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The distribution of scaled chrysophytes in the delta region of the Paraná River, Argentina

by

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With 54 figures and 2 tables

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Abstract: A total of 33 taxa of scaled chrysophytes were observed from 50 localities in and around the delta region of the Paraná River, situated in the subtropics of Argentina. The study sites were divided into five groups based on their physical and chemical characteristics and location within the delta complex. The five groups included waterbodies situated on the delta, channels of the river, tributaries draining mostly urban areas, tributaries draining farm or ranching areas, and streams draining areas with exposed limestome. The pH and specific conductivity of the localities ranged from 6.0 to 9.1 and 123 to 3,750 μS cm^{-1}, respectively. Species diversity and abundance clearly decreased with increasing pH and specific conductivity. The majority of species were found in the more dilute waterbodies located on the delta, while few taxa were observed within the river proper or the tributaries draining agricultural or urban lands. The flora contained species that are cosmopolitan, temperate, as well as tropical in nature. In particular, species reported to be common in the tropics and observed in this study included *M. matvienkoae* var. *grandis, M. guttata, M. peronoides* var. *peronoides, M. peronoides* var. *bangladeshica, M. portae-ferreae, M. mangofera* var. *reticulata* and *Synura australiensis. Mallomonas caudata* and *M. crassisquama,* often reported as the most abundant species of scaled chrysophytes in other regions of the world, were rare and absent, respectively, in the delta region.

Key words: Chrysophytes, subtropics, Paraná River, Argentina.

Introduction

Studies of scale bearing Chrysophyceae and Synurophyceae (Andersen 1987), hereafter referred to as scaled chrysophytes, have focused primarily on temperate regions of Europe and North America. As a result, our understanding of the importance, abundance and ecology of this algal group is heavily biased towards temperate regions of the northern hemisphere. The bulk of the studies from tropical (e.g.

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Wujek & Bicudo 1993; Saha & Wujek 1990; Vyverman & Cronberg 1993) and subtropical (e.g. Wujek & Bland 1990; Siver & Wujek 1993; Wee et al. 1993; Vigna 1989, 1990; Kristiansen & Tong 1995) regions have only recently been undertaken. Accordingly, much additional work needs to be done in tropical and subtropical localities in order to better understand the ecological and biogeographical relationships within this algal group.

Most of the studies in South America have been in either Argentina as a result of work by Vigna (1981, 1986, 1988, 1991) and Vigna & Kristiansen (1989), or Chile (e.g. Dürrschmidt 1980, 1982). Additional observations on waterbodies from Brazil (Cronberg 1989; Wujek & Bicudo 1993) and Columbia (Cronberg 1989) have also been made. Despite these surveys, many regions of the continent remain unexplored for scaled chrysophytes.

The subtropical region of the Southern Hemisphere is small compared to that in the Northern Hemisphere, with the largest expanses being in Australia and Argentina. In a recent series of papers, Croome & Tyler and co-workers described the scaled chrysophyte flora from parts of Australia (e.g. Croome & Tyler 1983, 1985, 1986; Croome et al. 1985; Dürrschmidt & Croome 1985; Preisig 1989). It is clear from their work that a rich, diverse and somewhat unique flora of scaled chrysophytes exists in Australia. Similarly, based on recent work, the scaled chrysophyte flora of subtropical regions from the Northern Hemisphere also appears to be rich and diverse (e.g. Wujek 1984a, 1984b; Wujek & Gardiner 1985; Siver & Wujek 1993; Wee et al. 1993). The subtropical region of Argentina, however, remains largely unexplored.

Little work has also been done on describing scaled chrysophyte floras from river systems (Kiss & Kristiansen 1994; Siver 1995). In addition, although much recent work has been done on correlating species distributions with ecological conditions from temperate regions, insufficient progress has been made on subtropical and tropical floras (Cronberg 1989; Saha & Wujek 1990; Siver & Wujek 1993; Siver 1995). The purpose of this paper was to describe the scaled chrysophyte flora in and around the delta of the Paraná River, and to correlate the flora with pH, specific conductivity and water temperature.

Materials and methods

Phytoplankton samples were collected from each of the 50 sites between April 18 and 28, 1994 using either a 10 or 20 μm mesh net. Half of each sample was immediately fixed with Lugol's solution and the remaining portion kept live for observation with light microscopy (LM). Usually, within 24 hours an aliquot from each sample was air dried onto a glass coverslip for LM observation, aluminum foil for observation with scanning electron microscopy (SEM), and a 200 mesh formvar coated copper grid for transmission electron microscopy (TEM).

Water temperature and specific conductivity were measured with a Yellow Springs Instruments model 33 S-C-T meter. The pH was measured with a Fisher Accumet model 640A pH meter. Secchi disk depth was measured with a 10 cm black and white disc.

Each sample was initially screened with LM in order to estimate the number and abundance of scaled chrysophytes. TEM preparations were made and observed for each sample where scaled chrysophytes were found with LM. All samples were thoroughly investigated with SEM. As necessary, TEM observations were utilized to verify identifications.

Samples for SEM observation were prepared as follows. A piece of each aluminum sample was trimmed and mounted onto an aluminum stub with Apiezon wax and coated with gold for between 1.5 and 4.5 minutes with a Polaron Sputter coater. Samples were observed with a Coates & Welter Field Emmission SEM at 20 to 25 kv (University of Connecticut). Samples for TEM were initially washed, air dried onto copper grids, and observed with a JEOL 1200 EXII TEM (National Institute of Agricultural Technology, Argentina). The relative proportions of all scaled chrysophyte taxa were qualitatively estimated according to the following three ranks. If taxa were among the most important species of algae in the sample they were scored as "abundant" (A in Table II). Taxa that were subdominant, but still important components, were listed as "common" (C). Species represented by a few whole cells or isolated scales were listed as "rare" (R).

Description of the study area

The Paraná River is the second largest river in length and volume in South America, spanning over 4,000 km (Gaea 1975) (Fig. 1). The river originates in southern Brazil at the junction of the Paraníba and Grande Rivers, between the states of Sao Paulo and Mato Grosso. The river drains 2.6×10^6 km^2 and passes through regions with different climatic and geological characteristics.

The course of the Paraná River can be differentiated into three parts based on its morphogenetic characteristics: a. Brazilian Plateau or high Paraná; b. the Ituzaing or median Paraná and; c. the Deltaic or low Paraná. Our study sites were located primarily within and surrounding the Deltaic portion of the river. This portion of the Paraná River extends from the junction with the Paraguay River to the Rió de La Plata and is situated in a sub-tropical climate. The Deltaic region, characterized by moderate slopes, is a true delta because it is composed of islands that are a result of sedimentary processes. At the City of Diamante the fluvial valley widens into an expanse of channels, islands and bars (Burkart 1957).

The study sites can be divided into five groups based on their location within the delta complex and physical and chemical characteristics. The "south" and "north" sides of the river refer to the Buenos Aires and Paraguay sides, respectively.

1. Pools, ponds and waterbodies on the delta that are not connected directly to the river:

These are bodies of water situated on land masses within the delta (except for site 37), and are, in general, not directly connected to the main channels of the river. The majority of the sites were located on the lower parts of the delta close to the Rió de La Plata (Fig. 1). The only exception was site 37; this is the northern most site situated on the Island Santa Cándida near the City of Paraná and above the true delta. These sites were mostly humic stained, low in sediment load, and were among the lowest in specific conductivity and pH (Table I). The specific conductivity and pH ranged from 123 to 650 μS cm^{-1} and 6.0 to 7.4, respectively. At the time of collection many of these sites were dominated or co-dominated by euglenophytes. Includes sites 1, 3, 5, 6, 21-28 and 37.

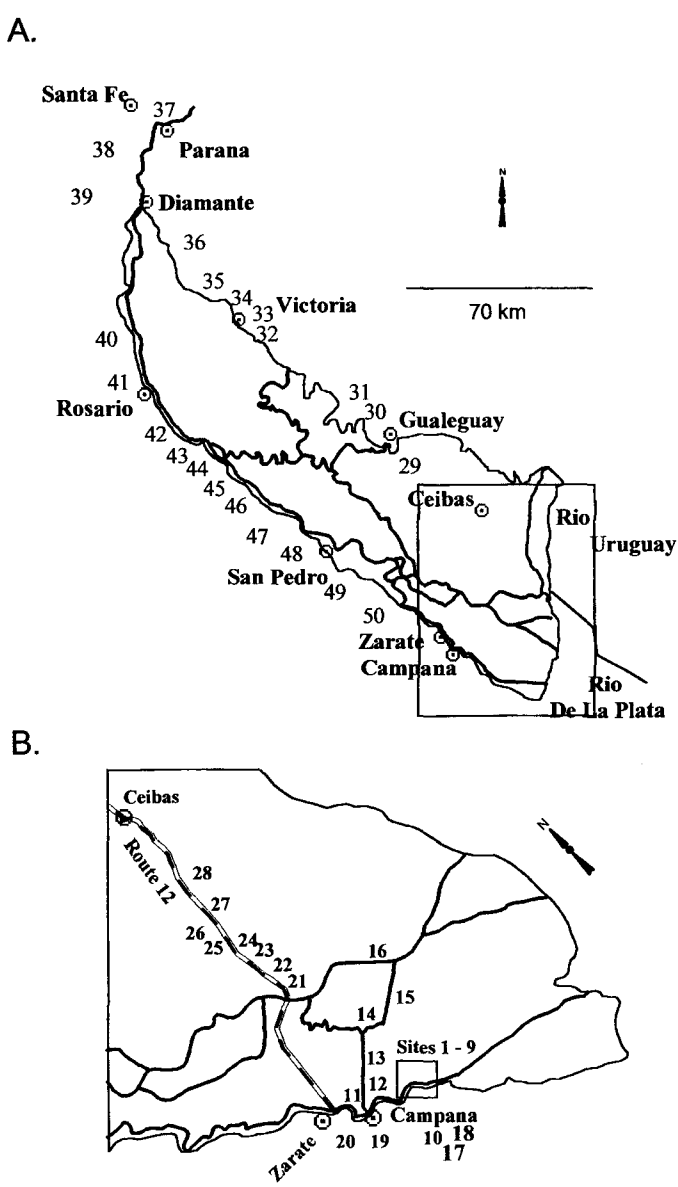


Fig. 1. Map of the study region depicting the locations of the study sites. A. Region of the Paraná River between the City of Santa Fe and the Río de la Plata. The delta proper, beginning at the City of Diamante, is outlined along with the major channels of the river. B. Close up of the lower portion of the delta outlined in A. Note that the north orientation of B is different from A.

Table I. Temperature, pH, specific conductivity and Secchi disk depths of 50 sampling sites on and around the delta region of the Paraná River, Argentina.

