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MOSS INHABITING SILICEOUS ALGAE FROM HUNGARIAN PEAT BOGS

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Comparative analysis of LM and SEM documentation of Bacillariophyceae and Chrysophycean stomatocysts inhabiting peat mosses revealed new results for these groups. 97 diatom taxa and some Chrysophycean stomatocyst types were identified on 13 peat moss species from 11 localities. 6 diatoms are new records for Hungary. The alarming diminishing of the mires' territory in the Carpathian Basin encouraged us to contribute to the knowledge and document siliceous algae living here. The data on Chrysophycean stomatocysts from Hungarian peat bogs are published for the first time. The high species diversity in *Eunotia* and *Pinnularia* was characteristic to the diatom vegetation of the mires.

Key words: bogs, bryophytic diatoms, Chrysophycean stomatocysts, coexistence, mires

INTRODUCTION

Peat bogs possess important ecological properties, far in excess of their spatial extent. Moreover, their territory is expected to diminish in response to drying up related to anthropogenic and climatic factors. Nutrient-poor peat bogs are one of the most important centres for maintaining the biodiversity of sensitive to eutrophication algae but unfortunately also one of the most threatened oligotrophic biotopes in Europe.

Yet, although mires have received some attention of almost every Hungarian algologist, and they have published some indispensable data on the algae of the mires, the knowledge of these biota still remained very incomplete. Such works include the most comprehensive elaboration of UHERKOVICH (1979), BORICS (2001), and BORICS *et al.* (2003).

The mires with their rich moss vegetation provide excellent opportunity to study the coexistence of mosses and their algal assemblages. The term of "bryophytic diatoms" was first recommended by JOHANSEN (1999) on the basis of the apparent uniqueness of the diatoms living in association with mosses.

Data on this subject have been accumulated as shown by numerous publications dealing with the "bryophytic" or moss diatoms (*e.g.* ANDO 1978, MAYAMA 1993, CANTONATI 2001, BERTRAND *et al.* 2004), though the intensive studies

were mainly restricted to the treeless Arctic and Antarctic regions (*e.g.* VAN DE VIJVER and BEYENS 1997, ALFINITO *et al.* 1998, DOUGLAS and SMOL 1995, 1999). Only a few Hungarian records are available about moss inhabiting algae (reviewed in BUCZKÓ 2003). To catch up with this field, as an initial step, a study of the diatoms living on peat mosses was recently undertaken.

In the planning process of the present study about the coexistence of algae and peat mosses an excellent opportunity was offered by the ongoing detailed survey on Hungarian peat mosses. The occurrences and changes of the distribution of *Sphagna* have been summarised by SZURDOKI and NAGY (2002), and SZURDOKI (2003). On the basis of these contributions in the present algological study we attempted to obtain wide spectra about the distribution of siliceous algae living on *Sphagna* and some other peat mosses. The dataset of mosses within the study consisted of 13 taxa from 11 localities, representing the most characteristic mires of Hungary.

Initially, the primary aim was to contribute to the knowledge of bryophytic diatoms in mires, but the presence and – in some cases the high abundance of Chrysophycean cysts – drew our attention to the distribution of the latter as well.

Chrysophytes (Chrysophyceae and Synurophyceae) are a common and diverse group of peat bog algae. They produce siliceous structures such as diatom's frustules, chrysophyte scales, and stomatocysts. Due to species-specific environmental preferences (sensitivity) they are also useful markers in biomonitoring. Chrysophycean cysts have been intensively studied during the last two decades all over the world and used in palaeoenvironmental reconstruction which has been greatly assisted by increasing availability of SEM studies.

In Hungary, there are only a few brief reports on Chrysophycean stomatocyst, usually only referring to their coexistence with diatoms or other algae (VÍZKELETY 1987, UHERKOVICH 1979). The present paper would like to provide some of the first SEM images of this unique group largely unknown from Hungarian mires to date.

MATERIAL AND METHODS

Siliceous algae from 11 locations were sampled (Fig. 1). Location and habitat descriptions of the mires, their present conservation status and the sampling procedure applied have been described in ÓDOR *et al.* (1996), SZURDOKI and NAGY (2002), and SZURDOKI (2003).

The mosses were collected and identified by E. Szurdoki between 1993 and 1995, as a part of her PhD study. Some complementary collections were carried out in 2003.

Sampling method: we soaked dry samples (herbarium specimens) in water and washed them to get the diatom samples. The diatoms were treated with H_2O_2 in order to remove the organic material, after which the preparata were embedded into Zrax. For LM, a Leica DM LB2 was used with HCX

Plan Apo ×100/1.35, with a Nikon Optiphot and Nikon FX-35 photomicroscopy. SEM was performed with a Hitachi S-2600N.

We followed the nomenclature of KRAMMER and LANGE-BERTALOT (1986–1991), the volumes of Diatoms of Europe (KRAMMER 2000, LANGE-BERTALOT 2001) and some others (LANGE-BERTALOT and METZELTIN 1996, WOJTAL 2004, WOJTAL *et al.* 1999). For Chrysophycean stomatocysts the Atlas of cysts (DUFF *et al.* 1995, WILKINSON *et al.* 2001), and Pla's monograph (PLA 2001) were used.

List of host species and sampling dates in the order of the sizes of the mires

Bábtava (raised bog, pH = 3.9–4.8): *Calliergon cordifolium*, 04.03.1995; *Sphagnum palustre*, 04.03.1995 and 26.03.1995.

Nyíres-tó (basin fen, pH = 4–4.5): *Sphagnum fimbriatum*, 31.03.1994; *Calliergon cordifolium*, *S. angustifolium*, *S. palustre*, 06.03.1995.

Kelemér 1. Nagy-Mohos-tó (raised bog, pH = 3.7–3.9): *Sphagnum fallax*, *S. squarrosum*, 08.03.1994; *S. palustre*, 08.03.1994 and 21.03.1995; *S. angustifolium*, 08.03.1995; *Aulacomnium palustre* and *S. fimbriatum*, 21.03.1995.

Kelemér 2. Kis-Mohos-tó (raised bog, pH = 3.7–3.8): *Sphagnum palustre*, 08.03.1995; *S. magellanicum*, 11.03.1995 and 15.03.1995; *Polytrichum commune*, 16.04.1995; *Dicranum scoparium*, *Pleurozium schreberi*, *S. angustifolium*, 12.03.1995 and 16.04.1995.

Sirok, Nyírjes-tó (raised bog, pH = 3.9–4.3): *Sphagnum angustifolium*, *S. fimbriatum*, *S. magellanicum*, *S. palustre*, 15.03.1995; *Aulacomnium palustre*, 16.04.1995.

Kőszeg, Nagyláp (no pH data is available): *Sphagnum angustifolium*, *S. fimbriatum*, *S. palustre*, *S. squarrosum*, 15.10.1994.

Farkasfa 1. Fekete-tó (basin fen, pH = 4): *Sphagnum palustre*, 19.07.1994.



Fig. 1. Sampling locations.

