Cyanobacteria from two subtropical water bodies in southernmost Brazil

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ABSTRACT – The research aimed to study the cyanobacterial flora of an artificial pond and marsh at the Lutheran University of Brazil (Canoas, Rio Grande do Sul State), while understanding the distribution and environmental conditions where these species occur. Samples were collected monthly between November 2009 and October 2010. Twenty-four species were identified, highlighting the colonial forms (50%), with the predominance of the order *Chroococcales* (67%). The identified filamentous cyanobacteria belonged to *Oscillatoriales* (25%), *Nostocales* (17%) and *Pseudanabaenales* (8%). Out of all the identified species, only six [*Microcystis aeruginosa* (Kützing) Kützing *M. wesenbergi* (Komárek) Komárek, *Oscillatoria curviceps* Agardh *ex* Gomont, *O. tenuis* Agardh *ex* Gomont, *Cuspidothrix issatschenkoi* (Usačev) Rajaniemi *et al.* and *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju] were observed in both analyzed water bodies. Over the study period, *Cylindrospermopsis raciborskii* blooms occurred in the pond, while blooms of *Microcystis aeruginosa* were observed in the marsh in spring and summer.

Key words: artificial pond, environmental conditions, marsh, taxonomy

RESUMO – **Cianobactérias de dois corpos d'água subtropicais no extremo sul do Brasil.** O trabalho teve como objetivos estudar a flora de cianobactérias de um lago artificial e de um banhado da Universidade Luterana do Brasil (Canoas, Rio Grande do Sul) e conhecer a distribuição e as condições ambientais em que as espécies foram encontradas. As amostras foram obtidas, mensalmente, entre novembro de 2009 e outubro de 2010. Foram identificadas 24 espécies, destacando-se as formas coloniais (50%), com predominância da ordem *Chroococcales* (67%). As cianobactérias filamentosas registradas pertenciam às *Oscillatoriales* (25%), *Nostocales* (17%) e *Pseudanabaenales* (8%). Dentre as espécies identificadas, somente seis [*Microcystis aeruginosa* (Kützing) Kützing, *M. wesenbergi* (Komárek) Komárek, *Oscillatoria curviceps* Agardh *ex* Gomont, *O. tenuis* Agardh *ex* Gomont, *Cuspidothrix issatschenkoi* (Usačev) Rajaniemi *et al.* e *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju] foram observadas nos dois corpos d'água analisados. Florações de *Cylindrospermopsis raciborskii* ocorreram ao longo do período de estudo no lago artificial e de *Microcystis aeruginosa* foram observadas no banhado na primavera e verão.

Palavras-chaves: banhado, condições ambientais, lago artificial, taxonomia

INTRODUCTION

Cyanobacteria is a group of organisms of extreme ecological and health importance in aquatic ecosystems, especially in eutrophic environments. Besides being bioindicators, many species can cause great damage to the aquatic biota and associated community due to bloom formation and the potential to produce toxins. The increase of nutrient concentrations, especially nitrogen and phosphorus, provides excessive proliferation of certain species, forming the called water blooms.

The number of records of toxic cyanobacteria in different aquatic systems all over the world has been

increasing, including blooms that remain over the years (Briand *et al*. 2002, Yunes 2009). In subtropical water bodies of southern Brazil, dense blooms of *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju have been observed over the years (Komárková *et al*. 1999, Yunes *et al*. 2003), withstanding sudden changes in temperature and other environmental conditions.

Due to the observation of cyanobacterial blooms in water bodies of the Lutheran University of Brazil, Canoas, Rio Grande do Sul State, the present study aims the taxonomic analysis of cyanobacteria in order to know the biodiversity of the group inhabiting two aquatic systems of that University. This work also aims the study of the phenotypic variability of the identified species, and the characterization of environmental conditions where the species occurred.

MATERIAL AND METHODS

The studied samples were taken from two water bodies located on the campus Canoas of the Lutheran University of Brazil (ULBRA), in the Central Depression of Rio Grande do Sul State, southern Brazil. The climate of the region, according to the Köppen system, is Cfa type, a subtropical humid climate. Monthly samplings from November 2009 to October 2010 were undertaken at two sites [water inlet (site 1) and water outlet (site 2)] of an artificial pond (29° 53'13 "S and 51° 09'29, 9"W) and in one bank of a natural marsh (29 ° 53'31 "S and 51 ° 08'58 "W), called Central pond and Chimarrão marsh, respectively. (Fig. 1).

Planktic material was collected with a plankton net (30 μm mesh), and benthonic and submerged thallus were obtained with a spatula or with bare hands. All samples were preserved in formaldehyde 4% and deposited in Prof. Dr. R. Alarich H. Schultz Herbarium (HAS) at the Museu de Ciências Naturais da Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul state, Brazil.

Whenever possible, for each sampling station, the water temperature (°C) and the eletric conductivity ($\mu S.cm^{-1}$) were obtained with the help of a *Yellowspring (model 30) thermosalinometer*, and the pH, with a *Hach EC 10 pH Metter*. The total depth (cm) and the transparence (cm) were measured with a measuring tape and a Secchi disc, respectively. Ammonium ($\mu g\ L^{-1}$), nitrate ($mg\ L^{-1}$), dissolved oxygen ($mg\ L^{-1}$), oxygen saturation (%) and organic matter ($mgO_2\ L^{-1}$) were measured according to APHA (2005).

Both alive and preserved materials were analyzed using a compound light microscope. Whenever possible, at least 15 specimens of each species were measured. They were identified by analyzing the variability of morphological and metric characteristics of vegetative and reproductive lives of natural populations. The mucilaginous structure was evidenced using Indian ink. The photographs were taken from the ocular image using a digital camera *Sony DSC-W290 – 12.1MP*, and the specimens were drawn with the aid of a *camera lucida*. The Hoffmann *et al*. (2005) classification system modified by Komárek (2006) was adopted. Basionyms and synonyms (when pertinent), descriptions, comments and environmental conditions to each species are presented. Environmental conditions are referred with the following abbreviations: WT = water temperature; CON = conductance; AMM = ammonium; DO = dissolved oxygen; OS = oxygen saturation; OM = organic matter; NIT = nitrate; SECCHI = transparency; DEP=depth.

RESULTS AND DISCUSSION

In the aquatic systems studied on the campus Canoas of the Lutheran University of Brazil were registered representatives of cyanobacteria of the orders *Synechococcales* (4), *Pseudanabaenales* (2), *Chroococcales* (8), *Oscillatoriales* (6) and *Nostocales* (4), presented bellow.

Synechococcales
Synechococcaceae
Anathece (Komárek & Anagnostidis) Komárek, Kaštovský & Jezberová, Eur. J. Phycol., 46(3): 315-326. 2011.
Anathece minutissima (W. West) Komárek, Kaštovský & Jezberová, Eur. J. Phycol., 46(3): 322. 2011. *Microcystis minutissima* W. West, Proc. R. Ir. Acad., 31: 35. 1912. *Aphanothece minutissima* (W. West) Komárková-Legnerová & Cronberg, Algolog. Stud., 72: 24. 1994.

(Fig. 2)

Colonies irregular, with irregularly and more or less densely aggregated cells; mucilage colorless, diffluent; cells oval, 1.0-1.5 (-2.0) μm long, 0.7-0.9 μm wide; cell content homogeneous, blue-green, without aerotopes.

Comments: Recently Komárek *et al*. (2011) raised the subgenus *Anathece* to the genus level (*Anathece* Komárek *et al*.) based on its position in the

phylogenetic tree, ultrastructure of cells, morphology (size of cells), mucilage structure, life cycles, and ecology.

According to Komárek & Anagnostidis (1998), the species occurs free-floating in freshwater of temperate zones. Although the examined material was from a subtropical region, the population was identified as *Anathece minutissima* because it corresponds to the Scanian (Sweden) material described by Komárková-Legnerová & Cronberg (1994) and also to subtropical populations from South Brazil studied by Werner (2002), and by Martins *et al*. (2012). These populations were identified as *Aphanothece minutissima* (W. West) Komárkova-Legnerová & Cronberg.

The species was observed only in the plankton of the artificial pond, in samples collected in spring (November 2009) and in summer (February 2010).

Environmental conditions: (n=2) WT 22.7-28 °C ($\bar{X}$ = 25.4 ± 3.7); pH 6.3-6.5 ($\bar{X}$ = 6.4 ± 0.1); AMM 60-430 µg L^{-1} ($\bar{X}$ = 245 ± 262); DO 6-7.7 mg L^{-1} ($\bar{X}$ = 6.9 ± 1.2); OS 76.2-88 % ($\bar{X}$ = 82.1 ± 8.3); OM 9.5-10.0 mgO_2 L^{-1} ($\bar{X}$ = 9.8 ± 0.4); CON 81.5-100 µS cm^{-1} ($\bar{X}$ = 90.8 ± 13.1).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 2, 11/XI/2009, *L. M. Silva & V. R. Werner* (HAS 108646), 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108652).

Anathece smithii (Komárková-Legnerová & Cronberg) Komárek, Kaštovský & Jezberová, Eur. J. Phycol., 46(3): 322. 2011. *Aphanothece smithii* Komárková-Legnerová & Cronberg, Algolog. Stud., 72: 24. 1994.

(Fig. 8)

Colonies elongated or irregular, with more or less regularly arranged cells, distant from each other; mucilage colorless, diffluent; cells oval to cylindrical, 1.8-2.5 µm long, 1-1.6 µm wide; cell content homogeneous, bright blue-green, sometimes with small aerotopes.

Comments: The transference of *Aphanothece smithii* Komárková-Legnerová & Cronberg to the genus *Anathece* was based on the same criteria established for *Anathece minutissima*.