Site #	Group #	Site Name	Temp °C	pH	Spec. Cond. $\mu S\ cm^{-1}$	Secchi Depth cm
1.	1	INTA Delta Island: fish tank 1.	17.5	6.9	175	20
2.	2	Canal connected with Paraná de las Palmas	19.5	7.4	180	20
3.	1	Canal on the Delta	15	6.5	238	50
4.	2	Canal connected to canal 6	20	7.4	180	15
5.	1	INTA Delta Island: fish pond 1.	18	7.4	170	40
6.	1	INTA Delta island: fish pond 2.	18	7.6	160	35
7.	2	Arroyo Las Piedritas	21.5	7.5	178	15
8.	2	Canal connected to Arroyo Las Piedritas	21.5	7.4	181	15
9.	2	Entrance to Canal 5	-	-	-	-
10.	3	Arroyo Pescado	18	7.6	510	65
11.	2	Canal Alem 1.5 km from Paraná de Las Palmas	13.2	6.3	163	40
12.	2	Arroyo Negro	18	7.0	153	15
13.	2	Arroyo Las Piedras	20	7.2	152	15
14.	2	Río Carabelas	20.5	7.2	152	15
15.	2	Arroyo Los Tigres	20	6.7	143	15
16.	2	Paraná Guazú	21.5	7.3	150	15
17.	3	Río Luján	17	8.0	1500	40
18.	3	Canal from Río Luján	17	8.0	1500	40
19.	3	Arroyo La Cruz	17.5	8.0	730	22
20.	3	Arroyo Pesquerías	18.5	7.8	1000	30
21.	1	Canal at km 91 along Route 12	14	6.6	175	45
22.	1	Arroyo Aguila Negra	15	6.0	125	35
23.	1	Río Brazo Largo	19.5	7.1	130	17
24.	1	Ibicuicito	18.5	6.5	123	30
25.	1	Canal Dos Caños	16	6.3	155	35
26.	1	Arroyo Alcazter	-	-	-	-
27.	1	Arroyo Cruz sin Brazo	23	6.4	262	135
28.	1	Arroyo Pirané	17	6.5	650	205

Table I (continued)

Site #	Group #	Site Name	Temp °C	pH	Spec. Cond. $\mu S\ cm^{-1}$	Secchi Depth cm
29.	4	Arroyo El Gallego	17.8	7.2	590	13
30.	4	Arroyo Clé	18	8.3	620	
31.	4	Arroyo Clé pool	16	8.1	550	-
32.	4	Little stream near Victoria.	18.5	-	-	-
33.	5	Stream 24 km before Victoria.	16	8.4	1300	>75
34.	5	Arroyo Ceibo	17	8.5	1130	35
35.	5	Arroyo Carballo	21.2	8.6	1500	65
36.	5	Arroyo Doll	20	8.8	1200	65
37.	1	Pool at Santa Cándida Island	23	7.2	270	18
38.	4	Arroyo de Los Padres	22	8.4	2830	10
39.	4	Arroyo Cinco Peces	23	8.6	2000	-
40.	4	Arroyo at km 32 along Route 9	21	8.9	1230	15
41.	3	Stream near Rosario	19.5	8.2	500	10
42.	3	Arroyo Frías	19.3	9.1	1020	35
43.	3	Arroyo Pavón	21	8.9	3750	35
44.	3	Pool near Arroyo	17	9.1	13300	-
45.	3	Arroyo Del Medio	21	9.1	2500	
46.	4	Arroyo Ramallo Pavón	18	9.0	1000	>75
47.	4	Arroyo Las Hermanas	17	8.6	780	65
48.	4	Arroyo Espinillo	15	8.6	780	65
49.	4	Arroyo El Tala	17.5	8.7	1200	20
50.	4	Arroyo Cañada Honda along Route 9	18	8.7	1300	25

2. Main branches or channels of the river or canals connecting different parts of the river:

Primarily lotic waterbodies with high sediment load and low penetration of light. All of these sites are part of or highly influenced by the Paraná River and situated on the lower part of the delta (Fig. 1). At the time of collection most of these sites were dominated by the diatom *Aulacoseira granulata* (Ehrenberg) Simonsen. The specific conductivity was comparatively low, ranging only from 143 to 181 $\mu S\ cm^{-1}$. The pH ranged from 6.3 to 7.5 (Table I). Includes sites 2, 4, 7-9, and 11-16.

3. **Streams or rivers draining into the river (delta) from mostly urbanized areas (sites 10, 17-20), or from a mixture of urban and farming areas (sites 41-45).**

Primarily lotic systems draining industrialized land areas or urban and farming lands. The sites were all situated on the southern side of the Paraná River. Sites 10 and 17-20 were close to Buenos Aires, while sites 41-45 were situated around the City of Rosario. The sites were variable in terms of humic content, amounts of sediment load, specific conductivity and pH. In general, the specific conductivity and pH were much higher than sites in either Groups 1 or 2. The range in specific conductivity, 510 to 3,750 μS cm^{-1}, and pH, 7.6 to 9.1, may indicate that these waterbodies are highly variable in terms of their quality and quantities of dissolved substances. Note that the specific conductivity value for site 44, 13,000 μS cm^{-1}, was not included in the range and may have been due to a malfunction of the meter.

4. **Streams or rivers draining primarily farming or ranching areas; a few also with urban influences. Areas lacking exposed $CaCO_3$ outcrops.**

These sites were situated either along the north side of the Paraná River near and above the City of Gualeguay (sites 29-32), or along the southern side of the Paraná River (sites 38-40 and 46-50) (Fig. 1). Sites 38-40 are technically situated in a floodplain region outside of the true delta, but eventually flow into the delta. Sites 46-50 are south of the City of San Nicholas. Some of the sites were pools of relatively calm water within slowly draining streams. The specific conductivity and pH ranged from 590 to 2,830 μS cm^{-1} and 7.2 to 9.0, respectively (Table I). Site 32 had a very high specific conductivity reading, 17,000 μS cm^{-1}, probably caused by some type of chemical contamination or malfunction of the meter; we were also unable to obtain stable pH readings at this site. Includes sites 29-32, 38-40, and 46-50.

5. **Streams or rivers draining into the river (delta) from mostly farming or ranching areas. Areas with exposed $CaCO_3$ bedrock.**

These sites were situated on the north side of the Paraná River around the City of Victoria (Fig. 1). Waters were generally very clear, low in sediment load and humic acid content, and presumably high in calcium due to the influence of the surrounding bedrock. The range in specific conductivity of 1,200 to 1,500 μS cm^{-1}, and pH from 8.4 to 8.6, were small. At the time of collection species of *Stephanodiscus* were co-dominant. Includes sites 33-36.

Results

Abundance and diversity of scaled chrysophytes

A total of 33 taxa of scaled chrysophytes, including 21 of *Mallomonas,* 7 of *Synura,* 2 of *Paraphysomonas,* 2 of *Chrysosphaerella,* and at least one of *Spiniferomonas,* were found in the study (Table I). The number of taxa found per site ranged from

none to 13, with ten sites containing seven or more species. Eight of these high diversity sites were waterbodies located on the delta (i.e. group 1) with low specific conductivity and relatively low pH (Tables I-II; Figs. 2-3). However, 17 of the sites (34%) had only one or no species; these sites were primarily ones associated with the river (group 2), or waterbodies in groups 3 and 4 with high pH and specific conductivity (Tables I-II; Figs. 2-3). Sites from the calcareous region (group 5) contained from two to four species. The mean number of taxa per collection ranged from 7.6 (group 1) to only 1.6 (group 2).

Although the number of species per collection varied greatly among the different types of waterbodies, distinct trends were observed along pH and specific conductivity gradients. The maximum number of species found at a site decreased significantly with either increasing pH (Fig. 3) or increasing specific conductivity (Fig. 2), to the point where no species were observed above pH 8.8 or 1,500 μS cm^{-1}. Most of the high diversity sites were also among the more humic stained waterbodies sampled. Although we found no relationship between the number of species per collection and Secchi disk depth, it is worth noting that most sites had values of 65 cm or less (Table I). No pattern was observed between the number of taxa per collection and the water temperature.

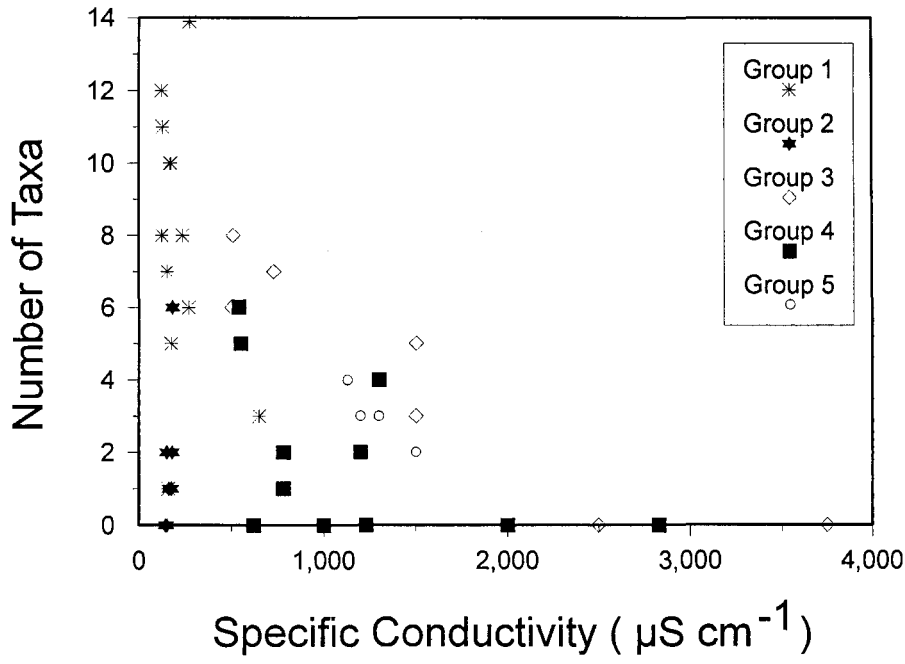


Fig. 2. The number of taxa of scaled chrysophytes per sample along a specific conductivity gradient. The five categories of sites are depicted.

