Matis, D., 1966: Bemerkung über die Infusorienfauna der Regentümpel vom St. Georg–Moorwald. Acta Fac. Rerum. Nat. Univ. Comenianae, Zool., *12*, p. 235–239.
Matis, D., 1975: Infusoria of the order Hypotrichida in some localities in the vicinity of Bratislava. Biológia (Bratislava), *30*, p. 583–588.
Mrva, M., 2003: Diversity of active gymnamoebae (Rhizopoda, Gymnamoebia) in dendrotelmae of oak-hornbeam forests in Malé Karpaty Mts (Western Slovakia). Protistology, *3*, p. 121–125.
Mrva, M., 2004: Naked amoebae (Rhizopoda: Lobosea, Filosea) of chosen forest habitats in Malé Karpaty Mts (in Slovak). Ph.D. Thesis, Comenius University, Bratislava, 101 pp.
Novotny, R.T., Lynn, D.H., Evans, F.R., 1977: *Colpoda spiralis* sp. n., a colpodid ciliate found inhabiting treeholes (Colpodida, Ciliophora). J. Protozool., *24*, p. 364–369.
Paradise, C.J., Dunson, W.A., 1997a: Effects of pH and sulphfate on insects and protozoans inhabiting treeholes. Arch. Environ. Contamin. Toxicol., *33*, p. 182–187.
Paradise, C.J., Dunson, W.A., 1997b: Insects species interactions and resource effects in treeholes: are helodid beetles bottom-up facilitators of midge populations? Oecologia, *109*, p. 303–312.
Podani, J., 1993: Syn-tax. Version 5.0. Computer programs for Multivariate Data Analysis in Ecology and Systematics. User's guide. Scientia Publishing, Budapest, 104 pp.
Ter Braak, C.J.F., Šmilauer, P., 1998: CANOCO References Manual and User's Guide to Canoco for Windows: Software for Canonical Community Ordination (version 4). Microcomputer Power. New York, 352 pp.
Tirjaková, E., 1997: Structure and dynamics of communities of ciliated protozoa (Ciliophora) in field communities. Succesion, genus–species relationships, nutrition. Ekológia (Bratislava), *16*, p. 243–252.
Tirjaková, E., 2000: Occurrence of *Bunonema richtersi* Jägerskiöld, 1905 (Nematoda, Bunonematidae) on some localities of Little Carpathians (Slovakia) (in Slovak). Folia Faunistica Slovaca, *5*, p. 55–59.
Washburn, J.O., Anderson, J.R., Mercer, D.R. 1991: Parasitism of newly-hatched *Aedes sierrensis* (Diptera: Culicidae) larvae by *Lambornella clarki* (Ciliophora: Tetrahymenidae) following habitat flooding. J. Invertebr. Pathol., *58*, p. 67–74.
Záruba, P., 2004: Tree-holes – special freshwater insect's habitat (in Czech). Živa, *5*, p. 221–222.

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Tirjaková E., Vďačný P.: **Spoločenstvá nálevníkov** (Protozoa, Ciliophora) **v dendrotelmách a vplyv vybraných environmentálnych faktorov na ich štruktúru.**

Sledovali sme spoločenstvá nálevníkov v dendrotelmách 3 druhoch drevín (*Acer campestre*, *Carpinus betulus*, *Quercus dalechampii*). V 136 vzorkách sme určili 94 taxónov nálevníkov. Iba v 2 dendrotelmách sa nálevníky nevyskytli. Diverzita bola veľmi nepravidelná od 0–15 druhov v jednej dendrotelme, väčšinou sa vyskytovalo 3–6 druhov. Podobne i početnosť bola veľmi nepravidelná a prudko kolísala od 0–200 000 ex/ml. Frekvencia výskytu vo vzorkách ani u jedného druhu neprekročila hodnotu 30%. Najvyššiu frekvenciu sme zaznamenali u druhov *Leptopharynx costatus* (28,68%) a *Sathrophilus mobilis* (27,21%). Bohato zastúpená bola podtrieda Peritrichia (najmä zástupcovia rodov *Propyxidium* a *Scyphidia*. Na základe CCA anylýzy (testovaných 15 nominálnych a 2 gradientové premenné, z ktorých 9 bolo štatisticky významných) boli rozlíšené štyri základné spoločenstvá nálevníkov. Ako rozhodujúce faktory ovplyvňujúce zloženie taxocenóz pôsobili druh dreviny, veľkosť (objem) a vek telmy, prítomnosť Rotifera a iných Metazoa. Tieto výsledky boli potvrdené aj hierarchickou klasifikáciou. Druhovo najbohatšie a od ostatných najodlišnejšie boli telmy odobraté z *Quercus dalechampii*, druhovo najchudobnejšie a osobitné postavenie mali telmy s objemom pod 1 ml a telmy s objemom nad 500 ml. Wishartov index na základe veku telmy zlúčil do jedného zhluku najmladšie a najstaršie telmy. Sørensenov index tiež potvrdil osobitné postavenie najmladších teliem a tým aj význam časového faktora na formovanie spoločenstiev nálevníkov v dendrotelmách.

SELECTED ECOLOGICAL CHARACTERISTICS OF CILIATE COMMUNITIES (Protozoa, Ciliophora) IN DECAYING WOOD MASS IN THE MALÉ KARPATY MOUNTAINS

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Abstract

Bartošová P., Tirjaková E.: Selected ecological characteristics of ciliate communities (Protozoa, Ciliophora) in decaying wood mass in the Malé Karpaty Mountains. Ekológia (Bratislava), Vol. 24, Supplement 2/2005, p. 37–50.

In total 28 samples of 14 tree species were collected from 13 localities of Slovakia during the research of ciliate communities in decaying wood mass in 2001–2004. Generally 58 ciliate species (Protozoa: Ciliophora) were determined in our samples and 9 species were recorded in Slovakia for the first time. Apart from the species diversity the research has included analyses on structure of systematic and feeding groups, genus–species relationships and forming the communities in dependence on tree species. Colpodids predominated in systematic categories and bacteriovores were dominant in feeding groups. The maximum of species (8) was noted in the genus *Colpoda*. Hierarchical classification based on identity of ciliate species on trees has differentiated two large groups of tree communities. However the tree species probably does not seem to play a very important role in forming ciliate communities. Even no special relation (or differences of species spectrum) has been proved between deciduous and coniferous trees.

