Nova Hedwigia 78 3 -4 507 -515 Stuttgart, May 2004

Silica-scaled chrysophytes in acid peat bogs of Bohemian Switzerland (Czech Republic) and Saxonian Switzerland (Germany)

by

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With 19 figures and 3 tables

Nováková, S., Y. Němcová, J. Neustupa, M. Řezáčová, L. Šejnohová & T. Kalina (2004): Silica-scaled chrysophytes in acid peat bogs of Bohemian Switzerland (Czech Republic) and Saxonian Switzerland (Germany). - Nova Hedwigia 78: 507-515.

Abstract: Sixteen species of silica-scaled chrysophytes were identified from peat bogs in Bohemian and Saxonian Switzerland. Due to low pH-values the most common species were *Mallomonas ouradion* and *Synura echinulata*. *Mallomonas adamas* and *M. mangofera* f. *foveata* are new records for the Czech Republic and *M. ouradion* is a new record for Germany. Environmental requirements and biogeography are mentioned for selected species.

Introduction

Silica-scaled chrysophytes (Chrysophyceae and Synurophyceae) can be reliably determined only on the basis of silica structures morphology studied by electron microscopy. In the territory of the Czech Republic (part of earlier Czechoslovakia) the investigation of silica-scaled chrysophytes was begun by Fott, one of the pioneers in this field (Fott 1955 etc.). Recently, the systematic research has been taken up again (e.g. Kalina et al. 2000, Němcová et al. 2001, 2003, Neustupa et al. 2001), aiming to reveal the biodiversity of silica-scaled chrysophytes in the Czech Republic.

Besides biodiversity, the effects of acidification and eutrophication have been studied in Germany (e.g. Dürrschmidt 1984, Kies & Berndt 1984, Hartmann & Steinberg

DOI: 10.1127/0029-5035/2004/0078-0507 0029-5035/04/0078-0507 $ 2.25

1989, Hickel & Maass 1989, Hartmann-Zahn 1991, Gutowski 1997, Günzl 2001). However, the presented paper is the first contribution to the silica-scaled chrysophycean flora of Saxonia.

Material and methods

Samples of water from the peat bogs in the Bohemian Switzerland National Park (NP České Švýcarsko) and Elbe Sandstones Protected Landscape Area (Chráněná krajinná oblast Labské pískovce) in the Czech Republic and the Saxonian Switzerland National Park (NP Sächsische Schweiz) and Saxonian Switzerland Protected Landscape Area (Landschaftsschutzgebiet Sächsische Schweiz) in Germany were collected in 2001 and 2002. Except for the central lake in the locality Moorteich, the examined waterbodies were small peaty pools up to 20 cm deep. The samples were obtained by collecting water and surface sediments and by squeezing the submerged mosses as well. The water temperature, pH and conductivity were measured at the time of collection by the WTW pH meter 330 with the combined electrode SenTix 41, and WTW conductometer LF 315. All localities were sampled twice or three-times, but only the samples in which silica-scaled chrysophytes were observed with a light microscope, were oxidized in peroxide and prepared for TEM (for detail methodology see Kalina et al. 2000). The grids were examined in a Philips 300 transmission electron microscope.

Results

The environmental conditions of the localities are described in Table 1. The complete species list of silica-scaled chrysophytes is given in Table 2. Selected species are discussed below:

Mallomonas adamas Harris & Bradley Fig. 3

Abundant in both samples from the Ostrov mire. First record for the Czech Republic. The environmental conditions of the present finding are in accordance with Harris & Bradley (1960), who found this species also in acid peaty pools. The ecology of Australian and Malaysian findings is not known.

Distribution: Scattered and rare species (Kristiansen 2002). The only previous records were from the United Kingdom (Harris & Bradley 1960), Malaysia and Australia - Tasmania (Dürrschmidt & Croome 1985) and Australia - Victoria (Lavau & Wetherbee 1994).

Mallomonas mangofera Harris & Bradley f. **foveata** Dürrschmidt Fig. 8

Isolated scales were found in a sample from the Ostrov mire. First record for the Czech Republic.

The scales of f. *foveata* differ from those of the nominate forma in that the papillose surface of the shield has a characteristically arranged row of circular pits, each with a bordered pore at the bottom, along the inner side of the V-rib. Only few circular pits with pores were present on the scales in our sample instead of the continual series.

