

CYANOPHYCEAE/CYANOBACTERIA IN RED MANGROVE FOREST AT MOSQUITOS AND COQUEIROS ESTUARIES, SÃO LUÍS, STATE OF MARANHÃO, BRAZIL

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ABSTRACT

This paper provides the results of a taxonomic survey of the Cyanophyceae/Cyanobacteria in a fringe red mangrove forest in the estuaries of Estreito dos Mosquitos and Coqueiros, São Luís, State of Maranhão, Brazil. A total of 15 taxa were identified in 8 families, as follows: Synechococaceae (2), Chroococccaceae (1), Hyellaceae (1), Xenococccaceae (1), Oscillatoriaceae (1), Scytonemataceae (2), Phormidiaceae (5) and Pseudanabaenaceae (2). The species listed in this paper are all new descriptions for Maranhão, and one of them is a new occurrence for Brazil.

Key words: mangrove Cyanobacteria, estuaries, *Rhizophora* forest.

RESUMO

Cyanophyceae/Cyanobacteria em um bosque de mangue vermelho nos estuários dos Estreitos dos Mosquitos e dos Coqueiros, São Luís, Estado do Maranhão, Brasil

Este trabalho fornece resultados de um levantamento taxonômico das Cyanophyceae/Cyanobacteria em um bosque de franja de mangue vermelho nos estuários dos Estreitos dos Coqueiros e dos Mosquitos, São Luís, Estado do Maranhão, Brasil. Um total de 15 táxons foram identificados em 8 famílias, como segue: Synechococaceae (2), Chroococccaceae (1), Hyellaceae (1), Xenococccaceae (1), Oscillatoriaceae (1), Scytonemataceae (2), Phormidiaceae (5) e Pseudanabaenaceae (2). Todas as espécies listadas neste artigo são descrições novas para o Maranhão e uma delas é citação nova para o Brasil.

Palavras-chave: Cyanobacteria de manguezal, estuários, bosque de *Rhizophora*.

INTRODUCTION

According to Dor (1984), the main focus of papers on mangrove associated algae has been on “Bostrychietum”, the species communities belonging to the genera *Bostrychia*, *Catenella* and *Caloglossa*. It is interesting to notice that studies of blue-green mangrove algae are usually secondary objectives on mangrove algae research worldwide (Branco, 1991).

Taxonomic studies on the Cyanophyceae are very scarce and limited to Dor (1984), who studied the vertical zonation and morphological adaptations of the epiphytic blue-green algae found at Sinai Estuary's mangroves and Lambert

et al. (1989), who reported 27 taxa of blue-green algae and their relative abundance (in different substracts), for South African mangroves.

In the case of Brazil, there are four papers that focus specifically on the cyanophytes from mangroves: Branco (1991), Neves & Tribuzi (1992), Branco *et al.* (1996) and Branco *et al.* (1997). All papers of Branco (1991) and Branco *et al.* (1996, 1997) compiled the cyanophyte flora from Ilha do Cardoso and Neves & Tribuzi (1992) studied mangrove cyanophyte from “Ponta do Pai Vitória”, Cabo Frio, Rio de Janeiro State. Another references are in: Möebius (1889), who reported the occurrence of *Microcoleus chthonoplastes* Thur. ex Gom. in Joinville's mangroves; Joly (1951) listed

Lyngbya confervoides C. Ag. ex Gom. *Dermocarpa* sp., *Sirocoleum* sp. and *Stigonema* sp., in Paraná State mangroves; Joly (1957) reported the presence of *Sirocoleum guyanense* Kütz. ex Gom. in Santos and surrounding mangroves; Sant'Anna *et al.* (1983) found *Oscillatoria bornetti* Zokal and *O. princeps* Vauch. ex Gom. in the Ilha do Cardoso mangroves; Oliveira (1984) observed the genera *Oscillatoria*, *Lyngbya*, *Microcoleus* and *Scytonema* in the Brazilian mangroves; Carmo (1987) cited *Microcoleus vaginatis* (Vauch.) Gom. ex Gom. as a representative species for the blue-green algae in the mangroves located in the North of Baía de Vitória, Espírito Santo State; Sant'Anna (1988) described a new species, *Scytonema insularis*, from the Ilha do Cardoso mangroves; and Moura (1991) recorded the occurrence of 29 Cyanophyceae taxa in a quali-quantitative study of periphytic algae in the rivers Paripe and Igarassu-Itamaracá Estuaries, in Pernambuco State.