This species was observed only in the plankton of Central pond, among *Cylindrospermopsis raciborskii* blooms. It was found in samples collected in summer (March 2010) and in spring (October 2010).

Environmental conditions: (n=3) WT 22.2-26.2 °C ($\bar{X}$ = 24.2 ± 2); pH 7.5-8.4 ($\bar{X}$ = 8 ± 0.5); AMM 140-500 µg L^{-1} ($\bar{X}$ = 273 ± 197); NIT 1.1-1.3 mg L^{-1} ($\bar{X}$ = 1.2 ± 1); DO 8-8.3 mg L^{-1} ($\bar{X}$ = 8.1 ± 1.5); OS 97.6-99 % ($\bar{X}$ = 98.4 ± 0.7); OM 8.8-11.5 mgO_2 L^{-1} ($\bar{X}$ = 10.5 ± 1.5); CON 128-273.4 µS cm^{-1} ($\bar{X}$ = 222 ± 81.5); SECCHI 15-27 cm ($\bar{X}$ = 22.3 ± 6.4); DEP 40-190 cm ($\bar{X}$ = 138.3 ± 85.2).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 2, 18/III/2010, *L. M. Silva & V. R. Werner* (HAS 108654); sites 1, 2, 27/X/2010, *L. M. Silva & V. R. Werner* (HAS 108670, 108671).

Merismopediaceae

Merismopedia Meyen, N. Syst. Pflanzen-Physiol., 3: 440. 1838.

Merismopedia glauca (Ehrenberg) Kützing, Phycol. Germ., 142. 1845. *Gonium glaucum* Ehrenberg, Infusions, 58. 1838.

(Fig. 9)

Colonies tabular, flat, rectangular, cells distributed in regular rows, close to each other, forming groups of 16-64; mucilage homogeneous, colorless, diffluent; cells spherical or oblong, after division hemispheric, 4-5.5 µm diam.; cell content blue-green, without aerotopes.

Comments: *Merismopedia glauca* was observed in only one occasion in the plankton of the artificial pond in summer (February 2010), when the highest water temperature was recorded (28° C). According to Komárek & Anagnostidis (1998) this species usually occurs in metaphyton and benthos, and only occasionally in plankton. This fact may explain its rare occurrence in the planktic community.

Environmental conditions: (n=1) WT 28 °C; pH 6.7; AMM 400 µg L^{-1}; nitrate 1mg L^{-1}; DO 6.7 mg L^{-1}; OS 85.1 %; OM 9.5 mgO_2 L^{-1}; CON 80.9 µS cm^{-1}; SECCHI 30 cm; DEP 35 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651).

Merismopedia tenuissima Lemmermann, Bot. Zbl., 76: 154. 1898.

(Fig.10)

Colonies tabular, flat, quadrate, with cells distributed in regular rows, close to each other,

forming groups of 16 up to more than 100 cells; mucilage colorless, diffluent; cells small, rounded, after division hemispheric, 1.5-1.8 µm diam.; individual mucilaginous envelopes inconspicuous when present, cell content blue-green, without aerotopes.

Comments: According to Komárek & Anagnostidis (1998), *Merismopedia tenuissima* is probably cosmopolitan, common in European freshwater, particularly in the warm season of the year. Even though it is also common in freshwater of subtropical zones (Vera Regina Werner – personal communication), in the present study the species was observed only in fall (May 2010) in the plankton of Central pond.

Environmental conditions: (n=1) WT 18.9 °C; pH 6.6; AMM 500 µg L^{-1}; NIT 1 mg L^{-1}; DO 8.2 mg L^{-1}; OS 88.4 %; OM 9.8 mgO_2 L^{-1}; CON 143 µS cm^{-1} ; SECCHI 30 cm; DEP 175 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 2, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108658).

Pseudanabaenales
Pseudanabaenaceae
Geitlerinema (Anagnostidis & Komárek) Anagnostidis, Plant. Syst. Evol., 164: 33-46. 1989.
Geitlerinema splendidum (Greville *ex* Gomont) Anagnostidis, Plant. Syst. Evol., 164: 35. 1989. *Oscillatoria splendida* Greville *ex* Gomont, Ann. Sci. Nat., 16: 224. 1892.
(Figs. 3, 4)

Trichomes straight or slightly coiled, attenuated at the ends, not constricted, 2-3 µm wide; cross-walls thick, sometimes granulated (1-2); cells 1.5-3 times longer than wide, 3-7.5 µm long, apical cells hooked; cell content homogeneous, without aerotopes.

Comments: The species was observed in the metaphyton among *Salvinia* sp., only in one sample from Chimarrão marsh collected in winter (June 2010).

Environmental conditions: (n=1) WT 14.6 °C; pH 5.8; AMM 400 µg L^{-1}; NIT 1mg L^{-1}; DO 2 mg L^{-1}; OS 19.4 %; OM 8.5 mgO_2 L^{-1}; CON 134.5 µS cm^{-1}; SECCHI 20 cm; DEP 20 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 24/VI/2010, *L. M. Silva & V. R. Werner* (HAS 108711).
Planktolyngbya Anagnostidis & Komárek, Algolog. Stud., 50-53: 394. 1988.
Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová & Cronberg, Algolog. Stud., 67: 21-22. 1992. *Lyngbya limnetica* Lemmermann, ForschBer. Biol. Sta. Plön, 6(2): 202. 1898.
(Fig. 5)

Filaments solitary, slightly curved, 1-1.1 µm wide; sheath well-defined, thin, colorless, extending beyond the trichome at one or both ends; trichomes straight, not constricted, not attenuated, 0.9-1 µm wide; cross-walls slightly visible; cells cylindrical, 2-3.5 times longer than wide, 2-3.5 µm long, apical cells rounded; cell content blue-green, with evident granules (1-2), without aerotopes.

Comments: *Planktolyngbya limnetica* was recorded only in the plankton of the artificial pond. It was observed in samples from all seasons, except during winter.

Environmental conditions: (n=6) WT 18.9-28 °C ($\bar{X}$ = 24.4 ± 3.9); pH 5.6-7.8 ($\bar{X}$ = 6.6 ± 0.7); AMM µg L^{-1} 220-510 ($\bar{X}$ = 410 ± 105); NIT 1-1.1 mg L^{-1} ($\bar{X}$ = 1.01 ± 0.41); DO 6-9 mg L^{-1} ($\bar{X}$ = 7.6 ± 1.1); OS 76.2-99.2 % ($\bar{X}$ = 89.5 ± 8.7); OM 9.5-11.5 mgO_2 L^{-1} ($\bar{X}$ = 10 ± 0.8); CON 80.9-170 µS cm^{-1} ($\bar{X}$ = 119.4 ± 34.8); SECCHI 15-45 cm ($\bar{X}$ = 29.2 ± 9.7); DEP 35-180 cm ($\bar{X}$ = 106.7 ± 76.7).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, sites 1, 2, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651, 108652); site 1, 18/III/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108653); site 2, 15/IV/2010, *L. M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 108656); site 2, 14/V/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108658); site 2, 14/X/2010, *L. M. Silva & V.R. Werner* (HAS 108669).

Chroococcales
Gomphosphaeriaceae
Coelomoron Buell, Bull. Torrey Bot. Club, 65: 379. 1938.
Coelomoron microcystoides Komárek, Folia Geobot. Phytotax., 30: 85. 1989.
(Fig. 11)

Colonies irregular, with cells disposed in the periphery of colonies; mucilage thin, diffluent; cells obovoid, without mucilaginous stalk system, 2.5-3.2 µm long, 2-3 µm wide; cell content blue-green, without aerotopes.

Comments: The species was observed in the plankton of the artificial pond only in one sample collected during spring (November 2009).

Environmental conditions: (n=1) WT 22.8 °C; pH 6.3; AMM 60 μg L^{-1}; DO 6.4 mg L^{-1}; OS 73.2 %; OM 10 mgO_2 L^{-1}; CON 94.8 μS cm^{-1}.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 11/XI/2009, *L. M. Silva & V. R. Werner* (HAS 108645).

Snowella Elenkin, Monogr. Algarum Cyanophyc., Pars Spec., 1: 278. 1938.
Snowella lacustris (Chodat) Komárek & Hindák, Algolol. Stud., 50-53: 212. 1988. *Gomphosphaeria lacustris* Chodat Bull. Herb. Bossier, 6: 180. 1898.
(Fig. 12)
Colonies solitary, rounded; mucilage thin, colorless; cells pyriform, 2.1-2.9 μm long, 2 μm wide, joined to the end of a mucilaginous stalk system, radiating from the colonial center; cell content blue-green, without aerotopes.

Comments: The species was observed in the plankton of the artificial pond only in fall (May 2010).

Environmental conditions: (n=1) WT 19.4 °C; pH 6; AMM 500 μg L^{-1}; NIT 1 mg L^{-1}; DO 9 mg L^{-1}; OS 97 %; OM 9.8 mgO_2 L^{-1}; CON 147 μS.cm^{-1}; SECCHI 30 cm; DEP 40 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108657).

Microcystaceae
Microcystis Kützing *ex* Lemmermann, Kryptogamenfl. Mark Brandenb., 3: 45. 1907.
Microcystis aeruginosa (Kützing) Kützing, Tab. Phycol., 1: 6. 1846. *Micraloa aeruginosa* Kützing, Linnaea, 8: 371. 1833.
(Fig. 13)
Colonies more or less spherical to irregular, with cells aggregated, irregularly distributed in the center of colonies; mucilage wide, homogeneous, colorless, diffluent; cells spherical, 4-5.9 (-7) μm diam.; cell content with many aerotopes.

Comments: *Microcystis aeruginosa* was found in the plankton of the artificial pond. Its occurrence was sporadic in samples from the different seasons, except in the ones from winter. Blooms of the species were observed in the marsh in spring and summer.