Table 1. The relative frequency of diatoms in the studied mires. Threatened categories (TC): EN = "endangered taxa", VU = "vulnerable", LR = "low risk", PR = "presumably endangered". Taxa were only found in additional study are marked by "x". Localities: Bábtava = B, Nyíres-tó = Ny, Kis-Mohos-tó = KM, Nyírjes-tó = Njt, Nagyláp (Kőszeg) = NK, Grajka-patak = GP, Szakonyfalvi-patak = SP, Felsőszölnök = FS

Taxa	TC	B	Ny	KM	Njt	NK	GP	SP	FS
Achnanthes cf. laevis Oestrup		0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0
Achnanthidium minutissimum (Kütz.) Czarnecki		0.0	3.0	2.4	0.3	0.0	0.0	0.5	0.0
Achnanthes subatomoides (Hustedt) Lange-Bert. et Archibald		0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Adlafia bryophila (J. B. Petersen) G. Moser, H. Lange-Bert. et Metzeltin (= *Navicula bryophila* Petersen)		0.0	0.0	0.0	1.5	0.1	**11.0**	**15.5**	0.0
Amphora lybica Ehr.		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Amphora pediculus (Kütz.) Grun.		0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Aulacoseira granulata (Ehr.) Sim.		0.0	0.0	2.4	0.9	0.0	0.0	1.6	0.0
Brachysira brebissonii Ross (= *Anomoeoneis brachysira* (Bréb.) Grun.)		0.0	0.0	0.0	3.3	0.4	0.0	0.0	0.0
Caloneis aerophila Bock		0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.9
Chamaepinnularia mediocris (Krasske) Lange-Bert. (= *Navicula mediocris* Krasske)		0.0	0.0	0.0	0.0	0.0	**37.9**	**42.5**	0.0
Chamaepinnularia soehrensis (Krasske) Lange-Bert. var. *hassaica* (Krasske) Lange-Bert. (= *Navicula soehrensis* Krasske var. *hassaica* (Krasske) Lange-Bert.)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Chamaepinnularia soehrensis (Krasske) Lange-Bert. et Krammer var. *soehrensis* (Krasske) Lange-Bert. (= *Navicula soehrensis* Krasske var. *soehrensis*)		0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
Cocconeis pediculus Ehr.		0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Cocconeis placentula Ehr. var. *placentula*		0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Cocconeis placentula Ehr. var. *lineata* (Ehr.) Van Heurck		0.0	2.2	1.2	0.0	0.0	0.0	0.0	0.0
Cyclotella meneghiniana Kütz.		0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Cyclotella ocellata Pant.		0.0	0.0	0.0	x	0.0	0.0	0.0	0.0
Cymbella cf. gaeumannii Meister		0.0	0.0	0.0	2.1	0.7	0.6	0.0	0.0
Cymbella minuta Hilse ex Rabenh.		0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0
Cymbopleura naviculiformis (Auerswald) Krammer (= *Cymbella naviculiformis* Auerswald)		0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0

Table 1 (continued)

Taxa	TC	B	Ny	KM	Njt	NK	GP	SP	FS
Encyonema mesiana (Cholnoky) D. G. Mann (= *Cymbella mesiana* Cholnoky)	**VU**	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eolimna minima (Grun.) Lange-Bert. (= *Navicula minima* Grun.)		4.9	5.6	0.0	0.6	0.0	0.0	0.0	0.0
Epithemia adnata (Kütz.) Bréb.		0.6	0.0	0.0	x	0.0	0.0	0.0	0.0
Eunotia arcus Ehr.		1.9	0.0	0.0	0.0	0.0	2.7	0.0	3.8
Eunotia bilunaris (Ehr.) Mills var. *bilunaris*		**10.5**	1.1	0.0	1.8	0.0	1.5	0.0	0.0
Eunotia bilunaris (Ehr.) Mills var. *mucophila* Lange-Bert. et Noerpel		1.9	**34.6**	0.0	0.0	0.0	0.6	0.0	**56.6**
Eunotia exigua (Bréb.) Rabenh. var. *exigua*		0.0	0.0	0.0	0.0	0.0	**15.8**	**18.1**	0.0
Eunotia exigua (Bréb.) Rabenh. var. *tridentula* Oestrup		0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
Eunotia groenlandica (Grun.) Noerpel-Schempp et Lange-Bert.		0.0	0.0	0.0	0.3	0.1	0.2	0.0	0.0
Eunotia implicata Noerpel, Lange-Bert. et Alles		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Eunotia lapponica Grun. ex Cl.		0.0	0.0	0.0	**13.1**	0.0	2.3	**10.9**	**29.2**
Eunotia meisteri Hustedt	**EN**	0.0	0.0	0.0	0.6	0.0	0.8	0.5	0.0
Eunotia microcephala Krasske		0.0	0.0	0.0	0.0	0.4	3.8	0.0	3.8
Eunotia minor (Kütz.) Grun.		0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Eunotia paludosa Grun.	**VU**	0.0	**10.6**	**80.7**	**16.4**	**93.6**	1.0	0.0	0.0
Eunotia paralella Ehr.		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Eunotia cf. praerupta Ehr.	**VU**	0.0	0.0	0.0	0.3	0.0	0.0	0.5	0.0
Eunotia rhomboidea Hustedt	**VU**	0.0	0.2	0.0	1.5	0.0	0.2	0.0	0.0
Eunotia steineckei Petersen		0.0	5.4	0.0	**11.2**	0.0	**10.5**	0.0	0.0
Eunotia trinacria Krasske		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Fragilaria capucina Desm. var. *amphicephala* (Grun.) Lange-Bert.	**LR**	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Fragilaria tenera (W. Smith) Lange-Bert.	**PR**	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria virescens Ralfs	**PR**	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Frustulia crassinerva (Bréb.) Lange-Bert. et Krammer		0.0	0.0	0.0	x	0.0	1.3	1.6	0.0
Frustulia saxonica Rabenh.		0.0	0.0	0.0	2.7	1.8	0.6	0.0	0.0
Gomphonema acuminatum Ehr.		0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema angustatum (Kütz.) Rabenh.		2.5	x	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema clavatum Ehr.		**26.5**	1.1	0.0	0.3	0.0	0.0	0.0	0.0
Gomphonema gracile Ehr.		**10.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1 (continued)

