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Biodiversity and biogeographical implications of silica-scaled chrysophytes (Chrysophyceae and Synurophyceae) of the northeast wetlands of Argentina

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With 2 figures and 2 tables

Abstract: Wetlands and water bodies in the Paraná Delta River and Iberá System of northeast Argentina were studied for scaled chrysophytes. The Delta region of the Paraná River is composed of a series of braided channels, streams and lagoons that extend over 17,500 km^2. Although the Delta is situated in the temperate zone, it experiences a more subtropical climate. The water ways of the Iberá System consist of interconnected ponds, lagoons, and creeks covering approximately 12,000 km^2. Twenty sites were sampled and their physico-chemical data measured. Twenty-seven species belonging to the genera *Spiniferomonas, Paraphysomonas, Chrysosphaerella, Chrysodidymus, Mallomonas* and *Synura* were recorded and in all cases the geographical distribution of these taxa were significantly expanded. A new variety, *Mallomonas pseudocratis* var. *deltaensis*, is described. Lastly, the colorless flagellate *Gyromitus disomatus* was found to be abundant in sites from Iberá.

Key words: Wetlands, chrysophytes, biodiversity, biogeography, *Mallomonas*, Paraná Delta River, Iberá System, Argentina.

Introduction

In spite of recent efforts to understand and document the scaled chrysophyte flora in tropical and subtropical regions of South America many regions

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remain unexplored (Vigna 1990, 1991, 1993, Francheschini et al. 1996 a, b, Kristiansen & Menezes 1998, Vigna & Duque Escobar 1999, Wujek & Bicudo 1993).

Some of the most important freshwater environments in Argentina, including the Paraná River and Delta regions, the Uruguay River region and the Iberá System, are situated in the northeast region of the country. This region contains a multitude of lakes, ponds, streams, rivers and creeks, many of which are associated with one of the two main rivers of the region: the Paraná River, on the west, and the Uruguay River, on the east. Based on initial studies, many of these water bodies harbor a high phytoplankton biodiversity, with especially rich floras dominated by green algae, mainly Desmidiaceae, and other interesting microalgae, including Xanthophyceae, mainly Mischococcales (Lacoste et al. 1986, 1987, Vigna et al. 1990), and silica-scaled Chrysophyceae and Synurophyceae (Vigna 1990, Siver & Vigna 1996, 1997). Despite these recent efforts, much additional work is needed in order to fully describe the algal flora in these important waterbodies.

The purpose of this study was to further document the biodiversity and biogeography of scaled chrysophytes in two regions, the Paraná Delta River region and the Iberá System.

Study areas

Altogether, collections from 20 sites, including six from the deltaic portion of the Paraná River (sites 51–56) and fourteen from the Iberá System (sites 57–70), were made and analyzed as part of this study. The Paraná Delta River is an extensive series of braided rivers, lagoons, streams and channels that extends over 17,500 km^2 (Bonfils 1962) and is situated between 32° 5′ S, 60° 42′ W in the southeast part of Entre Ríos Province and 34° 29′ S and 58° 28′ W near the city of Buenos Aires. Littoral zones are often dominated by *Scirpus giganteus* and *Schoenoplectus californicus* and sometimes floating macrophytes, including *Eichornia* spp. are abundant (Bonetto & Hurtado 1999). The Paraná Delta River is situated in the temperate zone, but the climate is more subtropical in nature (Malvarez 1999). The mean annual rainfall is 100 cm and the mean annual air temperature is 18 °C (Servicio Metereológico Nacional 1980). The Delta is easily flooded during periods of high precipitation.

The Iberá System is an extensive area covering approximately 12,000 km^2 that is relatively flat and with a low grade that eventually flows to the Paraná River. Roughly, the Iberá System crosses diagonally through Corrientes Province, between 27° 26′ S, 56° 29′ W and 29° 5′ S, 58° 46′ W. The region contains a rich number of interconnected ponds, lagoons and creeks that initially drain into either the Corrientes River, the Santa Lucía River or the Empedrado River and eventually into the Paraná River. One of the largest lagoons of this system is Laguna Iberá.

The lentic and semilentic waterbodies of the Iberá System are often dominated by submergent macrophytes, including *Cabomba australis, Egeria naias* and *Utricularia* *foliosa*, that grow on sediment rich with organic material. The littoral zone is often dominated by *Schoenoplectus californicus* (BONETTO & HURTADO 1999). The Iberá System is located in the subtropics, with an annual precipitation of 120–150 cm and a mean annual air temperature of 20 °C (Servicio Meterológico Nacional 1980).

