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Scaled Chrysophyceae and Synurophyceae from Florida, U.S.A.: VI. Observations on the flora from waterbodies in the Ocala National Forest

by

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With 37 figures and two tables

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Abstract: Thirty-two taxa of silica-scaled Chrysophyceae and Synurophyceae are reported from waterbodies in the Ocala National Forest, Florida, U.S.A. Many of the lakes in the Ocala area are poorly buffered and low in both pH and specific conductivity. The organisms observed were clearly differentially distributed over a pH gradient, with the majority of species being typical of acidic localities. Sixteen of the organisms were observed only in waterbodies with a pH below 5.5. *Mallomonas wujekii*, a species known to date only from this region, was one of the more common organisms found in half of the collections. Even though the localities are located in the subtropics, the flora had clear affinities to more northern regions of both North America and Europe, especially from acidic localities. In contrast, the flora had few similarities with those previously described from subtropical and tropical regions, including ones from Florida. This survey represents the first report of *Mallomonas duerrschmidtiae and M. acaroides* var. *muskokana* from the subtropics. The potential use of scaled chrysophytes in future paleolimnological studies of the Ocala region are discussed.

Key Words: Chrysophytes, subtropics, Florida, Ocala National Forest, acidic habitats.

Introduction

There are thousands of freshwater lakes and ponds in the State of Florida, representing a wide variety of lake types (Pollmann & Canfield 1991). Through a number of recent efforts much has been learned about the physical, chemical and biological

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components of the waterbodies (e.g. Canfield 1981; Canfield et al. 1985; Pollmann & Canfield 1991), including the phytoplankton communities (Brezonik et al. 1984). Despite these efforts scale-bearing Chrysophyceae and taxa in the Synurophyceae (Andersen 1987) have rarely been reported in routine monitoring efforts.

It is clear, however, based on the work of Wujek and co-workers (e.g Wujek & Siver 1997 and references therein) and Siver and co-workers (Siver 1991; 1994; Siver & Wujek 1993), that a rich flora of scaled chrysophycean and synurophycean organisms (hereafter referred to as scaled chrysophytes) exists in freshwater Florida localities. In total, 67 taxa have been reported from examination of a limited number of collections from 52 waterbodies (Wujek 1984; Wujek & Bland 1991; Siver & Wujek 1993; Wujek & Siver 1997), including original descriptions of nine new organisms (Wujek 1983; Wujek & Gardiner 1985; Wee & Wujek 1986; Wujek & Bland 1988; Siver 1991; Siver 1994). As many as 27 taxa have been reported from a single location based on a limited number of collections (e.g. Siver & Wujek 1993). Because of the high number of species encountered in a relatively low number of waterbodies it is likely that many additional organisms may be described from Florida.

Most of the waterbodies examined previously for scaled chrysophytes were located in the central (e.g. Wujek 1984), southern (e.g. Wujek & Bland 1991), or south-central (e.g. Siver & Wujek 1993) portions of the state. More recently, nineteen sites were added from the north-central region (Wujek & Siver 1997). The majority of the localities in the north-central region were humic stained with pH values ranging from 6.0 to 6.4. In this paper we report on the distribution of scaled chrysophytes in ten additional north-central Florida lakes situated in the Ocala National Forest. The majority of the lakes are acidic, clearwater, low in specific conductivity and relatively oligotrophic in nature (see below). As such, the waterbodies included in this work are chemically different from many of the waterbodies previously examined for scaled chrysophytes in Florida as well as other subtropical and tropical regions. The paper represents the sixth in a series aimed at describing the scaled chrysophyte flora of Florida.

The study area

The Ocala National Forest covers over 430,000 acres in central Florida and lies within the subtropical zone (Lincoln et al. 1982). There are over 600 lakes and ponds situated within the forest, most of which are solution basins that subsequently became lined with clay, and lack drainage streams (Greis 1985). The majority of the waterbodies are surrounded by acidic soils with low buffer capacities, and are not influenced by high pH groundwater (Fellows & Brezonik 1980; Greis 1985). As a result, many of the lakes are acidic and low in dissolved salts (Greis 1985).

In a study of 60 lakes in the forest Greis (1985) reported that over two-thirds of the waterbodies had a pH between 4 and 5, and a specific conductivity between 31 and 50 $\mu S\ cm^{-1}$. Mean levels of sodium, calcium and magnesium were 3.7 $mg\ L^{-1}$, 1.5 mg L^{-1} and 1.0 $mg\ L^{-1}$, respectively. Mean levels of chloride, sulfate and alkalinity were 8.2 $mg\ L^{-1}$, 4.7 $mg\ L^{-1}$ and 2.8 $mg\ L^{-1}$ (as $CaCO_3$), respectively. In general, many of the waterbodies had low chlorophyll-*a* and total phosphorus levels, and were classified as oligotrophic or mesotrophic (Greis 1985). The less acidic lakes tended to have elevated nutrient levels, to be more productive, and to be more brown in color.

Materials and methods

Plankton samples were collected from ten lakes within the Ocala National Forest (Fig. 1) between March 13 and 15, 1993. Both water samples and plankton net samples (10 μm mesh) were used in the analysis of scaled chrysophytes from each site. Water samples were initially concentrated with centrifugation. The water and net samples were prepared for scanning electron microscopy according to Siver (1987). Essentially, aliquots of each sample were dried onto aluminum foil, trimmed, mounted onto aluminum stubs with Apiezon wax, coated with gold with a Polaron sputter coater, and observed with a Coates and Welter field emission SEM (15 to 21 kV).

The relative proportions of each organism were qualitatively estimated from the concentrated water samples and scored according to the following system. Taxa that were among the most dominant species of algae in the sample were listed as "abundant". Taxa that were sub-abundant, but still important components of the flora were listed as "common". Taxa that were rare, but still represented by whole cells were scored as "rare". Organisms represented by only a few isolated scales were listed as "very rare".

