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Original Research

Importance of Microhabitats for Preservation of Species Diversity, on the Basis of Mesostigmatid Mites (Mesostigmata, Arachnida, Acari)

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Abstract

Mesostigmatid mites were studied in 50 microhabitats in a moderately humid pine-oak forest, markedly transformed by human activity, in the Rybnik Forest District (southern Poland). This study was aimed to show differences in species composition and abundance of mite communities in the studied microhabitats. In total, 1,936 mesostigmatid mites were collected of 65 species and 15 families. The most abundant and frequent species were *Paragamasus vagabundus* and *Gamasellodes bicolor*. The largest number of species (16-18) and the highest abundance of the mites (750-1,270 individuals/m^2) were found in dead wood (M15), leaf litter (M34), bark (M40), and an anthill (M62). In 30 microhabitats, only exclusive species were found, which significantly increased the mite species diversity in the forest floor.

Keywords: biodiversity, Mesostigmata, microhabitats, mites, pine-oak forest

Introduction

Assessment of biodiversity is one of the major problems of modern biology and environmental protection. An important aspect of its protection is the knowledge of species diversity of individual taxonomic groups of animals and understanding its complexity in each ecosystem [1]. Soil is one of the most diverse habitats, colonized by a variety of animal communities [2, 3]. In natural soils, animal distribution is patch-like. Various microhabitats – depending on many climatic factors such as vegetation, and physicochemical properties of the substrate [4] – offer different microclimates, availability of food, shelter, etc. The diversity of microhabitats is a key determinant of the high diversity of soil arthropods [5-7].

Forest ecosystems are characterized by a high diversity of microhabitats. The soil and needle litter in coniferous forests are favourable environments for microarthropods [8]. Mites (Acari), as one of the most numerously represented groups of soil organisms, inhabit a variety of structures found in the forest floor, and perform various functions, showing various life strategies. Among them, an important role is played by mesostigmatid mites. Predatory forms of those mites, formerly classified as the suborder Gamasina, do not change the soil structure but markedly affect the population size of their prey. Consequently, they indirectly influence the overall productivity of ecosystems. Their interactions with prey, not only in relation to the type of consumed food, but also to the soil profile and microhabitat diversity, are highly heterogeneous. The mite communities of forest ecosystems are characterized by a specific structural and functional composition, depending on forest type, its structure, and complexity [9].

Research on oribatid mites of microhabitats in oak-alder forest (dominated by *Quercus mongolica* and *Alnus hirsuta*) was initiated in Japan [5]. Acarological research, aimed at determining the microhabitats of pine forest floor, was con-

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ducted in Wielkopolska National Park [10]. Investigations into 41 microhabitats of Collembola in beech and spruce forests in the Czech Republic showed that their variety significantly affects the diversity of forest soils [11]. Results of detrended correspondence analysis (DCA) for mesostigmatid mites of 12 microhabitats in spruce forest (dominated by *Picea abies*) revealed that only one mite community was present there, rather than distinct communities of individual microhabitats [12]. The decaying wood maintains diverse subcommunities of oribatid mites, which vary little between different forests and latitudes [13].

Earlier reports of mesostigmatid mites in forest ecosystems did not describe the role of microhabitats in increasing their biodiversity. Those publications include only lists of species found in various microhabitats [14, 15], mostly in protected areas [16-19]. A detailed list of microhabitats in forest ecosystems and their effect on species diversity was reported so far only for one group of mesostigmatid mites, the family Ascidae [20].

The aim of our study was to answer the following questions.

- In which microhabitats of the studied forest, species number, and abundance of mesostigmatid mites are the highest?
- Which species are found exclusively in one or fewer types of microhabitats?
- Does the variety of microhabitat affect the species diversity of mesostigmatid mites in the soil?

Study Area

Field research was conducted in a moderately humid pine-oak forest (markedly transformed by human activity) located in forest plots 166b, 167a, 167b, 167g, and 168g of the Rybnik Forest District (southern Poland). The forest stands were aged 57 years on average. In the forest, most soils are classified as rusty brown-earth (except for plot 166b) or podsol on loose sands (plot 166b). The humus layer was acidic and several centimetres thick. The canopy was dominated by *Pinus sylvestris*, mixed with *Quercus robur*, *Q. rubra*, *Betula pendula*, *Fagus sylvatica*, *Acer platanoides*, *Carpinus betulus*, and *Larix decidua*.