Taxa	TC	B	Ny	KM	Njt	NK	GP	SP	FS
Gomphonema micropus Kütz.		0.0	0.0	0.0	0.0	0.0	x	0.0	0.0
Gomphonema olivaceum (Hornem.) Bréb. var. *calcareum* (Cl.) Cl.		x	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema parvulum (Kütz.) Kütz.		0.6	0.6	0.0	0.3	0.0	0.0	0.0	0.0
Gomphonema pumilum (Grun.) Reichardt et Lange-Bert.		0.0	1.1	0.0	0.3	0.0	0.2	0.0	0.0
Hantzschia amphioxys (Ehr.) Grun.		0.0	0.2	0.0	5.5	x	0.0	0.0	0.0
Hantzschia elongata (Hantzsch) Grun.	**EN**	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hippodonta hungarica (Grun.) Lange-Bert., Metzeltin et Witkowski (= *Navicula hungarica* Grun., *Navicula capitata* Ehr. var. *hungarica* (Grun.) Ross)		0.0	0.2	0.0	0.3	0.0	0.0	0.5	0.0
Kobayasiella subtilissima (Cl.) Lange-Bert. (= *Navicula subtilissima* Cl.)	**EN**	0.0	0.0	0.0	**17.3**	0.0		0.0	0.0
Kobayasiella sp.		0.0	0.0	0.0	0.0	0.0	x	0.0	0.0
Lemnicola hungarica (Grun.) Round et Basson (= *Achnanthes hungarica* (Grun.) Grun.)		1.2	**13.4**	0.0	0.9	0.0	0.2	0.5	2.8
Luticola mutica (Kütz.) D. G. Mann (= *Navicula mutica* Kütz.)		1.9	0.2	0.0		0.0	0.0	0.5	0.0
Mayamaea fossalis (Krasske) Lange-Bert. (= *Navicula fossalis* Krasske)		x	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meridion circulare (Grev.) Ag. var. *constrictum* (Ralfs) Van Heurck		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Navicula gregaria Donkin		0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Navicula phyllepta Kütz.		0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Navicula radiosa Kütz.		0.0	x	0.0	0.0	0.0	0.0	0.0	0.0
Navicula submuralis Hust. *sensu lato*		x	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Naviculadicta sp.		x	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia acidoclinata Lange-Bert.		**15.4**	4.8	0.0	0.6	0.0	0.0	0.0	0.0
Nitzschia capitellata Hust.		0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia fonticola Grun.		0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia microcephala Grun.		0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia cf. perminuta (Grun.) Peragallo		0.0	6.5	0.0	0.0	0.0	0.0	1.0	0.0
Nitzschia terrestris (Petersen) Hust.		0.0	0.0	0.0	0.3	0.0	1.0	0.0	0.0
Pinnularia biceps Gregory		0.0	0.0	0.0	1.2	0.3	0.0	0.5	0.0
Pinnularia borealis Ehr. var. *borealis*		0.0	0.0	0.0	1.5	0.0	0.4	0.0	0.0
Pinnularia borealis Ehr. var. *scalaris* (Ehr.) Grun.		0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

Table 1 (continued)

Taxa	TC	B	Ny	KM	Njt	NK	GP	SP	FS
Pinnularia esoxiformis Fusey		0.6	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Pinnularia microstauron (Ehr.) Cl. var. *microstauron*		0.0	0.2	0.0	2.4	0.4	0.0	0.0	0.0
Pinnularia microstauron (Ehr.) Cl. var. *brébissonii* (Kütz.) Mayer (= *Pinnularia brébissonii* Kütz.)		0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0
Pinnularia neomajor Krammer		2.5	0.0	0.0	0.0	0.5	0.6	0.0	0.0
Pinnularia silvatica Petersen		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Pinnularia sinistra Krammer		0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Pinnularia stomatophora (Grun.) Cl.		0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Pinnularia subcapitata Greg. var. *subcapitata*		0.0	0.0	0.0	0.0	0.3	1.1	0.0	0.0
Pinnularia subcapitata Greg. var. *elongata* Krammer		0.6	3.0	1.2	2.4	0.5	1.3	0.5	0.0
Pinnularia subgibba Krammer		0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Pinnularia transversa (A. Smith) A. Mayer		0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Pinnularia viridiformis Krammer morphotype 5.		1.9	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Pinnularia viridis (Nitzsch) Ehr.		0.0	0.2	0.0	0.3	0.1	0.6	0.5	0.9
Psammothidium chlidanos (Hohn et Hellerman) Lange-Bert. (= *Achnanthes chlidanos* Hohn et Hellerman)		0.0	0.0	0.0	x	0.0	0.0	0.0	0.0
Rhoicosphenia abbreviata (Ag.) Lange-Bert.		0.0	0.0	1.2	0.6	0.0	0.0	0.0	0.0
Sellaphora seminulum (Grun.) Mann (= *Navicula seminulum* Grun.)		x	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stauroneis anceps Ehr.		0.0	0.0	0.0	0.0	0.0	x	2.6	0.0
Stauroneis kriegerii Patrick		**12.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stenopterobia delicatissima (Lewis) Bréb.		0.0	0.0	0.0	0.9	0.0	0.2	0.0	0.0
Stephanodiscus sp.		0.0	0.0	0.0	x	0.0	0.0	0.0	0.0
Tabellaria flocculosa (Roth) Kütz.		0.0	0.0	0.0	1.8	0.2	0.0	0.0	0.0
Sum of counted valves		162	463	83	329	941	525	193	106
Number of taxa		26	31	13	46	17	36	19	8

Farkasfa 2. Ördög-tó (basin/floodplain fen, pH = 5): *Sphagnum fallax*, 1994.07.28.

Grajka-patak (no pH data is available): *Sphagnum angustifolium*, *S. fallax*, *S. obtusum*, summer of 1993; *S. angustifolium*, 31.03.1994; *S. subsecundum*, 21.07.1994.

Szakonyfalvi-patak (no pH data is available): *Sphagnum fallax*, *S. obtusum*, 20.09.1993; *S. subsecundum*, 04.09.1994.

Felsőszölnök (no pH data is available): *Sphagnum angustifolium*, 25.07.1994.

RESULTS

Altogether 97 diatom taxa were identified during the study (Table 1). Species composition of diatom assemblages was similar to that seen in other peat bogs' diatom studies, with the highest species diversity in *Eunotia* (15 species and 2 varietas) and *Pinnularia* (13 species and 3 varietas). They occurred in every sample location, however they were not dominant in each.

As is typical of periodically drying up aerophytic habitats such aerophytic diatoms as *Pinnularia borealis*, *Hantzschia amphioxys*, *Adlafia bryophila*, and *Mayamaea fossalis* were present in some localities (mainly Nyíres-tó, Nyírjes-tó, Gajka-patak, Szakonyfalvi-patak).

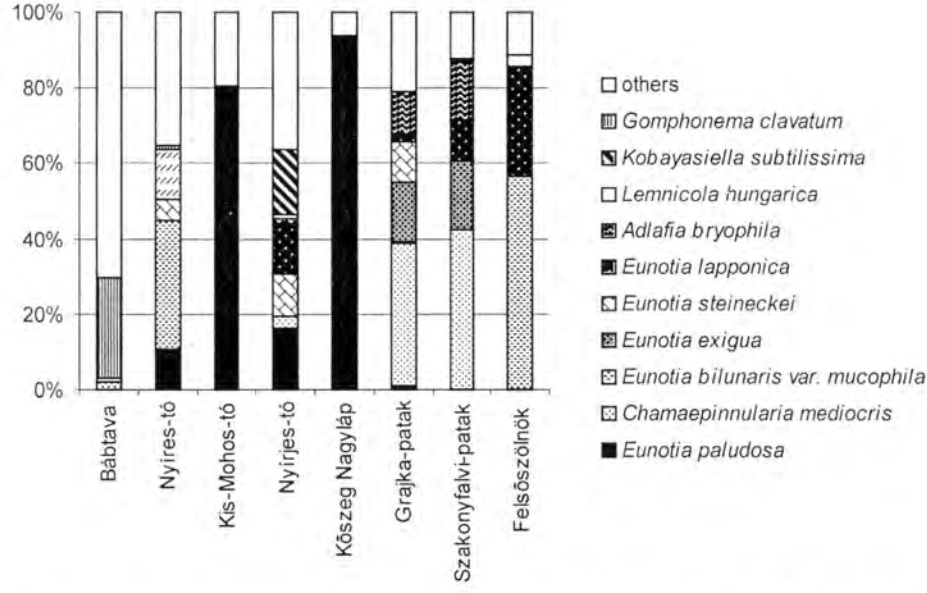


Fig. 2. The relative abundance of the dominant diatoms of peat moss periphyton in the studied mires. See also Table 1.

