Planktic Desmids from Merin Lagoon, a biosphere world reserve

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ABSTRACT - Merin Lagoon is a large, shallow and subtropical water body shared by the countries Uruguay and Brazil. The desmids composition of Merin Lagoon was analyzed at seven sites in March, July-August, November 1998 and January 1999, based on plankton net samples. The temperature and conductivity of the water presented the lowest values (15 ^{0}C and 70 µS.cm^{-1}) in July-August 1998 and highest (25 ^{0}C and 105 µS.cm^{-1}) in January 1999, the pH values varied from neutral to slightly alkaline, between 6.5 and 8.7. A total of 61 desmids *taxa* belonging to 15 genera were identified and *Staurastrum* Meyen *ex* Ralfs (19), *Cosmarium* Corda *ex* Ralfs (10), *Closterium* Nitzsch *ex* Ralfs (6), and *Staurodesmus* Teiling (6) were the greatest represented genera. The most frequent taxon was *Staurastrum leptocladum* Nordstedt var. *smithii* Grönblad. The high desmid richness in Merin Lagoon and the lack of information about this algal group in this lagoon justify the present study.

Key words: phytoplankton, desmids, *Zygnematophyceae*, Uruguay, Brazil.

RESUMO - **Desmídias do plâncton da Lagoa Merin, uma reserva da biosfera**. A Lagoa Merin é um ambiente lacustre raso e subtropical, compartilhada por dois países, Uruguai e Brasil. A composição das desmídias da Lagoa Merin foi analisada em sete locais nos meses de março, julho, agosto, novembro de 1998 e janeiro de 1999, baseada no plâncton de rede. Temperatura e condutividade apresentaram valores baixos (15°C e 70mS.cm $^{-1}$) em julho e agosto/1998 e valores elevados (25°C e105mS.cm^{-1}) em janeiro/1999; o pH variou de neutro a levemente alcalino (6,5 e 8,7) durante o período de estudo. Foi identificado um total de 61 táxons de desmídias distribuídas entre 15 gêneros. *Staurastrum* Meyen *ex* Ralfs (19), *Cosmarium* Corda *ex* Ralfs (10), *Closterium* Nitzsch *ex* Ralfs (6) e *Staurodesmus* Teiling (6) foram os gêneros mais bem representados, enquanto *Staurastrum leptocladum* Nordstedt var. *smithii* Grönblad foi o táxon mais freqüente no período estudado**.** A elevada riqueza de desmídias na lagoa Merin e as escassas informações sobre esse grupo de algas nessa lagoa justificam o presente estudo.

Palavras-chave: fitoplâncton, desmídias, *Zygnematophyceae*, Uruguai, Brasil.

INTRODUCTION

The *Chlorophyta* (green algae) compose the largest and most varied algal phylum and they are the most closely related to the higher plants because of their similar photosynthetic pigments, storage of starch and the fine structural organization of the chloroplast (Happey-Wood, 1988). The green algae include a larger diversity in cellular organization, morphological structure, and reproductive processes than are found in any other algal division (Bold & Wynne, 1978). Desmids (*Zygnematophyceae*) are almost exclusively freshwater algae confined to natural waters characterized by low salinities and hence low specific conductivities (Brook, 1981), they form an interesting and varied group of green algae with a great esthetic value by their forms.

The present study on the planktic desmids was conducted in the Merin Lagoon, a large, shallow, and subtropical water body shared by Uruguay and Brazil, where it is named Lagoa Mirim. Part of the wetlands adjacent to Merin lagoon is denominated an official protection area: the Uruguayan hydrographic basin of Merin Lagoon belongs to the Biosphere

Reservation "Bañados del Este" (Ramsar, 1993; Probides, 1995; Unesco, 1996), and the Brazilian wetlands to the National Conservation Unit "Estação Ecológica do Taim" since 1978 (Presidential Decree of 26 April 1978).

In general, the phytoplankton of Uruguayan coastal lagoons is scarcely known. Bonomi (1988) studying the phytoplankton of Clotilde Lagoon, located close to Merin Lagoon, recorded 43 Zygnematophyceaen taxa in a total of 55 phytoplankton taxa in this coastal system. Pérez *et al*. (1999) carried out a study on a bloom of the *Nodularia baltica-spumigena* complex (Cyanobacteria) in Castillos Lagoon. Comas & Pérez (2002) studied the planktic Chlorococcales in Merin Lagoon recording a new species of the genus *Lobocystis*. Bonilla (2002) and Bonilla *et al*. (2005) studied the phytoplankton community and the productivity of the Rocha Lagoon.

Pérez & Odebrecht (2005) carried out a study on the phytoplankton composition and abundance in the Merin Lagoon recording only a few genera and species (19) of desmids. On the other hand, various studies on phytoplankton (Bergesch *et al*., 1995; Torgan *et al*., 1995; Odebrecht & Abreu, 1997; Torgan, 1997) were undertaken in the nearby Patos Lagoon in Brazil, connected to Merin Lagoon by the São Gonçalo Channel, while Fia *et al*. (2009) studied the trophic state of the Merin Lagoon basin.

Within the framework of a fishing resource evaluating program conducted in the Merin Lagoon during 1998-1999, phytoplankton samples were collected in different seasons at several stations (Pérez & Odebrecht, 2005). The aim of this study is to present a taxonomic analysis of the planktic desmids found in this ecologically and culturally important water body.

The Merin Lagoon showed high species richness of desmids and this study is important to contribute to the knowledge of this group of algae, especially in phytoplankton of coastal lagoons.

MATERIALS AND METHODS

Merin Lagoon is a large (3749 km^2) and shallow (< 5 m, maximum ≈ 10 m depth; Vieira & Rangel, 1988) coastal lagoon shared by the countries Uruguay and Brazil (32º 10' S - 33º 37' S and 52º 38' W - 53º 40' W; Fig. 1). It is one of a series of coastal lagoons located in the southwestern Atlantic Ocean and is connected to Patos Lagoon forming the Patos-Merin Complex (total drainage basin of 201.626 km^2). With a length of 174 km and mean width of 45 km, approximately 30% (southwestern area) belongs to Uruguay and 70% (northeastern area) to Brazil (Vieira & Rangel, 1988).

The regional climate is subtropical humid (Bailey, 1998) with an average annual temperature between 16 ºC and 17 ºC, and regular rainfalls distributed over the year with averaging 1100 mm/year (Chebataroff, 1969; Probides, 1999). The main activities in the basin are rice culture and fisheries.

Water surface temperature, conductivity and pH were measured *in situ* with an YSI Model 85 multiparameter equipment. For taxonomical analysis, samples were taken at 38 sites throughout the whole ecosystem by horizontal and vertical tows at the pelagic zone using a plankton net (25 µm), in March, July-August and November of 1998 and January of 1999 but for this study, seven sites were selected by their important desmids species variety: 1-Bretanha, 2-Juncal, 3-Ponta Santiago, 4-Ponta Afogados, 5-São Simon, 6-Santa Victoria, and 7-São Luiz (Fig. 1). A concentrated subsample was immediately preserved with 2% buffered formaldehyde and the other part was maintained fresh for *in vivo* identification (Sournia, 1978).

Planktic desmids were identified with a Leitz Diaplan photomicroscope equipped with an Orthomat E photo tube and phase contrast and with an Olympus model BH 2 binocular microscope equipped with camera-lucida, phase contrast condenser and micrometer.

The taxonomic classification used in this study was based mainly on Mix (1972) supplemented by Růžička (1977), Kouwets & Coesel (1984), and Hoek et al. (1997). The measures are presented as cell length x width (lower and upper limits), w. apex = width of the apex, w. isthmus = width of the isthmus and w. polar lobe = width of the polar lobe. The vertical and lateral views only have been described and illustrated when observed during analysis of the material.