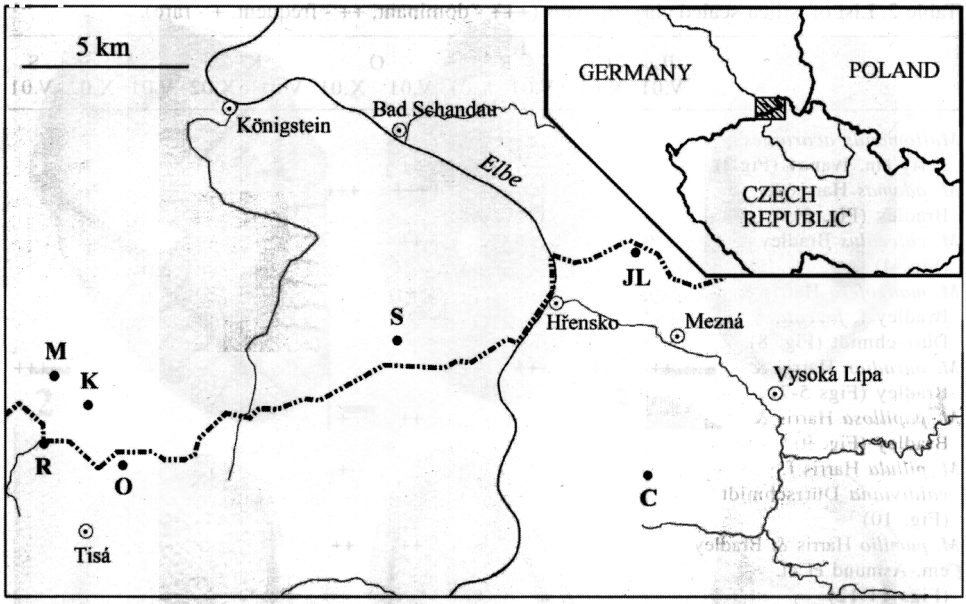


Fig. Location of sampling sites. For abbreviations see Table 1

Table Localities and environmental variables

Locality (Abbreviation)	Date	pH	Conductivity (µS/cm)	Temperature (°C)
Jelení louže (JL)	16.05.2001	3.7	70	10
Čabel (C)	16.10.2001	3.9	99	12
Rájec (R)	31.05.2001	3.7	141	14
– // –	16.10.2001	3.6	135	
Ostrov (O)	31.05.2001	5.8	56	16
– // –	16.10.2001	5.9	63	
Kachemoor (K)	31.05.2001	6.5	97	
– // –	22.10.2002	5.7	112	
Moorteich (M)	31.05.2001	4.2	56	
– // –	22.10.2002	4.5	81	
Schinkenwiese (S)	31.05.2001	4.2	242	

Our finding is in accordance with the statement of Siver (1991), that *M. mangofera* f. *foveata* is an acidophilic taxon. On the contrary, Gutowski (1997) found it in eutrophic water with pH 8.5.

Distribution: Cosmopolitan (Kristiansen 2002).

Table 2. List of silica-scaled chrysophytes (+++ - dominant, ++ - frequent, + - rare

	JL	C	R		O		K		M		S
	V.01	X.01	V.01	X.01	V.01	X.01	V.01	X.02	V.01	X.02	V.01
Mallomonas acaroides Perty em. Ivanov (Fig.2)											
M. adamas Harris & Bradley (Fig. 3)					+++	+++					
M. calceolus Bradley (Fig. 4)											
M. mangofera Harris & Bradley f. *foveata* Dürrschmidt (Fig. 8)											
M. ouradion Harris & Bradley (Figs 5-7)											+++
M. papillosa Harris & Bradley (Fig. 9)											
M. pillula Harris f. *valdiviana* Dürrschmidt (Fig. 10)											
M. pumilio Harris & Bradley em. Asmund et al. (Figs 11-12)											
M. schwemmlei Glenk em. Glenk & Fott (Fig. 13)											
M. striata Asmund (Fig. 14)											
M. tonsurata Teiling em. Krieger (Fig. 15)											
Synura echinulata Koršikov (Fig. 17)	+++			+++	+++		++		+++	+++	
S. petersenii Koršikov (Fig. 18)							+++				
S. sphagnicola (Koršikov) Koršikov (Fig. 16)											
S. spinosa Koršikov (Fig. 19)											
Paraphysomonas vestita (Stokes) De Saedeleer											

Mallomonas ouradion Harris & Bradley Figs 5-7

The most frequent species of *Mallomonas* in the area. First record for Germany.