According to the card file collection "Flora et Iconographia Algarum Hungariae" (BUCZKÓ and RAJCZY 1998) 6 taxa are new for the Hungarian flora.

Psammothidium chlidanos (Hohn et Hellerman) Lange-Bert. (Fig. 12): Valve length 14 µm, width 4 µm, 25–26 striae per 10 µm. Prefers oligotrophic waters with low mineral content. It was found in Sirok on *Sphagnum fimbriatum*.

Mayamaea fossalis (Krasske) Lange-Bert. (Fig. 34): Valve length 9.5 µm, width 3.5 µm, 23 striae per 10 µm. Aerophilous, typical of predominantly intermittently wet habitats. Cosmopolitan; according to LANGE-BERTALOT (2001) "locally populations with very high individual numbers". Here, it may be regarded as a bryophytic diatom, in our samples only one valve was found at Bábtava on *Calliergon cordifolium*.

Navicula submuralis Hust. *sensu lato* (Fig. 21): Valve length 7 µm, width 3.5 µm, 25 striae per 10 µm. The observed specimens were smaller than given in the original description. *N. submuralis* was found in Bábtava on *Calliergon cordifolium*.

Stauroneis kriegerii Patrick (Figs 25–26): Valve length 19–21 µm, width 4–4.5 µm, 26–27 striae per 10 µm. Cosmopolitan but usually not abundant, prefers the low concentration of electrolytes, *e.g.* bogs. It was recorded only from Bábtava on *Calliergon cordifolium*, but there more than 12% of the diatoms belonged to *S. kriegerii*.

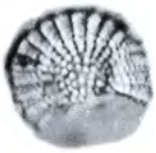
Nitzschia acidoclinata Lange-Bert. (Figs 63–65): Valve length 32–34 µm, width 2.5–3 µm; 34 striae per 10 µm, fibulae 12 per 10 µm. Common in Nyíres-tó and Bábtava.

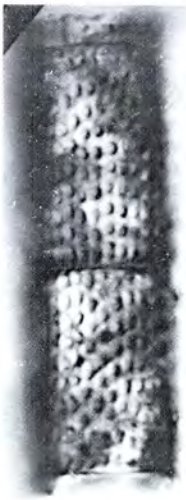
Cymbella cf. gaeumannii Meister (Fig. 42): Valve length 20 µm, width 6 µm, 14 striae in 10 µm. Characteristic for Northern European mires, in oligotrophic waters. It was found in Nagyláp (Kőszeg) on *Sphagnum fimbriatum*.

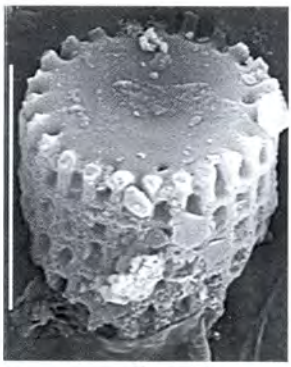
As a first attempt, 10 morphotypes of Chrysophycean stomatocysts could be distinguished during the study. The characteristic types of cysts are presented on Figures 69–81. Figure 69 illustrates the most abundant cysts-like plant being very similar to Stomatocyst S062 (PLA 2001), fitting well with the description. Very similar forms were published from Hungarian mires as *Trachelomonas* species (Longisetae group) (NÉMETH 1997).

On the basis of our present knowledge, it would be premature to name the cysts shown in Figures 70–81. The statospores documented by us resemble Stomatocyst 134 Duff and Smol, Stomatocyst 6 Duff and Smol, Stomatocyst 378 Taylor and Smol, Stomatocyst 91 Duff and Smol. Among the cysts there are some, which are nonspherical, and having no collar, no ornamentation. In other case (Fig. 74) two spherical cysts are and of different size and lacking any collar or ornamentation, the bigger one resembling Stomatocyst 42 Duff and Smol, the smaller one


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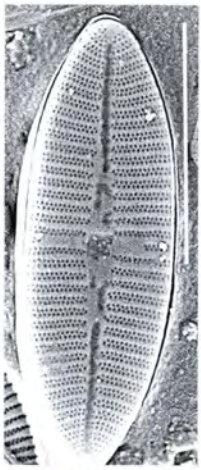

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Stomatocyst 189 Zeeb and Smol. The cyst in Figure 76 is ornamented with regular reticulum, while the one in Figure 77 has a different reticulum.

Two other figures are noteworthy. Figure 79 may be a *Trachelomonas*, while Figure 81 is SCP. SCP (Spheroidal Carbonaceous Particles) is the indicator of air-borne pollution from oil burning, and widely used in palaeolimnological studies. We documented its presence in Nagyláp (Kőszeg).

Csaroda, Bábtava: Associated to the 3 studied peat moss species 26 diatom taxa could be listed. The abundance values were low. The flora and the dominant taxa were markedly different from those of the other localities and their "usual" peat bog flora and vegetation. The most abundant were *Gomphonema clavatum* (Table 1, Fig. 2) and *Lemnicola hungarica*. In the material from this peat bog we recorded also *Hantzschia elongata* a rarely reported taxon from Hungary (NÉMETH 2005). The Shannon diversity of diatoms is 3.38. The ratio of cysts is 2% (expressed to the total of siliceous algae), which may refer to the fact that the algae only hardly form resting spores.

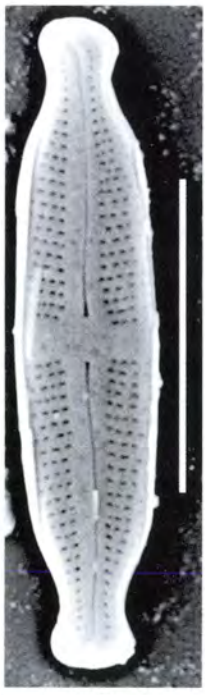
Csaroda, Nyíres-tó: 31 diatoms were identified from the 4 peat moss samples (Table 1, Fig. 2), *Eunotia bilunaris* var. *mucophila* was dominant, but the high abundance of the two *Nitzschia* species (*N. acidoclinata* and *N. cf. perminuta*) has distinguished the Nyíres bog's diatom vegetation from the other studied mires. The Shannon diversity of diatoms is similar to that of Bábtava, the largest studied mire: here it is also 3.38. The cysts/diatom ratio (expressed to the total of siliceous algae) is 20%.