In Maranhão, mangrove ecosystems have been studied by Frois-Abreu (1939), Damázio (1979/1980a, 1979/1980b), Damázio & Santos (1985, 1990), Santos & Damázio (1985), Santos (1986, 1989, 1997), and Mochel *et al.* (in press). Components of phycological associated flora are found in Ferreira-Correia & Brandão (1974), Ferreira-Correia *et al.* (1977), Ferreira-Correia (1986) and Cutrim (1998).

There is a total lack of knowledge on the phycological flora in fringe red mangrove forest. Regarding the taxonomy of the Cyanophyceae, no studies on estuarine mangrove environments, such as those of Maranhão, have been published.

This paper provides the results obtained from a qualitative study of the Cyanophyceae growing on *Rhizophora* dominated mangroves at Mosquitos and Coqueiros estuaries, in the Maranhão State, Brazil.

MATERIAL AND METHODS

The Mosquitos strait separates São Luís Island from the continent. This strait is 5 km long and 104 m wide, extending from Southeast to Northwest, and linking the Arraial Bay with São Marcos Bay. The coordinates are latitude 2°38'12"S and longitude 44°23'35"W (Fig. 1).

Two sampling areas were chosen, and in each one, a vertical transect (seaward landward) was established. Along the transects, stations were marked at 100 m intervals, and samples collected

every 10 m. Algae were collected by scrapping the trunks and roots of *Rhizophora mangle* L, where they usually grow.

In each area, five points were taken, and 12 samples were made from each one, totaling 60 samples from the Mosquitos strait, and also 60 samples from the Coqueiros strait.

Samples were stored in polietilene bottles and preserved in 4% formaldehyde solution. They were finally deposited in the Biology Herbarium (HDB) of the Federal University of Maranhão.

The distribution of the species in Brazil, is presented by states.

The systems of classification used in this study were those by Anagnostidis & Komárek (1988) for Oscillatoriales, Komárek & Anagnostidis (1989) for Nostocales, and Komárek & Anagnostidis (1999) for Chroococcales.

RESULTS

The Cyanophyceae estuarine flora consisted of the taxa described as follow:

Chroococcales

Synechococcaceae

Aphanotheceidae

Aphanothece Näg., 1849

A. cf. castagnei (Bréb.) Rabh.

Flor. Eur. Alg., II: 64, 1865.

Basionym: *Palmella castagnei* Kütz., Tab. Phyc., 1:9, 1846. (Fig. 2)

Colonies amorphous, mucilaginous, limous, blue-green or dark, with more or less densely and irregularly arranged cells, near the colonial margin regularly surrounded by their own, usually slightly lamellate and yellowish brown envelopes; cells oval or cylindrical, with widely rounded ends, 4-6.3 × 2.3-3.6 µm.

Material examined: Mosquitos and Coqueiros estuaries. Mosquitos Estuary: HDB1540, 1543, 1553 and 1557; Coqueiros Estuary: HDB1567, 1587 and 1612.

Distribution in Brazil: Distrito Federal (Senna, 1992); Pernambuco (Mora, 1990), Rio de Janeiro (Neves, 1988, 1991); Rio Grande do Sul (Franceschini, 1991); São Paulo (Sant'Anna *et al.*, 1991; Branco *et al.*, 1996).

Comments: According Komárek & Anagnostidis (1999), *Aphanothece castagnei* does not occur in aquatic biotops; this statement has made the

accurate identification of the species more difficult. However, the material studied showed the same habitat conditions as described by Branco *et al.* (1996), in Rio de Janeiro and São Paulo States: plant massed formed on the mud accumulated on plantlets.

