Silica-scaled chrysophytes of Southern Bohemian water bodies, including *Mallomonas conspersa* Dürrschmidt with occurrence so far reported from Japan and New Zealand

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Abstract: Silica-scaled chrysophytes are often important components of the phytoplankton community of freshwater lakes and reservoirs. A total of 25 taxa were recorded during an investigation of Borkovická Blata peat-bog and Novohradské Hory ponds, representing five genera. Along with cosmopolitan and widely distributed species, rare *Synura mollispina, Mallomonas conspersa, M. retifera* and *M. kalinae* were found. This study also represent only the third time that *M. conspersa* has ever been reported and documented by scale microphotographs. This taxon has so far been reported only from Japan and New Zealand. The close resemblance of scale morphology to *M. retifera* is discussed. *Synura mollispina*, *M. conspersa* and *M. pumilio* var. *munda* are recorded for the first time from the territory of the Czech Republic.

Key words: Silica-scaled chrysophytes, Chrysophyceae, Synurophyceae, *Mallomonas conspersa*

Introduction

Silica-scaled chrysophytes are often important components of the phytoplankton community of freshwater lakes and reservoirs (Siver 1995). They comprise free living and colonial flagellates from the classes Synurophyceae and Chrysophyceae (Stramenopila). Their cells are enclosed within a case formed by overlapping, species-specific, silica scales. Taxonomy within this group is still almost exclusively based on morphology of silica structures studied by a transmission or scanning electron microscopy (e.g. Siver 1991, Kristiansen 2002). Species with a narrow ecological optimum could be considered suitable bioidicators of recent and fossil environments (Munch 1980, Smol 1995).

Both areas investigated for this report represent unique biotopes. Borkovická Blata peat-bog (49°14'9.133"N; 14°37'25.632"E) originated before more than ten thousand years. A thickness of the peat layer reached four to eight meters. The blocks of peat were manually dug and they were used for heating till the middle of the 20th century. Then the industrial mining started here and it finished when the main deposits were empty. The samples were collected from small shallow pools, which originated in consequence of peat exploitation, and are situated in the preserved part of an area (54.5 ha), which has been protected since 1980. The Novohradské Hory (48°39'23.129"N; 14°40'56.122"E) represent a valuable untouched nature area with a lot of natural forests situated along Czech-Austrian border. This border area was closed to the public during the communist era (1948-1989). The Nature Park Novohradské Hory was founded in 2000. Investigated water bodies (so called "klauza", from Latin *clausura*) were established at the end of the 18th century to facilitate a wood floatation. A brief description of investigated sites is given in Table 1. The Czech Republic belongs to relatively well explored areas in central Europe (e.g. Fott 1955, Němcová et al. 2003, Řezáčová & Neustupa 2007), nevertheless still plenty of biologically valuable water habitats have, to date, not been investigated for the presence of silica-scaled chrysophytes. The purpose of this study is to expand our knowledge of autecology and biogeography of sampled species, and to extend the list of taxa reported from the territory of the Czech Republic. This study also represent only the third time that *Mallomonas conspersa* has ever been reported and documented by scale microphotographs.

Material and Methods

Plankton net (mesh 20 μm) collections were made during October and November 2007. Water temperature, pH and conductivity were measured at the time of collection with Combo pH EC (Hanna Instruments). Concentration of ammonium ions [NH_4^+], total nitrogen, total phosphorus and silica [SiO_2] were obtained in a laboratory using DR/890 Colorimeter (Hach). Water samples were centrifuged or concentrated by sedimentation. Drops of the sample were dried onto formvar coated grids. Dried material was washed by repeated transfer of the grid into drops of ionized water dispensed on the hydrophobic surface of a Parafilm strip (Pechiney Packing). Dried grids were examined with a JEOL 1011 transmission electron microscope.

Results and discussion

Silica-scaled chrysophytes found during this survey, accompanied with taxonomic authorities, are listed in Table 2. A total of 25 taxa were recorded in the five investigated localities, representing five genera. The number of taxa found in a given site in Borkovická Blata peat-bog (localities 1–3) ranged from 2 to 12, Novohradské Hory ponds (localities 4–5) hosted identically 11 taxa. The main physico-chemical parameters of the investigated water bodies are summarized in Table 1. While the sampling sites of both areas were relatively similar in pH, they differed in concentration of dissolved salts and nutrient content. The most common and abundant species observed in at least four study sites included *Synura petersenii*, *S. spinosa* and *Mallomonas papillosa.* The chrysophyte flora of Southern Bohemian localities consisted mainly of pH indifferent widely distributed taxa. Along with frequently reported taxa the rare species *Synura mollispina, Mallomonas conspersa*, *M. retifera* and *M. kalinae* were found.