Kelemér 1. Nagy-Mohos-tó: 7 samples were carefully studied, 6 of them was completely free of siliceous algae. Only on *Sphagnum squarrosum* were found 2 diatom taxa, *Lemnicola hungarica* and *Eunotia paludosa*. The diversity and the portion of cysts could not be calculated.

Kelemér 2. Kis-Mohos-tó: Of the 7 peat moss samples we studied, 4 have supported very poor siliceous algal vegetation. Altogether 85 valves could be found for identification. The most abundant of them was *Eunotia paludosa*, the occurrence of others were sporadical (1 or 2 valves), see Table 1. The ratio of cysts (cysts/sum of siliceous algae) is 88%.

Figs 3–23. Peat moss inhabiting diatoms. The scale bar is 10 μm in every SEM photo except Fig. 9, when it is 5 μm. The magnification of LM pictures are ×1500. 3 = *Cyclotella ocellata* Pant., Nyírjes-tó; 4–5 = *Aulacoseira granulata* (Ehr.) Sim., Nyírjes-tó; 6 = *Stephanodiscus* sp., Nyírjes-tó; 7–9 = *Achnanthidium* minutissimum (Kütz.) Czarnecki, Nyírjes-tó (Figs 7 and 8: LM, ×1500; 9: SEM, scale bar = 5 μm); 10 = *Sellaphora seminulum* (Grun.) Mann, Bábtava; 11 = *Naviculadicta* sp., Bábtava; 12 = *Psammothidium chlidanos* (Hohn and Hellerman) Lange-Bert., Nyírjes-tó; 13–14 = *Tabellaria flocculosa* (Roth) Kütz., Nyírjes-tó; 15–16 = *Eolimna minima* (Grun.) Lange-Bert., Bábtava; 17–20 = *Naviculadicta* or *Caloneis* sp., Bábtava; 21 = *Navicula submuralis* Hust. *sensu lato*, Bábtava; 22–23 = *Lemnicola hungarica* (Grun.) Round et Basson, Nyíres-tó.


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Sirok, Nyírjes-tó: 7 samples were analysed. This algal flora was found the most diverse (Table 1, Fig. 2). Its Shannon diversity was the highest (4.06), as well as the number of taxa: altogether 46 diatoms were found. *Kobayasiella subtilissima* was the most abundant and the most characteristic one. *Brachysira brebissonii* is also a rare diatom in Hungary, here we found it in relatively high numbers (although not shown in Fig. 2). The ratio of cysts/total siliceous algae is 62%.

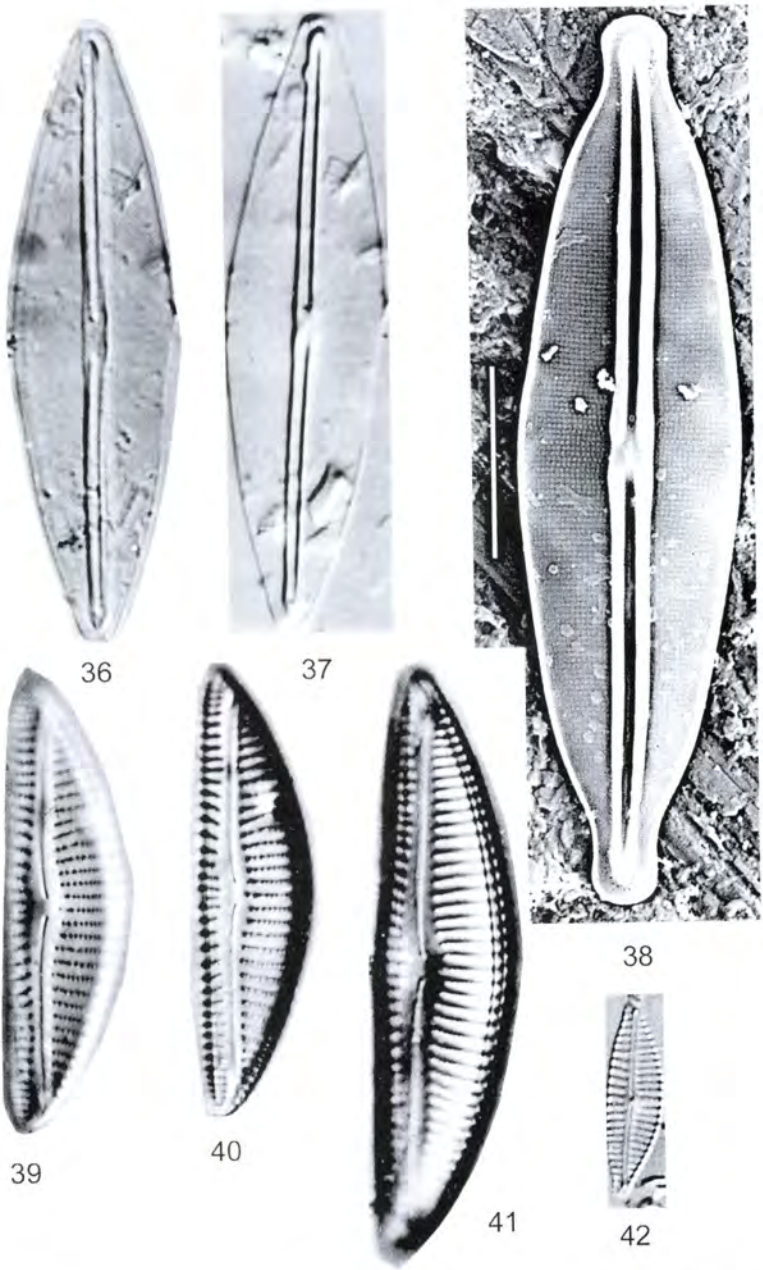
Kőszeg, Nagyláp: On the 5 peat moss samples only 17 taxa could be recorded, *Eunotia paludosa* was dominant, very abundant in every samples. Parallel to its high amount, the Shannon diversity of the diatoms is low in that locality, accurately 0.56. Only the genus *Pinnularia* (8 taxa) could contribute remarkably to the number of taxa. *Frustulia saxonica*, *Cymbella cf. gaeumannii* are also characteristic peat bog diatoms here. The ratio of cysts/total siliceous algae is somewhat less than 1%. In spite of this fact diversified flora of variable cysts were found here (Figs 70–81).

Farkasfa 1. Fekete-tó: Despite the careful investigation only a few diatom valves were recorded belonging to *Eunotia groenlandica* and *Eunotia paludosa*. Fekete-tó cannot be considered typical since it desiccated due to recent dry periods which may led to the high amounts of stomatocysts, as the Chrysophytes appeared to prepare for the resting stage. The ratio of cysts/total siliceous algae is 99%! Borics also reported a very poor diatom community of Fekete-tó, found only 2 diatom species on *Sphagna* (BORICS 2001).