A. cf. stagnina (Sprengel) A. Braun.
Rabenh., Flor. Eur. Alg., 2:66, 1863. (Figs. 5 and 6)

Colonies macroscopic, gelatinous, with distinct, firmly delimited margin, spherical or irregularly elongate and lobate, usually consisting of subcolonies, to 1.0 cm in diameter; sheath blue-green or dark homogeneous, with inner calcareous crystals; cells oval to widely cylindrical, $4.6-6.1 \times 2.2-2.7 \mu\text{m}$, dense or loosely dispersed cells in the

surroundings of the colony, and loosely dispersed cells in the center of colony.

Material examined: Mosquitos Estuary: HDB1548, 1562; Coqueiros Estuary: HDB1565, 1575, 1601 and 1613.

Distribution in Brazil: Distrito Federal (Cronberg, 1978), Minas Gerais (Sant'Anna, 1984); Rio de Janeiro (Neves, 1983, 1990); Rio Grande do Sul (Coutinho, 1982; Werner, 1984; Franceschini, 1991; Werner & Rosa, 1992).

Comments: Material periphytic, living on mangrove macroalgae. Komárek & Anagnostidis (1999) stated that material from marine water or mangrove are questionable and need confirmation.

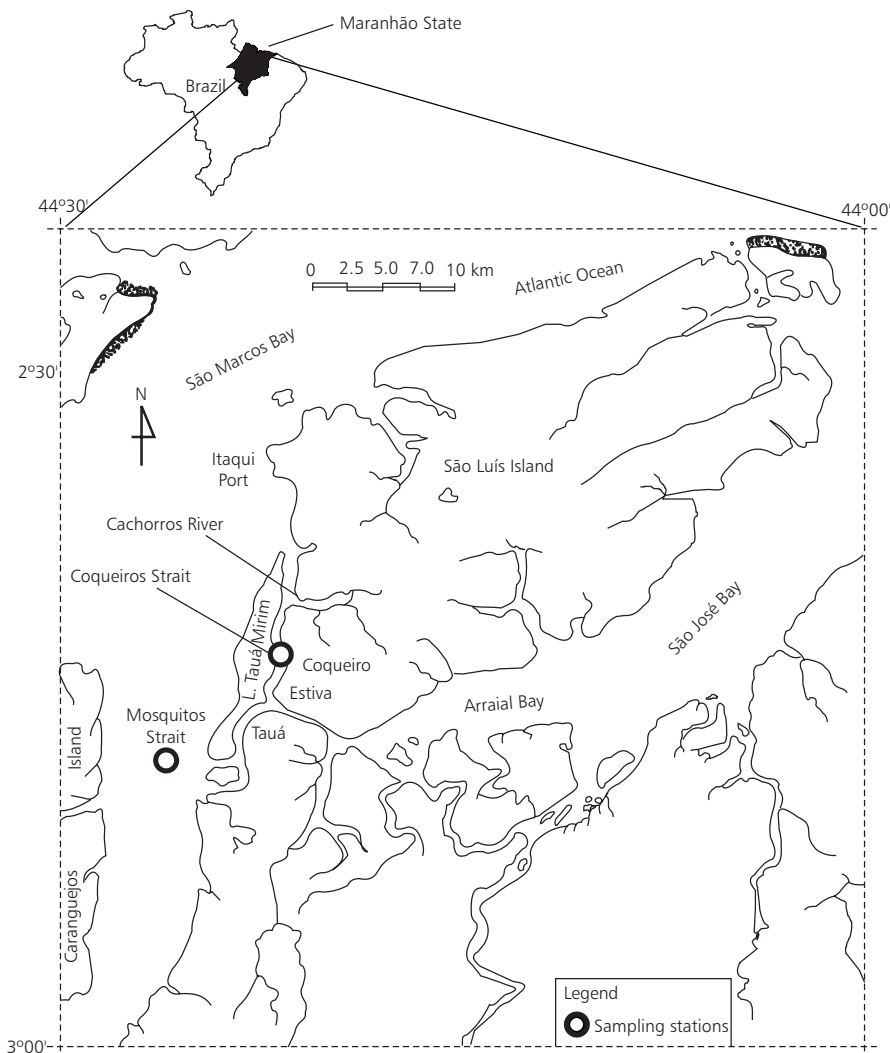


Fig. 1 — Location of the sampling stations.

Because of this, the specimen studied could not be accurately identified.