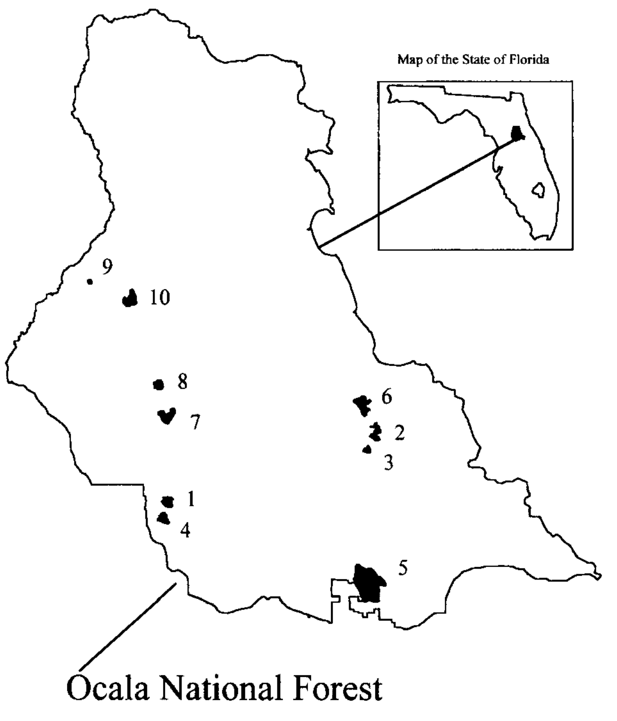


Fig. 1. Locations of the study lakes within the Ocala National Forest. Numbers refer to those listed in Table 1.

Specific conductance was measured in the field with a YSI model 33 SCT meter and later standardized to 25°C according to Siver (1993). The pH was measured in the field with a Fisher Accumet model 640A pH meter. Samples for dissolved concentrations of base cations were collected in acid washed polyethylene containers, filtered through glass-fiber filters, acidified to pH<2 with 50% nitric acid, and analyzed with a Perkin Elmer 2380 flame atomic absorption spectrometer. Concentrations were determined by comparison with calibration standards. Values for Secchi disc depth, total phosphorus and chlorophyll-*a* concentrations were taken from Greis (1985).

Results

Water chemistry

Despite the fact that the samples were taken two days after a severe storm event, the water chemistries of the study lakes were similar to measurements made by Greis (1985). The lakes ranged in pH from 4.1 to 7.3, with six localities less than pH 5.6 (Table 1). Lake Eaton, and at times Mill Dam, are influenced by high pH groundwater (Greis 1985). Except for Lake Eaton (90 µS cm^{-1}), all of the waterbodies had a specific conductivity between 38 and 70 µS cm^{-1} at the time of collection, and surface water temperatures between 13.5°C and 18°C (Table 1). All of the lakes contained higher levels of Na^+, relative to those of Ca^{++}, Mg^{++} or K^+ (Table 1). Concentrations of Na^+ ranged from 4.35 to 6.76 mg L^{-1}. On average, concentrations of Mg^{++} were double those of Ca^{++}. Concentrations of Ca^{++} and Mg^{++} were significantly higher in Lake Eaton than in the other waterbodies, most likely due to the influence of alkaline groundwater.

Lakes Eaton and Dorr contained high levels of organic acids and had low Secchi disc depths of 1 m or less; the other waterbodies were all clearwater in nature with mean Secchi disc values between 1.9 and 5.8 m (Greis 1985). According to Greis (1985) chlorophyll-*a* concentrations were relatively low, ranging from 0.5 to 3.7 µg L^{-1}, and in eight of the lakes total phosphorus levels were only 10 µg L^{-1} (Table 1).

Table 1. Physical and chemical characteristics of the ten study lakes located in the Ocala National Forest. Data for temperature, pH, specific conductivity and base cation concentrations were measured in March, 1993. Data for Secchi disc depth, total phosphorus and chlorophyll-*a* concentrations are from Greis (1985). Spec. Cond. = specific conductivity; SD = Secchi disc; TP = total phosphorus; Chloro-*a* = chlorophyll-*a*. The lake numbers refer to those listed in Table 2.

# / Lake	Temp. (°C)	Spec. Cond. (µS cm^{-1})	pH	Na^+ (mg L^{-1})	K^+	Ca^{++}	Mg^{++}	SD (m)	TP (µg L^{-1})	Chloro-*a* (µg L^{-1})
4. Catherine	16.5	58	4.9	5.31	0.46	0.98	1.70	4.3	10	0.71
5. Dorr	16.0	53	5.2	6.76	0.29	0.63	1.30	1.0	20	2.00
10. Eaton	13.0	90	7.3	6.17	0.13	3.57	4.00	0.3	50	0.90
9. Fore	17.0	38	6.8	4.35	0.29	0.82	0.70	1.9	10	3.70
2. Grasshopper	17.0	70	4.4	6.10	0.25	0.70	1.29	5.8	10	0.50
7. Half Moon	15.5	43	6.4	5.81	0.96	0.56	1.26	2.0	10	1.60
1. Mary	18.0	63	4.1	6.38	0.21	0.75	1.30	4.1	10	0.66
8. Mill Dam	17.5	48	6.6	5.56	0.54	0.52	1.35	3.7	10	1.70
3. Sellers	16.0	55	4.8	5.73	0.46	0.82	1.19	5.3	10	0.50
6. Wildcat	17.0	42	5.5	5.44	0.21	0.52	0.89	3.5	10	1.10

Scaled Chrysophytes

The abundances and taxonomic authorities of the organisms in the study lakes are listed in Table 2. A total of 32 taxa of scaled chrysophytes were found in the ten waterbodies (Table 2; Figs 2-37). The number of taxa in each lake ranged from 2 to 15, with a mean of 8. Based on estimates of cell counts the scaled chrysophytes accounted for over 20% of the phytoplankton communities in all waterbodies except Half Moon at the time of collection. Six of the organisms, *Mallomonas hamata, M. duerrschmidtiae, M. wujekii, Synura petersenii* f. *petersenii, S. echinulata* f. *echinulata and S. echinulata* f. *leptorrhabda,* were observed in four or more of the study lakes and were common or abundant in at least one locality. It is of special interest to note that *M. wujekii,* a species originally identified and to date only observed from this region (Siver 1994), was found in half of the lakes. Six other taxa, *M. caudata, M. corymbosa* var. *poseidonii, S. petersenii* f. *truttae, S. spinosa, Spiniferomonas trioralis, and P. vestita,* were common or abundant in at least one locality, but observed in only three or less of the collections. Twenty-two of the taxa were found in only one or two of the collections (Table 2).

There was a distinct distribution of species along a pH gradient (Table 2). Sixteen taxa were only found below a pH of 5.5. One group of taxa, including *Mallomonas canina, M. favosa, M. multisetigera, Synura sphagnicola and Spiniferomonas takahashii,* were only found in localities with a pH below 5. A second group of species, including *Mallomonas transsylvanica, M. corymbosa* var. *poseidonii, Synura petersenii* f. *truttae, S. spinosa* and *M. duerrschmidtiae* were more common between pH 4.9 and 6.6, but generally lacking above or below this range. A third group of five species, *M. striata* var. *serrata, M. matvienkoae, M. tonsurata, M. pseudocoronata,* and *Spiniferomonas trioralis,* were restricted to localities with pH above 6.4.

