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Original Paper

Planktonic chlorophyceans of a Brazilian subtropical river: taxonomy and ecological aspects

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Abstract

Given the extreme importance of understanding biodiversity in the contemporary context, this study performed a taxonomic survey of planktonic green algae from a subtropical river in Paraná state, broadening knowledge of the group's geographic distribution and the environmental conditions related to its occurrence. Monthly samplings of phytoplanktonic material were carried out from February 2015 to January 2016, resulting in the identification of 26 taxa belonging to the classes Chlorophyceae and Trebouxiophyceae, distributed among 16 genera and six taxonomic families. Among the taxa identified, seven are new citations for Paraná.

Key words: Chlorophyta, environmental conditions, phytoplankton, river, taxonomy.

Resumo

Dada a extrema importância do entendimento da biodiversidade no contexto contemporâneo, este estudo realizou um levantamento taxonômico das algas verdes planctônicas de um rio subtropical do estado do Paraná, ampliando o conhecimento da distribuição biogeográfica do grupo e as condições ambientais relacionados com a sua ocorrência. Foram realizadas coletas mensais do material fitoplanctônico no período de fevereiro de 2015 a janeiro de 2016, resultando na identificação de 26 táxons pertencenteas as classes Chlorophyceae e Trebouxiophyceae, distribuídos em 16 gêneros e seis famílias taxonômicas. Dentre os táxons identificados, sete são novas citações para o estado do Paraná.

Palavras-chave: Chlorophyta, condições ambientais, fitoplâncton, rio, taxonomia.

Introduction

Green algae are phylogenetically diverse, with extremely varied morphological, physiological, and ecological traits, they include motile and non-motile organisms, with cell arrangement being coccoid, flagellate, colonial, or filamentous, all of which reflects their diverse evolutionary histories (Komárek & Fott 1983; Coesel & Krienitz 2008). Moreover, green algae play a crucial role in the global ecosystem and their evolution was a key event in the history of plant life (Leliaert *et al.* 2012).

Because they cover an extremely broad group, the traditional classification proposed by Komárek & Fott (1983) has been revised since the rise of the polyphasic approach as an analytical tool, with the synthesis of morphological and molecular data resulting in proposals of new taxonomic arrangements (Krienitz & Bock 2012). Currently, green algae are classified in the sub-kingdom

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Viridiplantae with most of their taxa within the phylum Chlorophyta (Ruggiero *et al*. 2015), most of which are planktonic chlorophyceans assigned to the classes Chlorophyceae and Trebouxiophyceae (Bicudo & Menezes 2017). These algae are important indicators of the dynamics of aquatic systems such as rivers, lakes, and reservoirs, as their development is especially affected by nutrient availability, light, and temperature. They are also ecologically important as one of the major producers of biomass in continental ecosystems (Bellinger & Sigee 2010). In addition, planktonic chlorophyceans are important biodiversity indicators, particularly for meso- to eutrophic environments, which reflects the high functional variability of the group (Padisák *et al*. 2009).

Exclusively taxonomic works presenting descriptions and illustrations of planktonic chlorophyceans for the state of Paraná comprise nine contributions: Picelli-Vicentim (1987) surveyed 61 taxa from a lake in Iguaçu Regional Park, Curitiba; Rodrigues & Train (1993) documented 30 taxa from a lake in Alfredo Nyffler Park, Maringá; Bittencourt-Oliveira (1997) documented the occurrence of 18 taxa in the Tibagi River; Picelli-Vicentim *et al.* (2001) documented 32 taxa from the Passaúna River dam; Moresco & Bueno (2007) recorded 21 taxa belonging to the family Scenedesmaceae from Cascavel Municipal Lake; Biolo *et al.* (2009) identified 21 Chlorococcales taxa from the Itaipu reservoir; Bortolini *et al*. (2010) conducted a survey of 28 planktonic Chlorococcales taxa of the São João River, Iguaçu National Park; Menezes *et al.* (2011) identified, described and illustrated 17 taxa from Cascavel Municipal Park; Aquino *et al.* (2014) identified 30 taxa from the Cascavel River, in the western region of the state.

Given the important contributions of planktonic chlorophyceans to continental ecosystems, and the extreme importance of identifying biodiversity in the current scenario of global change, we conducted a taxonomic study of the planktonic green algae taxa in a subtropical river in the state of Paraná, in order to broaden knowledge of the group's geographic distribution, as well as to investigate the main environmental conditions related to its occurrence.

Material and Methods

Study area

The Coati Chico River (25°01'43.24"S, 53°28'02.61"W), situated in Cascavel municipality, Paraná state, Brazil, is an important tributary of the Cascavel River (Fig. 1). It is approximately 8.73 km long and is located in a rural area close to a sewage collection and treatment system (South Station - SANEPAR), receiving a large input of pretreatment material from this facility, in addition to suffering agricultural influences (Orssatto *et al.* 2009; Aquino *et al.* 2018). The sampling station has scant ciliary vegetation, in addition to silting for some months. Its channel has a mean depth of 0.95 m, mean width of 10.07 m, and mean flow of 3.66 $m^3\ s^{-1}$. The regional climate is categorized as type Cfa, being subtropical, humid, and mesothermic, with well-defined summer and winter periods and rains distributed through the year (Alvares *et al*. 2013).

Sampling methodology and data analysis

Water sampling for phytoplankton analysis was performed monthly from February 2015 to January 2016, with a plankton net (~25 µm), through horizontal dragging on the subsurface of the water column. Samples were preserved in 1:1 Transeau solution (Bicudo & Menezes 2017), and were stored in the herbarium of Universidade Estadual do Oeste do Paraná (UNOPA), Cascavel campus (Tab. 1). For the qualitative analyses, temporary slides were prepared, on average 15 slides per sample or until no new taxa occurred. The analyses were realized under an Olympus optical trinocular microscope, with infinite correction, model CX31, with a coupled camera. The morphometric data of the taxa are represented by the symbols: L = length; W = width; S = spine; D = diameter; Co = coenobium. The systematic and taxonomic framework was based on specialized literature. We calculated the constancy as a measure of taxa occurrence (C), which was expressed as follows: constant ($C \geq 70\%$), common ($30\% \geq C \leq 70\%$), sporadic ($10\% \geq C \leq 30\%$) and rare ($C \leq 10\%$) (Dajoz 2005). In order to verify the occurrence of taxa in the Paraná state, we considered only taxonomic studies with description, measures and/or ilustrations. Artificial keys to identify the taxa in each family were constructed for those families with more than two taxa.

We also collected water samples for analysis of environmental conditions such as dissolved oxygen (DO, mg L^{-1}), pH, water temperature (WT, °C), conductivity (Cond, mS cm^{-1}), and turbidity (Turb, NTU), which were measured in the field using a Horiba U-5000 multiparameter probe. Nutrient analysis included organic nitrogen (N_{org},

mg L^{-1}), ammoniac nitrogen (NH_4^+, mg L^{-1}), nitrate (NO_3^-, mg L^{-1}), nitrite (NO_2^-, mg L^{-1}), and total phosphorus (TP, mg L^{-1}) were analyzed according to the guidelines of the American Public Health Association - APHA (2005). The river flow was determined using the variables depth, width and flow speed, and was expressed in m^3 s.

Results and Discussion

We registered 26 taxa belonging to Chlorophyceae and Trebouxiophyceae, distributed among 16 genera and six taxonomic families. The most representative genera were *Monoraphidium* Komárková-Legnerová and *Desmodesmus* (Chodat) An, Friedl & Hegewald. Among the identified taxa, seven are new citations for the Paraná state. We present description of the taxa, frequency of occurrence, geographic distribution in the Paraná state and data of the maximum and minimum values of the environmental conditions in which the taxa occurred (when the taxa occurred only once, we present a single value). Taxonomical comments were added when relevant to the discussion.

