

Flagellate green algae from four water bodies in the state of Rio de Janeiro, Southeast Brazil

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ABSTRACT - (Flagellate green algae from four water bodies in the state of Rio de Janeiro, Southeast Brazil). Floristic survey of flagellate green algae (Chlorophyceae and Prasinophyceae) from four water bodies in the state of Rio de Janeiro, southeast Brazil. Samples were collected bimonthly from September 1988 to August 1991. Thirty-five taxa of which 31 in Chlorophyceae (24 Chlamydomonadales and seven Volvocales) and four in Prasinophyceae (Polyblepharidales) were identified. Twenty-three taxa are new records for Brazil and 31 are registered for the first time for Rio de Janeiro State. On basis of cell shape, location of the nucleus and degree of longitudinal striations on the chloroplast surface a new combination, *Vitreochlamys lefevrei* (Bourr.) Menezes & C. Bicudo, is proposed. Integrating studies among morphological analysis on natural/cultured material and characterizing of reproduction/life cycle as well the correlating between the occurrence of the species and environmental conditions are needed in order to better knowledge the degree of phenotypic plasticity within the members of the flagellate green algae in the country.

Key words: Chlorophyceae, continental waters, flora, Prasinophyceae

RESUMO - (Algas verdes flageladas de quatro corpos d'água no Estado do Rio de Janeiro, Sudeste do Brasil). Inventário florístico das algas verdes flageladas (Chlorophyceae e Prasinophyceae) de quatro corpos d'água do sudeste do estado do Rio de Janeiro, Brasil. Com base em amostras coletadas bimensalmente, entre setembro de 1988 e agosto de 1999, foram identificados 35 táxons distribuídos em 31 Chlorophyceae (24 Chlamydomonadales e sete Volvocales) e quatro Prasinophyceae (Polyblepharidales). Do total de táxons, 33 constituem novos registros para o Brasil e 31 para o estado do Rio de Janeiro. Com base na forma da célula, na localização do núcleo e no grau de estriação longitudinal da superfície do cloroplasto propõe-se *Vitreochlamys lefevrei* (Bourr.) Menezes & C. Bicudo como nova combinação. Estudos integrados entre análise morfológica de material natural/cultura e caracterização da reprodução/ciclo de vida bem como correlação entre a ocorrência das espécies e condições ambientais são necessários visando melhor conhecimento da plasticidade fenotípica dentro de representantes de algas verdes flageladas no País.

Palavras-chave: águas continentais, Chlorophyceae, flora, Prasinophyceae

Introduction

Few floristic and taxonomic investigations have been carried out on the pigmented flagellate algae in Brazilian freshwater systems. Information concerning these algae is dispersed in general floristic surveys and plankton studied ecology. Many of these publications, however, include neither illustration nor description of the material studied. To complicate matters, many of the latter publications just refer to the flagellate genus name or, even worse, simply mention them as 'phytoflagellates'.

Strict taxonomic studies of Brazilian phytoflagellates started effectively at the beginning of the last century

with the works of Cunha (1913, 1914), who recorded altogether 90 pigmented taxa including descriptions of nine new species of euglenoid flagellates.

Somewhat recently, other phytoflagellate groups have become the object of floristic and taxonomic studies. Knowledge of these organisms in Brazil, however, is still very scarce. Despite of being just a few, such studies have shown there to be a very rich and interesting Brazilian flagellate algal flora, especially in the tropical part of the country. Some of the latter publications include descriptions of new taxa (Castro *et al.* 1991, Conforti 1993a, b, 1994, Menezes 1996, Menezes & Huszar 1997).

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Seventy-six papers have already published on the pigmented flagellate algal flora of Brazil, of which 70% have focused on the Euglenophyceae. Regarding the other flagellate classes, publications can be summarized as follow: nine publications on Chrysophyceae and Synurophyceae, five on the Dinophyceae, three on the Raphidophyceae and Prasinophyceae, and three on the Chlorophyceae and the Cryptophyceae.

The present study is part of the floristic survey of the pigmented flagellate algae of Brazil. It includes the Chlorophyceae and Prasinophyceae from four selected water bodies located in the state of Rio de Janeiro. The paper is aimed at increasing knowledge of the flagellate algal flora from tropical Brazil, and includes critical taxonomic remarks on several taxa, information about species composition of each system,

as well as notes on the ecology and geographical distribution of each group.

Material and methods

All water bodies investigated are located in the southern part of the municipality of Rio de Janeiro, state of Rio de Janeiro, southeast Brazil (figure 1). The area includes a coastal plain region and some escarpments from the Precambrian Complex (Serra do Mar). Altitude is around 800 m above the sea level, and relief ranges from plane to slightly waved.

Local climate is tropical with warm and rainy summers and dry winters. The mean annual temperature varies between 18 and 24 °C and the annual rainfall from 1,200 to 2,000 mm. Dominant soils are hydromorphic latosols, which are associated with litosols and podzols. The major part of the coastal

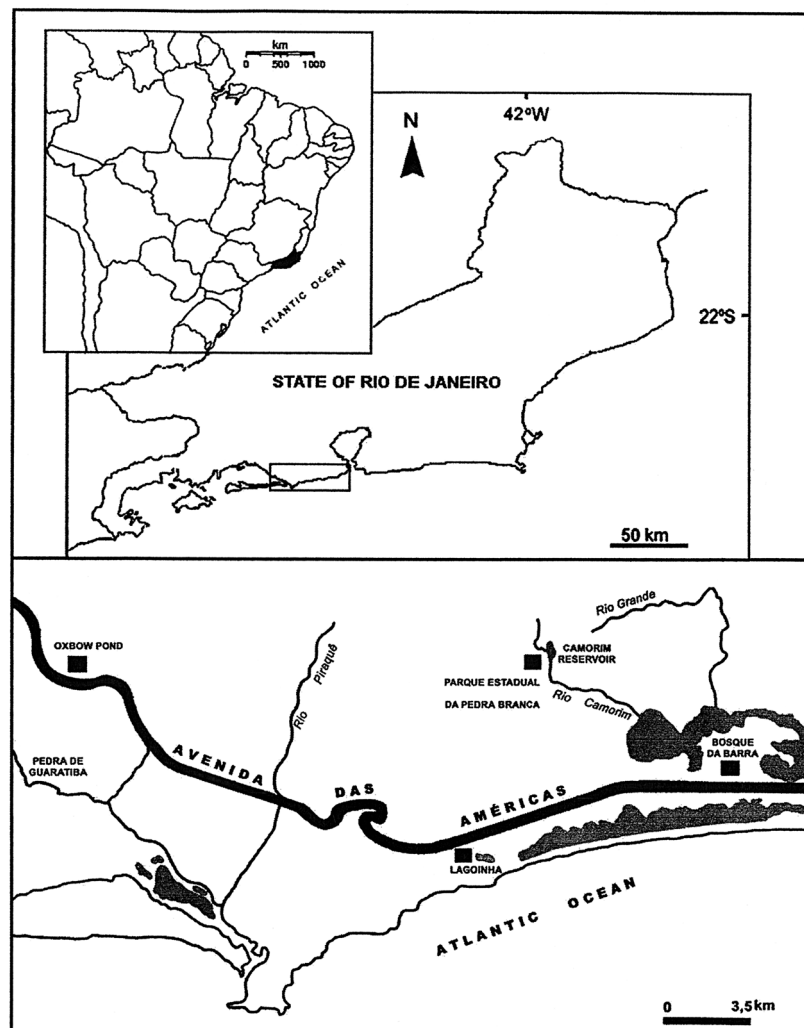


Figure 1. Map of the study area with the collecting sites (■).

plain consists of lagoons, the Jacarepaguá-Marapendi lagoon complex, that are interconnected by sandy strands. Due to its inclination, the lowland is crossed by diverging rivers which are broken close to the sea by penetration of tides raising pools, swamps, and mangroves. In this wet lowland dominates humid vegetation, dunes, and sandy coastal plains ("restingas"). Escarpment areas are found continuously throughout the coastal strand, where remnants of the Atlantic rainforest can be seen (Golfari & Moosmayer 1980, RADAMBRASIL 1983).

The four water bodies investigated can be described as follows:

1. Camorim Reservoir: located on the Pedra Grande massif, at approximately 430 m altitude (23°03'S and 43°27'W). The reservoir has total surface area of about 22 km², maximum depth 3 m, and alkaline, mesotrophic waters. This reservoir is the only source of water supply for the District of Jacarepaguá.

2. Unnamed oxbow pond: located in the Jacarepaguá lowland in front of the km 42 mark at the roadside of Avenida das Américas (22°50'00"S and 43°38'55"W). It has total surface area of approximately 0.1 km², maximum depth between 1 and 2 m and alkaline, eutropic waters. Extensive growth of macrophytes and mainly of *Typha domingensis* Person can be observed along its entire shoreline and the water surface is mostly covered by *Salvinia* sp.

3. Lagoinha: a coastal lagoon located in the Biological Reserve of Jacarepaguá (23°02'23"S and 43°28'97"W). It has total surface area of approximately 0.7 km², and mean depth of about 2.4 m. The bottom is covered with organic sediment mainly of plant origin, and the water is slightly acidic, oligohaline, eutrophic. Along the entire shoreline there is extensive macrophyte vegetation growth represented mostly by *Typha domingensis* Person, and its water surface is mostly covered with *Pistia stratiotes* Linnaeus.

4. Lake at the Bosque da Barra: a natural lake located in a preservation "restinga" area at Barra da Tijuca (22°59'02"S and 43°23'30"W). It has total surface area of around 0.2 km², mean depth of about 2 m, and oligotrophic, brown, acidic waters due to the presence of humic substances. Specimens of *Nymphaea* sp. and *Utricularia* sp. may sporadically occur along its shore.

Samples were collected from September 1988 to August 1991, every two months, from the shore by filling bottles directly with water and/or sediments using a 25 µm mesh size plankton net as well as by

gathering by hand macroscopic filamentous algae and cutting off submerged parts of macrophytes. In every case, material was kept in bottles and immediately examined alive under the light microscope. Three or four days after collection material was invariably fixed and preserved with 3%-5% neutralized formalin solution.

All taxa were described in detail. Taxonomic comments, whenever necessary, are given with illustrations and information on the geographic distribution of each taxon identified in Brazil.

The circumscription of classes is according to Round (1981). The systematic arrangement of orders and families essentially follows that of Ettl (1983). Although the groups names proposed by Ettl (1983) for the genus *Chlamydomonas* are not to be formed according International Code of Botanical Nomenclature these names have been adopted in this work aiming a more didactic presentation. The concept the species applied was the morphospecies from natural samples. When possible, the delimitation of taxa was complemented by works based on combined analysis of morphology by light microscopy and molecular biology, among them of Nozaki *et al.* (1998), Nozaki (2003), Nozaki & Kuroiwa (1992), Nozaki & Itoh (1994), Pröschold *et al.* (2001). For more information on the techniques used see Menezes (1994).

Results

The total flagellate green algal flora of the four investigated water bodies was 35 species of which 31 belong to the Chlorophyceae (24 Chlamydomonadales and seven Volvocales) and four to the Prasinophyceae (Polyblepharidales). Twenty-three taxa are new records for Brazil and 31 are registered for the first time for Rio de Janeiro State.

CHLOROPHYCEAE

Chlamydomonadales

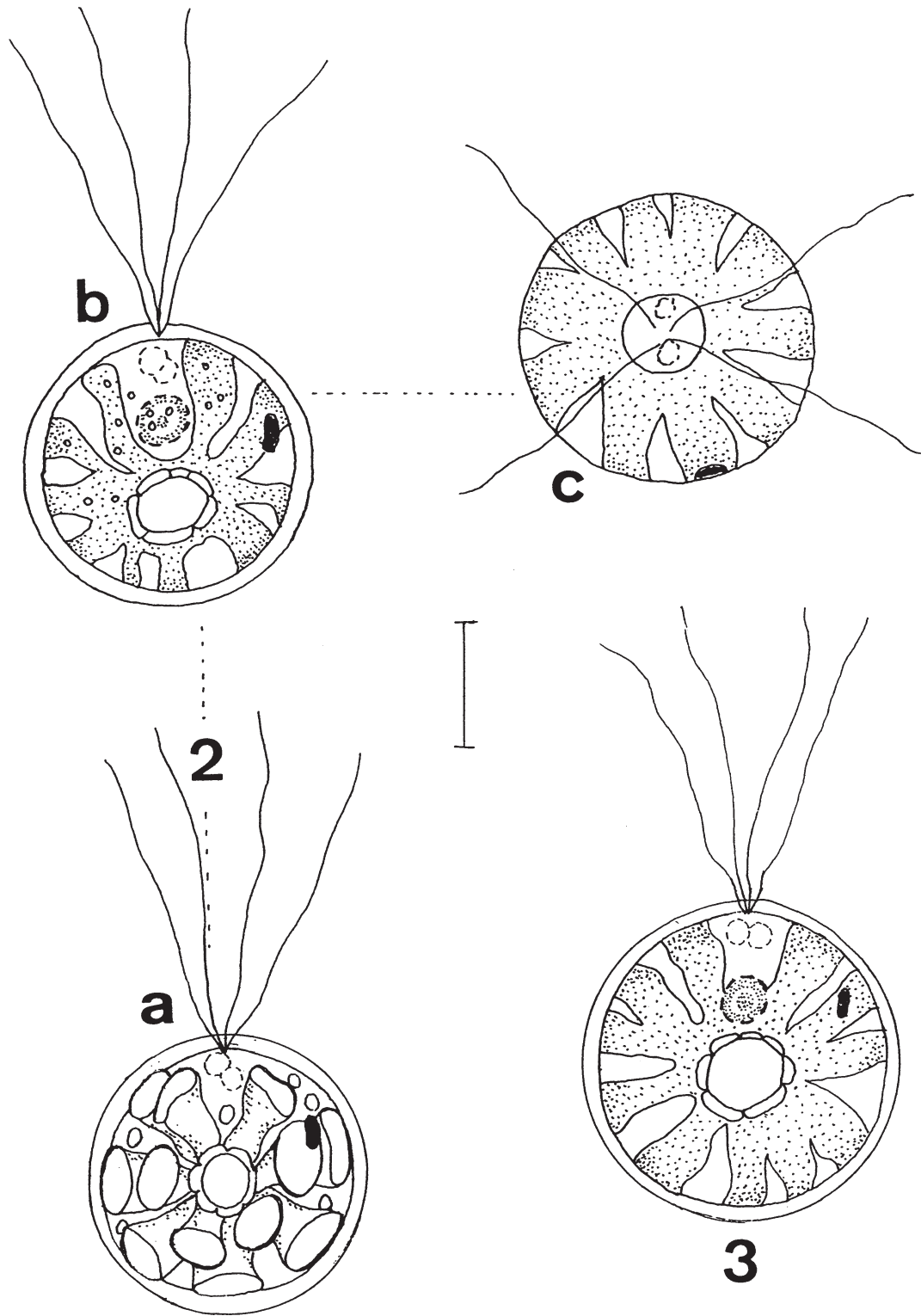
Chlamydomonadaceae

Carteria Diesing

Carteria lohammari Skuja, Nova Acta R. Soc. Scient. Upsal. ser. IV, 16(3): 115, pl. 15, fig. 1-4. 1956.

Figures 2-3

Cell 21-29 µm diam., spherical, without anterior papilla. Chloroplast cup-shaped, 9-12 radial incisions,



Figures 2-3. *Carteria lohammari*. 2a. Frontal view. 2b. Optical section of frontal view. 2c. Polar view. 3. Frontal view. Scale bar = 10 μm .

unequal rays, pyrenoid 1, spherical or elliptical, slightly displaced towards the posterior cell end. Nucleus central, located above the pyrenoid. Stigma elliptical, at the upper part of cell. Contractile vacuoles 2, apical. Flagella 2-2.5 times longer than the cell diameter.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at the Bosque da Barra, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173642); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173643); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173644); Camorim Reservoir, 22-I-1990, *M. Menezes & A.M. Werneck s.n.* (R173659).

Carteria lohammari belongs to a species-complex that is characteristic by having cells somewhat circular in outline, with a stelloid, cup-shaped chloroplast with one pyrenoid. The main diagnostic features to sort out species in this complex are the cell free-swimming or epibiont habit and the number of chloroplast incisions. Sometimes, secondary features like cell shape and size, presence of an anterior papilla, pattern of wall decoration, and distance between wall and protoplast can also be used.

