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Article

Taxonomic study and local environmental conditions of occurrence of Chlorophyceae (Chlorophyta) from subtropical lotic environments, Paraná, Brazil

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Abstract: Lotic environments are subjected to the impacts of human activities in an intense way in urban regions and one of the ways to assist in the environmental diagnosis is through the knowledge of the composition of bioindicator organisms, including microalgae. The objective of this work was to qualitatively characterize the Chlorophyceae Class Wille, providing descriptions and meristic data of the specimens as well as the environmental conditions in which the taxa were recorded. Water and phytoplankton samplings were carried out quarterly in 2020, in nine supply rivers, distributed in three river basins in the western region of Paraná (Paraná III basin, Piquiri basin and Baixo Iguaçu basin). The studied rivers were classified as oligotrophic or mesotrophic and the taxa were mostly rare. Thirty-six taxa belonging to the Chlorophyceae class were recorded, distributed in five families: Hydrodictyaceae Dumortier, Neochloridaceae Ettl & Komárek, Radiococcaceae Fott ex P.C.Silva, Scenedesmaceae Oltmanns, Selenastraceae Blackman & Tansley. These taxa have mainly cenobial representatives, with about 70% of the individuals in this thallus configuration, followed by 22% colonies and 8% unicellular thallus. Among the identified species, five occurred only in mesotrophic sites, warning for environments with tendencies to elevate their trophic, since they are genera previously associated with these conditions. Ten new citations were recorded for the State of Paraná, namely: *Pseudopediastrum boryanum* var. *longicorne* (Reinsch) P.M.Tsarenko, *Radiococcus skujae* I.Kostikov, T.Darienko, A.Lukesová & L.Hoffmann, *Desmodesmus perforatus* (Lemmermann) E.Hegewald, *Desmodesmus subspicatus* (Chodat) E.Hegewald & A.W.F.Schmidt, *Scenedesmus indicus* Philipose ex Hegewald, Engelberg & Paschma, *Ankistrodesmus bernardii* Komárek, *Monoraphidium capricornutum* (Printz) Nygaard, *Monoraphidium caribeum* Hindák, *Raphidocelis danubiana* var. *elegans* (Playfair) Taşkin & Alp, *Selenastrum rinoi* Komárek & Comas. Taxonomic studies, such as this one, are an important tool for understanding the flora, and in addition to contributing to the registration of species in aquatic ecosystems, they serve as a basis for ecological studies and other approaches used to preserve biodiversity in these places.
Keywords: *bioindicators; green algae; phytoplankton; rivers; taxonomy.*

Estudo taxonômico e condições ambientais locais da ocorrência de Chlorophyceae (Chlorophyta) de ambientes lóticos subtropicais, Paraná, Brasil

Resumo: Ambientes lóticos são ecossistemas muito vulneráveis aos impactos das atividades humanas, especialmente em regiões urbanas, e uma das formas para auxiliar no diagnóstico ambiental é utilizando o conhecimento da composição dos organismos bioindicadores, dentre eles as microalgas. O objetivo foi caracterizar qualitativamente as microalgas enquadradas na Classe Chlorophyceae Wille, fornecendo