Plantae
Viridiplantae
Chlorophyta
1. Chlorophyceae
1.1. Hydrodictyaceae

1.1.1. *Pediastrum duplex* var. ***duplex*** Meyen, Nova Acta Acad. Caesar. Leop. Carol. 14: 772. 1829. Fig. 2a,b

Coenobium circular, oblong and flat, usually formed by 8–16–32 concentrically arranged cells with intercellular spaces present. Marginal cells polygonal, "H" shaped, with 2 cylindrical tapered processes, short and truncated apices, deep "U" or "V" shaped incision, joined at the base. Inner cells rectangular or polygonal with 4 concavities and rounded angles. Parietal chloroplast with one pyrenoid. Co: 36.5–116.6 µm, L: 2.6–13.6 µm, W: 1.7–7.4 µm.

Examined material: UNOPA 4221, 4178, 4184, 4331.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Picelli-Vincentim (1987), Rodrigues & Train (1993), Oliveira *et al.* (1994), Bittencourt-Oliveira

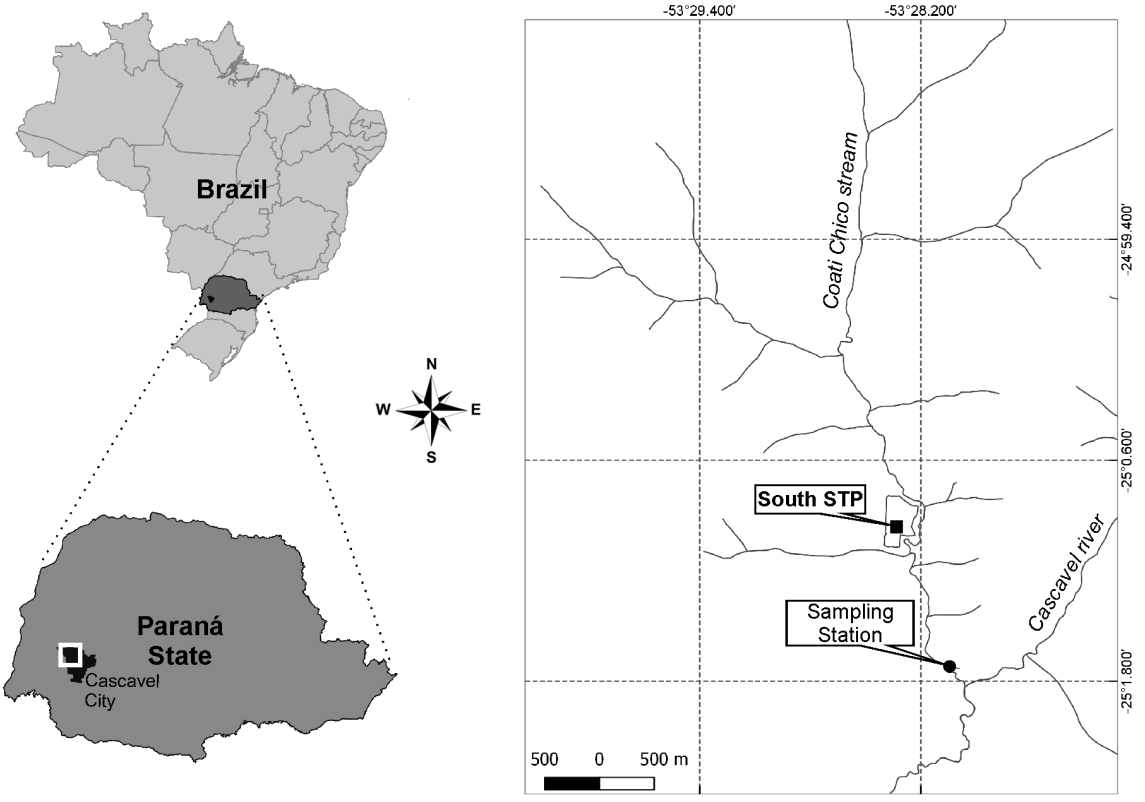

Figure 1 – Location of the sampling station in Coati Chico River, Cascavel, Paraná, Brazil.

Table 1 – Herbarium registration number in the Universidade Estadual do Oeste do Paraná (UNOPA), sampling date, geographic coordinates, and collector of samples collected in the Coati Chico stream.

UNOPA	Sampling date	Station	Geographic coordinates	Collector
4166	27/02/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4172	27/02/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4178	17/03/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4184	17/03/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4194	16/04/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4200	16/04/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4206	15/05/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4212	15/05/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4221	18/06/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4227	18/06/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4233	09/07/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4239	09/07/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4251	13/08/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4259	13/08/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4267	17/09/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4275	17/09/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4283	08/10/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4291	08/10/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4299	12/11/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4307	12/11/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4315	01/12/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4323	01/12/2015	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4331	21/01/2016	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*
4339	21/01/2016	Coati Chico stream	25°01'43.24"S, 53°28'2.61"W	*C.A.N. Aquino*

(1997), Picelli-Vicentim *et al.* (2001), Biolo *et al.* (2009), Bortolini *et al.* (2010), Aquino *et al.* (2014).

Environmental conditions: Flow 3.69–3.98 m³ s; WT 18.33–23.34 °C; pH 5.88–6.12; Cond 0.000–0.111 mS cm^{-1}; Turb 14.1–26.6 NTU; DO 9.63–10.04 mg L^{-1}; TP 0.017–0.092 mg L^{-1}; NO_2^- 0.674–1.254 mg L^{-1}; NO_3^- 0.0006–0.0010 mg L^{-1}; NH_4^+ 0.0287–0.0574 mg L^{-1}.

1.2. Neochloridaceae

1.2.1. ***Golenkinia radiata*** Chodat, J. Bot. 8: 305. 1894. Fig. 2c,d

Solitary cells, spherical, presenting numerous delicate, straight and long spines arranged irregularly along the length of the cell. In some cases, a thin and irregular mucilaginous layer is observed. Chloroplast with one pyrenoid. D: 4.6–8.9 µm, S: 4.8–20.3 µm. **Examined material**: UNOPA 4221, 4251, 4283, 4315.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Oliveira *et al.* (1994), Bittencourt-Oliveira (2002), Menezes *et al.* (2011), Aquino *et al.* (2014).

Environmental conditions: Flow 2.02–5.00 m³ s; WT 18.33–23.3 °C; pH 5.06–6.57; Cond 0.042–0.155 mS cm^{-1}; Turb 10.4–22.0 NTU; DO 7.26–9.99 mg L^{-1}; TP 0.013–0.028 mg L^{-1}; NO_2^- 0.134–0.874 mg L^{-1}; NO_3^- 0.0010–0.0016 mg L^{-1}; NH_4^+ 0.0041–0.1504 mg L^{-1}.