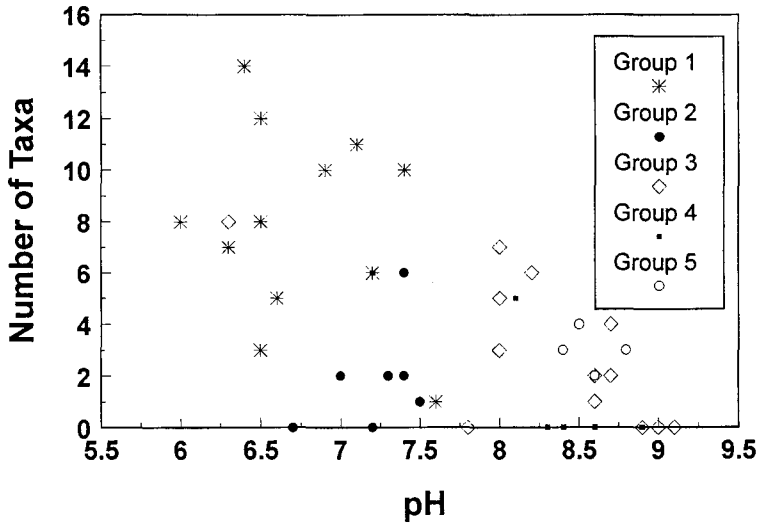


Fig. 3. The number of taxa of scaled chrysophytes per sample along a pH gradient. The five categories of sites are depicted.

Observations and distributions of species

Chrysosphaerella brevispina Korshikov Fig. 6

A few isolated scales of this taxon were observed at one site with a pH of 7.6 and a specific conductivity of 510 μS cm^{-1}.

Chrysosphaerella coronacircumspina Wujek et Kristiansen Fig. 4

Isolated body and spine scales were observed on the delta in a pond used to raise fish (Table I).

Mallomonas akrokomos Rutter in Pascher Fig. 5

Typical scales of *M. akrokomos* were very rare and found in only two localities (Table II).

Mallomonas alpina Pascher et Ruttner em. Asmund et Kristiansen Figs. 10-17

This taxon was one of the most common species encountered in the study. Most cells of this taxon possessed scales with a prominent V-rib with arms that were continuous with the anterior submarginal ribs, and lacked a secondary layer on the shield (Figs. 12-14). Scales possessed rather large and prominent domes, and in a few cases a single thickened transverse rib was present on the shield immediately posterior to

the dome (Fig. 13). Both V-ribs with acute (Figs. 10-12) as well as obtuse (Figs. 13-14) angles were observed on domed and domeless scales. Bristles were ribbed with a single serration and of two lengths (Figs. 15-16). Scales surrounding the flagellar pore had shorter bristles while body scales possessed bristles approximately 1.5 to 2 times the length of the cell.

A high degree of variation in scale and bristle morphology was observed. In some cases cells had a number of scales with a secondary layer (Fig. 10) and bristles where the distal most tooth was on the side opposite of the main serration (Fig. 15), typical of *Mallomonas corymbosa* Asmund et Hilliard. A few bristles on some cells had long needle-like tips similar to those of *Mallomonas areolata* Nygaard (Fig. 16). Most scales had a series of small pores each with a raised border in the window of the V-rib also characteristic of *M. areolata* (Fig. 11). Despite the high degree of morphological variation we believe this organism, observed in 28% of the collections, is best described as *M. alpina*. The difficulties in distinguishing between taxa in the Series Alpinae and Tonsuratae are discussed in Siver (1991).

Mallomonas caudata Ivanov. em. Krieger Fig. 7

This organism was restricted to five localities situated on the delta, each of which was low in specific conductivity and pH (Table II).

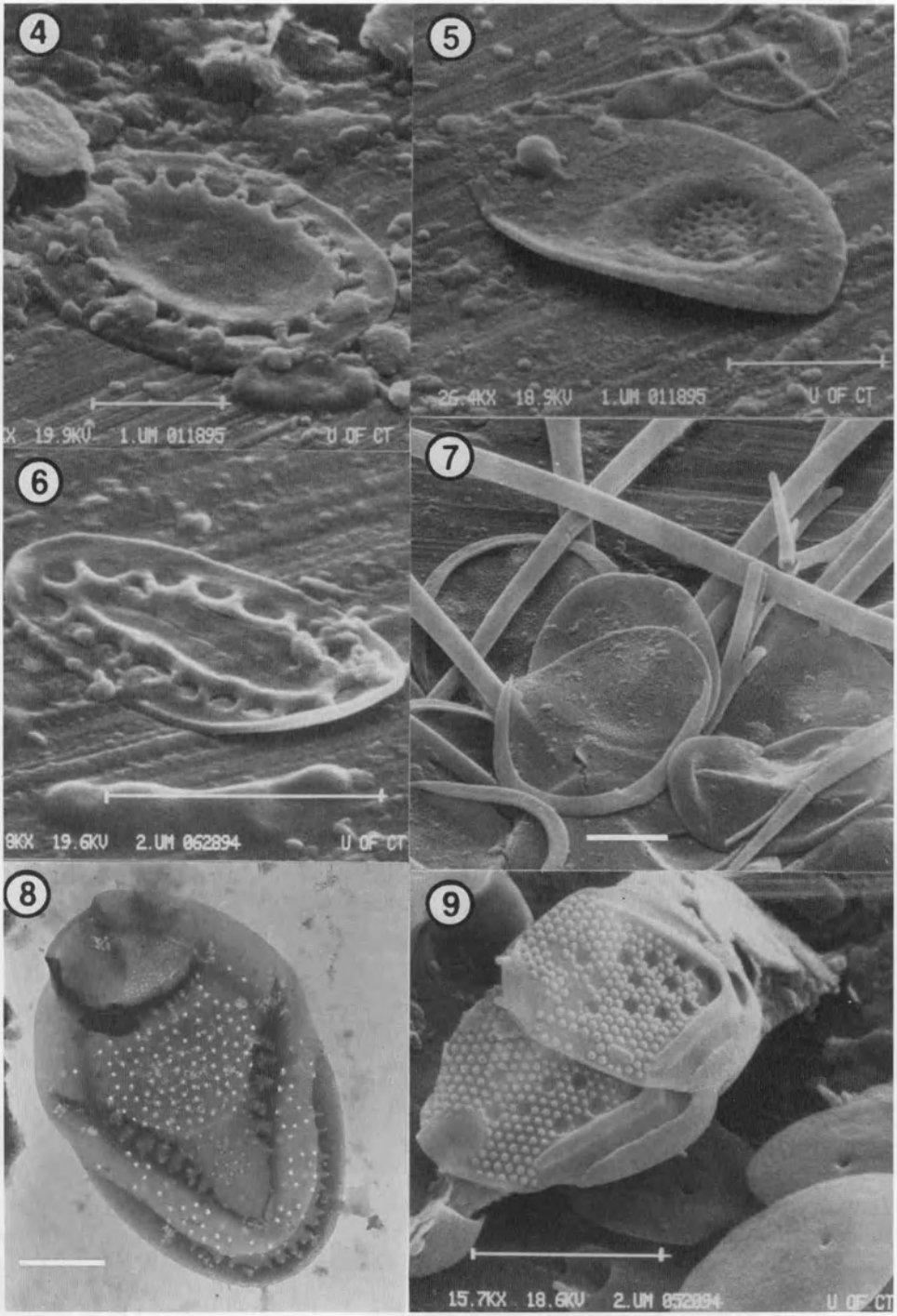
Mallomonas cristata Dürrschmidt Fig. 8

Isolated scales of this species, each with a prominent V-rib and flared anterior flanges, were found in only one site on the delta.

Mallomonas cyathellata Wujek et Asmund Figs. 18-20

Although we did not observe whole intact cells of this species, numerous isolated scales and groups of scales were observed at six localities (Table II). Domed scales were broadly obovate and often possessed well defined longitudinal ribs on the dome (Fig. 18). The anterior portion of the domeless body scales possessed the characteristic short, but thick, ribs (Figs. 19-20). The pits of the secondary layers of most scales were irregular in size and shape, a characteristic of this taxon (Figs. 18-20). Since we found posterior scales with only short spines, and none possessing the goblet-shaped or hare's ear-shaped protuberances, we did not distinguish between var. *cyathellata* and var. *chilensis* Dürrschmidt.

Figs 4-9. Fig. 4. *Chrysosphaerella coronacircumspina*. Scale bar = 1 μm. Fig. 5. *Mallomonas akrokomos*. Scale bar = 1 μm. Fig. 6. *C. brevispina*. Scale bar = 2 μm. Fig. 7. *M. caudata*. Scale bar = 2 μm. Fig. 8. *M. cristata*. Scale bar = 1 μm. Fig. 9. *M. guttata*. Scale bar = 2 μm.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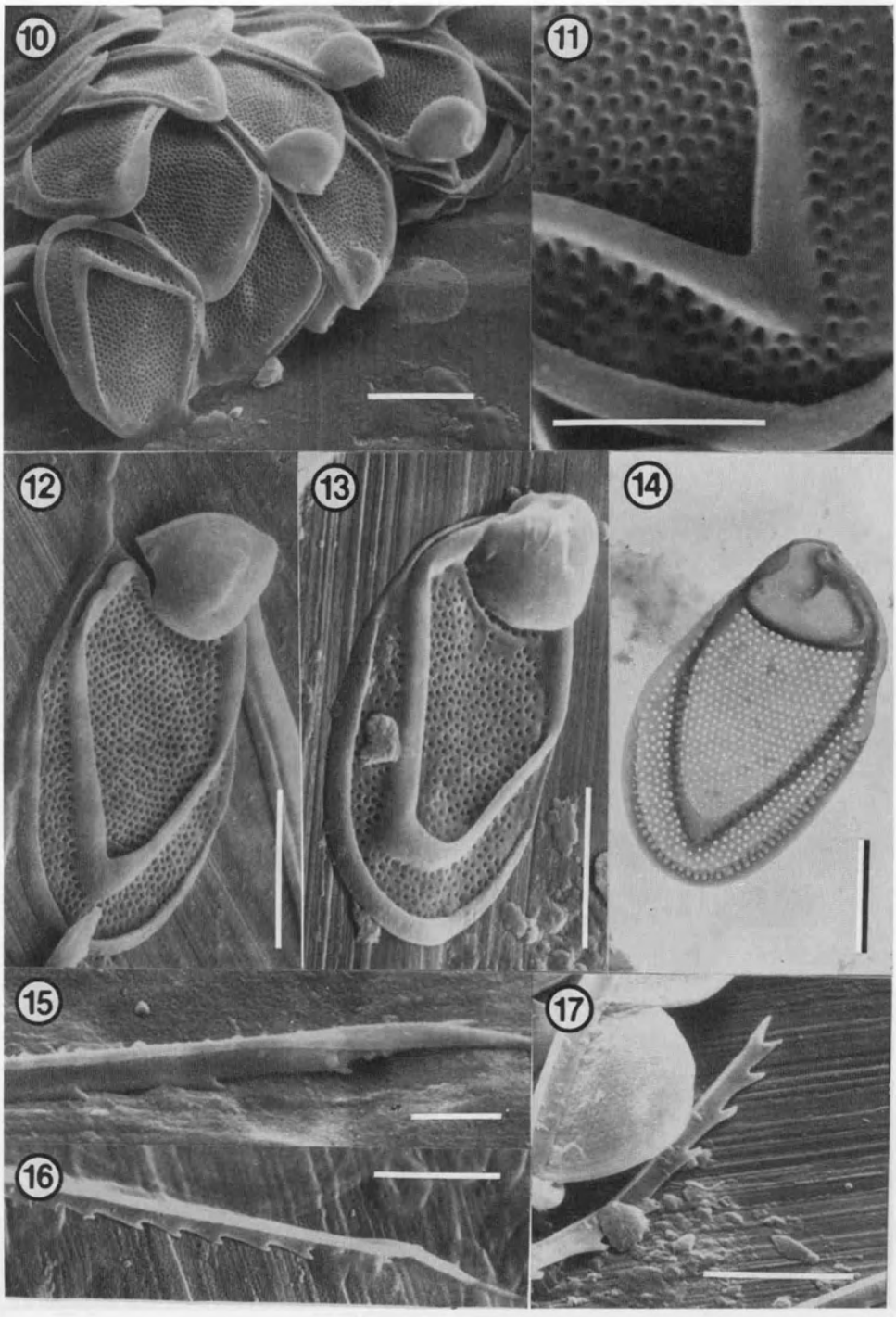
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Mallomonas guttata Wujek Fig. 9

Scales typical of this species were observed in two sites on the delta (Table II).