descrições e dados merísticos dos espécimes bem como as condições ambientais em que os táxons foram registrados. Foram realizadas amostragens de água e de fitoplâncton trimestralmente no ano de 2020, em nove rios de abastecimento, distribuídos em três bacias hidrográficas da região oeste do Paraná (bacia do Paraná III, bacia do Piquiri e bacia do Baixo Iguaçu). Os rios estudados foram enquadrados como oligotróficos ou mesotróficos e os táxons apresentaram em sua maioria ocorrência rara. Foram registrados 36 táxons pertencentes a classe Chlorophyceae distribuídos em cinco famílias: Hydrodictyaceae Dumortier, Neochloridaceae Ettl & Komárek, Radiococcaceae Fott ex P.C.Silva, Scenedesmaceae Oltmanns, Selenastraceae Blackman & Tansley. Esses táxons possuem representantes principalmente cenobiais, apresentando cerca de 70% dos indivíduos nessa configuração de talo, seguido por 22% de colônias e 8% de talos unicelulares. Entre as espécies identificadas, cinco ocorreram somente em locais mesotróficos, advertindo para ambientes com tendências a elevar sua trofia, visto que são gêneros já associados anteriormente a essas condições. Foram registradas 10 novas citações para o Estado do Paraná, sendo estas: *Pseudopediastrum boryanum* var. *longicorne* (Reinsch) P.M.Tsarenko, *Radiococcus skujae* I.Kostikov, T.Darienko, A.Lukesová & L.Hoffmann, *Desmodesmus perforatus* (Lemmermann) E.Hegewald, *Desmodesmus subspicatus* (Chodat) E.Hegewald & A.W.F.Schmidt, *Scenedesmus indicus* Philipose ex Hegewald, Engelberg & Paschma*, Ankistrodesmus bernardii* Komárek, *Monoraphidium capricornutum* (Printz) Nygaard*, Monoraphidium caribeum* Hindák, *Raphidocelis danubiana* var. *elegans* (Playfair) Taşkin & Alp, *Selenastrum rinoi* Komárek & Comas. Trabalhos taxonômicos, como este, *são uma importante ferramenta para o* conhecimento da flora, e além de contribuir no registro das espécies nos ecossitemas aquáticos, servem como base para estudos ecológicos e demais abordagens utilizadas na preservação da biodiversidade nesses locais.

Palavras-chave: *algas verdes; bioindicadores; fitoplâncton; rios; taxonomia.*

Introduction

The Chlorophyceae class is part of the "UTC clade" (Ulvophyceae, Trebouxiophyceae and Chlorophyceae) within the Chlorophyta division, and stands out for having its undeniable monophyly, supported by molecular and ultrastructural data (Fučíková et al. 2019). Owing to the high number of species, it is considered one of the most abundant and diverse group in Brazilian continental waters (Rodrigues et al. 2010), grouping around 563 genera and 3.797species (Guiry & Guiry 2023). The morphology of these organisms ranges from flagellated unicellular to unicellular devoid of locomotion organelles, motile or non-motile colonies, filaments and pseudoparenchyma structures (Wehr et al. 2015). The species of the Class Chlorophyceae present a wide morphometric and ecophysiological variability, being able to develop in different habitats, being influenced especially by the light exposure, availability of reactive soluble phosphorus and mixing of the water column (Happey-Wood 1988).

Increasingly, lotic environments are degraded due to urbanization and intense anthropic activities (Li et al. 2022). In this context the water for public supply is deteriorated, besides all aquatic biota that suffer the consequences of inadequate management of these environments (Peres et al. 2022). In this sense the taxonomic composition of the Class Chlorophyceae is an important tool to assist in environmental diagnosis, since the species are often associated with environments with organic pollution and potential eutrophication (Wijeyaratne & Nanayakkara 2020). The literature for the State of Paraná, mainly studies in lotic environments, is scarce when compared to lentic environments, in addition to all the richness of species that have not yet been described. Among the main works referring to the Chlorophyceae Class in rivers, we can mention: Oliveira et al. (1994) with 46 taxa distributed in 25 genera in the Paraná River; Bittencourt-Oliveira (1997) with 24 taxa distributed in the Chlorococcales, Oedogoniales and Volvocales orders in the Tibagi River; Medri et al. (2002) with the flora of the Tibagi River; Biolo et al. (2009) with the identification of 21 taxa distributed in six families in the São Francisco Falso River.

Among the most recent works we can still cite: Bortolini et al. (2010) with 28 taxa distributed in the families Hydrodictyaceae, Oocystaceae and Scenedesmaceae in the São João River; Aquino et al. (2014) with thirty taxa, distributed in six families and 16 genera in the Cascavel River; Medeiros et al. (2021) recorded 26 taxa in a subtropical river in the State of Paraná and Aquino et al. (2022) with a book chapter that synthesizes the taxa of green microalgae described in the works for western Paraná.

Thus, our study aimed to carry out a taxonomic survey of phytoplanktonic chlorophyceans in lotic environments with different physical and chemical conditions of the water of the western region of Paraná; Provide descriptions, illustrations, morphometric and meristic data of the species found along the environments; Contribute to the registration of species found on the UNOPA (herbarium of UNIOESTE – Universidade Estadual do Oeste do Paraná) species Link platform.