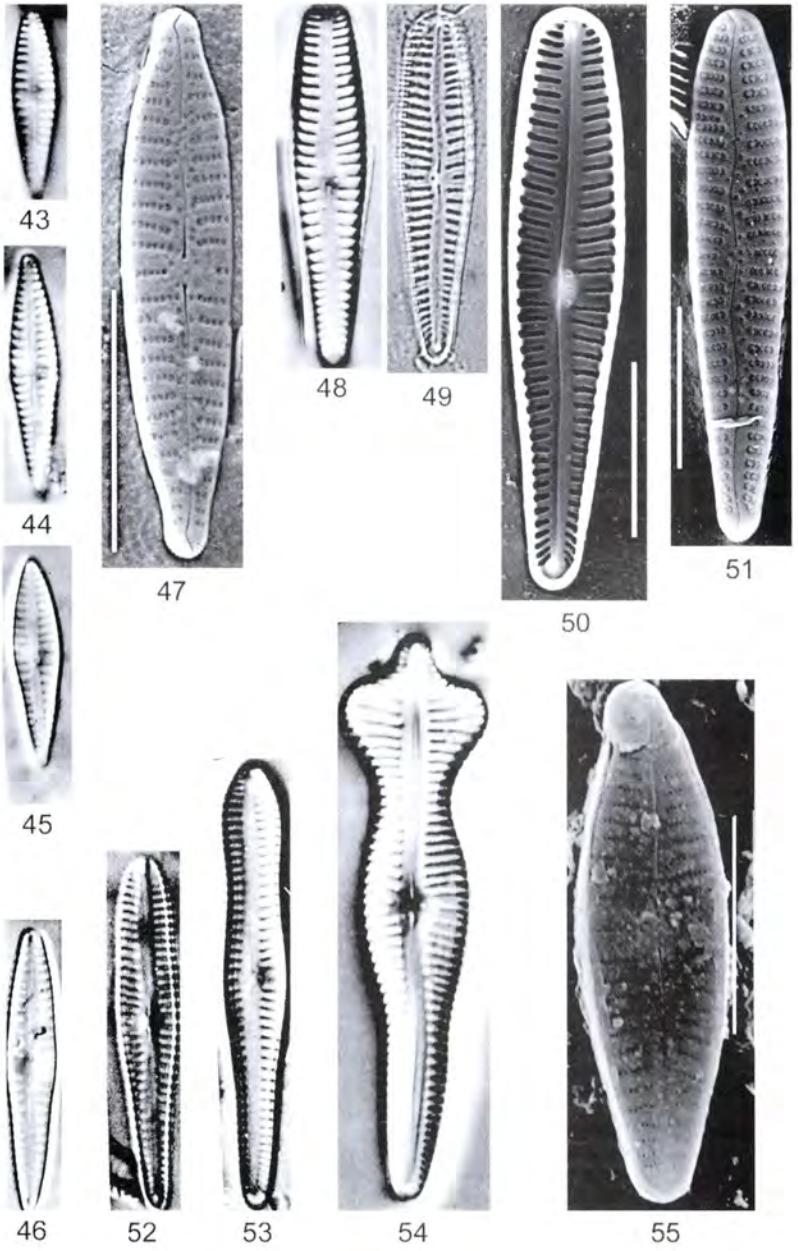
Farkasfa 2. Ördög-tó: Only two single valves of *Eunotia bilunaris* var. *mucophila* were found from this locality, with a single stomatocyst. Naturally, it would be unreasonable to calculate the diversity and the portion of cysts. Only 7 diatom taxa were recorded from peat mosses from this location (BORICS 2001).

Grajka-patak: 36 diatom taxa were recorded from 5 mosses. *Chamaepinnularia mediocris*, a small diatom was dominant, along with *Eunotia exigua*. Borics gave an account of 37 diatom taxa from peat mosses living at Grajka-patak. The almost perfect coincidence must be accidental, but the high number of taxa may refer to the stability of this habitat. The value of Shannon diversity is 3.19. The ratio of cysts/total siliceous algae is low: 4%.

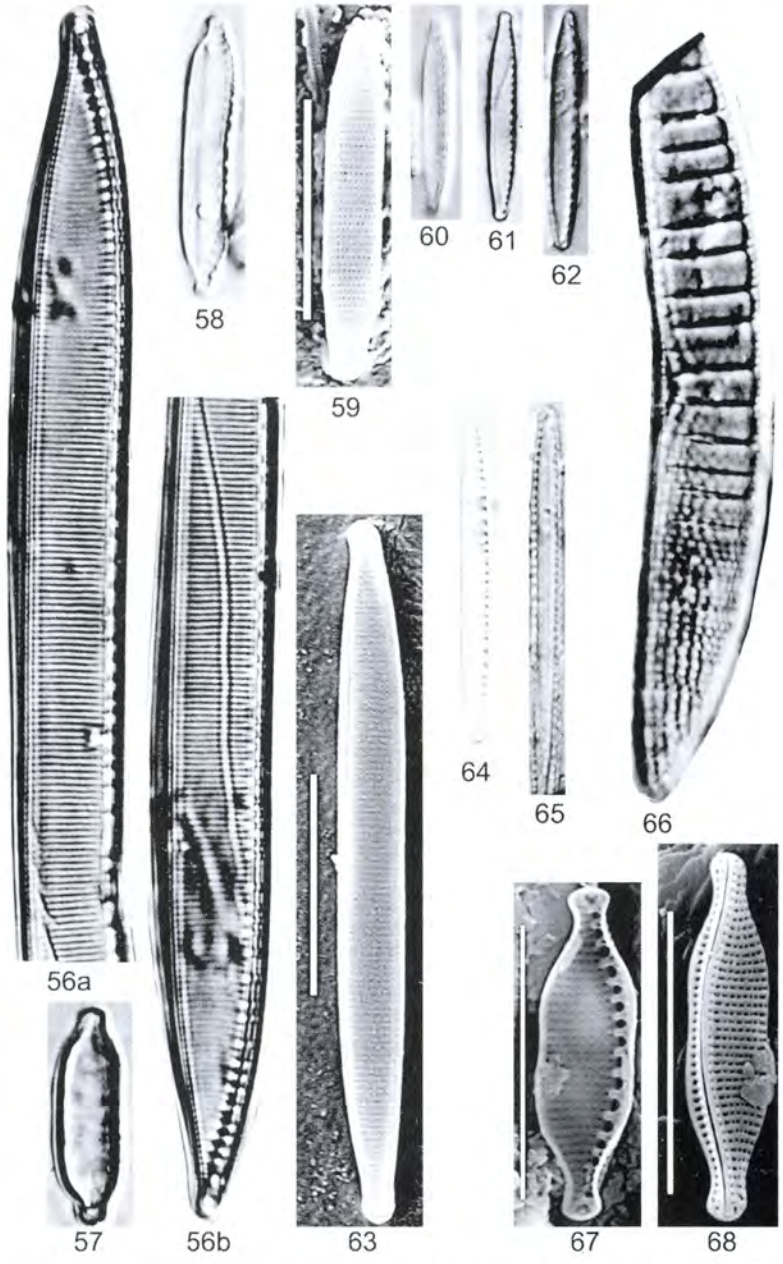
Figs 24–35. Peat moss inhabiting diatoms. The scale bar is 10 μm in every SEM photo. The magnification is ×1500 except Fig. 24 = *Stauroneis anceps* Ehr., Grajka-patak; 25–26 = *Stauroneis kriegerii* Patrick, Bábtava; 27–28 = *Kobayasiella* sp. 27: Grajka-patak, 28: Nyírjes-tó; 29 = *Kobayasiella subtilissima* (Cl.) Lange-Bert., Nyírjes-tó; 30 = *Hippodonta hungarica* (Grun.) Lange-Bert., Metzeltin et Witkowski, Nyíres-tó; 31 = *Luticola mutica* (Kütz.) D. G. Mann, Nyírjes-tó; 32–33 = *Brachysira brebissonii* Ross morphotype 1, Nyírjes-tó, Kőszeg; 34 = *Mayamaea fossalis* (Krasske) Lange-Bert., Bábtava; 35 = *Navicula radiosa* Kütz., Nyíres-tó (LM, ×900).