Materials and methods

Phytoplankton samples were taken during winter (July 1995) using a 20 µm mesh plankton net. Half of each sample was fixed with Lugol's solution and the other half kept alive for further observations with light microscopy (LM). Aliquots of each fixed sample were treated for observations with electron microscopy according to the methods of SIVER & VIGNA (1997). In brief, specimens were mounted on alumnium foil for observations with scanning electron microscopy (SEM) and on 200 mesh coated copper grids for observations with transmission electron microscopy (TEM). Samples were observed with a Coates & Welter Field Emmission SEM (University of Connecticut), a Philips 515 SEM (Technical Research Center of the Armed Forces, Buenos Aires) or a Jeol 1200 EXII TEM (National Institute of Agropecuary Technology, Buenos Aires).

Water temperature and specific conductivity were measured with a Yellow Springs Instruments model 33 SCT meter. The pH was measured with a Fisher Accumet model 640A pH meter.

The qualitative estimation of scaled chrysophyte taxa were made according to the following three ranks: abundant, if the taxon was among the most numerous species of algae in the sample; common, if it was subdominant; and rare, if it was represented by only a few cells or isolated scales.

Results

Physico-chemical data measured at the time of sample collection are given in Table 1. The first group of samples (sites 51–56) were taken in lotic water bodies in the Paraná Delta River region. The pH of these samples ranged from 6.6–8.2 and the conductivity from 105–900 µS cm^{-1}. The second group of samples (sites 57–70) belong to the Iberá System and include lotic and lentic water bodies. Samples 61 and 66–70 were taken from Laguna Iberá. Sample 61 was taken from the shore, while samples 66–70 were taken from a boat. Samples 66–68 were obtained near the center of the lagoon, sample 69 from the littoral/pelagic boundary and sample 70 within the littoral vegetation (Table 2). In this second group the physico-chemical measurements of pH are more acidic than in the first group: 6.0–6.3, and conductivity values are very low: 10–20 µS cm^{-1}.

A total of twenty-seven taxa of silica-scaled algae were observed. They included 1 of *Chrysosphaerella*, 1 of *Paraphysomonas*, 1 of *Spiniferomonas*, 15 of *Mallomonas*, 1 of *Chrysodidymus* and 8 of *Synura*. In addition, the colorless flagellate *Gyromitus disomatus* was found widely throughout Laguna Iberá.

Table 1. The pH, temperature and specific conductance of the study sites at the time of collection.

Sample	Locality	Date	pH	Temp. (°C)	Cond. (µS/cm)
51	Stream Pescado	7/13/1995	8.2	10	900
52	Stream km 91	7/13/1995	6.7	9.5	245
53	River Brazo Largo	7/13/1995	7.4	13.5	105
54	Stream Alcazter	7/13/1995	6.6	11	170
55	Stream Paso Ancho	7/13/1995	6.7	10	260
56	Stream Celbo	7/13/1995	6.7	11	300
57	River Empedrado	7/16/1995			
58	River Santa Lucia	7/16/1995			
59	Creek Betel	7/16/1995			
60	River Corrientes	7/16/1995			
61	Laguna Iberá	7/17/1995	6.3	12	13.5
62	Creek Iberá (1)	7/18/1995	6.0	10	14
63	Creek Iberá (2)	7/18/1995	6.0	10	14
64	Creek Iberá (3)	7/18/1995	6.0	10	14
65	Creek Iberá (4)	7/18/1995	6.0	10	14
66	Laguna Iberá (1)	7/19/1995	6.1	13	10
67	Laguna Iberá (2)	7/19/1995	6.1	13	10
68	Laguna Iberá (3)	7/19/1995	6.1	13	10
69	Laguna Iberá (4)	7/19/1995	6.1	13	13
70	Laguna Iberá (5)	7/19/1995	6.1	14	20

Chrysophyceae

Chrysosphaerella brevispina KORSHIKOV
Fig. 1, K

This cosmopolitan taxon was registered as rare in sites 62 and 65 (Table 1, 2) and for Laguna Iberá.

Paraphysomonas vestita (STOKES) DE SAEDELEER
Fig. 1, J

This cosmopolitan taxon had a wide distribution in the two regions surveyed in this study, but was a ŕare component of the phytoplankton composition.

Spiniferomonas trioralis TAKAHASHI
Fig. 1, N

It has a cosmopolitan but scattered distribution around the world. This species was recorded as rare in two sites, 51 and 64 (Table 2). Although only a spineless scale is noted in Figure 1 N, we also observed spined scales characteristic of this species.