The shrub layer was dominated by *Frangula alnus* and *Prunus padus* (plots 167a, 167b), or *Quercus robur* (167g), or *Picea abies* (166b), or *Populus tremula* (168g). The herb layer was composed mostly of *Pteridium aquilinum*, *Molinia caerulea*, *Deschampsia flexuosa*, *Dryopteris filix-max*, and *Phragmites australis* [21].

For this study, we selected 63 stable and unstable microhabitats:

- moss patches: *Atrichum undulatum* (M1), *Brachythecium rutabulum* (M2), *B. salebrosum* (M3), *Dicranella heteromalla* (M4), *Hypnum cupressiforme* (M5), *Lophocolea heterophylla* (M6), *Orthodicranum montanum* (M7), *Plagiothecium laetum* (M8), *Pohlia nutans* (M9), and *Polytrichastrum formosum* (M10)
- freshly fallen leaves: *Acer platanoides* (M11), *Carpinus betulus* (M12), *Fagus sylvatica* (M13), and *Pinus sylvestris* (M14)
- branches, 2nd stage of decomposition: *Betula pendula* (M15), *Fagus sylvatica* (M16)
- branches, 3rd stage of decomposition: *Fagus sylvatica* (M17), *Acer platanoides* (M18), *Quercus rubra* (M19)
- branches, 4th stage of decomposition: *Acer platanoides* (M20)
- fallen log: *Pinus sylvestris* (M21), *Populus tremula* (M22)
- fragment of the trunk of a windthrown tree: *Pinus sylvestris* (M23), *Salix* sp. (M24)
- root of a windthrown tree: *Pinus sylvestris* (M25), *Salix* sp. (M26)
- rotten stump: *Acer platanoides* (M27), *Picea abies* (M28), *Pinus sylvestris* (M29)
- humus from a tree stump: *Quercus robur* (M30)
- rotten branch: *Pinus sylvestris* (M31), *Quercus* sp.(M32)
- leaf litter: *Carpinus betulus*, *Acer platanoides* (M33)
- needle-and-leaf litter: *Pinus sylvestris*, *Carpinus betulus*, *Acer platanoides* (M34)
- needle litter: *Pinus sylvestris* (M35)
- fern leaves: *Dryopteris filix-mas* (M36), *Pteridium aquilinum* (M37)
- sod: *Deschampsia flexuosa* (M38)
- bark lying on the soil surface: *Betula pendula* (M39), *Pinus sylvestris* (M40), *Prunus padus* (M41), *Quercus rubra* (M42)
- seed cones: *Pinus sylvestris* (M43), *Picea abies* (M44), *Larix decidua* (M45)
- acorns (M46)
- bracket fungus collected from a fallen tree: *Salix* sp. (M47), *Betula pendula* (M48), *Quercus rubra* (M49)
- bracket fungus collected from a stump: *Quercus rubra* (M50), *Betula pendula* (M51)
- mushrooms: *Paxillus involutus* (M52), *Armillaria mellea* (M53), *Xerocomus badius* (M54)
- nest of blackbirds: *Turdus merula* (M55)
- feathers (M56), abandoned nest (M57), egg shells (M58)
- faeces of roedeer (M59), wild boar (M60), hare (M61)
- anthill (M62)
- molehill (M63)

Materials and Methods

Samples from each microhabitat were randomly collected three times in 2005 (on 22 March, 14 June, and 3 November), except for microhabitats M43, M44, and M45, where samples were taken three times but only on 3 November 2005. In total, 204 samples were taken. Samples of about 100 cm^2 each (10 cm × 10 cm) were collected manually.

Next, mites were extracted in Tullgren funnels for 5 days. Mesostigmatid mites were preserved in Faure's fluid. Among the Uropodina, only mites of the family Trachytidae were identified by species. All taxa were identified using keys [22, 23].