Chroococcaceae

Gloeocapsopsis Geit. ex Kom. 1993.

G. crepidinum (Thur.) Geit. ex Kom. 1993.

Basionym: *Gloeocapsa crepidinum* Thur. (Figs. 3 and 4)

Colonies formed by cells in 2-4 set groupings, round or ovoid, 12.0-14.0 μm diameter; sheath yellow or dark in the outer part and colourless or difluent inside, without lamellas; cells round rare but thickly arranged in the peripheric region and spread out at the centre, 1.8-4 μm diameter.

Material examined: Mosquitos Estuary: HDB1539, 1545 and 1561.

Distribution in Brazil: Rio de Janeiro (Neves, 1988, 1991); Rio Grande do Sul (Coutinho, 1982); São Paulo (Sant'Anna, 1995; Sant'Anna *et al.*, 1995).

Hyellaceae

Hyelloideae

Pleurocapsa sp. (Fig. 8)

Almost gelatinous colonies of varied size and forms; mutually pressed spherical or angular cells; blue-greenish, olive green, yellow or violet cellular content.

Material examined: Mosquitos Estuary: HDB1537, 1555; Coqueiros Estuary: HDB1572, 1580, 1585, 1597 and 1608.

Comments: The material was not identified at the specific level because it was insufficient, so it was impossible to measure it.

Xenococcaceae

Xenococcus Thur. in Born. et Thur. 1880.

X. pyriformis Setch. et Gardn. in Gardn. 1918.

University of California Publications in Botany, 6:436, 1918. (Figs. 7 and 9)

Colonies small, shining, blue-green, singular or occasionally coalescent, 9.0-11.0 μm long, 5.4 μm diameter; sheath conspicuous, dense, hyaline; cells slight angular when young, and pyriforms subsphericals when adult; same bacocyte angle and size for all cells, gonads formed by successive divisions.

Material examined: Mosquitos Estuary: HDB1536, 1550 and 1558; Coqueiros Estuary: HDB1566, 1576, 1590, 1603 and 1609.

Distribution in Brazil: São Paulo (Sant'Anna *et al.*, 1985).

Scytonemataceae

Scytonema Born. et Flah. ex C. Ag. 1887.

S. arcangeli Born. et Flah.

Ann. Sci. Nat. series Bot., 7(5):92, 1887. (Figs. 10, 11 and 13)

Plant mass blue green; filaments loosely entangled, 14.9-18.3 μm broad; false branches in pairs and single, frequent; sheath homogeneous or with parallel layers, colourless to brownish; some parts of the trichomes constricted; 9.5-15.0 μm broad; cells 5.3-8.0 μm long, contents blue-green; heterocytes intercalary, round or squarish, 6.8-10.9 μm long, 7.4-10.0 μm broad.

Material examined: Mosquitos Estuary: HDB1534 and 1535; Coqueiros Estuary: HDB1568, 1579, 1593, 1596 and 1607.

Distribution in Brazil: São Paulo (Sant'Anna, 1988; Branco, 1991).

S. insulare Sant'Anna.

Nova Hedwigia, 46(3-4):528, 1988. (Figs. 12, 14 and 15)

Plant mass blue-green; filaments tightly entangled, 9.7-12.0 μm broad; false branches in pairs, parallel, frequent; sheath firm, homogeneous; trichomes generally constricted and slightly attenuated at the apex, cells 4.0-7.8 μm long, 5.2-6.2 μm broad; heterocytes intercalary, squarish, cylindrical or sometimes rounded, 4.0-8.0 μm long, 4.0-7.6 μm broad.

Material examined: Mosquitos Estuary: HDB1534, 1546 and 1554; Coqueiros Estuary: HDB1556, 1563, 1574, 1584, 1594 and 1605.

Distribution in Brazil: São Paulo (Sant'Anna, 1988; Branco, 1991).

Oscillatoriales

Phormidiaceae

Porphyrosiphon Kütz. ex Gom. 1892.

P. luteus (Gom.) Anagn. et Kom.

Basionym: *Lyngbya lutea* Gom.