Table 2. The distribution of scaled chrysophyte organisms is waterbodies associated with the Parana River delta and the Iberá system of Argentina.

Localities	Parana Delta river						Iberá system														Total
															Laguna Iberá						
Sites	51	52	53	54	55	56	57	58	59	60	62	63	64	65	61	66	67	68	69	70	
Chrysosphaerella brevispina											*			*		*	*	*	*	*	3
Paraphysomonas vestita	*		*	*		*			*	*						*	*	*	*	*	7
Spiniferomonas trioralis	*												*								2
Mallomonas alpina	*							*													2
M. annulata	*																				1
M. crassisquama												*		*		*	*	*	*	*	3
M. cristata									*	*						*	*	*	*	*	3
M. guttata															*					*	2
M. heterospina																*	*	*	*	*	1
M. mangofera	*	*																			2
M. matvienkoae var. *matvienkoae*				*	*																2
M. matvienkoae var. *myakkana*				*			*														2
M. papillosa				*																	1
M. peronoides	*																				1
M. pseudocratis var. *deltaensis*				*																	1
M. punctifera var. *brasiliensis*											*	*		*	*	*	*	*	*	*	4
M. striata var. *serrata*	*	*		*				*		*											5
M. tonsurata											*			*	*	*	*	*	*	*	3
Chrysodidymus synuroideus					*																1
Synura curtispina	*	*	*	*		*	*	*						*							8
S. echinulata f. *echinulata*				*	*	*	*	*	*	*											7
S. echinulata f. *leptorrhabda*					*																1
S. spinosa f. *longispina*									*	*			*			*	*	*	*	*	4
S. sphagnicola							*									*	*	*	*	*	2
S. petersenii f. *petersenii*	*						*		*							*	*	*	*	*	4
S. petersenii f. *kufferathii*		*		*	*	*		*		*											6
S. uvella						*		*								*	*	*	*	*	3
Gyromitus disomatus																*	*	*	*	*	1
Total number of species	9	4	2	9	5	5	5	6	5	6	3	2	2	5	3	12	12	12	12	13	