Key words: ciliates, communities, wood mass, decay, Malé Karpaty Mountains

Introduction

Rocks, mushrooms, mosses and lichens growing at trees and decaying wood mass have their own characteristic fauna. The common feature of the mentioned microhabitat fauna has been derived from general soil fauna (Wallwork, 1976). A lot of studies have been published on decaying processes in wood. They are mainly concentrated on the role of various arthropod groups in decaying wood (e. g. Wallwork, 1976; Speight, 1989; Dajoz, 2000). The importance of Protozoa (ciliates too) in decaying processes has been studied sporadically. As the majority of ciliates living in terrestrial habitats are bacteriovores

(Brunberg Nielsen, 1968; Laminger, 1980; Nikolyuk, 1965, 1969 etc.), their role in the wood decay is mainly releasing the nutriments after the consumption by bacteria. Several authors have hinted at decaying processes in soil (Bamforth, 1973; Stout, 1973). An increased supply of nutriments positively influences the abundance of microfauna, which is trophicaly associated with successive wood decay caused by macrofauna.

Despite the rapid progress of terrestrial and semiterrestrial ciliate research in the recent years, there have not been published any entire data on ciliates living in decaying wood mass. Just several studies present some data on occurrence of ciliates in wood, however mainly with no details on studied tree species (Wenzel, 1953; Blatterer, Foissner, 1988; Foissner, 1993a). In fact there are only several authors determining relevant tree species (Miteva, 1992; Foissner, 1993b; Foissner, 1994; Foissner et al., 2002).

Some authors paid attention to the occurrence of ciliates living in the terrestrial habitats of the Malé Karpaty Mts, for instance Mrva, Matis (2000) and Mrva (2003) studied gymnamoebae (Protozoa: Amoebozoa) in the leaf-litter and dendrotelmae of oak-hornbeam forests. The large research on litter, soil and moss has contributed to the knowledge on species diversity of ciliates, amoebas (Tirjaková et al., 2002) and arthropods (Holecová et al., 2002, 2005) in oak-hornbeam forests of the Malé Karpaty Mts.

Material and methods

In total 28 samples of bark and wood mass in various stages of decay were collected from 13 localities of Slovakia during the years 2001–2004 (Table 1). The stage of wood decay (SD) was considered according to the following scale: 1 – bark of living steady tree, 2 – decaying wood mass without contact with soil, 3 – decaying wood mass in contact with soil and with well-preserved wood structure, 4 – decaying wood mass in contact with soil and in far-gone stage of decay, 5 – decaying wood mass in contact with soil without preserved wood structure. The material was collected from 14 tree species, as followed: *Acer campestre* (Ac), *A. pseudoplatanus* (Aps), *Alnus glutinosa* (Ag), *Betula pendula* (Bp), *Carpinus betulus* (Cb), *Cerasus avium* (Ca), *Fagus sylvatica* (Fs), *Fraxinus excelsior* (Fe), *Picea excelsa* (Pe), *Pinus sylvestris* (Ps), *Quercus dalechampii* (Qd), *Q. petraea* (Qp), *Q. pubescens* (Qpu) and *Q. robur* (Qr).

Resting cysts of ciliates from air-dried samples were reactivated using the „non-flooded Petri dish method" (Foissner, 1987c). Ciliate species were determined by combining „*in vivo*" observations and protargol impregnation (Foissner, 1991). Mainly the publications of Foissner (1981b, 1982, 1984, 1987a, b, 1993a, b, 1999) and Foissner et al. (2002) were used to determine the ciliate species.

The frequency of ciliate taxa was categorised according to Schwerdtfeger (1975): species of the 1st class (0–10%), 2nd class (11–25%), 3rd class (26–45%), 4th class (46–70%) and 5th class (71–100%).

Communities of ciliates were compared to each other using hierarchical classification, based on identity of species representation (Sørensen's index of dissimilarity, complete linkage method). The cluster analysis was made with the help of the program Syntax (Podani, 1993).

Table 1. The list of studied localities.

No.	Locality	DFS[a]	Tree species[b]	No. of samples
1	Borinka–under Pajštún reservation	7768	Cb,Qr	2
2	Bratislava–Bystrické forest park	7768	Fs	1
3	Bratislava–Karlova Ves under Sitina	7868	Ca	1
4	Bratislava–Koliba	7868	Ca,Cb,Fe,Pe, Ps,Qp	7
5	Bratislava–Železná studienka	7868	Ps	1
6	Devínska Kobyla above telecast	7867	Qpu	2
7	Fúgelka	7669	Aps,Qd	2
8	Lozorno–Rusniaky	7668	Ag,Cb	3
9	Naháč–Katarínka	7471	Ca	1
10	Pohanská NPR	7569	Ac,Fe	2
11	Stupava–Lintavy	7768	Bp,Cb,Fs,Qd	4
12	Vinosady–environment	7669	Ac	1
13	Zbojníčka	7768	Cb	1

Notes: a - square of the Databank of Slovak fauna; b - abbreviations of tree species see chapter Material and methods

Results and discussion

Generally 58 ciliate species (Protozoa: Ciliophora) being classified into 7 classes, 9 subclasses, 16 orders and 27 families were identified in 28 samples of decaying wood mass of 14 tree species. The highest species richness (33) (in sensu Spellerberg, Fedor, 2003) was recorded in the samples of *Carpinus betulus* (Table 2). All the ciliate species have been observed worldwide from various terrestrial habitats for instance in soil, litter, dry mosses and sand (e. g. Foissner, 1987a, b; Foissner et al., 2002; Tirjaková, Matis, 1987 etc.).

Nine species of the total number of ciliates were recorded in Slovakia for the first time: *Anictostoma terricola*, *Arcuospathidium japonicum*, *Bakuella pampinaria*, *Enchelys polynucleata*, *Ilsiella elegans*, *Litonotus muscorum*, *Oxytricha granulifera quadricirrata*, *Platyophrya macrostoma* and *Spathidium turgitorum*.

The first records of ciliates refer to wood mass of 7 tree species in 5 localities. All the first records were confirmed in 1–2 localities and in the samples of 1–3 tree species. Maximum of the records corresponds with the locality Stupava–Lintavy (Tirjaková, Bartošová, 2004).