Ann. Sci. Nat., 16:141, 1892. (Figs. 18 and 19)

Filaments solitary or entangled 5.3-7.0 μm broad, above 3 μm long; sheath hyaline, homogeneous; trichomes straight, not attenuated, not constricted, 4.0-4.2 μm broad; cells 1.2-1.3 times shorter than broad, 3.1-4.7 μm long; cross walls not granulated; cell content blue-green, homogeneous; apical cell rounded-conical, with or without thickened outer membrane.

Material examined: Coqueiros Estuary.



Fig. 2 — *Aphanothece castagnei* (Bréb.) Rabh. **Figs. 3-4** — *Gloeocapsopsis crepidinum* (Thur.) Geit. ex Kom. **Figs. 5-6** — *Aphanothece* cf. *stagnina* (Spreng) A. Braun — colony growing on *B. calliptera* (Montagne) Montagne. **Fig. 7** and **9** — *Xenococcus pyriformes* Setchell et Gardner. **Fig. 8** — *Pleurocapsa* sp. (Figs. 2-6: scale bars represent 10 μm ; Figs. 8-9: scale bars represent 60 μm).

Distribution in Brazil: Rio de Janeiro (Neves, 1988); Rio Grande do Sul (Coutinho, 1982); São Paulo (Sant'Anna *et al.*, 1985; Branco *et al.*, 1997; Sant'Anna & Simonetti, 1992; Sant'Anna, 1995).

Comments: The material wasn't deposited in herbarium because it was insufficient.

Oscillatoriaceae

Lyngbya C. Ag. ex Gom. 1824.

L. aestuarii Lieb. ex Gom.

Ann. Sci. Nat., 16:127, 1892. (Figs. 20 and 21)

Mass slightly green; filaments caespitose, 17.4-30.0 μm broad; sheaths hialine, homogeneous or lamellated, 2.0-6.2 μm width; trichomes constricted, 8.8-15.7 μm broad; cells round, 4 times

wider than long, 1.9-5.3 μm long; content blue-green; cross walls granulated or not; apex usually not thickened.

Material examined: Mosquitos Estuary: HDB1533 and 1552; Coqueiros Estuary: HDB1578, 1589 and HDB1599.

Distribution in Brazil: São Paulo (Sant'Anna *et al.*, 1985; Neves & Tribuzi, 1992; Azevedo & Sant'Anna, 1993).

Pseudanabaenaceae

Leptolyngbyoideae

Leibleinia (Gom.) L. Hoffm, 1985.

L. pellucida (Umezaki) Branco, Sant'Anna, Azevedo & Sormus.

Basionym: *Lyngbya pellucida* Umezaki.

Bot. Mag., 68(801):68, 1955. (Figs. 16 and 17)

Filaments solitary, 2.5-3.0 µm broad; sheath hyaline, homogeneous; trichome straight or curve, not attenuated, not constricted, 1.6-1.8 µm broad; cells 1.2 to 1.3 times longer than wider, 1.5-2.1 µm long; cross walls not granulated, pellucid; cell content green, homogeneous; apical cell conical rounded, without thickened outer membrane.

Material examined: Mosquitos Estuary: HDB1541 and 1560; Coqueiros Estuary: HDB1577, 1588, 1604 and HDB1610.

Distribution in Brazil: São Paulo (Sant'Anna *et al.*, 1985; Branco *et al.*, 1997; Sant'Anna & Simonetti, 1992).

Microcoleus Gom. ex Desma. 1892.

M. chthonoplastes Gom.

Ann. Sci. Nat., 15:253, 1892. (Figs. 22-24)

Filaments solitary or just a few together, 25.9-36.0 µm broad; sheath broad, hyaline; trichomes constricted, not attenuated; cell content green, homogeneous; apical cell rounded-conical, without thickened outer membrane.

Material examined: Mosquitos Estuary: HDB1538, 1541 and 1560; Coqueiros Estuary: HDB1564, 1583, 1591 and 1606.

Distribution in Brazil: Rio de Janeiro (Neves, 1983, 1990, 1992; Neves & Tribuzi, 1992); Rio Grande do Sul (Coutinho, 1982); Santa Catarina (Möebius, 1889; Drouet, 1937); São Paulo (Sant'Anna *et al.*, 1985; Branco *et al.*, 1997; Sant'Anna & Simonetti, 1992).

