJA, 2006). Thus, the high percentage of *U. pyriformis* can be regarded as a characteristic of communities inhabiting tree hollows (NAPIERAŁA and BŁOSZYK, 2013). However, the observations also show that abundance of this species in communities living in tree hollows is not the same in each region of Poland (BŁOSZYK, MARKOWICZ – unpublished data). Besides this, even material collected in one forest complex can show that the structure of dominance and species composition of the communities living in one type of microhabitat, in a small area, can be different (BŁOSZYK, MARKOWICZ – unpublished data). The previous studies on community structure of Uropodina mites inhabiting different areas in one forest complex usually focus only on

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those inhabiting soil and ignore microhabitats of dead wood (BŁOSZYK, 1999; NAPIERAŁA, 2008; NAPIERAŁA *et al.*, 2006).

As for dead wood, there are no studies which would be helpful in establishing the size of an area in which diversification of Uropodina communities in dead wood becomes noticeable. The diversity of Uropodina communities in particular regions of Poland seems to stem from the zoogeographical differences (BŁOSZYK *et al.*, 2003a). However, in the case of just one forest area the diversity of Uropodina communities is probably to a large extent determined by the microhabitat and microclimatic factors.

The major aim of the current study is to ascertain whether Uropodina communities inhabiting tree hollows and dead wood at the microscale level (in one forest complex) are different in their species composition and abundance from communities at the macroscale level of the whole country. The second aim of the study is to establish which of the abiotic and biotic factors such as temperature, level of moisture, tree species, and degree of decay of dead wood can have influence on community composition and cause such faunistic differences between communities inhabiting tree hollows and those in dead wood. The hypothesis postulated here is that community structure of Uropodina inhabiting all microhabitats containing dead wood material can become highly diverse even in a small area within one forest complex, and it is very likely that species composition of such communities is largely determined by microhabitat and microclimatic factors (i.e. the microgeographical conditions).

MATERIAL AND METHODS

STUDY SITE

The samples for the analysis were collected monthly between 2002 2004 and come from three natural forest reserves of Wielkopolska (western Poland). What is more important, the reserves under scrutiny are situated in one forest complex, which is a place with little human interference (Fig. I). The analysed forest complex covers an area of 2.33 km^2 and is located about 30 km westwards from Poznań. The following three collection sites were studied:

– Bytyńskie Brzęki Nature Reserve (15.15 ha, 52°28'N 16°28'E). An oak-hornbeam forest about 100 years old with admixture of pine, and many wild service trees (*Sorbus torminalis*) (Fig. II, 1).
– Brzęki przy Starej Gajówce Nature Reserve (6.71 ha, 52°28'N 16°29'E). A fragment of old (over 100 years old) oak-hornbeam forest with admixture of pine and one of the highest concentrations of *S. torminalis* in Wielkopolska (Fig. II, 2).
– Huby Grzebieniskie Nature Reserve (14.73 ha, 52°27'N 16°31'E). It was created in order to protect the oak-hornbeam forest (*Galio sylvatici-Carpinetum* association). The tree stand is over 80 years old with admixture of pine and larch trees. This forest reserve contains the only population of *Cypripedium calceolus* (Lady's Slipper orchid) in Wielkopolska (Rąkowski, 2006) (Fig. II, 3).