Scales of different shapes, density and development of papillae were observed. One "immature" scale similar to Harris & Bradley (1958, pl. 2, fig. 8) was observed as well. The immature scales were described as not fully silicified scales, with simplified secondary structure. It is not conceivable that immature scales can develop into fully formed ones after having been extruded to the cell surface (Asmund & Kristiansen 1986). Several interpretations of their occurrence may be considered. The immature scale may be extruded to the environment after the death of the cell (Harris & Bradley 1960) or disorder of the scale excretion may cause that the scale is extruded before it is fully developed (Němcová et al. 2000).

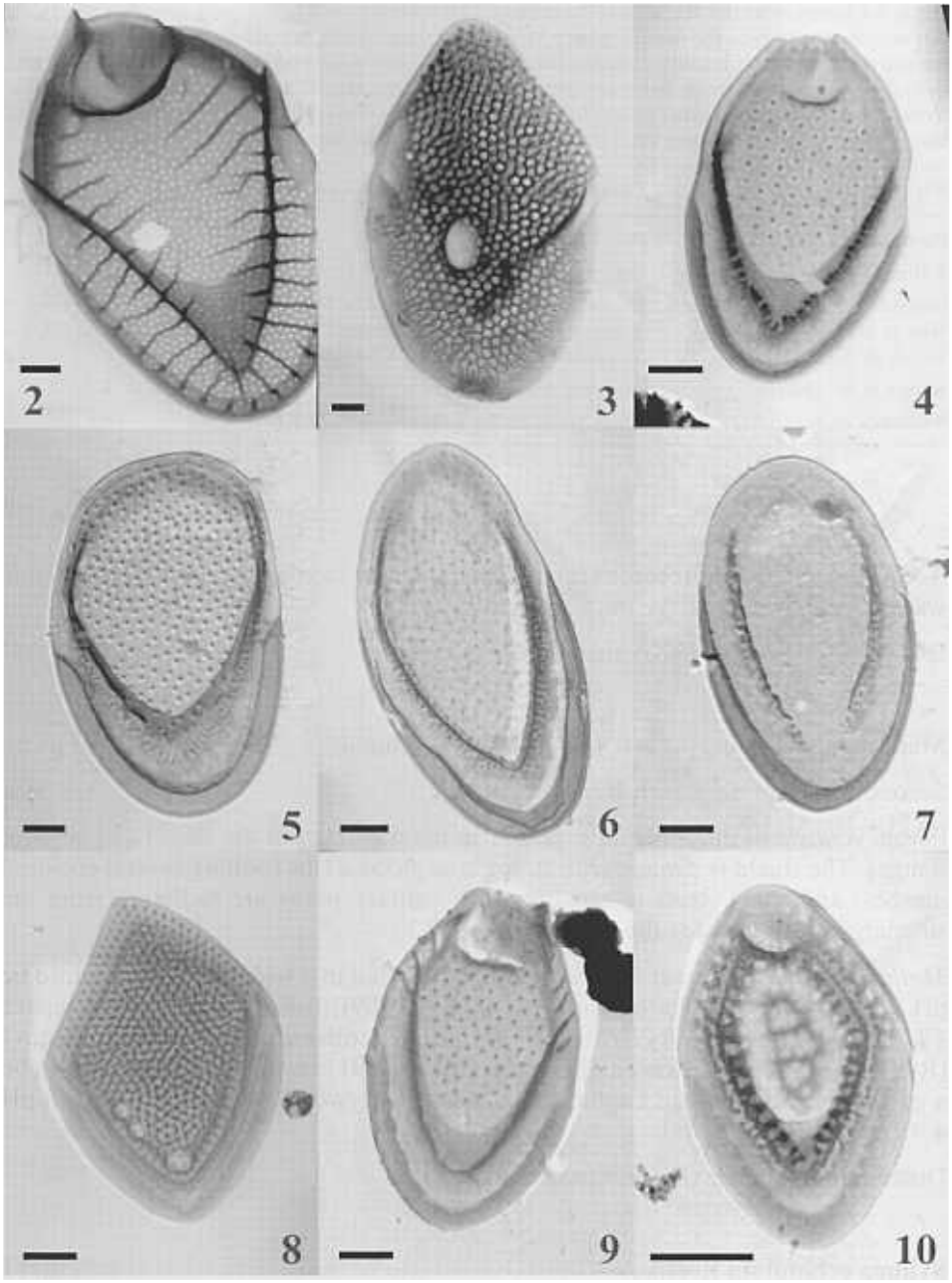


Fig. 2. *Mallomonas acaroides*. Fig. 3. *Mallomonas adamas*. Fig. 4. *M. calceolus*. Figs 5-7. *M. ouradion*. Figs 5-6. Variable scales, probably from apical and distal part of the cell. Fig. 7. "Immature" scale. Fig. 8. *M. mangofera* f. *foveata*. Fig. 9. *M. papillosa*. Fig. 10. *M. pillula* f. *valdiviana*. All scale bars 0.5 μm.