Stages of wood decomposition were determined on the scale of Orczewska and Szwedo [24].

In only 4 microhabitats (M9, M29, M34, M40) were mites found in all samples (seasons). In 12 microhabitats (M14, M28, M32, M37, M39, M48, M52, M56, M58, M59, M60, M61), no mesostigmatid mites were found. In M41, only 3 individuals of Uropodoidea were found. In the other 50 microhabitats, 1,936 mesostigmatid mites were collected (on average 12.65 individuals per sample), including 1,410 adults (72.8%) and 526 juveniles (27.2%). Among adult forms, 35 individuals (2.48%) were members of the suborder Sejina, 1,108 (78.58%) of the suborder Gamasina, and 267 (18.93%) of the suborder Uropodina. Uropodina were most abundant in M62 (650 individuals/m^2), M18 (360 individuals/m^2), M15 (200 individuals/m^2), and M34 (180 individuals/m^2).

The Chao-1 estimator of number of species was calculated from the formula:

$$S_1 = S_{obs} + (a^2/2b)$$

...where S_{obs} is the number of species observed, and a, b are the numbers of species represented by 1 (a) or 2 (b) individuals in the studied microhabitats [25].

Species diversity was assessed by the Shannon index (H') according to the formula:

$$H' = -\Sigma p_i \log p_i$$

...where p_i is the relative abundance of each species in the microhabitat (calculated as the proportion of individuals of a given species to the total number of individuals), and S is the number of species [26].

Species evenness e was calculated from the formula:

$$e = H'/\log s$$

...where H' is the Shannon index of species diversity, and S is the number of species [22].

Both H' and e were calculated by PAST software [27].

To determined the gradient of faunistic variation, we used detrended correspondence analysis (DCA) for log (n+1) transformed data, down-weighting of rare species by CANOCO software [28]. The DCA was carried out for 28 microhabitats (N>100 individuals/m^2) and 36 species represented by at least 4 individuals each.

The mite communities of microhabitats were compared qualitatively using the Sörensen number according to the formula:

$$Sö = 100\ (2c/a+b)$$

...where c is the number of species common to both microhabitats, a is the number of species in the first microhabitat, and b is the number of species in the second microhabitat [29].

Results

From all sampling sites, we collected 65 mesostigmatid species of 15 families (Table 1). Their abundance, number of species, and species composition differed between microhabitats (Table 2). The largest numbers of species (16-18) and individuals of mesostigmatid mites (750-1,270 individuals/m^2) were found in dead wood (M15), needle-and-leaf litter (M34), large piece of bark (M40), and an anthill (M62). A high abundance was recorded also in a stump of *Pinus sylvestris* (M29) (830 individuals/m^2), needle litter (M35) (590 individuals/m^2), and seed cones (M43 and M44) (570 and 520 individuals/m^2, respectively). *Paragamasus vagabundus* was the most common species (224 individuals, collected from 22 microhabitats), while *Gamasellodes bicolor* ranked second (151 individuals, collected from 17 microhabitats).

In 30 microhabitats only exclusive species were found (Table 1). For 23 microhabitats the Chao-1 estimator of species number was only 0-25% higher than the observed number (Table 2). The highest Shannon index of species diversity were recorded in mite communities of bark (M40), branches at the 2nd and 3rd stage of decomposition (M15, M17), needle-and-leaf litter (M34), and an anthill (M62) (Table 2).

In patches of various moss species (M1-M10), 29 species were collected. Among them, the most numerous were: *Zercon triangularis* (M9), *Paragamasus misellus* (M10), *P. vagabundus* (M1, M7), *Leioseius naglitschi* (M8), and *Zercoseius spathuliger* (M4). The species evenness of mite communities (*Sö*) in most of the compared microhabitats was very low. Most similar in qualitative terms were only microhabitats M5-M43 (*Sö*=0.86), M21-M27 (*Sö*=0.8), M1-M38 (*Sö*=0.75), and M1-M7 (*Sö*=0.73).