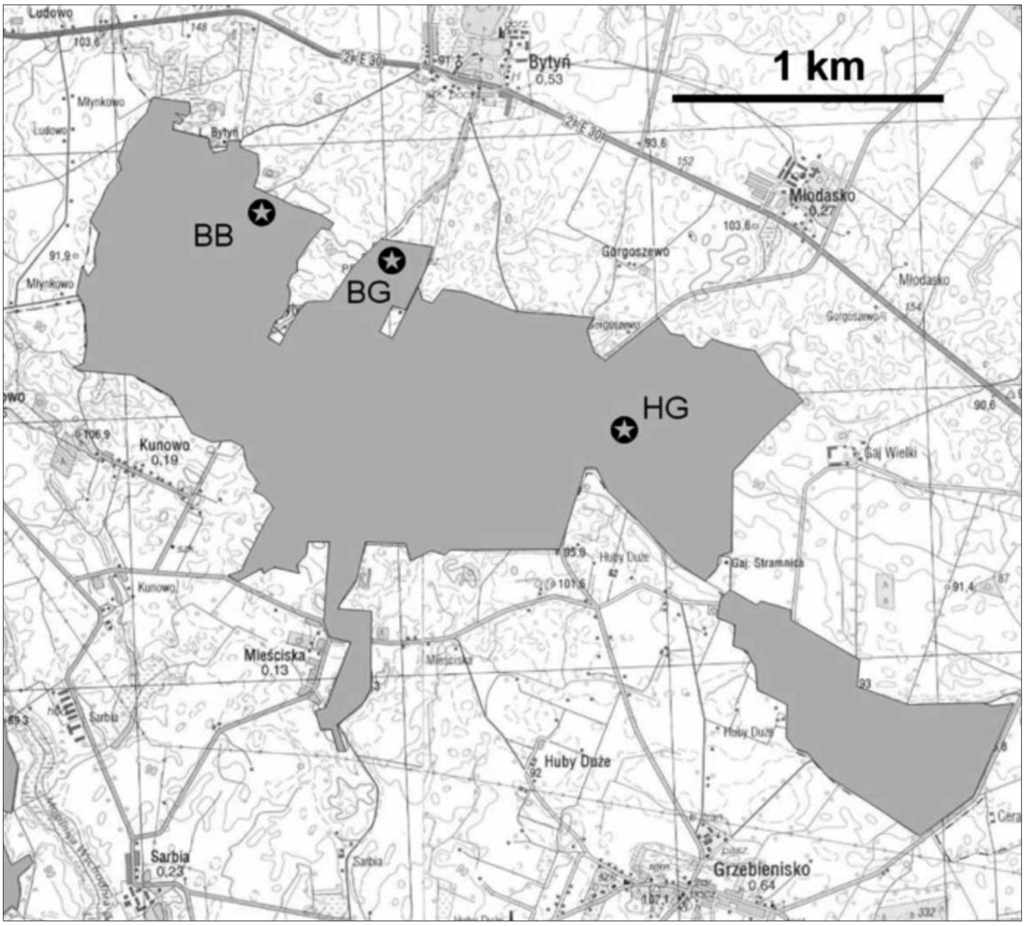

Fig. I – Location of the study sites in the forest complex near Bytyń Village: BB – Bytyńskie Brzęki Nature Reserve, BG – Brzęki near Stara Gajówka Nature Reserve, HG – Huby Grzebieniskie Nature Reserve.

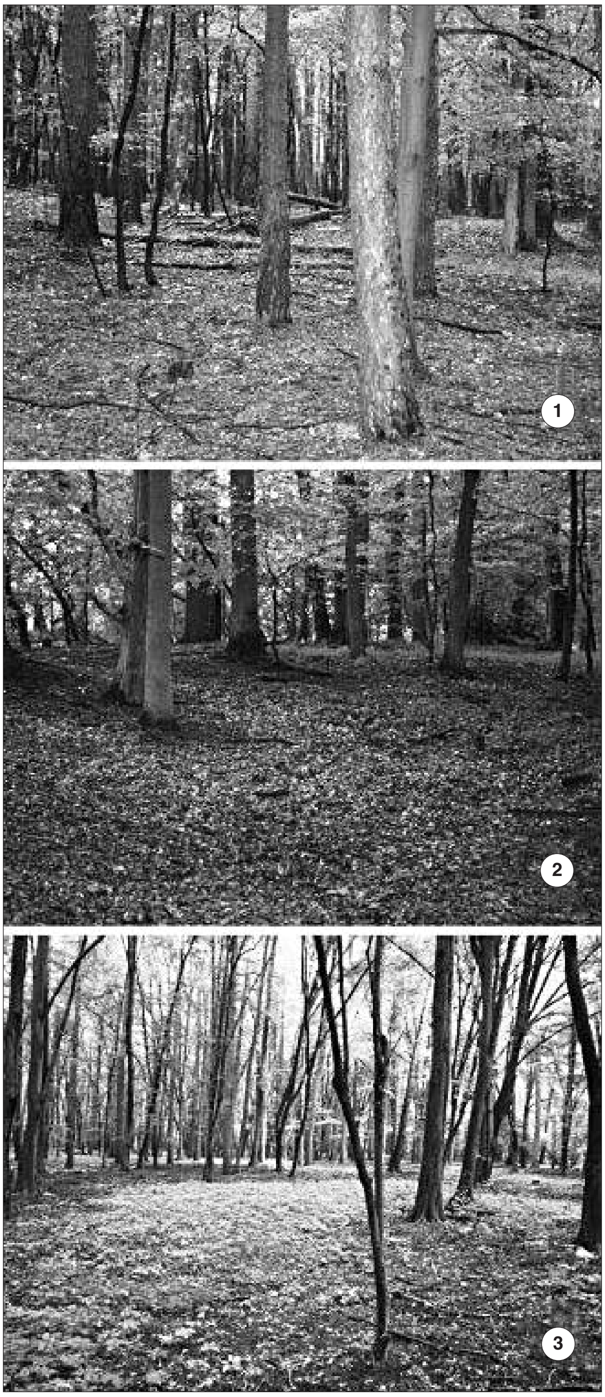

Fig. II – The study sites in the forest complex near Bytyń Village: 1 – Bytyńskie Brzęki Nature Reserve, 2 – Brzęki near Stara Gajówka Nature Reserve, 3 – Huby Grzebieniskie Nature Reserve.