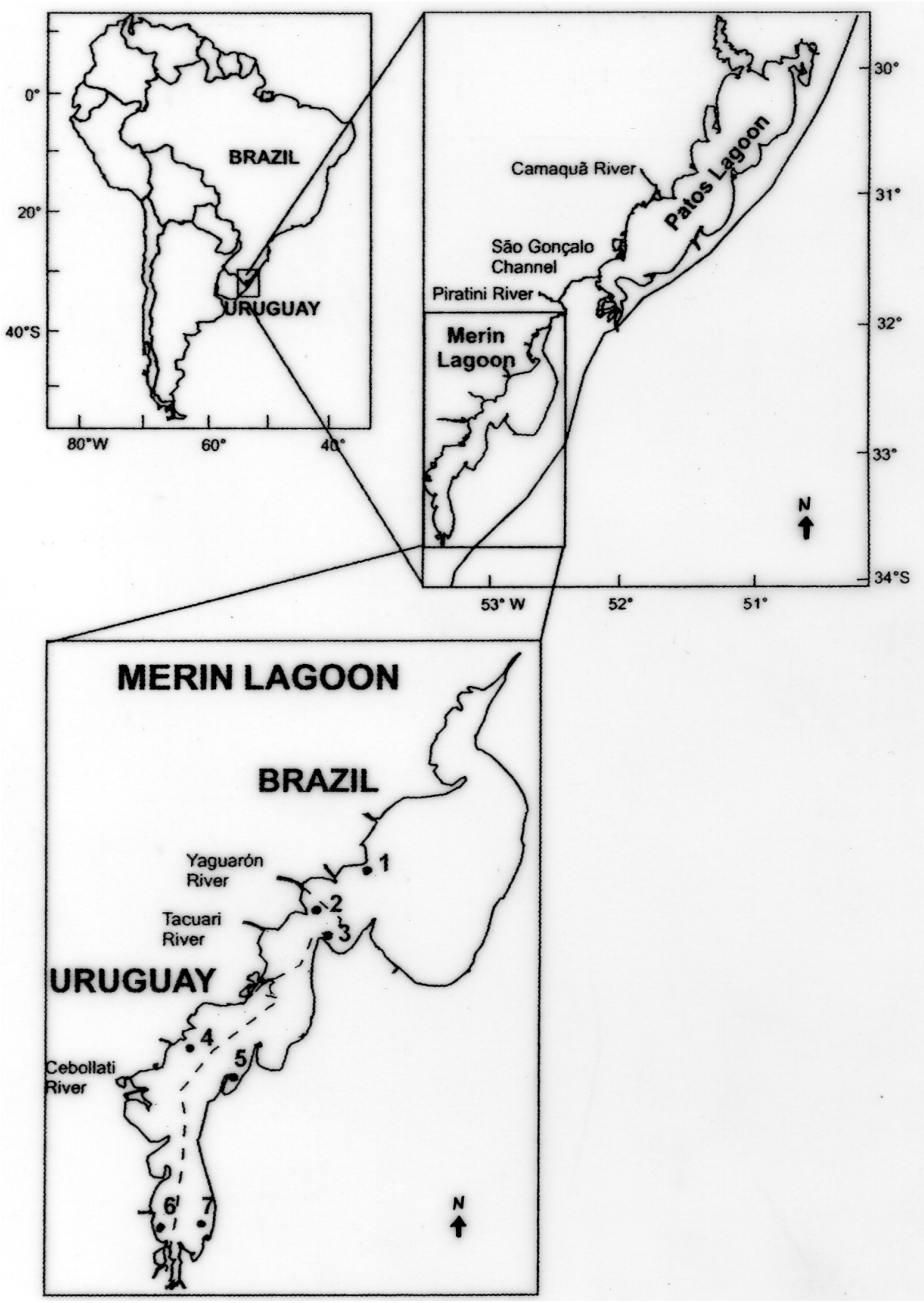

Fig. 1. Map of Merin Lagoon showing the region and the location of the sampled sistes: 1. Bretanha, 2. Juncal, 3. Ponta Santiago, 4. Ponta Afogados, 5. São Simão, 6. Santa Victoria and 7. São Luiz.

RESULTS AND DISCUSSION

The temperature and conductivity of Merin Lagoon presented the lowest values (15 ^{0}C and 70 µS.cm^{-1}) in July-August 1998 and highest (25 ^{0}C and 105 µS.cm^{-1}) in January 1999, the pH values varied from neutral to slightly alkaline, between 6.5 and 8.7.

A total of 61 taxa of planktic desmids belonging to three families (*Closteriaceae*, *Desmidiaceae*, and *Peniaceae*) distributed in 15 genera were identified. *Staurastrum* and *Cosmarium* were the most represented genera with 19 (31%) and 10 (16%) species, respectively, followed by *Closterium* and *Staurodesmus* with 6 species each. The most frequent taxa in all samples was *Staurastrum leptocladum* Nordstedt var. *smithii* Grönblad. The sampling site that presented the most important diversity was Ponta Santiago with 28 taxa recorded. The distribution of taxa recorded at the sites sampled in this study are shown in Table 1.

The identified taxa are presented as followed.

Closteriaceae

Closterium Nitzsch 1817

Closterium aciculare West, **Trans. Roy. Microsc. Soc**., v.8, p. 153, pl. 7, fig. 16. 1860.

(Fig. 3)

Cells thin 60-80 x longer than broad, 380-400 x 5-6 µm, w. apex 1.5-2 µm, very slightly curved, more at the ends, apex acutely rounded.

Closterium acutum Brébisson var. *variabile* (Lemmermann) W. Krieger, **Rabenhorst's Kryptogamen - Flora,** v.13, p. 262, pl. 13, fig. 18 - 22. 1935.

(Fig. 4)

Cells thin 20-25 x longer than broad, 50-60 x 2-3 µm, w. apex 0,5-0,8 µm, strongly curved, sometimes irregularly curved.

Closterium ehrenbergii Meneghini *ex* Ralfs var. *immane* Wolle, **Bull. Torrey Bot. Club,** v. 9, n. 3, p. 26. 1882.

(Fig. 5)

Cells stout and large, 3-4 x longer than broad, 290-303 x 94-98 µm, w. apex 10-12 µm, 150° of arc, ventral margin tumid, wall smooth.

Closterium kuetzingii Brébisson var. k*uetzingii***, Mém. Soc. Imp. Sci. Naturf. Cherbourg,** v. 4, p. 156, pl. 2, fig. 40. 1856.

(Fig. 6)

Cells almost straight, 20-24 x longer than broad, 350-370 x 14-16 µm, w. apex 2-2.5 µm, middle portion fusiform, ventral and dorsal margins equally convex, tapering abruptly into long processes, apex slightly incurved, obliquely rounded, wall smooth.

It was not possible to note stries in the cell wall of our individuals. According to Krieger (1937) this character is typical of *C. ehrenbergii* var. *laeve*. However, Růžička (1977) considered the variety *laeve* as synonymous of the typical species.

Closterium moniliferum (Bory) Ehrenberg *ex* Ralfs var. *moniliferum* f. *moniliferum*, **Britsh Desmidieae**, p. 166, pl. 28, fig. 3. 1848.

(Fig. 7)

Cells 4-5 x longer than broad, 190-290 x 30-65 µm, w. apex 6-10 µm, strongly curved, 70 - 130° of arc, ventral margin slightly tumid, apex rounded, wall smooth.

Closterium praelongum Brébisson var. *praelongum***, Mém. Soc. Impér. Sci. Nat. Cherbourg**, p.152, pl. 2, fig. 41. 1856.

(Figs. 9, 10)

Cells thin 25-31 x longer than broad, 590-670 x 22-24 µm, w. apex 3.5-8 µm, 25-30° of arc, margin parallel in the mid-region, gradually attenuated towards the somewhat re-curved apex, wall smooth.

Desmidiaceae

Bambusina Kützing *ex* Kützing 1849.

Bambusina borreri (Ralfs) Cleve, **Ofv. Kongl. Vet.-Akad. Förhandl**., v. 20, n. 10, p. 496. 1864.

(Fig. 8)

Filaments twisted, cells 1.5-1.6 x longer than broad, 24-27 x 15-17 µm, w. isthmus 13-16 µm, cells barrel-shaped slightly constricted, semicells with a small supraisthmial swelling, apex broad and truncate.

Cosmarium Corda *ex* Ralfs 1848

Cosmarium bioculatum Brébisson var. *canadense* Kriger & Gerloff, **Gatt. *Cosmarium***, v**.** 1, p. 60, pl. 15, fig. 5. 1962.

(Fig. 11)

Cells as long as broad, 25-28 x 22-25 µm, w. isthmus 5-6 µm, deeply constricted in the middle, sinus narrowly linear, semicells subelliptical, lateral margins rounded, apical margin convex, wall smooth.

Cosmarium contractum Kirchner var. *contractum*, **in Cohn's Krytogamen - Flora Schlesiens**, v. 2, n. 1, p. 147. 1878.

(Fig. 13)

Cells 1.5-1.6 x longer than broad, 40-58 (63) x 25-36 (44) µm, w. isthmus 6-12 µm, sinus deep and opening, semicells broadly elliptic, apex somewhat flattened, wall thick and punctuate.

Cosmarium contractum Kirchner var. *maximum* West & West, **Trans. Linn. Soc. London**, Bot. II, v. 5, n. 5, p. 252, 1896.

(Fig. 15)

Cells 1.3 x longer than broad, 60-67 x 42-44 µm, w. isthmus 11-13 µm, a variety larger than the typical, apex flattened or slightly retuse.