According to Ettl (1983), *C. lohammari* and *C. conochlii* Skuja belong to the group of epibiontic species. However, *C. lohammari* has 12-16 chloroplast incisions and a rounded anterior cell pole, whereas *C. conochlii* has eight chloroplast incisions and a truncate anterior cell pole.

Twenty individual free-swimming cells were studied. The fact of consistently having spherical cells with smooth wall and never a papilla at the anterior cell pole, led us to the conclusion that all Brazilian populations examined could be *C. abiscoensis* Skuja *sensu* Peterfi (1968), young cells of *C. disclusa* Skuja, or with free-swimming cells of *C. conochlii* and *C. lohammari*. Material presently examined showed cell dimensions and number of chloroplast incisions that did not fit exactly any of the above species, but the one most closely matching was *C. lohammari*. So, despite having never found individual cells attached to any substrate, we believe the material from the state of Rio de Janeiro most closely corresponds to the latter species.

Recorded only for Sweden up to now. New to Brazil. Found in plankton samples from Bosque da Barra Lake and Camorim Reservoir.

Chlamydomonas Ehrenberg

Euchlamydomonas

Chlamydomonas debaryana Gorozh. var. *micropapillata* Gerloff, Arch. Protistenk. 94: 455, fig. 17. 1940.

Figures 4-5

Cell (17-)18(-20) μm long, (12-)13(-15) μm broad, elliptical-ovoid, with a hemi-spherical, 2-3.2 μm long anterior papilla. Chloroplast cup-shaped, smooth, basal thickening filling up nearly 1/2 of cell, pyrenoid 1, spherical, basal. Nucleus anterior, approximately in the middle of cell. Stigma rounded, in the upper part of cell, ca. 2.3 μm diam. Contractile vacuoles 2, apical. Flagella about the length of the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 29-X-1988, *M. Menezes s.n.* (R172157); the same, 29-X-1988, *M. Menezes s.n.* (R172158); the same, 10-I-1989, *M. Menezes s.n.* (R173417); Lagoinha, 10-I-1989, *M. Menezes s.n.* (R173409); the same, 27-III-1989, *M. Menezes & I.C.A. Dias s.n.* (R173472).

Reported from Europe. In Brazil this species has previously been recorded for the state of Rio de Janeiro (Menezes 1999). It was found in plankton and metaphyton samples, respectively from Camorim Reservoir and Lagoinha.

Chlamydomonas monoica Strehlow var. *monoica*, Zeitschr. f. Bot. 21: 627, fig. 2. 1929.

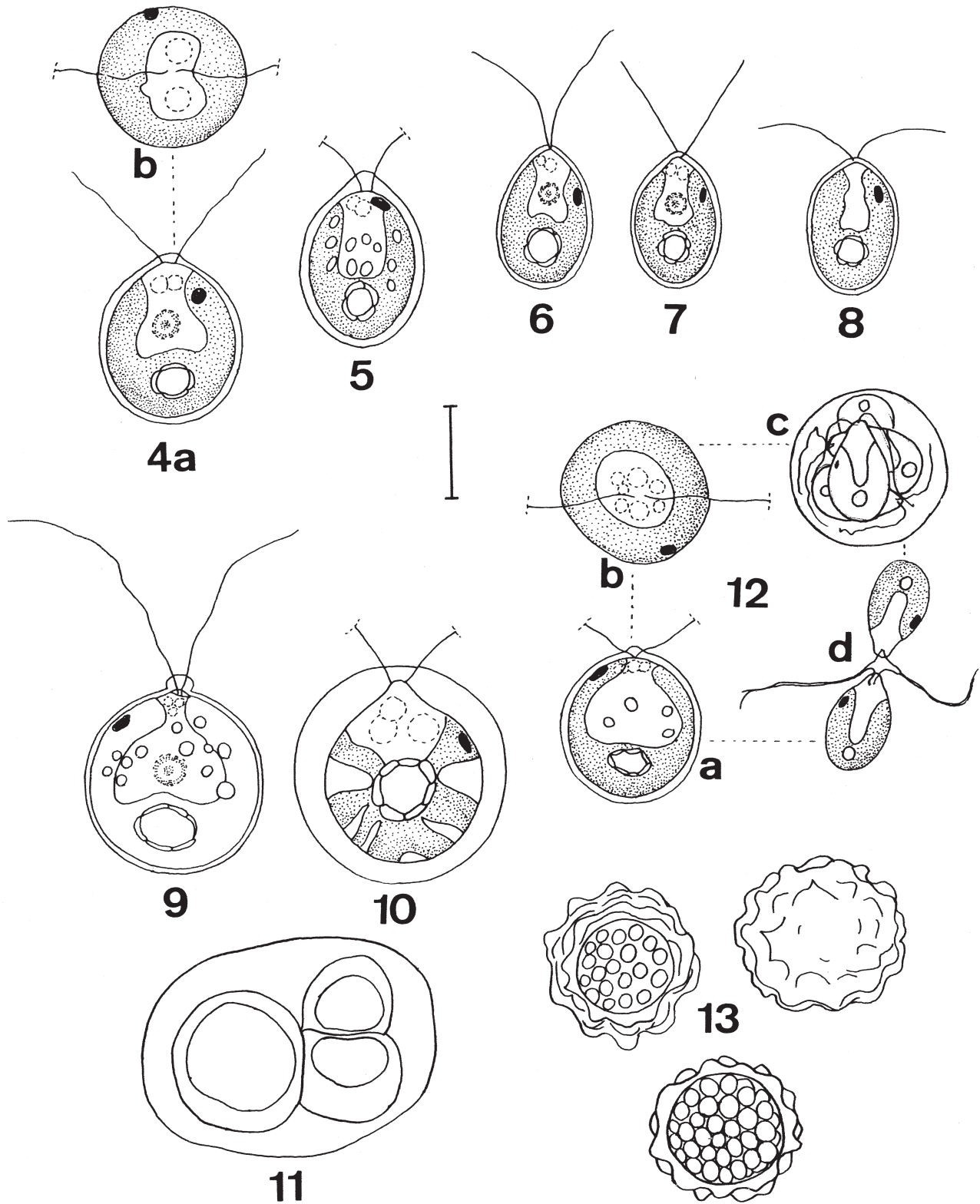
Figures 6-8

Cell (14-)18(-20) μm long, (9-)10(-14) μm broad, elliptical, ovoid or elliptical-ovoid. Cell hyaline, wall with a short anterior papilla, ca. 1.5 μm long. Chloroplast cup-shaped, smooth, basal thickening occupying usually nearly 1/2, sometimes up to 2/3 of the cell, pyrenoid 1, spherical, basal. Nucleus anterior, central. Stigma elliptical, in the upper part of cell, ca. 2.3 μm long. Two apical contractile vacuoles. Flagella about the length of the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 10-I-1989, *M. Menezes s.n.* (R173417); the same, 19-V-1990, *A.M. Werneck s.n.* (R173695).

Reported from Europe. New to Brazil. This species has found in both plankton and metaphyton samples from Camorim Reservoir.

Chlamydomonas pertyi Gorozh., Bull. Soc. Imp. Nat. Moscou, n.s. 5: 1, pl. 1, fig. 13-22. 1891.



Figures 4-13. Species of *Chlamydomonas* from Rio de Janeiro state. 4-5. *Chlamydomonas debaryana* var. *micropapillata*. 4a. Frontal view. 4b. Polar view. 5. Frontal view. Figures 6-8. *Chlamydomonas monoica* var. *monoica*. 9-13. *Chlamydomonas pertyii*. 9-10. Adult cells in frontal view. 11. *Gleocystis*-like stage. 12. Sexual reproduction. 12a. Frontal view. 12b. Polar view. 12c. Development of gametes. 12d. Isogametes. 13. Zygospores. Scale bar = 10 μ m.

Figures 9-13

Cells 16-24 μm long, 12-19 μm broad, broadly ovoid or rounded. Cell hyaline, wall with a hemispherical anterior papilla, sometimes cells enclosed in a mucilaginous sheath. Chloroplast cup-shaped, smooth, sometimes with radial, peripheric incisions, basal thickening occupying nearly 1/2 of the cell, pyrenoid 1, spherical or elliptical, basal. Stigma elliptical, in the upper cell part, ca. 2 μm long. Contractile vacuoles 7-10, at the anterior part of cell. Flagella 1.5-2 times the cell length. *Gloeocystis*-like stage with thick mucilaginous sheath surrounding each cell, all cells inside of a common yellowish mucilaginous envelope, 23-25 μm diameter. Isogametes, zygote globose, with a reddish verrucose wall, 15-19 μm in diameter.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lagoinha, 29-IX-1988, *M. Menezes s.n.* (R172914); the same, 29-IX-1988, *M. Menezes s.n.* (R172915); unammed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 4-IX-1989, *M. Menezes s.n.* (R173574); the same, 16-X-1989, *M. Menezes s.n.* (R173610); Lake at Bosque da Barra, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173642); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173643); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173644); Camorim Reservoir, 19-V-1990, *A.M. Werneck s.n.* (R173695); the same, 19-VII-1990, *M. Menezes s.n.* (R173750).

World-wide distributed, reported from Africa, Asia, Europe, and North America. New to Brazil. *Chlamydomonas pertyi* was a common species in the area studied, being found in all collecting sites both in plankton and metaphyton samples.

Chlamydomonas tetravacuolata Ettl, Bot. Tidsskr. 74(4): 212, pl. 15, fig. 1-4. 1980

Figures 14-15

Cells 15-18 μm long, 12-14 μm broad, ovoid or elliptical. Cell wall hyaline, with a conical, truncated anterior papilla. Chloroplast cup-shaped, smooth, basal thickening occupying nearly 1/4 of cell, pyrenoid 1, elliptical, sometimes rectangular, basal. Nucleus in the middle of the cell, slightly excentric. Stigma elliptical, at the upper part of cell, ca. 2.8 μm long. Contractile vacuoles 4, apical. Flagella ca. 1.5 times the cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unnamed oxbow pond, 4-IX-1989, *M. Menezes s.n.* (R173574).

This species was only recorded from Denmark. New to Brazil. Present in one plankton sample from an oxbow pond.

Material studied differs from the original description in Ettl (1980) by having a much smaller basal thickening of the chloroplast and sometimes a rectangular pyrenoid. *Chlamydomonas tetravacuola* shows basal thickening of the chloroplast occupying 1/2 of cell and elliptical pyrenoid.

Group Pleiochloris

Chlamydomonas pseudotarda Bourr., Hydrobiologia 3: 262, pl. 3, fig. 54. 1951.

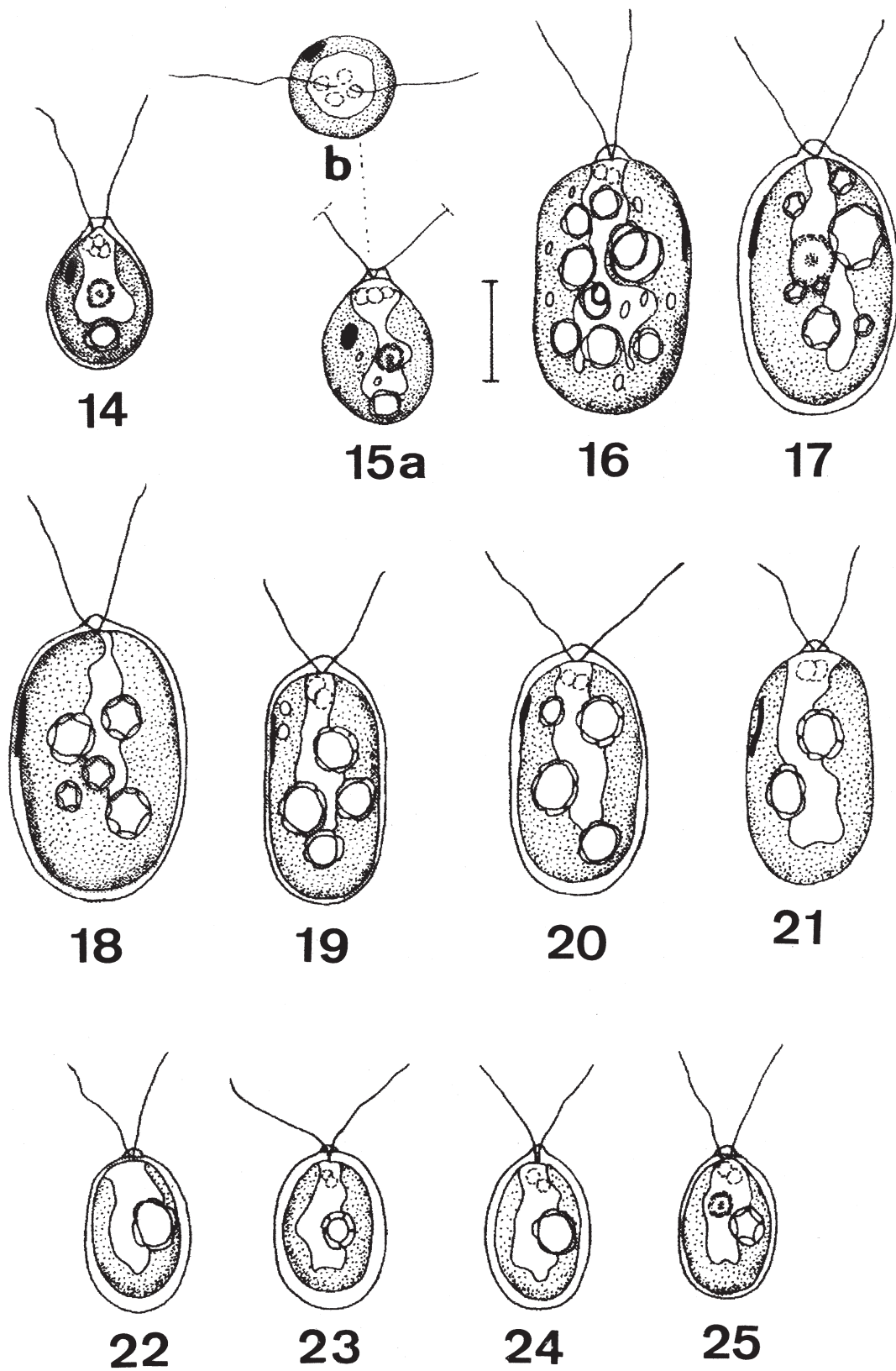
Figures 16-21

Cells (25-)28-30 μm long, (11-)13-17 μm broad, oblong, oblong-elliptical or elliptical. Cell wall hyaline, with a hemispherical anterior papilla 1-3 μm long. Chloroplast cup-shaped, smooth, basal thickening occupying 1/3 of cell, pyrenoids 2-13, spherical, irregularly distributed within the edge of chloroplast. Stigma linear, large, in the upper part of cell, ca. 6 μm long. Nucleus in the middle of cell. Contractile vacuoles 2, apical. Flagella ca. 0.5 times of cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-V-1990, *A.M. Werneck s.n.* (R173694); the same, Camorim Reservoir, 19-V-1990, *A.M. Werneck s.n.* (R173695); the same, Camorim Reservoir, 19-VII-1990, *M. Menezes s.n.* (R173750).

Chlamydomonas pseudotarda, *C. ambigua* Gerloff var. *minor* L.S. Peterfi, and *C. saccus* Pascher morphologically closely resemble each other. Their circumscriptions are very poorly delimited and based on cell shape and size, stigma morphology, and number of pyrenoids.

According to their original descriptions, *C. ambigua* var. *minor* is distinct from *C. pseudotarda* and *C. saccus* mainly in having smaller cell dimensions (12-16 \times 9-11 μm) and lesser number of pyrenoids (1-2). Also, in its sometimes ovoid cells. *Chlamydomonas saccus* has obovoid-oblong cell and the stigma is greater than in the other two species. *Chlamydomonas pseudotarda* differs from *C. saccus* only by having elliptical cell. Regarding cell dimensions and pyrenoid



Figures 14-21. Species of *Chlamydomonas* from Rio de Janeiro state. 14-15. *Chlamydomonas tetravacuolata*. 14. Frontal view. 15a. Frontal view. 15b. Polar view. 16-21. *Chlamydomonas pseudotarda*. Figures 22-25. *Chlamydomonas typhlos*. Scale bar = 10 μm .

number there are overlap between these two species, *i.e.* cells 22-30 × 13-20 µm and 4 pyrenoids in *C. saccus*; cells 26 × 13 µm and 4-6 pyrenoids in *C. pseudotarda*.