Mallomonas heterospina Lund Figs. 21-23

Scales of *M. heterospina* were observed at three localities (Table II). Although some typical scales were observed (Fig. 23), the dense reticulum of ribs on the shields of most scales was largely obscured by the deposition of additional silica (Figs. 21-22). Similar scales were recently reported from Tierra del Fuego (Vigna & Kristiansen 1995).

Mallomonas lychenensis Conrad Figs. 24-25

Whole cells of this taxon were observed at one site on the delta with a relatively low pH and specific conductivity.

Mallomonas mangofera Harris et Bradley f. **mangofera** Figs. 26-27

This taxon was observed in seven collections that were all relatively low in specific conductivity, and, except for one site, pH (Tables I-II). Most, but not all, of the specimens possessed scales where the distal ends of the V-rib arms furcated, yielding the "double" structure observed by Siver (1991). Due to the degree of overlap of the scales on intact cells, this feature was not always readily observed (Fig. 26). We also found several intact cells where, due to the overlap of the scales, we could not view the area along the inner margin of the V-rib; it is possible that some of these cells could have been f. *foveata* (see below).

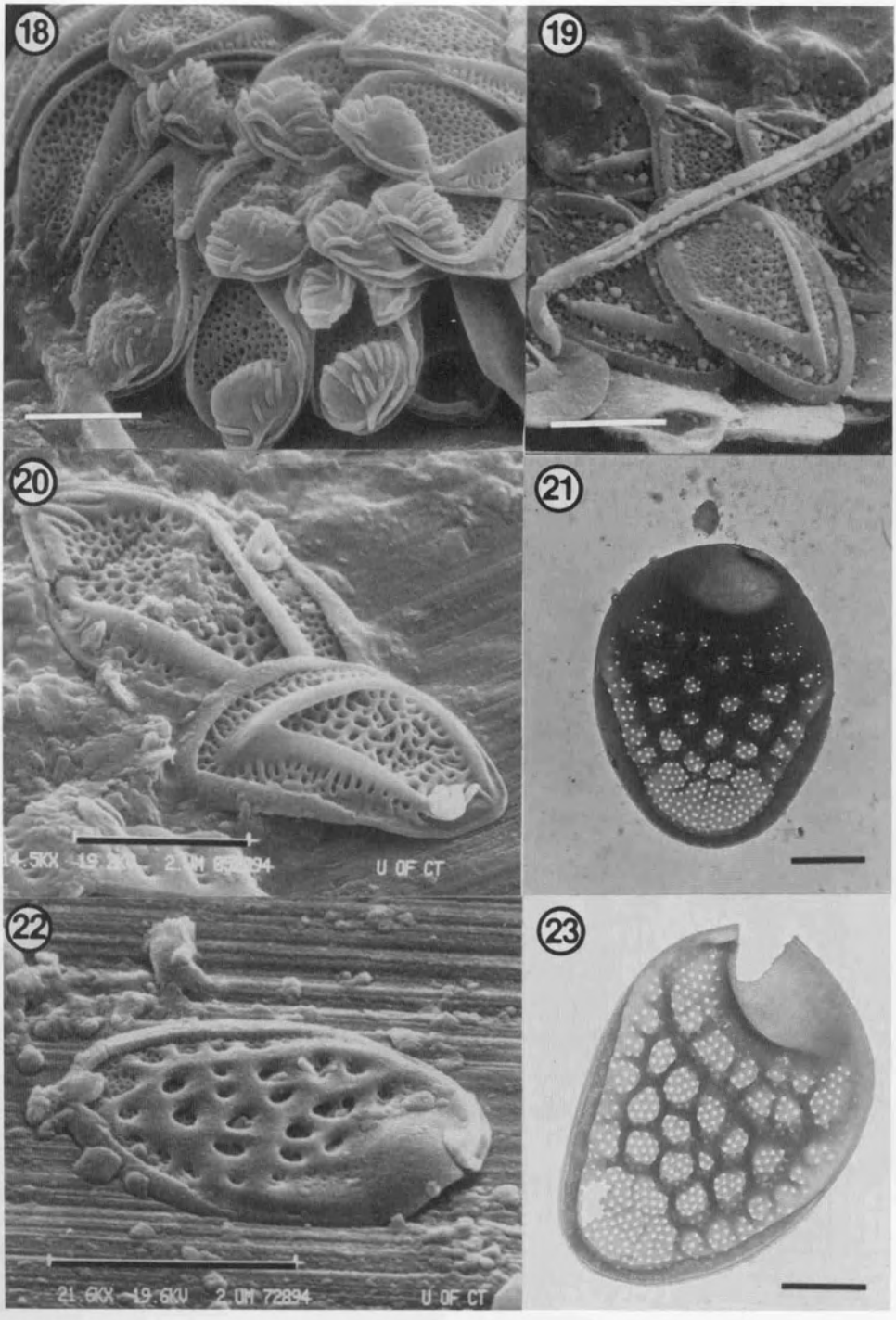
Mallomonas mangofera f. **reticulata** Cronberg Fig. 29

Scales of this variety, distinguished from the type in possessing an internal reticulated pattern on the shield, were very rare, observed at only site 27 with TEM.

Mallomonas mangofera f. **foveata** Dürrschmidt Fig. 28

Whole cells were observed at one locality on the delta (Table II). Scales possessed the large circular pits along the inner margin of the V-rib, and furcated V-rib arms.

Figs 10-17. *Mallomonas alpina*. Fig. 10. A group of domed and domeless scales. Scale bar = 1 μm. Fig. 11. Close up of a scale depicting the cluster of pores with raised borders at the base of the V-rib. Scale bar = 1 μm. Figs 12-14. Range in morphology of domed scales. Note the large domes, transverse rib just behind the dome (Fig. 13), and the acute (Fig. 12) or obtuse (Figs 13-14) V-ribs. Scale bars = 2 μm. Figs 15-17. Range in morphology of bristles. Scale bars = 2 μm.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Mallomonas matvienkoae (Matvienko) Asmund et Kristiansen var. **matvienkoae** Fig. 30

Scales of this taxon, which possessed a single large pore in the proximal region and lacked surface papillae, were very rare, found in only one locality on the delta.

Mallomonas matvienkoae var. **grandis** Dürrschmidt et Cronberg Figs. 31-33

It appears clear that this organism is identical with *Mallomonas matvienkoae* var. *myakkana* described by Siver (1991) from a subtropical lake in Florida, U.S.A. Scales differ from the type in: a) possessing a cluster of 3 to 5 large pores in the proximal region of the scale, instead of one; b) possessing a dense covering of papillae on the distal half of the scale; and c) lacking base plate pores on the distal portion of the scale (Siver 1991). As pointed out by Siver & Wujek (1993) the original description of var. *grandis* (Dürrschmidt & Cronberg 1989) did not mention the dense covering of papillae, prompting them to retain both varieties. However, we feel that var. *myakkana* and var. *grandis* are the same organism. Bristles (Fig. 33) of both varieties are similar.

This taxon was one of the most common species encountered, found in 22% of the localities. Although it was more common in waterbodies on the delta, it was also observed in several streams and rivers draining into the delta. Except for one finding, var. *grandis* was not found above 1,000 μS cm^{-1}.

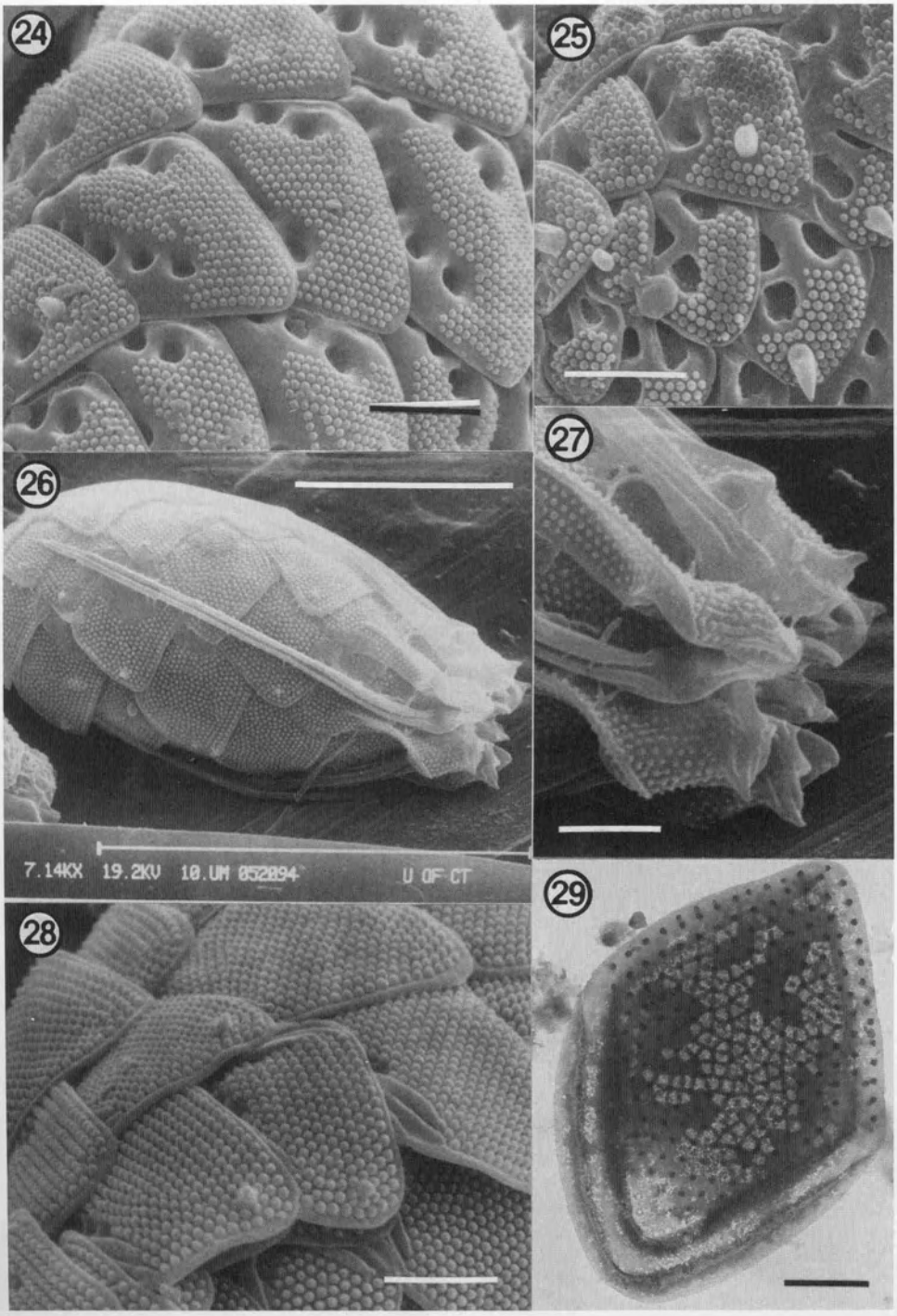
Mallomonas papillosa Harris et Bradley Fig. 34