Synura mollispina represents a widely distributed but scattered species, recorded from Europe, Northern and Southern America (KRISTIANSEN & PREISIG 2007). It differs from *S. spinosa* in the presence of a secondary hexagonal reticulum that covers almost completely the scale. The scales are often elongate with slightly pointed shape (CRONBERG & KRISTIANSEN 1980), but also rounded scales were noticed (ASMUND 1968, this study, see Fig. 2).

Mallomonas conspersa was reported from Japan, as an unidentified species (TAKAHASHI

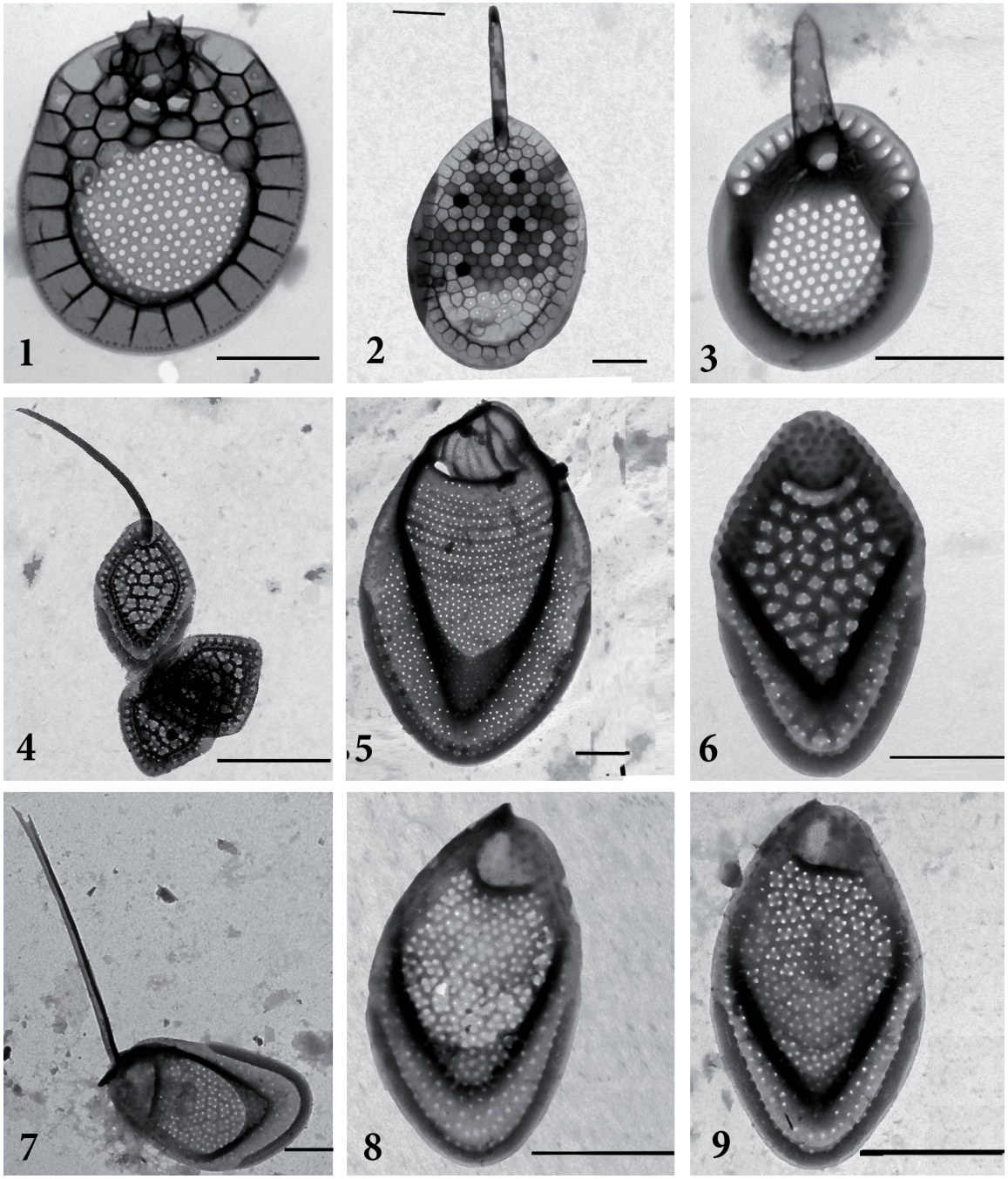
Table 1. Brief description of investigated sites accompanied with the main physico-chemical parameters and position data [(Cond.) conductivity, (Temp) temperature, (N) total nitrogen, (P) total phosphorus, (NH_4^+) ammonium ions concentration].