DATA COLLECTION

The total 278 comprises samples from different types of dead wood habitats (including rotten stumps, logs, and fallen branches) and 71 samples from tree hollows (191 from Brzęki near Stara Gajówka, 86 from Bytyńskie Brzęki, and 72 from Huby Grzebieniskie). The samples from dead wood and tree hollows were collected mainly from oaks (174), hornbeams (47), larches (36), pine trees (51), and also from birches (20) and other species of trees. The material from the examined tree hollows comes mainly from deciduous trees, but there were also samples from pines and larches. The samples from the tree hollows consisted mainly of entirely decayed material, but there was also material that was only partly decayed (i.e. the second stage of decay). The material for the analysis was collected with a plastic container with a scale (0.8 litre). The samples were extracted with Tullgren funnels for 4-6 days (depending on the level of moisture). The extracted mites were preserved in 75% ethyl alcohol. Some specimens were then placed on microscope slides and identified according to MAŠÁN (2001). This study is based on the taxonomic classification presented in BŁOSZYK (2008).

The level of decay observed in the collected dead wood and tree hollows material has been illustrated on a three-point scale, which has three major categories: I – slightly decayed, II – moderately decayed, III – entirely decayed. Similarly, the moisture has been recorded on a three-point scale: I – dry (with no traces of moisture on a piece of paper), II – slightly damp (leaving slight marks, but water could not be squeezed out from the material), III – wet (water could be squeezed out of the material) (LESZCZYŃSKA-DEJA, 2006). Over 90% of the dead wood material exhibited the II and III degree of decay, whereas almost 80% of the material from tree hollows exhibited the III degree of decay and 20% of it the II degree of decay. The temperature of the dead wood was measured at the time of the material collection at a depth of approx. 10 cm with an electronic thermometer (0.1°C). The collected specimens are now deposited in the Invertebrate Fauna Bank (Natural History Collections, Faculty of Biology, Adam Mickiewicz University, Poznań, Poland).

DATA ANALYSIS

The zoocenological analysis of Uropodina communities is based on indices of dominance and frequency. The following classes were discerned (BŁOSZYK, 1999):

– Dominance: D5 - eudominants (>30%); D4 - dominants (15.1-30.0%); D3 - subdominants (7.1-15.0%), D2 - recedents (3.0-7.0%); and D1 - subrecedents (<3%);
– Frequency: F5 - euconstants (>50%), F4 - constants (30.1-50%), F3 - subconstants (15.1-30.0%), F2 - accessory species (5.0-15.0%), and F1 - accidents (<5%).

The evaluation of the diversity of Uropodina communities in relation to the selected ecological and environmental factors is twofold, i.e. it provides a thorough description and data analysis (with single- and multi-variables). The single-variable analysis was conducted with the Mann-Whitney U test ($p \leq 0,05$), which is probably the best non-parametric alternative to the t-test for independent samples (STANISZ, 1998). The test used here is non-parametric because the analysed parameter did not have normal distribution. The analysis was carried out to check whether the selected habitats and species of Uropodina show any statistically significant differences. The multi-variable analysis (Factor Analysis as a Data Reduction Method - Principal Components Analysis) was used to utilise the factor analysis, whose main application leads to reduction in the number of variables, and also reveals the structure of the links between the variables. The analysis of the graphic representation of such a structure can be extremely helpful in the right interpretation of the potential effects of each factor. Moreover, the evaluation of the interdependence between the ecological and environmental factors and Uropodina communities was conducted by means of the Spearman rank-order coefficient. The statistical analysis embraces the data on the fauna of Uropodina and those cases where the species were represented by at least 10 specimens. The community similarity in different tree species was calculated by means of Marczewski-Steinhaus species similarity index: MS = c/(a + b - c), where c is the number of species present in both compared communities, and a and b stand for the total numbers of species in each community (MAGURRAN, 2004). The statistical analyses were computed with Statistica 6.0. The descriptions of the procedures applied in this study are based on those given by STANISZ (1998).

RESULTS

SPECIES COMPOSITION

The results of the analyses presented in the study show that the communities of Uropodina found in the selected types of dead wood microhabitats (i.e. rotten stumps, logs, and fallen branches) are different in their species composition from the communities found in the tree hollows. Among the 27 species found in the analysed material, all occurred in different types of dead wood, whereas 12 species were found in tree hollows (Table 1). All the species found in the tree hollows were also present in the samples with dead wood. The species which were quite numerous in the dead wood and tree hollows material were *O. ovalis* and *O. minima*. Other species frequently occurred in dead wood were *U. pulchella*, *T. aegrota*, *D. baloghi*, *D. carinatus*, *D. woelkei*, and *U. tecta*. However, *U. pulchella* did not occur in the material from the tree hollows. The presence of the other species in both types of microhabitats is accidental. It is noteworthy that the analysed microhabitats are different not only in their species composition of Uropodina communities, but also the frequency and average number of mites. As can be seen in the tabulation given below (Table 1), the material collected from the tree hollows had far fewer specimens (313) than the dead wood material (3,166). Furthermore, the results of the Mann-Whitney U test show that the differences in the number of selected species in both types on microhabitat are statistically significant ($U = 7984$, $z = 2.48$; $p < 0.05$) (see Table 2). Out of the eight species that were most numerous in the analysed material, four exhibited significant differences as to the type of the microhabitat (dead wood vs. tree hollows). These species are *T. aegrota*, *O. ovalis, O. minima*, and *U. pulchella*.