Cells were observed on one site on the delta (Table II).

Mallomonas peronoides (Harris) Momeu et Péterfi var. **peronoides** Fig. 35

Cells typical of *Mallomonas peronoides* according to the original description by Harris (1966) were observed at two localities (Table II). In each case the scales possessed the typical anterior "depression" surrounded and defined by a thickened system of ridges, had surface papillae, and lacked an anterior "grapnel-like" structure (Harris 1966; Takahashi & Hayakawa 1979; Asmund & Kristiansen 1986). A wide range in the morphological variability of the scales was observed and is discussed in a separate paper (Siver & Vigna 1996).

Figs 18-23. Figs 18-20. *Mallomonas cyathellata.* Scale bars = 2 μm. Fig. 18. Domed and domeless scales. Note the large domes with prominent ribs and the irregular pattern of the pores of the secondary layer. Fig. 19. Domeless scales. Fig. 20. Domeless (top) and a posterior scale with a small protrusion. Note the ribs in the anterior region of the domeless scale. Figs 21-23. *Mallomonas heterospina.* Note the dense secondary reticulum on the shields of scales in Fig. 21 (scale bar = 1 μm) and Fig. 22 (scale bar = 2 μm). Scale in Fig. 23 (scale bar = 2 μm) depicts the more commonly observed type of secondary layer.


24
25
26
27
7.14KX 19.2KV 10.UM 052894 U OF CT
28
29

Mallomonas peronoides var. **bangladeshica** (Takahashi et Hayakawa) Nicholls
Fig. 36

Cells of this taxon, possessing scales with a "hemispherical ornament" (Takahashi & Hayakawa 1979) or "grapnel-like" structure (Wujek & Timpano 1984), were observed at four localities (Table II). The "grapnel-like" appendage was originally used by Takahashi & Hayakawa (1979) as the primary feature for distinguishing this taxon as a variety of *Mallomonopsis peronoides,* and later by Wujek & Timpano (1984) to raise the taxonomic rank to the specific level (i.e. *Mallomonopsis bangladeshica*). Nicholls (1988) made the combination *Mallomonas bangladeshica* to achieve consistency within the section Mallomonopsis of *Mallomonas.* Because Dürrschmidt & Cronberg (1989) found cells with and without the "grapnel-like" structure, they suggested that its presence should not be used to separate *M. Peronoides* from *M. bangladeshica.* In a later paper Cronberg (1989) further stated that she believed that *M. peronoides* and *M. bangladeshica* were in fact "the same species". Although both taxa may indeed be the same organism we believe, based on our observations, that there is reason to maintain two separate taxa until further work is completed. We further suggest (Siver & Vigna 1996) that the distinction be made at the variety level as originally proposed by Takahashi & Hayakawa (1979).

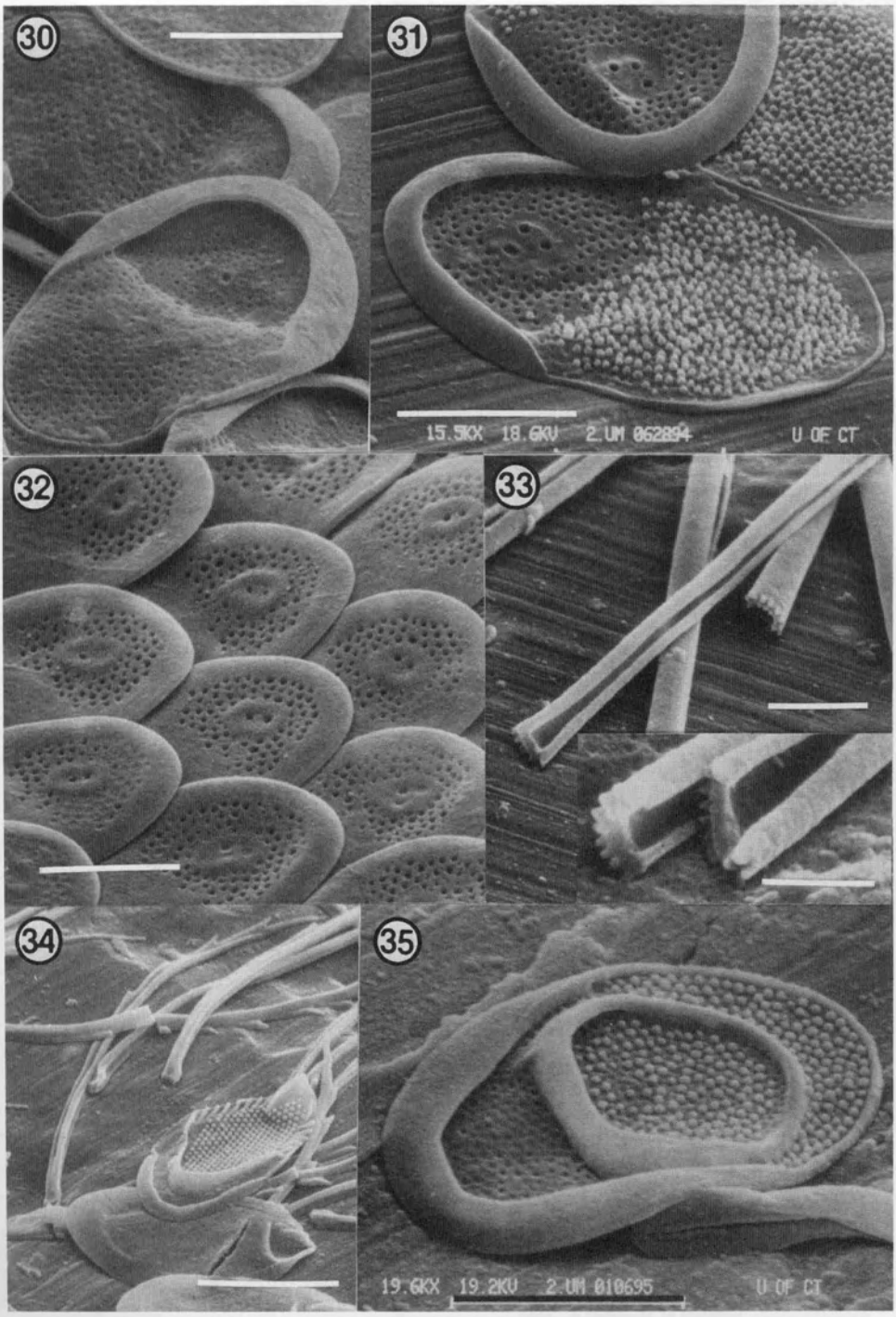
Mallomonas portae-ferreae Péterfi et Asmund var. **portae-ferreae** Fig. 37

This species was observed at four localities on the delta or in the river channels (Table II). On all scales the arms of the V-rib were continuous with the anterior submarginal ribs. On some scales the anterior submarginal ribs were often expanded and at a similar height from the base plate as the arms of the V-rib. Domes were large, strongly concave, and often had a series of parallel ribs.

Mallomonas portae-ferreae var. **reticulata** Gretz, Sommerfeld et Wujek Fig. 38

Specimens of this taxon, with an irregular reticulated pattern on the shield, were common in two samples. As was noted by Siver (1991) we also observed intact cells with domed scales lacking a secondary layer on the shield altogether; these scales resembled either *M. areolata* or *alpina.*

Figs 24-29. Figs 24-25. *Mallomonas lychenensis.* Scale bars = 2 μm. Figs 26-27. *Mallomonas mangofera* f. *mangofera.* Fig. 26. Whole cell. Note the small protrusions on the anterior portion of each scale. Scale bar = 5 μm. Fig. 27. Close up of the anterior portion of the cell in Fig. 26. Scale bar = 1 μm. Fig. 28. *Mallomonas mangofera* f. *foveata.* Note the large circular pits along the inner margin of the V-rib. Scale bar = 1 μm. Fig. 29. *Mallomonas mangofera* f. *reticulata.* TEM depicting the internal reticulated pattern of ribs on the shield. Scale bar = 1 μm.


30
31
15.5KX 18.6KV 2.UM 062894 U OF CT
32
33
34
35
19.6KX 19.2KV 2.UM 010695 U OF CT

Mallomonas pumilio (Harris et Bradley) emend. Asmund, Cronberg et Dürrschmidt Fig. 40

Body scales of an organism that we believe best match those of *M. pumilio* were found at one humic site with a relatively low specific conductivity (Table II). The shield of each scale consisted of more or less circular meshes each enclosing approximately five pores that were evenly spaced within the mesh. The anterior flange and submarginal rib areas were covered with rows of small papillae, and the posterior flange lacked struts. Rear scales possessed very small spines.