Discussion

A rich and diverse flora of scaled chrysophytes was found in the lakes and ponds of the Ocala National Forest, supporting the fact that a rich scaled chrysophyte flora exists in Florida (Wujek 1984; Wujek & Bland 1991; Siver & Wujek 1993; Wujek & Siver 1997). This is especially of interest since the lakes in the present study are, in general, lower in pH and dissolved salts than other regions previously surveyed in the state. Since the study was restricted to the spring period and to only ten waterbodies, it is most likely that many other species exist in this region.

The flora described in this study had clear affinities to more northern regions of both North America (e.g. Wawrzyniak & Andersen 1985; Siver 1987; 1988; Nicholls & Gerrath 1985) and Europe (e.g. Cronberg & Kristiansen 1980; Dürrschmidt 1984; Eloranta 1989), especially from acidic localities. In contrast, there were few similarities with floras previously described from subtropical and tropical regions (e.g. Cronberg 1989a; Saha & Wujek 1990; Vyverman & Cronberg 1993; Siver & Vigna 1997). In fact, none of the scaled chrysophytes reported by Cronberg (1989a) as being restricted to or primarily distributed in tropical regions of the world were observed in the Ocala region. The lack of similarity of the Ocala flora with more tropical floras is of

Table 2. Distribution of scaled chrysophytes in waterbodies located in the Ocala National Forest, Florida, U.S.A. The lakes are listed from low to high pH. Lake numbers refer to those listed in Table 1 and the pH values for each lake are listed in parentheses. Key to genera: *M.* = *Mallomonas, S.* = *Synura, Sp.* = *Spiniferomonas, C.* = *Chrysodidymus, P.* = *Paraphysomonas.* Key to abundances: A = abundant, C = common, R = rare, VR = very rare. See text for details.

	Lake Number (pH)										Total
	1 (4.1)	2 (4.4)	3 (4.8)	4 (4.9)	5 (5.0)	6 (5.5)	7 (6.4)	8 (6.6)	9 (6.8)	10 (7.3)	
M. hamata Asmund	C	C		R		R					4
S. echinulata Korsh. f. *echinulata*	C			A					VR	VR	4
S. echinulata Korsh. f. *leptorrhabda* Asmund	R	VR		A		R					4
Sp. takahashii Nicholls	VR		VR								2
M. canina Kristiansen	VR	R									2
M. akrokomos Ruttner in Pascher		C						R			2
S. petersenii Korsh. f. *petersenii*		R	C	R		A		R	VR	R	7
S. sphagnicola Korsh.		VR		R							2
M. wujekii Siver		VR		C	C	R		R			5
M. papillosa Harris et Bradley			VR						VR		2
M. cristata Dürrschmidt			VR							R	2
M. multisetigera Dürrschmidt			VR								1
M. mangofera Harris et Bradley f. *foveata* Dürrschmidt				C						R	2
M. favosa Nicholls				R							1
M. transsylvanica Péterfi et Momeu				R		C					2
M. corymbosa Asmund et Hilliard var. *poseidonii* Siver				C	R	R					3
S. petersenii Korsh f. *truttae* Siver					C						1
P. vestita (Stokes) De Saedeleer					C				VR		2
S. spinosa Korsh.					R	A				R	3
M. duerrschmidtiae Siver, Hamer et Kling					VR	VR	C	R	R		5
M. caudata Ivanov						VR		R		A	3
M. acaroides Perty em. Ivanov var. *muskokana* Nicholls						VR					1
S. petersenii Korsh. f. *praefracta* Asmund						VR					1
S. uvella Stein em. Korsh.						R				R	2
M. dickii Nicholls						R					1
M. punctifera Korsh.						VR					1
C. synuroideus Prowse						VR					1
Sp. trioralis Takahashi							R	R	C		3
M. striata Asmund var. *serrata* Harris et Bradley								R		R	2
M. matvienkoae (Matv.) Asmund et Kris.								R			1
M. tonsurata Teiling em. Krieger										R	1
M. pseudocoronata Prescott										VR	1
Total	5	7	6	10	6	15	2	8	6	10	

interest since studies of other areas in Florida clearly revealed a tropical element (Wujek & Bland 1991; Siver & Wujek 1993). It is possible that a tropical component does exist in the Ocala flora, but was not sampled in this survey because collections were not made during the warmer months. Most surveys from subtropical and tropical regions represent waterbodies with a higher pH and concentration of dissolved salts than the localities examined in the Ocala forest (Cronberg 1989a; Saha & Wujek 1990; Vyverman & Cronberg 1993; Siver & Vigna 1997). It is also possible that as more studies from subtropical and tropical areas low in pH and salt content are undertaken that more affinities with acidic localities from northern temperate regions will be made; such studies are clearly warranted.

Other observations on the distribution of scaled chrysophytes can be made based on this survey. First, the geographic distributions of several taxa, such as *Mallomonas duerrschmidtiae* and *M. acaroides* var. *muskokana,* have been significantly extended. Both of these taxa have been previously reported from the northeastern part of North America (Nicholls 1987; Siver 1989a; 1991), and *M. duerrschmidtiae* has also been found in Greenland (Jacobsen 1985). This survey represents the first report of both taxa from the subtropics. Second, *Synura petersenii* f. *truttae* was originally described from a humic stained locality in Connecticut (Siver 1987). In a previous study from Florida, Siver & Wujek (1993) also noted that *Synura petersenii* f. *truttae* was common in two habitats high in humic content. Results from this study further support the idea that this taxon appears to be primarily found in humic localities.

The scaled chrysophyte flora of the Ocala region is typical for acidic localities with low specific conductivity. Many of the 16 taxa observed below pH 5.5 are well documented as being primarily distributed at low pH values (see Siver 1989a; Siver 1991). *Mallomonas canina,* found in the two most acidic lakes in this study, was originally described from an acidic locality (Kristiansen 1982), and has consistently been reported from very acidic waterbodies (e.g. Eloranta 1989; Hartmann & Steinberg 1989; Siver 1989a; 1991). This study supports the concept that *M. canina* is one of the most acidic species of scaled chrysophytes known (see Siver 1991) and is a true acidobiontic taxon (Siver 1989a). Because the previous record of *M. canina* by Wujek & Bland (1991, fig. 2) from Florida was actually of the closely related taxon *M. pugio,* the Ocala collections represent the first observations of *M. canina* in Florida.

