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Silica-scaled chrysophytes of the Šumava National Park and the Třeboňsko UNESCO Biosphere Reserve (Southern Bohemia, Czech Republic)

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Thirty-five taxa of silica-scaled Synurophyceae and Chrysophyceae have been identified by means of transmission electron microscopy (TEM) from eight localities in the Šumava National Park and the Trebon UNESCO Biosphere Reserve. *Mallomonas alveolata, M. areolata, M. costata, M. doignonii* var. *doignonii, M. intermedia* var. *intermedia, M. punctifera, M. teilingii, M. transsylvanica, Synura leptorrhabda* and *Paraphysomonas takahashii* are new records for the Czech Republic. Autecology and distribution of selected species are discussed.

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Introduction

This study gives a survey of the silica-scaled chrysophytes found in the Šumava National Park and in the Třeboňsko UNESCO Biosphere Reserve situated in the southern part of the Czech Republic.

The Šumava Mts. (highest peak Plechý 1378 m) are a Hercynian range belonging to the Moldanubicum complex formed by igneous, mostly metamorphic rocks. During the Quarternary the range was covered with mountain glaciers whose remains today are glacial lakes - the only ones in the Czech Republic.

In contrast, the other studied territory, the Třeboň basin, covers a flatland formed by Mesozoic to Quarternary sediments. Alluvial pools in the floodplain of the Lužnice River are the periodic or permanent mesotrophic to eutrophic waterbodies.

The present study is a continuation of the previous investigations on biodiversity of silica-scaled chrysophytes in the Czech Republic (Kalina et al. 2000; Němcová et al. 2001; Neustupa et al. 2001). With the new findings reported in this study the flora of silica-scaled chrysophytes of the Czech Republic comprises 46 species.

Material and methods

The altogether 26 samples were collected during the

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Table 1. Description of the investigated localities and their basic environmental variables.

No.	Name	Description	Altitude (m)	Area (m^2)
1	"Povltavský luh"	mesotrophic alluvial pools on the upper Vltava River	730	—
2	Lake Černé	oligotrophic glacial lakes	1008	184700
3	Lake Prášilské		1079	37200
4	Lake Plešné		1089	74800
5	Pool T2	mesotrophic to eutrophic alluvial pools	460	330
6	Pool T3	in the floodplain of the Lužnice River	460	950
7	Pool Prokopova		460	188
8	Pool T1		460	206

years 1999 and 2000, taken mainly as whole water samples, sometimes combined with samples from plankton net hauls.

In the field the water surface temperature, pH and conductivity were measured using portable electronic WTW 330 pH-meter and WTW LF 315 conductometer. The samples were fixed with acidified Lugol solution. Preparation of the silica scales for TEM was described elsewhere (Kalina et al. 2000). Specimens were examined with a Philips 300 electron microscope.

Results

Thirty-five taxa of silica-scaled chrysophytes were found during our investigation, 32 belonging to the class Synurophyceae and three to the class Chrysophyceae. *Mallomonas alveolata, M. areolata, M. costata, M. doignonii* var. *doignonii, M. intermedia* var. *intermedia, M. punctifera, M. teilingii, M. transsylvanica, Synura leptorrhabda* and *Paraphysomonas takahashii* are new records for the Czech Republic.

The description of the localities with measured environmental variables is shown in Table 1. The position of investigated localities on the map of the Czech Republic is shown in Fig. 33. The silica-scaled chrysophytes found in investigated localities are listed in Table 2. Species that are new for the Czech Republic or are of biogeographical or ecological interest are discussed below.

Mallomonas alveolata Dürrschmidt

A rare species with scattered, probably bipolar occurrence. According to Asmund & Kristiansen (1986) the only reports of this species are from Chile and Netherlands. The scales of this species are typical in several features. The shield is marked with papillae connected by ribs and forming a reticulum of subcircular meshes. Collar scales bear dome with typical subcircular outline and a short obtuse peak. The ventral flange is usually more raised than the other. – (Fig. 17)

Mallomonas areolata Nygaard

A species with scattered but probably cosmopolitan distribution. It has been reported from the tropics (Dürrschmidt & Croome 1985) as well as from several temperate localities in both hemispheres (Asmund & Kristiansen 1986). This species occurs in alkaline, rather eutrophic waters (Péterfi et al. 1998a). – (Fig. 5).