DCA results show significant differences in species diversity between microhabitats (Fig. 1). The length of the gradient represented by the 1st ordination axis reaches 4.84 SD. This means that species composition is completely different, i.e. distant samples should not have any species in

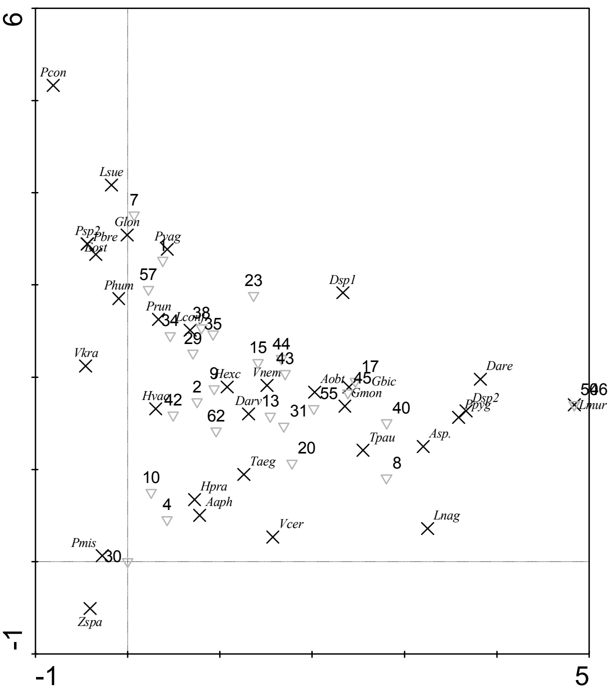

Fig. 1. DCA biplot species data for the different microhabitats of the forest floor (triangle – microhabitats, cross – species).

Table 1. List of species, their abbreviations, and total number of mites of individual species recorded in 50 forest microhabitats.

Species	Abbr.	Microhabitats	No. of mites
Sejus togatus C.L.Koch,1836	*Stog*	M15,17,20,21,22,23,26,29,31	35
Parazercon radiatus (Berlese, 1914)	*Prad*	M8	3
Prozercon kochi Sellnick, 1943	*Pkoc*	M8,24	3
Prozercon traegardhi (Halbert, 1923)	*Ptra*	M2,10,15,34	6
Zercon triangularis C.L.Koch, 1836	*Ztri*	M1,3,7,9,11,15, 29,34,35,38,42,49,50,57	76
Zercon sp.	*Zesp*	M10	1
Porrhostaspis lunulata Müller, 1859	*Plun*	M35	1
Vulgarogamasus kraepelini (Berlese, 1904)	*Vkra*	M10,12,34,35,53,57	9
Holoparasitus calcaratus (C.L.Koch, 1839)	*Hcal*	M1,4,5,15,26,29,34,38,40, 42,43,44,47,51,55,62	61
Leptogamasus parvulus (Berlese, 1903)	*Lpar*	M17	2
Leptogamasus suecicus Trägardh, 1936	*Lsue*	M1,7,9,23,34	12
Paragamasus digitulus (Karg, 1963)	*Pdig*	M29	1
Paragamasus conus (Karg, 1971)	*Pcon*	M1,7,51	5
Paragamasus misellus (Berlese, 1903)	*Pmis*	M4,9,10,30,34,42,62	30
Paragamasus runcatellus (Berlese, 1903)	*Prun*	M2,5,7,9,23,29, 35,42,43,62	26
Paragamasus vagabundus (Karg, 1968)	*Pvag*	M1,4,6,7,10,11, 13,15,19,21,22, 26,29,34,35,38,40,44, 53,54,57,62	224
Paragamasus sp.	*Prsp.*	M35	1
Pergamasus brevicornis Berlese, 1903	*Pbre*	M34	1
Geholaspis longispinosus (Kramer, 1876)	*Glon*	M15,34,57	6
Macrocheles opacus (C.L.Koch, 1839)	*Mopa*	M34	2
Eviphis ostrinus (C.L.Koch, 1836)	*Eost*	M29,33,34	22
Asca aphidioides (Linnae, 1758)	*Aaph*	M2,8,10,15,31,62	51
Asca bicornis (Can. et Fanz., 1887)	*Abic*	M9	1
Gamasellodes bicolor (Berlese, 1918)	*Gbic*	M5,6,8,9,15,16,17,23,25,29,31,40,43,44,45,55,62	151
Lasiosius confusus Evans, 1958	*Lcon*	M2,15,25,35,44	7
Lasioseius muricatus (C.L.Koch, 1839)	*Lmur*	M: 17,22,40,46,50,51	66
Lasioseius ometes (Oudemans, 1903)	*Lome*	M17	1
Lasioseius sp.1	*Lsp1*	M40	1
Lasioseius sp.2	*Lsp2*	M16	1
Leioseius naglitschi Karg, 1965	*Lnag*	M4,8,15,33,40	31
Melichares agilis Hering, 1838	*Magi*	M40	4
Proctolaelaps pygmaeus (Müller, 1860)	*Ppyg*	M40,62	7
Zercoseius spathuliger (Leonardi, 1899)	*Zspa*	M4,9,10,30	48
Arctoseius cetratus (Sellnick, 1940)	*Acet*	M8,45	2
Hypoaspis vacua (Michael, 1891)	*Hvac*	M2,15,19,29,30,34,55,57,62	39
Hypoaspis aculeifer (Canestrini, 1883)	*Hacu*	M22	1
Hypoaspis praesternalis Willmann, 1949	*Hpra*	M31,62	7
Hypoaspis lubrica Voigts et Oudemans, 1904	*Hlub*	M62	3
Hypoaspis minutisima Evans, Till, 1966	*Hmin*	M40	4