Material and Methods

1. Selection, location and characterization of study sites

We selected nine rivers used to capture water for public supply in the western region of Paraná, along the Lower Iguaçu River, Paraná III and Piquiri river basins (Table 1), which were distributed in nine municipalities: Guaraniaçu, Catanduvas, Três Barras do Paraná, Boa Vista Aparecida, Foz do Iguaçu, Medianeira, Santa Tereza do Oeste, Cascavel and Toledo (Figure 1).

The water sampling for physicochemical and biological analyses was performed in two sites in each river. These sites are similar in terms of flow, riparian vegetation and human influence, however, they were

Table 1. Herbarium sample number (UNOPA), weather station, geographic coordinates, river and watershed of the water samples for microalgae analysis.

UNOPA	Weather station	Geographic coordinates	River	Watershed	UNOPA	Weather station	Geographic coordinates	River	Watershed
6799	Summer				6817	Summer			
6989	Autumn	25°40'56"S	Baú	Piquiri	7007	Autumn	25°32'13'S	Tamanduá	Lower Iguaçu River
7066	Winter	52°53'29"W			7084	Winter	54°31'25"W		
7242	Spring				7260	Spring			
6801	Summer				6819	Summer			
6991	Autumn	25°40'27"S	Baú	Piquiri	7009	Autumn	25°18'35"S	Alegria	Lower Iguaçu River
7068	Winter	52°53'20"W			7086	Winter	54°30'31"W		
7244	Spring				7262	Spring			
6803	Summer				6821	Summer			
6993	Autumn	25°11'13"S	Passo Liso	Paraná III	7011	Autumn	25°17'30"S	Alegria	Lower Iguaçu River
7070	Winter	53°08'18"W			7088	Winter	54°40'35"W		
7246	Spring				7264	Spring			
6805	Summer				6823	Summer			
6995	Autumn	25°12'38"S	Passo Liso	Paraná III	7013	Autumn	25°20'29"S	Gonçalves Dias	Lower Iguaçu River
7072	Winter	53°07'51"W			7090	Winter	53°35'20"W		
7248	Spring				7266	Spring			
6807	Summer				6825	Summer			
6997	Autumn	25°26'11"S	Itaguaçu	Paraná III	7015	Autumn	25°30'47"S	Gonçalves Dias	Lower Iguaçu River
7074	Winter	53°11'17"W			7092	Winter	53°36'14"W		
7250	Spring				7268	Spring			
6809	Summer				6827	Summer			
6999	Autumn	25°26'21"S	Itaguaçu	Paraná III	6981	Autumn	52°53'29"S	Cascavel	Lower Iguaçu River
7076	Winter	53°10'50"W			7094	Winter	53°26'06"W		
7252	Spring				7270	Spring			
6811	Summer				6829	Summer			
7001	Autumn	25°25'17"S	Jacutinga	Paraná III	6983	Autumn	52°53'20"S	Cascavel	Lower Iguaçu River
7078	Winter	53°25'46"W			7096	Winter	53°26'19"W		
7254	Spring				7272	Spring			
6813	Summer				6831	Summer			
7003	Autumn	25°25'46"S	Jacutinga	Paraná III	6985	Autumn	24°45'49"S	Toledo	Lower Iguaçu River
7080	Winter	53°26'17"W			7098	Winter	53°39'50"W		
7256	Spring				7274	Spring			
6815	Summer				6833	Summer			
7005	Autumn	25°30'26"S	Tamanduá	Lower Iguaçu River	6987	Autumn	24°43'51"S	Toledo	Lower Iguaçu River
7082	Winter	54°31'50"W			7100	Winter	53°42'40"W		
7258	Spring				7276	Spring			

selected taking into consideration the characteristic of lotic systems, where the water flow carries dissolved materials including pollutants, making a comparison between the two possible (Vannote et al. 1980). Sampling was carried out during the year 2020 in all four seasons. All samples were deposited in the herbarium of UNIOESTE – Universidade Estadual do Oeste do Paraná – UNOPA, Campus Cascavel, connected to the Brazilian Network of Herbaria and the data were computerized and made available on speciesLink (www.splink.cria.org.br).

2. *Sampling and analysis of environmental variables in rivers*

Data were obtained on water temperature (Temp – °C), dissolved oxygen (DO – mg L^{-1}), pH, electrical conductivity (Condut – mS/cm^{-1}) and turbidity (Turb – NTU), measured at the moment of the samples through the multiparameter probe Horiba U-5000. The data referring to the flow (m^3 s) and maximum depth were collected with the aid of a ruler, measuring tape and a floating object, considering the multiplication between the average speed resulting from the displacement of the object and the cross-sectional area at the site to calculate the flow, measured *in situ*.