No.	Locality	Description	Lattitude	Longitude	pH	Cond. $\mu S.cm^{-1}$	Temp. °C	NH^{4+} $\mu g.l^{-1}$	N $\mu g.l^{-1}$	P $\mu g.l^{-1}$	Date of sampling
1.	Borkovická Blata peat-bog	A small artificial lake	49°14‘3.971“N	14°37‘36.575“E	5.6	149	6.7	2.16	2.4	0.31	19. 10. 07
2.	Borkovická Blata peat-bog	A small shallow pool	49°14‘8.173“N	14°37‘24.229“E	5.5	101	6.0	1.61	6.9	0.23	19. 10. 07
3.	Borkovická Blata peat-bog	A shallow pool with tufts of grass	49°14‘9.133“N	14°37‘25.632“E	5.9	85	6.8	1.87	2.8	0.35	19. 10. 07
4.	Novohradské Hory	A forest pond Uhlířský ice covered	48°38‘48.07“N	14°39‘19.962“E	5.6	45	0.2	0.41	1.8	0.18	14. 12. 07
5.	Novohradské Hory	A forest pond Huťský ice covered	48°39‘23.129“N	14°40‘56.122“E	5.9	46	0.0	0.21	1.7	0.2	14. 12. 07

Table 2. The complete list of all taxa found during this survey, accompanied with taxonomic authorities. Referred previous CZ records [(1) Pichrtová et al. 2007, (2) Řezáčová 2006, (3) Nováková et al. 2004, (4) Řezáčová et al. 2004, (5) Němcová et al. 2003, (6) Pichrtová & Veselá (in press)]. Asterisk denotes a new record for the Czech Republic.

Taxon		Locality No.					Previous CZ records
		1	2	3	4	5	
S. echinulata Korshikov	Fig. 3	X					5
S. mollispina (J.B.Petersen et J.B.Hansen) L.S.Péterfi et Momeu	Fig. 2	X					*
S. petersenii Korshikov	Figs 18–19	X	X	X	X	X	1; 4
S. sphagnicola (Korshikov) Korshikov		X	X				4; 5
Synura spinosa Korshikov		X	X		X	X	1; 4; 5
S. uvella Ehrenberg	Fig. 1						5
M. acaroides Perty emend. Iwanoff	Fig. 15		X	X	X	X	3; 4; 5
M. calceolus D.E.Bradley					X		1; 3; 4; 5
M. conspersa Dürrschmidt	Figs 7–9		X				*
M. costata Dürrschmidt	Fig. 6		X				1; 4; 5
M. crassisquama (Asmund) Fott						X	1; 4; 5
M. heterospina J.W.G.Lund	Fig.11				X	X	1; 4; 5
M. kalinae Řezáčová	Fig. 10					X	2
M. multisetigera Dürrschmidt					X		6
M. ouradion K.Harris et D.E.Bradley						X	5
M. papillosa K.Harris et D.E.Bradley emend. K.Harris	Figs 13–14	X	X		X	X	3; 4; 5
M. pumilio var. *pumilio* K.Harris et D.E.Bradley emend. Asm., Cronb. et Dürrs.		X	X				4; 5
Mallomonas pumilio var. *munda* Asmund, Cronberg et Dürrschmidt	Fig. 4		X		X		*
M retifera Dürrschmidt	Fig. 7		X				1; 4
M. schwemmlei Glenk emend. Glenk et Fott	Figs 16–17					X	1; 3; 4;5
M. striata K.Harris et D.E.Bradley	Fig. 12		X		X	X	1; 3; 4; 5
M. tonsurata Teiling			X			X	1; 3; 4; 5
Chrysosphaerella brevispina Korshikov	Figs 21–22				X		5
Paraphysomonas vestita De Saedeleer	Fig. 23				X		1; 5
Spiniferomonas trioralis E.Takahashi	Fig. 20					X	1; 5