Figs 36–42. Peat moss inhabiting diatoms. 36–37 = *Frustulia saxonica* Rabenh., Nyírjes-tó (LM, ×900); 38 = *Frustulia crassinerva* (Bréb.) Lange-Bert. et Krammer, Nyírjes-tó. (SEM, scale bar = 10 μm); 39–41 = *Encyonema mesiana* (Cholnoky) D. G. Mann, Bábtava (LM, ×1500); 42 = *Cymbella cf. gaeumannii* Meister, Kőszeg (LM, ×1500).



Figs 43–55. Peat moss inhabiting diatoms. The scale bar is 10 µm in every SEM photo. The magnification is ×1500. 43–47 = *Gomphonema angustatum* (Kütz.) Rabenh., 43–46: Bábtava, 47: Nyíres-tó. 48–51 = *G. clavatum* Ehr., 48–50: Nyíres-tó, 51: Bábtava; 52 = *G. olivaceum* (Hornem.) Bréb. var. *calcareum* (Cl.) Cl., Bábtava; 53 = *G. clavatum* Ehr., Bábtava; 54 = *G. acuminatum* Ehr., Bábtava; 55 = *G. micropus* Kütz., Grajka-patak.



Figs 56–68. Peat moss inhabiting diatoms. The scale bar is 10 µm in every SEM photo. The magnification is ×1500 except Figs 56 and 66. 56 = *Hantzschia elongata* (Hantzsch) Grun., Bábtava (LM, ×600); 57–58 = *H. amphioxys* (Ehr.) Grun., 57 = Kőszeg, 58 = Nyírjes-tó; 59–62 = *Nitzschia cf. perminuta* (Grun.) Peragallo, Nyíres-tó; 63–65 = *N. acidoclinata* Lange-Bert., Nyíres-tó; 66 = *Epithemia adnata* (Kütz.) Bréb., Nyírjes-tó (LM, ×900); 67–68 = *N. microcephala* Grun., Nyíres-tó.

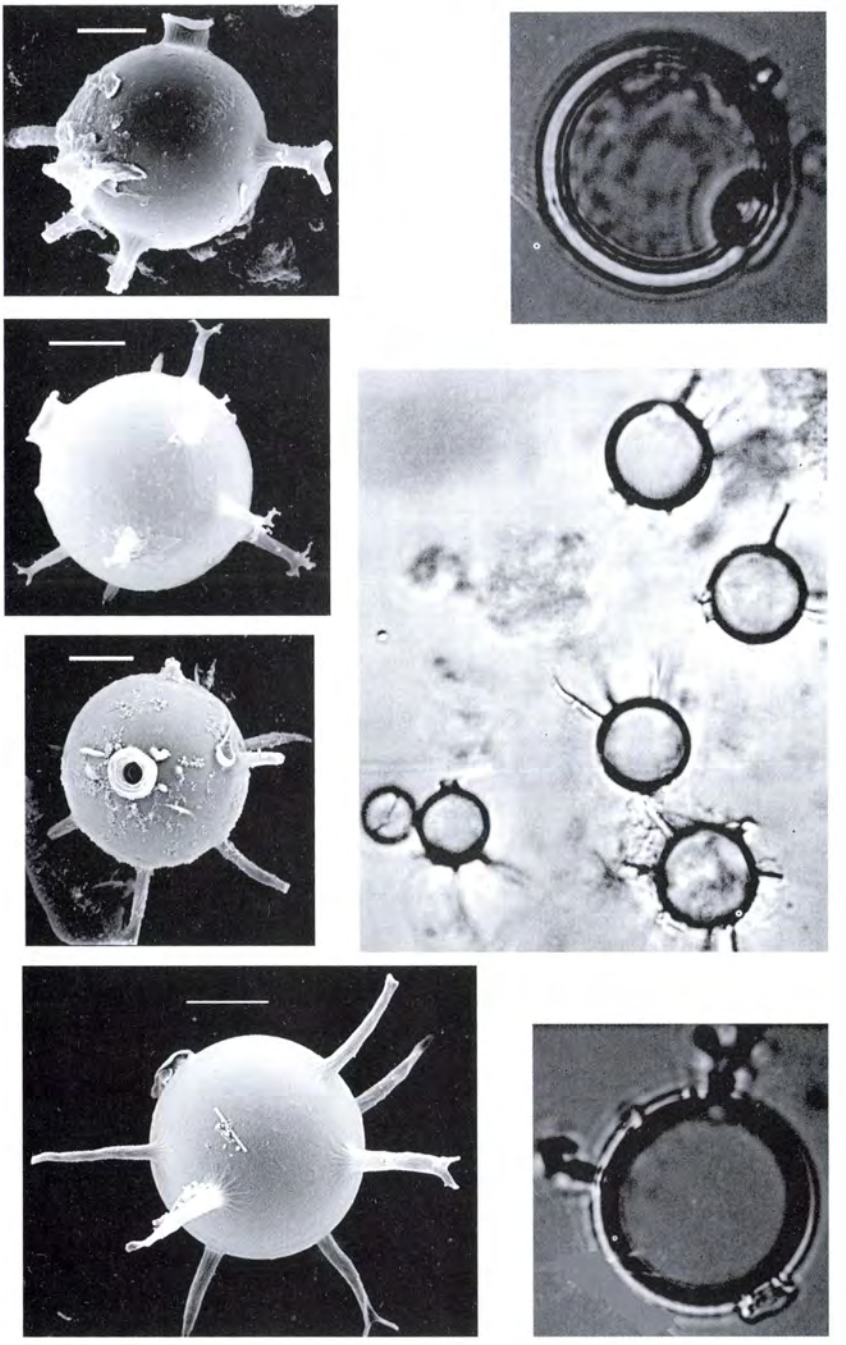
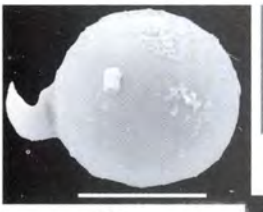


Fig. 69. The most common "cyst" resembling Stomatocysts S062, Fekete-tó and Nagyláp (Kőszeg). (SEM, scale bar = 5 μm).