For chemical analysis, water samples were collected by subsurface immersion of polyethylene bottles, being kept properly refrigerated and in the dark until their destination. Estimates of concentrations of nitrate (NO_3 – mg L^{-1}), ammonia nitrogen (N-NH3 – mg L^{-1}), total phosphorus (TP- mg L^{-1}), chlorophyll *a* (CL*a* – mg L^{-1}), were performed following the standardized methods in Standard Methods (APHA 2017).

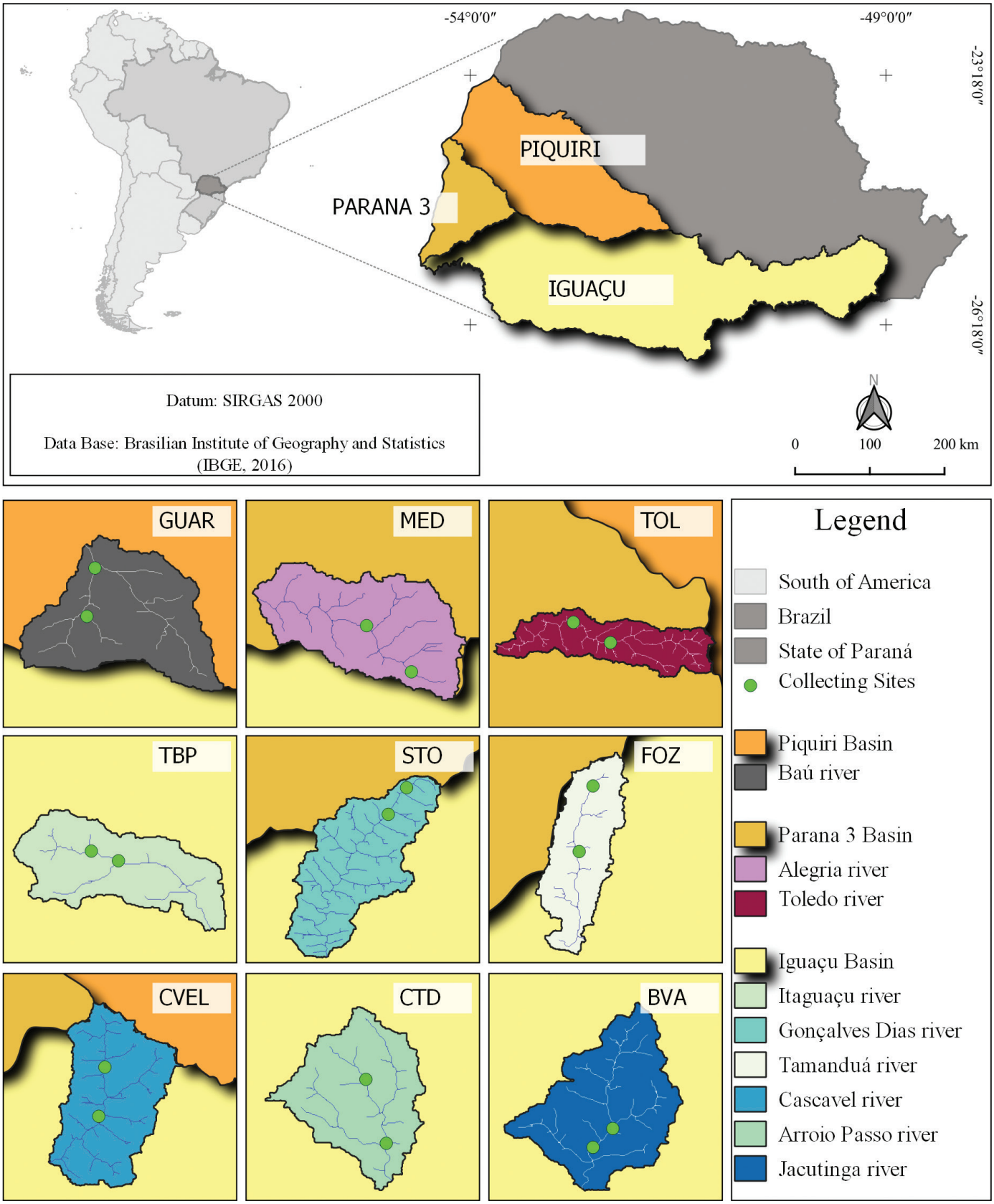

Figure 1. Municipalities in western Paraná, Brazil, selected for a taxonomic study of microalgae belonging to the Class Chlorophyceae. Abbreviations of the municipalities: GUAR: Guaraniaçu; MED: Medianeira; TOL: Toledo; TBP: Três Barras do Paraná; STO: Santa Tereza do Oeste; FOZ: Foz do Iguaçu; CVEL: Cascavel; CTD: Catanduvas; BVA: Boa Vista Aparecida.

3. Phytoplankton community

For the qualitative analysis, phytoplankton samples were obtained using a 25 µm mesh size plankton, were preserved in Transeau solution (Bicudo & Menezes 2017) in order to concentrate the phytoplanktonic material. The qualitative study of phytoplankton was carried out using an Olympus CX41 photomicroscope, coupled with an Olympus SC30 camera, and the morphometry of the taxa was performed at 40× and 100× magnification. The taxa were identified based on specialized literature, classification used follows Krienitz & Bock (2012). In order to verify the occurrence of taxa in the Paraná State, we considered only taxonomic studies with description, measures and/or illustrations, in lotic and lentic environments. The measurements (in µm) are represented by L – length; W – width; T – thorn; D – diameter; De – dent; Co – coenobium; P – process. Constancy is a measure of species occurrence (C) and was expressed as follows: constant (C ≥ 70%), common (30% ≥ C ≤ 70%), sporadic (10% ≥ C ≤ 30%) and rare (C ≤ 10%) (Dajoz 2005).