Environmental conditions: (n=4) WT 19.4-27.2 °C ($\bar{X}$ = 22.3 ± 2.9); pH 6.0-7.5 ($\bar{X}$ = 6.5 ± 0.6); AMM 60-520 μg.L^{-1} ($\bar{X}$ = 257 ± 210); NIT 1-1.2 mg.L^{-1} ($\bar{X}$ = 1050 ± 100); DO 4-9 mg.L^{-1} ($\bar{X}$ = 7.4 ± 1.9); OS 46.6-97.6 % ($\bar{X}$ = 83.2 ± 20.3); OM 8.5-11.5 mgO_2.L^{-1} ($\bar{X}$ = 10.1 ± 1); CON 92.9-264.6 μS.cm^{-1} ($\bar{X}$ = 136.9 ± 65.9); SECCHI 15-40 cm ($\bar{X}$ = 28 ± 10.3); DEP 33-185 cm ($\bar{X}$ = 74.5 ± 73.7).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, sites 1, 2, 11/XI/2009, *L. M. Silva & V. R. Werner* (HAS 108645, 108646); site 1, 13/I/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108649), site 1, 14/V/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108657); site 1, 15/IX/2010, *L. M. Silva & V. R. Werner* (HAS 108666); site 2, 27/X/2010, *L. M. Silva & V. R. Werner* (HAS 108671); Chimarrão marsh, 11/XI/2009, *L. M. Silva & V. R. Werner* (HAS 108703); 13/I/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108704); 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108705); 18/III/2010, *L. M. Silva & V. R. Werner* (HAS 108706).

Microcystis panniformis Komárek, Komárková-Legnerová, Sant'Anna, Azevedo & Senna, Cryptogamie, Algol., 23: 165. 2002.
(Fig. 14)
Colonies elongated, with cells densely aggregated, evenly distributed, mainly near the colonial surface; mucilage colorless, hyaline, diffluent, not extending beyond the cells; cells spherical, 3-3.5 μm diam.; cell content with small "dot-like" aerotopes.

Comments: *Microcystis panniformis* was found only in one sample collected in the plankton of the artificial pond during winter (September 2010).

Environmental conditions: (n=1) WT 19.4 °C; pH 6.7; AMM 260 μg.L^{-1}; NIT 1 mg.L^{-1}; DO 9 mg.L^{-1}; OS 97 %; OM 10.9 mgO_2.L^{-1}; CON 122 μS.cm^{-1}; SECCHI 15 cm; DEP 33 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 15/IX/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108666).

Microcystis protocystis Crow, New Phytol., 22: 62. 1923.

(Fig. 15)

Colonies irregular, without distinct lobes and never with holes, with cells sparsely distributed all over the colony; mucilage colorless, hyaline, diffluent, irregular in outline; cells spherical, slightly elongated during division, 3-6 µm diam., usually surrounded by individual mucilaginous envelopes; cell content with many aerotopes.

Comments: *Microcystis protocystis* was the second best represented species in Central pond, with a frequency of occurrence of 50 %. This species was found only in the plankton of this pond, in samples from spring and summer.

Environmental conditions: (n=8) WT 19.4-28 °C ($\bar{X}$ = 25.4 ± 3.1); pH 5.9-8.4 ($\bar{X}$ = 6.5 ± 0.8) ; AMM 60-660 µg.L^{-1} ($\bar{X}$ = 442 ± 187); NIT 1-1.2 mg.L^{-1} ($\bar{X}$ = 1.1 ± 0.09); DO 3.2-9 mg.L^{-1} ($\bar{X}$ = 6.3 ± 1.8); OS 36.6-98.6 % ($\bar{X}$ = 74 ± 20.7); OM 6.8-10.9 mgO_2.L^{-1} ($\bar{X}$ = 8.9 ± 1.3); CON 80.9-127.7 µS.cm^{-1} ($\bar{X}$ = 97.6 ± 16.2); SECCHI 15-40 cm ($\bar{X}$ = 31.9 ± 8.8); DEP 33-190 cm ($\bar{X}$ = 56.6 ± 54).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, sites 1, 2, 11/XI/2009, *L. M. Silva & V. R. Werner* (HAS 108645, 108646); sites 1, 2, 09/XII/2009, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108647, 108648); sites 1, 2, 13/I/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108649, 108650); sites 1, 2, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651, 108652); sites 2, 18/III/2010, *L. M. Silva & V. R. Werner* (HAS 108654); sites 1, 15/IX/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108666).

Microcystis smithii Komárek & Anagnostidis, Preslia Praha, 67: 21. 1995.

(Fig. 16)

Colonies spherical, with cells sparsely and regularly arranged (often in pairs); mucilage thick, homogeneous; cells rounded, 3.8-5 µm diam; cell content with few aerotopes (1-3).

Comments: This species was found in the plankton of Central pond only in fall (May 2010).

Environmental conditions: (n=2) WT 18.9-19.4 °C ($\bar{X}$ = 19.2 ± 0.4); pH 6-6.6 ($\bar{X}$ = 6.3 ± 0.4); AMM 500 µg.L^{-1}; NIT 1 mg.L^{-1}; DO 8.2-9 mg.L^{-1} ($\bar{X}$ = 8,600 ± 566); OS 88.4-97 % ($\bar{X}$ = 92.7 ± 6.1); OM 9.8 mgO_2.L^{-1}; CON 143.4-147.4 µS.cm^{-1} ($\bar{X}$ = 145.4 ± 2.8); SECCHI 30 cm; DEP 40-175 cm ($\bar{X}$ = 107.5 ± 95.5).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, sites 1, 2, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108657, 108658).

Microcystis wesenbergii (Komárek) Komárek *in* Kondrateva, Cvetenie vody, 13. 1968b. *Diplocystis wesenbergii* Komárek *in* Komárek & Ettl, Algologische Studien, 68. 1958.

(Fig. 17)

Colonies rounded, oval, elongated, irregular, lobate, usually with subcolonies, cells aggregated, irregularly distributed in the mucilage; internal mucilaginous envelope colorless, with refractive outline, sometimes with external diffluent, hyaline mucilage; cells rounded, 4.2-7 µm diam.; cell content blue-green with aerotopes.

Comments: *Microcystis wesenbergii* is easily distinguished from other species of the genus by the characteristic outline of its colonies: firm, homogeneous, and evident (refractive). Although it is easily recognized, the species presented wide phenotypic variety. The species was observed in the plankton of both studied water bodies. It occurred in all seasons at large pH and temperature ranges.

Environmental conditions: (n=9) WT 14.5-28 °C ($\bar{X}$ = 22 ± 4.4); pH 5.5-8.2 ($\bar{X}$ = 6.7 ± 0.8); AMM 140-530 µg.L^{-1} ($\bar{X}$ = 360 ± 146); NIT 1-1.3 mg.L^{-1} ($\bar{X}$ = 1.1 ± 1.2); DO 6.3-10.5 mg.L^{-1} ($\bar{X}$ = 8.2. ± 1.3); OS 71.7-99.1 % ($\bar{X}$ = 92.7 ± 9.4); OM 9.4-11.5 mgO_2.L^{-1} ($\bar{X}$ = 10.3 ± 0.8); CON 61-273.4 µS.cm^{-1} ($\bar{X}$ = 154.5 ± 74.9); SECCHI 15-30 cm ($\bar{X}$ = 25.2 ± 5.6); DEP 20-200 cm ($\bar{X}$ = 101.7 ± 81.9).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651); sites 1, 2, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108657, 108658); sites 2, 15/VII/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108662); site 2, 15/IX/2010, *L. M. Silva & V. R. Werner E. B. Neuhaus* (HAS 108667); sites 1, 2, 27/X/2010, *L. M. Silva & V. R. Werner* (HAS 108670, 108671); Chimarrão marsh, 18/III/2010, *L. M. Silva, & V. R. Werner* (HAS 108706); 15/IV/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108707).

Sphaerocavum Azevedo & Sant'Anna, Algolog. Stud., 109: 79-92. 2003.

Sphaerocavum brasiliense Azevedo & Sant'Anna, Algolog. Stud., 109: 79-92. 2003.

(Fig. 18)

Colonies rounded when young; later, irregular, hollow, frequently with holes; cells irregularly distributed or in small rows in the colony surface, sometimes in a net-like arrangement; mucilage thin, narrow, inconspicuous, colorless, hyaline, diffluent; cells spherical, 2.5-2.7 µm diam.; cell content brownish or greenish, with aerotopes.

Comments: This species was found in the plankton of Central pond only in fall (May 2010).

Environmental conditions: (n=1) WT 19.4 °C; pH 6; AMM 500 $\mu g.L^{-1}$; NIT 1 $mg.L^{-1}$; DO 9 $mg.L^{-1}$; OS 97%; OM 9.8 $mgO_2.L^{-1}$; CON 147 $\mu S.cm^{-1}$; SECCHI 30 cm; DEP 40 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108657)

Oscillatoriales

Spirulinaceae

Spirulina Turpin *ex* Gomont, Ann. Sci. Nat. Bot., sér. 7, 16: 249. 1892.

Spirulina princeps W. & G. S. West, Trans. Linn. Soc., 2. sér. Bot., 6: 205. 1902.

(Figs. 19, 21c)

Trichomes coiled, 4.6-5 µm wide; coils regular, 7.5-9.2 µm distant one from another, 10-11.5 µm high; apical cell rounded; cell content bright blue-green, without aerotopes.

Comments: The observed distance between coils differs from those presented by Komárek & Anagnostidis (2005), 8.2-11 µm distant. However, only this characteristic is not enough to identify the present *Spirulina* as another species, since the same authors comment *S. princeps* has highly variable features.