Cosmarium hexagonum Nordstedt, **Videnk Medd. Naturh. Foren. Kjöbenhaum** 1869, n.14-15, p. 208, pl. 3, fig. 18. 1870.

(Fig. 14)

Cells 1.2 x longer than broad, 44-50 x 36-40 µm, w. isthmus 10-11 µm, median constriction deep, sinus linear, semicells elliptic, angles slightly rounded, apex truncate with a series of 4-5 granules, wall granulate-punctate.

Cosmarium malmei Borge var. *malmei*, **Ark f. Bot**., v.1, p. 85, pl. 2, fig. 11, 1903.

(Fig. 16)

Cells 1.3-1.4 x longer than broad, 39-43 x 28-30 µm, w. isthmus 21-26 µm, semicells spherical, median constriction slight, sinus widely, open notch, wall uniformly granulate, granules disposed in horizontal series.

This species was described for the first time for Rio Grande do Sul State, Brazil, by Borge (1903).

Cosmarium margaritatum var. *margaritatum* f. *margaritatum* (Lundell) Roy & Bisset, **Jd. Bot.,** v. 27, n. 1, p. 194. 1886.

(Fig. 17)

Cells 1.1-1.2 x longer than broad, 57-65 x 49-55 µm, w.isthmus 15-19 µm, semicells sub-rectangular, sinus linear, opening in interior, lateral and apical margins convex, wall granulate.

Cosmarium ophelii Prescott & Scott, **Trans. Roy. Soc. S. Aust**., v. 75, p. 55. 1952.

(Fig. 12)

Cells 1.1-1.3 x longer than broad, 28-38 x 25-29 µm, w. isthmus 6-8 µm, semicells semicircular, sinus deep, closed, rounded angles, lateral margins convex with ondulation, 3 - 4 intra marginal granules.

Cosmarium phaseolus Brébisson var. *phaseolus* f. *minus* Boldt, **Ofv. Kongl. Vet - Akad. Förhandl**. 1887, v. 42, n. 2, p.102. 1885.

(Fig. 18)

Cells 1.2 x longer than broad, 23-25 x 18-21µm, w. isthmus 3-5 µm semicells reniform, median constriction deep, sinus narrow, dilated at the apex, protuberance in midregion of semicells not distinct, wall punctate, vertical view elliptic.

Cosmarium protractum (Nägeli) De Bary var. *protractum*, **Conjug**., p. 72. 1858.

(Figs. 19, 20)

Cells as long as broad, 32-39 x 35-37 µm, w. isthmus 7-12 µm, semicells 3-lobed, deeply constricted, sinus narrowly linear, dilated in the extremity, apical lobe short, with rounded angles, vertical view narrowly elliptic-oblong, a granulate protuberance in the midregion on either side.

Cosmarium tumidum Lundel var. *tumidum* f. *tumidum*, **Nova Acta Reg. Soc. Sci. Upsaliensis**, III, v. 8, n. 2, p. 45, pl. 3, fig. 16.1871.

(Figs. 21, 22)

Cells 1.2 x longer than broad, 30-36 x 25-29 µm, w. isthmus 6-8 µm, semicells broadly elliptic, median constriction deep, apex convex, lateral margin slightly reniform, wall punctate, vertical view elliptic.

Desmidium C. A. Agardh *ex* Ralfs 1848

Desmidium aptogonum Brébisson *ex* Kützing var. *aptogonum*, **Spec. Algar**., p. 190. 1849.

(Fig. 23)

Filaments twisted, cells 1.6-1.9 broad than longer, 13-17 x 22-31 µm, w.isthmus 15-24 µm; semicells sub-rectangular, deeply and narrowly constricted, lateral margins slightly concave and convergent to the apex, apical margin concave in the mid-region, angles produced into short connecting processes.

Euastrum Ehrenberg *ex* Ralfs 1848

Euastrum crameri Raciborski, **PamAkad. Um.Krakow**, Wydz. Mat-przyr , v.17, p. 104, pl. 6, fig. 5. 1889.

(Figs. 24, 25)

Cells 1.5-1.6 x longer than brad 55-60 x 37-40 µm, w. apex 27-30 µm, w. isthmus 8-9 mm, semicells subtrapeziform, basal lobes broad, lateral angles

retuse, apical margin elevated with a deep median notch, prominent spines on the angles, lateral view elliptic, poles produced, narrowly rounded.

Euastrum engleri Schmidle, **Engler's Bot. Jahrb**., v. 26, p. 44, pl. 2:33. 1898.

(Fig. 26)

Cells 1.2-1.3 x longer than broad, 16-22 x 13-16 μm, w. isthmus 4-5 μm, semicells rectangular, sinus open, lateral margin denticulate, sinus open, apical margin truncate, open shallow notch, face of semicell with a median granular protusion, several granules across the face, lateral view elliptic, vertical view broadly elliptic, margin crenate.

The main features for this taxon are the rectangular form of the semicell and the medium sinus open in form of "V". This species was described to Brazil by Forster (1969), who studied material from Tapajós river, State of Pará. Our material from Merin Lagoon is identical to the pictures of Forster (1969). On the other hand, the description and pictures of Krieger (1937) about this taxon are with closed isthmus, very different from the pictures of Schmidle (1898). Krieger (1937) recorded this taxa as a typical variety together with other two varieties: var. *victoriae* Woloszynska and var. *woloszynska* Krieger, with open isthmus. Because of this taxa is not very common, we prefer recording it like species, without variety level, until new studies about this interesting taxa are conducted.

Hyalotheca Ehrenberg ex Ralfs 1848

Hyalotheca dissiliens (Smith) Brébisson ex Ralfs var. *dissiliens,* **Brit. Desm**., p. 51, pl. 1, fig. 1. 1848.

(Fig. 27)

Filaments straight, cells 1.2-1.4 x broad than longer, 13-24 x 16-32 μm, w. isthmus 12-31 μm, semicell transversely, constriction slight, sinus very shallow, oblong, lateral margins slightly convex, apical margin broadly truncate, semicells in vertical view circular.

Micrasterias Agardh ex Ralfs 1848

Micrasterias decemdentata (Nägeli) Archer var. *decemdentata, in* **Pritchard's Infuso,** p. 726. 1861.

(Fig. 28)

Cells as broad as long, 60-64 x 60-61 μm, w. polar lobe 49-52 μm, w. isthmus 9-12 μm, semicells 5-lobed, sinus open, polar lobe broad, laterally fusiform, flattened at apex, lateral lobes horizontally extend, once or twice divided, wall smooth.

This species is mainly characterized by having the polar lobe separated from the lateral and basal lobes, however, for treating of a species with countless morphological expressions in the population, some times it can be confused with *M. truncata* (Corda) Brébisson *ex* Ralfs var. *pusilla* West.

Micrasterias laticeps Nordstedt var. *laticeps* f. *laticeps* Vidensk, **Medd. Naturh. Foren. Kjöbenhavn** 1869, n.14-15, p. 220, pl. 2, fig. 14. 1870.

(Fig. 29)

Cells 1.2 broader than long, 120-125 x 150-155 μm, w. polar lobe 141-143 μm, w. isthmus 17-18 mm, semicells 3-lobed, polar lobe horizontally extended terminating in one short tooth, lateral lobe long, constricted in the ends, terminating in two short teeth, wall punctate.

Micrasterias radiosa Ralfs var. *radiosa* f. *radiosa,* **Brit. Desm**., p.72, pl. 8 fig. 3. 1848.

(Fig. 30)

Cells circular, as long as broad, 140-149 x 141-150 μm, w. polar lobe 20-26 μm, w. isthmus 12-14 mm, semicells 5-lobed, major incisions radial, deep, narrow, upper lateral lobule large, lower lateral lobule more divided, polar lobe narrow, retuse notched apex, angles bidentate.

Micrasterias truncata (Corda) Brébisson *ex* Ralfs var. *truncata* f. *truncata,* **Brit. Desm**., p. 75, pl. 8, fig. 5. 1848.

(Fig. 31)

Cells circular, as long as broad or a little broader than long, 120-130 x 135-141μm, w. polar lobe 100-120μm, w. isthmus 15-21μm, semicells 5-lobed, polar lobe cuneate, fusiform, interlobular incisions moderately deep, wall delicately punctate.

Onychonema Wallich 1860

Onychonema laeve Nordstedt var. *rectangulare* Grönblad, **Acta Soc. Sci. fenn**. sér. B, v. 2, n. 6, pl. 33, fig. 306- 307. 1945.

(Fig. 32)

Filaments twisted, cells 1.7-1.8 x broad than longer, 14-17 x 24-29 μm, w. isthmus 3-4 μm, semicells quadrangular, deeply and narrowly constricted, lateral angles ending in a short spine, two apical processes, apical margins truncate.