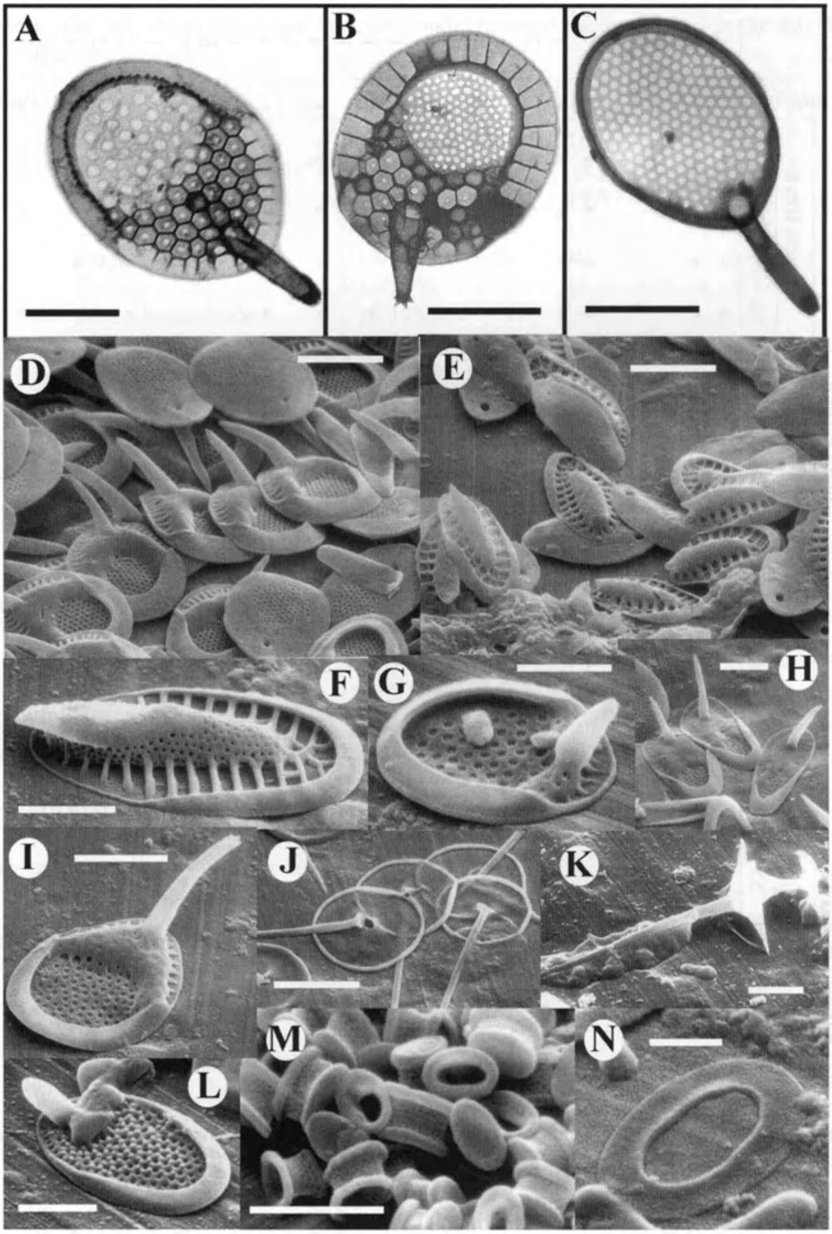

Fig. 1. A. *Synura curtispina* (bar = 1 µm); **B.** *S. uvella* (bar = 2 µm); **C.** *S. sphagnicola* (bar = 2 µm); **D.** *S. echinulata* var. *echinulata* (body scales, bar = 2 µm); **E.** *S. petersenii* var. *kufferathii* (bar = 2 µm); **F.** *S. petersenii* (bar = 1 µm); **G.** *S. echinulata* f. *leptorrhabda* (bar = 1 µm); **H.** *S. echinulata* var. *echinulata* (caudal scales, bar = 1 µm); **I.** *S. spinosa* f. *longispina* (bar = 2 µm); **J.** *Paraphysomonas vestita* (bar = 2 µm); **K.** *Chrysosphaerella brevispina* (bar = 1 µm); **L.** *Chrysodidymus synuroideus* (bar = 1 µm); **M.** *Gyromitus disomatus* (bar = 1 µm); **N.** *Spiniferomonas trioralis* (bar = 0.5 µm).