Other species found in the more acidic localities of the Ocala National Forest, including *Synura echinulata* f. *echinulata, S. echinulata* f. *leptorrhabda, S. sphagnicola, Mallomonas hamata, M. acaroides* var. *muskokana,* and *Chrysodidymus synuroideus,* are also well documented from low pH habitats. Taxa in the *Synura echinulata* group were an especially important component of the spring phytoplankton flora in Ocala lakes with a pH less than 5. Although *Synura echinulata* has been reported over a wide pH range (e.g. Kristiansen 1975; Siver 1989a), it is clearly more commonly found in acidic localities (e.g. Kristiansen 1975; Cronberg & Kristiansen 1980; Smol et al. 1984; Siver 1988; 1989a; Hartmann & Steinberg 1989). As a result of its preference for acidic localities, relatively low weighted mean pH values of 5.7 (Charles & Smol 1988), 5.9 (Siver 1989a) and 6.0 (Siver 1989a) have been reported for *S. echinulata. Synura echinulata* is also commonly found in association with *Synura sphagnicola* in more northern latitudes (Wawrzyniak & Andersen 1985; Roijackers & Kessels 1986; Eloranta 1989; Hartmann & Steinberg 1989). *Synura sphagnicola* is consistently reported at even lower pH than *S. echinulata* with reported weighted mean values of 5.3 (Siver 1989a; Eloranta 1989), 5.4 (Siver 1989a) and 5.9 (Charles & Smol 1988). Both of these species of *Synura* have been used in paleolimnological studies of acidic deposition (e.g. Hartmann & Steinberg 1989).

Mallomonas acaroides var. *muskokana* (Siver 1989b), *M. hamata* (Kristiansen 1986; Siver 1989a; Smol et al. 1984), and *Chrysodidymus synuroideus* (Charles & Smol 1988), have also often been reported in localities with a pH below 5.5, in agreement with findings from this study. Weighted mean pH values of 5.2, 5.4 and 5.8 (Charles

& Smol 1988; Siver 1991) have been reported for *Mallomonas acaroides* var. *muskokana,* and this organism has been observed to increase in abundance in dilute lakes with the onset of acidification (Christie & Smol 1986).

Mallomonas hamata is often reported from dilute, poorly buffered, oligotrophic waterbodies that are acidic in nature (e.g. Siver 1989a; Cronberg 1989b). Although *M. hamata* is most commonly found between pH 5.5 and 6.5, and remains an important species in collections below pH 5.5 (Siver 1989a), it becomes rarer at pH values above 7 (Siver 1989a; Eloranta 1989). *Chrysodidymus synuroideus* is also known to be most abundant in acidic waters (Charles & Smol 1988).

Some taxa, such as *M. duerrschmidtiae, M. punctifera, M. trannsylvanica and M. dickii,* are often found in acidic waters but above pH 5, and all have reported weighted mean pH values between 5.8 and 6.3 (see Siver 1989a; 1991 and references therein); this pattern is further supported by the present study. Although less is known about *Spiniferomonas takahashii,* Nicholls (1981) found this organism to prefer acidic waters. Three species previously recorded as having weighted mean pH optima above 7.2 (Siver, 1989a), *Mallomonas tonsurata, M. pseudocoronata* and *M. striata,* were restricted to localities in the Ocala region with a pH above 6.6. A newly described variety of *Mallomonas corymbosa,* var. *poseidonii* (Siver 1998), was found at three sites between pH 4.9 and 5.5.

In addition to representing a more acidic flora, the Ocala flora also differs from those in other regions in Florida in that it contains taxa more commonly found in low conductivity habitats. For example, the weighted mean specific conductivity values for *M. punctifera, M. duerrschmidtiae, M. acaroides* var. *muskokana, M. transsylvanica and S. sphagnicola* have all been reported as less than 51 μS (Siver 1993), similar to the specific conductivity values of the Ocala lakes (Greis 1985; this study). Other taxa common in the Ocala region, including *S. echinulata* and *M. hamata,* are also most commonly observed in habitats with low specific conductivity (Siver 1993). It is most likely that a combination of low pH and low specific conductivity has resulted in the Ocala flora being considerably different from those described from other regions in Florida.

Over the past decade it has become clear that the remains of scaled chrysophytes can be effectively utilized in paleolimnological studies in order to assess the degree and timing of historical changes in lacustrine ecosystems (see Smol 1995 and references therein). In particular, scaled chrysophytes have been successfully used to model changes in pH (e.g. Siver & Hamer 1990; Cumming et al. 1992), specific conductivity (Siver 1993; Lott et al. 1994) and trophic condition (Siver & Marsicano 1996).

Much paleolimnological work has indicated that acidic deposition has caused recent mineral acidification of many dilute drainage lakes in North America (see Charles, 1991). An alternative hypothesis is that some lakes were naturally acidic and the effects of acidic deposition are superimposed on the naturally occurring processes (Krug & Frink 1983). In order to fully understand the effects of acidic deposition on lacustrine ecosystems we need to understand the effects of natural vs. anthropogenic acidifying processes. Based on paleolimnological work using diatoms Sweets et al.

(1990) determined that some lakes in Florida appeared to be naturally acidic, and that they had not significantly decreased in pH in recent decades. Because of the apparent diversity and importance of scaled chrysophytes in the Ocala region, this organismal group could potentially become another valuable paleolimnological tool for understanding the effects of acidifying processes on seepage lakes in Florida.

Explanation of figures

Figs. 2-7. Fig. 2. *Mallomonas acaroides* var. *muskokana.* Group of domed body scales. Scale bar = 2 µm. Fig. 3. *Mallomonas canina.* Body scale with shield papillae. Scale bar = 1 µm. Figs 4-5. *Mallomonas akrokomos.* Fig. 4 depicts the bristle bearing scales of the anterior end of a cell; Scale bar = 2 µm. Fig. 5 is a close-up of body scales. Scale bar = 0.5 µm. Fig. 6. *Mallomonas crassisquama.* Domed body scales. Scale bar = 2 µm. Fig. 7. *Mallomonas cristata.* Two scales with bristles. Scale bar = 2 µm.