Ettl (1976) distinguished *C. pseudotarda* from *C. saccus* and *C. ambigua* var. *minor* on the basis of pyrenoid size. *Chlamydomonas pseudotarda* has pyrenoids with different sizes while *C. saccus* and *C. ambigua* var. *minor* have pyrenoids of the same size.

Populations presently studied showed variable cell shape and pyrenoid number and size, which could relate to all three taxa above. As similar situation was recorded by Jakubiec (1988) in material from Poland, *i.e.* cells oblong, oblong-elliptical to elliptical, with 2-13 pyrenoids. The specimens with oblong-elliptical to elliptical cells had 4-5 differently-sized pyrenoids (figures 18-20), except for those with 2 pyrenoids that had equally-sized pyrenoids (figure 21). Individual oblong-celled organisms had differently-sized pyrenoids that varied in number from 7 to 13 (figure 16).

We decided to attribute the present material from the state of Rio de Janeiro to *C. pseudotarda* due to the high frequency of cells with more than four pyrenoids, and because we never found specimens typically of *C. saccus*.

Reported from Europe (Austria, France, Spain). New to Brazil. This species was only found in the Camorim Reservoir plankton.

Group Chlamydomonadales

Chlamydomonas typhlos Gerloff, Arch. Protistenk. 94(3): 464, fig. 33. 1940.

Figures 22-25

Cells 13-17 µm long, 7-11 µm broad, elliptical. Cell wall hyaline, with an anterior conical papilla 1.5-2 µm long. Chloroplast cup-shaped, smooth, lateral thickening with 1 spherical pyrenoid, sometimes angular in outline, in the middle of the chloroplast. Nucleus in the middle of the cell or slightly displaced to the posterior. Stigma not observed. Contractile vacuoles 2, apical. Flagella about same length as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-VII-1990, A.M. Werneck & M.M. Marinho *s.n.* (R173752).

This species is very similar to *C. pseudogloegama* Gerloff, from which it differs in the lack of a stigma.

Gerloff (1940) had, however, referred to the sporadic occurrence of a pale yellowish stigma in the original description of *C. typhlos*. All Brazilian specimens presently studied never showed a structure that could be a stigma.

Reported from Germany. New to Brazil. Found in just one plankton sample unit from the Camorim Reservoir.

Group Amphichloris

Chlamydomonas parisii Bourr., Hydrobiologia 3: 260, pl. 2, fig. 45-46. 1951.

Figures 26-27

Cells 20-25 µm long, 11-14 µm broad, elliptical, cylindrical-elliptical or ovoid. Cell wall hyaline, with a conical-truncated, double, anterior papilla. Chloroplast tubular, outer side with vertical ribbons, small rectangular space in the cell middle in which lies the nucleus. Pyrenoids 2, spherical, above and below the space. Stigma elliptical, in the upper part of the cell or behind the nucleus. Contractile vacuoles 2, apical. Flagella 1.3-1.5 times the cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 27-XII-1990, M. Menezes & I.S. Nogueira *s.n.* (R173642); the same, 27-XII-1990, M. Menezes & I.S. Nogueira *s.n.* (R173643); the same, 27-XII-1990, M. Menezes & I.S. Nogueira *s.n.* (R173644).

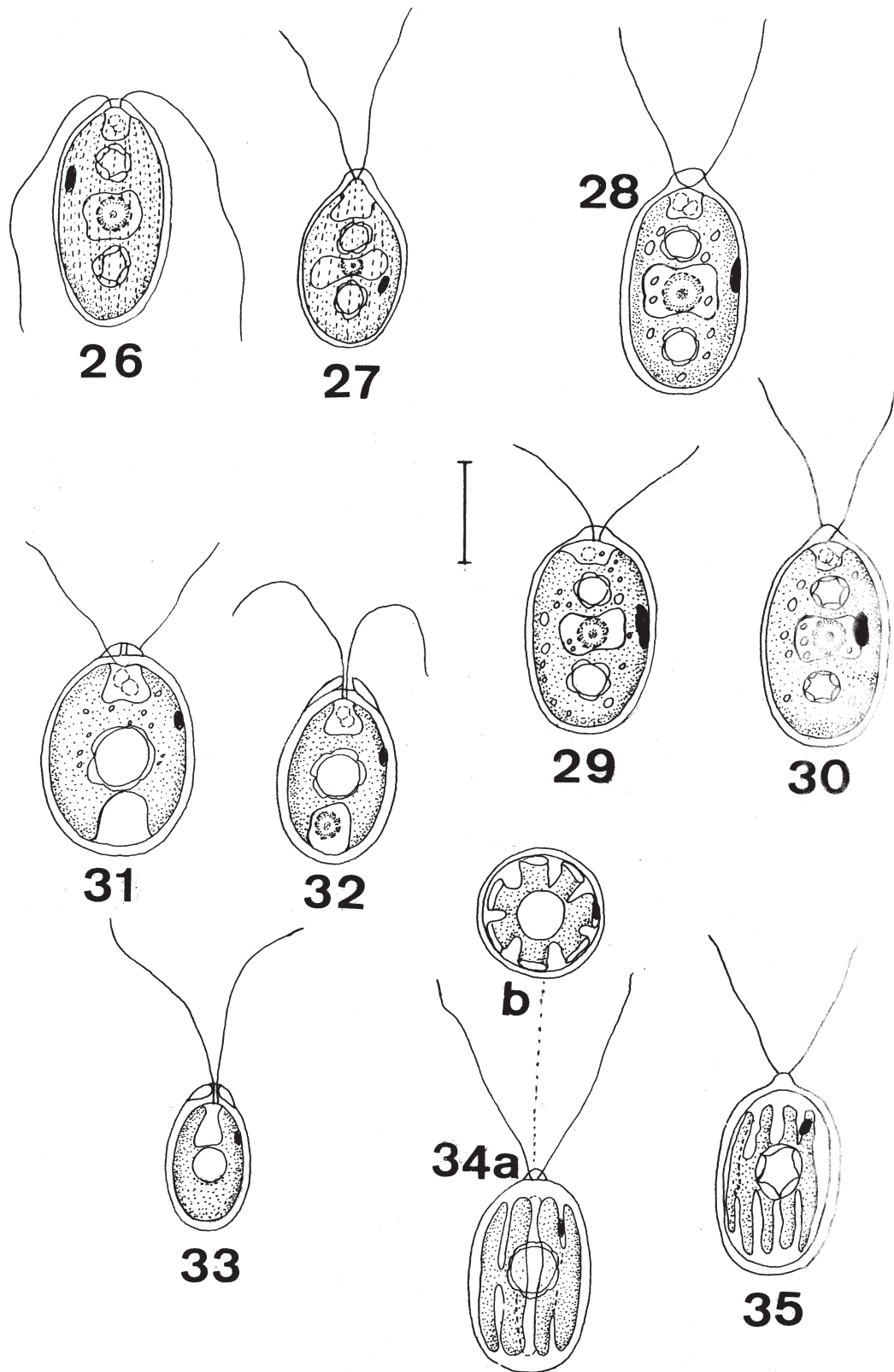
Some individuals (5% of total examined) were found, which were different from the original description of *C. parisii* by having ovoid-shaped cell and the stigma located behind the nucleus (figure 27).

Recorded from France. New to Brazil. The species was found in the plankton of Bosque da Barra Lake.

Chlamydomonas pseudopertusa H. Ettl, Arch. Protistenk. 108: 410, fig. 96. 1965.

Figures 28-30

Cells 18-21 µm long, 12-14 µm broad, elliptical or oblong. Cell wall hyaline, with a conical, truncated anterior papilla 1.3-2 µm long. Chloroplast tubular, smooth, rectangular outline to space in middle of cell, in which lies the nucleus. Pyrenoids 2, spherical, located below and above the space. Stigma elliptical, in the upper portion of cell, 3-4 µm long. Contractile vacuoles 2, apical. Flagella 0.5-1.5 times the cell length.



Figures 26-35. Species of *Chlamydomonas* from Rio de Janeiro state. 26-27. *Chlamydomonas parisi*. 28-30. *Chlamydomonas pseudopertusa*. 31-33. *Chlamydomonas glans*. 34-35. *Chlamydomonas virgata*. 34a. Frontal view. 34b. Polar view. 35. Frontal view. Scale bar = 10µm.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-V-1990, *A.M. Werneck s.n.* (R173695); the same, 20-V-1989, *M. Menezes s.n.* (R180714).

Regarding cell shape, part of the material studied is similar to *C. pertusa* Chodat. However, the structure of the papilla was a very stable characteristic that led us to consider the Brazilian specimens identical to *C. pseudopertusa*.

Reported from Asia, Europe, New Zealand. New to Brazil. This species was collected only from the plankton of Camorim Reservoir.

Chlamydomonas aff. *glans* Pascher, Arch. Protistenk. 69: 117, fig. 12. 1930.

Figures 31-33

Cells (12-)-17(-22) μm long, 7.8-14.4 μm broad, elliptical. Cell wall hyaline, with a conical rounded as well as a truncated anterior papilla, a large pore at the center of a papilla present. Chloroplast tubular, open at both ends, smooth, rarely cup-shaped. Pyrenoid 1, spherical, in the middle of a transverse plate. Nucleus in the posterior space of the chloroplast. Stigma elliptical, lying in the upper cell portion, 1.2-2 μm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173642); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173643); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173644).

Material from the state of Rio de Janeiro differs from the original description of the species in its homogeneous and thick cell wall and, sometimes, in the occurrence of a cup-shaped chloroplast. Our material also differs from of *C. glans* in having a conical rounded sometimes truncated anterior papilla.

Recorded from Europe. New to Brazil. This species was collected from the Bosque da Barra Lake plankton.

Chlamydomonas virgata Pascher, Arch. Protistenk. 69: 120, fig. 15. 1930.

Figures 34-35

Cells 25-30 μm long, 10-13 μm broad, cylindrical-ellipsoidal, with a conical anterior cell pole. Cell wall

hyaline, with a rounded anterior papilla. Chloroplast tubular, open at both ends, with vertically arranged superficial incisions, 5-7 unequal and parallel lobes, slightly curved towards the cell inside, sometimes interrupted at the transverse plate, with a spherical pyrenoid at the middle of the transverse plate. Nucleus in the posterior space of the chloroplast. Stigma elliptical, lying in the upper cell portion, about 2 μm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 10-I-1989, *M. Menezes s.n.* (R173417).

Part of the present material differs from the original description of *C. virgata* in that the outer side of the chloroplast is interrupted by incisions that produce lobes of different extent. However, we are of the opinion that localization, extensions, and number of chloroplast incisions and lobes are not good taxonomic characters. Similar conclusions also apply to *Carteria lohammarii* Skuja that was also identified in the present study.

Reported from Europe. New to Brazil. This species was found in plankton and metaphyton samples from the Camorim Reservoir.

Group Chlorogoniella

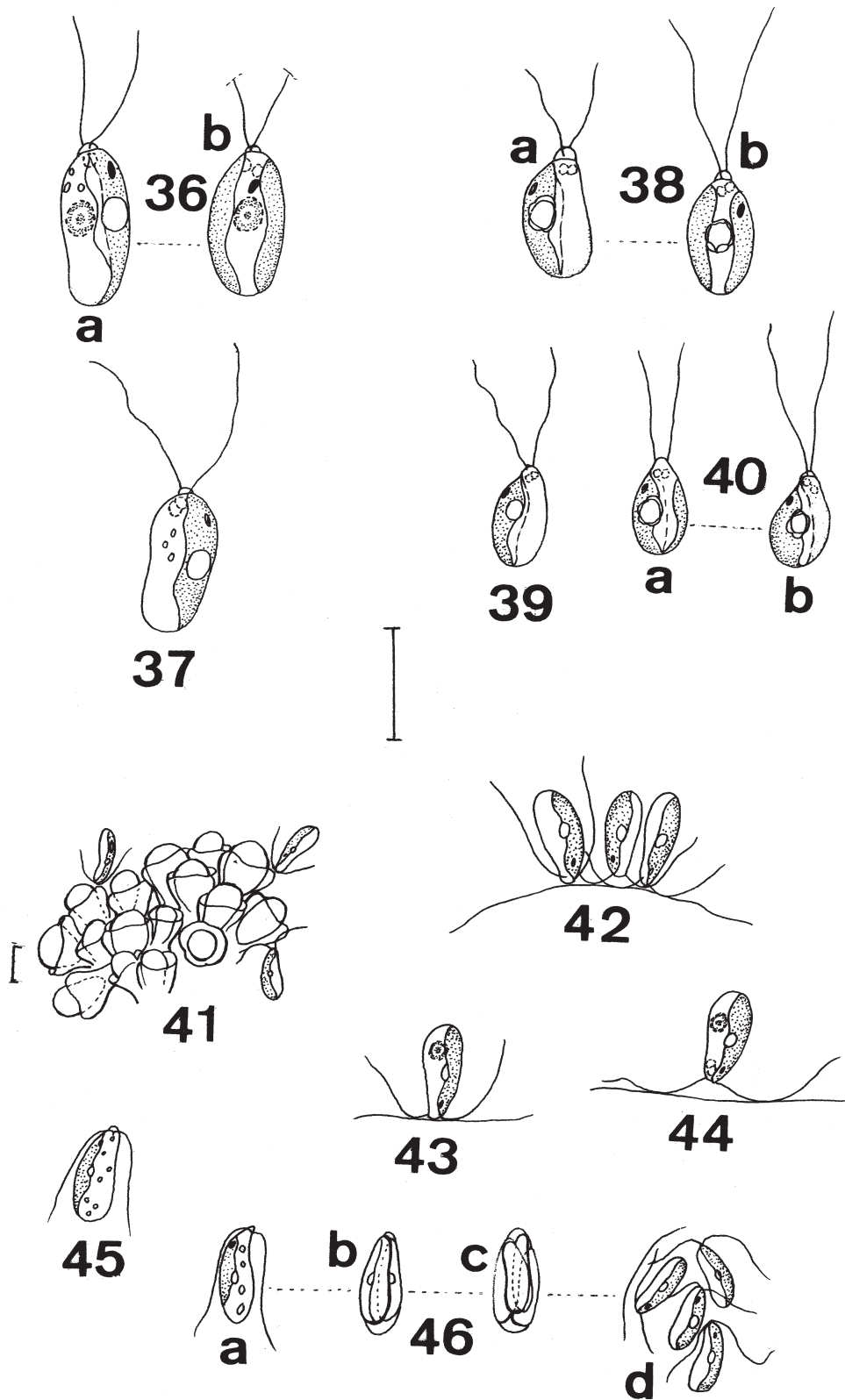
Chlamydomonas lunata Pascher & Jahoda, Arch. Protistenk. 61: 262, fig. 16. 1928.

Figures 36-37

Cells 12-15 μm long, 5-7 μm broad, dorsiventral, elliptical in frontal view, ventrally curved, convex on dorsal side, convex in anterior 2/3 or retuse in its mid portion. Cell wall hyaline, with a hemispherical anterior papilla. Chloroplast dorsal, laminar, smooth, with a spherical pyrenoid in the middle of the dorsal side, sometimes below the cell equator. Nucleus central. Stigma elliptical, in the upper part of the cell, ca. 1.8 μm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173644).

Reported from Austria. New to Brazil. This species was collected just once in the Bosque da Barra Lake plankton.



Figures 36-46. Species of *Chlamydomonas* and *Botryococcus* from Rio de Janeiro state. 36-37. *Chlamydomonas lunata*. 36a. Lateral view. 36b. Frontal view. 38-40. *Chlamydomonas sordida*. 38a. Lateral view. 38b. Frontal view. 40a. Frontal view. 40b. Lateral view. 41-46. *Chlamydomonas rattuli*. 41-44. Epibiont cells on mucilage of *Botryococcus braunii*. 45. Free swimming cell. 46. Zoosporulation. 46a. Free vegetative cell. 46b. Initial stage of zoosporulation. 46c. Cell with zoospores. 46d. Zoospores. Scale bar = 10 μ m.