Mallomonas striata Harris et Bradley var. **serrata** Figs. 39, 41

Scales and serrated bristles of this organism was observed over a wide range of specific conductivity (125 to 1,500 μS cm^{-1}) and pH (6.0 to 8.1), perhaps accounting for its occurrence in 20% of the collections. Specimens had a small group of minute pores near the base of the V-rib easily visible on the undersurface of the scale. A high degree of variability was found in the angle of the V-rib, and in the extent of overlap of the V-rib arms (compare Figs. 39 and 41). A few scales lacking the struts on the anterior flanges were observed.

Mallomonas tonsurata Teiling emend. Krieger Fig. 42

Specimens were rare in collections from two localities. In each case both short, thick, uniseriate bristles and longer, non-serrated ones with bifurcate tips were observed.

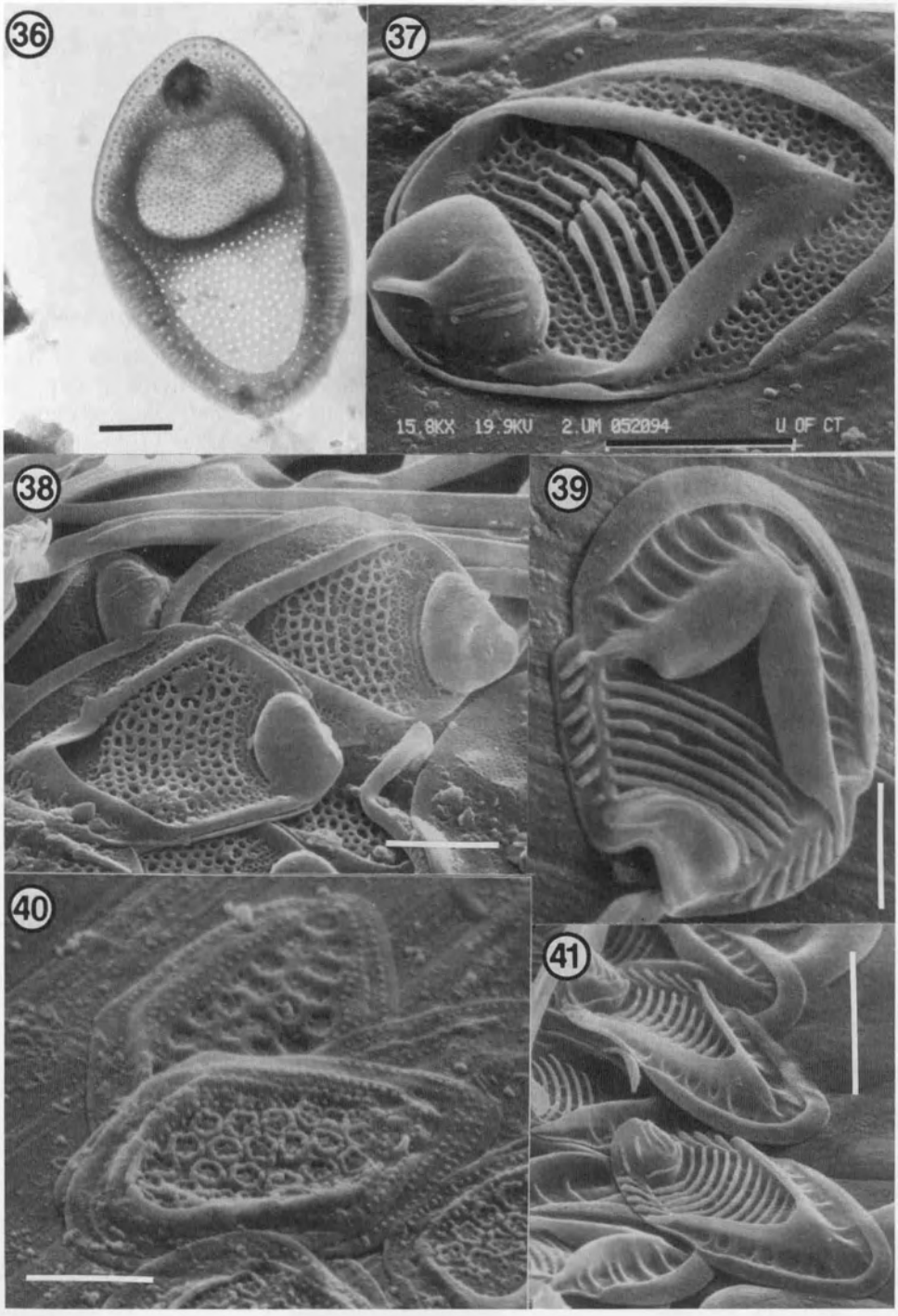
Paraphysomonas undulata Preisig et Hibberd Fig. 43

To our knowledge *Paraphysomonas undulata* has only been reported from Michigan (Wujek & Igoe 1989) since its original description by Preisig & Hibberd (1982). We found this taxon at two sites (Table II).

Paraphysomonas vestita (Stokes) de Saedeleer Fig. 45

Paraphysomonas vestita was the second most common organism, found in 42% of the collections. In a survey of tropical areas Cronberg (1989) also reported this taxon from 40% of the samples examined.

Figs 30-35. Fig. 30. *Mallomonas matvienkoae* var. *matvienkoae*. Note the large single pore in the posterior of the shield. Scale bar = 2 μm. Figs 31-33. *Mallomonas matvienkoae* var. *grandis*. Fig. 31. Note the dense layer of papillae on the anterior of the scale and the group of three large posterior pores. Scale bar = 2 μm. Fig. 32. Morphology of the undersurface of scales. Scale bar = 2 μm. Fig.33. Bristle morphology. Scale bar = 1 μm. Insert depicts the morphology of the tips of the bristles. Scale bar = 0.5 μm. Fig. 34. *Mallomonas papillosa*. Scale bar = 2 μm. Fig. 35. *Mallomonas peronoides* var. *peronoides*. Scale bar = 2 μm.


36
37
15.8KX 19.9KV 2.UM 052094 U OF CT
38
39
40
41

Spiniferomonas trioralis Takahashi Fig. 44

Cells of this taxon were very rare, found at only one locality. Isolated scales, possibly representative of *S. trioralis,* were observed at five additional sites (Table II).

Synura australiensis Playfair Fig. 46

Synura australiensis possesses scales that look like those of *Synura petersenii,* but are much longer and more slender in shape. Scales from the two populations found in this study had a mean length and width of 10 μm and 2 μm, respectively. This species was observed at two locations in or around the delta (group 1) with low specific conductivity.

Synura curtispina (Petersen et Hansen) Asmund Figs. 47-48

Synura curtispina was the most common taxon in this survey, found in 24 localities (Table II). Generally, the anterior one-third to one-half of the scales were covered with a secondary layer, and all spined scales had a series of parallel ribs along the anterior margin. A feature common to all populations was the relatively large size of the base plate pores. The sizes of the openings of the meshes of the secondary reticulum varied in size from quite small and almost closed to large and open. All forms of spineless scales reported by Wee (1982), including the elongated posteriormost scales with large upturned rims, were observed.

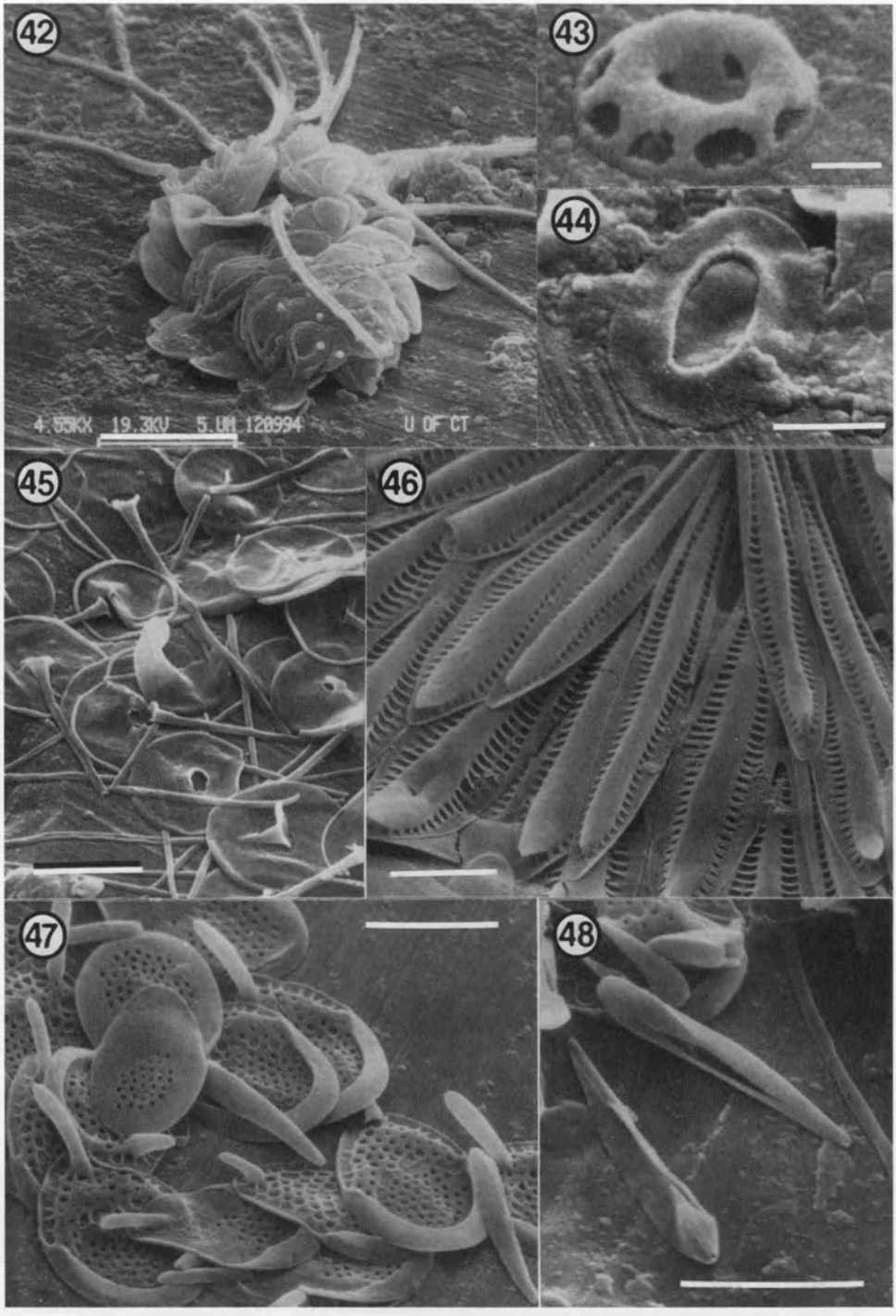
Although most populations had scales with relatively short spines, several had scales with longer spines more commonly associated with *Synura spinosa.* In each case, however, scales with short spines, as well as the elongated posterior scales common to *S. curtispina* (Fig. 48) were observed, leading us to conclude that the populations were indeed *S. curtispina.*

Synura curtispina was found over wide pH (pH 6.3 to 8.8) and specific conductivity (123 to 1,500 μS cm^{-1}) ranges, but noticeably absent from the extremely high conductivity sites (Tables I-II).