Pleurotaenium Nägeli 1849

Pleurotaenium ehrenbergii (Brébisson) De Bary var. *ehrenbergii,* **Untersuchungen über Die Familie**

Der Conjugaten (Zygnemeen und Desmidieen), p. 75. 1858.

(Figs. 36, 37)

Cells 13-15 x longer than broad, 380-505 x 25-35 µm, w. apex 19-22 µm, semicells with conspicuous basal inflation, 1-3 smaller swellings above it, apex truncate, with a circle of tubercles, 3 visible in face view.

Pleurotaenium repandum (Wolle) Krieger var. *repandum* f. r*epandum,* **Rabenhorst's - Kryptogamen- Flora,** v.13, p. 405, pl. 41, fig. 9. 1937.

(Figs. 38, 39)

Cells 16-17 x longer than broad, 450-500 x 27-30 µm, w.apex 21-22 µm, semicells slightly tapered from base to apex, basal inflations slight, margins undulate to the truncate apex.

Pleurotaenium trabecula (Ehrenberg) ex Nägeli var. *trabecula,* **New Denkschr. d. allg. Scweiz. Gesellsch**. f. d. Ges. Naturwissench., v.10, p. 104. 1849.

(Figs. 40, 41)

Cells 14-16 x longer than broad, 530-540 x 30-36 µm, w. apex 20-22 µm, semicells with a swollen in midregion, slightly tapered to the rounded-truncate apex, apex smooth, cell wall punctate.

Sphaerozosma Corda *ex* Ralfs 1848

Sphaerozosma vertebratum (Brébisson) Ralfs var. *punctulatum* West & West, **Trans. J. Proc. Bot. Soc. Edinburgh,** v**.** 23, p. 28. 1905.

(Fig. 33)

Filaments twisted, cells 1.3-1.5 x broad than longer, 11-14 x 17-23 µm, w. isthmus 7-11 µm semicells oblong, constriction deep, sinus narrow, linear, lateral margin rounded, apical margin flattened.

Spondylosium Brébisson ex Kützing 1849

Spondylosium moniliforme Lundell var. *moniliforme*, **Nova Acta Reg. Soc Sci Upsaliensis**, III, v. 8, n. 2, p. 92, pl. 5, fig. 16. 1871.

(Fig. 35)

Filaments twisted, cells 1.1-1.2 x longer than broad, 30-35 x 26-29 µm, w.isthmus 8-10 µm, semicells nearly triangular, constriction deep, sinus very widely open, lateral margin rounded, apical margin convex.

Spondylosium pulchrum (Bailey) Archer var. *pulchrum,* **Pritchard's Infusoria,** p. 724. 1861.

(Fig. 34)

Filaments twisted, cells 1.6-1.8 x broad than longer, 39-42 x 64-75 µm, w. isthmus 18-21 µm, semicells transversely elliptic, constriction deep, sinus sublinear, gradually opening to the outside, lateral margins rounded, upper margin elevated in its central position.

Staurastrum Meyen 1829

Staurastrum avicula Brébisson var. *subarcuatum* (Wolle) West & West f. *subarcuatum,* **Jour. Roy. Microsc. Soc**. 1894, p. 10. 1894.

(Fig. 42)

Cells 25-27 x 32-36 µm (with spines), w. isthmus 9-11 µm, semicells triangular, median constriction deep, sinus open, apical margin straight, angles of semicells slightly produced, with a pair of spines, wall with small spines**.**

Staurastrum boergesenii Raciborski var. *glabrum* Förster, **Amazoniana**, v. 2, n. 1/2, p. 77, pl. 47, fig. 4-6. 1969.

(Figs. 45, 46)

Cells 90-93 x 88-100 µm (with processes), 38-42 x 28-31 µm (without processes), w. isthmus 17-21 µm, semicells globose, sinus open, relatively broad, apical margin strongly convex, six processes long and smooth, wall smooth, vertical view circular, 6-radiate.

Staurastrum comptum Wolle var. *pinnatiforme* Scott & Grönblad, **Acta Soc. Sci. Fennicae**, nova série, B, v. 2, n. 8, p. 33, pl. 25, figs. 11,12. 1957.

(Figs. 47, 48)

Cells 29-33 x 32-44 µm (with processes), w. isthmus 7-12 µm, semicells columnar- capitate, with a concentric circle of granules on the base, apical angles with short processes, vertical view 6 - radiate.

Staurastrum distentum Wolle, **Bull. Torr. Bot. Club**, v. 9, n. 3, p. 28, pl. 13, fig. 7. 1882.

(Figs. 43, 44)

Cells 23-28 x 33-49 µm (with processes), w. isthmus 7-9 µm, semicell broadly bowl-shaped, apical angles extended into five horizontal processes, vertical view 5-radiate, a small spine at the base of each processe, wall smooth.

Staurastrum furcigerum Brébisson var. *armigera* (Brébisson) Nordstedt, **Vid. Medd. Naturh. Foren. Kjöbenhavn** 1888, p. 207. 1888.

(Figs. 51, 52)

Cells 70-78 x 78-85 µm (with processes), 45-47 x 31-37 µm (without processes), w. isthmus 14-15 µm, semicells globular, lateral angles produced into

three long processes, apex of semicells with an apical whorl of six accessory processes, margins crenulate, vertical view triangular, lateral margins concave.

Staurastrum gracile Ralfs var. *pusillum* West & West, **Trans. Limn. Soc. London**, Bot. 2, v. 5, p. 77, pl. 9, fig. 4. 1895.

(Figs. 49, 50)

Cells 24 x 40-51 µm (with processes), w. isthmus 3-6 µm, semicells subfusiform, three long processes parallel, undulated, vertical view triangular, six intra marginal granules.

Staurastrum leptacanthum Nordstedt var. *borgei* Föster, **Amazoniana**, v. 2, n. 1-2, p. 86, pl. 50, fig. 4-6. 1969.

(Figs. 53, 54)

Cells 104-106 x 46-48 µm (with processes), 88-90 x 28-30 µm (without processes), w. isthmus 4-17 µm, semicells globular, sinus obtusely rounded not closed, nine long processes in the in the middle of the semicell and six at the apex of thesemicell, vertical view circular.

Staurastrum leptocladum Nordstedt var. *leptocladum,* **Vidensk. Meddr dansk naturh. Foren**. 1869, p. 228, pl. 4, fig. 57. 1870.

(Fig. 55)

Cells 38-48 x 89-91 µm (with processes), w. isthmus 6-7 µm, semicells subcampanulate slightly inflated at the base with a transverse series of granules, lateral margins concave, subparallel, diverging into long processes divergent with crenate margins, apical margin convex, elevated, with a median pair of spines.

This species and its varieties need a better taxonomic delimitation. Our population in Merin Lagoon could be identified as belonging to the variety *cornutum* Wille. However Croasdale *et al*. (1994) consider this variety a synonym of the typical species. The authors are based on the fragility of the apical thorn that can be lost easily according to Nordstedt (1869). The material also showed variability in the curvature of the processes, and this character is used for the separation of the different varieties of *St. leptocladum*.

Staurastrum leptocladum Nordstedt var. *smithii* Grönblad, **Acta Soc. Sci. Fennica**, n.s. B. 2, n. 6, p. 27, pl. 11, fig. 224. 1945.

(Fig. 56)

Cells 45-47 x 138-152 µm (with processes), isthmus 7-9 µm wide, semicells sub-cuneate, swollen base with a supraisthmial ring of granules, processes slender, serrate evenly curving up, apical margin tumid with spines.

The studied material presented semicells with longer processes than those recorded in literature.

Staurastrum limneticum Schmidle var. *cornutum* Smith, **Wisconsin Geol. & Nat. Hist. Surv. Bull**., v.57, n. 2, p. 117, pl. 82, figs. 1, 2. 1924.

(Figs. 57, 58)

Cells 47-60 x 75-110 µm (with processes), w. isthmus 8-10 µm, semicells bowl-shaped, median constriction deep, apical margin truncate, elevated with three verrucae visible, vertical view 7-radiate with a circle of seven verrucal, one at the base of each process.

Staurastrum muticum (Brébisson) Ralfs var. *muticum,* **Brit. Desm**. 1848, p. 125, pl. 21, fig. 4; pl. 34, fig. 13. 1848.

(Figs. 59, 60)

Cells 1.4 x longer than broad, 20-23 x 15-19 µm, w. isthmus 7-8 µm, semicells nearly circular, sinus open, apical and ventral margin convex, wall smooth, vertical view triangular, rounded angles, concave sides.

Staurastrum orbiculare (Ehrenberg) Ralfs var. *depressum* Roy & Bisset, **Journ. Bot**., v. 24, p. 237, pl. 268, fig. 14. 1886.