Comments: The length and width of the trichomes were not measured because the material was insufficient.

M. tenerimus Gom.

Ann. Sci. Nat., 15:355, 1892. (Figs. 25 and 26)

Filaments solitary or few together; sheath broad, hyaline; trichomes slightly constricted, not attenuated; cells 3 times longer than wider, 4.8-7.0 × 1.6-2.6 µm; cell content blue-green to green, homogeneous; apical cell acicular, long, sometimes curved, without thickened outer membrane.

Material examined: Mosquitos Estuary: HDB1544; Coqueiros Estuary: HDB1571, 1582, 1592 and HDB1595.

Distribution in Brazil: Rio Grande do Sul (Coutinho, 1982); São Paulo (Branco *et al.*, 1997).

Phormidium Kütz. ex Gom. 1892.

P. corallinae (Gom. ex Gom.) Anagn. et Kom.

Basionym: *Oscillatoria corallinae* Gom.

Ann. Sci. Nat., 16:218, 1892. (Figs. 27-30)

Trichomes, isolated, not attenuated, 6.4-6.8 µm broad; cells 2-3 times longer than wider, 2.2-3.4 µm long; blue-green content, cross walls finely granulated or not; apical cell rounded, slightly twisted; slender apex.

Material examined: Coqueiros Estuary (HDB1569).

Distribution in Brazil: Rio de Janeiro (Neves & Tribuzi, 1992); São Paulo (Sant'Anna *et al.*, 1985; Sant'Anna & Simonetti, 1992).

Pseudanabaenaceae

Leptolyngbyoideae

Leptolyngbya Anagn. & Kom. 1988.

L. cf. fragilis (Gom) Anagn. & Kom.

Basionym: *Phormidium fragile* Gomont. (Figs. 31-33)

Filaments mucilaginous, lamellated, yellowish or brownish blue-green; sheath diffuent; trichomes more or less flexuous, distinctly constricted, septa not granulated, attenuated at the ends, 3.4-4.0 µm broad; cells nearly quadrate, 2.5-3.0 µm long, end cell acute-conical, calyptra absent.

Material examined: Coqueiros Estuary.

Distribution in Brazil: Rio Grande do Sul (Coutinho, 1982).

Comments: This species was not identified with accuracy because of the diameter of trichomes. Our material presents trichomes with diameter higher than the studied by Desikachary (1959) but, it occur in the same habitat, estuary water.

The material was not deposited in the herbarium because it was insufficient.