Synura echinulata Korshikov f. **echinulata** Fig. 49

This taxon was quite common, observed at eight sites (Table II). Although it was found at one site with pH 8.7 and 1,300 μS cm^{-1}, *S. echinulata* was most often present at lower pH and specific conductivity.

Figs 36-41. Fig. 36. *Mallomonas peronoides* var. *bangladeshica.* Scale bar = 1 μm. Fig. 37. *Mallomonas portae-ferreae* var. *portae-ferreae.* Scale bar = 2 μm. Fig. 38. *Mallomonas portae-ferrreae* var. *reticulata.* Note the domed scale lacking a secondary layer. Scale bar = 2 μm. Fig. 39. *Mallomonas striata.* Scale bar = 1 μm. Fig. 40. *Mallomonas pumilio.* Scale bar = 1 μm. Fig. 41. *Mallomonas striata.* Scale bar = 2 μm.


42
4.55KX 19.3KV 5.UM 120994 U OF CT
43
44
45
46
47
48

Synura echinulata f. **leptorrhabda** Asmund Fig. 50

Two features were used to distinguish this form from the type. First, the anterior vermiform ornamentation of the scales was very reduced or absent. Second, the anterior series of distal ribs were quite long (Nicholls & Gerrath 1985) and often connected by perpendicular ribs.

Except for one location within the river, this taxon was found in sites on the delta with relatively low pH (pH 6.3 to 7.4) and low specific conductivity (123 to 238 μS cm^{-1}).

Synura petersenii Korshikov f. **petersenii** Fig. 52

Synura petersenii was reported from 34% of the localities, spanning wide pH (6.3 to 8.7) and specific conductivity (123 to 1,500 μS cm^{-1}) gradients (Tables I-II).

Synura petersenii f. **kufferathii** (Korshikov) Petersen et Hansen Fig. 51

This form of *Synura petersenii* is distinguished from the type by the presence of ribs that are aligned parallel with the scale axis and connect adjacent struts (Petersen & Hansen 1958). Forma *kufferathii* was observed at nine sites mostly low in specific conductivity (Tables I-II).

Synura uvella (Stein) emend. Korshikov Figs. 53-54

This species was very rare; it was found in only two collections from localities on the delta with low specific conductivity (Table I).

Figs 42-48. Fig. 42. *Mallomonas tonsurata.* Whole cell. Scale bar = 5 μm. Fig. 43. *Paraphysomonas undulata.* Scale bar = 0.25 μm. Fig. 44. *Spiniferomonas trioralis.* Scale bar = 0.5 μm. Fig. 45. *Paraphysomonas vestita.* Scale bar = 2 μm. Fig. 46. *Synura australiensis.* Scale bar = 2 μm. Figs 47-48. *Synura curtispina.* Scale bars = 2 μm. Note the typical elongated slipper shaped posterior scales.

Figs 49-54. Fig. 49. *Synura echinulata* f. *echinulata.* Note expanded anterior region with vermiform ribs. Scale bar = 2 μm. Fig. 50. *Synura echinulata* f. *leptorrhabda,* Note the reduced region of vermiform ribs. Scale bar = 2 μm. Fig. 51. *Synura petersenii* f. *kufferathii.* Scale bar = 2 μm. Fig. 52. *Synura petersenii* f. *petersenii.* Scale bar = 2 μm. Figs 53-54. *Synura uvella.* Scale bars = 2 μm. Domed (Fig. 53) and domeless (Fig. 54) scales.

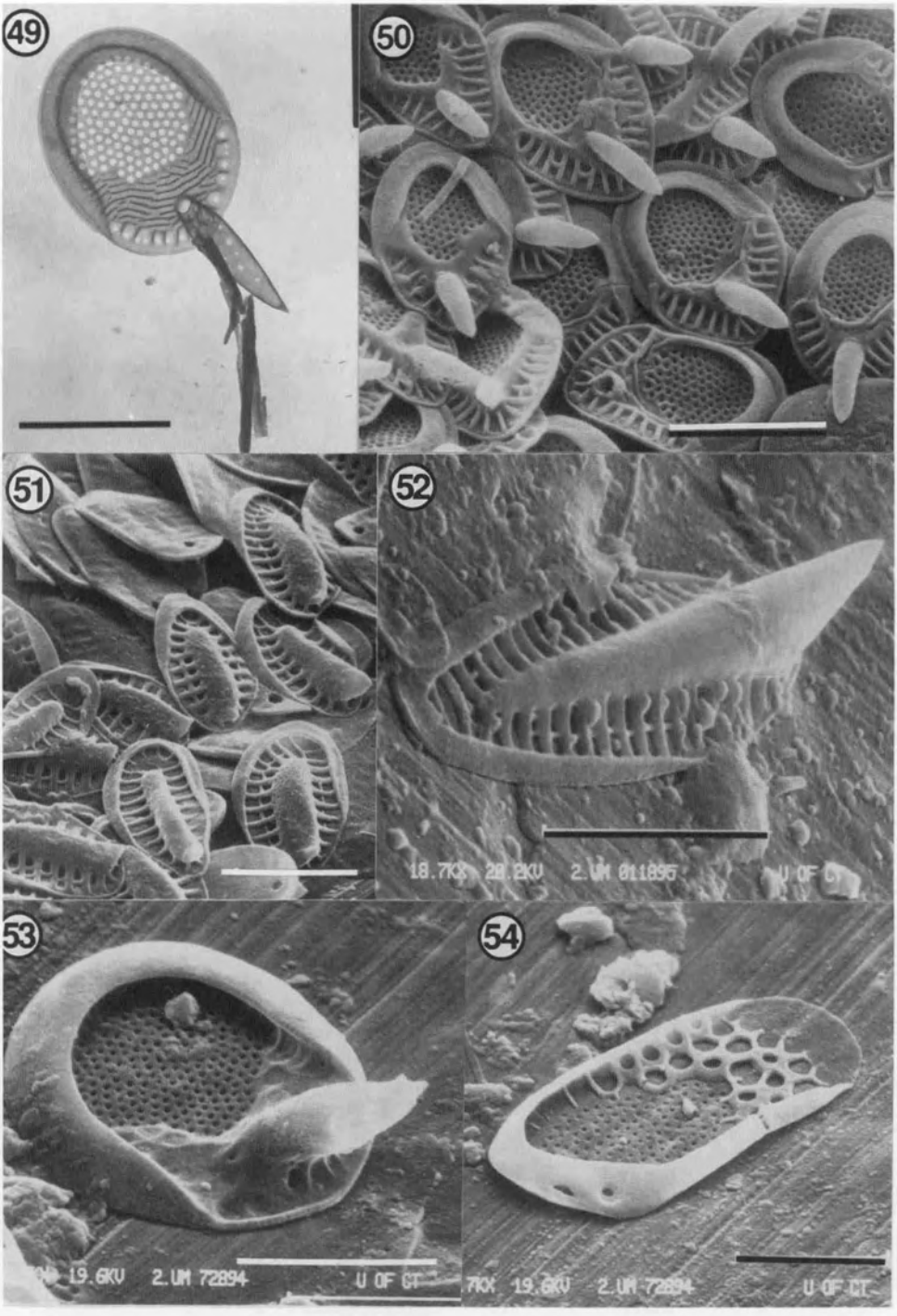

49
50
51
52
18.7KX 20.2KV 2.UM 011895 U OF CT
53
19.6KV 2.UM 72894 U OF CT
54
7KX 19.6KV 2.UM 72894 U OF CT

Table II. The occurrence and relative abundances of scaled chrysophytes in 50 collections from the delta region of the Paraná River, Argentina, during April, 1991. A = abundant; C = common; R = rare.

Taxon	Site																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Chrysosphaerella																		
C. brevispina	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
C. coronacircumspina	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallomonas																		
M. akrokomos	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
M. alpina	C	-	-	-	R	-	-	-	-	-	-	R	-	-	-	-	R	-
M. caudata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. cristata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. cyathellata	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
M. guttata	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. heterospina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. lychenensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. mangofera f. mangofera	R	-	R	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
M. mangofera f. reticulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. mangofera f. foveata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. matvienkoae var. matvienkoae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. matvienkoae var. grandis	C	R	R	-	-	-	-	-	-	C	-	-	-	-	-	R	-	-
M. papillosa	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. peronoides var. peronoides	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. peronoides var. bangladeshica	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
M. portae-ferreae var. portae-ferreae	-	-	-	-	A	R	-	R	R	-	-	-	-	-	-	-	-	-
M. portae-ferreae var. reticulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. pumilio	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
M. striata var. serrata	-	-	R	-	-	-	-	R	-	R	-	-	-	-	-	-	R	-
M. tonsurata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paraphysomonas																		
P. undulata	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
P. vestita	R	R	R	R	R	-	R	C	-	R	-	R	-	-	-	-	C	A
Spiniferomonas																		
S. trioralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
S. spp.	R	-	-	-	R	-	-	R	-	-	-	-	-	-	-	-	-	-
Synura																		
S. australiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. curtispina	-	-	R	-	-	-	-	R	-	A	-	-	-	-	-	-	R	C
S. echinulata f. echinulata	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-
S. echinulata f. leptorrhabda	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. petersenii f. petersenii	R	-	-	-	-	-	-	R	-	C	-	-	-	-	-	-	R	-
S. petersenii f. kufferathii	C	-	R	-	R	-	-	-	-	C	-	-	-	-	-	-	-	C
S. uvella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	10	2	8	2	10	1	1	6	2	8	1	2	0	0	0	2	5	3

Table II (continued)