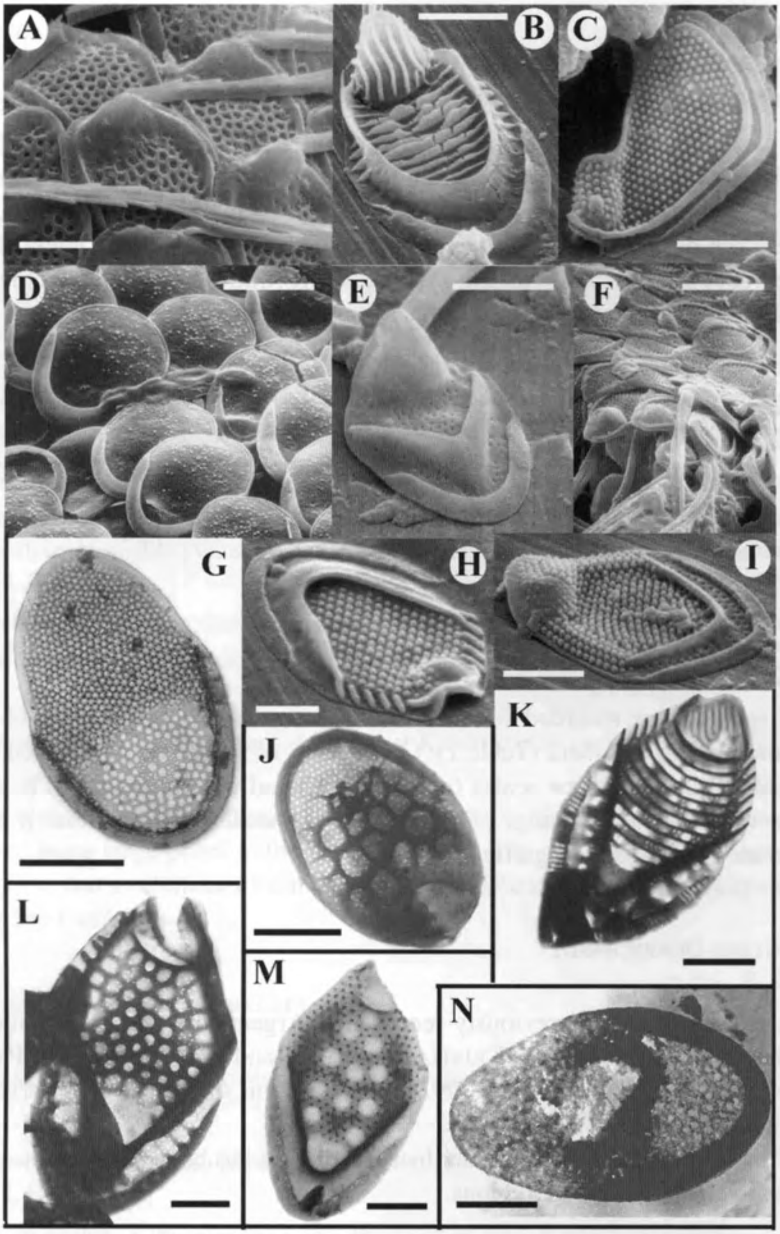

Fig. 2. A. *Mallomonas punctifera* var. *brasiliensis* (bar = 1 µm); **B.** *M. pseudocratis* var. *deltaensis* (bar = 1 µm); **C.** *M. mangofera* (bar = 1 µm); **D.** *M. matvienkoae* var. *matvienkoae* (bar = 2 µm); **E.** *M. cristata* (bar = 1 µm); **F.** *M. tonsurata* (bar = 2 µm); **G.** *M. matvienkoae* var. *myakkana* (bar = 2 µm); **H.** *M. papillosa* (bar = 0.5 µm); **I.** *M. annulata* (bar = 1 µm); **J.** *M. heterospina* (bar = 1 µm); **K.** *M. striata* var. *striata* (bar = 1 µm); **L.** *M. crassisquama* (bar = 1 µm); **M.** *M. guttata* (bar = 1 µm); **N.** *M. peronoides* (bar = 1 µm).

Synurophyceae

Mallomonas alpina Pascher et Ruttner emend. Asmund et Kristiansen

This taxon was observed as rare in sites 51 and 58 (Table 2). Curiously, this species was one of the most common species in our previous study of the Paraná Delta River Region (Siver & Vigna 1997). In that study the samples were taken during the southern autumn. Since the occurrences of many silica-scaled chrysophytes are seasonal (Vigna & Munari 2001), it is possible that this factor has influenced the presence of this species.

M. annulata (Bradley) Harris
Fig. 2, I

This organism was recorded as rare in one site (51). This is the second record of this species for Argentina. It was previously found in water bodies situated in Buenos Aires (Vigna 1988).

M. crassisquama (Asmund) Fott
Fig. 2, L

This species was recorded for the Iberá System as rare in sites 63–65 and common in Laguna Iberá (Table 2). Our records of this taxon were based only on isolated scales. A few scales (e.g. Fig. 2, L) had what appeared to be short struts on the anterior flange. Further work is needed to determine if these struts are of taxonomic significance.

M. cristata Dürrschmidt
Fig. 2, E

This species has been previously recorded in Argentina from six localities in Tierra del Fuego (Vigna & Kristiansen 1996) and at one site in the Paraná River Region (Siver & Vigna 1997). In the present study, it was observed as rare in Laguna Iberá (Table 2).

This taxon has a cosmopolitan distribution, but has been reported more often from cooler temperate regions.

M. guttata Wujek
Fig. 2, M

It was observed only in Laguna Iberá (Table 2) and its relative frequency was rare. It was previously recorded in Argentina for two water bodies in the Paraná Delta River Region (Siver & Vigna 1997).

M. heterospina LUND
Fig. 2, J

Specimens with typical scales were registered as common in Laguna Iberá (Table 2).

M. mangofera HARRIS et BRADLEY
Fig. 2, C

This species was common in two sites, 51 and 52, in the Paraná Delta River Region (Table 2). In our previous study (SIVER & VIGNA 1997), *M. mangofera* was recorded at seven sites in the Paraná River Region, all of which had low pH and low specific conductivity. In this study, this species was found at site 51 with a relatively high pH and specific conductivity of 8.2 and 900 $\mu S\,cm^{-1}$, respectively (Table 1).

M. matvienkoae (MATVIENKO) ASMUND et KRISTIANSEN var. *matvienkoae*
Fig. 2, D

This variety, characterized by scales possessing a single large pore in the proximal region, was recorded as rare in two sites (Table 2).

M. matvienkoae (MATVIENKO) ASMUND et KRISTIANSEN var. *myakkana* SIVER
Fig. 2, G

This variety is characterized by scales covered with papillae and possessing two or more large pores in the proximal region (SIVER 1991). In this survey it was recorded as abundant from two sites, 54 in Paraná Delta River Region and 57 in the Iberá System.

M. papillosa HARRIS et BRADLEY
Fig. 2, H

It was recorded as rare in site 54 in the Paraná Delta River Region.