Mallomonas costata Dürrschmidt

This species is known from few localities in temperate and subarctic Europe (Asmund & Kristiansen 1986) as well as from tropical Northeast India (Saha & Wujek 1990). It has been reported to occur in mesotrophic to eutrophic waters. – (Fig. 7).

Mallomonas doignonii Bourelly emend. Asmund & Cronberg var. doignonii

A species with scattered occurrence in subtropic and temperate ecosystems of the Northern Hemisphere. This species prefers waters of lower conductivity (Siver 1995). – (Fig. 8).

Maximum depth (m)	Date of taking samples	Temperature (°C)	pH	Conductivity ($\mu S.cm^{-1}$)
—	15.6.99 - 24.9.99	16-19	6.4-8.8	63-77
39.8	25.9.99	15	4.6	27
14.9	25.9.99	15	4.9	18
47	15.6.99	12	4.3	23
2	3.3.00	6	6.4	204
2.6	3.3.00	5.5	6.4	238
1.6	3.3.00	4.5	6.3	288
1.7	20.6.00	18	6.7	170

Mallomonas intermedia Kisselev emend. Péterfi & Momeu var. intermedia

A species known from several localities in temperate Europe (Asmund & Kristiansen 1986; Péterfi et al. 1998a). Péterfi et al. (1998a) regarded this species as apparently acidophilic. However, our specimens indicate that *M. intermedia* is capable to inhabit also waters with only slightly acidic pH. – (Fig. 11).

Mallomonas oviformis Nygaard

A species with scattered occurrence in subtropic to temperate ecosystems of the Northern Hemisphere, preferably alkaliphilic species, mesotrophic to eutrophic (Siver 1989; Péterfi et al. 1998b). – (Fig. 13).

Mallomonas pumilio Harris & Bradley emend. Asmund, Cronberg & Dürrschmidt var. pumilio

A species with known scattered bipolar distribution (Kristiansen & Vigna 1996). Var. *pumilio* differs from the other varieties in the somewhat irregular arrangement of the shield pattern and in reduction of the struts on the anterior flanges to dots. Roijackers & Kessels (1986) assume *M. pumilio* var. *pumilio* to be a pH neutral and cold water species, which corresponds with our results. – (Fig. 15).

Mallomonas punctifera Koršikov var. punctifera

A widely distributed species preferring neutral to alkaline waters (Péterfi et al. 1998a). Var. *punctifera* has been reported mostly from Europe, whereas the majority of scales found in North and South America belong to var. *brasiliensis* (Kristiansen & Menezes 1998). – (Fig. 16).

Mallomonas schwemmlei Glenk emend. Glenk & Fott

A species with scattered distribution on the Northern Hemisphere (Asmund & Kristiansen 1986). In our samples from Třeboňsko Biosphere Reserve *M. schwemmlei* was the dominant species of the chrysophycean flora. – (Fig. 18).

Mallomonas teilingii Conrad

A species with scattered occurrence in temperate and subarctic ecosystems of the Northern Hemisphere, prefers mesotrophic to eutrophic conditions. – (Fig. 20).

Mallomonas transsylvanica Péterfi & Momeu

An acidophilic species with bipolar distribution (Siver 1989, Kristiansen & Vigna 1996). – (Fig. 22).

Mallomonas trummensis Cronberg

The scales of this species are to a certain extent similar to the scales of *M. portae-ferreae*. The main distinguishing features on the scales are the smaller number of ribs on the shield (*M. trummensis* has got up to seven ribs, *M. portae-ferreae* up to approx. ten ribs) and generally smaller size of all types of scales (Asmund & Kristiansen 1986). *M. trummensis* has been reported from localities in temperate and subarctic zone of the Northern Hemisphere (Neustupa et al. 2001). It seems to be a typical cold water species. – (Fig. 23).