INFLUENCE OF ENVIRONMENTAL FACTORS ON UROPODINA COMMUNITIES

The analysis of the abundance of particular species in relation to the temperature and moisture of the dead wood material has revealed that only the first factor is slightly correlated with the size of the analysed Uropodina community. In the case of the samples from the dead wood material, the correlation is statistically significant for both all Uropodina and the four most frequent species, i.e. *O. ovalis*, *T. aegrota, O. minima,* and *U. pulchella* (Table 3). However, in the case of the samples from the tree hollows, this correlation is significant only for *O. ovalis*.

Apart from this, the two biological factors which seem to have considerable influence on the structure of the communities inhabiting the analysed merocoenoses were the type of tree (i.e. deciduous vs. coniferous) and the degree of dead wood decay (Table 4). In both groups the changes in the moisture and temperature of the dead wood during the whole year were not statistically significant (Table 4).

The graphic representation of the multifactor analysis of the data shows that in the dead wood material the main factors which seem to affect positively the abundance of the found Uropodina mites are the degree of wood decay and temperature (Fig. III, 1). In the case of the material from the tree hollows, the important factors which have positive influence on the community structure are the temperature of the substrate, the species of the tree, and moisture (Fig. III, 2).

UROPODINA COMMUNITY DIVERSITY IN SELECTED RESERVES OF WIELKOPOLSKA

Despite the fact that the three reserves are located within the same forest complex and they have almost identical type of flora, there are some differences between them both in the species composition and community structure of the Uropodina mites inhabiting the dead wood merocoenoses. Table 5 shows the structure of Uropodina communities in the three examined reserves in the dead wood material and the material from tree hollows. The most common species, which occurred in each of the three reserves, are *O. ovalis*, *O. minima*, *D. baloghi*, *D. woelkei*, *T. aegrota*, *U. tecta*, *T. pauperior*, and *D. arcuatus*. They constituted 25.8% of all species found in the dead wood material of the examined forest complex. Another quite numerous group of Uropodina contained such species as *U. pulchella*, *D. carinatus*, *D. perforatus*, and *U. obovata*. The other species (i.e. 58.1%) were found only in one of the three reserves.

The highest species diversity was observed in the two adjacent reserves, i.e. in Brzęki near Stara Gajówka (19 species) and Bytyńskie Brzęki (18 species). The material from Huby Grzebieniskie contained 15 Uropodina species. In this case *O. ovalis* was the species with the highest abundance (over 72% of all Uropodina mites). Moreover, *O. minima* and *U. pulchella* also occurred quite frequently in the analysed material.

COMMUNITY STRUCTURE AND TREE SPECIES

The analysis of the community structure of Uropodina mites inhabiting all the merocoenoses of dead wood (e.g. rotten stumps, logs, and tree hollows) embraces five most common species of trees growing in the three examined reserves (Table 6). There are eight species of Uropodina which form the "core" of the community, i.e. *O. ovalis*, *D. woelkei*, *U. pulchella*, *D. baloghi*, *D. carinatus*, *O. minima*, *T. aegrota*, and *U. tecta*. Only *D. perforatus* occurs in four tree species but the other species were found in three or in only one tree species. The average number of mites in one sample was very low, as it usually was not more than 10 specimens.

The highest diversity of Uropodina mites has been observed in the material collected from oaks (*Quercus*), which contained 24 species. In the material from the other more numerous tree species there were from 10 to 14 Uropodina species. The analysis of the species composition of Uropodina has revealed close similarities between the communities inhabiting the material collected from the birches and larches, and those from the hornbeams and pines (Fig. IV).

DISCUSSION

There are many studies which emphasise the importance of dead wood for the sustenance of Uropodina diversity in forest ecosystems. However, most of them consider tree hollow microhabitats simply as another type of dead wood habitat (ATHIAS-BINCHE, 1993; ATHIAS-BINCHE and HABERSAAT, 1988; BŁOSZYK, 1990; BŁOSZYK *et al.,* 2003a; GWIAZDOWICZ and KLEMT, 2004; GWIAZDOWICZ and KMITA, 2004; NAPIERAŁA *et al.,* 2010, 2011). It is noteworthy that results of more recent studies suggest that tree hollows should be regarded as entirely different microenvironments (NAPIERAŁA and BŁOSZYK, 2013). This is evident not only in much lower species diversity of

Table 1 – Uropodina species found in dead wood and tree hollows. Explanations: n – number of specimens, D – dominance, F – frequency, Ecol. - ecological and trophic requirements of species, Eu – eurytopic, L – lignicolous, E – edaphic, M – myrmecophilous, N – nidicolous, * – phoretic species.