(Figs. 61, 62)

Cells as long as broad, 27-30 x 26-29 µm, w. isthmus 7-10 µm, semicells depressed sub-semicircular, sinus closed, apical margin convex, basal angles rounded, cell wall smooth, vertical view triangular, margins convex.

This variety is similar to *Staurastrum suborbiculare* West & West that presents cells bigger to our variety.

Staurastrum pingue Teiling, **Bot. Notiser** , p. 66, pl. 1: 3-5. 1942.

(Figs. 63, 64)

Cells 45-53 x 85-88 µm (with processes), 45-53 x 24-30 µm (without processes), w. isthmus 7-9 µm, semicells bowl-shaped, sinus open, slight swelling above it, lateral margins divergent, apex slightly

convex, upper angles produced forming long processes with undulate margins, vertical view triangular.

Staurastrum polymorphum var. *pusillum* West**, Proc. Roy. Irish Acad**., v.31, n.16, p. 23. 1912.

(Figs. 65, 66)

Cells 17-19 x 26-28 µm (with processes), w. isthmus 8-9 µm, semicells subelliptic, lateral margins prolonged to form truncate processes, vertical view quadrangular, margins concave, undulate, wall with irregular vertical series of granules.

Staurastrum pseudosebaldi Wille var. *pseudosebaldi*, **Christiania Vid. Selsk Förhandl**., 1880, p. 45, pl. 2, fig. 30. 1880.

(Figs. 68, 69)

Cells 50-56 x 55-62 µm (with processes), w. isthmus 10 µm, semicells cyathiform, basal margins rounded, lateral margins prolonged into the three short processes curved, apical margin broadly convex, serrate, transverse series of verrucal above the isthmus, vertical view triangular.

Staurastrum quadrangulare (Brébisson) Ralfs var. *contactum* (Turner) Grönblad, **Acta Soc. Sci. Fenn**., ser B, v. 2, n. 6, p. 29, fig. 255. 1945.

(Fig. 67)

Cells 28-30 x 28-35 µm (with spines), w. isthmus 9-11 µm, semicells cuneate-bowl-shaped, basal margins with two angles which are bifurcated and forming a pair of long spines, apical margin convex, wall smooth.

The measures of the material observed at the Merin Lagoon are a little larger than those found by Grönblad (1945).

Staurastrum rotula Nordstedt, **Vidensk. Medd. Naturh. Foren. Kjöbenhaun** 1869, n. 14-15, p. 227, pl. 4, fig. 38. 1970.

(Figs. 70, 71)

Cells 1.2-1.4 x longer than broad, 35-40 x 20-23µm (without processes), 35-40 x 60-80 µm (with processes), w. isthmus 10-12µm, semicells sub-hexagonal, sinus open, apex convex decorated with a few teeth processes long, slightly divergent, apex, wall smooth, vertical view 8-radiate, processes with dentate-crenate margins.

Staurastrum sebaldi Reinsh var. *ornatum* Nordstedt, **Acta Univ. Lund,** v.9, p. 34, pl. 1, fig. 15. 1873.

(Figs. 72, 73)

Cells 60-65 x 70-83 µm (with processes), w. isthmus 14-16 µm, semicells cup-shaped, supraisthmial region cylindrical, apex convex with verrucae, processes long, nearly parallel, wall with groups of verrucae, vertical view 3-radiate.

Staurastrum trifidum Nordstedt var. *inflexum* West & West, **Trans. Linn. Soc., London**, Bot.II, v.5, n. 5, p. 258, pl. 16, fig. 22, 1896.

(Figs. 74, 75)

Cells 30-34 x 40-45 µm (with spines), w. isthmus 10-12 µm, semicells sub-trapezoidal, median constriction deep, sinus open, apical margin truncate, spines at the apical angles longer, strongly downturned, wall smooth, vertical view triangular, angles furnished with three spines.

Staurodesmus Teiling 1948

Staurodesmus convergens (Ehrenberg) Teiling var. *ralfsii* Teiling, **Arkiv för Botanik,** v. 6, n. 11, p. 590, pl. 25, fig. 14; pl. 26, figs. 4, 5. 1967.

(Fig. 76)

Cells 1.4-1.5 x longer than broad, 30-45 x 35-50 µm, w.isthmus 9-11 µm, semicells elliptic, constriction deep, lateral margin rounded, with lateral spine of varying shape and size, apical margin convex.

Staurodemus dejectus (Brébisson) Teiling var. *apiculatus* (Brébisson) Teiling, **Arkiv. för Botanik,** v. 6, n. 11, p. 530, pl. 9, fig. 6, 1967.

(Figs. 77, 78)

Cells as broad as longer or 1.2 x broad than longer, 26-29 x 27-36 µm, w. isthmus 6-10 µm, semicells cup-shaped, compressed, sinus open, apical margin convex with small spines placed in the rounded corners.

Staurodesmus dickiei (Ralfs) Lillieroth var. *dickiei,* **Acta Limnol**., v. 3, p. 264. 1950.

(Fig. 82)

Cells as broad as long, 18-35 x 20-36 µm (with spines), w. isthmus 7-10 µm; semicells elliptic, sinus acute, deeply constricted, apex convex, spines convergent and short, wall punctate, vertical view triangular, concave sides, a short spine in the corners.

Staurodesmus glaber (Ehrenberg) Teiling var. *limnophilus* Teiling, **Arkiv. för Botanik,** v.6, n. 11, p. 559, pl. 14, fig. 7,15. 1967.

(Fig. 83)

Cells 1.1-1.2 (without spines) x longer than broad, 28-30 x 23-27 µm, w. isthmus 4-6 µm, spines 20-23 µm; semicells triangular, constriction deep, sinus acute, lateral and apical margins straight, spines mostly long convergent.

Staurodesmus subulatus (Kützing) Croasdale, **Trans. Am. Microsc. Soc**., v.76, n. 2, p. 134. 1957.

(Figs. 79, 80)

Cells 1.1-1.2 x longer than broad, without spines, 35-41 x 32-35 µm (without spines), isthmus 7-10 µm, spines 32-37 µm; semicells semicircular, deeply constricted, lateral margin more convex than the apical margin, lateral angles rounded, furnished with a long and horizontal spine, vertical view elliptic, each pole with a long spine.

Our population presented variability on the position of the spines, parallels or divergents.

Staurodesmus validus (West) Thomasson var. *subvalidus* (Grönblad) Teiling, **Arkiv. för Botanik,** v.6, n. 11, p. 566, pl. 17, fig. 11. 1967.

(Fig. 81)

Cells 2.0-2.3 x broad than longer, 27-33 x 64-67 µm (with spines), 25-27 x 24-32 µm (without spines), w. isthmus 6-9 µm, semicells cup-shaped, apex broader, slightly convex.

Our population at the Merin Lagoon presented minor measures in comparison with recorded by other authors (Thomason, 1965; Prescott *et al*., 1982, as *Arthrodesmus validus* var. *subvalidus*), mainly on the cellular length. Mature individuals with reduced spines in one semicell were observed frequently.

Xanthidium Ehrenberg *ex* Ralfs 1848

Xanthidium antilopaeum (Brébisson) Kützing var. *antilopaeum* f. a*ntilopaeum,* **Spec. Algar**., p. 177. 1849.

(Fig. 84)

Cells 64-77 x 66-70 µm (with spines), 46-50 x 42-46 µm (without spines), w. isthmus 10-13 µm, semicells hexagonal, angles rounded, each of the four angles furnished with a pair of diverging long spines; central region of semicells scrobiculated, wall smooth.

Xanthidium antilopaeum (Brébisson) Kützing var. *basigranulatum* Prescott, **A sinopsis of North American Desmids 2**. Desmidiaceae: Placodermae, section 4, p. 48, pl. 311, fig. 4. 1982.

(Fig. 85)

Cells 90-96 x 100-105 µm (with spines), 55-61 x 58-65 µm (without spines), w. isthmus 22-25 µm. This variety is distinct from the typical by having slender, longer, and slightly upwardly spines, presence of one rounded tubercle in the midregion of the semicells.

According to Prescott *et al*. (1982) this species presents a marked polymorphism that difficults its adequate identification. Our population presented the semicells more rectangular, the spines straight and bigger dimensions (until double) in comparison with the specialized literature.

Xanthidium antilopaeum (Brébisson) Kützing var. *hebridarum* West & West, **Trans. Roy. Soc. Edinburgh**, v.41. n. 3, p. 500, pl. 7, fig. 21. 1905a.

(Figs. 86, 87)

Cells 80-86 x 85-88 µm (with spines), 55-64 x 47-54 µm (without spines), w. isthmus 11-14 µm. This variety is distinguished from the typical by its semicells with three spines in the lateral margin**,** semicell face with a mamillate protuberance, vertical view elliptic with three spines at the poles.