Chlamydomonas sordida H. Ettl, Arch. Protistenk. 108: 381, fig. 75. 1965.

Figures 38-40

Cells (7-)10(-16) μm long, (4.6-)5(-8) μm broad, slightly dorsiventral, elliptical-ovoid or ovoid in frontal view, ventrally curved, dorsal margin convex, ventral margin slightly concave to the anterior portion of the cell. Cell wall hyaline, with a hemispherical anterior papilla. Chloroplast laminar, dorsal, smooth with a spherical pyrenoid in the middle of the dorsal part. Nucleus basal, excentric. Stigma elliptical, below the pyrenoid, 1.2-2 μm long. Contractile vacuoles 2, apical. Flagella ca. 1.5 times of cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-VII-1990, A.M. Werneck & M.M. Marinho s.n. (R173752).

Present plants from Rio de Janeiro State showed slightly longer cells when compared to the original description.

Reported from Europe. In Brazil this species has previously been recorded for the state of São Paulo (Bicudo 2004). This species was found just once in a plankton sample from Camorim Reservoir.

Chlamydomonas rattuli Korš., Arch. Protistenk. 78: 590, fig. 48-49. 1932.

Figures 41-46

Cells free-swimming or an epibiont in the mucilage of plankton algae, 7-9 μm long, 2.8-3.2 μm broad, ovoid or club-shaped, sometimes curved, dorsal side convex, ventral side flattened or concave in the anterior third of cell, without papilla or with a small anterior protrusion similar to a membranaceous hemispherical papilla. Chloroplast dorsal, laminar, smooth, with a spherical pyrenoid in the middle of the dorsal part. Stigma punctiform, in the upper part of the cell, dorsal, near to the vacuoles. Contractile vacuoles 2, apical. Flagella 1-1.5 times the cell length. Asexual reproduction while cell is actively motile, by division into 4 daughter cells.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-VII-1990, M. Menezes s.n. (R173750).

Chlamydomonas rattuli is closely related to *C. gloeophila* Bourr. Both species are epibiontic in the mucilage of rotifers and plankton algae when vegetative and differ from each other by the presence of papilla in *C. gloeophila*. Bourrelly (1951) described

and sketched *C. rattuli* with an anterior papilla, and considered *C. gloeophila* a synonym of the former. Ten years latter, Huber-Pestalozzi (1961) maintained *C. rattuli sensu* Korš. and considered *C. rattuli* described by Bourrelly (1951) to be synonymous with *C. gloeophila*.

We sometimes found in the same sample on the mucilage of *Botryococcus braunii* Kützing coexisting with some others that were actively motile. At other times, they were observed free-swimming in the plankton. Epiphytic cells were mostly attached to the substrate by their flagella. The latter were ovoid in shape, with a rounded anterior pole that did not touch the host surface (figures 41-42, 44). Club-shaped cells with their anterior pole attached to the substrate were also observed, which presented a slight short protuberance that was well delimited from the rest of the cell body (figures 43, 45).

Approximately the same variation above was also observed in populations of free-swimming specimens. Very often, epiphytic vegetative cells released from the substrate later on formed zoospores which kept themselves in a motile stage (figure 46).

Reported from Asia, Europe. New to Brazil. This species was found solely in the Camorim Reservoir plankton.

Chloromonas Gobi

Chloromonas cf. *vesterbottnica* (Skuja) Gerloff & H. Ettl, Beih. Nova Hedwigia 34: 128, pl. 37, fig. 2. 1970 \equiv *Chlamydomonas vesterbottnica* Skuja, Nova Acta R. Soc. Scient. Upsal. s.r. 4, 16(3): 140, pl. 20, fig. 9-11. 1956.

Figure 47

Cells 20-23 μm long, 11-18 μm broad, ovoid. Cell wall hyaline, with a hemispherical or truncate anterior papilla. Chloroplast cup-shaped, dissected into discoid portions. Nucleus central. Stigma elliptical, at the upper portion of cell, 6-7 μm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unnamed oxbow pond, 27-XII-1989, M. Menezes s.n. (R173641).

Our material differs from of *C. vesterbottnica* in having hemispherical sometimes truncate papilla. *Chloromonas vesterbottnica* shows a spherical-conical anterior papilla (Ettl 1983)

Reported from Denmark, Rumania, Sweden. New to Brazil. Present species was found in one plankton sample from the oxbow pond.

Gloeomonas Klebs

Gloeomonas tubulosa (Pascher & Jahoda) H. Ettl, Ber. Nat.-med. Ver. Innsbruck 58: 1970 = *Chlamydomonas tubulosa* Pascher & Jahoda, Arch. Protistenk., 61: 274, fig. 27. 1928.

Figures 48-49

Cells 11-14 µm long, 8-10 µm broad, ovoid. Cell wall hyaline, with a short rounded sometimes truncate anterior papilla. Chloroplast cup-shaped, smooth, basal thickening occupying 1/3 of cell, without pyrenoid. Nucleus central. Stigma elliptical, at the upper part of cell, 3-3.5 µm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-VII-1990, *M. Menezes s.n.* (R173750); the same, 19-VII-1990, *A.M. Werneck & M.M. Marinho s.n.* (R173751).

Reported from Austria. New to Brazil. Found in the plankton of Camorim Reservoir.

Vitreochlamys Batko

Vitreochlamys cylindrica (Skuja) Maidana & Vigna, Physis, sec. B, 46(110): 17. 1988 = *Sphaerellopsis cylindrica* Skuja, Symb. Bot. Upsal. 9(3): 93, pl. 9, fig. 20-26. 1948.

Figures 50-51

Cells 28-32 µm long, 14-18 µm broad, oblong, rounded poles, sometimes sides slightly concave. Cell membrane hyaline, wide. Protoplast 20-22 µm long, 7-10 µm broad, ovoid, widely distant from the membrane. Chloroplast urn-shaped, with conspicuous longitudinal striations, posterior lateral thickening, sometimes a spherical pyrenoid in the mid region. Nucleus central. Stigma elliptical, at the upper portion of cell, ca. 2 µm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell, penetrating the cell membrane at both sides of papilla, surrounded by short tubes at the base.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 19-V-1990, *A.M. Werneck s.n.* (R173694); the same, 19-V-1990, *A.M. Werneck s.n.* (R173695).

Reported from Austria, Sweden. New to Brazil. This species was found in the plankton of Camorim Reservoir.

Vitreochlamys fluviatilis (Stein) Batko, Acta Hydrobiol. 6: 415. 1970 = *Chlamydococcus fluviatilis* Stein, Infus. 3 (1): pl. 24, fig. 26-46. 1878.

Figures 52-55

Cells 15-20 µm long, 11-14 µm broad, elliptical-ovoid, rounded poles. Cell membrane hyaline, wide. Protoplast 11-13 µm long, 6-8 µm broad, ovoid, elliptical-ovoid or pear-shaped widely separated from the membrane. Chloroplast cup-shaped, smooth, basal thickening occupying 1/3 of protoplast, with a spherical pyrenoid. Nucleus central, slightly displaced to the anterior cell end. Stigma elliptical, at the upper part of cell, ca. 1 µm long. Contractile vacuoles 2, apical. Flagella about the same length as the cell, penetrating the cell membrane at both sides of papilla, surrounded by short tubes at the base.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Bosque at Lake da Barra, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173642); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173643); the same, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173644).

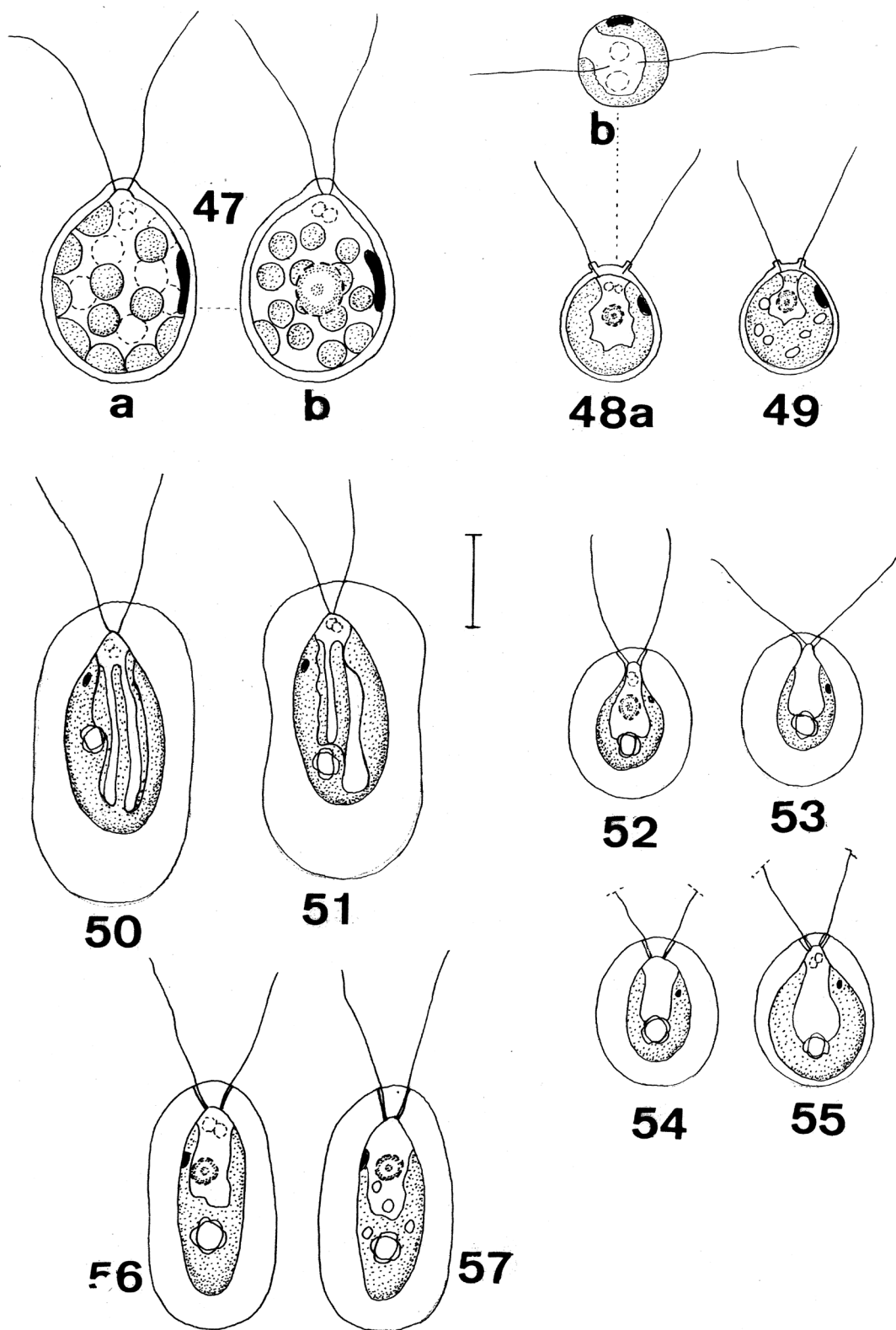
Some specimens were morphologically close to *S. alpina* Pascher & Jahoda (= *Vitreochlamys alpina*?) and *V. ordinata* (Skuja) Nakazawa, respectively, since having the protoplast at a much shorter distance from the membrane and the elliptical-ovoid protoplasts.

Reported from Hungary, India, Japan, North America, Rumania, Scandinavia, Ukraine. New to Brazil. Material studied was planktonic and collected from the Bosque da Barra Lake.

Vitreochlamys lefevrei (Bourr.) Menezes & C. Bicudo, comb. nov. = *Sphaerellopsis lefevrei* Bourr. Hydrobiologia 3: 266, pl. 5, fig. 99. 1951.

Figures 56-57

Cells 25-28 µm long, 12-15 µm broad, oblong, poles rounded. Cell membrane hyaline, wide. Protoplast 15-18 µm long, 7-9 µm broad, elliptical or elliptical-ovoid, widely distant (about 3.5 µm) from the membrane. Chloroplast cup-shaped, smooth, basal thickening occupying almost 1/2 of protoplast, with a spherical basal pyrenoid. Nucleus anterior, median, sometimes shifted from the longitudinal axis. Stigma



Figures 47-57. Species of *Chloromonas*, *Gloeomonas* and *Sphaerellopsis* from Rio de Janeiro state. 47. *Chloromonas vesterbottnica*. 47a. Frontal view. 47b. Optical section of frontal view. 48-49. *Gloeomonas tubulosa*. 48a. Frontal view. 48b. Polar view. 50-51. *Vitreochlamys cylindrica*. 52-55. *Vitreochlamys fluviatilis*. 56-57. *Vitreochlamys lefevrei*. Scale bar = 10 μ m.

elliptical, anterior, 1.5-2 μm long. Contractile vacuoles 2, apical. Flagella about 0.6 times the cell length, penetrating the cell membrane at both sides of papilla, surrounded by short tubes at the base.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 29-IX-1988, A.M. Werneck *s.n.* (R173160).

The genus has been revised by Nakazawa *et al.* (2001) based upon strains isolate from different parts of Japan, the Czech Republic, Slovak Republic and Germany using comparative light and electron microscopy and *rbcL* (large subunit of Rubisco, ribulose-1,5-bisphosphate carboxylase/oxygenase) gene phylogeny. The results of this work showed that the delimitation of the six studied species- *V. fluviatilis* (Stein) Batko, *V. gloeocystiformis* (Dill) Nakazawa, *V. ordinata* (Skuja) Nakazawa, *V. nekrassovii* (Korš.) Nakazawa, *V. aulata* (Pascher) Batko, and *V. pinguis* Nakazawa based on the morphological differences used in the traditional taxonomic system were consistent with molecular data: cell and protoplast shape, numbers of contractile vacuoles and pyrenoids, form and position of the stigma, location of the nucleus, degree of longitudinal striations on the chloroplast surface. Besides of these characters Nakazawa *et al.* (2001) included as criteria for species delimitation the ultrastructure of the pyrenoid and stigma.

Although our material have not been analyzed under electron microscopy the populations previously identified as *S. lefevrei* belong to the group of species of *Sphaerellopsis/Vitreochlamys* with chloroplast surface smooth or with inconspicuous striations and nucleus sometimes shifted from the longitudinal axis. However, it can be distinguished from these species by clearly its oblong cell.

Reported from Austria, France and Switzerland. New to Brazil. This species has been found in the plankton of an oxbow pond.

Haematococcaceae

Chlorogonium Ehrenberg

Chlorogonium fusiforme Matv., Proc. Kharkov A. Gorky State Univ. 14: 62, pl. 4, fig. 43-33. 1938.

Figures 58-59

Cells 25-30 μm long, 5-8 μm broad, fusiform, anterior end truncate, posterior end acuminate. Chloroplast laminar, smooth, with a spherical central

pyrenoid. Nucleus almost central. Stigma elliptical, anterior, ca. 1.3 μm long. Contractile vacuoles 2, one anterior, the other one posterior to the nucleus. Flagella 0.3-0.5 times the cell length. Asexual reproduction while cell actively motile, by division into 4 daughter cells.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Bosque at Lake da Barra, 27-XII-1989, M. Menezes & I.S. Nogueira *s.n.* (R173642); the same, 27-XII-1989, M. Menezes & I.S. Nogueira *s.n.* (R173643); the same, 27-XII-1989, M. Menezes & I.S. Nogueira *s.n.* (R173644).

Reported from Austria, Czech Republic, Denmark, Japan, Slovakia, Rumania, Ukraine. In Brazil this species has previously been recorded for the state of São Paulo (Bicudo 2004). The species was collected from the Bosque da Barra Lake plankton.

Haematococcus C. Agardh *emend.* Flotow.

