First records of Zygnematales (Zygnematophyceae, Streptophyta) for the state of Bahia, Brazil

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ABSTRACT
This study presents the first taxonomic inventory of the order Zygnematales in the Litoral Norte Environmentally Protected Area, in the state of Bahia, Brazil. Fifty samples of planktonic and periphytic material were collected, from lotic and lentic environments, during the summer (January-March) and winter (June-August) of 2009. We identified 18 taxa distributed among five genera (Cylindrocystis, Mougeotia, Netrium, Spirogyra, and Spirotaenia). Of those 18 taxa, eight were new additions to the Brazilian desmid flora: Mougeotia calcarea; Mougeotia elegantula; Spirogyra gracilis; Cylindrocystis crassa var. elliptica; Cylindrocystis brebissonii var. minor; Cylindrocystis brebissonii var. turgida; Netrium digitus var. parvum; and Netrium oblongum var. oblongum. The geographical distributions of ten taxa were extended to include northeastern Brazil.

Key words: Brazil, continental microalgae, desmids, Streptophyta, taxonomy

Introduction
Zygnematales (Zygnematophyceae, Streptophyta) are characterized by having cell walls composed of a single unit, without pores or other ornamentations. The order comprises approximately 1000 species and 20 genera distributed between two families: Zygnemataceae, comprising 13 filamentous genera whose cells are united at their poles to form filaments; and Mesotaeniaceae (known as saccoderm desmids), comprising seven genera, composed of individual unicellular algae that sometimes form amorphous colonies within an abundant muclaginous matrix (Gerrath 1993; Parra & Bicudo 1996; Graham et al. 2009).

To our knowledge, there have been no previous studies of the order Zygnematales in the state of Bahia, Brazil. Therefore, the present study sought to undertake the first taxonomic inventory of genera of the order within the state, with the objective of increasing the knowledge of this taxon in Brazil.

Materials and methods
The Litoral Norte Environmentally Protected Area (EPA) was created by State Decree no. 1.046, on March 17, 1992. The Litoral Norte EPA covers a coastal strip approximately 144 km long and 10 km wide (Fig. 1), including five municipalities (Jandaira, Esplanada, Conde, Entre Rios, and Mata de São João), thus constituting the second-largest EPA in the state of Bahia. Fifty periphytic and planktonic algae samples were collected, from lotic and lentic environments, in the summer (January-March) and winter (June-August) of 2009. The collections were made following standard methodologies used in taxonomic studies of continental microalgae (Bicudo & Menezes 2006).

The metric characteristics of the populations were determined using an ocular micrometer. Photomicrographs were obtained using a digital camera coupled to an optical microscope, and species identifications were based on the specialized literature.

Samples were preserved in Transeau’s solution, following Bicudo & Menezes (2006), and incorporated into the liquid collection at the Herbarium of the (Bahia) State University of Feira de Santana (code, HUEFS).

Results and discussion
Analyses of the 50 samples allowed the identification of 18 taxa among five genera, of which two belonged to the family Zygnemataceae (Mougeotia and Spirogyra) and three belonged to the family Mesotaeniaceae (Cylindrocystis, Netrium, and Spirotaenia).

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Ivania Batista de Oliveira, Carlos Eduardo de Mattos Bicudo and Carlos Wallace do Nascimento Moura

**Mougeotia C.Agardh**


Fig. 2 and 3.

Simple filaments, vegetative cells 11-12.4 times longer than wide, 145-200 μm long, 12-17.5 μm wide, lateral margins parallel, straight, smooth, septum region lenticular, angles subquadratic; cell walls hyaline, smooth; chloroplast axial, laminar, pyrenoids 4-5; zygospores 25-30 μm diam., circular outlines, walls smooth, colorless, or light yellow.

Distribution in Brazil: Bahia (present study).

Material selected: **Brazil. Bahia:** Conde, EPA Litoral Norte, 12/VII/2009, Oliveira et al. s.n. (HUEFS 155723); 02/ VIII/2009, Oliveira & Moura s.n. (HUEFS 155796, HUEFS 155799, HUEFS 155815).