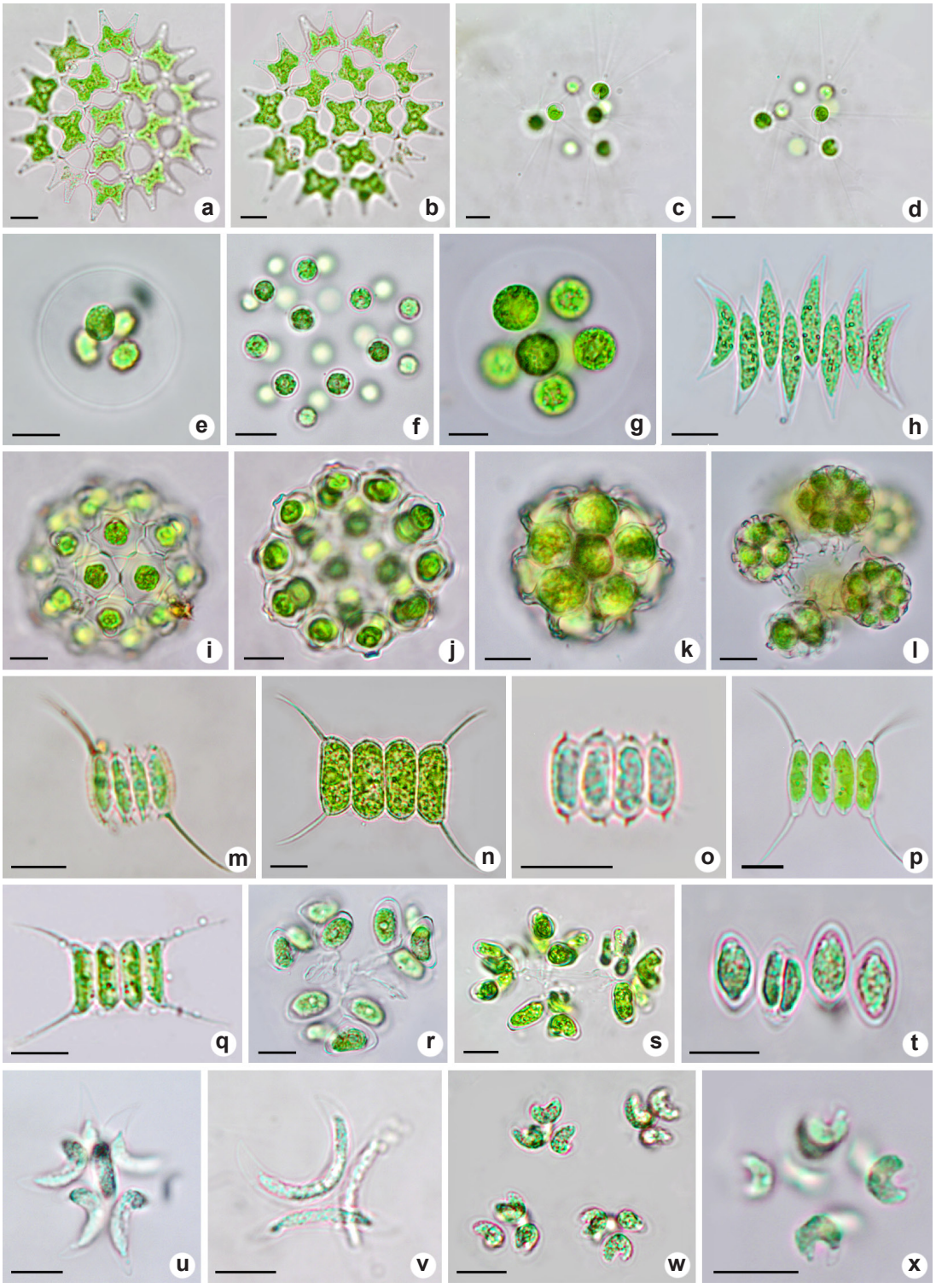

Figure 2 – a,b. *Pediastrum duplex* var. *duplex*. c,d. *Golenkinia radiata*. e. *Coenocystis subcylindrica*. f. *Eutetramorus tetrasporus*. g. *Radiococcus fotti*. h,i. *Coelastrum pulchrum* var. *pulchrum*. j,k. *Coelastrum reticulatum* var. *cubanum*. l. *Desmodesmus armatus* var. *bicaudatus*. m. *D. communis*. n. *D. opoliensis*. o. *D. opoliensis* var. *mononensis*. p. *D. pseudodenticulatus*. q,r. *Dimorphococcus lunatus*. s. *Tetradesmus dimorphus*. t. *T. lagerheimii*. u,v. *Ankistrodesmus bibraianus*. w,x. *Kirchneriella dianae.* Scale = 10 µm.

1.3. Radiococcaceae

Identification key for family taxa Radiococcaceae

1. Colonies with conspicuous hyaline mucilage 2
   2. Slightly elliptical to oval cells ..... 1.3.1. *Coenocystis subcylindrica*
   2'. Crown-shaped cells ..... 1.3.3. *Radiococcus fottii*
1'. Colonies with scattered in inconspicuous hyaline mucilage ..... 1.3.2. *Eutetramorus tetrasporus*

1.3.1. *Coenocystis subcylindrica* Korsikov, Protococcineae 330: 303. 1953. Fig. 2e

Colonies rounded, formed of 4–8–16 slightly elliptical to oval cells, arranged parallel to foreground and background, irregularly separated from each other. Presence of hyaline mucilage. Parietal chloroplast with one pyrenoid per cell. L: 2.7–6.2 µm, W: 2.1–3.4 µm.

Examined material: UNOPA 4166, 4194, 4233, 4275.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Picelli-Vicentim (1987).

Environmental conditions: Flow 2.64–6.35 m³ s; WT 16.58–23.35 °C; pH 5.06–6.38; Cond 0.103–0.155 mS cm^{-1}; Turb 17.0–46.9 NTU; DO 8.36–13.3 mg L^{-1}; TP 0.013–0.092 mg L^{-1}; NO_2^- 0.214–1.384 mg L^{-1}; NO_3^- 0.0001–0.0024 mg L^{-1}; NH_4^+ 0.0171–0.0573 mg L^{-1}.

According to Nogueira (1991), the genus *Coenocystis* Koršikov is easily confused with *Coccomyx* Schmidle, however it differs by presenting conspicuous mucilage and absence of pyrenoids. Although the individuals found in the present study had smaller cell dimensions than those found by Picelli-Vicentim (1987) (L: 7.5–8.0 µm, W: 2.7–5.4 µm) and Rosini *et al.* (2012) (L: 6.4–12.1 µm, W: 3.2–5.6 µm), they were in agreement with Comas (1996).

1.3.2. *Eutetramorus tetrasporus* Komárek, Nova Hedwigia, 37: 94. 1983. Fig. 2f

Colonies irregularly spherical or tetrahedral, consisting of 4–8–16 cells. Cells spherical, separated from each other, scattered in inconspicuous hyaline mucilage. Single parietal chloroplastid with one pyrenoid. D: 5.2–8.8 µm.

Examined material: UNOPA 4178, 4251, 4259, 4323, 4339.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 3.46–4.15 m³ s; WT 19.2–22.93 °C; pH 5.86–6.57; Cond 0.000–0.126 mS cm^{-1}; Turb 14.1–26.6 NTU; DO 7.26–10.04 mg L^{-1}; TP 0.013–0.092 mg L^{-1}; NO_2^- 0.364–1.254 mg L^{-1}; NO_3^- 0.0006–0.0016 mg L^{-1}; NH_4^+ 0.0197–0.1504 mg L^{-1}.

According to Nogueira (1991), *Eutetramorus tetrasporus* differs morphologically from *Radiococcus fottii* (F.Hindák) I.Kostikov, T.Darienko, A.Lukesová, & L.Hoffmann due to smaller cell dimensions and the tetrahedral arrangement of cells. The dimensions found in the specimens of the Coati Chico River are in agreement with Alves *et al.* (2014). *E. tetrasporus* is commonly found in eutrophic lakes, slow-moving rivers or swamps (Kim 2014).