Peniaceae

Gonatozygon De Bary 1856

Gonatozygon kinahani (Archer) Rabenhorst, **Flora Europaea Algarum** 1868, p. 156. 1868

(Fig. 2)

Cells 17-19 x longer than broad, 130-155 x 7-9 µm; semicells cylindric, dilated and truncate, apex, wall smooth.

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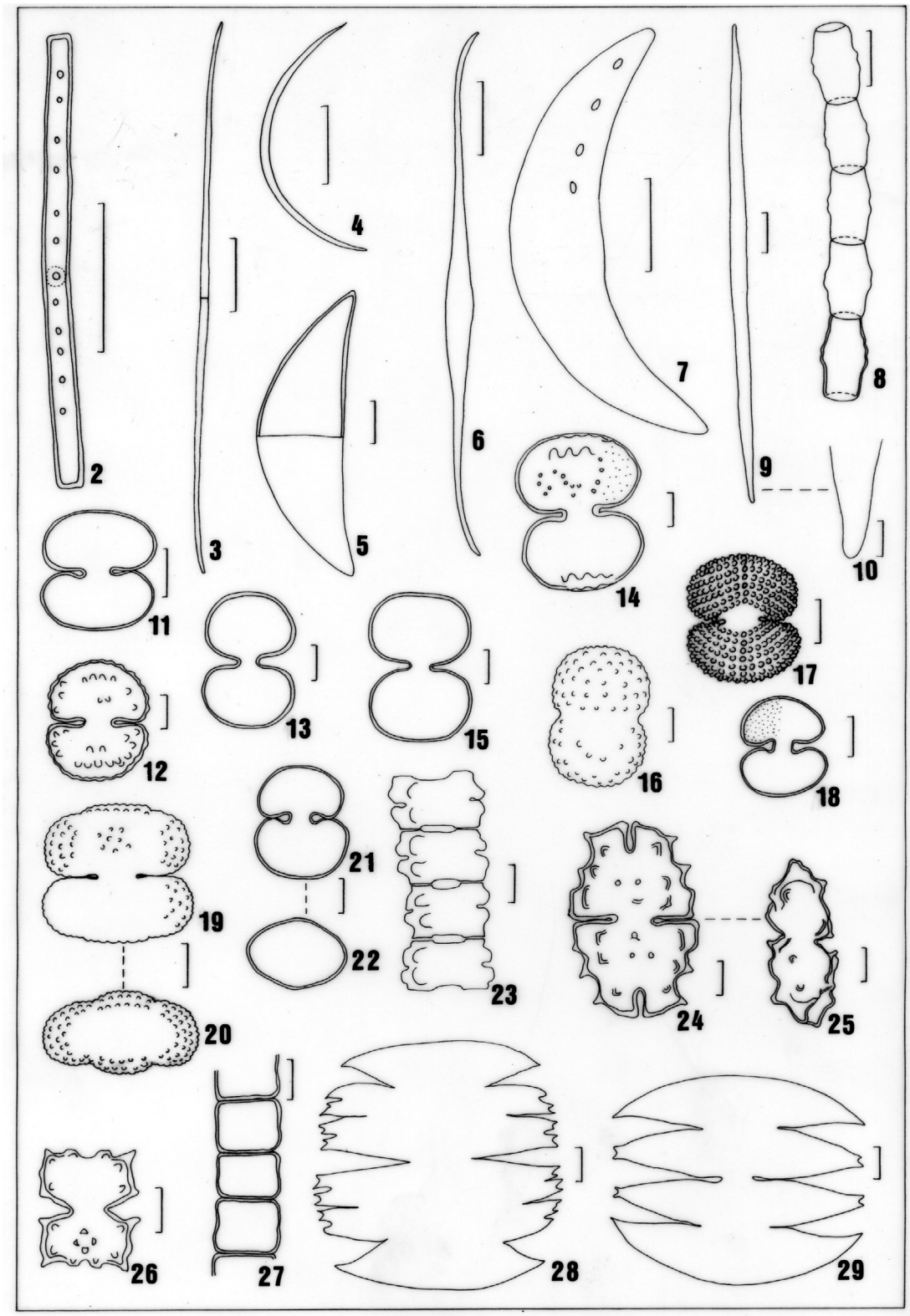
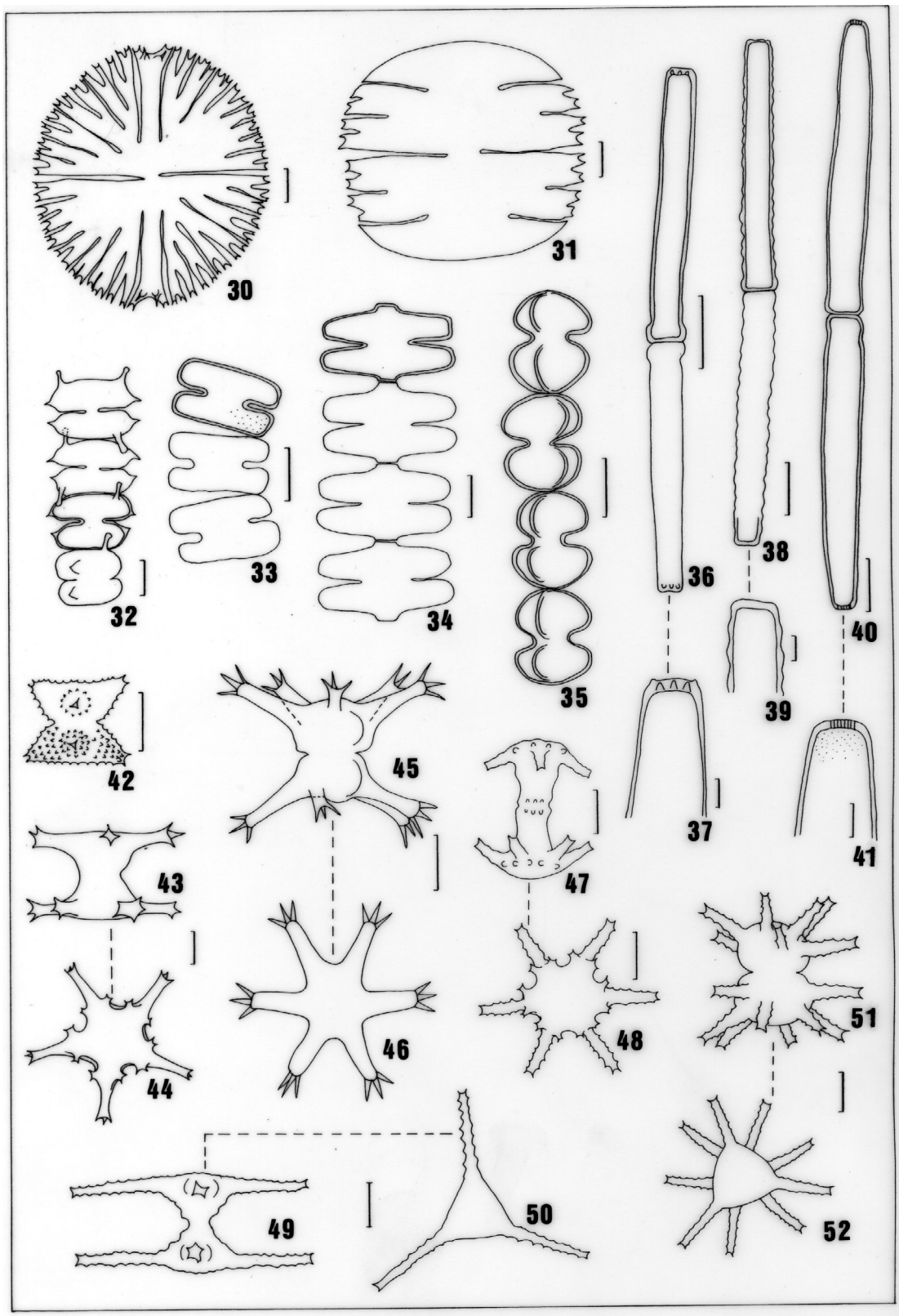
TABELA 1 - Occurrence of taxa recorded in the sampled sites in Merin lagoon during the research period.