Species	Ecol.	Σ (n)	Dead wood		Σ (n)	Three hollows	
			D (%)	F (%)		D (%)	F (%)
*Oodinychus ovalis** (C. L. Koch, 1904)	Eu	2,340	73.91	59.35	168	53.67	46.48
*Uroobovella pulchella** (Berlese, 1904)	L	271	8.56	14.75			
Olodiscus minima (Kramer, 1882)	Eu	168	5.31	16.19	18	5.75	7.04
Trachytes aegrota (C. L. Koch, 1841)	Eu	88	2.78	17.63	6	1.92	5.63
Discourella baloghi Hirschmann et Zirngiebl-Nicol, 1969	L	57	1.80	5.40	35	11.18	4.23
Dinychus carinatus Berlese, 1903	L	57	1.80	7.55	17	5.43	7.04
Dinychus woelkei Hirschmann et Zingiebl-Nicol, 1969	L	57	1.80	5.40	35	11.18	4.23
Trachytes pauperior (Berlese, 1914)	Eu	29	0.92	1.80	2	0.64	1.41
Urodiaspis tecta (Kramer, 1876)	E	25	0.79	5.40	10	3.19	7.04
*Polyaspis sansonei** Berlese, 1916	L	17	0.54	1.44			
Dinychus arcuatus (Trägårdh, 1922)	E	9	0.28	1.80	2	0.64	1.41
Dinychus perforatus Kramer, 1882	E	9	0.28	1.44	1	0.32	1.41
*Uroobovella obovata** (Canestrini et Berlese, 1884)	E	7	0.22	0.72			
Cilliba cassideasimilis Błoszyk, Stachowiak & Halliday 2006	E	6	0.19	0.72			
*Trematurella elegans** (Kramer, 1882)	L	5	0.16	0.72	7	2.24	5.63
Trachyuropoda coccinea (Michael, 1891)	M	4	0.13	0.36			
*Uropoda orbicularis** (Müller, 1776)	N	4	0.13	0.36			
Cilliba rafalskii Błoszyk, Stachowiak & Halliday 2006	E	2	0.06	0.36			
Trichouropoda sp.		2	0.06	0.72			
*Apionoseius infirmus** (Berlese, 1916)	N	1	0.03	0.36			
Cilliba erlangensis (Hirschmann et Zirngiebl-Nicol, 1969)	E	1	0.03	0.36			
Dinychura cordieri (Berlese, 1916)	E	1	0.03	0.36			
*Uroobovella pyriformis** (Berlese, 1920)	L	1	0.03	0.36			
Leiodinychus orbicularis (C. L. Koch, 1839)	N	1	0.03	0.36	4	1.28	2.82
*Nenteria breviunguiculata** (Willmann, 1949)	N	1	0.03	0.36			
Nenteria stylifera (Berlese, 1904)	E	1	0.03	0.36			
Polyaspinus cylindricus Berlese, 1916	E	1	0.03	0.36			
*Trichouropoda tuberosa** Hirschmann et Zirngiebl-Nicol, 1969	L	1	0.03	0.36			
Dinychus sp. (unidentified juveniles)					8	2.56	2.82
Number of specimens		3,166			313		
Number of species		27			12		
Average number of specimens per sample		11.40			4.40		
+- Standard deviation		22.90			9.60		
Frequency of Uropodina (%)		64.75			59.15		

communities found in tree hollows (in comparison to those inhabiting dead wood), but also in the abundance of the species found in such places. The differences in species composition between communities inhabiting dead wood and tree hollows probably stem from the spatial isolation of the latter and the lack of direct contact with soil. For example, in dead wood merocoenoses (e.g. logs or rotten stumps) *O. ovalis, T. aegrota* and *O. minima* often belong to the group of the most dominant species and they are far more numerous than in tree hollows. All these species are eurytopic, which means that they can occur in different types of habitats, but the last two occur mainly in soil and forest litter (Błoszyk, 1983, 1990, 1999; Błoszyk and Krysiak, 2000; Błoszyk *et al.,* 2003a, 2010; Mašán, 2001), which proves the importance of direct contact with soil for community structure of Uropodina inhabiting

Table 2 – Mann-Whitney U test for differences between average number of Uropodina in microhabitats of dead wood and tree hollows ($p \leq 0.05$). Explanations: U, Z = test value, p = significance level, ns = not significant ($p > 0.05$).

Species	Sum of ranks	Sum of ranks	U	Z	p
D. carinatus	48691.00	12384.00	9828.00	0.12	ns
D. woelkei	48766.00	12309.00	9753.00	0.40	ns
D. baloghi	48766.00	12309.00	9753.00	0.40	ns
O. minima	49535.50	11539.50	8983.50	1.92	0.05
T. aegrota	49830.50	11244.50	8688.50	2.49	0.01
O. ovalis	50941.50	10133.50	7577.50	3.15	0.001
U. pulchella	50105.50	10969.50	8413.50	3.43	0.001
U. tecta	48487.50	12587.50	9706.50	-0.53	ns
Uropodina	50535.00	10540.00	7984.00	2.55	0.01

Table 3 – Values of Spearman rank- order co-efficient (r) between the temperature of the dead wood and tree hollows material and the number of selected Uropodina species ($p \leq 0.05$). Explanations: p = significance level, ns = not significant ($p > 0.05$).