1.3.3. *Radiococcus fottii* (F.Hindák) I.Kostikov, T.Darienko, A.Lukesová & L.Hoffmann. Arch. Hydrobiol. Suppl. 142 (Algol. Stud. 104): 39. 2002. Fig. 2g

Colonies rounded, irregular, consisting of 2–4–8 spherical, crown-shaped cells. Subcolonies arranged in two parallel planes in conspicuous hyaline mucilage. Parietal chloroplast with one basal pyrenoid. D: 2.8–7.7 µm.

Examined material: UNOPA 4251, 4259, 4331.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Cited as *Eutetramorus fottii* in Rodrigues & Train (1993) and Oliveira *et al.* (1994).

Environmental conditions: Flow 3.69–4.15 m³ s; WT 19.2–20.93 °C; pH 5.86–6.12; Cond 0.088–0.111 mS cm^{-1}; Turb 14.1–14.4 NTU; DO 9.66–10.04 mg L^{-1}; TP 0.013–0.017 mg L^{-1}; NO_2^- 0.364–0.674 mg L^{-1}; NO_3^- 0.0006–0.0016 mg L^{-1}; NH_4^+ 0.0574–0.1504 mg L^{-1}.

Kostikov *et al.* (2002) carried out a review of the family Radiococcaceae based on easily identifiable characteristics. The authors transferred *Eutetramorus fottii* (Hindák) Komárek to *Radiococcus fottii*, since representatives of the genus *Radiococcus* Schmidle are characterized by having spherical cells and autospores in adult stages. The cell dimensions found in the Coati Chico River are in agreement with Alves *et al.* (2014) and D'Alessandro & Nogueira (2017).

1.4. Scenedesmaceae

Identification key for family taxa Scenedesmaceae

1. Spherical colony with oblong or rounded cells 2
   2. Oblong cells with pyramidal or concave intercellular space ..... 1.4.1. *Coelastrum pulchrum* var. *pulchrum*
   2'. Rounded cells linked in a thin appendage without intercellular space ..... 1.4.2. *Coelastrum reticulatum* var. *cubanum*

1'. Colony flat with linearly arranged cells 3
   3. Cells with spine 4
      4. Cells with rounded poles 5
         5. Marginal cells with one long spine ..... 1.4.3. *Desmodesmus armatus* var. *bicaudatus*
         5'. Marginal cells with two long and bent spine ..... 1.4.4. *Desmodesmus communis*
      4'. Cells with truncated or tapered poles 6
         6. Cells with ribs and long spines 7
            7. Marginal cells with truncated poles ..... 1.4.5. *Desmodesmus opoliensis*
            7'. Marginal cells with tapered poles ..... 1.4.6. *Desmodesmus opoliensis* var. *mononensis*
         6'. Cells without ribs and short spines ..... 1.4.7. *Desmodesmus pseudodenticulatus*
   3'. Cells without spine 8
      8. Coenobium spherical or elongated ..... 1.4.8. *Dimorphococcus lunatus*
      8'. Coenobium flat 9
         9. Inner cells slightly straight and marginal cells strongly concave, straight or slightly convex ..... 1.4.9. *Tetradesmus dimorphus*
         9'. Inner cells spindle-like and marginal cells curved or lunate, with tapered and pointed ends ..... 1.4.10. *Tetradesmus lagerheimii*

1.4.1. *Coelastrum pulchrum* Schmidle var. ***pulchrum***, Ber. dt. bot. Ges. 10(4): 206 1892. Fig. 2h,i

Coenobium spherical, consisting of 8–16–32 ovoid or subovoid cells with truncated conical projections. Intercellular spaces triangular to spherical. Processes joining adjacent cells. Parietal chloroplast wih one pyrenoid. Co: 27.7–47.1 µm.

Examined material: UNOPA 4166, 4206, 4251.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Oliveira *et al.* (1994), Picelli-Vicentim *et al.* (2001), Biolo *et al*. (2009), Bortolini *et al*. (2010), Menezes *et al.* (2011), Aquino *et al.* (2014).

Environmental conditions: Flow 3.98–4.83 m³ s; WT 18.66–23.04 °C; pH 5.86–6.36; Cond 0.062–0.121 mS cm^{-1}; Turb 14.4–26.7 NTU; DO 7.76–10.27 mg L^{-1}; TP 0.013–0.092 mg L^{-1}; NO_2^- 0.214–1.254 mg L^{-1}; NO_3^- 0.0009–0.0016 mg L^{-1}; NH_4^+ 0.0284–0.2247 mg L^{-1}.

1.4.2. *Coelastrum reticulatum* var. ***cubanum*** Komárek, Preslia (Praga) 47: 277. 1975. Fig. 2j,k

Coenobium spherical, consisting of 8–16–32 spherical cells linked by protrusions of the cell wall. Each cell is linked with adjacent cells by a thin cylindrical appendix, arranged in hyaline mucilage. Chloroplast poculiform with one pyrenoid. Co: 18.7–35.1 µm.

Examined material: UNOPA 4194.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Aquino *et al.* (2014).

Environmental conditions: Flow 3.13 m³ s; WT 21.42 °C; pH 6.37; Cond 0.155 mS cm^{-1}; Turb 46.9 NTU; DO 13.3 mg L^{-1}; TP 0.020 mg L^{-1}; NO_2^- 0.464 mg L^{-1}; NO_3^- 0.0013 mg L^{-1}; NH_4^+ 0.0517 mg L^{-1}.

1.4.3. *Desmodesmus armatus* var. ***bicaudatus*** (Guglielmetti) E.H.Hegewald, Algol. Stud. 96: 4. 2000. ≡ *Scenedesmus acutiformis* Schröder var. *bicaudatus* Guglielmetti, N. Not. 21: 31. 1910. Fig. 2l

Coenobium flat, consisting of 2–4 linearly arranged cells. Inner cells cylindrical to ellipsoidal, containing ribs that can reach both ends continuously or interrupted in the median region. Marginal cells concave with a long spine, with cells presenting rounded and spindle-shaped poles. Parietal chloroplast with one pyrenoid. L: 3.0–7.2 µm, W: 2.5–14.3 µm, S: 5.3–12.6 µm.

Examined material: UNOPA 4178.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Moresco & Bueno (2007), Biolo *et al.* (2009), Bortolini *et al*. (2010), Menezes *et al.* (2011), Aquino *et al*. (2014).

Environmental conditions: Flow 3.98 m³ s; WT 22.93 °C; pH 5.88; Cond 0.000 mS cm^{-1}; Turb 26.6 NTU; DO 9.63 mg L^{-1}; TP 0.092 mg L^{-1}; NO_2^- 1.254 mg L^{-1}; NO_3^- .0.10 mg L^{-1}; NH_4^+ 0.0287 mg L^{-1}.

1.4.4. ***Desmodesmus communis*** (E.Hegewald) E.Hegewald, Algol. Stud. 96: 8. 2000. ≡ *Scenedesmus communis* E.Hegewald, Algol. Stud. 19: 151. 1977. Fig. 2m

Coenobium flat, consisting of 2–4–8 oblong ellipsoidal linearly arranged cells. Inner cells rounded at the ends, with rounded poles lacking spines. Marginal cells with a long and bent spine at each apex. Parietal chloroplast with one pyrenoid. L: 3.7–14.2 µm, W: 5.6–12.3 µm, S: 9.6–13.0 µm.

Examined material: UNOPA 4166, 4221, 4233.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Moresco & Bueno (2007), Biolo *et al.* (2009), Bortolini *et al.* (2010), Menezes *et al.* (2011), Aquino *et al.* (2014).