4. TSI – Trophic State Index

The Trophic State Index presented and used in the calculation of VAT (Index of Preservation of Aquatic Life), was composed by the Trophic State Index for phosphorus – TSI(PT) and the Trophic State Index for chlorophyll *a* – TSI(CL), modified by Lamparelli (2004), being established to lotic environments, according to the equations:

Rivers

$$TSI\ (CL) = 10 \times (6–((–0{,}7–0{,}6 \times (\ln CL)) / \ln 2)) –20$$

$$TSI\ (PT) = 10 \times (6–((0{,}42–0{,}36 \times (\ln PT)) / \ln 2)) –20$$

Where: PT: total phosphorus concentration measured at the water surface, in µg L^{-1}; CL: chlorophyll *a* concentration measured at the water surface, in µg L^{-1}; ln: natural logarithm. To classify the Trophic State for rivers, the Carlson Index (1977) modified by Toledo et al. (1983).

Results

Were registered 36 taxa belonging to the class Chlorophyceae Wille, distributed in five families: Hydrodictyaceae Dumortier, Neochloridaceae Ettl & Komárek, Radiococcaceae Fott ex P.C.Silva, Scenedesmaceae Oltmanns, Selenastraceae Blackman & Tansley and 16 genera : *Ankistrodesmus* Corda, *Coelastrum* Nägeli, *Comasiella* E.Hegewald, M.Wolf, A.Keller, Friedl & Krienitz, *Desmodesmus* (R.Chodat) S.S.An, T.Friedl & E.Hegewald, *Golenkinia* Chodat, *Kirchneriella* Schmidle, *Lacunastrum* H.A.McManus, *Monoraphidium* Komárková-Legnerová, *Pediastrum* Meyen, *Pseudopediastrum* E.Hegewald, *Radiococcus* Schmidle, *Scenedesmus* Meyen, *Stauridium* Corda, *Selenastrum* Reinsch, *Tetrallantos* Teiling, *Westella* De Wildeman (Figures 2–4).