L. crosbyana (Til.) Anagn. et Kom.

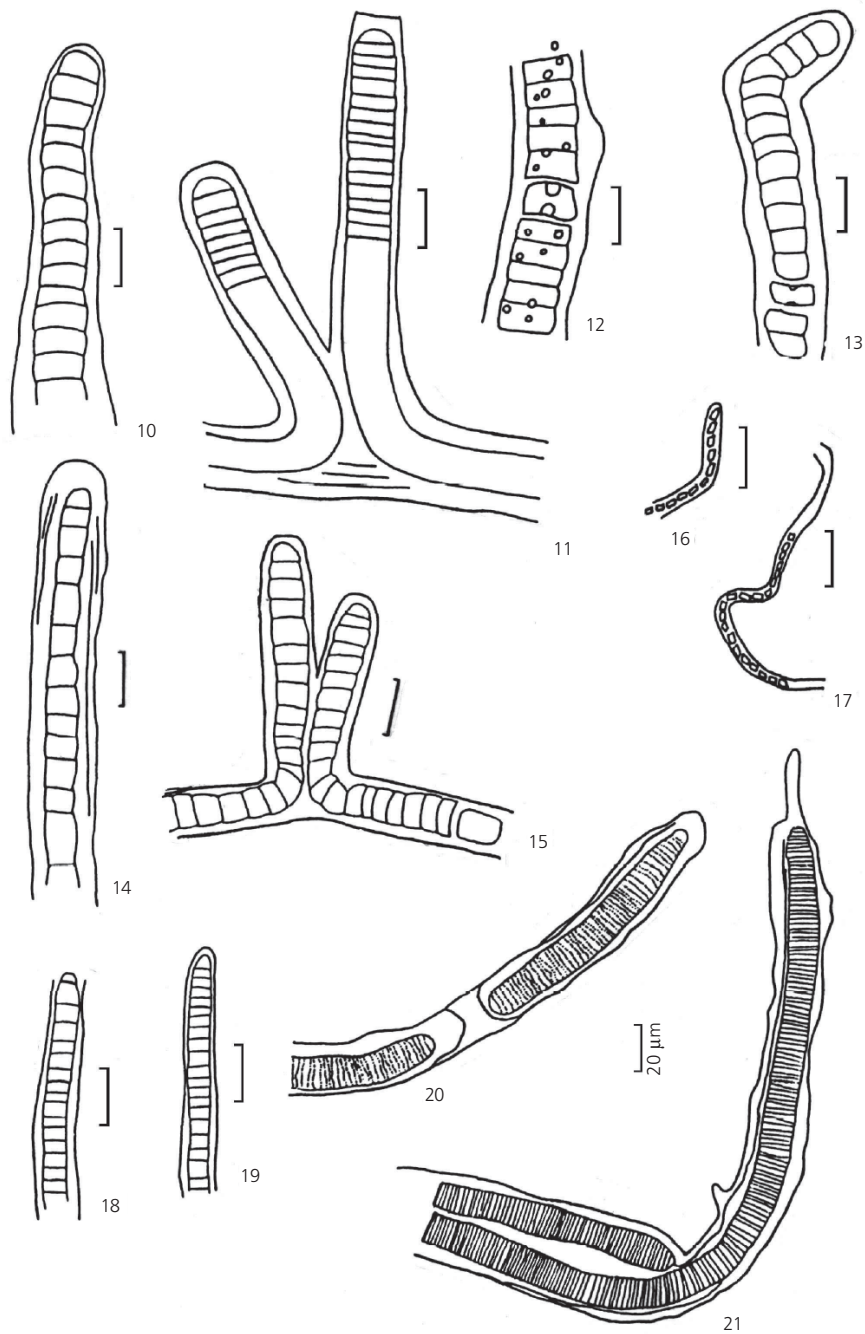
Basionym: *Phormidium crosbyanum* Tilden. (Fig. 34)

Filaments solitary, 2.0-4.0 µm broad; sheath hyaline, delicate, homogeneous; trichomes tarnished brown, not attenuated, not constricted, 1.9-2.5 µm broad; cells 1.9 times longer than wider, 3.6-7 µm long; apical cell conical-rounded, without calyptra.

Material examined: Coqueiros Estuary.

Distribution in Brazil: reported for the first time for Brazil.

Comments: The material was not deposited in the herbarium because it was insufficient.



Figs. 10, 11 and 13 — *Scytonema arcangeli* Bornet et Flahault. **Fig. 10** — Rounded apex; **11** — False branched; **13** — Trichome with intercalary heterocyte. **Figs. 12, 14 and 15** — *Scytonema insulare* Sant'Anna. **12** — Trichome with intercalary, square heterocyte; **14** — Rounded apical cell; **15** — False branched. **Figs. 16-17** — *Leibleinia pellucida* (Umezaki) Branco, Sant'Anna, Azevedo & Sormus. **Figs. 18-19** — *Porphyrosiphon luteus* (Gomont) Anagnostidis et Komárek. **18** — Apical cell conical; **19** — Apical cell rounded. **Figs. 20-21** — *Lyngbya aestuarii* Liebmann ex Gomont. **20** — Filament with hormogonio and granulated cross-wall; **21** — Filaments with two trichomes. (Figs. 10-19: scale bars represent 10 μ m; Figs. 20-21: scale bars represent 20 μ m).