18 from a total of 58 ciliate species identified occurred in one sample and 7 of them were recorded in two samples. This fact reflects a high proportion of rare species (Fig. 1), being also proved by Fig. 2 with 44% of species with frequency ≤ 10%. None of the species occurred in all the samples. *Leptopharynx costatus* – the most frequent euryoecious species occurred in 82.1% of the samples (Fig. 1, Table 2). It has been classified in the 5th frequency category together with *Colpoda steinii* (Fig. 2). The 4th and 5th frequency categories have included just 5 species (*Colpoda cucullus*, *C. inflata*, *C. steinii*, *Gonostomum affine* and *Leptopharynx costatus)* with their frequency > 45% (Fig. 2, Table 2). All these species are common in terrestrial habitats. Colpodids belong

Table 2. List of recorded ciliate species (Protozoa, Ciliophora) on the studied localities and in trees in years 2001–2004.

Ciliate species	Locality number[a]	Tree species[b]	SD[c]	F[d]
Anictostoma terricola Foissner, 1993	8, 11	Ag, Qd	3.5	10.71
Apospathidium atypicum (Buitkamp et Wilbert, 1974)	10	Ac, Fe	3.4	7.14
Arcuospathidium australe Foissner, 1988	11	Cb	5	3.57
Arcuospathidium japonicum Foissner, 1988	8	Cb	-	3.57
Bakuella pampinaria Eigner et Foissner, 1992	11	Fs	4	3.57
Blepharisma hyalinum Perty, 1849	4, 7, 8, 11, 12	Ac, Ag, Cb, Fe, Fs, Pe, Qd, Qp,	2,3,4,5	32.14
Bresslaua vorax Kahl, 1931	3	Ca	5	3.57
Colpoda aspera Kahl, 1926	4	Fe	4	3.57
Colpoda cucullus (Müller, 1773)	1, 2, 3, 4, 5, 8, 9, 10, 11	Ac, Ag, Bp, Ca, Cb, Fe, Fs, Pe, Ps, Qd, Qp, Qr	2,3,4,5	67.86
Colpoda edaphoni Foissner, 1980	4, 6, 8, 11	Ag, Cb, Fs, Ps, Qpu	3,4,5	17.86
Colpoda henneguyi Fabre-Domergue, 1889	2, 11	Bp, Fs	3	7.14
Colpoda inflata (Stokes, 1884)	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 13	Ac, Ag, Bp, Ca, Cb, Fe, Fs, Ps, Qd, Qpu, Qr	1,2,3,4,5	67.86
Colpoda lucida Greeff, 1888	8, 11, 13	Ag, Cb, Fs, Qd	2,3,4	14.29
Colpoda maupasi Enriquez, 1908	6, 8, 9, 10, 11, 13	Ag, Ca, Cb, Fe, Fs, Qd, Qpu	1,2,3,4	32.14
Colpoda steinii Maupas, 1883	1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13	Ac, Ag, Aps, Bp, Ca, Cb, Fe, Fs, Ps, Qd, Qp, Qpu, Qr	1,2,3,4,5	75.00
Cyclidium muscicola Kahl, 1931	2, 4, 5, 7, 8, 10, 11, 12	Ac, Ag, Bp, Ca, Cb, Fs, Pe, Ps, Qd	2,3,4,5	42.86
Cyrtohymena muscorum (Kahl, 1932)	11	Fs	4	3.57
Cyrtolophosis acuta Kahl, 1926	4, 6, 8, 10, 11	Ac, Ag, Cb, Fe, Qp, Qpu	1,3,4,5	25.00
Cyrtolophosis elongata (Schewiakoff, 1892)	2, 4, 6, 8, 9, 10, 11	Ac, Bp, Ca, Cb, Fe, Fs, Qpu	1,3,4,5	32.14
Cyrtolophosis mucicola Stokes, 1885	1, 4, 8	Cb, Qp, Qr	3.4	10.71
Dileptus breviproboscis Foissner, 1981	8	Cb	-	3.57
Drepanomonas pauciciliata Foissner, 1987	4, 11	Bp, Cb, Qp	2,3,5	14.29
Drepanomonas revoluta Penard, 1922	1, 4, 8,11	Ag, Cb, Fe, Fs, Ps	3,4,5	21.43
Enchelys polynucleata Foissner, 1984	10	Ac, Fe	3.4	7.14
Epispathidium amphoriforme (Greeff, 1888)	1, 8	Cb, Qr	4	10.71
Euplotes muscicola Kahl, 1932	8, 10, 11, 12	Ac, Bp, Cb, Fe, Fs	3.4	17.86
Frontonia angusta Kahl, 1931	11	Bp	3	3.57
Frontonia depressa (Stokes, 1886)	4, 5, 8, 11, 13	Bp, Cb, Ps, Qp	2,3,5	21.43
Gonostomum affine (Stein, 1859)	1, 2, 4, 5, 8, 10, 11, 13	Ac, Ag, Bp, Cb, Fe, Fs, Pe, Ps, Qd, Qr, Qp	2,3,4,5	67.86
Hausmanniella patella (Kahl, 1931)	2	Fs	3	3.57
Hemisincirra gellerti (Foissner, 1982)	4, 11	Cb, Fe, Qd	3,4,5	10.71
Hemisincirra interrupta (Foissner, 1982)	4, 13	Cb, Fe	2.4	7.14

Table 2. (Continued)