Environmental conditions: Flow 3.98–6.35 m³ s; WT 16.58–23.35 °C; pH 5.86–6.36; Cond 0.042–0.121 mS cm^{-1}; Turb 10.4–21.3 NTU; DO 9.04–10.27 mg L^{-1}; TP 0.014–0.092 mg L^{-1}; NO_2^- 0.134–1.384 mg L^{-1}; NO_3^- 0.0001–0.0024 mg L^{-1}; NH_4^+ 0.0041–0.0284 mg L^{-1}.

1.4.5. ***Desmodesmus opoliensis*** (R.G.Richter) E.Hegewald, Algol. Stud. 96: 14. 2000. ≡ *Scenedesmus opoliensis* Richter, Z. allg. Mikrobiol. 1: 7. 1895. Fig. 2n

Coenobium flat, consisting of 4–8 linearly arranged cells. Inner cells spindle-like, truncated or oblong. Cell wall smooth or ornamented with ribs. Marginal cells naviculoid with truncated poles, presenting one spine at each pole. Parietal chloroplast with one pyrenoid. L: 12.2–22.7 µm, W: 5.2–7.9 µm, S: 7.3–16.6 µm.

Examined material: UNOPA 4251, 4331, 4339.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Cited as *Scenedesmus opoliensis* Richter in Rodrigues & Train (1993) and Picelli-Vicentim *et al.* (2001); Moresco & Bueno (2007).

Environmental conditions: Flow 3.69–4.15 m³ s; WT 18.2–20.96 °C; pH 5.86– 6.12; Cond 0.088–0.111 mS cm^{-1}; Turb 14.1–14.4 NTU; DO 9.66–10.04 mg L^{-1}; TP 0.013–0.017 mg L^{-1}; NO_2^- 0.364–0.674 mg L^{-1}; NO_3^- 0.0006–0.00161 mg L^{-1}; NH_4^+ 0.0574–0.1504 mg L^{-1}.

1.4.6. ***Desmodesmus opoliensis*** var. ***mononensis*** (Chodat) E.Hegewald, Algol. Stud. 96: 15. 2000. ≡ *Scenedesmus opoliensis* (Richter) Hegewald var. *mononensis* Chodat, Z. Hydrol. 3: 210. 1926. Fig. 2o

Coenobium flat, consisting of 4–8 ellipsoidal and oblong linearly arranged cells. Inner cells spindle-like. Marginal cells with truncated and acute poles, having one spine at each pole. Parietal chloroplast with one pyrenoid. L: 4.7–15.1 µm, W: 2.8–13.0 µm, S: 15.1–16.5 µm.

Examined material: UNOPA 4251, 4267, 4331.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Bortolini *et al.* (2010).

Environmental conditions: Flow 2.64–4.15 m³ s; WT 19.20–22.68 °C; pH 5.06–5.97; Cond 0.088–0.142 mS cm^{-1}; Turb 14.4–17.6 NTU; DO 8.36–10.04 mg L^{-1}; TP 0.013–0.017 mg L^{-1}; NO_2^- 0.214–0.674 mg L^{-1}; NO_3^- 0.0001–0.0016 mg L^{-1}; NH_4^+ 0.0317–0.1504 mg L^{-1}.

1.4.7. ***Desmodesmus pseudodenticulatus*** (E.Hegewald) E.Hegewald, Algol. Stud. 96: 16. 2000. ≡ *Scenedesmus pseudodenticulatus* E.Hegewald in Hegewald & Schnepf, Algol. Stud. 20: 312. 1978. Fig. 2p

Coenobium flat, consisting of 4 oblong linearly arranged cells, with rounded or truncated poles. Ribs absent. Marginal cells ornamented with small, independent spines, separated from each other. Parietal chloroplast with one pyrenoid. L: 1.8–9.0 µm, W: 4.1–12.3 µm, S: 1.6–2.0 µm.

Examined material: UNOPA 4206, 4251, 4233.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Aquino *et al.* (2014).

Environmental conditions: Flow 4.15–6.35 m³ s; WT 16.58–19.20 °C; pH 5.06–5.97; Cond 0.062–0.103 mS cm^{-1}; Turb 14.4–16.7 NTU; DO 7.76–9.71 mg L^{-1}; TP 0.013–0.026 mg L^{-1}; NO_2^- 0.214–1.384 mg L^{-1}; NO_3^- 0.0009–0.00124 mg L^{-1}; NH_4^+ 0.0171–0.2247 mg L^{-1}.

1.4.8. ***Dimorphococcus lunatus*** A.Braun, Alg. unicell: 44. 1855. Fig. 2q,r

Coenobium spherical or elongated, consisting of 4–8 alternately arranged cells. Inner cells ovoid or ellipsoid. Marginal cells reniform, curved, both with rounded poles. Cells are joined through the

median region of the cell by mucilage filaments. Parietal chloroplast with one pyrenoid. L: 5.0–8.8 µm, W: 2.4–4.8 µm.
Examined material: UNOPA 4166, 4178, 4194, 4283, 4299.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Picelli-Vicentim (1987) and Picelli-Vicentim *et al*. (2001).

Environmental conditions: Flow 1.35–4.83 m³ s; WT 18.66–23.04 °C; pH 4.98–6.57; Cond 0.000–0.155 mS cm^{-1}; Turb 14.1–46.9 NTU; DO 7.26–13.3 mg L^{-1}; TP 0.016–0.166 mg L^{-1}; NO_2^- 0.214–1.844 mg L^{-1}; NO_3^- 0.0006–0.0027 mg L^{-1}; NH_4^+ 0.0197–0.3244 mg L^{-1}.

According to Bicudo (2012), *Dimorphococcus lunatus* is a species of easy taxonomic identification due to the characteristic shape of its cells. The coenobium is formed by two reniform and cordiform marginal cells and two oblong inner cells. The dimensions found in Coati Chico River are smaller than those found by Bicudo (2012) and Comas (1996), however, they are in agreement with the illustrations provided in the same studies.

1.4.9. *Tetradesmus dimorphus* (Turpin) M.J.Wynne 2016: 84 ≡ *Achnanthes dimorpha* Turpin, Mém. Mus. Nat. Hist. Natur. 16: 313. 1828. Fig. 2s

Coenobium flat, consisting of 4–8 ovoid, spindle-like, linear or alternately arranged cells, with acute ends. Inner cells slightly straight. Marginal cells strongly concave, straight or slightly convex. Parietal chloroplast with one pyrenoid. L: 11.7–20.0 µm, W: 2.6–5.8 µm.
Examined material: UNOPA 4233, 4299.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Cited as *Scenedesmus obliquus* var. *dimorphus* (Turpin) Hansgirg in Bortolini *et al.* (2010) and Aquino *et al.* (2014).

Environmental conditions: Flow 1.35–6.35 m³ s; WT 16.58–23.04 °C; pH 4.98–5.06; Cond 0.103–0.120 mS cm^{-1}; Turb 21.3–26.9 NTU; DO 8.01–9.71 mg L^{-1}; TP 0.014–0.166 mg L^{-1}; NO_2^- 1.384–1.844 mg L^{-1}; NO_3^- 0.0024–0.0027 mg L^{-1}; NH_4^+ 0.0171–0.3244 mg L^{-1}.

1.4.10. *Tetradesmus lagerheimii* M.J.Wynne & Guiry, Not. algarum 12:1. 2016. Fig. 2t

Coenobium flat, consisting of 2–4–8 linearly or alternately arranged cells. Inner cells spindle-like. Marginal cells curved or lunate, with tapered and pointed ends. Single parietal chloroplast with one pyrenoid. L: 7.2–10.4, W: 1.2–1.6 µm.
Examined material: UNOPA 4178, 4194, 4206, 4299, 4323, 4331.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Cited as *Scenedesmus acuminatus* (Lagerheim) R. Chodat in Picelli-Vicentim (1987), Rodrigues & Train (1993), Oliveira *et al.* (1994), Picelli-Vicentim *et al.* (2001), Moresco & Bueno (2007).