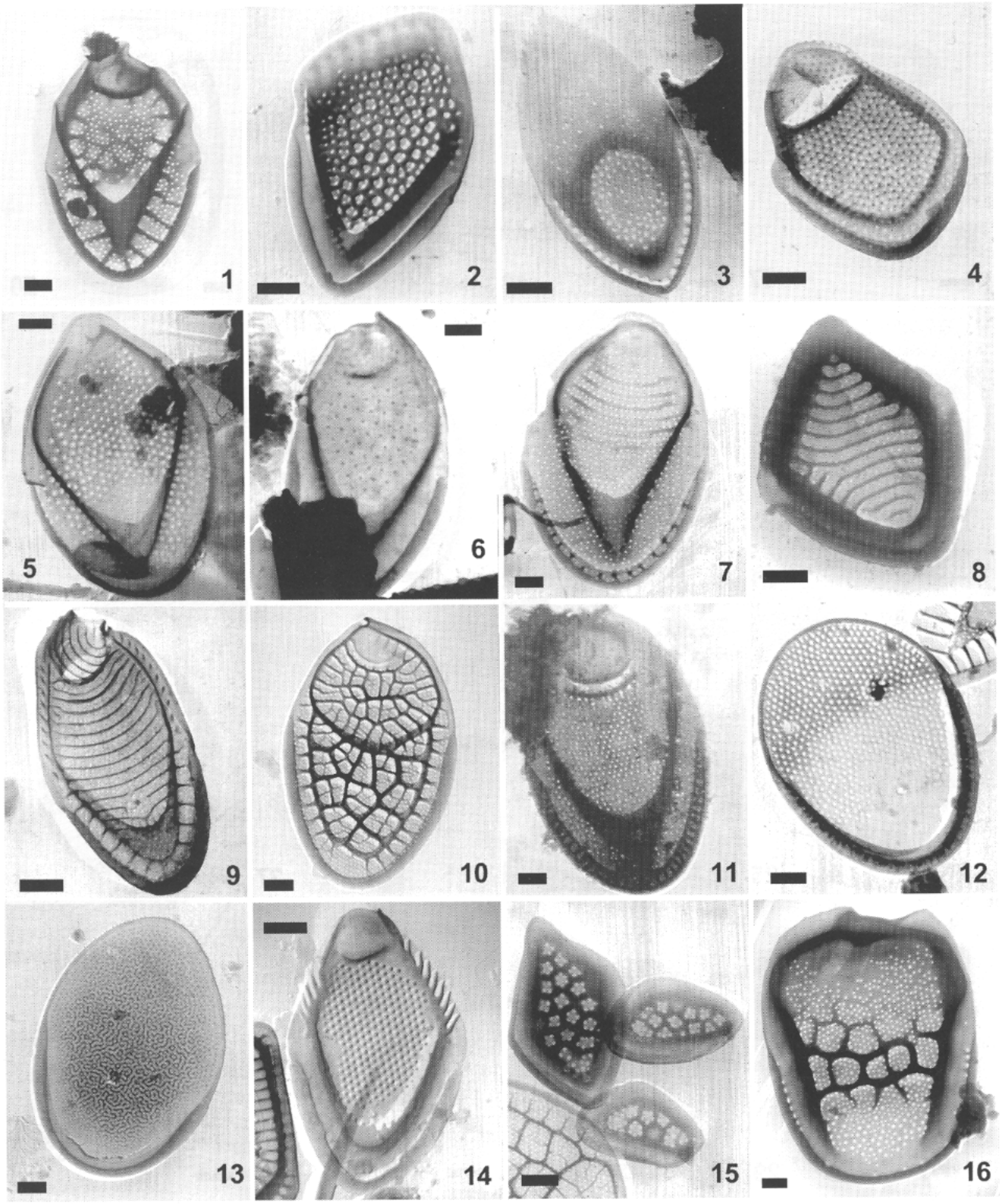
Table 2. The list of silica-scaled chrysophytes found in investigated localities.

	1	2	3	4	5	6	7	8	CZ records	Fig.
M.acaroides. var. *acaroides*	+				+				e, h, j, l	1
M. akrokomos					+	+			j, l	3
M. alata f. *alata*					+	+	+		j	2
M. alveolata					+				first record	17
M. annulata					+	+			j	4
M. areolata					+				first record	5
M. caudata	+	+							c, j, l	-
M. calceolus					+				i, k	6
M. costata	+								first record	7
M. crassisquama var. *crass.*	+								e, j, k, l	-
M. doignonii var. *doignonii*	+				+				first record	8
M. flora var. *flora*					+				k	9
M. heterospina					+	+	+		d, f, j, k	10
M. intermedia var. *intermedia*								+	first record	11
M. matvienkoe var. *matv.*					+				l	12
M. oviformis					+		+		j	13
M. papillosa var. *papillosa*					+		+		k	14
M. pumilio f. *pumilio*					+	+			l	15
M. punctifera var. *punctifera*	+								first record	16
M. schwemmlei	+				+	+	+		c, g, l	18
M. striata					+	+	+		j	19
M. teilingii						+			first record	20
M. tonsurata	+								h, j	21
M. transsylvanica					+		+		first record	22
M. trummensis					+				l	23
S. curtispina var. *curtispina*					+	+	+		b	24
S. echinulata		+		+		+			b, j, k, l	25
S. leptorrhabda							+		first record	26
S. petersenii	+		+	+	+	+	+		b, h, j, k, l	27
S. sphagnicola			+						b, j, k, l	28
S. spinosa f. *longispina*	+		+						b	29
S. uvella	+	+	+		+				b, j, l	30
C. brevispina	+	+			+				a, h, l	31
P. takahashii					+				first record	32
P. vestita var. *vestita*			+		+		+		h, j, l	-