	Dead wood (n=278)		Tree hollows (n=71)	
Species	r	p	r	p
D. carinatus	0.10	ns	0.09	ns
D. woelkei	0.09	ns	0.00	ns
D. baloghi	0.09	ns	0.00	ns
O. minima	0.18	0.003	0.03	ns
T. aegrota	0.19	0.001	0.12	ns
O. ovalis	0.23	0.00009	0.26	0.03
U. pulchella	0.14	0.02	–	–
U. tecta	0.04	ns	-0.03	ns
Uropodina	0.23	0.0001	0.18	ns

Table 4 – Variation of the analysed factors in the studied microhabitats (dead wood and tree hollows) – Mann-Whitney U Test species ($p \leq 0.05$). Explanations: U, Z = test value, p = significance level, ns = not significant ($p > 0.05$).

Traits	Sum of rank	Sum of rank	U	Z	p
tree species	46,405.50	12,590.50	9277.50	-0.55	ns
tree type (deciduous or coniferous)	51,215.00	9,860.00	7304.00	4.51	0.000006
degree of decay	51,827.50	9,247.50	6691.50	4.76	0.000002
degree of moisture	47,426.50	12,951.50	8923.50	-1.10	ns
temperature	48,458.50	12,616.50	9677.50	-0.25	ns

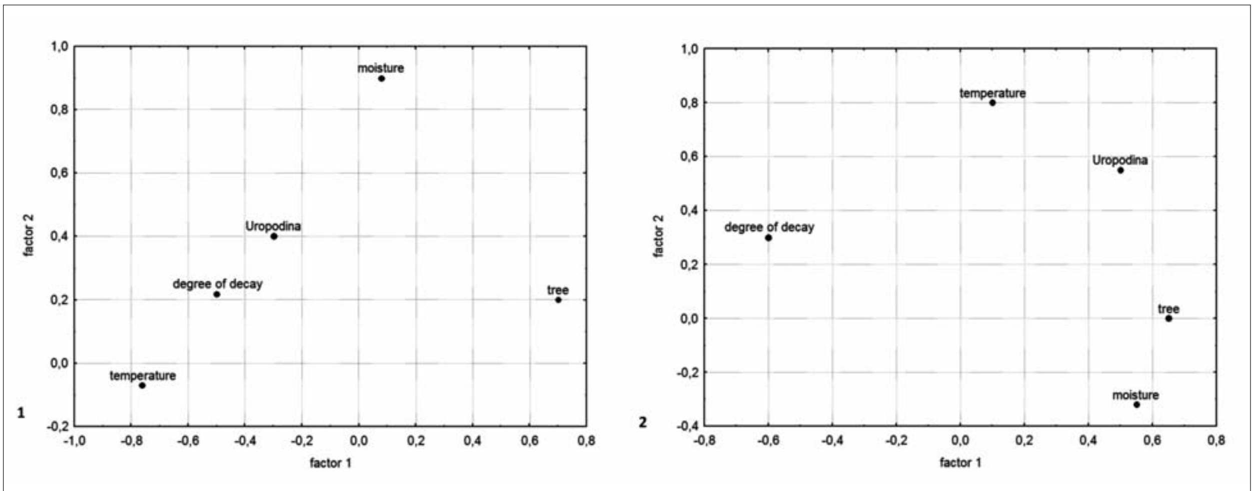

Fig. III – Multifactor analysis of habitat characteristics (1 - dead wood, 2 - tree hollows).

Table 5 – Zoocenological analysis of dominance (classes D1-D5) and frequency (F1-F5) of the uropodine communities in the three reserves: BB – Bytyńskie Brzęki Nature Reserve, BG – Brzęki near Stara Gajówka Nature Reserve, HG – Huby Grzebieniskie Nature Reserve (see "Material and methods" for a description of the classes).

Dominance (%)		Frequency (%)	
BG			
D5	*O. ovalis*—30.65	F5	0
D4	0	F4	*O. ovalis*—42.41
D3	0	F3	0
D2	0	F2	*O. minima*—9.42
D1	18 species		*D. carinatus*—7.85
			T. aegrota—7.33
			U. tecta—5.24
		F1	14 species
BB			
D5	*O. ovalis*—38.70	F5	*O. ovalis*—67.44
D4	0	F4	0
D3	0	F3	*O. minima*—26.74
D2	*O. minima*—4.33		*T. aegrota*—25.58
D1	16 species	F2	*U. pulchella*—10.47
			U. tecta—9.30
			D. carinatus—6.98
			Di. baloghi—5.81
			D. woelkei—5.81
		F1	8 species
HG			
D5	*O. ovalis*—37.65	F5	*O. ovalis*—85.00
D4	0	F4	*U. pulchella*—35.00
D3	0	F3	*T. aegrota*—25.00
D2	*U. pulchella*—5.10	F2	*O. minima*—13.33
D1	13 species		*D. baloghi*—6.67
			D. woelkei—6.67
			D. perforatus—6.67
			D. carinatus—6.67
		F1	7 species

dead wood. Logs and rotten stumps are often situated on the ground and this is why these two species are more numerous in dead wood habitats than in tree hollows. Due to the higher amount of available food resources, as well as more stable temperature conditions and higher moisture, dead wood offers far better conditions for weakly sclerotised juvenile stages than soil (BŁOSZYK, 1983, 1990, 1999; NAPIERAŁA, 2008; NAPIERAŁA and BŁOSZYK, 2013). It has been proved that the number of juvenile specimens of Uropodina (i.e. larvae and protonymphs) in dead wood is higher than in soil, especially during winter. The processes of decay operating in dead wood produce heat, which makes the temperature of rotten dead wood higher than in soil where trees used to grow, and the fluctuations in daily temperature are much lower than in soil in the same location (BŁOSZYK *et al.* 2013).