Environmental conditions: Flow 1.35–4.83 m³ s; WT 18.66–23.04 °C; pH 4.98–6.57; Cond 0.000–0.155 mS cm^{-1}; Turb 14.1–46.9 NTU; DO 7.26–13.3 mg L^{-1}; TP 0.016–0.166 mg L^{-1}; NO_2^- 0.214–1.844 mg L^{-1}; NO_3^- 0.0006–0.0027 mg L^{-1}; NH_4^+ 0.0197–0.3244 mg L^{-1}.

According to Wynne & Guiry (2016), the genus *Acutodesmus* was proposed in 1978 as a subgenus of *Scenedesmus* by Hegewald, and was later raised to the generic level by Tsarenko & Petlevanny (2001). In 2015, Wynne & Hallan proposed the transfer of *Acutodesmus* taxa to *Tetradesmus*, including *Tetradesmus acuminatus* (Lagerheim). Therefore, *T. acuminatus* is currently considered a synonym of *T. lagerheimii*.

1.5. Selenastraceae

Identification key for family taxa Selenastraceae

1. Colonial organisms with 2–64 cells 2
   2. Cenobial organisms with 2–16 cells 3
      3. Coenobium with 4–16, semicircular, sickle-shaped cells, tapering towards both ends ..... 1.5.1. *Ankistrodesmus bibraianus*
      3’. Coenobium with 2–4–8 narrow, elongated, semilunate to sickle-shaped cells, with the convex portion of the cells facing the center of the colony ..... 1.5.3. *Messastrum gracile*
   2’. Cenobial organisms with 12–64 cells ..... 1.5.2. *Kirchneriella dianae*
1’. Unicellular organisms 4
   4. Curved and spindle-shaped or arched or sigmoid cells 5
      5. Cells 10.1–11 µm in length ..... 1.5.4. *Monoraphidium circinale*
      5’. Cells 6.3–12.8 µm in length ..... 1.5.5. *Monoraphidium contortum*

4’. Straight solitary cells longer than wide 6
6. Spindle-like, arcuate, slightly curved cells ..... 1.5.8. *Monoraphidium pusillum*
6’. Spindle-like, straight, elongated cells 7
7. Cells 12–16 times longer than wide, slightly tapered ending at an acute tip ..... 1.5.6. *Monoraphidium griffithii*
7’. Cells 21–23 times longer than wide, median region cylindrical, gradually tapering towards the ends..... 1.5.7. *Monoraphidium komarkovae*

1.5.1. *Ankistrodesmus bibraianus* (Reinsch) Korsikov, Protococcineae 302. 1953. ≡ *Selenastrum bibraianum* Reinsch, Algenfl. Franken. 6(2): 64. 1866. Fig. 2u,v

Colonies irregular, consisting of 4–16, semicircular, sickle-shaped cells, tapering towards both ends. Ventral margin facing the colony. Cells joined by hyaline mucilage. Parietal chloroplast lacking pyrenoid. L: 8.0–16.6 µm, W: 2.2–2.5 µm.
Examined material: UNOPA 4166, 4194, 4221.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Picelli-Vicentim (1987), Bortolini *et al.* (2010), Aquino *et al.* (2014).

Environmental conditions: Flow 3.98–5.00 m³ s; WT 18.33–23.35 °C; pH 4.98–5.06; Cond 0.042–0.155 mS cm^{-1}; Turb 10.4–46.9 NTU; DO 9.04–13.3 mg L^{-1}; TP 0.020–0.092 mg L^{-1}; NO_2^- 0.134–1.254 mg L^{-1}; NO_3^- 0.0010–0.0013 mg L^{-1}; NH_4^+ 0.0041–0.0517 mg L^{-1}.

1.5.2. *Kirchneriella dianae* (Bohlin) Comas, Acta bot. Cubana 2: 4. 1980. ≡ *Kirchneriella lunaris* var. *dianae* Bohlin, Bih. K. Svenska Vet. Akad. Handl. 23(3): 20. 1897. Fig. 2w,x

Colonies irregular, consisting of 12–64 lunate cells, with semiovoid margins and apices facing away from the colony, arranged irregularly in inconspicuous and hyaline mucilage. Single parietal chloroplast with one pyrenoid. L: 4.5–6.3 µm, W: 2.4–4.5 µm.
Examined material: UNOPA 4178, 4307.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 1.35–3.98 m³ s; WT 22.93–23.04 °C; pH 4.98–5.88; Cond 0.000–0.120 mS cm^{-1}; Turb 26.6–26.9 NTU; DO 8.01–9.63 mg L^{-1}; TP 0.092–0.166 mg L^{-1}; NO_2^- 1.254–1.844 mg L^{-1}; NO_3^- 0.0010–0.0027 mg L^{-1}; NH_4^+ 0.0287–0.3244 mg L^{-1}.

According to Rosini *et al.* (2012), *Kirchneriella dianae* has been confused by many authors as a variety of *Kirchneriella lunaris* (Kirchner). However, according to D’Alessandro & Nogueira (2017), these taxa differ morphologically in the length and organization of the colony and cell incision. The dimensions found in Coati Chico River are in agreement with Comas (1996).

1.5.3. *Messastrum gracile* (Reinsch) T.S.Garcia, Fottea 17(1): 4. 2016. ≡ *Selenastrum gracile* Reinsch, Algenfl. Franken 6(2): 65. 1866. Fig. 3a,b

Colonies irregular, consisting of 2–4–8 narrow, elongated, semilunate to sickle-shaped cells, arranged with the convex portion of the cells facing the center of the colony. Free and colonial individuals are arranged irregularly in hyaline mucilage. Single parietal chloroplast lacking pyrenoid. L: 9.7–31.7 µm, W: 1.3–4.0 µm.
Examined material: UNOPA 4251.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Cited as *Selenastrum gracile* (Rein.) in Bittencourt-Oliveira (1997); cited as *Ankistrodemus gracilis* (Reinsch) Korsikov in Bortolini *et al.* (2010).

Environmental conditions: Flow 4.15 m³ s; WT 19.2 °C; pH 5.86; Cond 0.088 mS cm^{-1}; Turb 14.4 NTU; DO 9.66 mg L-1; TP 0.013 mg L^{-1}; NO_2^- 0.364 mg L^{-1}; NO_3^- 0.00161 mg L^{-1}; NH_4^+ 0.1504 mg L^{-1}.

According to D’Alessandro & Nogueira (2017) the taxa *Messastrum gracile* was described by Silva *et al.* (2017), initiating the taxonomic review of the genus *Selenastrum* (Reinsch). Although the dimensions found in Coati Chico River were smaller when compared to those found by Comas (1996), they were close to those found by Silva *et al.* (2017).

1.5.4. *Monoraphidium circinale* (Nygaard) Nygaard, Bot. Tidsskr. 73(1): 212. 1979. ≡ *Monoraphidium capricornutum* (Printz) Nygaard var. *circinale* Nygaard, K. dansk Vidensk. Selsk. Skr. 21(1): 60. 1977. Fig. 3c

Solitary, irregular, spindle-like, arcuate, semicircular to spiral cells, slightly tapered at the

ends. Single parietal chloroplast lacking pyrenoid. L: 10.1–11.8 µm, W: 1.9–2.7 µm.