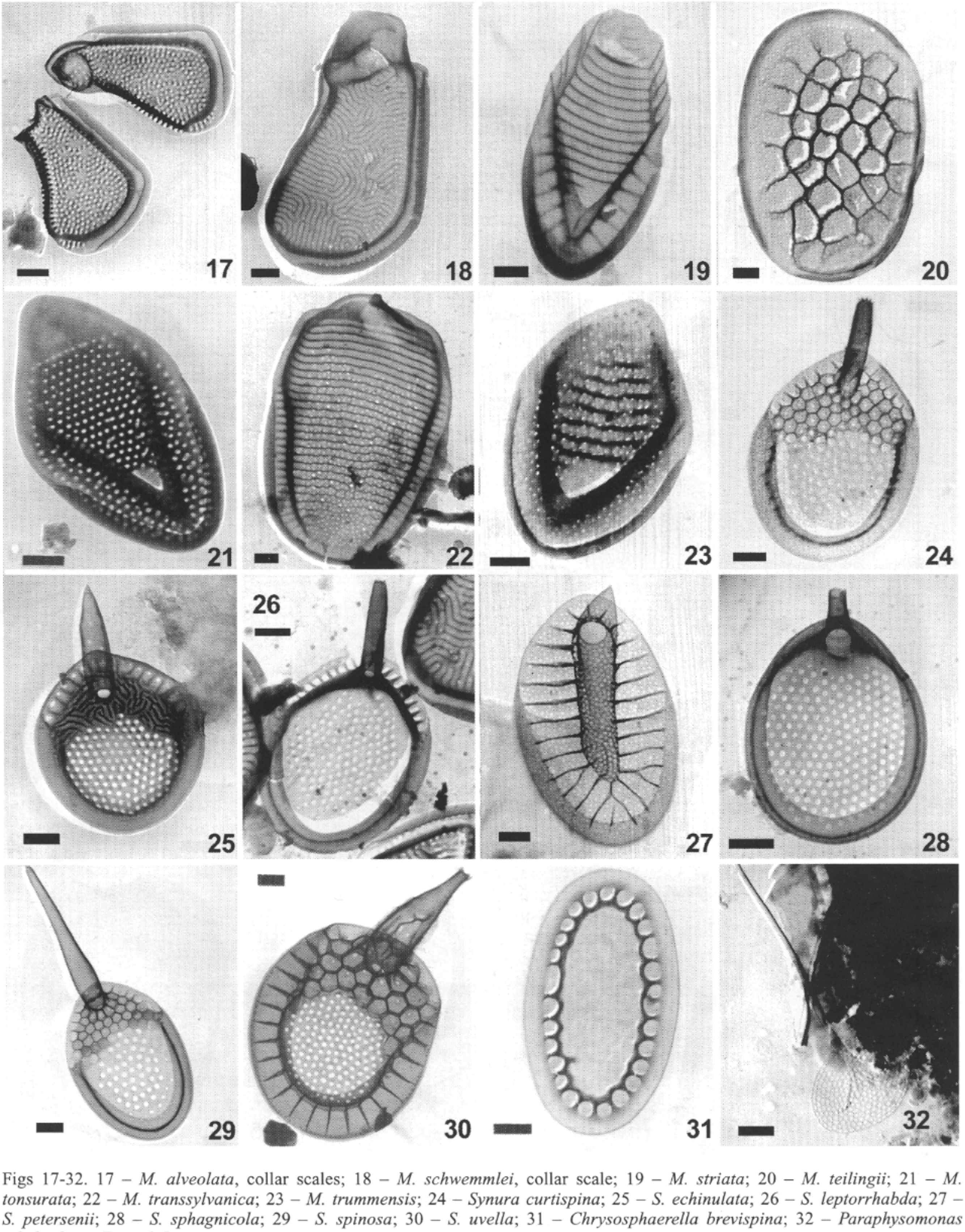
References: a: Fott & Ludvík (1956), b: Fott & Ludvík (1957), c: Fott & Ettl (1959), d: Fott & Ludvík (1961), e: Fott (1962), f: Fott (1966), g: Glenk & Fott (1971), h: Štefanová & Kalina (1992), i: Němcová et al. (1999), j: Kalina et al. (2000), k: Němcová et al. (2001), l: Neustupa et al. (2001).