The results of the current study also show that the differences in community structure of Uropodina inhabiting dead wood and tree hollows can be observed both in the whole country and at the level of just one forest complex. Many previous studies on Uropodina diversity in dead wood are usually faunistic studies focusing only on selected small areas (BŁOSZYK *et al.,* 2003b; GWIAZDOWICZ and KLEMT, 2004; GWIAZDOWICZ and KMITA, 2004; MICHALSKI *et al.,* 1992b; SKORUPSKI, 2001). There are few studies based on data from large areas into account (BŁOSZYK, 1990; NAPIERAŁA and BŁOSZYK, 2013). However, one should remember that any comparison of Uropodina communities living in a small area with those inhabiting a large area (for example a country) should take the zoogeographical factor into account. In one of their recent studies NAPIERAŁA & BŁOSZYK (2013) claim that tree hollows are a different type of microhabitat, and adduce evidence with 34 species of Uropodina found in 238 samples from tree hollows examined in different regions of Poland. The community structure was different from that presented above because one of the dominant species in this case was *U. pyriformis*, which is considered to be common in this type of microhabitat (NAPIERAŁA and BŁOSZYK 2013). However, in the material from the tree hollows collected in the three reserves of Wielkopolska *U. pyriformis* was not present. This probably stems from the regional differences in the structure of Uropodina communities in tree hollows. Furthermore, the fact that the material from the three reserves of Wielkopolska did not contain such species as *Trachytes irenae* Pecina, 1969, *T. minima* Trägårdh 1910, *T. montana* WILLMANN 1953, *Oodinychus obscurasimilis* (Hirschmann *et* Zirngiebl-Nicol, 1961), *Urodiaspis stammeri* Hirschmann *et* Zirngiebl-Nicol 1969, and *Cilliba sellnicki* (Hirschmann *et* Zirngiebl-Nicol, 1969), whose northern range of distribution is in the southern parts of Poland (BŁOSZYK, 1999; BŁOSZYK *et al.,* 2003a), seems to confirm the importance of the zoogeographical factor in diversification of species composition in Uropodina communities inhabiting tree hollows in large areas.

Table 6 – Zoocenological analysis of dominance (classes D1-D5) and frequency (F1-F5) of the uropodine communities of the analysed tree species (see "Material and methods" for a description of the classes). Explanations: n – number of specimens, D – dominance, F – frequency.

Species	Oak			Pine			Larch			Hornbeam			Birch		
	n	**D**	**F**	**n**	**D**	**F**	**n**	**D**	**F**	**n**	**D**	**F**	**n**	**D**	**F**
O. ovalis	725	D5	F4	386	D5	F5	311	D5	F5	872	D5	F5	94	D5	F5
D. woelkei	17	D1	F1	1	D1	F1	29	D2	F2	40	D2	F2	4	D1	F2
U. pulchella	80	D3	F2	19	D2	F2	68	D3	F3	100	D3	F3	3	D1	F2
D. baloghi	17	D1	F1	1	D1	F1	29	D2	F2	40	D2	F2	4	D1	F2
D. carinatus	43	D2	F2	2	D1	F1	6	D1	F2	22	D1	F2	1	D1	F3
O. minima	90	D3	F2	18	D2	F3	9	D1	F2	31	D1	F2	30	D4	F3
T. aegrota	26	D1	F2	25	D2	F3	9	D1	F3	9	D1	F3	25	D3	F4
U. tecta	23	D1	F1	4	D1	F2	1	D1	F1	5	D1	F1	2	D1	F2
D. perforatus	1	D1	F1				1	D1	F1	3	D1	F1	5	D1	F2
T. pauperior	25	D1	F1				1	D1	F1				1	D1	F2
D. arcuatus	6	D1	F1							4	D1	F2	1	D1	F2
P. sansonei	1	D1	F1	15	D2	F1				1	D1	F1			
U. obovata	1	D1	F1							6	D1	F1			
Trichouropoda sp.	1	D1	F1										1	D1	F2
C. erlangensis	1	D1	F1												
C. rafalskii	2	D1	F1												
C. cassideasimilis	6	D1	F1												
Dinychus sp.	8	D1	F1												
L. orbicularis	5	D1	F1												
N. stylifera	1	D1	F1												
T. tuberosa	1	D1	F1												
T. coccinea	4	D1	F1												
T. elegans	12	D1	F1												
U. orbicularis	4	D1	F1												
N. breviunguiculata				1	D1	F1									
D. cordieri							1	D1	F1						
U. pyriformis							1	D1	F1						
A. infirmus										1	D1	F1			
P. cylindricus										1	D1	F1			
Number of specimens	1,100			472			466			1,135			171		
Number of species	24			10			12			14			12		
Number of samples	174			51			36			47			20		

The two microenvironments discussed here are also different as to other parameters. The results of the multifactor analysis show that moisture is a more important factor in tree hollows than in dead wood. This may be due to the fact that tree hollows are more isolated from soil and that they are more prone to becoming dry. Moreover, the results of the analyses presented here also show that other biological factors can have influence on community structure of Uropodina in both types of microhabitats, for example the species of tree and the degree of dead wood decay.