M. peronoides (HARRIS) MOMEU et PÉTERFI
Fig. 2, N

Typical scales of this species were observed as rare in site 51 (Table 2).

M. pseudocratis DÜRRSCHMIDT var. *deltaensis* SIVER et VIGNA nov. var.
Fig. 2, B

Diagnosis: Var. *deltaensis* differt a var. *pseudocratis* numero minore costarum transversarum scuti, quae non plus quam decem sunt; costis centralibus forte et irregulariter incrassatis; absentia notabilissimorum pororum laminae basalis; atque costis posterioribus scuti non interruptis.

Typus mense Julii anni 1995 in Arroyo Alcaztar, Paraná Delta Regio, Argentina, inventus, figura nostra 2B depictus, in Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" depositus.

The scales are oval without lateral incurvings. Var. *deltaensis* differs from var. *pseudocratis* in: the lower number of transverse ribs of the shield, no more than ten; in that the central ribs are very coarse, raised and irregularly silicified; and in lacking the conspicuous basal plate pores and the interrupted posterior ribs on the shield.

Observations: This new variety presents some features that resemble *M. flora* HARRIS et BRADLEY var. *palermii* Vigna, recorded in Buenos Aires, Argentina (VIGNA 1981). *Mallomonas flora* var. *palermii* has only a single anterior thickened and raised rib on the shield and a different rib pattern on the dome than *M. pseudocratis* var. *deltaensis*.

M. punctifera KORSHIKOV var. *brasiliensis* KRISTIANSEN et MENEZES
Fig. 2, A

This variety is only known from sites in North and South America (VIGNA 1990, SIVER 1991, WEE et al. 1993, WUJEK & BICUDO 1993, FRANCESCHINI et al. 1996a, KRISTIANSEN & MENEZES 1998). In this survey, it was recorded for sites 62 and 63 as rare, common in sites 61 and 65, and abundant in sites 66–70.

M. striata ASMUND var. *serrata* HARRIS et BRADLEY
Fig. 2, K

This is a cosmopolitan taxon that was recorded as rare in the Paraná Delta River Region and the Iberá System (Table 2).

M. tonsurata TEILING emend. KRIEGER
Fig. 2, F

This species has a worldwide distribution. Specimens were rare in the two sites from the Iberá System where it was found (Table 2). Previously, it was recorded in Argentina from the Paraná River Region (SIVER & VIGNA 1997).

Chrysodidymus synuroideus PROWSE
Fig. 2, L

Two-celled colonies were observed only in site 55 (Table 2). This species has previously been reported from Tierra del Fuego (VIGNA & KRISTIANSEN 1996) and from Buenos Aires (VIGNA & MUNARI 2001).

Synura curtispina (PETERSEN et HANSEN) ASMUND
Fig. 1, A

This taxon was the most frequently observed species in our survey (Table 2), as was the case in our previous investigation (SIVER & VIGNA 1997). It was common in sites 51 and 57, and rare in sites 52, 55, 56, 58 and 65.

S. echinulata KORSHIKOV f. *echinulata*
Fig. 1, G

Like *S. curtispina*, this species is widely distributed (Table 2). It was rare in sites 54, 55, 57, 59–60; common in site 58 and abundant in site 56, where pH and specific conductivity were relatively low (Table 1).

S. echinulata KORSHIKOV f. *leptorrhabda* ASMUND
Fig.12, G

This taxon was recorded as common in site 55. The pH and the specific conductivity of this water body were relatively low (Table 1).

S. petersenii KORSHIKOV var. *petersenii*
Fig. 1, F

This organism is a cosmopolitan taxon with a wide environmental tolerance and a worldwide distribution. It was common in sites 51 and 59 and rare in sites 57, 66–70 (Table 2).

S. petersenii KORSHIKOV f. *kufferathii* PETERSEN et HANSEN
Fig. 1, E

This form is distinguished from the type by the interconnected parallel ribs of the scales. It was found as common in sites 52 and 58 and rare in sites 54–56, 60 (Table 2).

S. spinosa KORSHIKOV f. *longispina* PETERSEN et HANSEN
Fig. 1, I

This form is characterized by the length of the spine. It was common in site 59 and rare in all the others (Table 2).

S. sphagnicola (KORSHIKOV) KORSHIKOV
Fig. 1, C

It was found as rare in site 57 and in Laguna del Iberá (Table 2). Previously, it was recorded from Tierra del Fuego (VIGNA 1988, KRISTIANSEN & VIGNA 2002) and the Buenos Aires region (VIGNA & MUNARI 2001).