Table 3. Literature records indicating the ecological preferences of *Mallomonas ouradion*. (* pH was not recorded exactly in the sample where *M. ouradion* was found, but pH-values 5.1 and 5.76 were measured in the same locality on other dates. ** Examined waterbodies were mostly stained with dissolved humic substances. In the sample with *M. ouradion*, also *M. corcontica, M. transsylvanica, Synura sphagnicola* and other acidophilic species were recorded. The authors themselves admitted that some species might have been brought from upstream swamps.)

Reference	Character and location of sampling site	pH
Harris & Bradley (1958)	Peaty pools near Reading (UK)	
Kalina (1969)	Peat bog Swamp (CZ)	5.0
Donaldson & Stein (1984)	Urban lake with humic water in Vancouver (Canada)	about 5.5 *
Wee et al. (1993)	Stream, ephemeral pool, "bayou" (Louisiana, USA)	4.4, 5.4, 7.0
Wujek & Siver (1997)	Suwannee River (Florida, USA) **	6.0
Kalina et al. (2000)	Peat bog Swamp (CZ)	3.3
Němcová et al. (2001)	Peaty pools in the Krkonoše Mts. (CZ)	3.9, 5.2

According to previous records (Table 3) *M. ouradion* seems to prefer acid and humic waters.

Distribution: Scattered (Kristiansen 2002).

Mallomonas pillula Harris f. **valdiviana** Dürrschmidt Fig. 10

Second record in the Czech Republic.

Forma *valdiviana* differs from f. *pillula* in the markings of the shield and anterior flanges. The shield is marked with strong conspicuous ribs forming several enclosed meshes, and short struts alternating with solitary pores are radiating from the submarginal rib towards the reticulum.

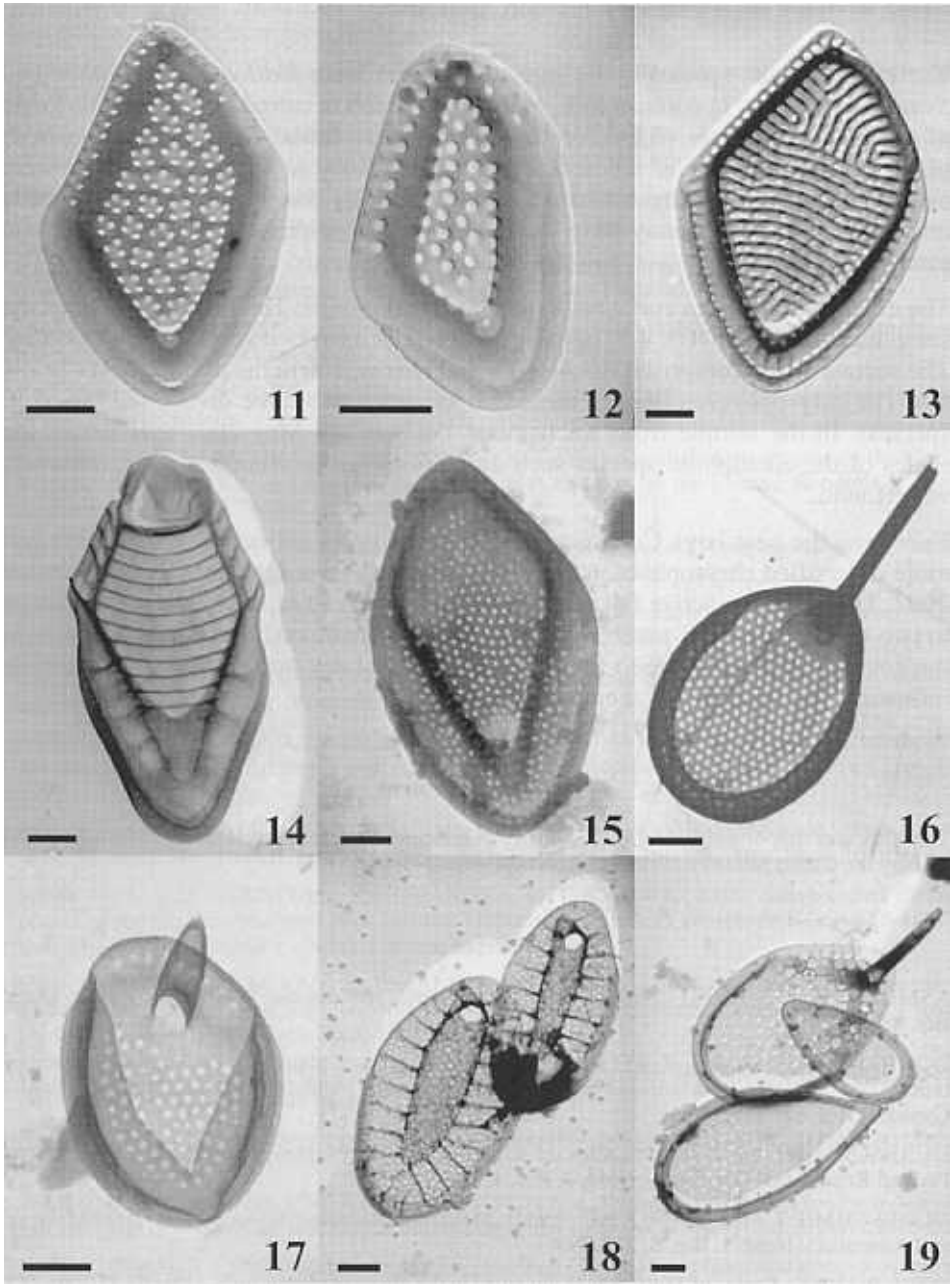
Mallomonas pillula f. *valdiviana* has been reported in a wide range of conditions: pH varied from 5.2 (Hartmann & Steinberg 1989) to 8.4 (Wujek & Menapace 1985) and conductivity from 16 $\mu S.cm^{-1}$ (Jacobsen 1985) to 402 $\mu S.cm^{-1}$ (Roijackers 1981). However, Hartmann-Zahn (1991) considered this taxon to be a good indicator for acid conditions in the region (weighted arithmetic mean pH 4.49).