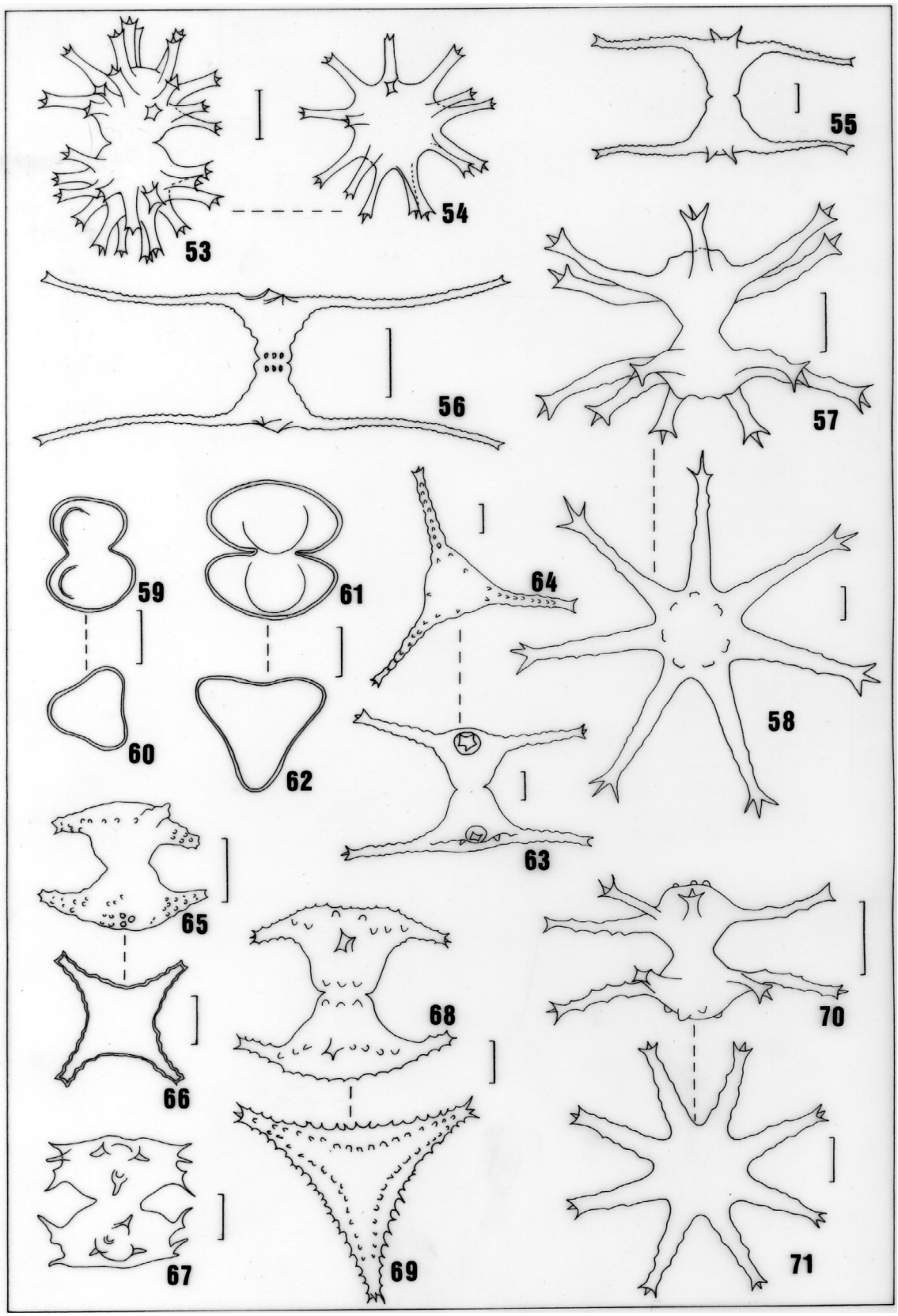
Family / Taxa	Bretanha	Juncal	Ponta Santiago	Afogados	São Simon	Santa Victoria	São Luiz
Closteriaceae							
Closterium aciculare	-	X	-	-	-	-	-
Closterium acutum var.variabile	-	-	-	-	-	-	X
Closterium ehrenbergii var. immane	-	-	X	-	-	-	-
Closterium kuetzingii var. kuetzingii	-	-	-	-	-	-	X
Closterium moniliferum var. moniliferum f. moliferum	-	-	-	-	-	-	X
Closterium praelongum var. praelongum	-	X	-	-	-	-	-
Desmidiaceae							
Bambusina borreri	-	-	X	-	-	-	-
Cosmarium bioculatum var. canadense	-	-	X	-	-	-	-
Cosmarium contractum var.contractum	-	-	-	-	-	X	-
Cosmarium contractum var.maximum	-	-	-	-	-	X	-
Cosmarium hexagonum	X	-	-	-	-	-	-
Cosmarium malmei var. malmei	-	-	-	-	X	-	-
Cosmarium margaritatum var. margaritatum f. margaritatum	X	-	-	-	-	-	-
Cosmarium ophelii	X	-	X	-	-	-	X
Cosmarium phaseolus var. phaseolus f. minus	X	-	-	-	-	-	-
Cosmarium protractum var. protractum	-	-	-	-	-	X	-
Cosmarium tumidum var. tumidum f. tumidum	-	-	-	-	-	X	-
Desmidium aptogonum var. aptogonum	X	-	-	-	X	-	-
Euastrum crameri	-	-	X	-	-	-	-
Euastrum engleri	X	-	-	-	-	-	-
Hyalotheca dissiliens var. dissiliens	X	-	X	-	-	-	-
Micrasterias decemdentata var. decemdentata	-	-	X	-	-	-	-
Micrasterias laticeps var. laticeps f. laticeps	-	-	X	-	-	-	-
Micrasterias radiosa var. radiosa f. radiosa	-	-	-	-	-	X	-
Micrasterias truncata var. truncata f. truncata	-	-	X	-	-	-	-
Onychonema laeve var. quadrangulare	X	-	-	-	-	-	-
Pleurotaenium ehrenbergii var. eherenbergii	X	-	-	-	-	-	-
Pleurotaenium repandum var. repandum f. repandum	-	-	X	-	-	-	-
Pleurotaenium trabecula var. trabecula	-	-	X	-	-	X	X
Sphaerozosma vertebratum var. punctulatum	-	-	X	-	-	X	X
Spondylosium moniliforme var. moniliforme	-	-	-	-	-	-	X
Spondylosium pulchrum var. pulchrum	-	-	X	-	-	-	-
Staurastrum avicula var. subarcuatum	-	-	-	-	-	X	-
Staurastrum boergesenii var.glabrum	-	-	X	-	-	-	-
Staurastrum comptum var. pinnatiforme	-	-	X	-	-	-	-
Staurastrum distentum	-	-	X	-	-	-	-
Staurastrum furcigerum var.armigera	X	-	X	-	-	X	-
Staurastrum gracile var. pusillum	-	X	-	-	-	-	-
Staurastrum leptacanthum var. borgei	-	-	X	-	-	-	-
Staurastrum leptocladum var. leptocladum	-	-	-	X	-	-	-
Staurastrum leptocladum var. smithii	X	X	X	X	-	-	-
Staurastrum limneticum var. cornutum	-	-	-	-	-	X	-
Staurastrum muticum var. muticum	-	X	-	-	-	-	-
Staurastrum orbiculare var.depressum	X	-	X	-	-	-	-
Staurastrum pinge	X	X	-	X	-	-	-
Staurastrum polymorphum var. pusillum	-	-	X	-	-	-	-
Staurastrum pseudosebaldi var. pseudosebaldi	X	-	-	-	-	-	-
Staurastrum quadrangulare var. contectum	-	-	-	-	-	X	-
Staurastrum rotula	-	-	X	-	-	-	-
Staurastrum sebaldi var.ornatum	-	-	-	-	-	X	-
Staurastrum trifidum var. inflexum	X	-	-	-	-	-	-
Staurodesmus convergens var. ralfsii	-	-	X	-	-	-	-
Staurodesmus dejectus var. apiculatus	-	-	-	-	-	X	-
Staurodesmus dickiei var. dickiei	-	-	-	-	-	-	X
Staurodesmus glaber var. limnophilus	X	-	-	-	-	-	-
Staurodesmus subulatus	X	-	X	-	-	X	-
Staurodesmus validus var. subvalidus	-	-	X	-	-	-	-
Xanthidium antilopaeum var. antilopaeum f. antilopaeum	-	-	X	-	-	-	-
Xanthidium antilopaeum var. basigranulatum	X	-	-	-	-	-	X
Xanthidium antilopaeum var. hebridarum	-	-	X	-	-	X	X
Peniaceae							
Gonatozygon kinahani	-	-	X	-	-	X	-