FAMILY HYDRODICTYACEAE

Lacunastrum gracillimum (West & G.S.West) H.A.McManus., J. Phycol., 47(1): 123-130, 2011. Basionym: *Pediastrum duplex* var. *gracillimum* West & G.S.West, J. Bot., 33:52, 1895.
Figure 2: A
Flat coenobium, with circular to oval shape; formed by 16 cells, clathrated; marginal cells in an asymmetrical “H” shape, concave base, two slender, long processes of equal length, ending in a slightly rectused papilla, deeply excavated “U” incision; inner cells similar to outer ones; chloroplast with the shape of the cell, one central pyrenoid.
Morphometric data: Co = 32.5-62.5 µm; L = 12.5-15.0 µm; W = 5.0-10.0 µm.
Paraná State citation: Aquino et al. (2014) as *Pediastrum duplex* var. *gracillimum* West & G.S.West, Aquino et al. (2022).
Taxonomic remarks: molecular studies, associated with cell wall scan data, considering the differential characteristics of the coenobium, elongated cell lobes and smooth cell wall, made it possible to transfer the species *Pediastrum gracillimum* (West & G.S.West) Thunmark to the genus *Lacunastrum* H.A.McManus (McManus et al. 2011). Some specimens in this work presented larger dimensions than those recorded in Aquino et al. (2014), however they are in agreement with their description and illustration.
Occurrence in samples: UNOPA 6985, 6987, 6995, 7001
Frequency of occurrence: rare

Pediastrum duplex Meyen, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat., 14: 768-778, 1829.
Figure 2: B
Circular coenobium; formed by 16 to 32 cells (sometimes four, eight or 64 cells) arranged concentrically; intercellular spaces present; polygonal marginal cells joined at the base; square to angled inner cells; chloroplast with the shape of the cell; pyrenoid not observed.
Morphometric data: Co = 32.5-50.0 µm; L = 7.5-15.0 µm; W = 7.5-15.0 µm.
Paraná State citation: Picelli-Vicentim (1987), Rodrigues & Train (1993), Oliveira et al. (1994), Bittencourt-Oliveira (1997), Picelli-Vicentim et al. (2001), Train et al. (2001), Borges et al. (2003), Biolo et al. (2009), Bortolini et al. (2010), Felisberto & Rodrigues (2010, 2012), Aquino et al. (2014), Medeiros et al. (2021) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6983, 6985, 6987, 7094
Frequency of occurrence: rare

Pseudopediastrum boryanum* var. *longicorne (Reinsch) P.M.Tsarenko, Algae of Ukraine: diversity, nomenclature, taxonomy, ecology and geography, 3: 280-355, 2011.
Basionym: *Pediastrum boryanum* f. *longicorne* Reinsch, Algenfl. Franken, 96, 1866.
Figure 2: C
Circular to oval coenobium; formed by 16 to 32 cells arranged in concentric rings without intercellular space; marginal cells extended into two longer processes, ending in swollen, stubby spines; polygonal inner cells with straight sides; cell wall usually granulated or smooth; parietal chloroplast, with one pyrenoid.
Morphometric data: Co = 32.5-41.0 µm; L = 7.5-18.0 µm; W = 5.0-13.0 µm; P = 7.0-10.0 µm.
Paraná State citation: first record.
Taxonomic remarks: the lineage of *Pseudopediastrum boryanum* (Turpin) E.Hegewald is divided into varieties through a set of morphological characters, such as the number of coenobium cells, the size and shape of the marginal cells, the absence of perforations between the cells and the density of the granules from the surface (Lenarczyk & Saluga 2018). The specimens of this work were identified as

P. boryanum var. *longicorne* (due to the size of the marginal cells, which are longer than the type species, resembling a "U" shape, and are in agreement with the specialized literature (Rai & Misra 2013).
Occurrence in samples: UNOPA 6805, 6815, 6995
Frequency of occurrence: rare