Taxon	Site															
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Chrysosphaerella																
C.brevispina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C.coronacircumspina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallomonas																
M. akrokomos	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
M. alpina	C	-	-	-	R	R	-	-	R	-	-	-	-	R	R	R
M. caudata	-	-	-	-	R	A	R	-	C	R	-	-	-	-	-	-
M. cristata	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
M. cyathellata	R	-	-	-	R	R	R	-	-	-	-	-	-	-	-	-
M. guttata	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
M. heterospina	-	-	-	R	-	R	-	-	-	-	-	-	-	-	-	-
M. lychenensis	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
M. mangofera f. mangofera	-	-	-	-	-	-	-	R	R	R	-	-	-	-	-	-
M. mangofera f. reticulata	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
M. mangofera f. foveata	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
M. matvienkoae var. matvienkoae	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
M. matvienkoae var. grandis	-	-	-	R	R	R	A	-	-	-	R	-	-	-	-	-
M. papillosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. peronoides var. peronoides	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
M. peronoides var. bangladeshica	R	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-
M. portae-ferreae var. portae-ferreae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. portae-ferreae var. reticulata	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-
M. pumilio	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-
M. striata var. serrata	-	-	C	R	A	-	-	-	-	-	R	-	R	-	-	-
M. tonsurata	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Paraphysomonas																
P. undulata	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
P. vestita	R	-	-	C	C	-	R	R	R	-	C	-	R	-	A	R
Spiniferomonas																
S. trioralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. spp.	-	-	R	-	-	-	-	-	R	-	-	-	-	-	-	-
Synura																
S. australiensis	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
S. curtispina	R	-	R	R	R	R	R	-	R	-	C	-	R	-	R	R
S. echinulata f. echinulata	R	-	C	R	R	-	-	-	R	-	C	-	-	-	-	-
S. echinulata f. leptorrhabda	-	-	-	-	-	R	C	R	-	-	-	-	-	-	-	-
S. petersenii f. petersenii	R	-	-	-	R	R	C	-	R	-	C	-	-	C	-	C
S. petersenii f. kufferathii	-	-	C	R	-	-	-	R	-	-	-	-	R	-	-	-
S. uvella	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-
TOTAL	7	0	5	8	11	12	7	5	14	3	6	0	5	2	3	4

Table II (continued)

Taxon	Site																
	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Total
Chrysosphaerella																	
C.brevispina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
C.coronacircumspina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Mallomonas																	
M. akrokomos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
M. alpina	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	14
M. caudata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
M. cristata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
M. cyathellata	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	6
M. guttata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
M. heterospina	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	3
M. lychenensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
M. mangofera f. mangofera	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	7
M. mangofera f. reticulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
M. mangofera f. foveata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
M. matvienkoae var. matvienkoae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
M. matvienkoae var. grandis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	11
M. papillosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
M. peronoides var. peronoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
M. peronoides var. bangladeshica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
M. portae-ferreae var. portae-ferreae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
M. portae-ferreae var. reticulata	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	2
M. pumilio	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	3
M. striata var. serrata	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	10
M. tonsurata	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	2
Paraphysomonas																	
P. undulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
P. vestita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21
Spiniferomonas																	
S. trioralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
S. spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Synura																	
S. australiensis	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	2
S. curtispina	C	C	R	-	-	-	R	-	-	-	-	-	R	R	C	C	24
S. echinulata f. echinulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	8
S. echinulata f. leptorrhabda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
S. petersenii f. petersenii	-	R	-	-	-	-	R	-	-	-	-	-	-	R	R	R	17
S. petersenii f. kufferathii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
S. uvella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
TOTAL	2	3	6	0	0	0	6	0	0	0	0	0	1	2	2	4	

Discussion

The scaled chrysophyte flora in and around the delta region of the Paraná River can best be described as relatively diverse in nature, harboring at least 33 different taxa. It is clear that within this region the waterbodies situated on the delta with lower pH and specific conductivity values harbored the most diverse and abundant numbers of species. All but one of the localities containing eight or more species were waterbodies on the delta with a pH between 6.0 and 7.4, specific conductivity between 123 and 262 μS cm^{-1}, and a moderate dissolved humic acid content. Localities that are slightly acidic in nature, low in specific conductivity, and with a moderate dissolved humic content are commonly associated with a rich diversity of scaled chrysophytes (Siver 1995; Eloranta 1995). The requirement for dissolved humic substances, also observed by Vyverman & Cronberg (1993); may be why Cronberg (1989) noted that scaled chrysophytes are more abundant in small waterbodies.

The lowest specific conductivity values observed in the delta of the Paraná River (e.g. 123 μS cm^{-1}) are still considerably higher than many waterbodies examined for chrysophytes in other parts of the world, such as New England (Siver 1991), the Adirondacks (Siver 1988a; Cumming et al. 1992) and Finland (Eloranta 1989, 1995). All of the scaled chrysophyte taxa reported by Siver (1993, 1995) with weighted mean specific conductivity levels below 60 μS cm^{-1}, such as *Synura sphagnicola* Korshikov, *Mallomonas duerrschmidtiae* Siver, Hamer et Kling, *M. acaroides* Perty emend. Ivanov var. *muskokana* Nicholls and *Chrysosphaerella longispina* Lauterborn, were not observed in this survey. This further supports the hypothesis that some taxa of scaled chrysophytes may exist only under very low specific conductivity levels.

It is also of importance to note that half of the sites examined had either no or less than two taxa, suggesting that there are numerous localities with a low diversity of scaled chrysophytes; these waterbodies included the river itself (group 2) and many of the tributaries draining into the river through industrial or farming areas (groups 3, 4 and 5). Localities within the river and its main channels were relatively low in pH and specific conductivity, similar to localities situated on the delta (group 1), but differed in having a high sediment load and low humic content. It is perhaps the combination of a high sediment load and low humic acid content that resulted in low numbers of scaled chrysophytes in the river proper. Despite the low number of scaled chrysophytes, large concentrations of diatoms, especially *Aulacoseira granulata,* were present within the river.

It was also clear in this study that as the pH and specific conductivity of the tributaries draining into the delta increased above 8.0 and 1,000 μS cm^{-1}, respectively, that significantly fewer species were found. Even though all 33 species were found in waters with a specific conductivity below 1,000 μS cm^{-1}, only eight were found at sites above this value, further supporting the idea that the diversity of scaled chrysophytes decreases as the concentration of dissolved salts increases (see Siver 1995 and references therein).

The majority of localities surveyed from tropical and subtropical regions contain scaled chrysophyte species that have a cosmopolitan distribution, as well as ones common

to temperate areas (e.g. Cronberg 1989; Saha & Wujek 1990; Vyverman & Cronberg 1993; Wujek & Bicudo 1993; Siver & Wujek 1993). However, there also appears to be a number of taxa primarily distributed in or with an affinity to tropical or subtropical regions. In a review of studies of scaled chrysophytes from the tropics Cronberg (1989) concluded that *Mallomonas matvienkoae* var. *grandis, M. bronchartiana* Compère, M. mangofera f. *reticulata* and species in the Peronoides group were restricted to the tropics or warm water lakes. Cronberg added that *Synura australiensis, Mallomonas portae-ferreae* and *M. guttata* also had a dominance in the tropics. Other researchers, including Dürrschmidt & Cronberg (1989), Saha & Wujek (1990) and Vyverman & Cronberg (1993), have commented on additional taxa that are found primarily in more tropical regions.

The scaled chrysophyte flora of the Paraná River delta also contained taxa that are cosmopolitan in nature, as well as ones commonly found in tropical or temperate regions. Taxa often reported from the tropics, including *M. matvienkoae* var. *grandis, M. guttata, M. peronoides* var. *peronoides, M. peronoides* var. *bangladeshica, M. portae-ferreae, M. mangofera* var. *reticulata* and *Synura australiensis,* were found in this study, indicating a tropical element to the flora. It is also of interest that over 70% of the 59 localities surveyed in India by Saha & Wujek (1990) contained subspecific taxa of *Mallomonas cyathellata* or *M. mangofera,* and 50% of the samples contained *Synura curtispina;* these three taxa were among the more common species found in this study. Other taxa observed in the Paraná River delta region, including *Mallomonas akrokomos, M. caudata, M. heterospina, M. papillosa, M. striata, M. tonsurata* and *Synura echinulata,* are commonly reported from northern temperate regions (Siver 1987, 1991; Wee 1982; Takahashi 1978). Interestingly, taxa of *Spiniferomonas* and *Chrysosphaerella,* genera commonly reported from temperate regions (Takahashi 1973; Nicholls 1981; Skogstad 1982; Siver 1988b), were only rarely observed.

Many authors have suggested that *Mallomonas crassisquama* (Asmund) Fott, *Mallomonas caudata,* and *Synura petersenii* are the most common species in their respective genera on a worldwide basis (for a review see Siver 1991 and Siver 1987). However, such generalizations are based largely on studies of temperate regions, especially ones in Europe and North America. Despite its apparent worldwide abundance, *Mallomonas crassisquama* is very rare in South America (Siver 1991), having been reported only from Columbia (Cronberg 1989). Kristiansen & Tong (1991) also commented on the fact that *M. crassisquama* was surprisingly missing from studies done in China. In other recent studies from Brazil (Wujek & Bicudo 1993), Korea (Kristiansen et al. 1990), Papua New Guinea (Vyverman & Cronberg 1993), and Argentina (this study) *M. crassisquama* was not found. In an examination of 59 localities in India, Saha & Wujek (1990) reported *M. crassisquama* as rare, found in only 6% of the collections; this species is perhaps even rarer since the micrograph of it (Fig. 6 of Saha & Wujek 1990) is actually of *Mallomonas pseudocoronata* Prescott. It appears that *M. crassisquama* is a rather rare taxon in subtropical and tropical areas, and primarily distributed in temperate regions (Cronberg 1989).

A similar case can be made for *Mallomonas caudata,* another rare species in our survey. Based on a review of the literature representing primarily temperate locali-

ties in the northern hemisphere, Siver (1991) found *M. caudata* to be among the most common species of scaled chrysophytes. Other researchers have also reported this taxon as being among the most common species (Asmund & Takahashi 1969; Takahashi 1978; Nicholls 1982; Eloranta 1989). However, *Mallomonas caudata* has now been reported as missing or rare from Australia and Malaysia (Dürrschmidt & Croome 1985), China (Kristiansen & Tong 1991), Papua New Guinea (Vyverman & Cronberg 1993); India (Saha & Wujek 1990), Korea (Kristiansen et al. 1990), Brazil (Wujek & Bicudo 1993) and Sri Lanka (Dürrschmidt & Cronberg 1989).

In a similar manner *Synura petersenii* is often reported as the most common species of *Synura*. However, in some areas of the world other species of *Synura* are as, or more, common. For example, in a study in the Adirondacks, Siver (1988a) found *S. sphagnicola* and *S. echinulata* to be as abundant as *S. petersenii*. In surveys from India (Saha & Wujek 1990), Papua New Guinea (Vyverman & Cronberg 1993), and Arkansas (Andersen & Meyer 1977), *S. curtispina* was reported to be much more common than *S. petersenii*. *Synura curtispina* was also the most common taxon of *Synura* in the delta of the Paraná River.

In summary, the scaled chrysophyte flora of the Paraná is relatively diverse and contains species common to both tropical and temperate regions. Further study is needed in order to understand seasonality aspects of the flora and to include areas north of the delta region.

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