S. uvella STEIN emend. KORSHIKOV
Fig. 1, B

This organism was recorded in site 59 and in Laguna Iberá as rare.

Other silica-scaled organisms

Gyromitus disomatus SKUJA
Fig. 1, M

This colorless organism, characterized by its armour of silica rings, is infrequently recorded from plankton surveys around the world. It has an uncertain taxonomical position and in Argentina this species was previously observed in Tierra del Fuego (VIGNA 1989). In our study, it was observed only in Laguna Iberá where it was a rare component of the phytoplankton.

Discussion

Twenty-eight taxa with silica scales were registered in this survey (Table 2). Eighteen species were recorded for sites located in the Paraná River Region and twenty-six for sites located in the Iberá System. *Chrysodidymus synuroideus, Mallomonas annulata, M. crassisquama, S. spinosa* f. *longispina, S. sphagnicola* and *Gyromitus disomatus* represent new records for the Paraná River Region, and all twenty-eight taxa represent new records for the Iberá System.

Synura curtispina had the widest distribution being recorded for eight water bodies (considering that sites 61, 66–70 belong to the same water body, Laguna Iberá) (Table 2). This coincides with our previous findings for the Paraná River Region (SIVER & VIGNA 1997) where this species was the most frequently recorded. It was followed in importance by *S. echinulata* f. *echinulata* and *Paraphysomonas vestita*, both of which were recorded from seven localities (Table 2). *Paraphysomonas vestita*, a colorless flagellate often difficult to observe except by means of electron microscopy, was also reported as an important species in our previous research (SIVER & VIGNA 1997).

We noted that while *S. curtispina* is the *Synura* species with widest distribution in the northeast region of Argentina, in the southermost region of the country, Tierra del Fuego, *S. spinosa* was the most common species of *Synura* recorded (KRISTIANSEN & VIGNA 2002). Among the genus *Mallomonas* the cosmopolitan *M. striata* var. *serrata* was recorded for five water bodies. It was followed in importance by *M. punctifera* var. *brasiliensis* that was registered in four water bodies from the Iberá System (Table 2). Because it was recorded for the Uruguay River (VIGNA 1990), but not in the Paraná River Region, there might be a connection between the eastern part of the Iberá System and the Uruguay River Basin. Further studies are necessary to confirm this hypothesis.

Mallomonas crassisquama, recorded here for only the second time in Argentina (Thomasson 1963), has also been reported from Colombia (Cronberg 1989, Vigna & Duque Escobar 1999) and Brazil (Couté & Franceschini 1998). Although records now indicate that *M. crassisquama* is distributed in warmer regions of South America, it is much rarer than in temperate regions of the northern hemisphere (Cronberg 1989, Siver 1991).

Some of the taxa reported in this study, including *M. guttata, M. mangofera, M. matvienkoae* var. *myakkana*, and *M. peronoides*, have a typical tropical and subtropical geographic distribution. These findings confirm the tropical influence on the northeast freshwaters environments of Argentina.

Laguna Iberá, with low values of pH and specific conductivity (Table 1), had the highest species richness with thirteen species (Table 2), supporting the idea of Siver (1995) that the occurrence of silica-scaled chrysophytes is related, in part, to waterbodies with relatively low values of these factors.

References

Bonetto, A. & Hurtado, S. (1999): Región 1. Cuenca del Plata. – In: Canevari, P., Blanco, D. E., Bucher, E., Castro, G. & Davidson, I. (eds.): Los humedales de Argentina. Clasificación, situación actual, conservación y legislación. – Wetlands International. Publicación N° – **46:** 32–72.

Bonfils, C. G. (1962): Los suelos del Delta del río Paraná. Factores generadores, clasificación y uso. – Revista de Investigaciones Agrícolas. **XVI:** 257–370.

Couté, A. & Franceschini, I. M. (1998): Scale-bearing chrysophytes from acid waters of Florianapolis, Santa Catarina Island, south Brazil. – Algol. Stud. **88:** 37–61.

Cronberg, G. (1989): Scaled Chrysophytes from the tropics. – Beih. Nov. Hedw. **95:** 191–232.

Franceschini, I. M., Couté, A. & Silva, A. Jr. (1996 a): Synurophyceae et Chrysophyceae) à écailles siliceuses de l'extreme sud-est du Brésil. – Algolog. Stud. **80:** 59–85.

Franceschini, I. M., Prado, J. F. & Couté, A. (1996 b): Contribution à la flore des Chrysophytes à écailles siliceuses de Santa María, RS, à l'extrème sud du Brésil. – Bull. Jard. Bot. Nat. Belg. **65:** 103–116.