Examined material: UNOPA 4166, 4178, 4194, 4331.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 3.98 m³ s; WT 22.93–23.35 °C; pH 5.88–6.38; Cond 0.000–0.121 mS cm^{-1}; Turb 17–26.6 NTU; DO 9.63–10.27 mg L^{-1}; TP 0.092 mg L^{-1}; NO_2^- 1.254 mg L^{-1}; NO_3^- 0.0010–0.0012 mg L^{-1}; NH_4^+ 0.02874–0.0287 mg L^{-1}.

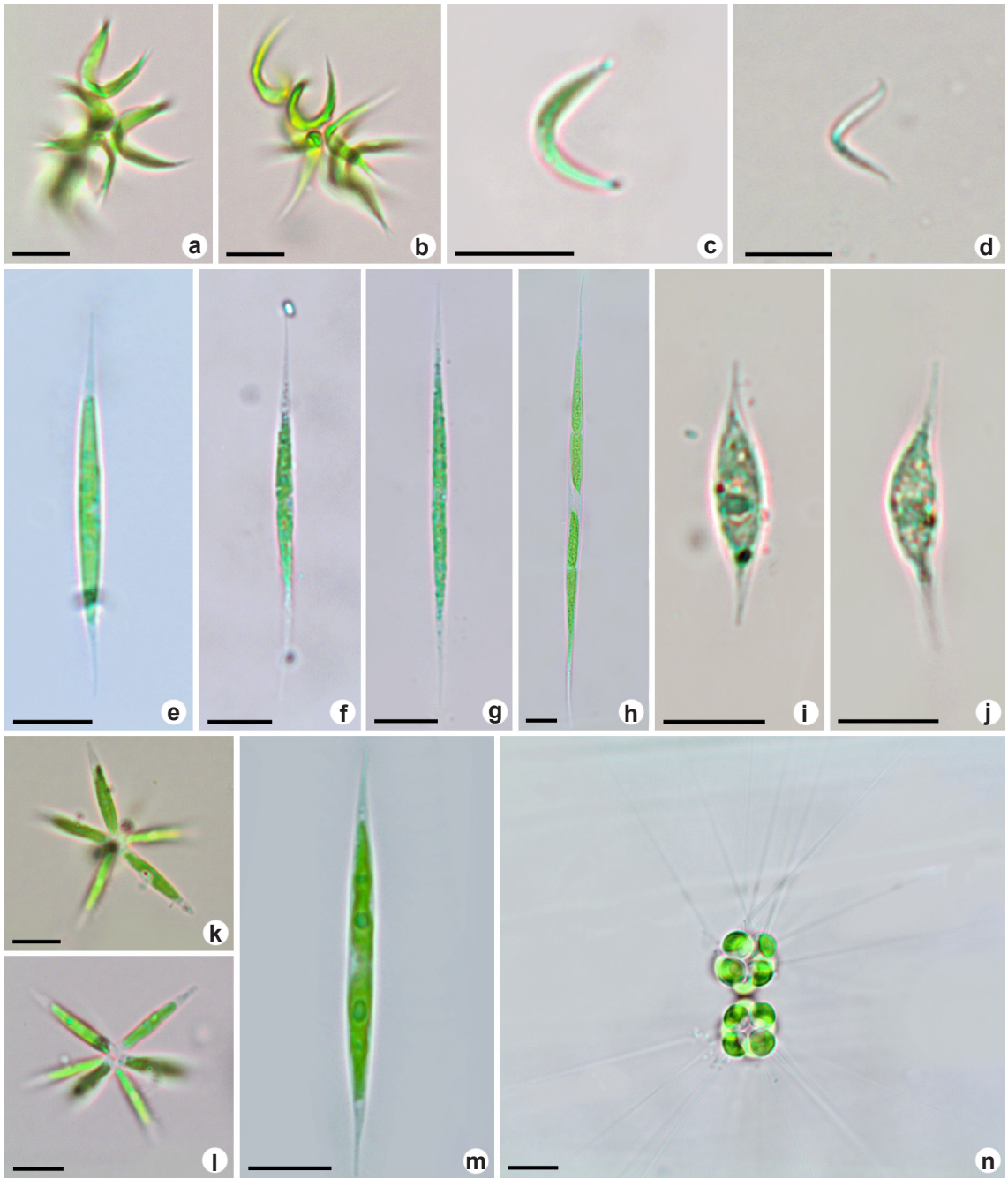

Figure 3 – a,b. *Messastrum gracile*. c. *Monoraphidium circinale*. d. M. *contortum*. e,f. *M. griffithii*. g,h. *M. komarkovae*. i,j *M. pussilum*. k,l. *Actinastrum hantzschii*. m. *Closteriopsis acicularis*. n. *Micractinium pusillum*. Scale = 10 µm.

According to Ramos *et al*. (2012), *Monoraphidium circinale* is morphologically similar to *Monoraphidium minutum* (Nägeli) Komárková-Legnerová, however, this taxa differs by having cylindrical poles and generally broader cells. In the same study, the dimensions found were smaller, however, measurements of our individuals are in agreement with those described by Comas (1996).

1.5.5. *Monoraphidium contortum* (Thuret) Komárková-Legnerová, Stud. Phycol. 104. 1969. ≡ *Ankistrodesmus contortus* Thuret, Mem. Soc. Imper. Sci. Nat. Cherbourg 4: 158. 1856. Fig. 3d

Solitary, curved, spindle-like, irregular, sigmoid or spiral cell, with gradually conic apices ending in acute tip. Parietal chloroplast lacking pyrenoid. L: 6.3–12.8 µm, W: 1.6–2.1 µm.

Examined material: UNOPA 4166, 4178.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: Rodrigues & Train (1993), Bittencourt-Oliveira (1997), Picelli-Vicentim *et al.* (2001), Bortolini *et al.* (2010), Menezes *et al.* (2011).

Environmental conditions: Flow 3.98 m³ s; WT 22.93–23.35 °C; pH 5.88–6.38; Cond 0.000–0.121 mS cm^{-1}; Turb 17–26.6 NTU; DO 9.63–10.27 mg L^{-1}; TP 0.092 mg L^{-1}; NO_2^- 1.254 mg L^{-1}; NO_3^- 0.0010–0.0012 mg L^{-1}; NH_4^+ 0.02874 –0.0287 mg L^{-1}.

1.5.6. *Monoraphidium griffithii* (Berkeley) Komárková-Legnerová, Stud. Phycol. 98. 1969. ≡ *Closterium griffithii* Berkeley, Ann. Mag. Nat. Hist. 13: 256. 1854. Fig. 3e,f

Solitary, spindle-like, straight cells, 12–16 times longer than wide, slightly tapered and curved, ending at an acute tip with a short spine. Parietal chloroplast lacking pyrenoid. L: 22.2–65.3 µm, W: 1.7–2.6 µm.

Examined material: UNOPA 4194, 4221, 4267, 4291,4307, 4315, 4331.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Picelli-Vicentim (1987), Bortolini *et al.* (2010).

Environmental conditions: Flow 1.35–5.00 m³ s; WT 18.33–23.34 °C; pH 4.98–6.57; Cond 0.042–0.155 mS cm^{-1}; Turb 10.4–46.9 NTU; DO 7.26–13.30 mg L^{-1}; TP 0.013–0.166 mg L^{-1}; NO_2^- 20.134–1.844 mg L^{-1}; NO_3^- 0.0001–0.0027 mg L^{-1}; NH_4^+ 0.0041–0.3244 mg L^{-1}.

1.5.7. *Monoraphidium komarkovae* Nygaard, Bot. Tidsskr. 73(1): 212. 1979. Fig. 3g,h

Solitary, spindle-like, straight, elongated cells, 21–23 times longer than wide. Median region of the cell cylindrical, gradually tapering towards the ends. Parietal chloroplast lacking pyrenoid. L: 78.5–113.5 µm, W: 3.6–4.9 µm.