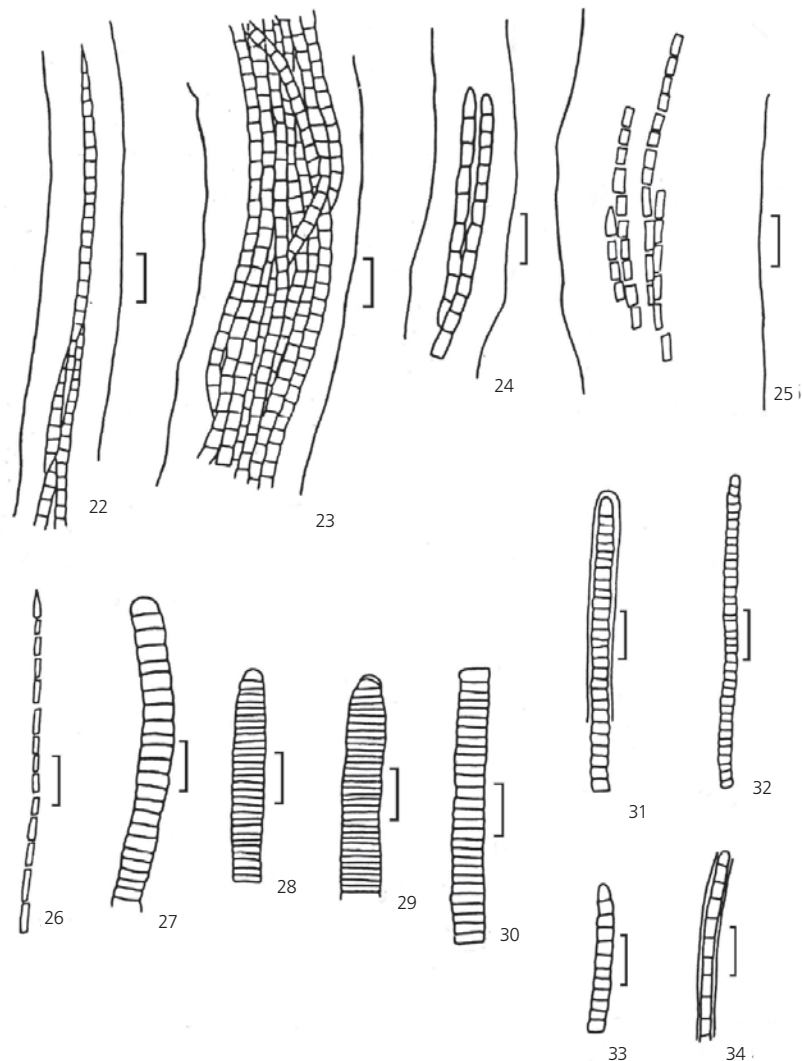


Fig. 22-24 — *Microcoleus chthonoplastes* Gomont. **Fig. 22** — Acuminated apex; **23** — Many trichomes in a wide sheath; **24** — Apical cell conic. **Fig. 25-26** — *Microcoleus tenerrimus* Gomont. **Fig. 25** — Trichomes in a wide sheath; **26** — Apical cell acute. **Fig. 27-30** — *Phormidium corallinae* Gomont. **Fig. 27** — General aspect; **28** — Apical cell conical; **29** — Apical cell with thickened outer membrane. **Fig. 31-33** — *Leptolyngbya* cf. *fragilis* (Gomont) Anagnostidis & Komárek. **Fig. 31** — Trichome with a hyaline sheath; **32** — Trichome general aspect; **33** — Rounded apical cell. **Fig. 34** — *Leptolyngbya crosbyana* (Tilden) Anagnostidis & Komárek. (Scale bars represent 10 μ m.)

CONCLUSIONS

A total of 15 species of algae growing on the trunks and roots of *Rhizophora mangle* L. were examined. These species were distributed within the families, as follows: Synechococcaceae (2), Chroococcaceae (1), Hyellaceae (1), Xenococcaceae (1), Oscillatoriaceae (1), Scytonemataceae (2), Phormidiaceae (5) and Pseudanabaenaceae (2).

Among the species identified, *Leptolyngbya crosbyana* Tilden is reported for the first time for Brazil, and the other fourteen (14) species are cited for the first time for Maranhão. The species occurring in most of the samples were *Scytonema insulare* Sant'Anna, *Scytonema arcangelii* Bornet et Flahault, *Microcoleus chthonoplastes* Thuret ex Gomont, *Leibleinia pellucida* (Umezaki) Branco, Sant'Anna, Azevedo & Sormus e *Pleurocapsa* sp.

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