Ciliate species	Locality number[a]	Tree species[b]	SD[c]	F[d]
Holosticha tetracirrata Buitkamp et Wilbert, 1974	10	Ac, Fe	3.4	7.14
Homalogastra setosa Kahl, 1926	10	Ac	3	3.57
Chilodonella uncinata (Ehrenberg, 1838)	11	Fs	4	3.57
Chilodontopsis muscorum Kahl, 1931	8, 11	Cb, Fs	4	7.14
Ilsiella elegans Foissner, Agatha et Berger, 2002	4, 10	Ac, Fe, Qp	3.4	10.71
Kahlilembus attenuatus (Smith, 1897)	8	Cb	-	3.57
Leptopharynx costatus Mermod, 1914	1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13	Ac, Ag, Aps, Bp, Ca, Cb, Fe, Fs, Pe, Ps, Qd, Qp, Qr	2,3,4,5	82.14
Litonotus muscorum (Kahl, 1931)	7	Qd	-	3.57
Odontochlamys gouraudi Certes, 1891	8	Cb	-	3.57
Opercularia arboricolum (Biegel, 1954)	4, 8, 11	Ag, Pe, Qd	2,3,5	14.29
Oxytricha granulifera quadricirrata Blatterer et Foissner, 1988	11	Cb	5	3.57
Oxytricha setigera Stokes, 1891	4, 8, 11	Ag, Fe, Fs, Qd	3.4	14.29
Platyophrya macrostoma Foissner, 1980	8	Ag	3	3.57
Platyophrya spumacola Kahl, 1927	2, 4, 7, 8, 11	Ag, Aps, Bp, Cb, Fs, Ps, Qd	3,4,5	32.14
Platyophrya vorax Kahl, 1926	2, 8, 11	Ag, Fs, Qd	3.5	10.71
Pseudocohnilembus pusillus (Quennerstedt, 1896)	5, 7	Aps, Ps, Qd,	-	10.71
Sathrophilus muscorum (Kahl, 1931)	1, 4, 8, 10, 11, 13	Ac, Ag, Ca, Cb, Fe, Fs, Ps, Qd, Qp	2,3,4,5	46.43
Spathidium bavariense Kahl, 1930	4	Fe, Qp	2.4	7.14
Spathidium muscicola Kahl, 1930	2, 4, 8, 11, 13	Ag, Cb, Fs, Qd, Qp	2,3,4	25.00
Spathidium spathula (Müller, 1773)	4, 8, 11	Cb, Fs, Ps	4.5	14.29
Spathidium turgitorum Foissner, Agatha et Berger, 2002	11	Fs	4	3.57
Sphaerophrya terricola Foissner, 1986	11	Qd	3	3.57
Sterkiella histriomuscorum (Foissner, Blatterer, Augustin et Kohmann, 1991)	4, 8, 11	Ag, Bp, Fs, Qd, Qp	3.4	17.86
Telotrochidium cylindricum Foissner, 1978	4, 8, 11	Ag, Cb, Fs, Pe	2,3,4,5	14.29
Urosomoida agiliformis Foissner, 1982	2, 11	Fs, Qd	3.4	10.71
Vorticella astyliformis Foissner, 1981	4, 7, 8, 10, 11	Cb, Fe, Fs, Pe, Qd, Qp	2.4	21.43

Notes: [a] – see Table 1.; [b, c] – abbreviations of tree species and consideration of stage of wood decay see chapter Material and methods; [d] – frequention of ciliate occurrence in studied samples (%)

to r-strategists and fast-growing species well adapted to utilise very short and wet periods. The cell division in cysts is considered as an r-selective life strategy and serves for the fast multiplying in a short time, what enables ciliates their wide distribution and to colonise various terrestrial habitats (Lüftenegger et al., 1985; Foissner et al., 2002).

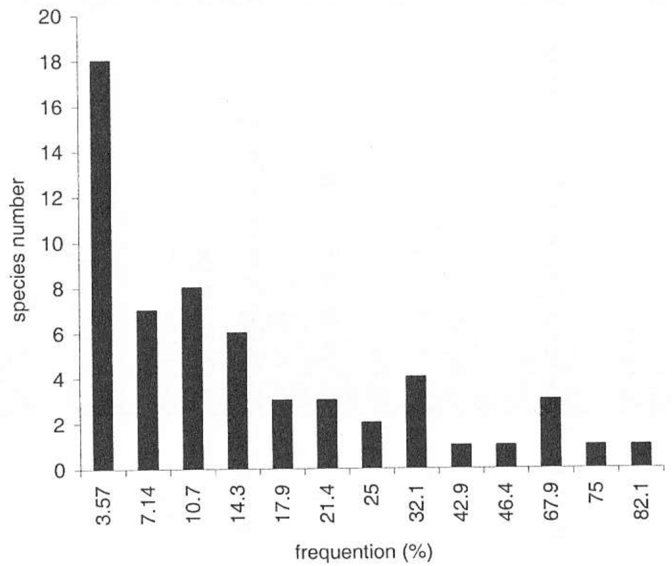

Fig. 1. Frequentions of 58 ciliate species recorded in 28 samples of decaying wood mass.

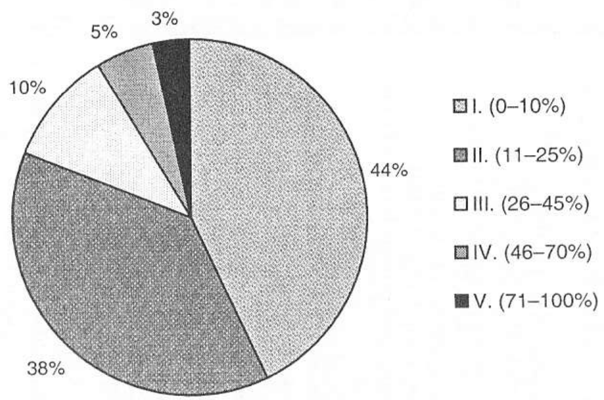

Fig. 2. Percentual representation of ciliate species in frequention groups (categorization in groups according to Schwerdtfeger, 1975).

Blatterer, Foissner (1988) show 23 species with frequency ≥ 50% in soil samples from Australia. The total of 20 species occurred with the frequency ≥ 50% in Germany (Foissner, 2000). 17 and 13 species were recorded in Austria (Tullnerfeld or alpine habitats) (Foissner et al., 1985; Foissner, 1981a) and 12 species with the same frequency occurred in South America (Foissner, 1997). Totally 11 species with frequency ≥ 48% were found in samples from Namibia (Foissner et al., 2002) and 19 species with their frequency > 55% were noted in Kenya (Foissner, 1999). 15 species belonged to the most frequent in Antarctica (Foissner, 1996). Many samples collected in Antarctica did not include any species, what might refer to very low frequency values. Therefore species with their frequency ≥ 5.1% have been classified into the category of the most frequent species.

Structure of systematic classes

The percentual structure of ciliates recorded in the samples from decaying wood is demonstrated on the Fig. 3 and 4 according to their systematic classes. From this point of view we can submit following ascendant rank: Heterotrichea (1.7%), Phylopharyngea (5.2%), Nassophorea (6.9%), Oligohymenophorea (17.2%), Spirotrichea and Litostomatea (19.0%) and Colpodea (31.0%) (the system accords to Lynn, Corliss, 1991, Fig. 3). Being based on the older system by Corliss (Corliss, 1979) (Fig. 4) the structure appears as followed: Polyhymenophora (20.7%), Oligohymenophora (24.1%) and Kinetofragminophora (55.2%).