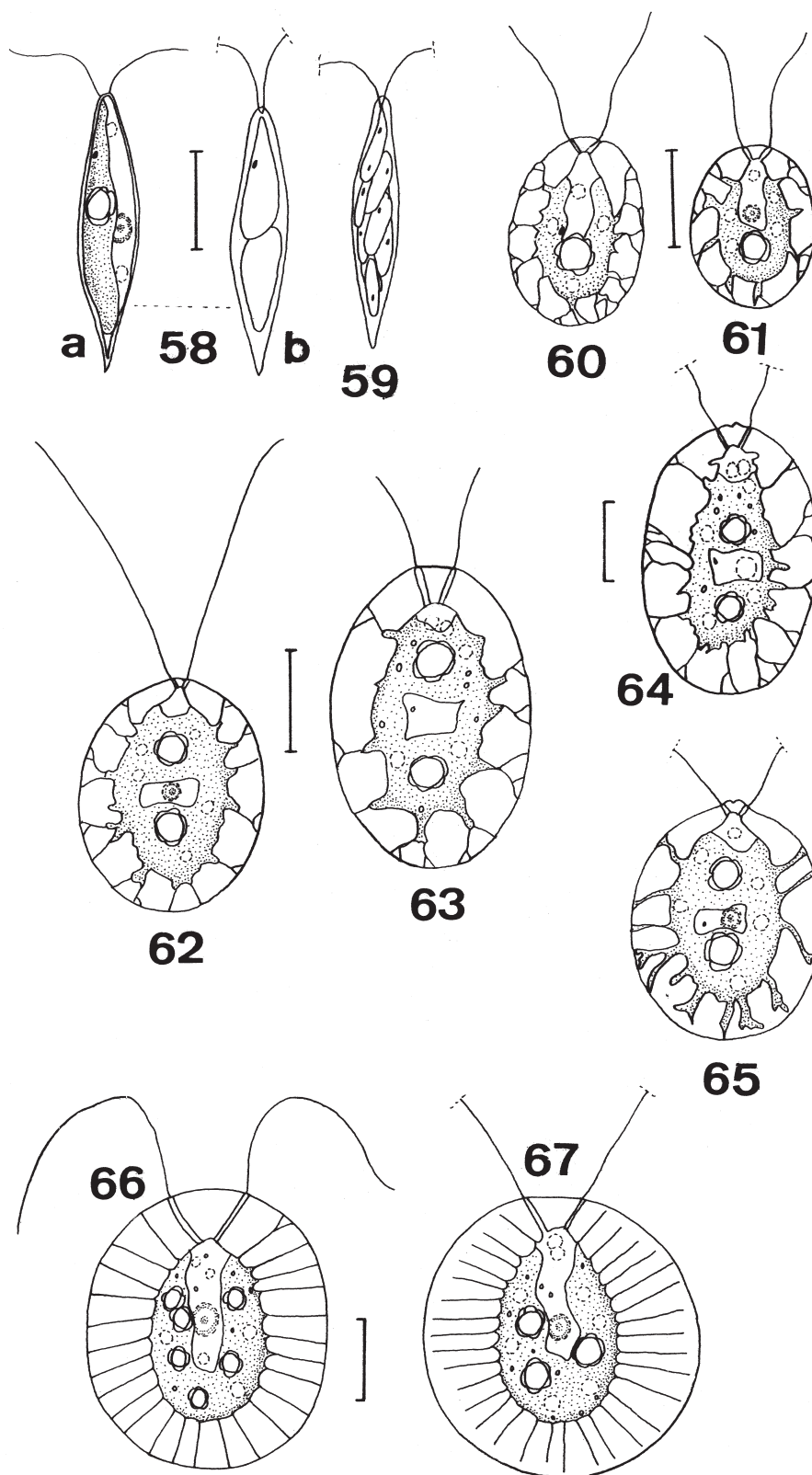
Haematococcus capensis Pocock var. *capensis*, Trans. R. Soc. S. Afr. 36(1): 13, fig. 1-2, pl. 1b-c, pl. 2d-g. 1960.

Figures 60-61

Cells (15-)19(-25) μm long, (11-)13(-17) μm broad, elliptical, rounded poles. Cell membrane hyaline, wide, lacking papilla. Protoplast 12-15 μm long, 7-8.5 μm broad, ovoid, distant from the outer membrane (ca. 3-5 μm), with a hyaline anterior end forming a conspicuous mammillae projected, which is distant from the outer membrane of about 2 μm . Coarse radiating protoplasmic processes branched or not, 13-14 hyaline cytoplasmic strands frequently branched and connecting the protoplasmic processes to the outer membrane. Chloroplast cup-shaped, smooth, basal thickening occupying almost 1/2 of protoplast, with a spherical basal pyrenoid. Stigma elliptical, near to the pyrenoid, ca. 1 μm long. Contractile vacuoles numerous, irregularly distributed. Flagella about the same length as the cell, penetrating the cell membrane at both sides of papilla, surrounded by short, divergent tubes at the base.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 22-I-1990, M. Menezes & A.M. Werneck *s.n.* (R173658).

Present material somewhat differs from the original description of the species in the smaller cell dimensions.



Figures 58-67. Species of *Chlorogonium* and *Haematococcus* from Rio de Janeiro state. 58-59. *Chlorogonium fusiforme*. 58a. Adult cell. 58b. Initial stage of zoosporulation. 59. Cell with zoospores. 60-61. *Haematococcus capensis*. 62-65. *Haematococcus droebakensis* var. *droebakensis*. 66-67. *Haematococcus pluviialis*. Scale bar = 10 μ m.

Reported from South Africa. New to Brazil. Found in the plankton of Camorim Reservoir.

Haematococcus droebakensis Wollenw. var. *droebakensis*, Ber. dt. bot. Ges. 25: 318, fig. 10-15. 1907.

Figures 62-65

Cells (30-)33(-37) μm long, (20-)23(-26) μm broad, elliptical, rounded poles. Cell membrane hyaline, wide, sometimes with a 2-lobed papilla. Protoplast (22-)26(-32) μm long, (20-)23(-26) μm broad, elliptical or ovoid, apart 5-7 μm from the outer cell membrane, anterior end hyaline, projecting into a conspicuous conical-rounded mammilla which is 1.2-3.5 μm from the outer cell membrane. Coarse radiating protoplasmic processes branched or not, mostly with 11 branched hyaline cytoplasmic strands connecting protoplasmic processes with the outer membrane, sometimes cytoplasmic strands absent and the protoplasmic processes touching the cell membrane. Chloroplast tubular, with a central space rectangular in outline, smooth, pyrenoids 2, one anterior, the other one posterior to the space. Hematochrome granules numerous, disperse in the cytoplasm. Nucleus in the space of the chloroplast. Stigma elliptical, in the space of chloroplast, ca. 1 μm long. Contractile vacuoles numerous, irregularly distributed. Flagella about the same length as the cell, penetrating the cell membrane at both sides of papilla, surrounded by short tubes at the base.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 25-III-1990, A.M. Werneck & M.C. Bernardes *s.n.* (R173686); the same, 20-V-1989, M. Menezes *s.n.* (R180714).

Some individuals studied showed some features of *H. zimbabwiensis* Pocock, such as longer flagellar tubes (figure 63) and a small papilla at the anterior protoplast pole (figure 64). Furthermore, about 1% of individual cells examined lacked cytoplasmic strands, the protoplasmic processes being more developed and sometimes touching the cell membrane (figure 65). Latter specimens do not agree with Pocock's (1960) circumscription of the species that states that presence of cytoplasmic strands is a diacritic character for *Haematococcus*.

Reported from Hungary, South Africa. In Brazil it was previously reported for the Amazonas State (Bittencourt-Oliveira 1993). The species was collected from the Camorim Reservoir plankton.

Haematococcus pluviialis Flotow *emend.* Wille, Nyt. Mag. Naturvid. 41: 89. 1903.

Figures 66-67

Cells 30-37 μm long, 25-35 μm broad, broadly elliptical or spherical, rounded poles. Cell membrane hyaline, wide. Protoplast 22-25 μm long, 13-16 μm broad, ovoid, 5-7 μm from the outer membrane, anterior pole hyaline, projecting into a conspicuous conical-rounded mammilla, which is 3-7 μm from the outer membrane. Radiating hyaline protoplasmic processes delicate, mostly with 25-52 branched hyaline cytoplasmic strands connecting the protoplasmic processes with the outer membrane, sometimes cytoplasmic strands absent, the protoplasmic processes then touching the cell membrane. Chloroplast cup-shaped, smooth, basal thickening occupying 1/3 of protoplast, pyrenoids 3-7, spherical, irregularly distributed. Hematochrome granules numerous, dispersed in the cytoplasm. Nucleus central. Stigma elliptical, at the upper cell part, ca. 1 μm long. Contractile vacuoles numerous, irregularly distributed. Flagella about the same length as the cell, penetrating the cell membrane at both sides of the papilla, surrounded by short divergent tubes at the base.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 20-V-1989, M. Menezes *s.n.* (R180714).

Registered from Hungary and Slovakia. New to Brazil. The species was found in the plankton of Camorim Reservoir.

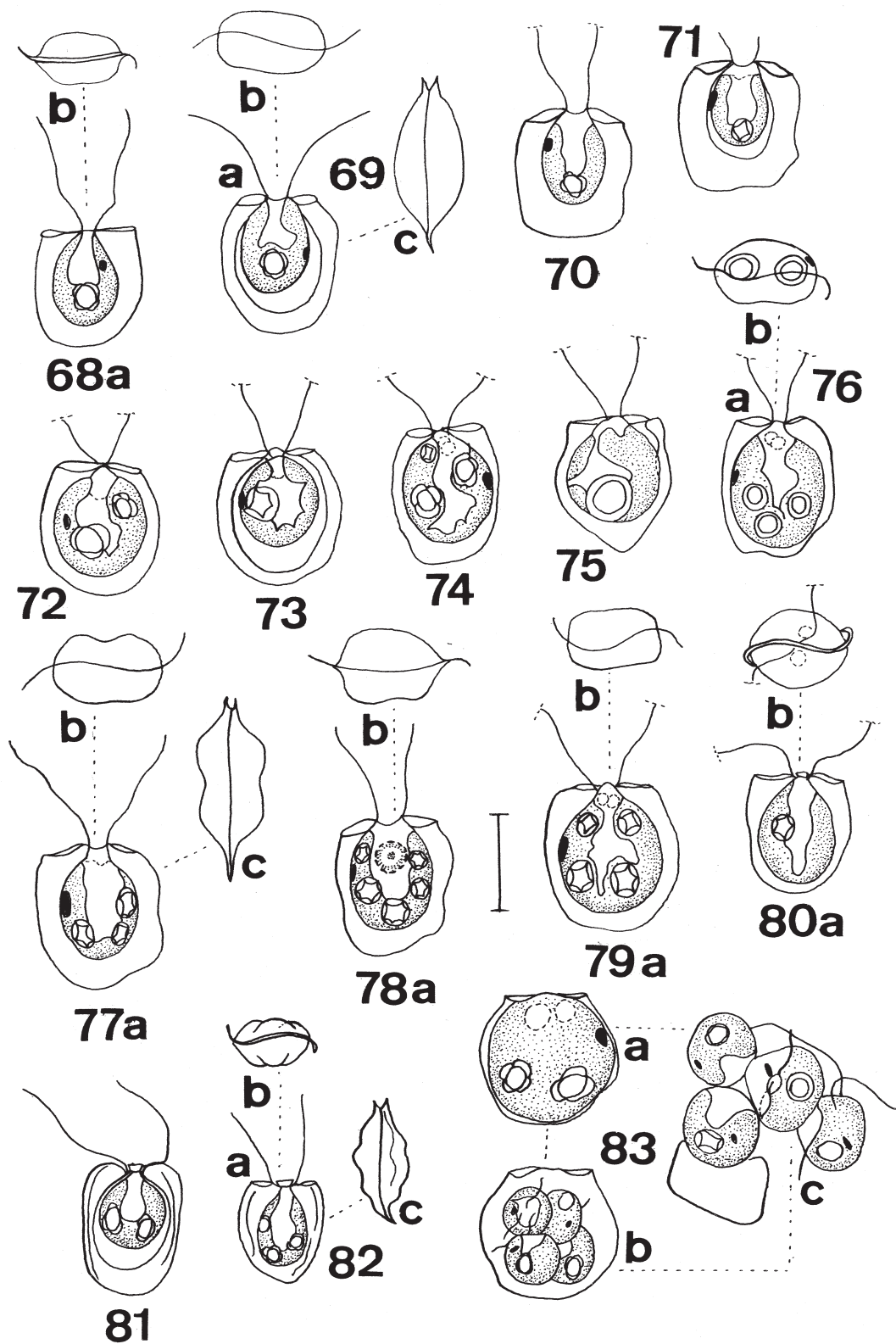
Phacotaceae

Pteromonas Seligo

Pteromonas pseudoangulosa L.S. Peterfi, Strudii si cercet. biol. ser. Bot. 17: 272, pl. 1, fig. 18-19. 1965.

Figures 68-83

Cells 12-25 μm long, 10-13 μm broad, in front view bell-shaped, outline irregular, poles truncate, sometimes posterior end rounded. Cell wall composed of 2 overlapping halves, broadly elliptical or slightly hexagonal in lateral view, sides with concave depressions, oblong, elliptical or hexagonal in apical view, rarely quadrangular, sides straight or 1 or both sides with concave depressions, 2 colorless, short, longitudinal wing-like projections on each valve half,



Figures 68-83. *Pteromonas pseudoangulosa*. 68a, 69a, 70-75, 76a, 77a, 78a, 79a, 80a, 81, 82a. Frontal view. 68b, 69b, 76b, 77b, 78b, 79b, 80b, 82b. Polar view. 69c, 77c, 83c. Lateral view. 83. Zoosporulation. 83a. Initial stage of zoosporulation. 83b. Cell with zoospores. 83c. Release of zoospores. Scale bar = 10 μ m.

sigmoid in apical view. Protoplast 8-12 µm long, 5-10 µm broad, 1-1.5 µm from outer membrane. Chloroplast cup-shaped, smooth, basal thickening taking almost 1/2 of protoplast, pyrenoid 1, spherical, usually basal or lateral, sometimes 2-5 irregularly distributed. Nucleus central. Stigma elliptical, at the upper portion of cell, ca. 2 µm long. Contractile vacuoles 2, apical. Flagella 1-2 times the cell length. Asexual reproduction while actively motile, by division into 4 daughter cells.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unammed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173690).

Specimens from the state of Rio de Janeiro showed variation in cell shape that partially agreed with the one registered by Peterfi (1965, 1968) for *P. pseudoangulosa* L.S. Peterfi. Some specimens resembled those of *P. angulosa* Lemm. in having one or both sides of the cell with a median concave depression (figures 71, 77-78). Some other ones were similar to *P. cordiformis* Lemm. in having a flagellar tube (figures 80-81). In all individuals examined variation was detected in the number of pyrenoids, from one to five, as well as in their location in the cell.

After fixation, some cells showed wall surface somewhat waved (figure 82) that, when the specimens had two or more pyrenoids, were very much similar to those of *P. aequiciliata* (Gicklhom) Bourr.

Reported from Rumania. New to Brazil. *Pteromomonas pseudoangulosa* was found in plankton and metaphyton samples from a roadside oxbow pond.

Volvocales

Goniaceae

Gonium O.F. Müller

Gonium formosum Pascher in Pascher, Süßwasserfl. Deutschl. 4: 418. 1927.

Figures 84-85

Vegetative colonies, ca. 60 µm long, ca. 60 µm broad, quadrangular, 16-celled. Cells 10-11 µm long, 9-10.5 µm broad, ovoid, connecting processes almost 2/3 of cell length. Chloroplast cup-shaped, smooth, basal thickening taking more than half of cell, pyrenoids 1-2, spherical, basal. Stigma globose. Contractile vacuoles 2, apical. Flagella homodynamic, 2 times as long as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 29-IX-1988, *M. Menezes & A.M. Werneck s.n.* (R172159); the same, 19-V-1990, *A.M. Werneck s.n.* (R173695); the same, 27-VIII-1990, *M. Menezes s.n.* (R173754); Lagoinha, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173657); unammed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173691).

Reported from Hungary and North America. In Brazil it was previously reported for the state of Rio Grande do Sul (Francheschini 1992). This species was found in the plankton from Camorim Reservoir, and in the sediment of the unnamed roadside oxbow pond.

Gonium multicoccum Pocock, Madráno 13: 1955.

Figures 86-88.