Spirulina princeps was found in the metaphyton of Chimarrão marsh in summer (February 2010) and also in macroscopic thallus among *Oscillatoria tenuis* filaments in fall (April 2010).

Environmental conditions: (n=2) WT 23.1-27.5 °C ($\bar{X} = 25.3 \pm 3.1$); pH 5.5-6.2 ($\bar{X} = 5.9 \pm 0.5$); AMM 420 $\mu g.L^{-1}$; NIT 1 $mg.L^{-1}$; DO 6.3 $mg.L^{-1}$; OS 71.7%; OM 9.8 $mgO_2.L^{-1}$; CON 61-79.5 $\mu S.cm^{-1}$ ($\bar{X} = 70.3 \pm 13.1$); SECCHI 30 cm; DEP 30 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108705); 15/IV/2010, *L.M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 109282).

Phormidiaceae

Phormidium Kützing *ex* Gomont, Ann. Sci. Nat. Bot., sér. 7, 16: 156. 1892.

Phormidium* cf. *tergestinum (Kützing) Anagnostidis & Komárek., Arch. Hydrobiol./Suppl., 80(1-4), Algolg. Stud. 50-53: 406. 1988. *Oscillatoria tergestina* Kützing, Alg. Aq. Dulc. Germ., 13: 123. 1836. *Oscillatoria tenuis* Agardh *ex* Gomont *sensu auct. post*., Ann. Sci. nat., sér. 7 16: 220. 1892. *Phormidium tenue* (Agardh *ex* Gomont) Anagnostidis & Komárek *sensu auct. post*., Arch. für Hydrobiol./Suppl., 80: 406. 1988.

(Fig. 20)

Trichomes straight, sometimes slightly and irregularly curved, sometimes bent at the ends, not or slightly attenuated, not or slightly constricted, 7-9 µm wide; cells quadratic, sometimes up to 3 times wider than their length, 2-6 µm long, apical cell rounded, with or without thickened cell wall; cell content blue-green, homogeneous, sometimes granulated, cross-walls usually not granulated.

Comments: The observed specimens were identified based on Komárek & Anagnostidis (2005) and are in accordance with the description presented by the authors, except for the usually non-granulated cross-walls. According to these authors, they are usually granulated.

Despite the similarities of the studied material with the description and illustrations (Figs. 662a, f) presented by the authors aforementioned, it was denominated as *Phormidium* cf. *tergestinum* because granulated cross-walls is an important feature in the taxonomy of Oscillatoriales. Besides, Komárek & Anagnostidis (2005) comment that the species presents wide morphological variability, possibly a collective species, but its taxonomy needs to be revised.

The present species was found in the benthos of Chimarrão marsh, in macroscopic, dark-green thallus among *Oscillatoria tenuis* filaments. It was also observed in planktic samples collected during summer, fall and winter. According to Komárek & Anagnostidis (2005), *Phormidium tergestinum* is commonly benthic on the surface of mud and other substrates. Since the samples were collected in a shallow place (10-30 cm), some specimens could

have detached from the substratum and become free-floating. Furthermore, the species was also found in plankton by Santos & Sant'Anna (2010) and Martins *et al.* (2012).

Environmental conditions: (n=4) WT 10.2-27.7 °C ($\bar{X}$ = 19.6 ± 7.6); pH 5.5-6.9 ($\bar{X}$ = 6.2 ± 0.8); AMM 300-530 μg.L^{-1} ($\bar{X}$ = 438 ± 103); NIT 1-1.1 mg.L^{-1} ($\bar{X}$ = 1.02 ± 0.005); DO 6.3-9 mg.L^{-1} ($\bar{X}$ = 7± 1.14); OS 63.7-99.1 % ($\bar{X}$ = 81.9 ± 16.9); OM 8.9-9.8 mgO_2.L^{-1} ($\bar{X}$ = 9.3 ± 0.4); CON 61-134.5 μS.cm^{-1} ($\bar{X}$ = 105.6 ± 32.5); SECCHI 10-30 cm ($\bar{X}$ = 20 ± 10); DEP 10-30 cm ($\bar{X}$ = 12.5 ± 9.6).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 18/III/2010, *L. M. Silva & V. R. Werner* (HAS 108706); 15/IV/2010, *L.M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 109282); 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108708); 15/VII/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108712).

Oscillatoriaceae

Oscillatoria Vaucher *ex* Gomont, Ann. Sci. Nat. Bot., sér. 7, 16: 198. 1892.

Oscillatoria curviceps Agardh *ex* Gomont, Ann. Sci. Nat. Bot., sér. 7, 16: 213. 1892.

(Fig. 22)

Trichomes almost straight, slightly curved at the ends, slightly attenuated, not constricted, 11.5-13.8 μm wide; cells up to 9.2 times wider than their length, 1.5-4.6 μm long, apical cells rounded-truncate, not capitate, sometimes with slightly thickened cell all; cell content olive-green, sometimes granulated at the cross-walls, without aerotopes.

Comments: The species was observed in the plankton of Central pond in summer (February 2010). It was also found in the benthos among *O. tenuis* filaments in Chimarrão marsh in fall. According to Komárek & Anagnostidis (2005) *O. curviceps* is a periphytic species. The shallow depths (30-35 cm) of the sites where the species grew may justify its occurrence in planktic samples. Solitary trichomes of the species in planktic samples from the littoral zone of a subtropical coastal lagoon were also observed by Martins (2010) and Martins *et al*. (2012).

Environmental conditions: (n=2) WT 23.1-28 °C ($\bar{X}$ = 25.6 ± 3.5); pH 5.5-6.7 ($\bar{X}$ = 6.1 ± 0.8); AMM 400-420 μg.L^{-1} ($\bar{X}$ = 410 ± 14.1); NIT 1 mg.L^{-1}; DO 6.3-6.7 mg.L^{-1} ($\bar{X}$ = 6.5 ± 0.2); OS 71.7-85.1 % ($\bar{X}$ = 78.4 ± 9.5); OM 9.5-9.8 mgO_2.L^{-1} ($\bar{X}$ = 9.7 ± 0.2); CON 61-80.9 μS.cm^{-1} ($\bar{X}$ = 71 ± 14.1); SECCHI 30 cm; DEP 30-35 cm ($\bar{X}$ = 32.5 ± 3.5).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651); Chimarrão marsh, 15/IV/2010, *L.M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 109282).

Oscillatoria limosa Agardh *ex* Gomont, Ann. Sci. Nat. Bot., sér. 7, 16: 210. 1892.

(Figs. 21d, 23, 24)

Trichomes almost straight, not or slightly attenuated, not constricted, 10-14 μm wide; cells 3-6 times wider than their length, 2-6 μm long, apical cells rounded-truncate, not capitate, frequently with slightly thickened cell wall; cell content bright blue-green, usually finely granulated, granulated or not at the cross-walls, without aerotopes.

Comments: *Oscillatoria limosa* was observed among *O. tenuis* filaments in benthonic, macroscopic, dark-green thallus in Chimarrão marsh, only in a sample from fall.

Environmental conditions: (n=1) WT 23.1 °C; pH 5.5; AMM 420 μg.L^{-1}; NIT 1 μg.L^{-1}; DO 6.3 mg.L^{-1}; OS 71.7 %; OM 9.8 mgO_2.L^{-1}; CON 61 μS.cm^{-1}; SECCHI 30 cm; DEP 30 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 15/IV/2010, *L.M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 109282).

Oscillatoria princeps Vaucher *ex* Gomont, Ann. Sci. Nat. Bot., sér. 7, 16: 206. 1892.

(Figs. 25-27)

Trichomes straight or slightly curved in the apex, slightly attenuated, not or slightly constricted, 22-24 μm wide; cells 7-8 times wider than their length, 3.5-4.5 μm long; apical cells rounded, hemispherical or rounded-truncate, sometimes subcapitate, without or with slightly thickened cell wall; cell content blue-green, homogeneous or slightly granulated, not granulated at the cross-walls, without aerotopes.

Comments: *Oscillatoria princeps* was found in the metaphyton of the margins of Chimarrão marsh, near the vegetation, in winter (July 2010). It was also observed among other oscillatorialean filaments, forming macroscopic, dark-green thallus in the benthos, in fall (April 2010).

Environmental conditions: (n=2) WT 10.2-23.1 °C ($\bar{X}$ = 16.7 ± 9.1); pH 5.5-6.9 ($\bar{X}$ = 6.2 ± 0.9); AMM 300-420 µg.L^{-1} ($\bar{X}$ = 360 ± 84.9); NIT 1 mg.L^{-1}; DO 6.3-7.2 mg.L^{-1} ($\bar{X}$ = 6.8 ± 0.6); OS 63.7-71.7 % ($\bar{X}$ = 67.7 ± 5.7); OM 9.2-9.8 mgO_2.L^{-1} ($\bar{X}$ = 9.5 ± 0.4); CON 61-134.5 µS.cm^{-1} ($\bar{X}$ = 97.8 ± 52); SECCHI 10-30 cm ($\bar{X}$ = 20 ± 14.1); DEP 10-30 cm ($\bar{X}$ = 20 ± 14.1).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 15/IV/2010, *L.M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 109282), 15/VII/2010, *L. M. Silva & E. B. Neuhaus V. R. Werner* (HAS 108712).

Oscillatoria tenuis Agardh *ex* Gomont Ann. Sci. Nat. Bot., ser. 7, 16: 220. 1892.

(Figs. 21b, 28-30)

Trichomes straight or slightly curved, not or rarely somewhat attenuated, not or very slightly constricted, 7.5-8.5(10) µm wide; cells 2.5-5 times wider than their length, 1.8-3.5 µm long, apical cells rounded or rounded-truncate, sometimes somewhat capitate, at times with slightly thickened cell wall (well developed trichomes); cell content blue-green, sometimes with dispersed granules, usually not granulated at the cross-walls, without aerotopes.