*Mougeotia elegantula* demonstrates conjugation of the scalariform type, with quadratic zygospores, cruciate with rounded angles. In terms of its morphology, *M. elegantula* can be compared to *M. virescens* (Hassall) Borge, although differing from the latter by having larger zygospores with deeply concave sides, and larger vegetative cells.


*Mesocarpus gotlandicus* Cleve, Monogr. öf. Zygn. 31. 1868.

Fig. 6.

Simple filaments, vegetative cells 4-8 times longer than wide, 67.5-165 μm long, 16-20 μm wide, lateral margins parallel, straight, smooth; septum region straight; cell walls hyaline, smooth; neither chloroplasts nor pyrenoids were observed; zygospore 30-35 μm diam., outline circular-ovate, wall smooth, hyaline.

Distribution in Brazil: São Paulo (Pereira & Branco 2010), Bahia (present study).


*Mougeotia cf. gotlandica* shows scalariform type conjugation, with globose zygospores. We only tentatively identified the present material due to the absence of chloroplasts in the cells and only small numbers of specimens in the samples.

**Spirogyra Link**


Fig. 7 and 8.

Simple filaments, vegetative cells 2.8-4 times longer than wide, 75-100 μm long, 22-25 μm wide, lateral margins parallel, straight, smooth, septum region straight, cell walls hyaline, smooth; chloroplasts 2, ribbon-like, parietal, helicoidal, with 3-4 twists, various pyrenoids in each chloroplast; zygospores 55-58 μm long, 32.5-35 μm wide; outline ellipsoidal, cell walls smooth, brownish.

Distribution in Brazil: Bahia (present study).

Material selected: **Brazil. Bahia:** Conde, EPA Litoral Norte, 11/I/2009, Oliveira & Moura s.n. (HUEFS 155603); 15/II/2009, Oliveira & Moura s.n. (HUEFS 155637); 01/
First records of Zygnematales (Zygnematophyceae, Streptophyta) for the state of Bahia, Brazil


Morphologically, Spirogyra gracilis can be compared to S. acantophora (Skuja) Czurda but differs from it by having larger vegetative and reproductive cells and zygospores with irregular and spiny walls. During the analyses of S. gracilis, we observed some specimens in the process of scalariform conjugation, with swollen gametangia and ellipsoidal zygospores with rounded poles.

Cylindrocystis Meneghini ex Ralfs
Cylindrocystis brebissonii Menegh. ex De Bary var. brebissonii, Unter. Conjugaten. 35, pl. 7, fig. E1-22. 1858. Fig. 9 and 10.

Cells 3.5-4 times longer than wide, 70-90 μm long, 20-22.5 μm wide, lateral margins parallel, poles truncate-rounded; cell walls smooth; 2 axial chloroplasts, star-shaped in transversal section, lamellate, 1 pyrenoid per chloroplast. Distribution in Brazil: Amazonas (Förster 1969; Scott et al. 1965); Bahia (present study); Minas Gerais (Wille 1884).

Cylindrocystis brebissonii Menegh. ex De Bary var. minor
Fig. 11. Cells 1.7-2 times longer than wide, 30-35 μm long, 16-17.5 μm wide, lateral margins parallel, poles truncate-rounded; cell walls smooth; 2 axial chloroplasts, star-shaped in transversal section; 1 pyrenoid per chloroplast. Distribution in Brazil: Bahia (present study).


Cylindrocystis brebissonii var. minor differs from the typical variety of this species only by having smaller cell dimensions (47.3-71 x 14-14.4 μm) for samples from the state of Paraná as compared with those from Bahia.

Cylindrocystis crassa var. crassa De Bary var. crassa, Unter. Conjugaten. 37, pl. 7C, fig. 1-12. 1858.

Fig. 13. Cells 1.4-1.5 times longer than wide, 30-32.5 μm long, 20-22.5 μm wide, poles rounded; lateral margins straight, parallel to each other, cell walls smooth; 2 axial chloroplasts, star-shaped in transversal section, 1 pyrenoid per chloroplast.