Vegetative colonies, 60-65 µm long, 60-65 µm broad, quadrangular or rhomboidal, 32-celled. Cells 10-14 µm long, (7-)8(-11) µm broad, elliptical or rounded, connecting processes up to 1/2 the cell length. Chloroplast cup-shaped, smooth, basal thickening taking up to half of cell, pyrenoids 3-7, spherical, irregularly distributed in the inner edge of plastid. Stigma globose. Contractile vacuoles 2, apical. Flagella homodynamic, 1-1.5 times the cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unammed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173691).

Reported from Australia, North America. Previously reported for Brazil from Amazonas State (Bittencourt-Oliveira 1993). The species was found in plankton and sediments from a roadside oxbow pond.

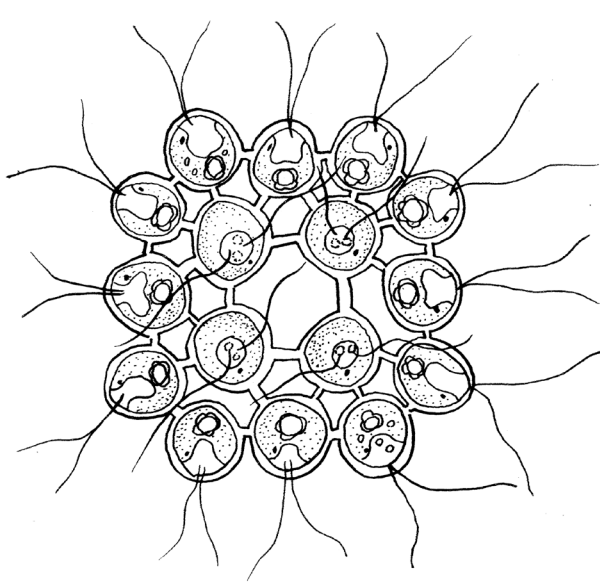
Volvocaceae

Eudorina Ehrenberg

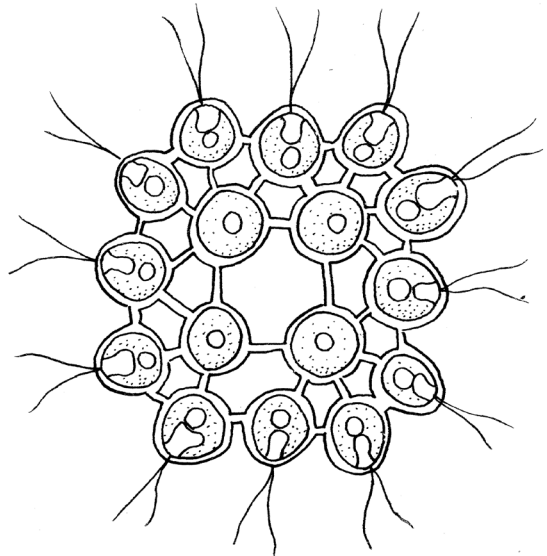
Eudorina elegans Ehrenberg, Phys. Abh. K. Akad. Wiss. Berlin, 1831: 78, pl. 2, fig. 10a-d. 1831.

Figures 89-94

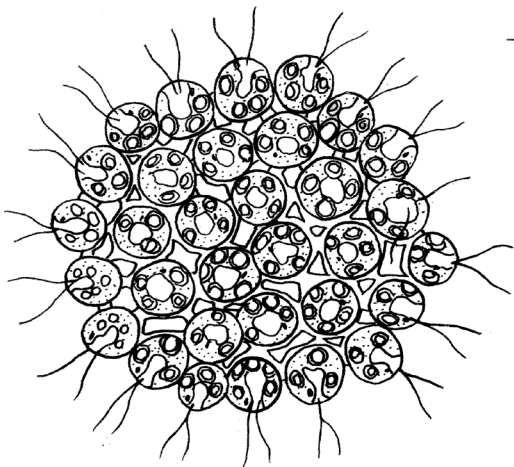
Vegetative hollow colonies, mature colonies (50-)100(-150) µm long, 43-110 µm broad, young colonies 60-70 µm diam., daughter colonies (26)30 (-37) µm diam., elliptical or rounded, 32-celled.



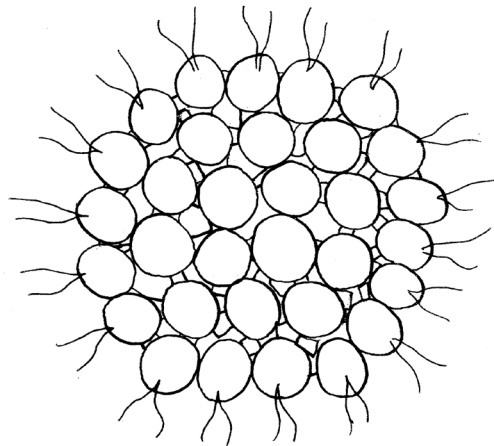
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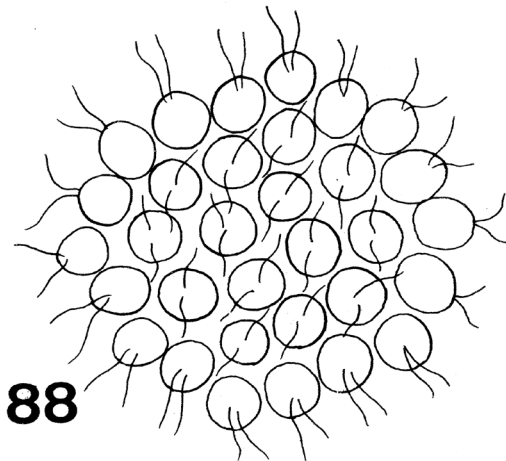
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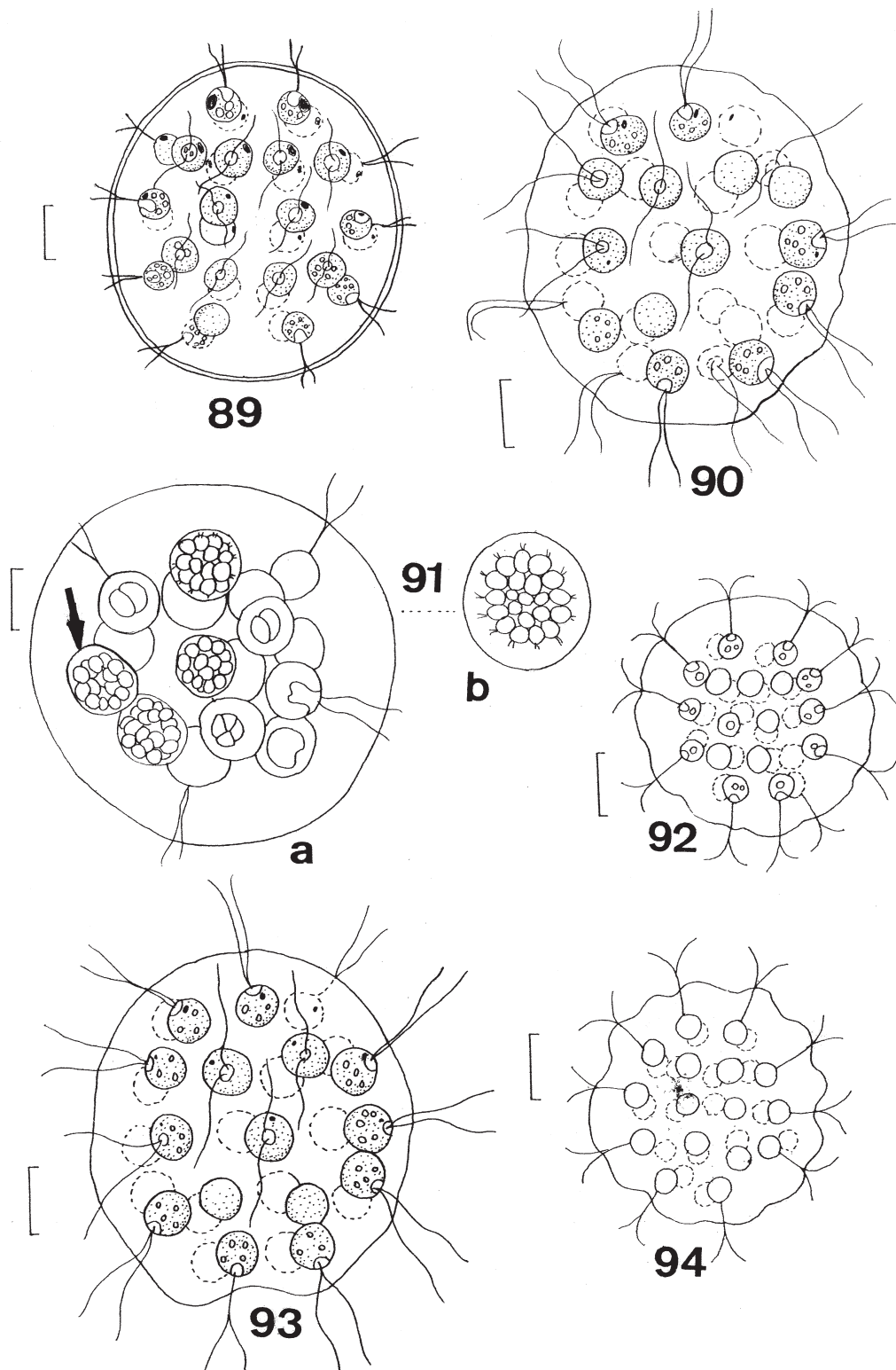


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Figures 84-88. Species of *Gonium* from Rio de Janeiro state. 84-85. *Gonium fimosum*. 86-88. *Gonium multicoccum*. Scale bar = 10 μ m.



Figures 89-94. *Eudorina elegans*. 89-90. Variation in gelatinous envelope of the adult colonies (living material). 91a. Different development stage of vegetative cells showing daughter colonies surrounded by a gelatinous envelope (arrow). 91b. Daughter colony surrounded by a mucilaginous sheath 92. Young colony (living material). 93. Variation in gelatinous envelope of the adult colonies (living material). 94. Deformation in gelatinous envelope of the young colony after fixation (formalin solution 3%). Scale bar = 10 μ m.

Daughter colonies surrounded by a mucilaginous sheath. Colonial sheath double, confluent, smooth or wavy, posterior pole rounded, truncate or with mammillae. Cells 5-7 µm diam., spherical, surrounded by a mucilaginous sheath. Chloroplast cup-shaped, smooth, basal thickening taking more than half of cell, pyrenoids 1-2 in the young cells, 3-4 in the mature cells, spherical, basal. Stigma globose, decreasing in size towards the posterior cells tiers where it may sometimes be absent. Contractile vacuoles two, apical, and several others randomly distributed. Flagella homodynamic, 1.5-2 times the cell length. Cellular division not synchronous.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 1-X-1988, *M. Menezes s.n.* (R172923); the same, 16-X-1989, *M. Menezes s.n.* (R173614); unnamed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 19-VI-1990, *M. Menezes & I.S. Nogueira s.n.* (R173747); the same, 27-VIII-1990, *M. Menezes s.n.* (R173758); Camorim Reservoir, 27-VIII-1990, *M. Menezes s.n.* (R173754).

The presence of an extra cellular matrix of the gelatinous parental envelope, together the maximum numbers of cells in a colony and modes of sexual reproduction have been considered important morphological features for delimiting volvocacean genera based on cultures, ultrastructure and molecular phylogeny studies. *Pandorina* Bory have up to 16 vegetative cells without the cellular envelopes of the matrix with isogamous reproduction without sperm packets. Within genera with up to 32 cells per colony, like *Eudorina* Ehrenb. and *Yamagishiella* Nozaki, each vegetative cell is enclosed by the cellular envelope. *Eudorina* has anisogamous sexual reproduction with sperm packets while *Yamagishiella* shows isogamous sexual reproduction without sperm packets (Nozaki & Kuroiwa 1992, Nozaki & Krienitz 2001, Nozaki *et al.* 1997, 2000, Coleman 2001).

Although we have not observed sexual reproduction in the Brazilian populations, these can be assigned to the genus *Eudorina* in having more than two contractile vacuoles. These reject the possibility that material belongs to the genus *Yamagishiella* which has only two contractile vacuoles (H. Nozaki, unpublished data).

Colonial envelope varied both in the young and adult colonies, being smooth, wavy, with the posterior pole sometimes truncate. Mammillae at the posterior pole of colonial matrix were only observed in adult colonies, where they became more evident after

fixation (figure 94). Frequently, in asexual reproduction the cells showed division not synchronous resulting in an irregular distribution and differentiation of daughter colonies development in a colony (figure 91).

Cosmopolitan distribution. The species was previously recorded from samples from North, Southeast, and South Brazil (Cunha 1913, Kammerer 1938, Uherkovich & Schmidt 1974, Bittencourt-Oliveira 1993, Huszar 1984, Dewes & Huszar 1986, Huszar *et al.* 1987, Sant'Anna *et al.* 1988, Franceschini 1992). Found in plankton and metaphyton samples from Bosque da Barra Lake and a roadside oxbow pond.

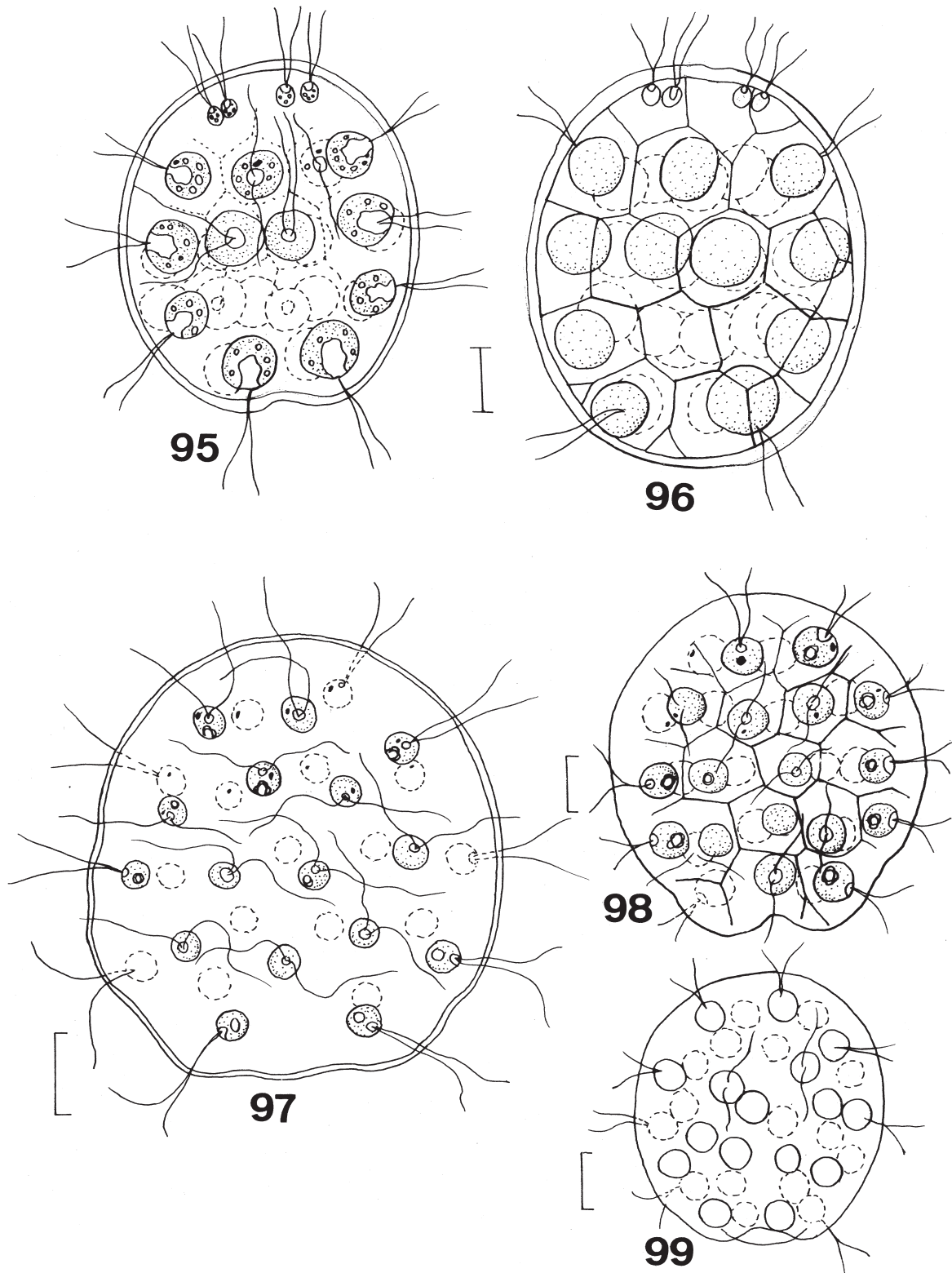
Eudorina illinoisensis (Kofoid) Pascher *in* Pascher, Süßwasserfl. Deutschl. 4: 443, fig. 464-465. 1927 = *Pleodorina illinoisensis* Kofoid, Bull. Ill. St. Lab. Nat. Hist., 5: 273, pl. 36-37. 1898.