Comments: *Oscillatoria tenuis* formed macroscopic dark green thallus on the substratum which resembled mats (Fig. 21a). Those thallus were observed in the margins of Chimarrão marsh, together with other oscillatorialean species. The species was also found in the plankton of both water bodies. According to Komárek & Anagnostidis (2005) *O. tenuis* is a benthic or metaphytic species. The shallow depths (10-35 cm) of the sites where the thallus of the species grew may justify its occurrence in the plankton.

Environmental conditions: (n=4) WT 10.2-28 °C ($\bar{X}$ = 22.2 ± 8.3); pH 5.5-6.9 ($\bar{X}$ = 6.3 ± 0.6); AMM 300-420 µg.L^{-1} ($\bar{X}$ = 373 ± 64); NIT 1 mg.L^{-1}; DO 6.3-7.2 mg.L^{-1} ($\bar{X}$ = 6.7. ± 0.5); OS 63.7-85.1 % ($\bar{X}$ = 73.5 ± 10.8); OM 9.2-9.8 mgO2.L^{-1} ($\bar{X}$ = 9.5 ± 0.3); CON 61-134.5 µS.cm^{-1} ($\bar{X}$ = 89 ± 31.7); SECCHI 10-30 cm ($\bar{X}$ = 23.3 ± 11.5); DEP 10-35 cm ($\bar{X}$ = 25 ± 13.2).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651); Chimarrão marsh, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108705); 15/IV/2010, *L.M. Silva, V.R. Werner & E. B. Neuhaus* (HAS 109282); 15/VII/2010, *L. M. Silva & E. B. Neuhaus V. R. Werner* (HAS 108712).

Nostocales

Nostocaceae

Aphanizomenon Morren *ex* Bornet *et* Flahault, Ann. Sci. Nat. Bot., sér. 7, 7: 241. 1886.

Aphanizomenon gracile (Lemmermann) Lemmermann, Kryptogamenfl. Mark Brandenb., 3(2): 193. 1907. *Aphanizomenon flos-aque* var. *gracilis* Lemmermann, ForschBer. Biol. Sta. Plön, 6(2): 204. 1898.

(Fig. 6)

Trichomes solitary, straight, slightly attenuated, somewhat constricted; cells cylindrical, rounded-truncate at the ends, 3-4 µm wide, 4-6 µm long; apical cell slightly capitate, 2.5-3.8 µm wide, 4-6 µm long; cell content blue-green, slightly granulated, usually with aerotopes; heterocytes intercalary, solitary, barrel-shaped to elliptical, usually only 1-2 per trichome, 3-5 µm wide, 4-7.5 µm long; akinetes solitary, rarely in pairs, cylindrical, separated from the heterocytes (1-4 vegetative cells), 5-6 µm wide, 9.3-12.5 µm long; epispore smooth.

Comments: Even though Komárek (2013) commented that this species possibly represents another genus, he kept the species in *Aphanizomenon*. The studied population is in accordance with *Aphanizomenon gracile* presented by Komárek (2013), which justifies this current identification.

According to Komárek & Kováčik (1989), *A. gracile* trichomes are gradually attenuated and present capitate apical cells. They also mentioned that the capitate apical cells seem to be typical of this species, and this feature was constant in all observed specimens.

The species was registered only in the plankton of Chimarrão marsh among *Cuspidothrix issatschenkoi* filaments in fall (May 2010).

Environmental conditions: (n=1) WT 17.3 °C; pH 5.5; AMM 500 µg.L^{-1}; NIT 1 mg.L^{-1}; DO 9 mg.L^{-1}; OS 93.1 %; OM 8.9 mgO_2.L^{-1}; CON 123.9 µS.cm^{-1}; SECCHI 10 cm; DEP 10 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108708).

Cuspidothrix Rajaniemi, Komárek, Willame, Hrouzek, Kaštovská, Hoffmann & Sivonen, Algolog. Stud., 117: 388. 2005.

Cuspidothrix issatschenkoi (Usačev) Rajaniemi, Komárek, Willame, Hrouzek, Kaštovská, Hoffmann

& Sivonen, Algolog. Stud., 117: 388. 2005. *Anabaena issatschenkoi* Usačev, Mat. Gidrobiol. Litol. Kasp. Morja, 109. 1938. *Aphanizomenon issatschenkoi* (Usačev) Proškina-Lavrenko, Bot. Mat. Otd. Sporov. Rast. Bot. Inst. Komarova Akad. Nauk SSSR 15: 30. 1962.

(Fig. 7)

Trichomes solitary, straight or slightly bent, gradually attenuated and pointed toward the ends, not or slightly constricted; cells cylindrical, 3-4 µm wide, 4-6 µm long; apical cell elongated, narrowed, and pointed, usually bent, and usually hyaline; cell content blue-green, finely granulated, usually with scarce aerotopes; heterocyte intercalary, solitary, cylindrical, 3 µm wide, 6 µm long; akinete solitary, cylindrical, distant from the heterocyte, 4.5 µm wide, 21 µm long.

Comments: *Cuspidothrix tropicalis* (Horecká & Komárek) Rajaniemi *et al.* is the most related species with *C. issatschenkoi* (similar morphology of trichomes and apical cells), which differs from the latter mainly by having spherical to ellipsoidal heterocytes and oval to cylindrical akinetes situated on one or both sides of the heterocytes. They differ also by their geographic distribution: *C. tropicalis* is a planktic species from tropical regions while *C. issatschenkoi* occurs in lower temperature waters.

According to Komárek (2013), *C. issatschenkoi* has already been recorded in the whole northern temperate zone. In the present study the species was observed in both analyzed water bodies in different seasons, with water temperature ranging between 14.6-27.2 °C ($\bar{X}$ = 20.6 ± 5.7). In the artificial pond, the species occurred among the *Cylindrospermopsis raciborskii* blooms, in spring (December 2009) and in summer (January 2010); in the marsh it was recorded in fall (May 2010) and in winter (June 2010).

Environmental conditions: (n=4) WT 14.6-27.2 °C ($\bar{X}$ = 20.6 ± 5.7); pH 5.5-6 ($\bar{X}$ = 5.8 ± 0.2); CON 92.8-134.5 $\mu S.cm^{-1}$ ($\bar{X}$ = 110 ± 21.4); AMM 400-630 $\mu g.L^{-1}$ ($\bar{X}$ = 512.5 ± 94.3); NIT 1-1.2. $mg.L^{-1}$ ($\bar{X}$ = 1.1 ± 0.1); DO 2-9 $mg.L^{-1}$ ($\bar{X}$ = 5.4 ± 3); OS 19.4-93.1 % ($\bar{X}$ = 58.7 ± 32.5); OM 7.2-8.9 $mgO_2.L^{-1}$ ($\bar{X}$ = 8.3 ± 0.7); SECCHI 10-40 cm ($\bar{X}$ = 26.3 ± 13.8); DEP 10-40 cm ($\bar{X}$ = 27.5 ± 15).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, site 1, 09/XII/2009, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108647); site 1, 13/I/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108649); Chimarrão marsh, 14/V/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108708); 24/VI/2010, *L. M. Silva & V. R. Werner* (HAS 108710).

Cylindrospermopsis Seenaya & Subba Raju, Tax. Biol. Blue-green Alg. (Madras), 55. 1972.

Cylindrospermopsis raciborskii (Wolosynska) Seenaya & Subba Raju, Tax. Biol. Blue-green Alg., 55-57. 1972. *Anabaena raciborskii* Wolosynska, Bull. Int. Acad. Sci. Lett. Cracovie. Ser. B, 1912: 84. 1913.

(Figs. 31-33)

Trichomes solitary or in clusters, straight, curved, coiled or circular, attenuated at the ends, not or slightly constrict; cells cylindrical, 2-4 µm wide, 2.5-9 µm long; apical cell pointed, conical-rounded or cylindrical; cell content with aerotopes; heterocytes terminal, solitary, flame-shaped, 2-4 µm wide, 3.8-10.5 µm long; akinetes subterminal, cylindrical with rounded ends, 2.2-4 µm wide, 7-14 µm long.

Comments: *Cylindrospermopsis raciborskii* was the best represented species in Central pond, occurring in all samples and forming blooms during the whole studied period. It gave colors to the water that ranged from yellow-green to yellow. Sometimes it formed tiny yellowish thallus, which migrated along the water column, and also scum. Production of neurotoxins (saxitoxins and goniautoxins) in a population collected in the spring (November 2010) was detected (João Sarkis Yunes – personal communication; Silva, 2011). It was observed in the marsh only late summer (March 2010).

Environmental conditions: (n=25) WT 12.6-28 °C ($\bar{X}$ = 21.7 ± 5.1); pH 5.4-8.7 ($\bar{X}$ = 6.7 ± 0.9); CON 80.9-273.4 $\mu S.cm^{-1}$ ($\bar{X}$ = 154.3 ± 58.6); AMM 140-660 $\mu g.L^{-1}$ ($\bar{X}$ = 373.7 ± 150.1); NIT 1-1.3 $mg.L^{-1}$ ($\bar{X}$ = 1.04 ± 0.08); DO 2.5-10 $mg.L^{-1}$ ($\bar{X}$ = 7.4. ± 2.1); OS 24.8-99,7 % ($\bar{X}$ = 83,7 ± 21,9); OM 6.8-11.5 $mgO_2.L^{-1}$ ($\bar{X}$ = 9.9 ± 1.2); SECCHI 10-45 cm ($\bar{X}$ = 26.9± 9.8); DEP 10-200 cm ($\bar{X}$ = 91.3 ± 73.6).