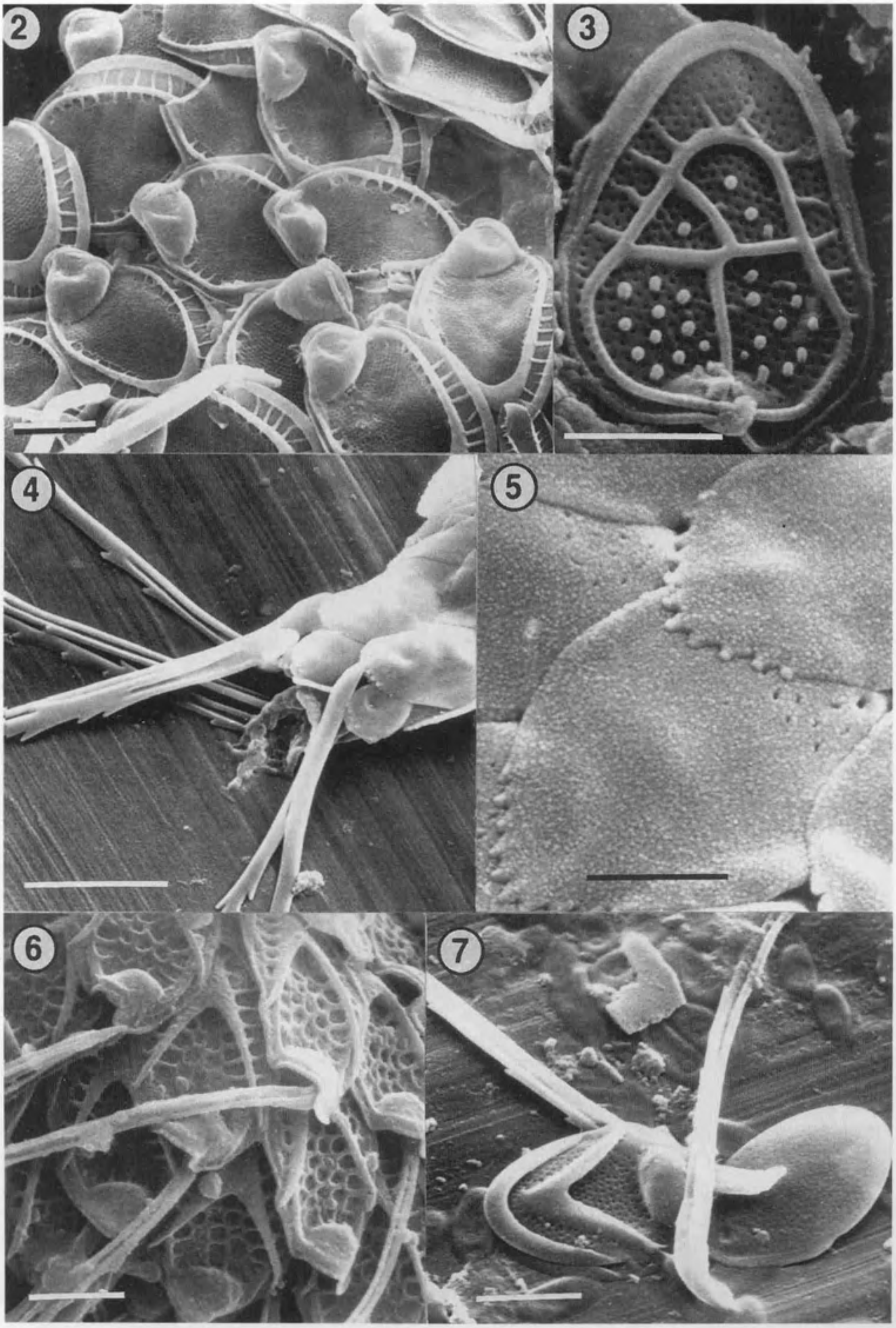
Figs. 8-13. Fig. 8. *Mallomonas corymbosa* var. *poseidonii.* Whole cell. Scale bar = 2 µm. Fig. 9. *Mallomonas dickii.* Close-up of the body of a cell. Scale bar = 1 µm. Figs 10-11. *Mallomonas duerrschmidtiae.* Fig. 10. Two anterior scales. Note the continuation of the V-rib with the anterior submargial ribs. Scale bar = 2 µm. Fig. 11. Body scales on an intact cell. Scale bar = 2 µm. Figs 12-13. *Mallomonas hamata.* Fig. 12 depicts the remains of a whole cell. Note the two bristle types. Scale bar = 2 µm. Fig. 13 is a close-up of several body scales. Scale bar = 2 µm.

Figs. 14-19. Fig. 14. *Mallomonas favosa.* Whole cell. Scale bar = 2 µm. Fig. 15. *Mallomonas heterospina.* Group of body scales. Scale bar = 2 µm. Fig. 16. *Mallomonas mangofera* f. *foveata.* Whole intact cell. Scale bar = 2 µm. Fig. 17. *Mallomonas multisetigera.* Part of a scale. Note the papillae on the shield and the larger pores in the posterior flange. Scale bar = 1 µm. Fig. 18. *Mallomonas matvienkoae.* Group of body scales. Scale bar = 2 µm. Fig. 19. *Mallomonas papillosa.* Single scale. Note the lack of ribs on the anterior submarginal flanges. Scale bar = 1 µm.

Figs. 20-25. Figs 20-21. *Mallomonas transsylvanica.* Fig. 20 depicts the anterior portion of an intact cell. Scale bar = 2 µm. Fig. 21 represents a single body scale. Scale bar = 2 µm. Fig. 22. *Mallomonas punctifera.* Anterior part of an intact cell. Scale bar = 2 µm. Fig. 23. *Mallomonas pseudocoronata.* Posterior spined scale. Scale bar = 2 µm. Figs 24-25. *Mallomonas striata* var. *serrata.* Body scales (Fig. 24) and bristles (Fig. 25). Scale bars = 2 µm.

Figs. 26-31. Fig. 26. *Synura petersenii* f. *praefracta.* Single scale. Note the blunt spine tip with teeth. Scale bar = 1 µm. Fig. 27. *Mallomonas tonsurata.* Domeless body scale. Scale bar 2 µm. Fig. 28. *Synura uvella.* Two spined scales. Scale bar = 2 µm. Fig. 29. *Synura petersenii* f. *petersenii.* Close-up of a group of body scales. Scale bar = 1 µm. Fig. 30. *Synura spinosa.* Single spined scale. Scale bar = 2 µm. Fig. 31. *Synura petersenii* f. *truttae.* Group of scales. Scale bar = 2 µm.