Examined material: UNOPA 4166, 4178, 4323, 4331.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 3.46–3.98 m³ s; WT 20.93–23.35 °C; pH 5.88–6.57; Cond 0.000–0.126 mS cm^{-1}; Turb 14.1–66.6 NTU; DO 7.26–10.27 mg L^{-1}; TP 0.016–0.092 mg L^{-1}; NO_2^- 0.654–1.254 mg L^{-1}; NO_3^- 0.0061–0.0012 mg L^{-1}; NH_4^+ 0.0197–0.0574 mg L^{-1}.

According to Ramos *et al*. (2012), *Monoraphidium komarkovae* is morphologically similar to *Monoraphidium griffithi* (Berkeley) Komárková-Legnerová, since both possess straight and tapered spindle-like cells, however, *M. komarkovae* differs by larger cell dimensions and tapering, pointed apices. The dimensions found in Coati Chico River were larger than those described by Domingues & Torgan (2012) and Ramos *et al.* (2012).

1.5.8. *Monoraphidium pusillum* (Printz) Komárková-Legnorová, Stud. Phycol. 102. 1969. ≡ *Ankistrodesmus braunii* (Nägeli) Collins var. *pusillus* Printz, Skr. Vidensk. Selsk. 1913(6): 96. 1914. Fig. 3i,j

Solitary, spindle-like, arcuate, slightly curved cells, usually larger in the median region, with tapered ends. Parietal chloroplast lacking pyrenoid. L: 39.4–45.1 µm, W: 3.9–10.0 µm.

Examined material: UNOPA 4166, 4251, 4331.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 3.98–4.15 m³ s; WT 23.35–19.2 °C; pH 5.86–6.36; Cond 0.088–0.121 mS cm^{-1}; Turb 14.1–17.0 NTU; DO 9.66–10.27mg L^{-1}; TP 0.013–0.092 mg L^{-1}; NO_2^- 0.364–1.254 mg L^{-1}; NO_3^- 0.0062–0.0061 mg L^{-1}; NH_4^+ 0.0284–0.1504 mg L^{-1}.

According to Ramos *et al*. (2012), *Monoraphidium pusillum* is similar to *Monoraphidium litorale* Hindák, however, *M. pusillum* has more conical apices and smaller cells. The individuals found in the Coati Chico River presented larger dimensions when compared to those described by Comas (1996) and Ramos *et al.* (2012), however, all other characteristics are in agreement.

2. Trebouxiophyceae
2.1. Chlorellaceae

Identification key for family taxa Chlorellaceae

1. Colonial or cenobial organisms.....2
   2. Coenobium radial, conical, formed of 4–8, cylindrical, with attenuated or slightly rounded apices ..... 2.1.1. *Actinastrum hantzschii*
   2'. Colonies quadratic, formed of 4–8–16 spherical cells, with numerous straight and hyaline spines .....2.1.3. *Micractinium pusillum*
1'. Solitary organisms.....2.1.2. *Closteriopsis acicularis*

2.1.1. *Actinastrum hantzschii* Lagerheim, Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar Arg. 39(2): 70. 1882. Fig. 3k,l

Coenobium radial, conical, consisting of 4–8, cylindrical, spindle-like cells, with attenuated or slightly rounded apices. Cells 3–6 times longer than wide. Axial chloroplast with one pyrenoid. L: 9.5–20.0 µm, W: 1.6–7.5 µm.

Examined material: UNOPA 4166, 4194, 4251,4331.

Frequency of occurrence: rare.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 3.13–4.15 m³ s; WT 19.2–23.35 °C; pH 5.86–6.37; Cond 0.088–0.155 mS cm^{-1}; Turb 14.4–46.9 NTU; DO 9.66–13.3 mg L^{-1}; TP 0.013–0.092 mg L^{-1}; NO_2^- 0.364–1.254 mg L^{-1}; NO_3^- 0.0006–0.0016 mg L^{-1}; NH_4^+ 0.0284–0.1504 mg L^{-1}.

According to Rosini *et al.* (2012), *Actinastrum hantzschii* differs from *Actinastrum acicularis* Playfair by presenting cylindrical, attenuated and tapered cells towards the rounded apices, whereas *A. acicularis* var. *acicularis* possesses more spindle-like cells, erect, tapering towards pointed apices. The populations analyzed agree with the material described and illustrated by Komárek & Fott (1983).

2.1.2. *Closteriopsis acicularis* (Chodat) J.H.Belcher & Swale, Brit. Phycol. Bull. 2: 132. 1962. Fig. 3m

Solitary, thin, straight or slightly curved cells, with tapered-attenuated ends and pointed poles. Parietal chloroplast with 2–4 pyrenoids. L: 40.4–96.9 µm, W: 2.0–2.7 µm.

Examined material: UNOPA 4178, 4194, 4251.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: first citation for the Paraná state.

Environmental conditions: Flow 3.13–4.15 m³ s; WT 19.2–22.93 °C; pH 5.86–6.37; Cond 0.000–0.155 mS cm^{-1}; Turb 14.4–46.9 NTU; DO 9.63–13.3 mg L^{-1}; TP 0.013–0.092 mg L^{-1}; NO_2^- 0.364–1.254 mg L^{-1}; NO_3^- 0.0010–0.0016 mg L^{-1}; NH_4^+ 0.0516–0.1504 mg L^{-1}.

According to Ramos *et al.* (2015), *Closteriopsis acicularis* differs morphologically from *Closteriopsis longissima* (Lemmer) Lemmer by presenting smaller cell dimensions and pointed poles. The dimensions found in Coati Chico River are in agreement with Comas (1996).

2.1.3. *Micractinium pusillum* Fresenius, Abh. Senckenb. Naturforsch. Ges. 2: 236. 1858. Fig. 3n

Colonies quadratic, consisting of 4–8–16 spherical cells, with numerous straight and hyaline spines arranged in the cell wall. Poculiform chloroplast with one pyrenoid. D: 3.1–10.4 µm, S: 4.91–17.5 µm.

Examined material: UNOPA 4315, 4331, 4339.

Frequency of occurrence: sporadic.

Geographic distribution in the Paraná state: Picelli-Vicentim (1987), Rodrigues & Train (1993), Bittencourt-Oliveira (1997), Perbiche-Neves *et al.* (2007), Riediger *et al.* (2014).

Environmental conditions: Flow 3.46–3.69 m³ s; WT 20.93–21.09 °C; pH 6.12–6.57; Cond 0.111–0.126 mS cm^{-1}; Turb 14.1–22.0 NTU; DO 7.26–10.04 mg L^{-1}; TP 0.016–0.017 mg L^{-1}; NO_2^- 0.654–0.674 mg L^{-1}; NO_3^- 0.0006–0.0012 mg L^{-1}; NH_4^+ 0.0197–0.0574 mg L^{-1}.

The planktonic chlorophyceans sampled in the Coati Chico River included 26 taxa, largely represented by sporadic (15) and rare (11) taxa. In addition, the following seven new occurrences for the state of Paraná were described:

Eutetramorus tetrasporus, *Kirchneriella dianae*, *Monoraphidium circinale*, *M. komarkovae*, *M. pusillum*, *Actinastrum hantzschii*, and *Closteriopsis acicularis*. Floristic studies are the basis for understanding the biogeographic distribution of taxa, as well as being important in identifying measures for the management and conservation of biodiversity (Aquino *et al*. 2018). Although this study is of a qualitative nature, we were able to determine the occurrence of taxa and its local environmental conditions, as well as increase knowledge of the phycological flora of western Paraná state.

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