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Central pond, sites 1, 2, 09/XII/2009, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108647, 108648); sites 1, 2, 13/I/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108649, 108650); sites 1, 2, 24/II/2010, *L. M. Silva & E. B. Neuhaus* (HAS 108651, 108652); sites 1, 2, 18/III/2010, *L. M. Silva & V. R. Werner* (HAS 108653, 108654); sites 1, 2, 15/IV/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108655, 108656);

sites 1, 2, 14/V/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108657, 108658); sites 1, 2, 24/VI/2010, *L. M. Silva & V. R. Werner* (HAS 108659, 108660); sites 1, 2, 15/VII/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108661, 108662); sites 1, 2, 05/VIII/2010, *L. M. Silva, V. R. Werner, L. K. Audibert & E. B. Neuhaus* (HAS 108664, HAS 108665); sites 1, 2, 15/IX/2010, *L. M. Silva, V. R. Werner & E. B. Neuhaus* (HAS 108666, 108667); sites 1, 2, 14/X/2010, *L. M. Silva & V. R. Werner* (HAS 108668, HAS 108669); site 1, 27/X/2010, *L. M. Silva & V. R. Werner* (HAS 108670, 108671). Chimarrão marsh, 18/III/2010, *L. M. Silva & V. R. Werner* (HAS 108706).

Dolichospermum (Ralfs *ex* Bornet *et* Flahault) Wacklin, Hoffmann *et* Komárek, Fottea 9(1): 60. 2009.

Dolichospermum planctonicum (Brunnthaler) Wacklin, Hoffmann & Komárek, Fottea, 9(1): 62. 2009. *Anabaena planctonica* Brunnthaler, Sitzungsb. K. Akad. Wiss. Wien, mat.–nat., 103(1): 4. 1903.

(Fig. 34)

Trichomes solitary, straight or slightly curved, not attenuated, constricted, with hyaline, diffluent, thick (7-7.5 µm wide) mucilaginous envelope; filaments 20-30 µm wide; cells shortly barrel-shaped, 9-11.5(12) µm wide, 7-9.5 µm long; apical cell rounded; cell content blue-green with numerous dark aerotopes; heterocytes intercalary, solitary, rounded, 9.2-11.7 µm diameter; akinetes intercalary, solitary, sometimes 2-3 in rows, distant from the heterocyte, elliptical or cylindrical with rounded ends, 13.2-18 µm wide, 24.5-26 µm long; epispore evident, smooth, colorless.

Comments: Trichomes surrounded by thick mucilage, cells shortly barrel-shaped, compressed, and usually shorter than their width are typical characteristics of *D. planctonicum*, easily distinguishing it from the other species of *Dolichospermum* with straight trichomes.

Komárek (2013) commented that the morphological variability of the species is not very wide, and the shape of mature akinetes varies from oval to cylindrical.

The species was originally denominated as *Anabaena planctonica* but, recently, based on molecular analyses, planktic species of *Anabaena* were transferred to the genus *Dolichospermum* by Wacklin *et al*. (2009), including *D. planctonicum*.

Dolichospermum planctonicum was found in the plankton only in Chimarrão marsh in fall (April 2010).

Environmental conditions: (n=1) WT 23.1 °C; pH 5.5; AMM 420 µg.L^{-1}; NIT 1mg.L^{-1}; DO 6.3 mg.L^{-1}; OS 71.7 %; OM 9.8 $mgO_2.L^{-1}$; CON 61 µS.cm^{-1}; SECCHI 30 cm; DEP 30 cm.

Examined material: BRAZIL, RIO GRANDE DO SUL, Canoas, ULBRA, Chimarrão marsh, 15/IV/2010, *L. M. Silva, E. B. Neuhaus & V. R. Werner* (HAS 108707).

The distribution of the cyanobacteria in the two analyzed water bodies is presented in Table 1. Out of the 24 identified species, only six (*Microcystis aeruginosa, M. wesenbergii*, *Oscillatoria curviceps*, *O. tenuis*, *Cuspidothrix issatschenkoi,* and *Cylindrospermopsis raciborskii*) were observed in both the artificial pond (Central pond) and Chimarrão marsh. Among these, *O. curviceps* and *O. tenuis* were found either free-floating or in macroscopic, dark green thallus, similar to mats on the substratum, while the others were observed only in the plankton. *Cylindrospermopsis raciborskii* was the species with the highest frequency of occurrence in the artificial pond (FO = 100 %), forming dense blooms along the whole studied period. On the other hand, its frequency of occurrence in Chimarrão marsh was only 9.1 %, where *Phormidium* cf. *tergestinum* was the best represented species (FO = 36.4 %) followed by *O. tenuis* (FO = 27.3 %). Both species were found free-floating and also in benthos. Despite the occurrence of *C. raciborskii* blooms in Central pond, the species richness of cyanobacteria in this artificial water body was higher (18 taxa) than that observed in Chimarrão marsh (13). The highest species richness in the artificial pond was registered in summer (February 2010) and in fall (May 2010), when eight species were identified among *C. raciborskii* blooms in each season. In the samples collected in June and August, the lowest species richness was registered in pond, when only one species was identified (*C. raciborskii*). In Chimarrão marsh, the species richness was low (1 to 8; $\bar{X} = 3 \pm 2$), when the highest number was recorded in April and the lowest, in November 2009 and in June 2010.

Among the identified cyanobacteria in both water bodies, some species are highlighted: *Cylindrospermopsis raciborskii*, *Cuspidothrix issatschenkoi*, *Dolichospermum planktonicum*, *Microcystis aeruginosa*, *M. protocystis*, *M. wesenbergii,* and *Snowella lacustris* for being potentially toxic, and *Cuspidothrix issatschenkoi* for its first recorded in Brazil, and *Oscillatoria tenuis,* and *Spirulina princeps* for it is the first time these species are documented in Rio Grande do Sul State.

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Table 1. Occurrence of the cyanobacteria in the two analyzed water bodies of the Lutheran University of Brazil (Canoas, Rio Grande do Sul State) from November 2009 to October 2010. (P = pond, M = marsh; + = presence, - = unobserved; * = no collection).

Date	Nov.		Dez.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.	
	2009												2010											
Taxa/Site	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M
Anathece minutissima	+	-	-	*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. smithii	-	-	-	*	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Aphanizomenon gracile	-	-	-	*	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Coelomoron microcystoides	+	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cuspidothrix issatschenkoi	-	-	+	*	+	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-
Cylindrospermopsis raciborskii	+	-	+	*	+	-	+	-	+	+	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Dolichospermum planctonicum	-	-	-	*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Geitlerinema splendidum	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Merismopedia glauca	-	-	-	*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. tenuissima	-	-	-	*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Microcystis aeruginosa	+	+	-	*	+	+	-	+	-	+	-	-	+	-	-	-	-	-	-	-	+	-	+	-
M. panniformis	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
M. protocystis	+	-	+	*	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
M. smithii	-	-	-	*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
M. wesenbergii	-	-	-	*	-	-	+	-	-	+	-	+	+	-	-	-	+	-	-	-	+	-	+	-
Oscillatoria curviceps	-	-	-	*	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
O. limosa	-	-	-	*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
O. princeps	-	-	-	*	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-
O. tenuis	-	-	-	*	-	-	+	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-
Phormidium cf. *tergestinum*	-	-	-	*	-	-	-	-	-	+	-	+	-	+	-	-	-	+	-	-	-	-	-	-
Planktolyngbya limnetica	-	-	-	*	-	-	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	+	-
Snowella lacustris	-	-	-	*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Sphaerocavum brasiliense	-	-	-	*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Spirulina princeps	-	-	-	*	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