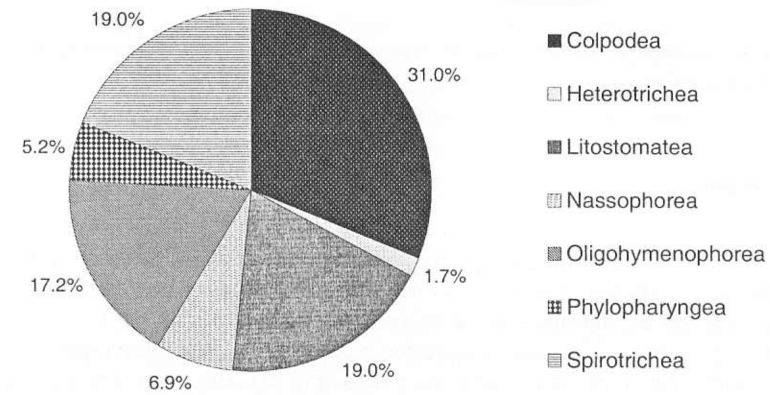

Fig. 3. Percentual representation of ciliate species in systematic groups (the system according to Lynn, Corliss, 1991).

Tirjaková (1988), who has been studying soil ciliates in field communities, found out, that Kinetofragminophora and Polyhymenophora (43%) had been dominantly represented. Soil habitats are mainly characteristic by distinct prevalence of Kinetofragminophora, actually proved by Foissner (1981a), Buitkamp (1977), etc. According to Foissner (1985), the high proportion of colpodids is one of the most important characteristics of soil ciliate community in contrast to limnic habitats. This has been proved by many other studies, for instance by Foissner et al. (2002). Oligohymenophora and Polyhymenophora (mainly Spirotrichea) keep the dominant position in limnic habitats e.g. Baláži, Matis (2002) considered Spirotrichea as a dominant class with prevalence of hypotrichs (49%). Oligohymenophora with 57% of peritrichs were the second dominant class, what actually refers to the Foissner's arguments (1981a, 1987c; Foissner et al., 2002), that peritrichs and sessile forms are predominant in limnic habitats and in soils they are substituted by Kinetofragminophora and Polyhymenophora.

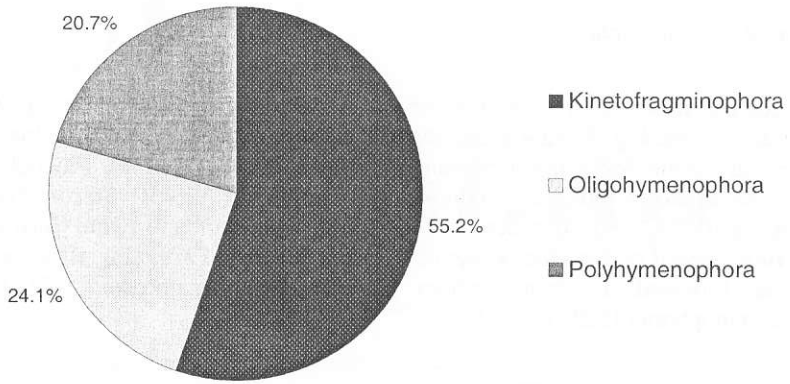

Fig. 4. Percentual representation of ciliate species in systematic groups (the system according to Corliss, 1979).

Trophic groups

The ingestion of 10 various feeding groups were studied to set the food preference of ciliates: bacteria, ciliates, diatoms, zooflagellates, phytoflagellates, hyphae and fungal spores, gymnamoebae, thecamoebae, rotifers and detritus.

Ciliates split into 3 trophic categories according to the above-mentioned food sources: bacteriovores, predators and omnivores (Fig. 5). Bacteriovores include species feeding on bacteria. However, if a species feeds on minimally 2 various food sources apart from bacteria, it is classified as an omnivore. Generally, omnivores included ciliate species feeding minimally on 3 various food sources. Predators were defined as the species feeding on ciliates, flagellates, amoebas, rotifers and nematodes.

During the evaluation of ciliate food preference we established, that the highest percentage of the recorded ciliate species fed on bacteria (51.7%). The prevalence of

bacteriovores in the samples may be explained by sufficient food supply as bacteria considerably participate on wood mass decay. In accordance with couple of authors as well as our results most of ciliate species living in soil are bacteriovores (e. g. Brunberg Nielsen, 1968; Laminger, 1980; Nikolyuk, 1965, 1969). Foissner (1981a) shows as many as 86 resp. 94% bacteriovores in alpine soils. Tirjaková (1997) generally recorded 66% ciliate species feeding on bacteria in agrocoenoses. However, some of the recorded omnivores were classified into bacteriovores as well. Gellért (1956) noted only 27% portion of exclusive bacteriovores (without omnivores) in the humus horizon under mosses.

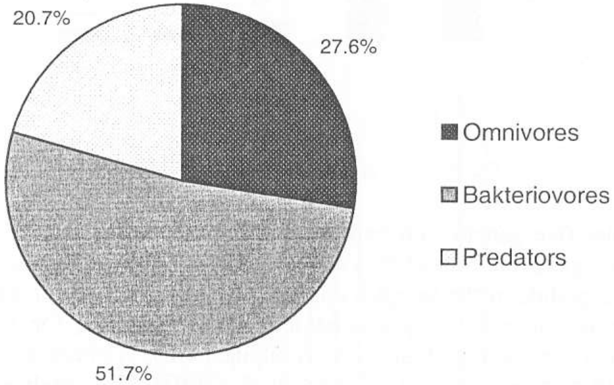

Fig. 5. Percentual representation of ciliate species in feeding groups.

The rest portion was formed by omnivores (27.6%) and predators (20.7%) in our samples. Tirjaková (1997) and Gellért (1956) published higher values in representation of predators (33.5% and 37.8%) in field communities or humus. Foissner (1981a) recorded only 7 resp. 2.8% of predators in alpine soils. Predators were represented by a relatively high percentage (about 21%) in decaying wood mass.

Genus–species relationships

The 58 identified ciliate species have been classified into 39 genera. Most of them were represented by one species (76.9%, Fig. 6) what may hint at similar food requirements of the same genus species, which are in mutual competition.

The results from various authors have been considerably different. Foissner (1981a) recorded 67% genera with one species only in the ciliate community research of alpine soils. The maximum values did not exceed 80% in agrocoenoses studied by Tirjaková (1997). Foissner et al. (2002) noted just 20.2% genera with one species in their samples from Namibian terrestrial habitats.