Synura leptorrhabda (Asmund) Nicholls

The species was originally described as a form of *S. echinulata* (Asmund 1968). However, it differs from *S. echinulata* in several clearly distinguishable stable features. The ornamentation of the distal portion of the *S. leptorrhabda* scales is reduced to narrow unpatterned area. The ribs in the distal portion of the *S. leptorrhabda* scales are often longer than in *S. echinulata*. *S. leptorrhabda* has been found in Alaska (Asmund 1968), Russia (Balonov & Kuzmin 1974), Chile (Dürrschmidt 1980), Norway (Skogstad 1982, cited after Nicholls & Gerrath 1984), Central and Northern Canada (Kling & Kristiansen 1983) (identified as *S. echinulata*), Ontario (Nicholls &

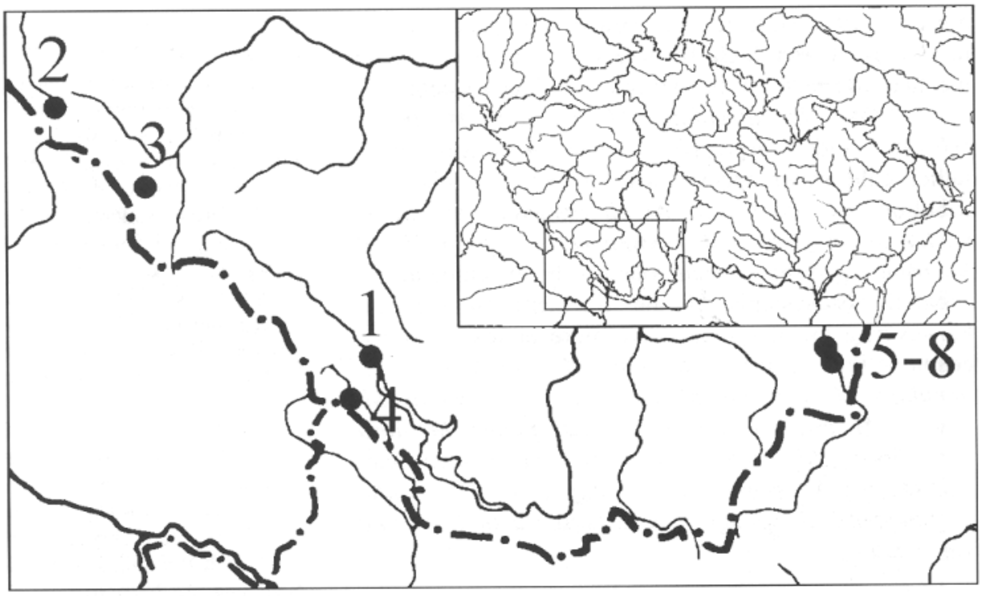


Figs 1-16. 1 – *Mallomonas acaroides*; 2 – *M. alata*; 3 – *M. akrokomos*; 4 – *M. annulata*, apical scale; 5 – *M. areolata*; 6 – *M. calceolus*; 7 – *M. costata*; 8 – *M. doignonii*; 9 – *M. flora*; 10 – *M. heterospina*; 11 – *M. intermedia*; 12 – *M. matvienkoae*; 13 – *M. oviformis*; 14 – *M. papillosa*; 15 – *M. pumilio*, body scale and rear scales; 16 – *M. punctifera*. – Bars: 0.5 μm.