Table 1. Continued.

Species	Abbr.	Microhabitats	No. of mites
Veigaia cervus (Kramer, 1876)	*Vcer*	M10,13,20,22,29,30,40,62	16
Veigaia kochi (Trägardh, 1901)	*Vkoc*	M34	1
Veigaia nemorensis (C.L.Koch, 1839)	*Vnem*	M2,6,9,10,11,12,13,15,17,18,20, 29,34,35,40,43,62	56
Veigaia transisale (Oudemans, 1902)	*Vtra*	M62	1
Gamasellus montanus (Willmann, 1936)	*Gmon*	M15,17,20,35,44,45	14
Rhodacarus clavulatus Athias – Henriot, 1961	*Rcla*	M3	1
Rhodacarus coronatus Berlese, 1921	*Rcor*	M63	3
Pachylaelaps furcifer Oudemans, 1903	*Pfur*	M11,19	2
Pachylaelaps magnus Halbert, 1915	*Pmag*	M19	1
Pachylaelaps sp.1	*Psp1*	M7,10,31	4
Pachylaelaps sp.2	*Psp2*	M34	1
Pachyseius humeralis Berlese, 1910	*Phum*	M29	1
Pachyseius sp.	*Pasp*	M44	1
Dendroseius reticulatus Sheals, 1956	*Dret*	M62	1
Dendrolaelaps arvicolus (Leitner, 1949)	*Darv*	M13,15,18,27,31	19
Dendrolaelaps arenarius Karg, 1971	*Dare*	M40	5
Dendrolaelaps oudemans Halbert, 1915	*Doud*	M45	2
Dendrolaelaps sp. 1	*Dsp1*	M15,17,23,24	9
Dendrolaelaps sp. 2	*Dsp2*	M9,40	18
Dendrolaelaps sp. 3	*Dsp3*	M40	4
Ameroseius longitrichus Hirschmann, 1963	*Alon*	M40	2
Epicriopsis rivus Karg, 1971	*Eriv*	M35	2
Amblyseius obtusus (C.L.Koch, 1839)	*Aobt*	M13,17,31,34,	11
Amblyseius sp.	*Amsp*	M8,36,40,55	16
Trachytes aegrota (C.L.Koch, 1841)	*Taeg*	M2,10,13,15,18,20,34,36,40,53,62	35
Trachytes pauperior (Berlese, 1914)	*Tpau*	M8,13,20,31,35,40,62	17