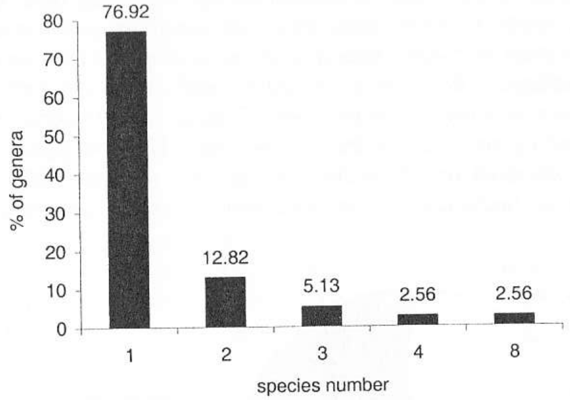

Fig. 6. Genus–species relationships of ciliates.

In the samples five genera were represented by two species (12.8%), two genera by three (5.1%), one genus by four (2.6%) and one (*Colpoda*) by eight species (2.6%). The prevalence of colpodids in the samples corresponds with the general statement, that the genus *Colpoda* is commonly represented in soils world-wide, for instance Foissner (1981a) recorded six colpodid species in alpine soils, Tirjaková (1988) recorded 8 species in field communities and Foissner et al. (2002) 17 colpodids from the genus *Colpoda*.

The similarity of ciliate communities

Communities of ciliates were mutually compared using hierarchical classification, based on identity of species representation (Sørensen's index of dissimilarity, complete linkage method). Totally 58 ciliate species recorded in the samples from 14 tree species were included in the analysis.

Hierarchical classification (Fig. 7) has differentiated two large groups of tree communities, which split up into several smaller groups.

The first group of the communities has divided into two smaller clusters. The first most diversified cluster consists of the following tree species: *Acer campestre*, *Fraxinus excelsior*, *Quercus petraea*, *Alnus glutinosa*, *Quercus dalechampii*, *Fagus sylvatica* and *Carpinus betulus*. It includes 56 ciliate species, actually 96.6% of the total number of species recorded in the decaying wood mass samples. The second cluster is formed by four tree species (*Betula pendula*, *Pinus sylvestris*, *Quercus robur* and *Picea excelsa*) and is characterised by presence of 25 ciliate species. Two of them appear with a low frequency (*Colpoda henneguyi* and *Frontonia angusta*).

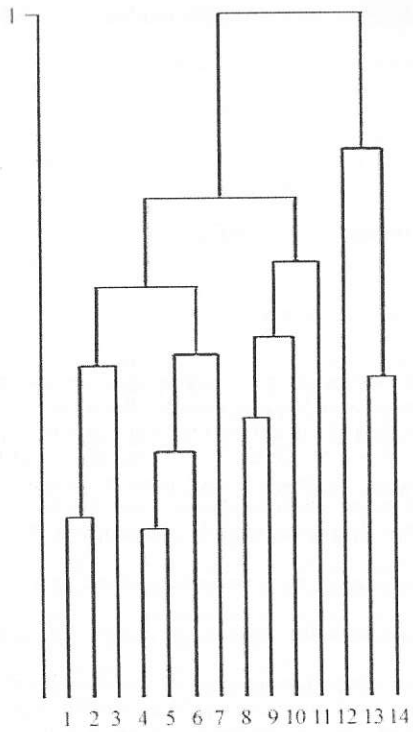

Fig. 7. Hierarchical classification of ciliate communities at tree species (Sörensen's index, complete linkage) (vertical axis – dissimilarity, horizontal axis – tree species: 1– *Acer campestre*, 2 – *Fraxinus excelsior*, 3 – *Quercus petraea*, 4 – *Alnus glutinosa*, 5 – *Quercus dalechampii*, 6 – *Fagus sylvatica*, 7 – *Carpinus betulus*, 8 – *Betula pendula*, 9 – *Pinus sylvestris*, 10 – *Quercus robur*, 11 – *Picea excelsa*, 12 – *Acer pseudoplatanus*, 13 – *Cerasus avium*, 14 – *Quercus pubescens*).

The second group of the communities has split up into the other two clusters. The first one determined by *Acer pseudoplatanus* has been established at a relatively high value of dissimilarity. Only 4 ciliate species were recorded in the relevant samples. They may be considered as common terrestrial ciliates (*Colpoda steinii*, *Leptopharynx costatus*, *Platyophrya spumacola* and *Pseudocohnilembus pusillus*). The second cluster joins to the first one at the lower value of dissimilarity. It includes 11 ciliate species being recorded in the samples of *Cerasus avium* and *Quercus pubescens*. The rare species *Bresslaua vorax* was confirmed in the sample of *Cerasus avium*.

Although splitting the communities on the basis of a tree species structure is relatively distinct, we do not have to overrate its effect. Confrontation with other papers (Bartošová et al., 2005) hints at the contradiction. From this point of view a tree species structure is not supposed to play a significant role in forming ciliate communities. Any special relation or differences in species diversity have not been proved even between deciduous and coniferous trees.

Translated by authors

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References

Baláži, P., Matis, D., 2002: The species diversity, seasonal dynamics and trophic relations of the pelagic ciliated protozoa in the selected rivers of Slovakia. Ekológia (Bratislava), *21*, p. 3–14.

Bamforth, S.S., 1973: Population dynamics of soil and vegetation protozoa. Amer. Zool., *13*, p. 171–176.

Bartošová, P., Tirjaková, E., Holecová, M., 2005: The influence of selected factors on the communities of ciliates (Protozoa, Ciliophora) in the decaying wood mass. In Book of Abstracts of the "8th Central European Workshop on Soil Zoology", České Budějovice, Czech Republic, p. 11.

Blatterer, H., Foissner, W., 1988: Beitrag zur terricolen Ciliatenfauna (Protozoa, Ciliophora) Australiens. Stapfia (Linz), *17*, p. 1–84.

Brunberg Nielsen, L., 1968: Investigations on the microfauna of leaf litter in a Danish beech forest. Natura Jutl., *14*, p. 79–87.

Buitkamp, U., 1977: Die Ciliatenfauna der Savanne von Lamto (Elfenbeinküste). Acta Protozool., *16*, p. 249–276.

Corliss, J. O., 1979: The ciliated Protozoa. Characterization, classification and guide to the literature. 2nd ed. Pergamon Press, Oxford–New York–Toronto–Sydney–Paris–Frankfurt, 455 pp.