Figs 17-32. 17 – *M. alveolata*, collar scales; 18 – *M. schwemmlei*, collar scale; 19 – *M. striata*; 20 – *M. teilingii*; 21 – *M. tonsurata*; 22 – *M. transsylvanica*; 23 – *M. trummensis*; 24 – *Synura curtispina*; 25 – *S. echinulata*; 26 – *S. leptorrhabda*; 27 – *S. petersenii*; 28 – *S. sphagnicola*; 29 – *S. spinosa*; 30 – *S. uvella*; 31 – *Chrysosphaerella brevispina*; 32 – *Paraphysomonas takahashii*. – Bars: 0.5 µm.

Fig. 33. The map showing the location of the investigated localities.



Gerrath 1985), Connecticut (Siver 1987) and Florida (Siver & Wujek 1999). Thus, this species can be assumed to exhibit bipolar distribution. The only subtropic report comes from Florida, whose chrysophycean flora has affinities to rather temperate regions of the North America and Europe (Siver & Wujek 1999). We can assume from the published data that *S. leptorrhabda* prefers acidic to slightly acidic waters. – (Fig. 26).

Paraphysomonas takahashii Cronberg & Kristiansen

Two kinds of scales have been described: long-spined scales and scales with only a small spine sometimes reduced to an almost invisible protrusion (Preisig & Hibberd 1982). Only long-spined scales have been observed in our sample. *P. takahashii* is a widely distributed cosmopolitan species. – (Fig. 32).

Discussion

In oligotrophic glacial lake samples of the Šumava National Park (localities 2, 3 and 4) silica-scaled chrysophytes were rare organisms with low species abundance. *S. echinulata, M. caudata* and *S. petersenii* exhibited higher quantities in the investigated samples. The low pH in studied localities (4.3 – 4.9) has probably significant negative effect on biodiversity of silica-scaled chrysophytes in these lakes. Apart from acidophilic species *S. echinulata* and *S. sphagnicola,* only pH indifferent species *M. caudata, M. pumilio* f. *pumilio, S. petersenii, S. spinosa, S. uvella* and *C. brevispina* were found.

However, silica-scaled chrysophytes were quite common and highly diversified in most of the investigated localities in mesotrophic to eutrophic alluvial pools of the Vltava River in the Šumava National Park and the Lužnice River in the Třeboňsko Biosphere Reserve. The pool T2 (designated as locality 5 in this study) with 24 recorded species was the locality with highest biodiversity of silica-scaled chrysophytes in the Czech Republic.

The most frequent species in the pools were *M. schwemmlei, M. alata* f. *alata, M. heterospina, M. striata, S. curtispina* and *S. petersenii*. The majority of species found in these localities can be considered as pH indifferent or neutrophilic. These were e.g. *M. akrokomos, M. annulata, M. caudata, M. crassisquama* var. *crassisquama, M. heterospina, M. matvienkoe* var. *matvienkoe, M. papillosa* var. *papillosa, M. pumilio* f. *pumilio, S. petersenii* or *P. vestita* var. *vestita*.

Some of the species occurring in the alluvial pools can be considered as acidophilic in accordance with the slightly acidic pH measured in most of these localities. These were e.g. *M. calceolus, M. flora* var. *flora, M. intermedia* var. *intermedia, M. transsylvanica, S. curtispina* or *S. echinulata*.

Surprisingly some rather alkaliphilic species were also found, like *M. acaroides* var. *acaroides, M. alata* f. *alata, M. areolata, M. oviformis* or *M. striata*. Pithart et al. (1997) reported the pH values of the investigated Lužnice River alluvial pools increasing to 7.6 – 8.0 in warmer periods. Higher pH values have also been reported in shallow littoral parts of the pools. Hence, we can assume that the presence of differently ecologically adapted species in one pool and high biodiversity can exist due to the heterogeneity of the alluvial pool ecosystem.

M. alata, M. alveolata, M. pumilio, M. transsylvanica and *S. leptorrhabda* can be considered as rather cold water species with probably bipolar distribution. *M. doignonii, M. intermedia* var. *intermedia, M. oviformis, M. schwemmlei, M. teilingii* and *M. trummensis* have been found only in temperate to subarctic ecosystems of the Northern Hemisphere. However, a lot of species have more or less scattered cosmopolitan distribution (e.g. *M. akrokomos, M. annulata, M. areolata, M. calceolus, M. caudata, M. costata, M. crassisquama* var. *crassisquama, M. flora* var. *flora, M. heterospina, M. matvienkoe* var. *matvienkoe, M. papillosa* var. *papillosa, M. striata, S. petersenii, S. sphagnicola, S. spinosa* or *P. vestita* var. *vestita*).

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