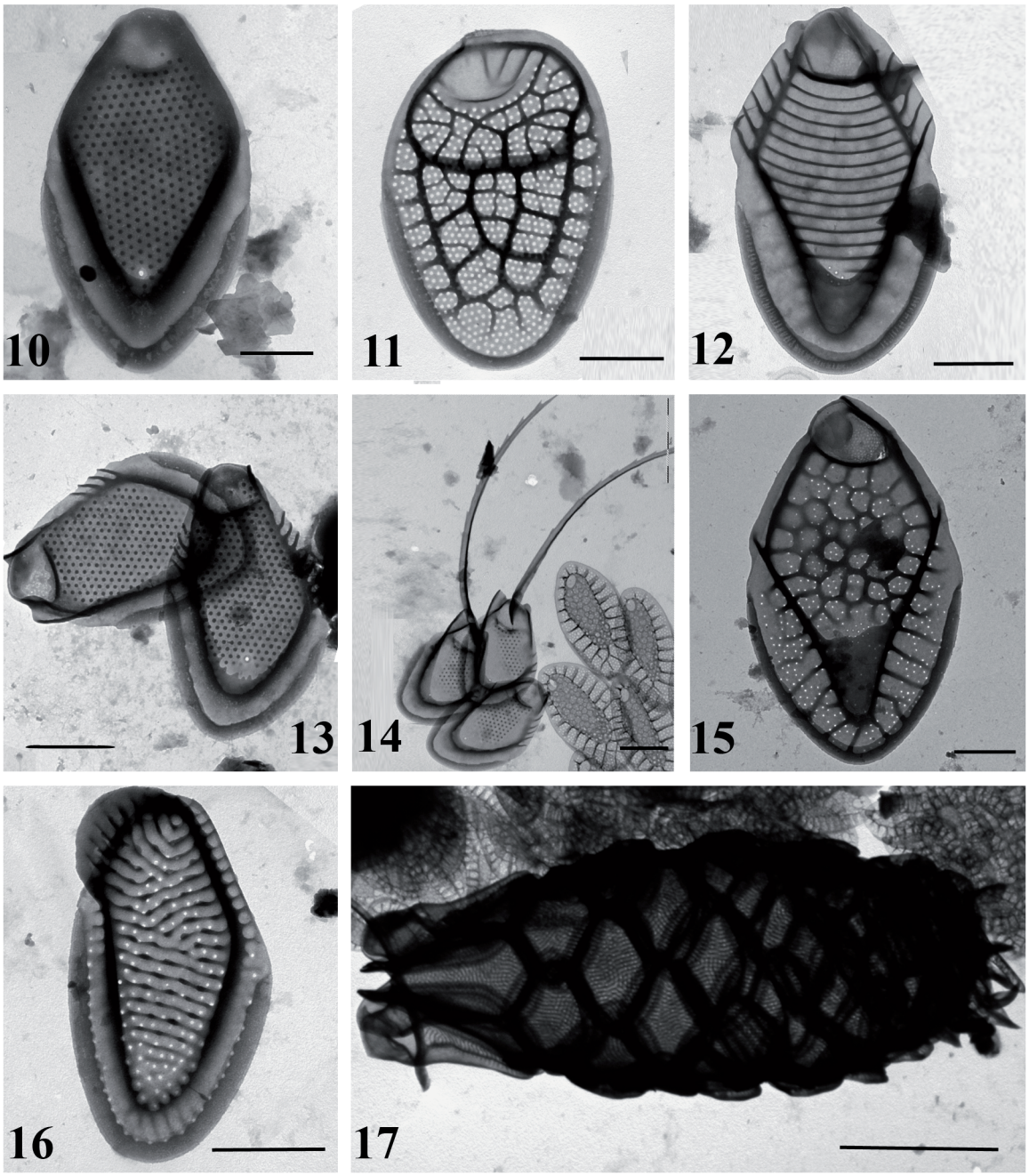
1959) and later it was described from New Zealand (Dürrschmidt 1986). *Mallomonas conspersa* was also listed in two Japanese species surveys, but the presence was not documented by scale microphotographs (Ito 1990, 1991). *M. conspersa* was delimited from *M. calceolus* (Dürrschmidt 1986), but the structure of the scales is also very similar to that of the scales of *M. retifera* (Dürrschmidt 1982). The most distinctive difference between these two species should be the sizes of the entire cell and the scales (*M. conspersa*: cell size 8–15 x 5–7 μm, scale size: 2.8–3.5 x 1.5–2 μm; *M. retifera*: cell size 17–20 x 5–9 μm, scale size 3.2–3.7 x 2–2.4 μm), but we have revealed scales of almost the same size for both taxa (compare Figs 6 with 8 and 9). Both discussed species were found at the same locality (see Table 2) during this survey. Siver (1991) hypothesized, on the bases of very similar scale morphology, that these two rare taxa may represent the same species. However, scales of *M. retifera* have a transverse rib on the shield positioned just behind the dome, the character that clearly distinguishes them from those of *M. conspersa*. The posterior flanges of investigated scales were not smooth, but possessed inconspicuous struts, radiated from the V-rib (Fig. 6). These struts have not been mentioned in *M. conspersa*. As the species concept is based on scale morphology (Siver 1991, Kristiansen 2002), the border between two species may be artificial and always reflecting a personal approach of the scientists who described them. While *M. retifera* was reported from Europe (e.g. Hartmann & Steinberg 1989, Pichrtová et al. 2007), South America (Dürrschmidt 1980, 1982) and East Asia (Ito 1990), *M. conspersa* was thought to be an extremely rare species. This species may be widely distributed or cosmopolitan, but forming only relatively small populations compared to