Distribution: Bipolar (Kristiansen 2002).

Synura echinulata Koršikov Fig. 17

The most frequent species in the area.

In addition to typical scales, one with a structure resembling *Mallomonas*-like V-rib was observed (Fig. 17).



Figs 11-12. *Mallomonas pumilio*. Fig. 11. Body scale. Fig. 12. Rear scale. Fig. 13. *M. schwemmlei*. Fig. 14. *M. striata*. Fig. 15. *M. tonsurata*. Fig. 16. *Synura sphagnicola*. Fig. 17. *S. echinulata*, atypical scale. Fig. 18. *S. petersenii*. Fig. 19. *S. spinosa*, body and caudal scales. All scale bars 0.5 μm.

Discussion

The most frequent species in the studied locations were *Mallomonas ouradion* and *Synura echinulata*. In contrast to *S. echinulata*, which occurred over the whole range of recorded pH-values (3.6-6.5), *M. ouradion* was found only in localities with pH $\leq$ 4.2. Acidophility of this species and its tendency to occur in peat bogs were probably the reasons why it had not been previously found in Germany, because most papers from Germany have dealt with the chrysophycean flora of lakes and eutrophic waters.

The examined localities could be divided into two groups: The first one included the sampling sites with pH $\leq$ 4.5. In these localities at most two species were recorded. The second group comprised Kachemoor and Ostrov, where the pH was never below 5.5. The chrysophycean flora of these two localities was more diversified (up to 10 species). In the sample from Kachemoor, collected in May 2001 (pH = 6.5), the scales of the alkaliphilic species such as *Mallomonas acaroides* and *M. tonsurata* were found.

Excepting the peat bogs Čabel and Rájec, the samples collected in May 2001 had more diversified chrysophycean floras than samples from October 2001 or October 2002. The most distinctive fall of diversity was observed in Kachemoor, from seven to two species. In small waterbodies the environmental conditions distinctly vary in the course of the year due to intermittent rainy and dry periods, and this naturally influences the diversity of their microflora.

Acknowledgement

The work was supported by the Czech Ministry of Education research project No. J13/98113100004 and by the Czech Ministry of the Environment grant No. 610/7/01.

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Received 5 May 2003, accepted in revised form 4 November 2003