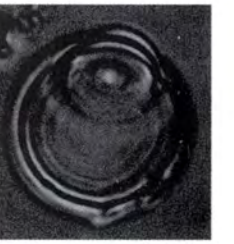
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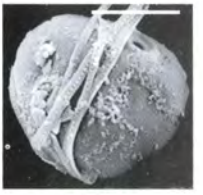
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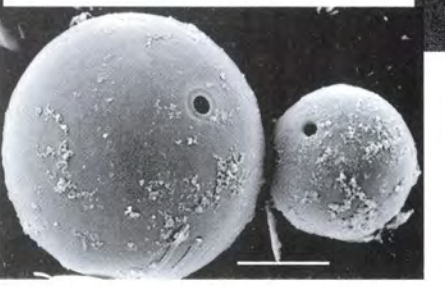
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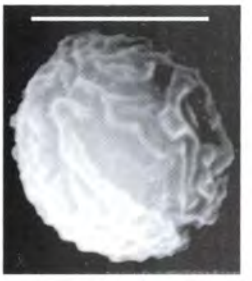
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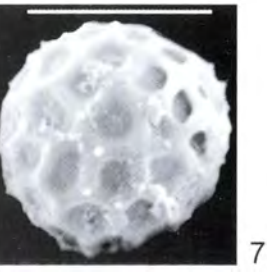
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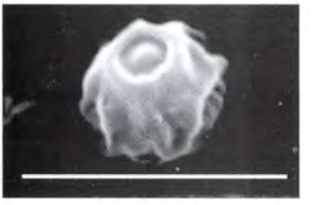
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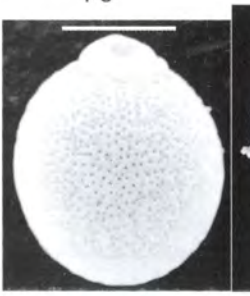
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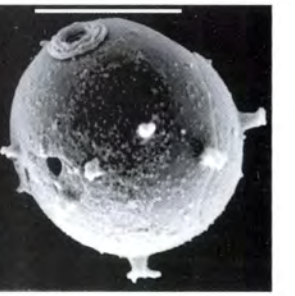
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Szakonyfalvi patak: On the 3 peat moss samples 19 diatoms could be collected. A small, recently separated genus, *Chamaepinnularia* was peculiar to this locality. The Shannon diversity is 2.59, of a medium value. The ratio of cysts/total siliceous algae is 23%.

Felsőszölnök: Altogether only 8 taxa were recorded, most of them are typical acidophilous bog diatoms: *Eunotia bilunaris* var. *mucophila* (most abundant) and *Eunotia lapponica* were often found. The value of Shannon diversity is 1.72, low. The ratio of cysts/total siliceous algae is 7%.

DISCUSSION

The main purpose of the study was to collect records on the floristics and characteristics of the assemblages (if any) of peat moss inhabiting diatoms. Additionally, we obtained some preliminary data also on Chrysophycean stomatocysts. Their ratio (cysts/all siliceous algae) is varying on a broad scale. This ratio is smaller on the large mires (which may be regarded as the more stable bogs), meaning that there are less stomatocysts and at the same time more diatoms. But in the smaller, periodically drying-up mires this ratio is higher, to such a degree that the cysts become entirely dominant (most typically, Fekete-tó). The increasing ratio of stomatocysts may be attributed to the Chrysophytes preparing for the resting stage.

The lack of sufficient records on Chrysophycean stomatocysts in Hungary is one reason, which makes the above records valuable. The "man of vision" in Hungarian mire algology, Borics, has not reported on mass occurrences of stomatocysts in his large-scale investigation of mires (BORICS 2001, and Borics, *pers. com.*). Vízkelety has only reported on the subdominance of cysts of *Ochromonas fragilis* in Fekete-tó (VÍZKELETY 1987).

Comparing our diatom list with that of the Red list of the Hungarian algae (NÉMETH 2005) 10 of the 97 diatom taxa fall within some of the threatened catego-

Figs 70–81. Peat moss inhabiting diatoms. The scale bar is 5 μm. 70 = Cyst resembling Stomatocyst 134 Duff and Smol. 70a = Nagy-Mohos-tó (SEM), 70b = Nagyláp (Kőszeg) (LM); 71 = Cyst resembling Stomatocyst 6 Duff and Smol, but the collar morphology is closer to Stomatocyst 86., Fekete-tó; 72 = Cyst resembling Stomatocyst 378 Taylor and Smol, 9 μm diameter Nagy-Mohos-tó; 73 = Non-spherical no collar, no ornamentation stomatocyst, Nagyláp (Kőszeg); 74 = Two different spherial stomatocysts lacking a collar or ornamentation Nagyláp (Kőszeg). The bigger one resembles Stomatocyst 42 Duff and Smol, the smaller one resembles Stomatocyst 189 Zeeb and Smol; 75 = Unidentified cyst, Bábtava; 76 = Reticulum regular, Nagyláp (Kőszeg); 77 = Reticulum variable, Fekete-tó; 78 = Cyst resembling Stomatocyst 91 Duff and Smol, Bábtava; 79 = *Trachelomonas* sp.?, Bábtava; 80 = Unidentified cyst, Fekete-tó; 81 = Spheroidal Carbonaceous Particles (SCP), indicator of air-borne pollution from oil burning, Nagyláp (Kőszeg).

ries (see also Table 1). *Hantzschia elongata*, *Kobayasiella subtilissima* and *Eunotia meisteri* are among the "endangered taxa". *Encyonema mesiana*, *Eunotia paludosa*, *E. cf. praerupta* and *E. rhomboidea* are "vulnerable", *Fragilaria capucina* var. *amphicephala* falls in the "low risk" category, while *Fragilaria tenera* and *F. virescens* are "presumably endangered".

Chamaepinnularia soehrensis formerly belonged to *Navicula*, and only one occurrence is documented from Hungary, although what we present is a different variety. CHOLNOKY (1933) has found *Navicula soehrensis* var. *capitata* Krasske in a spring close to the Danube more than 70 years ago. NÉMETH (2005) has not listed it at all. In the present study 2 forms of *Chamaepinnularia soehrensis* (differing from var. *capitata*) are distinguished (Table 1). As one conclusion, we may state that this is a very rare species in Hungary.

Otherwise – naturally NÉMETH's paper (2005) does not deal with the new records, which we publish here – probably these new occurrences must be referring to rare diatoms in the Hungarian flora.

To summarise the above, according to the rare, new and threatened diatoms, altogether 18 taxa (more than 19% of the total flora) are of conservation concern and require special attention in the studied mires.

The significance of aerophytic diatoms within the entire vegetation can not be neglected, with the mass appearance of stomatocysts they are among the markers of drying up the mires.

It is among the most surprising results of the study that the diatom flora of the "large" Hungarian bogs, Kis-Mohos-tó and Nagy-Mohos-tó, is very poor. Apparently, undisturbed and extensive habitats in this area do not support diversified diatom assemblages, the species number is limited and their abundance is very low. In Nagy-Mohos-tó, *Lemnicola hungarica*, a recently expanding diatom was recorded on *Sphagnum angustifolium*. Further developing of sampling strategy and more studies are planned for the verification of presence and dynamics of siliceous algae on mosses and to collect more algological data from other localities within Kis-Mohos-tó and Nagy-Mohos-tó.

We feel urgency in a better documentation (LM and SEM) of the diatom flora of Hungary, especially in accordance with the trends of European standards (Water Framework Directives) which draw special attention to mires.

* * *

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