common. Eigenvalues of the axes show that the gradient represented by the 1st ordination axis considerably differentiates species distribution (0.761). The other axes are less important. The 1st axis explains 17% of variation, while the 2nd axis only 10.1%. Ranking of the microhabitats reflects the sequence of mites collected from unstable microhabitats, e.g. acorns (M46), bracket fungus (M50) with the dominant *Lasioseius muricatus*, and bark (M40), located at one end of the 1st ordination axis, to the microhabitats characterized by a higher stage of decomposition of dead organic matter (M29, M34, M35, M38) or more closely linked to the soil (M42, M62, moss patches), located at the other end of the axis. This axis can be interpreted as a decreasing gradient of organic matter content of the substrate. The microhabitats located in the central part of the diagram are not directly linked with the soil (M13, M15, M43, M44). At the left end, *Zercon spathuliger* is located. It is a dominant species in humus from the stump of *Quercus robur* (M30) and in moss patches (M4, M10).

Discussion

Microhabitats of forest ecosystems are characterized by high diversity, sometimes even within a small area. They include fallen trees, tree holes, rotting wood, dead branches and twigs, dead lying or standing trees, pits formed under uprooted trees, stacks of fallen branches, pieces of bark, fruiting bodies of bracket fungi and mushrooms, and many other components of forest structure. These varied microhabitats are colonized for long periods. Various microhabitats provide organisms with varied living conditions. They are key elements of forest complexity, so they can be also used in evaluation of forest biodiversity [30].

Table 2. Species number (observed *S*, estimated S_1), abundance (*N*, ind/m^2), diversity (*H'*), and evenness (*e*) of mesostigmatid mites found in 50 microhabitats (M1-M63) of the forest floor. In M41, only 3 specimens of Uropodoidea were recorded, while no mesostigmatids were detected in M14, M28, M32, M37, M39, M48, M52, M56, M58, M59, M60, and M61.

M:	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M15	M16	M17	M18	M19	M20
S	5	7	2	5	3	3	6	8	9	11	4	2	7	16	2	9	3	4	6
S_1	7	11	6	5.5	12	3.25	10.5	16	13.1	17	8	3	15	18.5	3	10.6	3	8	7
N	240	130	20	400	30	50	290	320	380	310	90	30	270	750	50	140	100	100	130
H'	1.13	1.73	0.69	0.88	1.09	1.05	1.11	1.44	1.18	1.76	1.21	0.64	1.37	2.28	0.50	2.14	0.95	1.19	1.49
e	0.7	0.89	1	0.54	1	0.96	0.62	0.69	0.5	0.73	0.84	0.95	0.66	0.61	0.82	0.95	0.86	0.83	0.74
M:	**M21**	**M22**	**M23**	**M24**	**M25**	**M26**	**M27**	**M29**	**M30**	**M31**	**M33**	**M34**	**M35**	**M36**	**M38**	**M40**	**M42**	**M43**	**M44**
S	2	5	5	2	2	3	1	12	4	8	2	17	11	2	3	18	4	4	6
S_1	2	7.25	14	3	3	4	1	16.1	13	44	6	20.1	13.2	3	3	20	6	5	10
N	80	70	150	30	80	80	20	830	170	180	20	1270	590	50	180	750	130	570	520
H'	0.66	1.55	1.08	0.64	0.38	0.97	0	1.71	0.66	1.69	0.69	2.02	1.66	0.5	0.98	2.57	0.94	0.44	1.02
e	0.97	0.94	0.59	0.95	0.73	0.88	1	0.46	0.48	0.68	1	0.44	0.48	0.82	0.89	0.72	0.64	0.39	0.46
M:	**M45**	**M46**	**M47**	**M49**	**M50**	**M51**	**M53**	**M54**	**M55**	**M57**	**M62**	**M63**							
S	4	1	1	1	2	3	3	1	4	5	16	1							
S_1	4.25	2	1	1	2	4	12	1	4	6	25	1							
N	180	180	40	40	420	90	30	20	160	270	1010	40							
H'	0.92	0	0	0	0.41	0.96	1.09	0	1.24	0.82	2.0	0							
e	0.66	1	1	1	0.75	0.85	1	1	0.86	0.45	0.46	1							