Figures 95-96

Vegetative hollow colonies, (102-)132(-140.6) µm long, (182-)112(-114) µm broad, elliptical, 32-celled. Colonial sheath double, confluent, smooth or with usually posterior, rarely anterior, mammillae. Cells spherical or ovoid, surrounded by a mucilaginous matrix, cells of first anterior tier 9-10 µm long, 5-7.6(-8) µm broad, all remaining cells tiers (19-)20(-23) µm diam. Chloroplast cup-shaped, smooth, basal thickening taking more than 1/2 of cell, pyrenoid 1 in the anterior somatic cells, 3-5, spherical, irregularly distributed in the others cells. Stigma globose, decreasing in size towards the posterior cells tiers. Contractile vacuoles two, apical, and several others randomly distributed. Flagella homodynamic, ca. 1.5 times the cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unnamed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160).

Eudorina illinoisensis (Kofoid) Pascher resembles some species of *Pleodorina* Shaw, like in *P. thompsonii* Ott, Nozaki & Coleman and *Pleodorina westii* Tiffany, in having 16- or 32-celled colonies with small somatic cells. However, thirty-two-celled colonies of *E. illinoisensis* have four small anterior cells that may or may not divide to form a daughter colony. *i.e.* facultative somatic cells (Goldstein 1964, Nozaki 1986). Moreover, in 32-celled colonies of *P. westii* the small somatic cells are nearly equal in number as large reproductive cells and are distributed in both anterior and posterior portions of colony (Tiffany 1935). In



Figures 95-98. Species of *Eudorina* from Rio de Janeiro state. 95-96. *Eudorina illinoisensis*. 95. Vegetative cells with hexagonal gelatinous sheath (living material). 96. Vegetative cells with hexagonal gelatinous sheath (stained with methylen blue). 97-99. *Eudorina unicocca*. 98. Somatic cells with hexagonal gelatinous sheath (living material). 99. Young colony (living material). Scale bar = 10 μ m.

32-celled colonies of *P. thompsonii* there are 12 small somatic cells that are only at the anterior pole of the colony and do not divide (Nozaki *et al.* 2006).

Populations studied always showed individual cells having gelatinous sheath that was hexagonal in outline. Sheaths were clearly evident in adult colonies without staining (figure 95). In young colonies, however, sheaths were evident only after staining (figure 96).

World-wide distribution. In Brazil it was previously recorded from North, Southeast, and South areas (Kammerer 1938, Thomasson 1971, Bittencourt-Oliveira 1990). This species was collected from the plankton of an unnamed roadside oxbow pond.

Eudorina unicocca G.M. Smith, Bull. Torrey bot. Club 57: 363, pl. 17, fig. 3-4. 1930.

Figures 97-99

Vegetative hollow colonies, (95-)123(-133) μm long, (79.8-)95(-114) μm broad, elliptical or elliptical-obovoid, 32-celled. Colonial sheath double, confluent, slightly waved, internal layer formed by individual cells envelopes in the larger colonies, posterior pole with mammillae. Cells 7-11 μm diam., spherical, sometimes surrounded by a mucilaginous hexagonal matrix. Chloroplast cup-shaped, smooth, basal thickening taking more than 1/2 of cell, pyrenoid 1, spherical, basal. Stigma decreasing in size towards the posterior tiers. Contractile vacuoles two, apical, and several others randomly distributed. Flagella homodynamic, about 2 times the cell diameter.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 1-X-1988, *M. Menezes s.n.* (R172923); the same, 8-IV-1990, *M. Menezes s.n.* (R173689); unnamed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160).

Based upon the single basal pyrenoid in the cup-shaped chloroplast of the vegetative cells our populations could be assignable to *Eudorina unicocca* G.M. Smith or *Yamagishiella unicocca* (Rayburn & Starr) Nozaki (Goldstein 1964, Nozaki *et al.* 1997). However, the occurrence of more than two contractile vacuoles led us to consider the Brazilian specimens as *E. unicocca*.

Cells in colonies may or may not have individual gelatinous sheaths. Individual sheaths clearly observed without staining were detected in adult colonies, which also had more developed posterior mammillae.

Reported from Central and North America, Switzerland. In Brazil, it was previously recorded from North, Southeast, and South areas (Uherkovich & Rai 1979, Stankiewicz 1980, Huszar 1984, 1985, Dewes & Huszar 1986, Bittencourt-Oliveira 1993). This species was found in plankton, neuston and metaphyton samples from Bosque da Barra Lake and from an unnamed roadside oxbow pond.

Volvulina Playfair

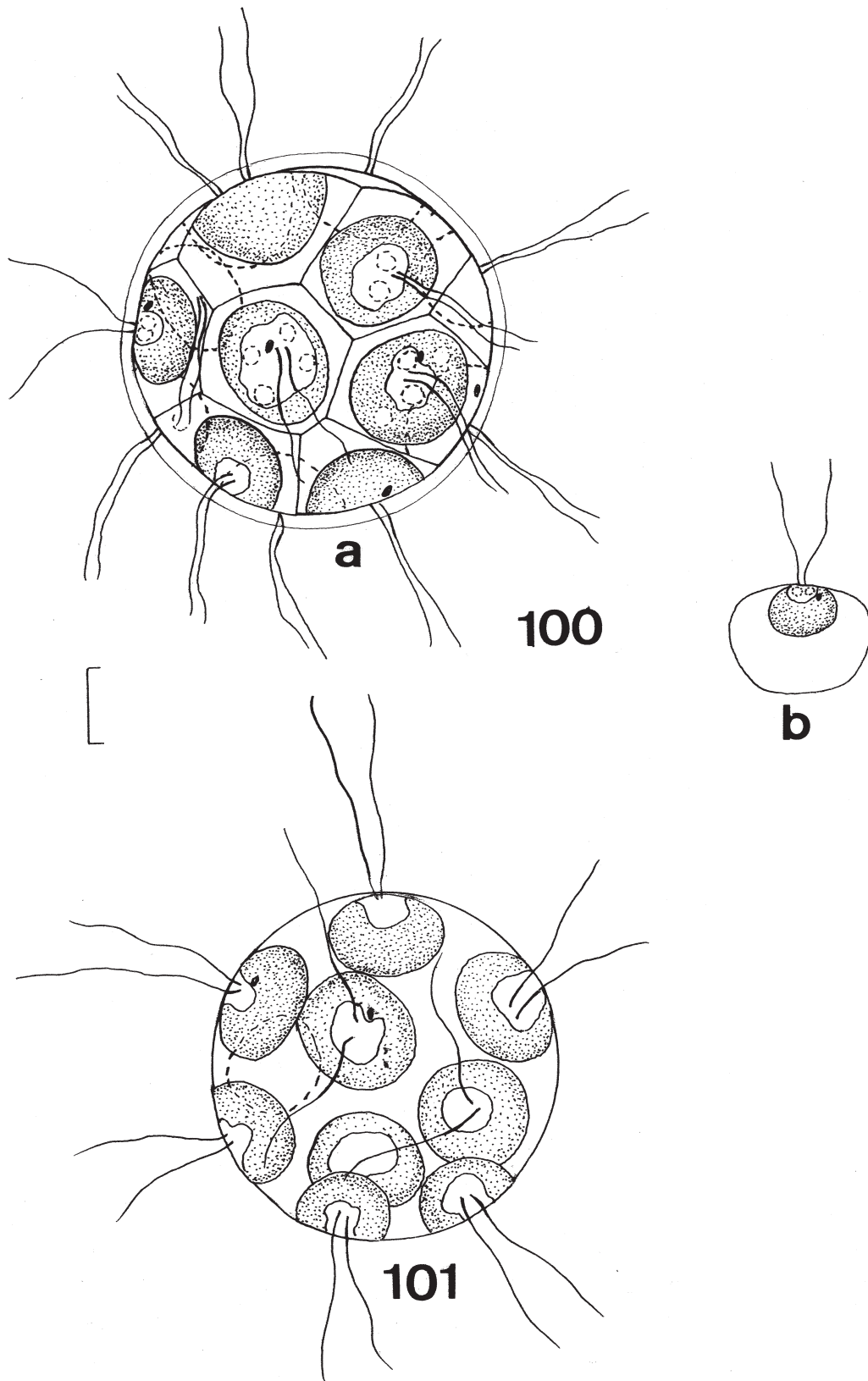
Volvulina steinii Playfair, Proc. Linn. Soc. N. S. W. 40(2): 337, pl. 43, fig. 3-4, 8. 1915.

Figures 100-101

Vegetative colonies compact, (42-)45(-68) μm diam., globose to almost perfectly spherical, 16-celled. Colonial sheath sometimes formed by confluence of cellular envelopes. Cells (6-)9(-10) μm long, (11)12-13(-15) μm broad, hemispherical or lenticular in front view, spherical in polar view, peripherically distributed in the colonial envelope in alternating tiers of 4 cells each, surrounded by a mucilaginous, hexagonal envelope, which may sometimes be confluent. Chloroplast cup-shaped, smooth, basal thickening taking almost the whole cell, pyrenoid absent. Stigma elliptical, at the anterior 1/3 of the cell, largest in the 1st tier, reduced in the 2nd and 3rd tiers, lacking in the posterior one. Contractile vacuoles 4-6, apical. Flagella about 2 times as long as the cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unnamed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173691).

According to Starr (1962), *V. steinii* Playfair differs from *V. pringsheimii* Starr mainly in the presence of pyrenoids in the vegetative cells of the latter species. However, light and electron microscopy studies carried out by Nozaki (1982) and Nozaki *et al.* (1987) have shown that *V. pringsheimii* has pyrenoids always at the bottom of the chloroplast, and pyrenoids do not vary with culture age. Vegetative cells of *V. steinii*, however, may also have pyrenoids located at the chloroplast edge but only in some culture conditions. Nozaki and collaborators also observed that during the daughter colonies formation of *V. pringsheimii* the parental pyrenoid divided and was distributed to each one of the cells of the newly formed colonies. In *V. steinii*, pyrenoids do not divide but remain in one of the



Figures 100-101. *Volvulina steinii*, general view of two colonies. 100a. Somatic cells with hexagonal gelatinous sheath (living material). 100b. Detail of a somatic cell. Scale bar = 10 μ m.

daughter cells of newly formed colonies. Moreover, *V. pringsheimii* has two contractile vacuoles while *V. steinii* shows two to eight (Ettl 1983).

In the Rio de Janeiro State material, some colonies were similar to those of *V. pringsheimii* in having the colonial sheath distinct from the cellular one. However, in all colonies studied cells with 4-6 contractile vacuoles without pyrenoids were observed, what led us to identify the Brazilian material with *V. steinii*.

World-wide distribution. In Brazil, it was previously reported from Amazonas State (Gessner 1931, Bittencourt-Oliveira 1993). This species was found in the plankton and sediments from an unnamed roadside oxbow pond.

Yamagishiella Nozaki

Yamagishiella sp.

Figures 102-105

Vegetative colonies compact, mature colonies 40-45 µm long, 35-42 µm broad, young colonies 20-25 µm long, 15-20 µm broad, daughter colonies 8-15 µm long, 5-10 µm broad, elliptical, rounded or oblong, 16-celled. Daughter colonies surrounded by a mucilaginous sheath. Mature cells 10-15 µm long, 8-15 µm broad, young cells 5-7 µm long, 4-5 µm, daughter cells 3-5 µm long, 2.5-3.5 µm broad, pear-shaped. Chloroplast cup-shaped, smooth or dissected into vertical lobes, basal thickening taking more than 1/2 the cell, pyrenoid 1, spherical, basal. Stigma globose, decreasing in size in posterior cells tiers. Contractile vacuoles 2, apical. Flagella homodynamic, 1-1.5 times the cell length.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unammed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173160); the same, 19-VI-1990, *M. Menezes & I.S. Nogueira s.n.* (R173747); the same, 27-VIII-1990, *M. Menezes s.n.* (R173758); Camorim Reservoir, 27-VIII-1990, *M. Menezes s.n.* (R173754).

Our populations were identified initially as *Pandorina morum* (O.F. Müller) Bory in having compact colonies with up to 16 cells. However, the presence of the transparent vesicle inside the parental colonial envelope (figures 103a) and in the daughter colonies (figure 103b, c) is not characteristic of *Pandorina* where the cell division takes place in a 'keystone shaped space' in the parental gelatinous

matrix only (Angeler 1998, Nozaki & Kuroiwa 1992). The presence of this gelatinous (extracellular) matrix of vegetative colonies and the two contractile vacuoles indicated that Rio de Janeiro material can be assigned to *Yamagishiella unicocca* or even represent a new species of this genus. Since we have not worked with cultures and not observed sexual reproduction it was impossible to define a better circumscription of Brazilian populations (see comments of *E. elegans*).

Reported from Europa, Asia, South America, North America China, Finland, Chile, Austria, Germany, Ukraine, Japan, and North America. The material was collected from the plankton of Camorim Reservoir and metaphyton of a roadside oxbow pond.

PRASINOPHYCEAE

Polyblepharidales

Pedinomonadaceae

Monomastix Scherffel

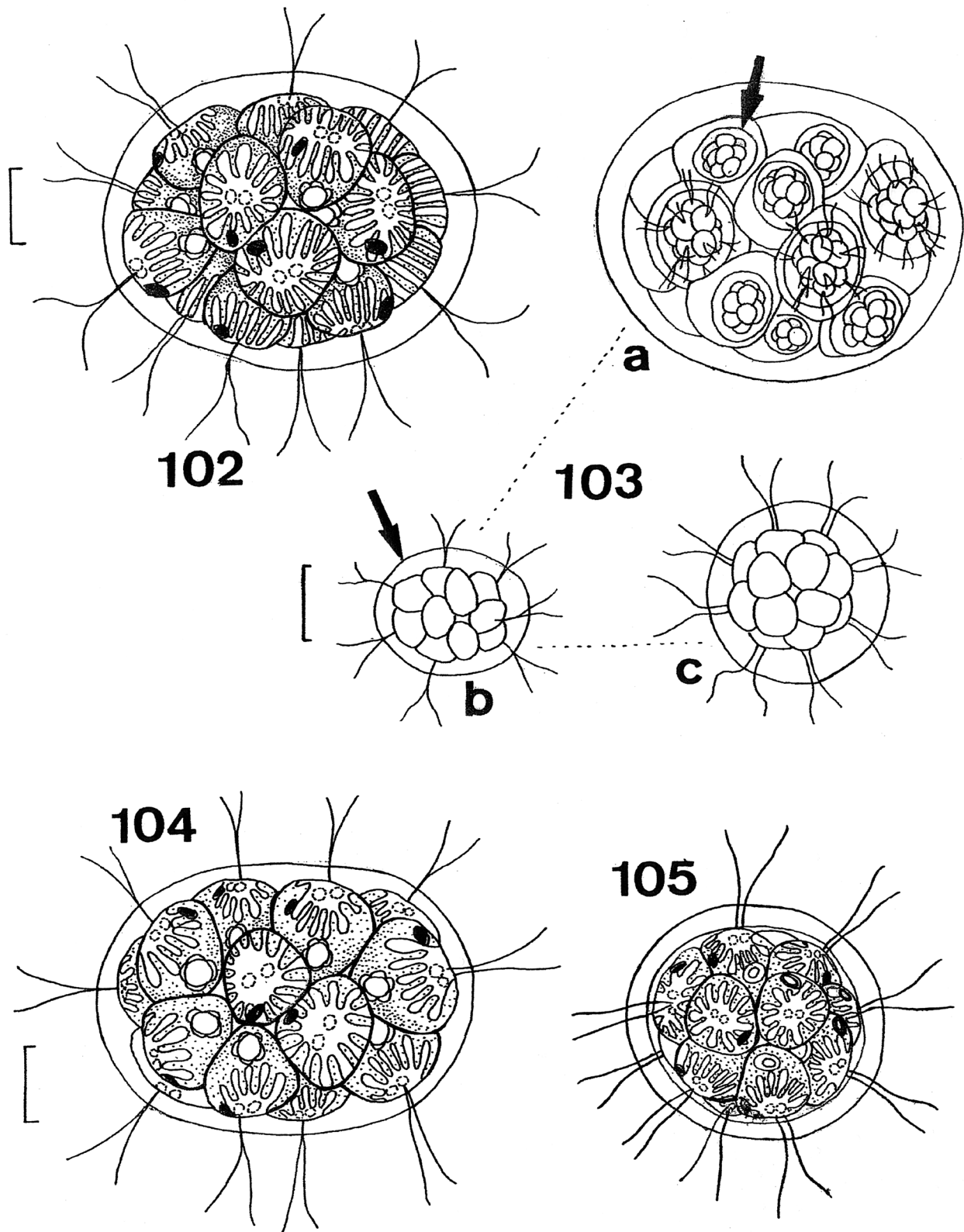
Monomastix ophisthostigma Scherffel, Arch. Protistenk. 27: 107, fig. 1-46. 1912.