Distribution in Brazil: Amazonas ( Förster 1969); Bahia (present study); Pará ( Förster 1969).


During the current study, specimens of Cylindrocystis crassa var. crassa always occurred isolated and never within a mucilaginous sheath as often described in the literature. Förster (1969) reported specimens from the Amazon with smaller dimensions (23 x 18 μm) than those encountered in the present study.

Cylindrocystis crassa De Bary var. elliptica West & G.S. West, Trans. Linn. Soc. London: ser. 2, 5: 48, pl. 5, fig. 27. 1895.

Fig. 14-16. Cells 1.2-1.3 times longer than wide, 25-27.5 μm long, 18.5-22.5 μm wide, margins smooth, poles widely rounded; cell walls smooth; 2 axial chloroplasts, star-shaped in transversal section, with prominent longitudinal projections, 1 pyrenoid, central.

Distribution in Brazil: Bahia (present study).


Cylindrocystis crassa var. elliptica differs from the typical variety of this species by having subcircular cells with widely rounded poles. In terms of its morphology, this variety can be confused with Mesotaenium chlamydosporum De Bary var. violascens (De Bary) Willi Krieger, although the latter has smooth and straight parietal laminar chloroplasts, and its cell walls are violet colored.

Netrium (Nägeli) Itzigsohn & Rothe emend. Lütke. Netrium digitus (Ralfs) Itzigsohn & Rothe var. digitus, In Rabenhorst, Alg. Sachsen n° 508. 1856. Pennium digitus Ralfs, Brit. Desm.: 150, pl. 25, fig. 3. 1848. Fig. 17.

Cells straight, fusiform-truncated, 4-5.8 times longer than wide, 150-320 μm long, 37.5-55 μm wide, gradually narrowing towards the apex, poles truncate-rounded, lateral margins equally convex; cell walls smooth; 2 axial chloroplasts, with prominent and denticulate longitudinal projections, pyrenoids 2-3 in median series per chloroplast.

Distribution in Brazil: Amazonas (Scott et al. 1965); Bahia (present study); Mato Grosso (De-Lamonica-Freire &
First records of Zygnematales (Zygnematophyceae, Streptophyta) for the state of Bahia, Brazil


**Netrium digitus** var. *digitus* can be identified relatively easily due to a number of unique characteristics, such as the fusiform-truncated shape of its cells; smooth, hyaline cell walls; and chloroplasts with denticulate projections. Felisberto & Rodrigues (2008) reported smaller cell dimensions (133-146 × 35-38 μm) than those found in Bahia.


Fig. 18.

Cells straight, elliptical-elongated, 4.5-5.5 times longer than wide, 202.5-280 μm long, 44-50 μm wide, slight median constriction, lateral margins subparallel to each other, poles rounded; cell walls smooth; 2 axial chloroplasts, with prominent lateral projections, pyrenoids 2-3 in median series per chloroplast.

Distribution in Brazil: Bahia (present study); Pará (Grönblad 1945; Scott et al. 1965); Rio Grande do Sul (Borge 1903); São Paulo (Bicudo 1969).


**Netrium digitus** var. *lamellosum* differs from the typical variety of the species by having smaller and relatively narrow cells, although it is sometimes difficult to establish limits between the two varieties given the existence of intermediate forms. Bicudo (1969) reported smaller cell dimensions (85-120 × 23.5-33.5 μm) for material collected in the state of São Paulo as compared with the material collected in Bahia.


Fig. 20.

Cells fusiform, 2.5-2.6 times longer than wide, 100-110 μm long, 39-42.5 μm wide, lateral margins more or less parallel to each other, poles truncate-rounded; cell walls smooth; 2 axial chloroplasts, with prominent lateral projections, 2-3 pyrenoids in median series per chloroplast.

Distribution in Brazil: Bahia (present study).


The differences between the *parvum* variety and the typical variety of this species are its truncate-rounded poles, chloroplasts with prominent lateral projections, and relatively smaller cell dimensions.