Stauridium tetras (Ehrenberg) E.Hegewald, J. Phycol., 41: 1039-1054, 2005.
Basionym: *Micrasterias tetras* Ehrenberg, Infus., 155, 1838.
Figure 2: D-F
Rectangular, oval or circular coenobium; formed by four, eight or 16 cells without intercellular spaces; marginal cells divided into two lobes, by a deep linear incision, from the outside reaching the middle of the cell; internal cells formed by four to six sides with a single linear incision; smooth cell wall, parietal chloroplast; pyrenoid not observed.
Morphometric data: D = 22.5-35.0 µm; L = 7.5-12.5; W = 7.5-13.5 µm.
Paraná State citation: Cited as *Pediastrum tetras* (Ehrenberg) Ralfs in Lozovei & Luz (1976), Lozovei & Hohmann (1977), Picelli-Vicentim (1986), Rodrigues & Train (1993), Oliveira et al. (1994), Train et al. (2001), Train et al. (2003), Algarte et al. (2006), Borges et al. (2008) and Felisberto & Rodrigues (2012), Biolo et al. (2009), Bortolini et al. (2010), and as *Stauridium tetras* in Menezes et al. (2011), Aquino et al. (2014), Aquino et al. (2022).
Taxonomic remarks: in the species proposition, some specimens from the sampling had been identified as *Pediastrum tetras*, however, Buchheim et al. (2005) proposed the transference of *Pediastrum tetras* to the genus *Stauridium* Corda from molecular analyses. Despite being a well-defined species, it can present considerable morphological variation (Ramos et al. 2016), and therefore the dimensions of the specimens also vary, as verified in Aquino et al. (2022).
Occurrence in samples: UNOPA 6799, 6981, 6983, 6995, 7072, 7096, 7272
Frequency of occurrence: rare

FAMILY NEOCHLORIDACEAE

Golenkinia radiata Chodat, J. Bot., 8: 305-308, 1894.
Figure 2: G
Spherical cells, isolated; with numerous long and delicate spines (12-14); parietal and single chloroplast; an elliptical to reniform pyrenoid.
Morphometric data: D = 13 .5- 15.0 µm; T = 19.0-25.0 µm.
Paraná State citation: Cecy et al. (1976), Lozovei & Luz (1976), Stankiewicz et al. (1981), Oliveira et al. (1994), Train et al. (2000), Bittencourt-Oliveira (2002), Train et al. (2003), Perbiche-Neves et al. (2007), Borges et al. (2008), Felisberto & Rodrigues (2010), Menezes et al. (2011), Aquino et al. (2014), Riediger et al. (2014), Medeiros et al. (2021) and Aquino et al. (2022).
Taxonomic remarks: the dimensions analyzed in this study are smaller than in Aquino et al. (2022), however they are in agreement with the specimens by Tucci et al. (2014), and in both works the description and illustration are also in agreement.
Occurrence in samples: UNOPA 6805, 6821, 6991, 6995
Frequency of occurrence: rare

FAMILY RADIOCOCCACEAE

Radiococcus skujae I.Kostikov, T.Darienko, A.Lukešová & L.Hoffmann, Algol. Stud., 104:40, 2002.
Figure 2: H
Spherical colonies; tetrahedrally or octahedrally arranged cells; sporangial cell wall fragments at the periphery of the mucilage; pyrenoid not observed.
Morphometric data: D = 4.0 – 6.0 µm.
Paraná State citation: first record.
Taxonomic remarks: in the specialized literature, some authors identified *R. skujae* as *Thorakochloris nygaardii* Komárek, however this taxon was transferred to the genus *Hindakochloris nygaardii* (Komárek) Comas. Kostikov et al. (2002) considered this genus as a synonym of *R. skujae*, due to the cell shape and reproductive behavior, with *Radiococcus* being the most used nowadays.
Occurrence in samples: UNOPA 6981
Frequency of occurrence: rare

FAMILY SCENEDESMACEAE

Coelastrum astroideum De Notaris, Desmidacée delle Val Itrasca, pp. 1-84,1867.
Figure 2: I
Spherical coenobium; formed by eight to 32 ovoid-shaped cells; intercellular spaces present, quadrangular; smooth cell wall, often with apical thickening; parietal chloroplast, with one pyrenoid.
Morphometric data: Co = 15.0-25.0 µm; D = 5.0-7.0 µm.
Paraná State citation: Biolo et al. (2009) and Aquino et al. (2022).
Taxonomic remarks: *Coelastrum astroideum* De Notaris can be confused with other species, such as *Coelastrum microporum* Nägeli, however it differs in that its cells are ovoid in lateral view.
Occurrence in samples: UNOPA 6805, 6809, 6981
Frequency of occurrence: rare