Dajoz, R., 2000: Insects and forests. The role and diversity of insects in the forest environment. Tec & Doc., Londres–Paris–New York, 668 pp.

Foissner, W., 1981a: Die Gemeinschaftsstruktur der Ciliatenzönose in alpinen Böden (Hohe Tauern, Österreich) und Grundlagen für eine Synökologie der terricolen Ciliaten (Protozoa, Ciliophora). Veröff. Österr. MaB-Programms, *4*, p. 7–52.

Foissner, W., 1981b: Morphologie und Taxonomie einiger neuer und wenig bekannter kinetofragminophorer Ciliaten (Protozoa: Ciliophora) aus alpinen Böden. Zool. Jb. Syst., *108*, p. 264–297.

Foissner, W., 1982: Ökologie und Taxonomie der Hypotrichida (Protozoa: Ciliophora) einiger österreichischer Böden. Arch. Protistenk., *126*, p. 19–143.

Foissner, W., 1984: Infraciliatur, Silberliniensystem und Biometrie einiger neuer und wenig bekannter terrestrischer, limnischer und mariner Ciliaten (Protozoa: Ciliophora) aus den Klassen Kinetofragminophora, Colpodea und Polyhymenophora. Stapfia (Linz), *12*, p. 1–165.

Foissner, W., 1985: Klassifikation und Phylogenie der Colpodea (Protozoa: Ciliophora). Arch. Protistenk., *129*, p. 239–290.

Foissner, W., Peer, T., Adam, H., 1985: Pedologische und protozoologische Untersuchung einiger Böden des Tullner Feldes (Niederösterreich). Mitt. öst. bodenk. Ges., *30*, p. 77–117.

Foissner, W., 1987a: Faunistische und taxonomische Notizen über die Protozoen des Fuscher Tales (Salzburg, Österreich). Jber. Haus der Natur, Salzburg, *10*, p. 56–68.

Foissner, W., 1987b: Neue terrestrische und limnische Ciliaten (Protozoa, Ciliophora) aus Österreich und Deutschland. Sber. Akad. Wiss. Wien, *195*, p. 217–268.

Foissner, W., 1987c: Soil Protozoa: fundamental problems, ecological significance, adaptations in ciliates and testaceans, bioindicators, and guide to the literature. Progr. Protistol., *2*, p. 69–212.

Foissner, W., 1991: Basic light and scanning electron microscopic methods for taxonomic studies of ciliated protozoa. Europ. J. Protistol., *27*, p. 313–330.

Foissner, W., 1993a: Colpodea (Ciliophora). Protozoenfauna Vol. 4/1. Gustav Fischer Verlag, Stuttgart–Jena–New York, 798 pp.

Foissner, W., 1993b: *Corticocolpoda kaneshiroae* n. g., n. sp., a new colpodid ciliate (Protozoa, Ciliophora) from the bark of Ohia trees in Hawaii. J. Euk. Microbiol., *40*, p. 764–775.

Foissner, W., 1994: *Pentahymena corticicola* nov. gen., nov. spec., a new colpodid ciliate (Protozoa, Ciliophora) from bark of Acacia trees in Costa Rica. Arch. Protistenk., *144*, p. 289–295.

Foissner, W., 1996: Faunistics, taxonomy and ecology of moss and soil ciliates (Protozoa, Ciliophora) from Antarctica, with description of new species, including *Pleuroplitoides smithi* gen. n., sp. n.. Acta Protozool., *35*, p. 95–123.

Foissner, W., 1997: Soil ciliates (Protozoa: Ciliophora) from evergreen rain forests of Australia, South America and Costa Rica: diversity and description of new species. Biol. Fertil. Soils, *25*, p. 317–339.

Foissner. W., 1999: Notes on the soil ciliate biota (Protozoa, Ciliophora) from the Shimba Hills in Kenya (Africa): diversity and description of three new genera and ten new species. Biodiv. Conserv., *8*, p. 319–389.

Foissner, W., 2000: A compilation of soil and moss ciliates (Protozoa, Ciliophora) from Germany, with new records and descriptions of new and insufficiently known species. Europ. J. Protistol., *36*, p. 253–283.

Foissner, W., Agatha, S., Berger, H., 2002: Soil ciliates (Protozoa, Ciliophora) from Namibia (Southwest Africa), with emphasis on two contrasting environments, the Etosha Region and the Namib Desert. Part I: Text and line drawings. Denisia, *5*, p. 1–1063.

Gellért, J., 1956: Ciliaten des sich unter dem Moosrasen auf Felsen gebildeten Humus. Acta. Biol. Acad. Sci. Hung., *6*, p. 337–359.

Holecová, M., Zach, P., Kardošová, J., 2002: Epigaeic weevils (Coleoptera, Curculionidea) of oak-hornbeam forest in a vicinity of Bratislava (SW Slovakia) (in Slovak). Folia Faunistica Slovaca, *7*, p. 39–48.

Holecová, M., Lukáš, J., Haviar, M., Harakaľová, E., 2005: Ants (Hymenoptera, Formicidae) as an important part of the epigeic fauna in Carpathian oak-hornbeam forests. In Tajovský, K., Schlaghamerský, J., Pižl, V. (eds): Contributions to Soil Zoology in Central Europe I. ISB AS CR, České Budějovice, p. 31–35.

Laminger, H., 1980: Bodenprotozoologie. Microbios, *1*, p. 1–142.

Lüftenegger, G., Foissner, W., Adam, H., 1985: R- and K-selection in soil ciliates: a field and experimental approach. Oecologia, *66*, p. 574–579.

Lynn, D. H., Corliss, J.O., 1991: Phyllum Ciliophora. In Harrison, F.W., Corliss, J.O. (eds): Microscopic Anatomy of Invertebrates, New York, p. 333–467.

Miteva, D., 1992: A study of Protozoa in communities of *Quercus frainetto* Ten. and *Q. cerris* L. in the northern part of the Strandja Mountain. Godišnik na Sofijiskija Universita „Kliment-Ochridski" Biologičeski Fakulti, *81*, p. 127–132.

Mrva, M., Matis, D., 2000: Rhizopoda in Leaf-litter of Some Localities of Oak-hornbeam Forest in Malé Karpaty Mts (Western Slovakia) (in Slovak). Folia Faunistica Slovaca, *5*, p. 1–9.