Figures 106-112

Cells 14-21 µm long, 6-10 µm broad, oblong, ovoid or elliptical-oblong, slightly dorsiventrally compressed. Chloroplasts usually 2, sometimes 1, parietal, cup-shaped, a deep vertical incision dividing the chloroplast in to 2 lateral lobes, pyrenoid 1, spherical, in the middle of each lobe. Posterior part of cell with (1-)3-4 cylindrical trichocystis, 3-5 µm long, parallel to each other or almost so, sometimes absent. Stigma elliptical, 1.5 µm long, in the posterior part of cell. Contractile vacuole 1, apical.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Camorim Reservoir, 29-IX-1988, *M. Menezes & A.M. Werneck s.n.* (R172159); the same, 19-V-1990, *A.M. Werneck s.n.* (R173695); the same, 27-VIII-1990, *M. Menezes s.n.* (R173754); the same, 20-V-1989, *M. Menezes s.n.* (R180714); unammed oxbow pond, 30-IV-1990, *M. Menezes & L.H.S. Silva s.n.* (R173691).

Fifty cells were observed and most (ca. 80%) had exactly the morphology and dimensions described in Scherffel (1912). Some individuals (about 20% of total specimens seen), however, resembled young



Figures 102-105. *Yamagishiella* sp. 102. Vegetative colony. 103a. Vegetative colony with daughter colonies surrounded by a mucilaginous sheath (arrow). 103b. Daughter colonies inside the mucilaginous sheath (arrow). 103c. Daughter colonies inside the mucilaginous sheath. Scale bar = 10 μ m.

cells of *M. ophistostigma* described by Belcher (1965) in having relatively shorter cells (ca. 11 µm long), a single chloroplast divided in two portions and in the number (2-4) of trichocysts (figures 109-110). In May 1990, oblong ellipsoidal individual cells with rounded poles, trichocysts number varying from 0-3 were found (figures 111-112), might be identified as *M. minuta*.

As far as we now, *M. ophistostigma* is only reported from Europe; new to Brazil. This species was collected from the plankton of Camorim Reservoir.

Pedinomonas Koršikov

Pedinomonas minutissima Skuja, Nova Acta R. Soc. Scient. Upsal. Ser. IV, 16(3): 99, pl. 9, fig. 25. 1956.

Figures 113-114

Cells 3-4 µm long, 2-3.5 µm broad, flattened laterally, elliptical to discoid in frontal view. Chloroplast cup-shaped taking nearly the entire cell, pyrenoid 1, spherical, basal. Stigma punctiform, approximately at the cell equator. Flagellum about as long as the cell diameter.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, unnamed oxbow pond, 27-XII-1989, *M. Menezes s.n.* (R173641).

Cosmopolitan in distribution. In Brazil the species was previously recorded from a brackish coastal lagoon in the state of Rio de Janeiro (Menezes & Domingos 1994, Domingos & Menezes 1998). *Pedinomonas minutissima* was found only once in a plankton sample from the roadside oxbow pond.

Polyblephariadaceae

Nephroselmis Stein

Nephroselmis discoidea Skuja, Sym. Bot. Upsal. 9(3): 65, pl. 5, fig. 12-18. 1948.

Figures 115-116

Cells 5.5-9 µm long, 6-12 µm broad, flattened laterally, outline globose in front view, sometimes elliptical, anterior end round, with a apical swelling. Chloroplast cup-shaped, taking half of the cell, pyrenoid 1, spherical, basal. Contractile vacuole 1, apical. Stigma small, near the insertion of flagella. Flagella heterodynamyc, unequal in size, the shorter

one about the cell length, the longer one ca. 1.5 times as long as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 16-X-1989, *M. Menezes s.n.* (R173616); Lagoinha, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173648).

Reported from Europe; new to Brazil. The species was found in two plankton samples from the Bosque da Barra Lake and in one of metaphyton from Lagoinha.

Tetraselmidales

Tetraselmidaceae

Tetraselmis Sein

Tetraselmis bichlora (H. Ettl & O. Ettl) Norris *et al.*, Bot. Mag. Tokyo 93: 336. 1980 = *Platymonas bichlora* H. Ettl & O. Ettl, Arch. Protistenk. 105: 281, fig. 1. 1961.

Figures 117-118

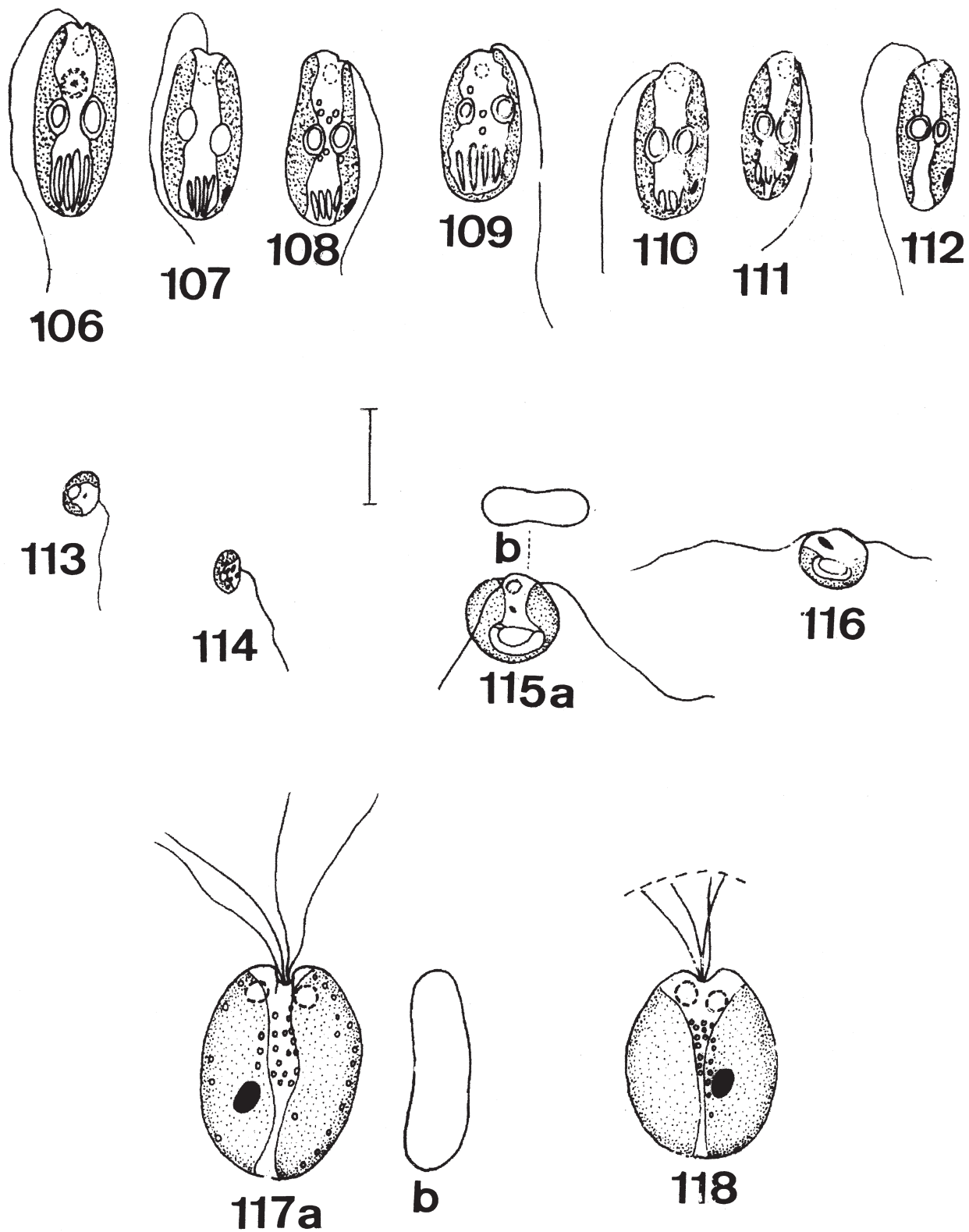
Cells 20-24 µm long, 12-16 µm broad, dorsiventrally flattened, broadly elliptical in frontal view, kidney-shaped in lateral view, anterior end rounded, with a deep apical depression. Chloroplasts 2, lateral, laminar, filling the entire cell, without pyrenoid. Two irregular rows of rounded trichocysts extending towards the posterior part of cell, others dispersed in the cytoplasm periphery. Stigma elliptical or rounded, short distance below the cell equator. Contractile vacuoles 2, apical. Flagella about as long as the cell.

Material studied: BRASIL. RIO DE JANEIRO: Rio de Janeiro, Lake at Bosque da Barra, 27-XII-1989, *M. Menezes & I.S. Nogueira s.n.* (R173644).

Reported from Europe; new to Brazil. This species was gathered just once, from the plankton of Bosque da Barra Lake.

Discussion

The circumscription of unicellular and colonial volvocacean species is problematic because most of their original descriptions were based on light microscope of a few specimens from natural samples without information of the intraspecific variation of morphological characters or of the life history



Figures 106-118. Species of *Monomastix*, *Pedinomonas*, *Nephroselmis* and *Tetraselmis* from Rio de Janeiro state. 106-112. *Monomastix opisthostigma*. 113-114. *Pedinomonas minutissima*. 115-116. *Nephroselmis discoidea*. 115a. Frontal view. 115b. Polar view. 116. Frontal view. 117-118. *Tetraselmis bichlora*. 117a. Frontal view. 117b. Polar view. 118. Frontal view. Scale bar = 10 μ m.

(Pröschold *et al.* 2001, Nozaki & Krienitz 2001, Nozaki *et al.* 2006). Several species have been recently analyzed using combined morphology, reproduction, and molecular data, however, a reasonable part of these results are divergent with respect to their taxonomy and many questions still remain concerning their revisions that must be solved before accepting their new generic names for clades (Colemann 2002, Hoham *et al.* 2002, Pollio *et al.* 2005, Nozaki *et al.* 2006).

In this work morphological characteristics used to distinguish species of flagellate green algae were, in general, often adequate for that purpose and the majority of examined populations were morphologically well defined and easy to distinguish under light microscope. However, the variability detected for some morphological features only from field observations and the absence of reproductive aspects becomes confusing and a clear delineation of some taxa was not possible like *Chlamydomonas* aff. *glans*, *Chloromonas* cf. *vesterbottnica* and *Yamaguishiella* sp. Possibly many of these organisms here identified can represent new taxa for the science or only morphotypes but would be necessary to analyze better the phenotypic living population characteristics from field observations and cultured material to determine the range of their sexual reproduction, size and shape.

Observation of cell habit did not help in the identification of *Carteria lohammari* and *Chlamydomonas rattuli*, both species being described in the literature as epibiotic on zooplankton or phytoplankton organisms. Skuja (1948) had already reported free-swimming vegetative cells of *C. lohammari* forming zoospores in the absence of substrate and for other epibiotic species of *Chlamydomonas*, especially during the warm season of the year. According to Burkholder (1996), such a kind of interaction apparently is not obligatory since the alga may also be epizotic. This could be well interpreted as a dispersal mechanism or adaptation strategy to increase the organism's access to nutrients, to escape predators, or to get an advantageous location for growing. Then, it is possible to understand the epibiotic habit as a facultative phase that would constitute an adaptation process under stressed environmental conditions.

Variation in the number and extend of the chloroplasts in *Carteria lohammari* and *Chlamydomonas virgata*, as well as in the pyrenoid number and size in *Chlamydomonas pseudotarda* needs to be re-evaluated. Apparently, these characteristics

could be related to the growth and/or physiology of the organism. However, in the present study increase of pyrenoid number was closely related to the increase of cell dimensions, especially with the cell breadth. Concerning size, different pyrenoid development stages in the same specimen might correspond to the formation of secondary pyrenoids in adult cells, as it was already observed in some Hematococaceae (Nozaki *et al.* 1998).

In relation to occurrence of identified taxa in different communities and environments our results agreed with literature data based on morphospecies criteria. Among the present unicellular species of Chlorophyta (24 of Chlorophyceae and four of Prasinophyceae), all 27 were always found in the plankton, mainly in Camorim Reservoir. Colonial volvocacean, in particular species of *Gonium* and *Volvulina*, were more frequent in the plankton, metaphyton, and sediments of the oxbow pond. Flagellated green algae are found in a variety of differing aquatic habitats. In such environments their life cycle provides for rapid colonization and further growth (Desnitski 2000, 2002, 2003). Particularly, Chlamydomonadales and colonial representatives of the Volvocales are frequently associated with small, mild alkaline, shallow water bodies. The latter group (Volvocales) is also often associated with high solar radiation (Menezes 1999, Pocock 1933a, b, Reynolds 1997) hot dry weather, warm water temperatures (Znachor & Jezberova 2005).

From the geographical distribution view based on phenotypic approach available in literature the flagellate chlorophyte flora (taxa size < 0,15 mm) was represented mainly by taxa that are common in temperate climates and that constituted about 57% of the total number of identified taxa. 17% of identified taxa were common to temperate and tropical climates, and 12% were typical of warmer climate. Cosmopolitan and worldwide distributed taxa accounted for 14% of total taxa identified.

Even retaining the concept of morphospecies our findings did not support the main idea about the distribution of microorganisms, "cosmopolitan hypothesis", which predicts that free-living microbes will be present in all kinds of environments where they can live due to unrestricted dispersal capabilities (Finley 2004, Fenchel 2005). This means that free-living microbes have a lack of biogeography pattern and a low global diversity (Logares 2006). This capacity of ubiquitous dispersal is driven by huge population sizes leading to low probability of local

extinction and, then the most microorganisms with size smaller than 1 mm have worldwide distribution while those larger than 10 mm are much less abundant and rarely cosmopolitan (Fenchel & Finlay 2003, Finlay & Fenchel 2004). Although some molecular studies support the “cosmopolitan hypothesis” (Daugbjerg *et al.* 2000) for microalgae this idea is controversy because more recently available data suggest that micro-organisms (including protists and algae) have distribution patterns similar to those known from higher plants and animals, and that these patterns reflect historical (Gondwanan/Laurasian), ecological (tropical/temperate), and continental/local conditions (Coleman 2002, Foissner 2006, Luo *et al.* 2006).

In summary, our results may reflect, just how little is known about the chlorophytes flora from tropical and subtropical regions of the World. It is important to highlight the limited sampling of tropical species in the studies encompassing more complete description of intraspecific variation on natural and cultured material and/or more advanced tools like molecular phylogenetic.

Then, further investigations of Brazilian green flagellates should proceed, at least, to integrate morphological analysis on natural and cultured material in order to analyze the degree of phenotypic plasticity, to observe the characteristics of reproduction/life cycle, and correlate them to environmental conditions.

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