The largest numbers of species and individuals were found in habitats that differ in substrate quality and structure as well as microhabitat conditions (branches of *Betula pendula* at the 2nd stage of decomposition, needle-and-leaf litter or pure needle litter, a rotten stump of *Pinus sylvestris*, a large piece of bark of *Pinus sylvestris*, seed cones of *Pinus sylvestris* and *Picea abies*, and an anthill). The birch branches, piece of pine bark, and seed cones were collected from the surface of the soil. The surface of the forest floor is subject to much greater fluctuations of moisture and temperature than soil microhabitats. Moisture and temperature are the most important factors affecting the abundance and species composition of mites [23]. Those factors resulted in a smaller number of species of mesostigmatid mites and a simplified structure of their communities in the microhabitats located at the surface of the soil [5]. Consequently, branches of trees were assigned to the group of moderately complicated, poor habitats [5]. The reactions to variable microhabitat conditions of the more mobile, predatory mesostigmatids are different from those of the less mobile mesostigmatids. Although the seed cones were hard and were not decomposed yet, they were readily colonized by mites. In this specific microhabitat, we found 8 mesostigmatid species. Among them, *Gamasellodes bicolor* constituted 89.47% of the total number of mesostigmatids in cones of *Pinus sylvestris*, and 70.83% in cones of *Picea abies*. *G. bicolor* was also abundant in acorns (M46) and in branches at the 2nd stage of decomposition (M15). This is a widespread species, common in forest microhabitats, e.g. forest litter, dead wood, and beetle galleries [20].

A similar abundance and diversity of mesostigmatid mites in cones was reported by Aoki [5]. That author paid special attention to fallen alder cones characterized by a higher abundance of mesostigmatids than the layer of fallen leaves and branches. He assigned fallen alder cones to the group of moderately complicated, rich habitats. Different results for predatory mesostigmatid mites were reported from spruce forest microhabitats, where partly decomposed, but still hard cones, were characterized by a lower abundance and number of species than other microhabitats [12].

Mesostigmatid communities of the studied microhabitats were characterized by a simple structure. In 14 microhabitats, only 1-2 species were found. In only 5 microhabitats the Shannon diversity index exceeded 2. Research conducted by Čoja, Bruckner [12], and Silkava and Huhta [31] showed that because of the high mobility, non-specific predatory strategy, and no tendency for clustered distribution, mesostigmatid mites do not form distinct communities colonizing specific microhabitats.

Our results indicate that the large variety of microhabitats has a positive influence on the species diversity of mesostigmatid mites. The concordance of mechanisms between above and belowground communities suggests that the relationship between environmental heterogeneity and species richness may be a general property of ecological communities [32]. The low species evenness of mite communities in most microhabitats suggests that they are distinct. In 30 microhabitats only exclusive species were found, which significantly increased mite species diversity of the forest floor. Ruf and Beck [33] indicate that some mesostigmatid mites show microhabitat preferences. The specialization of soil organisms in individual microhabitats is one of the causes of their high diversity in soils [34]. Salmane and Brumelis [35] indicate that removal of the moss layer caused a decline in species richness and Shannon diversity. In patches of various moss species, as many as 29 species were collected. Among them, in a patch of *Plagiothecium laetum* (M8), *Leioseius naglitschi* was abundant, known from only several locations in Poland [20]. Nine individuals of this species were also found in a large piece of bark of *Pinus sylvestris*, and single individuals in M4, M15, and M33. Thus, microhabitats may be refugia of rare species. Arroyo et al. [36] indicate that the differences between assemblages of mesostigmatid mites in the different microhabitats, occurring in Irish Sitka spruce (*Picea sitchensis*), showed that communities in canopies are habitats colonized by characteristic fauna.

It is impossible to assess the total species diversity of forests [30]. In studies of biodiversity of habitats with heterogeneous soils, microhabitats should be taken into account. However, it is necessary to develop proper methods of sampling, as the abundance and diversity of mites estimated for manually sampled microhabitats may be misleading [5].

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