The var. *parvum* could be initially confused with Closterrium closterioides (Ralfs) Louis & Peeters var. *intermedium* (Roy & Bisset) Růžička, although the latter has lamellate chloroplasts and apical vacuole containing one or more granules of calcium sulfate.


**Penium interruptum** Bréb. ex Ralfs, Brit. Desmidiaceae. 151, pl. 25, fig. 4. 1848.

Fig. 21.

Cells cylindrical, 5-5.4 times longer than wide, 125-135 μm long, 25 μm wide, apex 12.5 μm wide, lateral margins straight, parallel to each other, narrowing towards the apex, poles rounded; cell walls smooth; 2 axial chloroplasts per semicell, lamellate; pyrenoids 4 in each chloroplast.

Distribution in Brazil: Amazonas (Scott et al. 1965); Bahia (present study).
First records of Zygnematales (Zygennematophyceae, Streptophyta) for the state of Bahia, Brazil


Scott et al. (1965) and Croasdale & Flint (1986) identified specimens with smaller cell dimensions (330 × 34 μm and 150-400 × 30-82 μm, respectively) than the material collected in Bahia.


Fig. 22.

Cells cylindrical, 3.4-4.4 times longer than wide, 85-110 μm long, ca. 25 μm wide, apex ca. 12.5 μm wide, lateral margins straight, parallel to each other, narrowing slightly towards the apex, poles truncated; cell walls smooth; 2 axial chloroplasts in each semicell, lamellate, pyrenoids 4 in each chloroplast.

Distribution in Brazil: Bahia (present study); Pará (Förster 1969); Rio de Janeiro (Bicudo & Picelli-Vicentim 1988); São Paulo (Bicudo 1969).


Netrium interruptum var. minor differs from the typical variety of the species only by having smaller cell dimensions.


Penium oblongum De Bary, Unter. Fam. Conjug. 73, pl. 7G, fig. 1, 3. 1858.

Fig. 23.

Cells oblong, 4.1-4.4 times longer than wide, 79-85 μm long, 18-20 μm wide, lateral margins straight, parallel to each other, narrowing toward the apex, poles truncate-rounded; cell walls smooth; 2 axial chloroplasts, with lamellae. Distribution in Brazil: Bahia (present study).


Netrium oblongum var. oblongum can be identified relatively easily because of unique characteristics, such as: (1) the oblong shape of its semicells; (2) chloroplasts with lamellae saw-edged along their entire length.

Netrium oblongum (De Bary) Lütkem. var. cylindricum West & G.S. West, J. Bot. 41: 40, pl. 446, fig. 10. 1903.

Fig. 24.

Cells cylindrical, 2.8-3 times longer than wide, 50-56 μm long, 17-19 μm wide, lateral margins straight, parallel to each other, narrowing slightly towards the apex, poles truncate-rounded; cell walls hyaline, smooth; 2 axial chloroplasts, with lamellae; pyrenoids 4 in each chloroplast. Distribution in Brazil: Amazonas (Förster 1969); Bahia (present study); São Paulo (Borge 1918).


Netrium oblongum var. cylindricum can be distinguished from the typical variety of the species by having more cylindrical cells, proportionately smaller cell dimensions, and poles that are more rounded.

Spirotaenia Bréb. in Ralfs

Spirotaenia condensata Bréb. ex Ralfs, Brit. Desm. 179, pl. 34, fig. 1. 1848.

Fig. 25.

Cells cylindrical, 8.5-9.5 times longer than wide, 120-190 μm long, 15-20 μm wide, lateral margins parallel to each other, smooth, poles rounded; cell walls hyaline, smooth; chloroplast ribbon-shaped, parietal, twisted 15 times, pyrenoids 2-3 in median series.

Distribution in Brazil: Amazonas (Förster 1969); Bahia (present study); Minas Gerais (Soares et al. 2007); Rio de Janeiro (Bicudo & Bicudo 1969).


Spirotaenia condensata can be identified relatively easily due to a number of unique characteristics: cells almost perfectly cylindrical; chloroplasts ribbon-shaped and wide, helicoidal; and poles rounded.

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