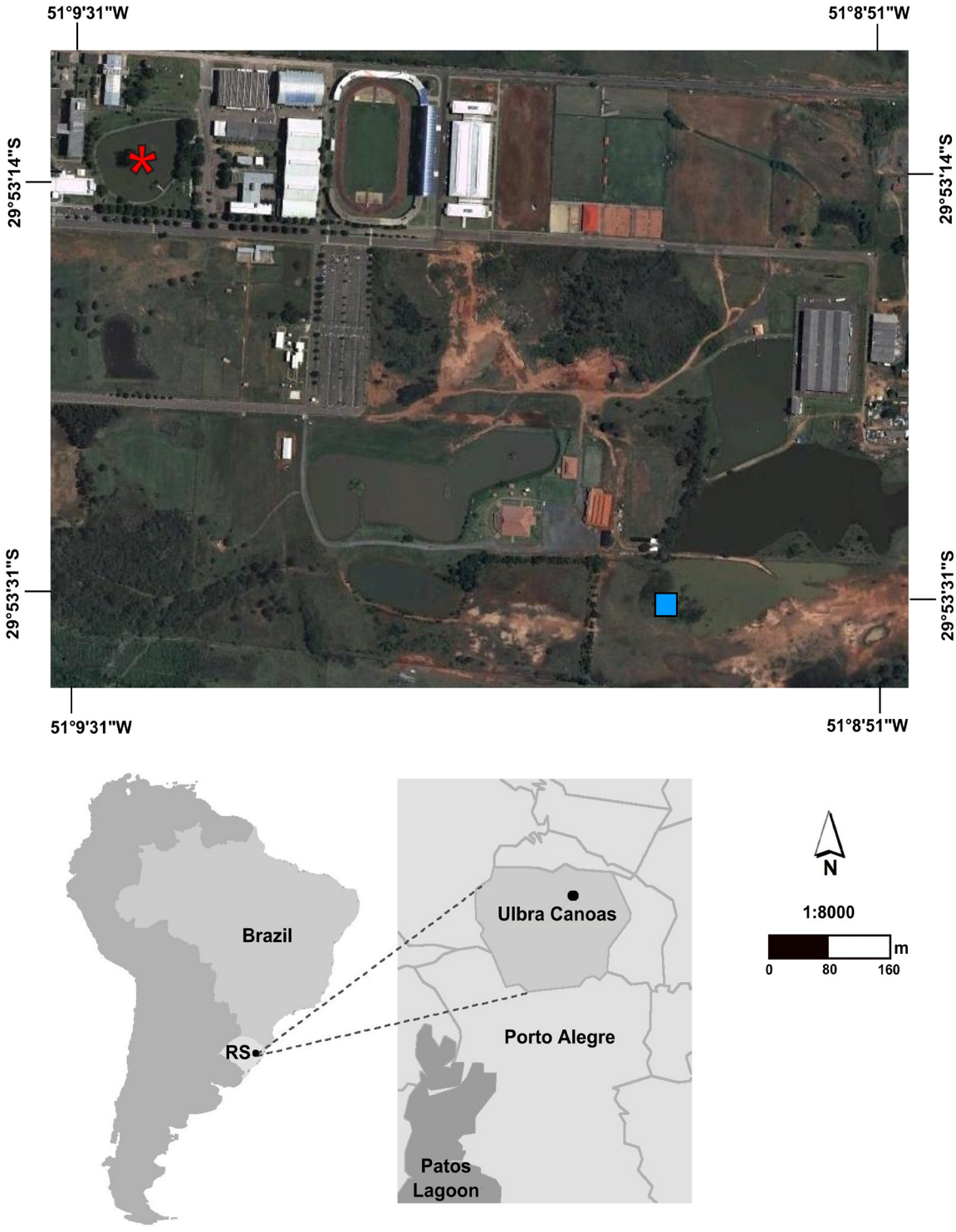
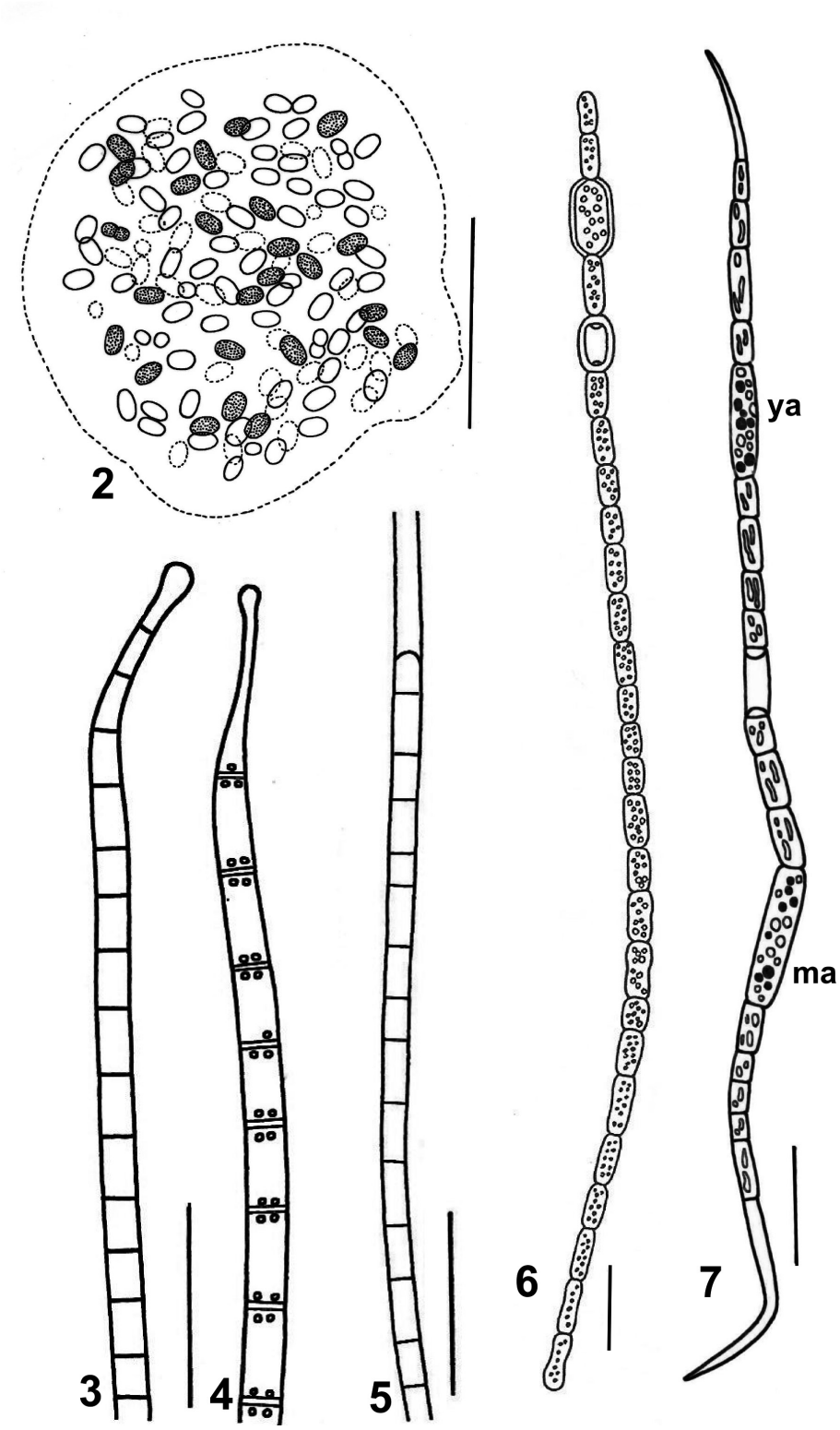
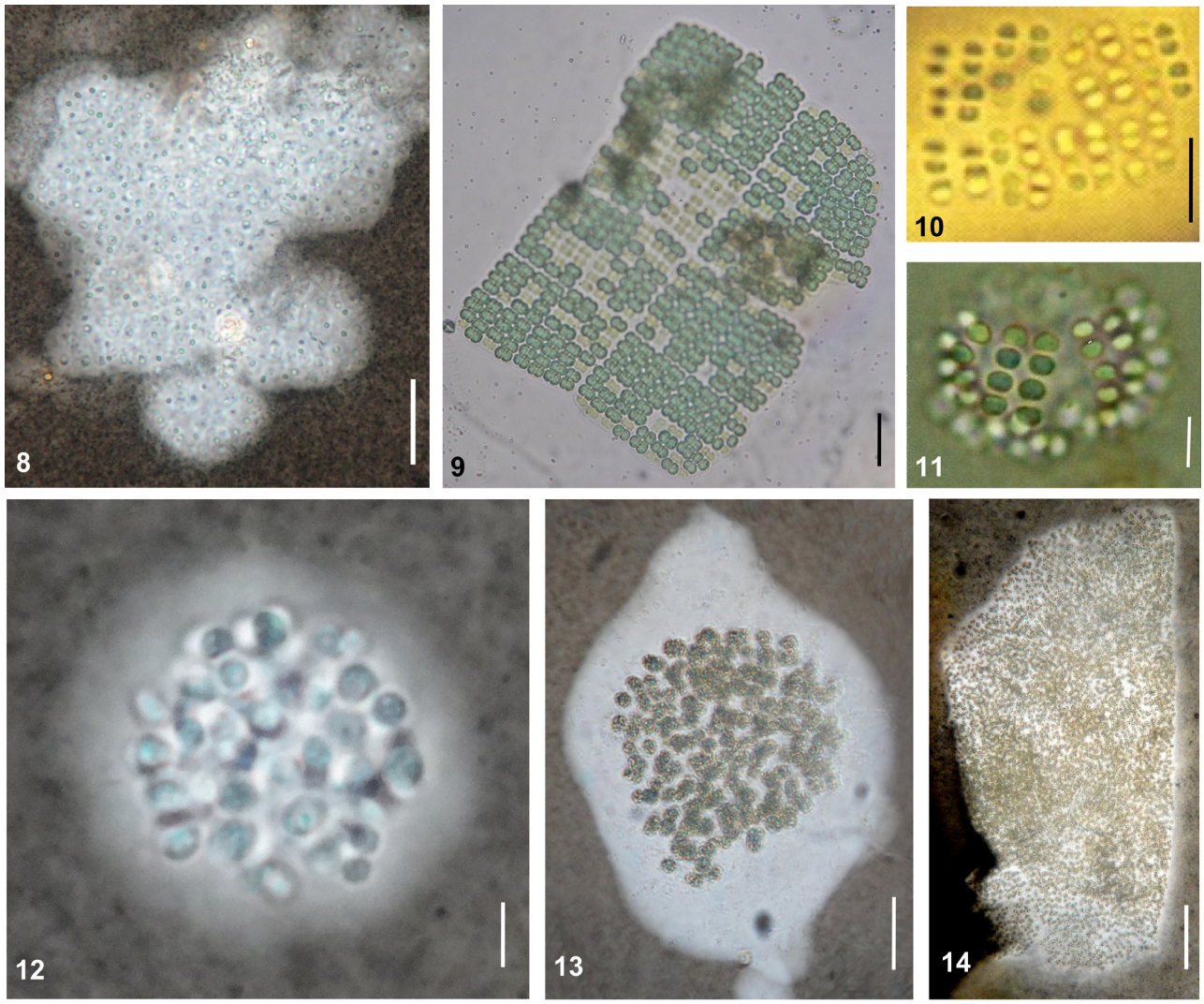