Figs. 32-37. Fig. 32. *Synura echinulata* f. *leptorrhabda.* Two scales. Note the series of anterior ribs and the reduced secondary layer. Scale bar = 1 µm. Fig. 33. *Synura echinulata* f. *echinulata.* Group of mostly posterior scales. Note the wide secondary layer with parallel ribs. Scale bar = 2 µm. Fig. 34. *Synura sphagnicola.* Single spined scale. Scale bar = 2 µm. Fig. 35. *Paraphysomonas vestita.* Three spined scales. Scale bar = 2 µm. Fig. 36. *Spiniferomonas trioralis.* Remains of a whole cell depicting both spined and non-spined scales. Scale bar = 2 µm. Fig. 37. *Spiniferomonas takahashii.* Single spined scale. Scale bar = 1 µm.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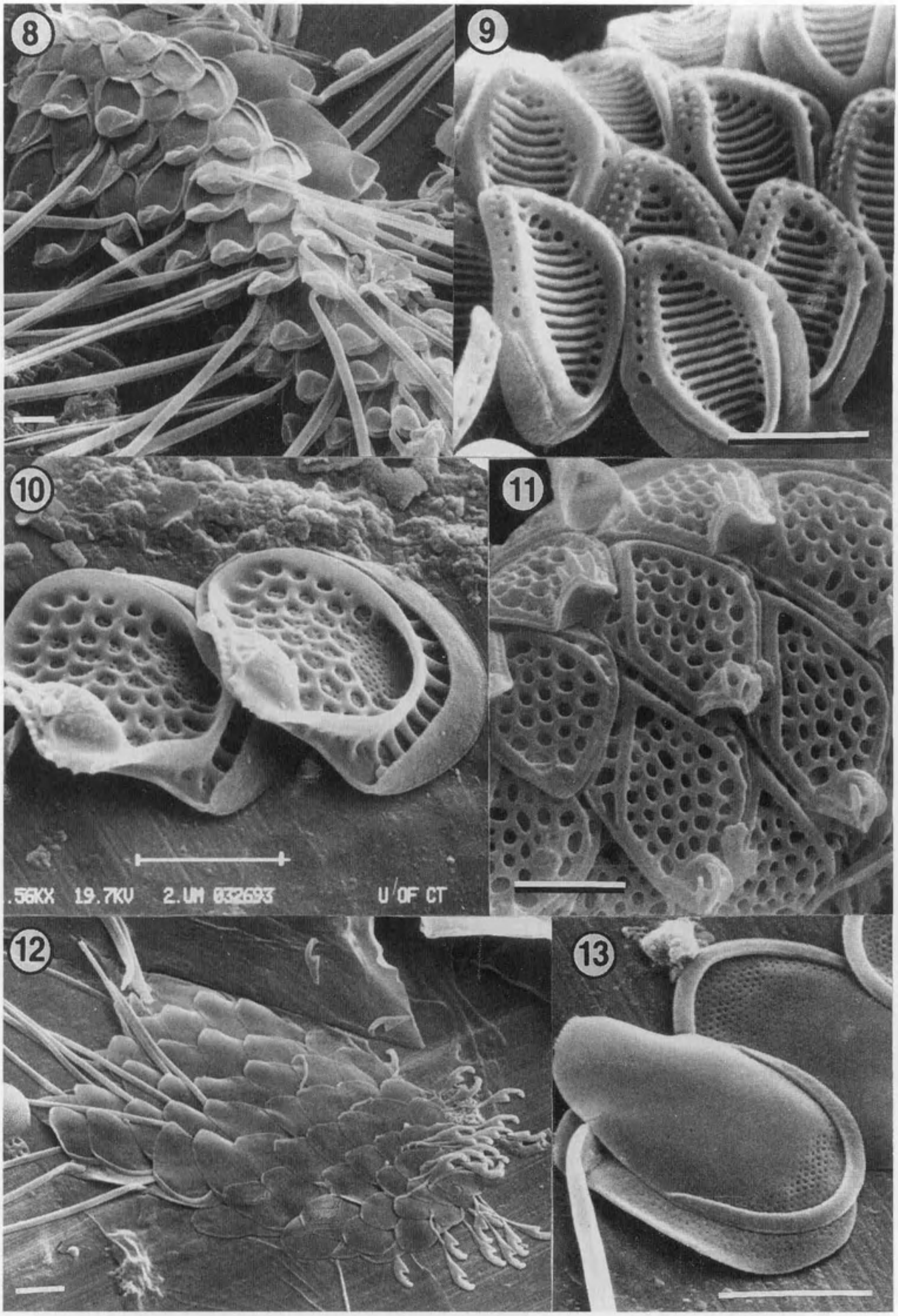