Mrva, M., 2003: Diversity of active gymnamoebae (Rhizopoda, Gymnamoebia) in dendrotelmae of oak-hornbeam forests in Malé Karpaty Mts (Western Slovakia). Protistology, *3*, p. 121–125.

Nikolyuk, V.F., 1965: Antagonistic interrelationship between some soil protista and certain phyto-pathogenous fungi affecting cotton plants. Progress in Protozool. (Proc. 2nd Int. Congr. Protozool.), *2*, p. 118–119.

Nikolyuk, V.F., 1969: Some aspects of the study of soil protozoa. Acta Protozool., *7*, p. 99–109.

Podani, J., 1993: Syn–tax. Version 5.0. Computer programs for Multivariate Data Analysis in Ecology and Systematics. User's guide. Scientia Publishing. Budapest, 104 pp.

Schwerdtfeger, F., 1975: Ökologie der Tiere. Band III - Synökologie. Verlag Paul Parey, Hamburg–Berlin, 451 pp.

Speight, M.C.D., 1989: Saproxylic invertebrates and their conservation. Council of Europe: Publications and Documents Division, Strasbourg, 81 pp.

Spellerberg I.F., Fedor, P.J., 2003: A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the Shannon-Wiener's index. Global Ecology and Biogeography, *12*, p. 177–179.

Stout, J.D. 1973: The relationship between protozoan populations and biological activity in soils. Am. Zool., *13*, p. 193–201.

Tirjaková, E., Matis, D., 1987: Ciliated protozoa (Ciliophora) from submerged, wet, moist and dry mosses in selected localities of Slovenský raj. Acta Fac. Rerum Nat. Univ. Comenianae Zool., *29*, p. 1–16.
Tirjaková, E., 1988: Structures and dynamics of communities of ciliated protozoa (Ciliophora) in field communities. 1. Species composition, group dominance, communities. Biológia, Bratislava, *43*, p. 479–503.
Tirjaková, E., 1997: Structure and dynamics of communities of ciliated Protozoa (Ciliophora) in field communities. Succession, genus-species relationships, nutrition. Ekológia (Bratislava), *16*, p. 243–252.
Tirjaková, E., Mrva, M., Hlúbiková, D., 2002: Ciliophora and Rhizopoda in soil, leaf-litter and mosses of oak-hornbeam forests in the Malé Karpaty Mts (Western Slovakia). In Tajovský, K., Balík, J, Pižl, V. (eds): Studies on Soil Fauna in Central Europe, ISB AS CR, České Budějovice, p. 233–240.
Tirjaková, E., Bartošová, P., 2004: The first record of ciliated protozoa (Protozoa, Ciliophora) from Slovakia in the decaying wood mass (in Slovak). Folia Faunistica Slovaca, *9*, p. 11–20.
Wallwork, J.A., 1976: The distribution and diversity of soil fauna. Academic Press, London, 355 pp.
Wenzel, F., 1953: Die Ciliaten der Moosrasen trockner Standorte. Arch. Protistenk., *99*, p. 70–141.

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Bartošová P., Tirjaková E.: **Vybrané ekologické charakteristiky spoločenstiev nálevníkov** (Protozoa, Ciliophora) **v odumretej drevnej hmote na území Malých Karpát.**

V rokoch 2001–2004 sme v rámci výskumu spoločenstiev nálevníkov v odumretej drevnej hmote odobrali 28 vzoriek drevnej hmoty 14 druhov drevín z územia Malých Karpát. Vo vzorkách sme zaznamenali 58 druhov nálevníkov, z ktorých 9 sme zistili na území Slovenska prvýkrát. Okrem druhového spektra sme študovali zastúpenie systematických tried, potravné, rodovo–druhové vzťahy a formovanie spoločenstiev v závislosti od druhu dreviny. Zo systematických tried prevažovali zástupcovia triedy Colpodea a z potravných skupín bakteriovory. Maximálny počet druhov (8) sme zaznamenali v rode *Colpoda*. Hierarchická klasifikácia podľa identity druhového zastúpenia nálevníkov na jednotlivých druhoch drevín vyčlenila dve výrazné spoločenstvá. Napriek tomu druh dreviny pravdepodobne nezohráva významnú úlohu pri formovaní spoločenstiev nálevníkov. Nezistili sme dokonca ani osobitnú väzbu resp. odlišnosť druhového spektra medzi listnatými a ihličnatými drevinami.

DIVERSITY OF ACTIVE GYMNAMOEBAE (Rhizopoda, Gymnamoebia) IN MOSSES OF THE MALÉ KARPATY MTS (SLOVAKIA)

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Abstract

Mrva M.: Diversity of active gymnamoebae (Rhizopoda, Gymnamoebia) in mosses of the Malé Karpaty Mts (Slovakia). Ekológia (Bratislava), Vol. 24, Supplement 2, p. 51–58.

In the period of 2000–2002 the fauna of active naked amoebae (Rhizopoda, Gymnamoebia) was studied in mosses at five sites in oak-hornbeam forests of the Malé Karpaty Mts (Slovakia). The dry sample material was moistened by distilled water and after 5 days of incubation the amoebae were identified by direct examination. Identification of amoebae was performed on the base of morphological characters of the active stages. Relatively high diversity of 32 taxa of naked amoebae was recorded. The diversity at the sites varied from 17 to 23 taxa. The highest richness appeared in the family Thecamoebaidae (9 species), however some other families – Hartmannellidae, Vannellidae and Paramoebidae were significantly represented as well. The observed community of species of naked amoebae in mosses indicate considerable similarity to freshwater communities.

Key words: Gymnamoebia, moss, diversity, Slovakia, oak-hornbeam forests

Introduction

Terrestrial habitats are recognised as specific freshwater ecosystems because active stages of protists always depend on presence of water (e.g. Bamforth, 1980; Finlay et al., 2000). Generally, higher moisture enhances the species diversity (Bamforth, 1973).

Modern studies of diversity of naked amoebae were focused mainly on water habitats. Some of them refer to freshwater (Smirnov, Goodkov, 1996) or sea (Butler, Rogerson, 2000). In terrestrial habitats quantity of amoebae has been analysed (Singh, 1946; Bischoff, Anderson, 1998; Anderson, 2000), however their systematic diversity in these habitats remains practically unknown. Recently only Brown, Smirnov (2004) have brought several results from a study on diversity of Gymnamoebia in soil.

The differences between the fauna in freshwater and in terrestrial habitats are well known for ciliates, which have formed specific morphological and physiological