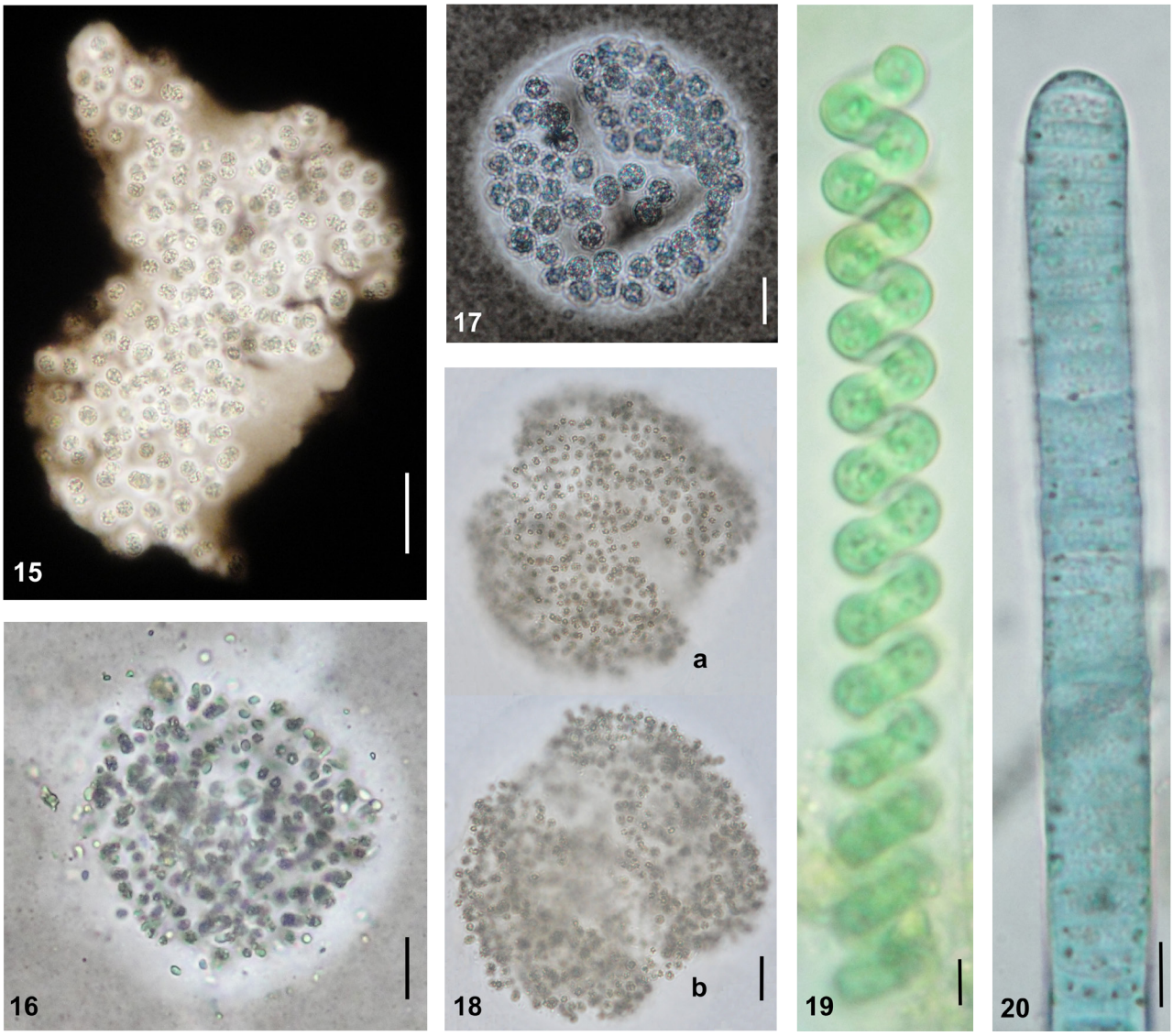
Fig. 1. Map of the studied area showing the sampling water bodies. (✻ = Central pond; ■ = Chimarrão marsh; RS = Rio Grande do Sul State).



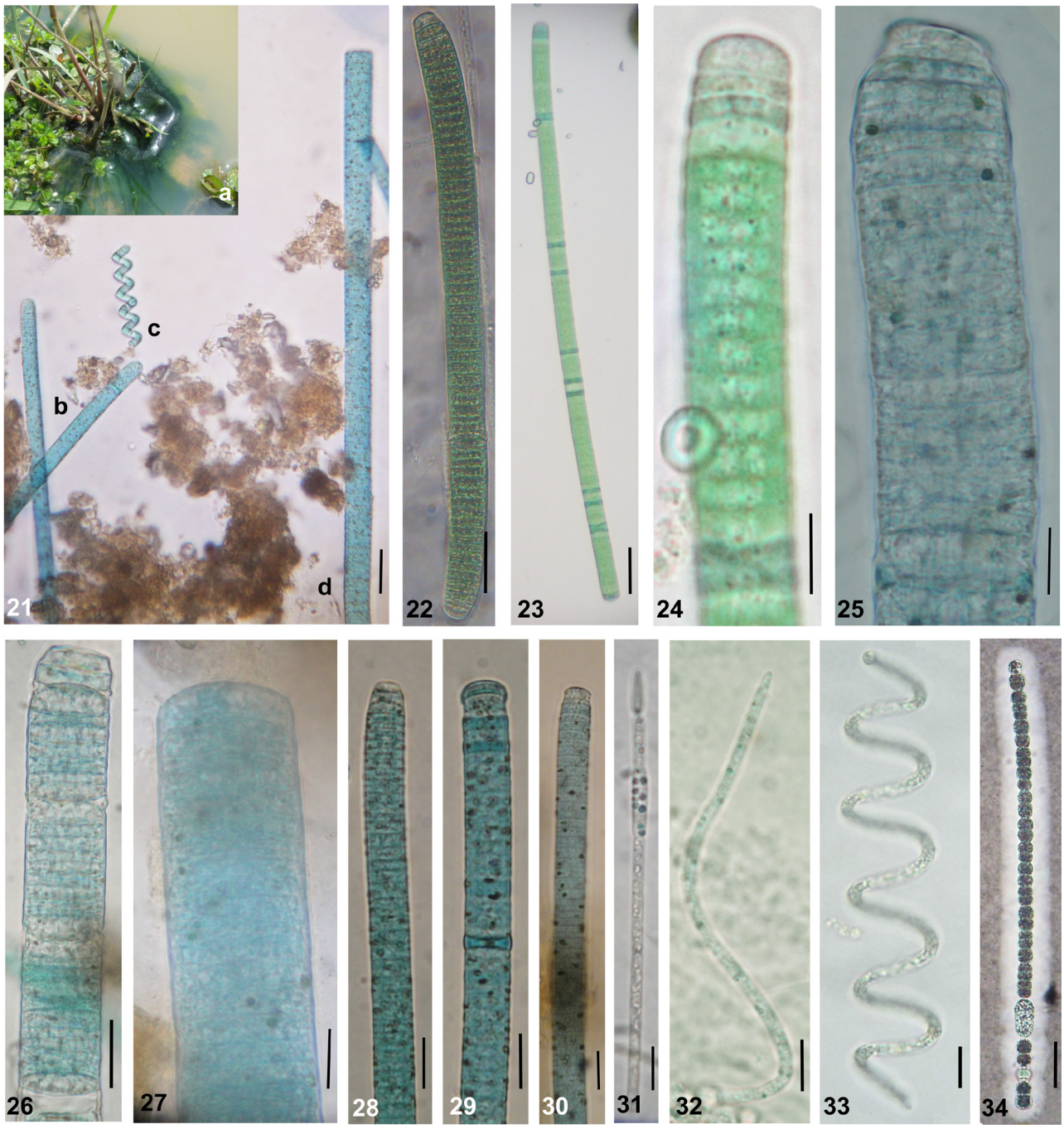
Figs. 2-7. 2. *Anathece minutissima*; **3, 4.** *Geitlerinema splendidum*; **5.** *Planktolyngbya limnetica*; **6.** *Aphanizomenon gracile*; **7.** *Cuspidothrix issatschenkoi*: **ya** = young akinete, **ma** = mature akinete. Scale bars = 10 µm.



Figs. 8-14. 8. *Anathece smithii*; **9.** *Merismopedia glauca*; **10.** *M. tenuissima*; **11.** *Coelomoron microcystoides*; **12.** *Snowella lacustris*; **13.** *Microcystis aeruginosa*; **14.** *M. panniformis*. Scale bars: **Figs. 8, 9, 13** = 20 µm; **Figs. 10-12** = 5 µm; **Fig. 14** = 30 µm.



Figs. 15-20. 15. *Microcystis protocystis*; **16.** *M. smithii*; **17.** *M. wesenbergii*; **18. a-b.** *Sphaerocavum brasiliense* showing different focus adjustments: **a** = top, **b** = bottom; **19.** *Spirulina princeps*; **20.** *Phormidium* cf. *tergestinum*. Scale bars: **Figs. 15, 16** = 20 μm; **Figs. 17, 18** = 10 μm; **Figs. 19, 20 =** 5 μm.



Figs. 21-34. 21. a-d. non-heterocytous filamentous cyanobacteria forming macroscopic thallus in Chimarrão marsh. **a.** general aspect of a macroscopic thallus; **b-d.** general aspect of part of a thallus; **b.** *Oscillatoria tenuis*; **c.** *Spirulina princeps*; **d.** *O. limosa*; **22.** *O. curviceps*; **23, 24.** *O. limosa*; **25-27.** *O. princeps*; **28-30.** *O. tenuis* (variation of the apical cells); **31-33.** *Cylindrospermopsis raciborskii* (morphological variability of the trichomes); **34.** *Dolichospermum planctonicum*. Scale bars: **Figs. 21, 22, 26** = 20 µm; **Figs. 23, 34** = 30 µm; **Figs. 24, 25, 27-33** = 10 µm.