Figs 1–9. Silica-scaled chrysophytes of Borkovická Blata: (1) *Synura uvella*; (2) *S. mollispina*; (3) *S. echinulata*; (4) *Mallomonas pumilio* var. *munda*; (5) *M. costata*; (6) *M. retifera*; (7–9) *M. conspersa* [(7) an irregular apical scale with a prominent dome, bearing a bristle, (8–9) body scales]. Scale bars 1 μm.

frequently recorded species. The probability to reveal the scales on electron microscopic preparations is thus much lower, despite of the considerable degree of sampling effort. FINLAY & CLARKE (1999) demonstrated positive correlation between worldwide commonness of the species, and its local abundance. *M. conspersa* was described from a small pool in a semi-swamp forest, with pH of 5.6 and conductivity 90 $\mu S.cm^{-1}$ (DÜRRSCHMIDT 1986). These environmental conditions are comparable to those of recorded on Loc. 2, where this species was sampled in this study.

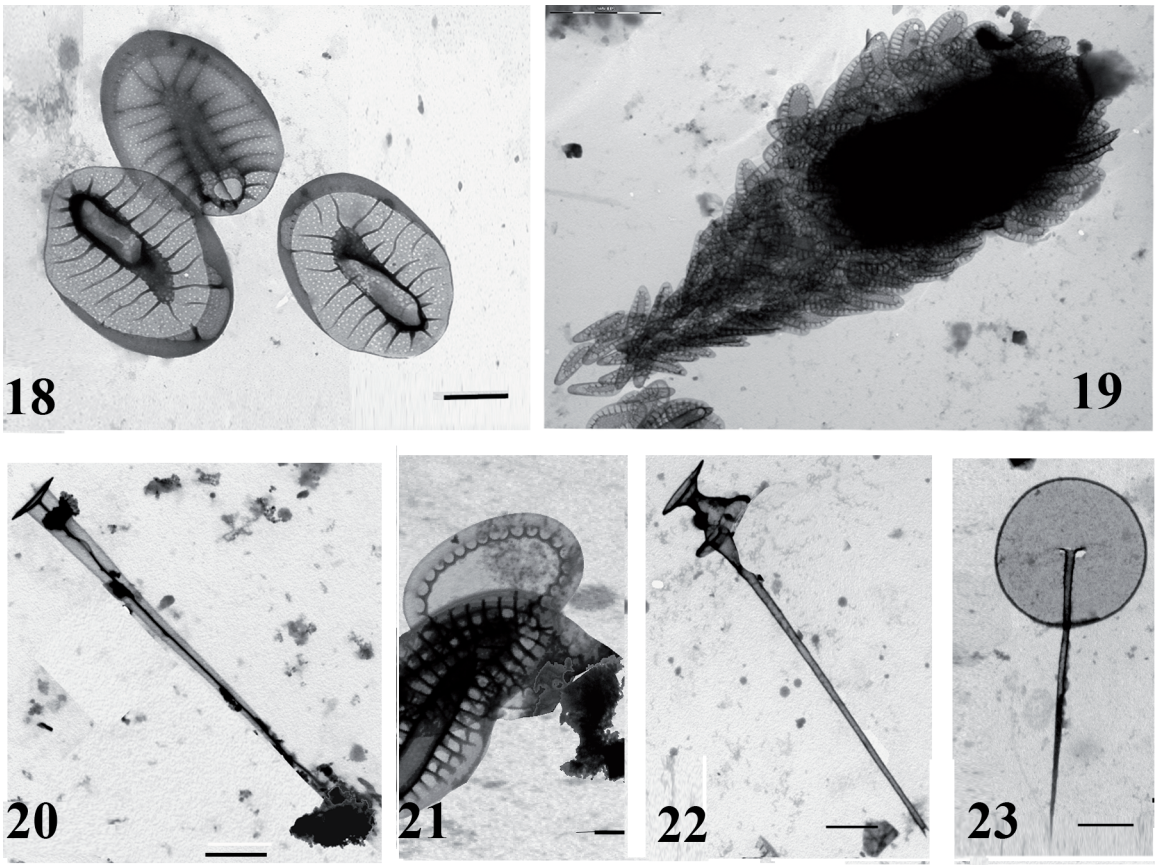
M. kalinae is a widespread, but rare, taxon found primarily at higher temperatures (DÜRRSCHMIDT & CROOME 1985, CROOME & TYLER 1988, ŘEZÁČOVÁ 2006). *M. kalinae* was discovered in Loc. 5 under the ice cover, where the temperature reached 0 °C, thus this species has probably wider temperature tolerance. *M.*



Figs 10–17. Silica-scaled chrysophytes of Novohradské Hory: (10) *Mallomonas kalinae*; (11) *M. heterospina*; (12) *M. striata*; (13–14) *M. papillosa* [(13) body scales, (14) scales bearing bristles]; (15) *M. acaroides*; (16–17) *M. schwemmlei* [(16) a scale from a posterior part of the cell, (17) a whole scale case, scale bar 5 μm]. Other scale bars 1 μm.