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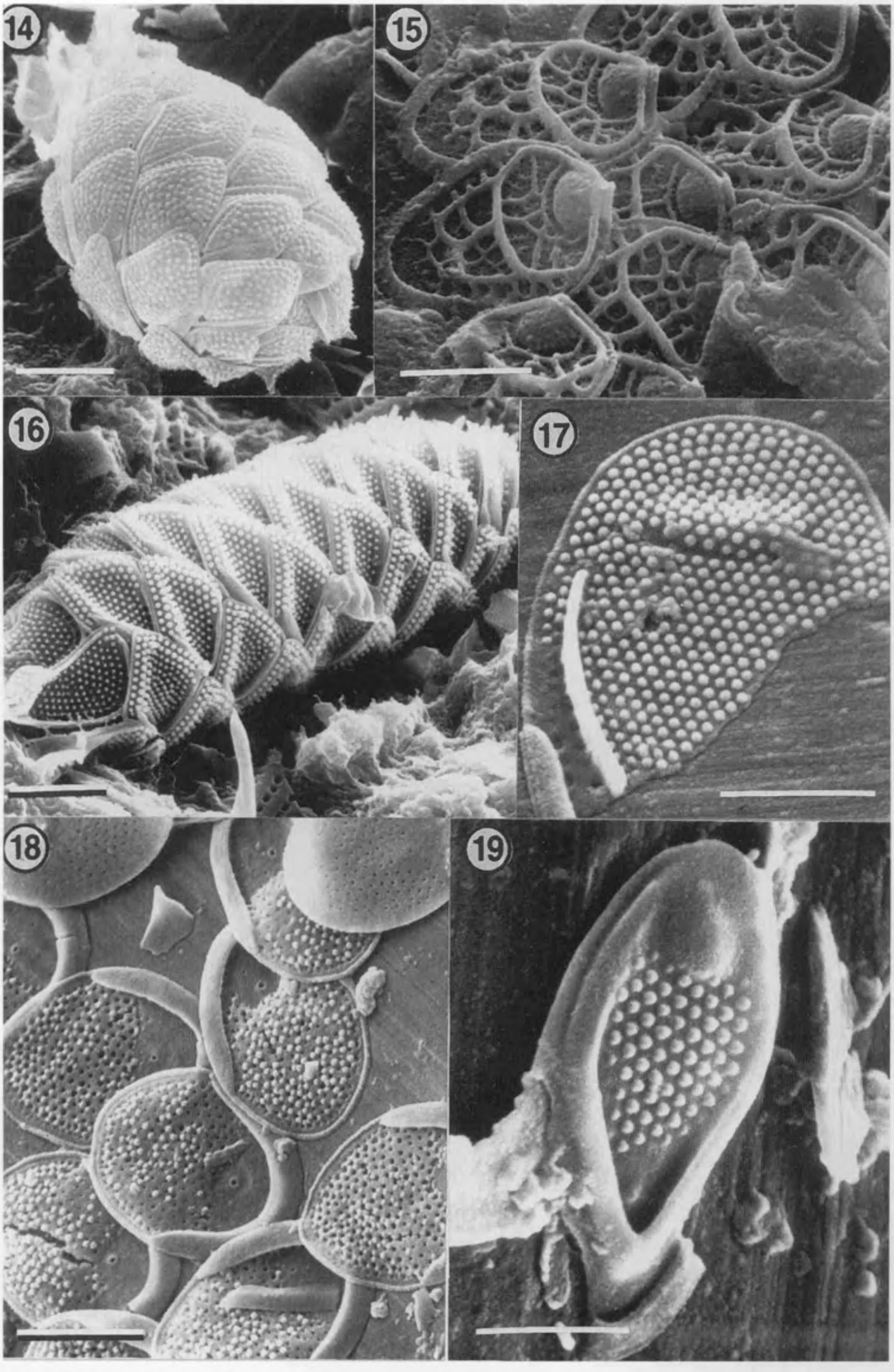
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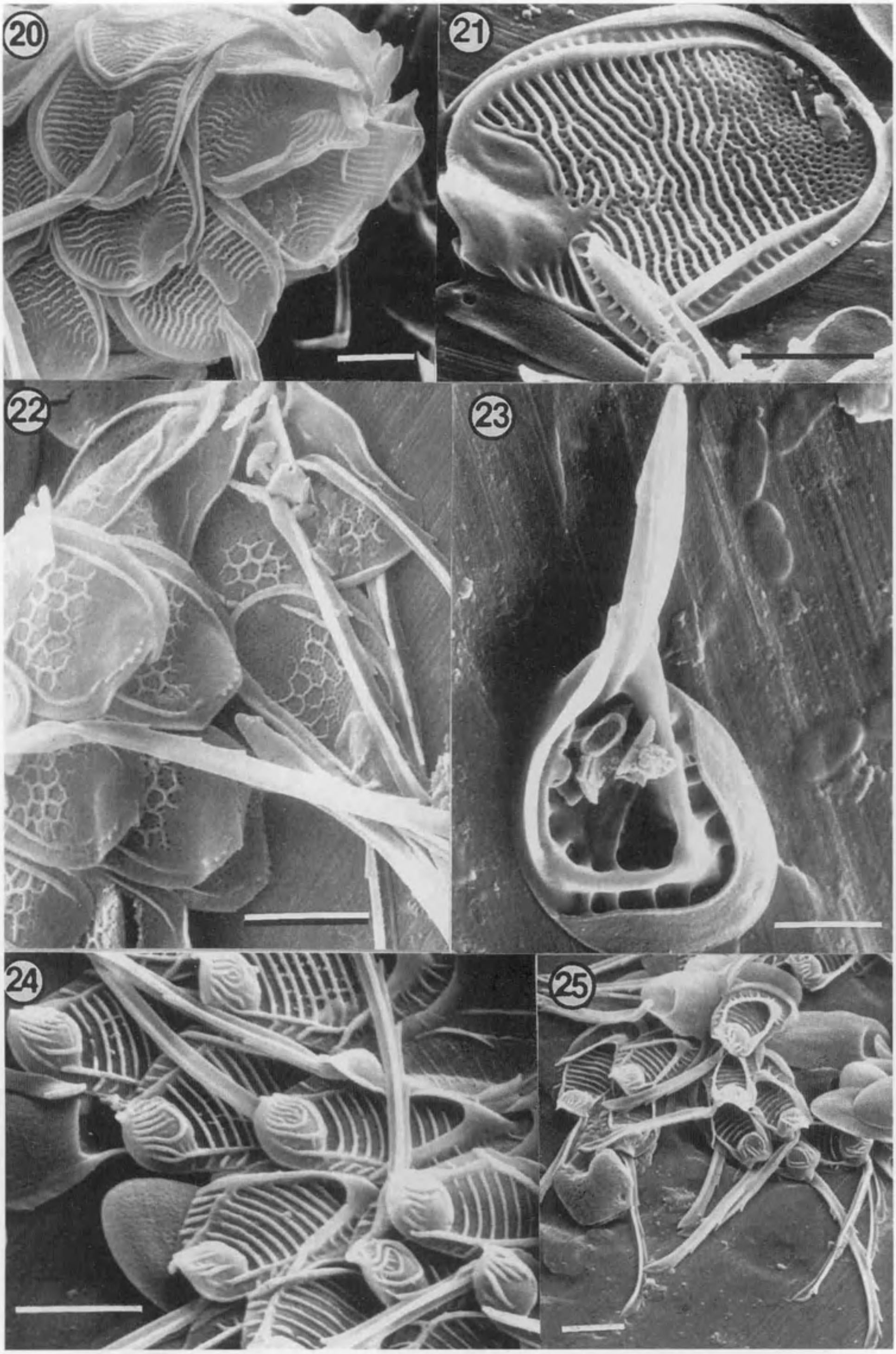
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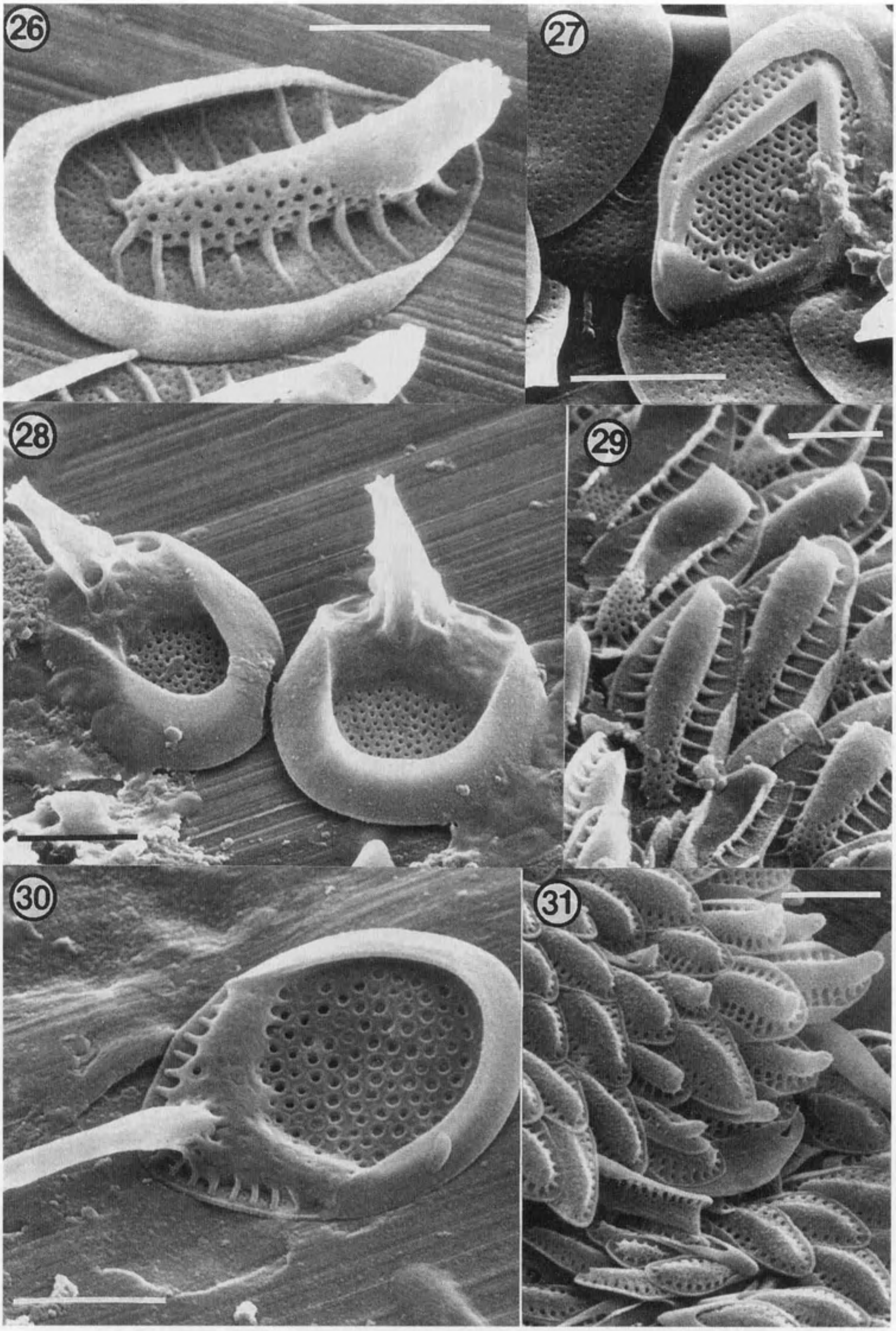
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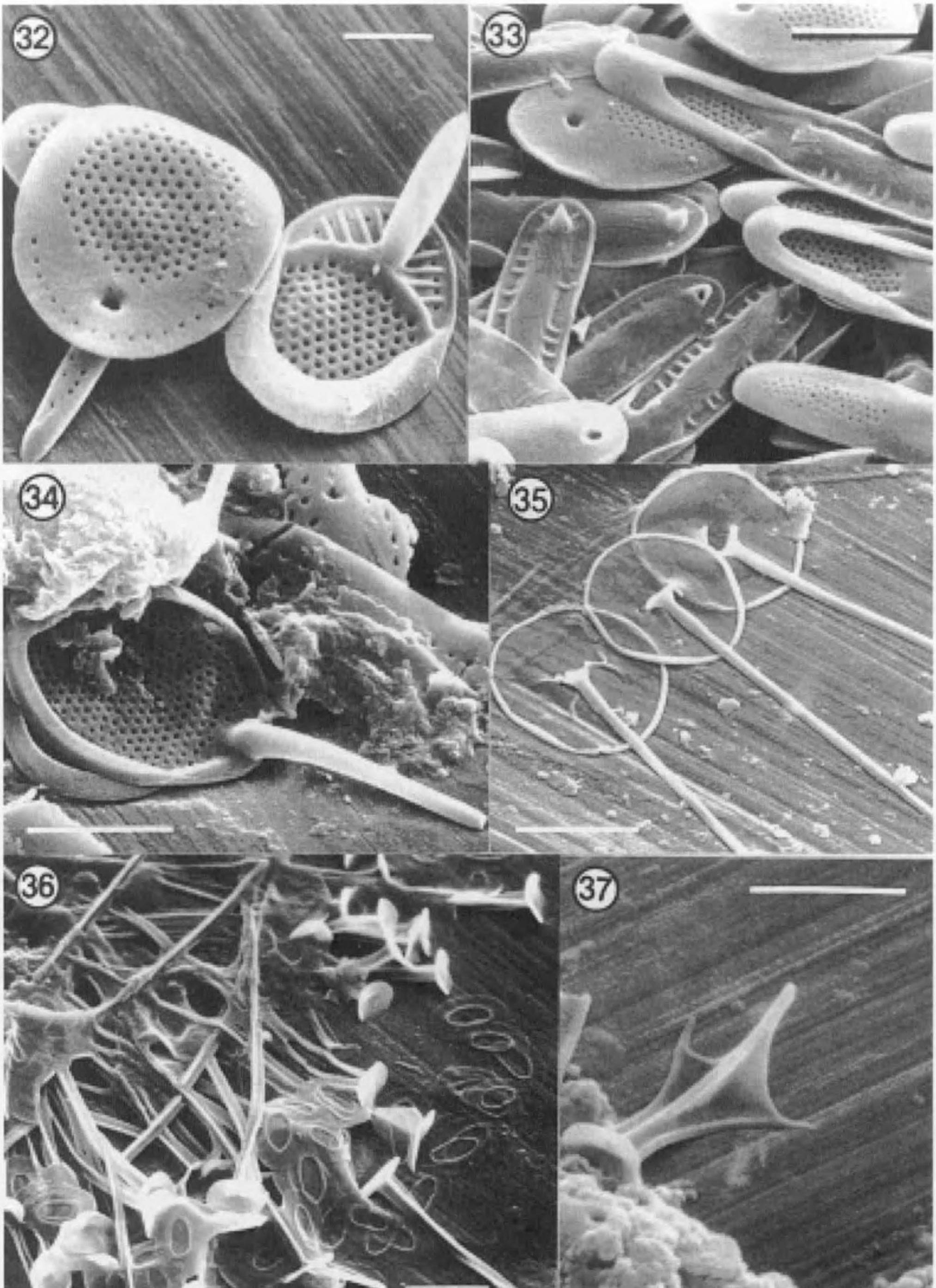

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