Little has been done so far to explain the mechanisms governing the development and diversification of Uropodina communities inhabiting dead wood merocoenoses. The accounts which describe microhabitat diversity of Uropodina communities usually focus only on soil microenvironments (BŁOSZYK, 1999; NAPIERAŁA, 2008; NAPIERAŁA *et al.,* 2006, 2009). These studies often emphasise the importance of the age, species composition, protection status, and anthropogenic factors of the tree stand for species diversification of Uropodina mites within one forest complex. The data presented in this study show

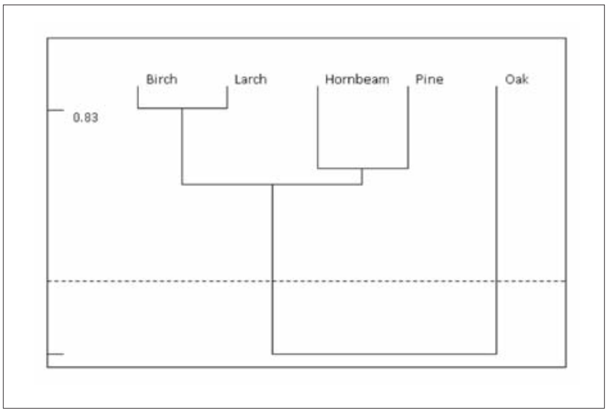

Fig. IV – The results of the cluster analysis (MS, single-linkage clustering) of the species composition of Uropodina communities inhabiting dead wood merocoenoses (with tree hollows) in the analysed tree species.

that differences in community structure of Uropodina inhabiting even one small forest complex are also present in dead wood microenvironments. The studies show that the Uropodina communities in the examined reserves usually constitute between 48.4% and 61.3% of all species usually inhabiting the dead wood merocoenoses (NAPIERAŁA and BŁOSZYK, 2013). The differences in the species composition and abundance of Uropodina mites in the analysed material suggest that the changes probably take place at the microgeographic level. The results of the comparative analysis of the species composition in the Uropodina communities in the reserves under scrutiny show that the communities of Uropodina inhabiting dead wood and tree hollows in Bytyńskie Brzęki and Brzęki near Stara Gajówka exhibited the highest diversity. Due to the fact that the examined reserves are fairly close to each other the species composition of the found communities was not determined by the weather conditions in these areas. The similarities and differences in the structure of the analysed communities seem to stem from the microclimatic factors. The high species diversity of the Uropodina communities in these reserves also stems from the fact that the tree stand of the examined areas consists of hornbeam forests with a bit of many wild service trees and pines. The tree stand in Huby Grzebieniskie contains mainly hornbeams with sporadic larches. The undergrowth of Huby Grzebieniskie is also different from that of the other reserves. In this reserve Lady's Slipper orchid occurs, which is not present in the other reserves, and the litter contains a large amount of decaying larch needles. Thus, the similarities and differences between Uropodina communities in the analysed dead wood material from the examined sites probably stem from the complexity of the microhabitat factors, including the species composition of the tree stand and its age. The results obtained from the analysis of the collected material corroborate the hypothesis put forward by BŁOSZYK (1999), who claims that Uropodina mites have very specific habitat preferences. Most of the species found in the reserves were stenobiont and oligobiont species. That is why even apparently minor microclimatic and microhabitat differences can be the key factors that affect both species composition and abundance in Uropodina communities, which has been also proved in the studies on community diversity of Uropodina inhabiting soil (BŁOSZYK, 1999; NAPIERAŁA, 2008; NAPIERAŁA *et al.*, 2006, 2009). Interestingly, similar results were also obtained in analyses conducted for centipede communities in these reserves (LEŚNIEWSKA *et al.*, 2005). The influence of environmental factors on species composition and abundance in Uropodina communities in dead wood definitely requires further research, which would provide more data on other factors responsible for species diversification in Uropodina communities inhabiting such microhabitats. The results of the analyses presented here are preliminary and they obviously require further research.

However, the results of this study are certainly a contribution into the research on the ecology of Uropodina mites, especially on functioning and diversification of Uropodina communities inhabiting in dead wood microhabitats. The results of the analyses confirm the great importance of presence of different forms of dead wood (e.g. stumps, fallen logs) and tree hollows in forest ecosystems as a significant factor increasing biodiversity of Uropodina mites and other invertebrates (STOKLAND *et al.*, 2012).

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