pumilio has been shown to occur predominantly at temperatures less than 13 °C. There seems not to be a difference in the ecological requirements of the varieties (Siver 1991). Both sampled varieties (*pumilio* and *munda*) have a bipolar distribution (Kristiansen & Preisig 2007). *M. pumilio* var. *munda* differs from the nominal variety in the presence of a regularly built hexagonal reticulum of the shield, with mostly six pores enclosed in each mesh. The important character is also the presence of struts on the anterior flanges.

M. schwemmlei is best described as winter species, distributed over the Northern temperate regions. Abundant populations of *M. schwemmlei* were discovered in Huťský pond (Loc. 5) under the ice cover. Chrysophytes were often reported to form high population densities at low temperatures (e.g. Sandgren 1988, Siver 1995). They may be better adapted to surviving conditions under an ice cover (low temperature combined with



Figs 18–23. Silica-scaled chrysophytes of Novohradské Hory: (18–19) *Synura petersenii* [(18) body scales, (19) a partly disintegrated scale case]; (20) *Spiniferomonas* cf. *trioralis*, spine; (21–22) *Chrysosphaerella brevispina* [(21) a plate scale, (22) a spine scale]; (23) *Paraphysomonas vestita*, a spine scale. Scale bars 1 μm.

low light intensities), giving them the advantage once the ice disappears (SIVER 1995). Taxa from the other genera were represented by widely distributed species *Chrysosphaerella brevispina*, *Paraphysomonas vestita* and *Spiniferomonas* cf. *trioralis*, with wide ecological tolerances. The presence of *Synura mollispina*, *Mallomonas conspersa* and *M. pumilio* var. *munda* are recorded for the first time from the territory of the Czech Republic.

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