Kristiansen, J. & Menezes, M. (1998): Silica-scaled chrysophytes from an Amazonian flood-plain lake, Mussurá lake, northern Brazil. – Algolog. Stud. **90:** 97–118.

Kristiansen, J. & Vigna, M. S. (2002): Chrysophyceae y Synurophyceae de Tierra del Fuego (Argentina). – Monografías del Museo Argentino de Ciencias Naturales **3:** 1–45.

Lacoste, E., Vigna, M. S., Maidana, N. & MacCarthy, S. (1986): Algas de aguas continentales de Argentina V. Entre Ríos I. – Darwiniana **27:** 107–141.

Lacoste, E., Vigna, M. S., MacCarthy, S. & Maidana, N. (1987): Algas de aguas continentales de Argentina VII. Entre Ríos II. – Darwiniana **28:** 105–145.

MALVAREZ, A. I. (1999): El Delta del río Paraná como mosaico de humedales. – In: MALVÁREZ, A. I. (ed.): Tópicos sobre humedales subtropicales y templados de Sudamérica, pp. 35–53.
Servicio Meteorológico Nacional (1980): Estadística climatológica. Serie B n° 6. Fuerza Aérea Argentina. Buenos Aires, Argentina, 156 pp.
SIVER, P. A. (1991): The biology of *Mallomonas*: Morphology, taxonomy and ecology. – Kluwer Academic Publishers, Dordrecht, 230 pp.
– (1995): The distribution of chrysophytes along environmental gradients: their use as biological indicators. – In: SANDGREN, C. D., SMOL, J. P. & KRISTIANSEN, J. (eds.): Chrysophyte algae: Ecology, phylogeny and development. – Cambridge University Press, Cambridge, pp. 232–268.
SIVER, P. A. & VIGNA, M. S. (1996): Notes on species of *Mallomonas* in the series Peronoides (Mallomonadaceae, Synurophyceae) – Nord. J. Bot. **6:** 223–231.
– – (1997): The distribution of scaled chrysophytes in the Delta Region of Paraná River, Argentina. – Nov. Hedw. **64:** 421–453.
THOMASSON, K. (1963): Araucanian Lakes – Act. Phytogeogr. Suec. **47:** 1–139.
VIGNA, M. S. (1981): Estudio con microscopio electrónico de barrido de nuevos taxones de la familia Synuraceae. – Physis **39:** 15–20.
– (1988): Contribution to the knowledge of Argentine Mallomonadaceae. – Nov. Hedw. **47:** 129–144.
– (1989): *Gyromitus disomatus* Skuja, nuevo registro para Argentina. – Physis (Buenos Aires), Secc. B, **46:** 91–92.
– (1990): Silica-scaled Chrysophytes from the Uruguay River (Argentina). – Phycologia **29:** 524–540.
– (1991): Chrysophytas escamosas (*Mallomonadaceae* y *Paraphysomonadaceae*) del Parque Nacional Nahuel Huapi (Argentina): I. – Bol. Soc. Arg. Bot. **27:** 149–155.
– (1993): Crisofitas escamosas (Chrysophyta, Synurophyceae) en una turbera de Tierra del Fuego. – Darwiniana **32:** 299–302.
VIGNA, M. S. & DUQUE ESCOBAR, S. (1999): Silica-scaled chrysophytes from the Amazonian region in Colombia. – Nov. Hedw. **69:** 151–162.
VIGNA, M. S. & KRISTIANSEN, J. (1996): Biogeographic implications of new records of scale-bearing chrysophytes from Tierra del Fuego (Argentina). – Arch. Protistenkd. **147:** 137–144.
VIGNA, M. S., MAIDANA, N. & MACCARTHY, S. (1990): Algas de aguas continentales de Argentina VIII. Entre Ríos III. – Darwiniana **30:** 205–213.
VIGNA, M. S. & MUNARI, C. (2001): Seasonal occurrence of silica-scaled chrysophytes in a Buenos Aires lake (Argentina). – Nov. Hedw. **122:** 195–209.
WEE, J. L., BOOTH, D. J. & BOSSIER, M. A. (1993): Synurophyceae from the southern Atlantic Coastal Plain of North America: A preliminary survey in Louisiana, U.S.A. – Nord. J. Bot. **13:** 95–106.
WUJEK, D. E. & BICUDO, C. (1993): Scale-bearing chrysophytes from the state of Sao Paulo, Brazil. – Nov. Hedw. **56:** 247–257.

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