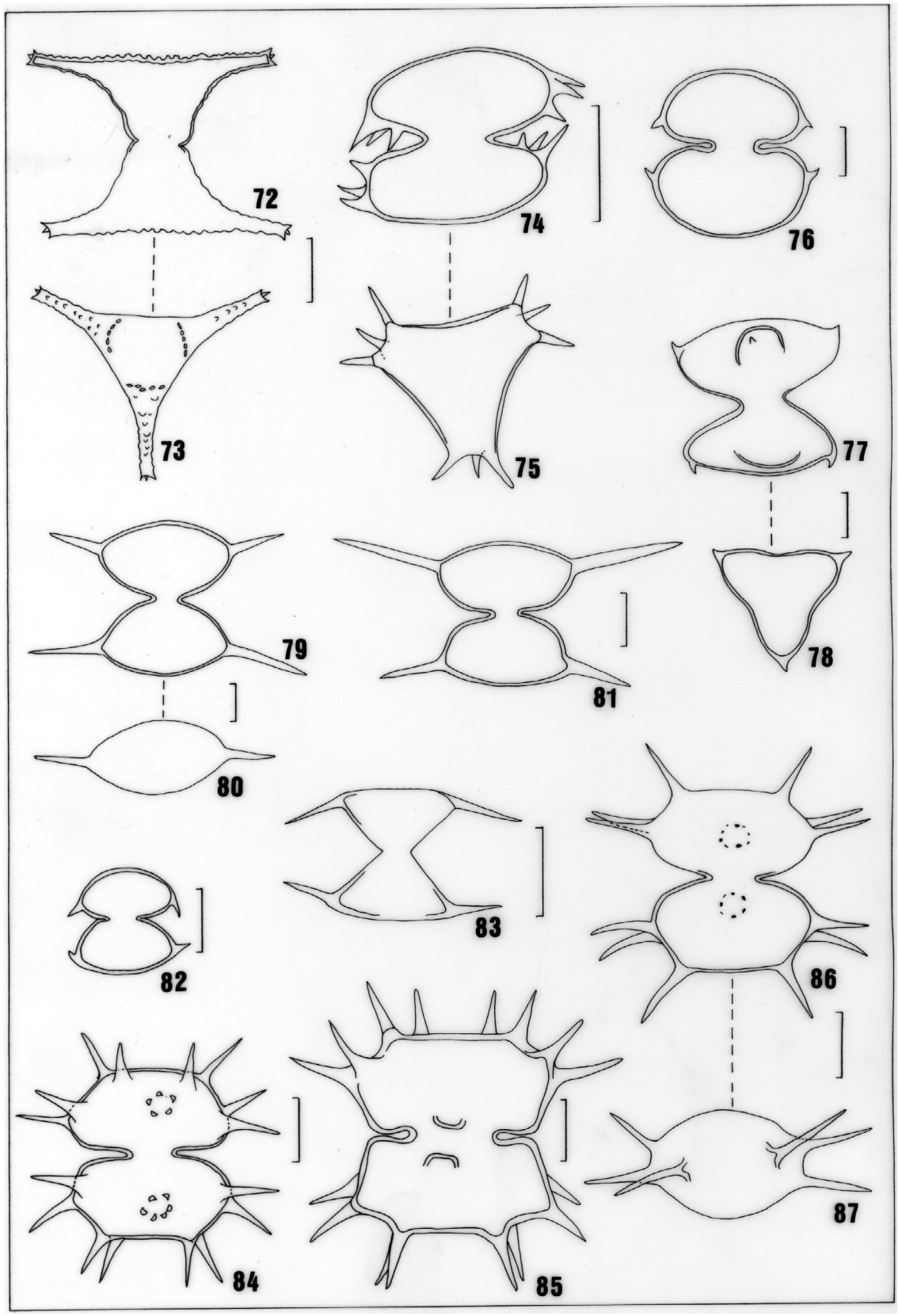
Figs. 2-29. **2**. *Gonatozygon kinahani*; **3**. *Closterium aciculare*; **4.** *Closterium acutum* var. *variabile*; **5.** *Closterium ehrenbergii* var. *immane*; **6**. *Closterium kuetzingii* var. *kuetzingii*; **7**. *Closterium moniliferum* var. *moniliferum* f. *moniliferum*; **8**. *Bambusina borreri*; **9-10**. **9**.*Closterium praelongum* var. *praelongum*, **10**. apex; **11**. *Cosmarium bioculatum* var. *canadense*; **12**. *Cosmarium ophelii*; **13**. *Cosmarium contractum* var. *contractum*; **14**. *Cosmarium hexagonum*; **15**. *Cosmarium contractum* var. *maximum*; **16**. *Cosmarium malmei* var. *malmei*; **17**. *Cosmarium margaritatum* var. *margaritatum* f. *margaritatum*; **18**. *Cosmarium phaseolus* var. *phaseolus* f. *minus*; **19-20**. **19**. *Cosmarium protractum* var. *protractum*, **20**. vertical view; **21-22**. **21**.*Cosmarium tumidum* var. *tumidum* f. *tumidum*, **22**. vertical view; **23**. *Desmidium aptogonum* var. *aptogonum*; **24-25**. **24**. *Euastrum crameri*, **25**. lateral view; **26**. *Euastrum engleri*; **27**. *Hyalotheca dissiliens* var. *dissiliens*; **28**. *Micrasterias decemdentata* var. *decemdentata*; **29**. *Micrasterias laticeps* var. *laticeps* f. *laticeps*. Scale bars: **Figs.** 10-16,18-27=10µm; **Figs**. 4, 8, 17, 28-29=20µm; **Figs**. 2-3, 5-7, 9 =50µm.



Figs. 30-52. 30. *Micrasterias radiosa* var. *radiosa*; **31**. *Micrasterias truncata* va. *truncata* f. *truncata*; **32.** *Onychonema laeve* var. *rectangulare*; **33**. *Sphaerozosma vertebratum* var. *puctulatum*; **34**. *Spondylosium pulchrum* var. *pulchrum*; **35**. *Spondylosium moniliforme* var. *moniliforme*; **36-37. 36**. *Pleurotaenium ehrenbergii* var. *ehrenbergii*, **37**. apex; **38-39. 38**. *Pleurotaenium repandum* var. *repandum* f. *repandum,* **39**. apex; **40-41. 40**. *Plaurotaenium trabecula* var. *trabecula*, **41**. apex; **42**. *Staurastrum avicula* var. *subarcuatum*; **43-44. 43**. *Staurastrum distentum*, **44**. vertical view; **45-46**. **45.** *Staurastrum boergesenii* var. *glabrum*, **46.** vertical view; **47-48. 47**. *Staurastrum comptum* var. *pinnatiforme*, **48**. vertical view; **49-50. 49**. *Staurastrum gracile* var. *pusillum*, **50**. vertical view; **51-52. 51**. *Staurastrum furcigerum* var. *armigera*, **52**. vertical view. Scale bars: **Figs**. 32, 33, 37,39, 41, 43,44, 47-48=10µm; **Figs**. 30, 31, 34, 35, 42, 45, 46, 51, 52=20µm; **Figs**. 36, 38, 40 =50µm.



Figs. 53-71. 53-54. 53. *Staurastrum leptacanthum* var. *borgei*, **54**. vertical view; **55**. *Staurastrum leptocladum* var. *leptocladum*; **56**. *Staurastrum leptocladum* var. *smithii*; **57-58. 57**. *Staurastrum limneticum* var. *cornutum*, **58**. vertical view; **59-60. 59**. *Staurastrum muticum* var. *muticum*; **61-62. 61**. *Staurastrum orbiculare* var. *depressum*, **62**. vertical view; **63-64. 63**. *Staurastrum pinge*, **64.** vertical view; **65-66. 65.** *Staurastrum polymorphum* var. *pusillum*, **66.** vertical view; **67**. *Staurastrum quadrangulare* var. *contectum*; **68-69. 68**. *Staurastrum pseudosebaldi* var. *pseudosebaldi*, **69**. vertical view; **70-71. 70**. *Staurastrum rotula*, **71**. vertical view. Scale bars: **Figs**. 53-55, 58-69= 10µm; **Figs**. 56, 57, 70 = 20µm.



Figs. 72-87. 72-73. 72. *Staurastrum sabaldi* var. *ornatum*, **73.** vertical view; **74-75. 74**. *Staurastrum trifidum* var. *inflexum*, **75**. vertical view; **76**. *Staurodesmus convergens* var. *ralfsii*; **77-78. 77**. *Staurodesmus dejectus* var. *apiculatus* , **78**. vertical view; **79-80. 79**. *Staurodesmus subulatus*, **80**. vertical view; **81**. *Staurodesmus validus* var. *subvalidus*; **82**. *Staurodesmus dickiei* var. *dickiei*; **83**. *Staurodesmus glaber* var. *limnophilus;* **84**. *Xanthidium antilopaeum* var. *antilopaeum* f. *antilopaeum*; **85**.*Xanthidium antilopaeum* var. *basigranulatum*; **86-87. 86**. *Xanthidium antilopaeum* var. *hebridarum*, **87**. vertical view. Scale bars: **Figs**. 76-82, 84= 10µm; **Figs**. 72-75, 83,85-87= 20µm.