Coelastrum microporum Nägeli, Algarum unicellularium genera nova et minus cognita praemissis verificationibus de algis unicellularibus in genere, p.70, fig. 6, 1855.
Figure 2: J
Spherical coenobium; formed by eight to 32 cells joined directly by the cell wall; spherical cells, without connective processes; small triangular or rectangular intercellular spaces; smooth cell wall, without apical thickening; parietal chloroplast, one central pyrenoid.
Morphometric data: Co = 22.5-25 µm; D = 4-6 µm.
Paraná State citation: Picelli-Vicentim (1987) and Picelli-Vicentim et al. (2001).
Taxonomic remarks*: Coelastrum microporum* can be confused with *Coelastrum astroideum*, however, it differs in that its cells are spherical in both lateral and apical views. The specimens in this study have relatively smaller dimensions than those analyzed by Ramos et al. (2015), in comparison with Tucci et al. (2019) the dimensions are larger, however, the description and morphology are in agreement with both works.
Occurrence in samples: UNOPA 6805, 6829, 7096
Frequency of occurrence: rare

Coelastrum proboscideum Bohlin, Algae aquae dulcis exsiccatae praecipue scandinavicae quas adjectis algis marinis chlorophyllaceis et phycochromaceis, 1201-1400, 1896.
Figure 2: K-L
Tetrahedral coenobium; formed by four to 32 triangular cells, in lateral view; outer poles with crown-like thickening; quadratic intercellular spaces; single parietal chloroplast.
Morphometric data: Co = 15.5 µm; L = 4.0-8.0 µm.
Paraná State citation: Lozovei & Luz (1976), Lozovei & Hohmann (1977), Picelli-vicentim (1986), Aquino et al. (2014) and Aquino et al. (2022)
Taxonomic remarks: the specimens in this study have smaller dimensions than those analyzed by Tucci et al. (2019), but they are in agreement with other studies as in Aquino et al. (2022), in addition to having illustration and description according to these works.
Occurrence in samples: UNOPA 6995, 7274
Frequency of occurrence: rare

Coelastrum pulchrum Schmidle, Ber. Deutsch. Bot. Ges., 10: 206-211, 1892.
Figure 3: A-B
Spherical coenobium; formed by eight to 32 cells; intercellular spaces present; octagonal cells, joined by conical-truncated processes, facing the periphery of the coenobium; thickened apices; parietal chloroplast with one pyrenoid.
Morphometric data: Co = 30.0-62.5 µm; D = 5.0 -7.5 µm.
Paraná State citation: 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), Medeiros et al. (2021) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6827, 6829, 6981, 6983, 7094, 7270
Frequency of occurrence: rare

Coelastrum reticulatum **var.** ***cubanum*** Komárek, Preslia, 47: 277, 1975.
Figure 3: C
Spherical coenobium found singly or in multiples; formed by 16 to 32 spherical cells connected to each other by cylindrical processes; intercellular spaces present; parietal chloroplast with one pyrenoid.
Morphometric data: Co = 10.0-35.0 µm; D = 4.0-7.5 µm .
Paraná State citation: Rodrigues & Train (1993), Aquino et al. (2014), Medeiros et al. (2021) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6805, 6827, 6829, 6833, 6981, 6983, 7005, 7094, 7096
Frequency of occurrence: sporadic

Comasiella arcuata **var.** ***platydisca*** (G.M.Smith) E.Hegewald & M.Wolf, Phycologia, 49 (4): 325-335, 2010.
Basionym: *Scenedesmus arcuatus* var. *platydiscus* G.M.Smith, Trans. Wis. Acad. Sci. Arts Lett., 18: 451, 1916.
Figure 3: D-E
Flat coenobium; formed by four to eight reniform cells with rounded poles; cells arranged in double, alternating series, sheathed with inconspicuous mucilage; outer cells not fully aligned; parietal chloroplast with one pyrenoid.
Morphometric data: Co = 14.0-23.0; L = 9.0-13.0 µm; W = 4.0-5.0 µm.
Paraná State citation: Menezes et al. (2011) cited as *Scenedesmus arcuatus* var. *platydiscus*, Aquino et al. (2014) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6981, 6983 7072, 7094
Frequency of occurrence: rare

Desmodesmus armatus (Chodat) E.H.Hegewald, Algol. Stud., 96: 1-18, 2000.
Basionym: *Scenedesmus hystrix* var. *armatus* Chodat, Algues vertes de la Suisse, p.25, 1902.
Figure 3: G
Flat coenobium; formed by two to four cells arranged linearly; ellipsoid inner cells; ellipsoid to arcuate outer cells, often with frontal ribs; main spines in linear arrangement; parietal chloroplast with one pyrenoid.
Morphometric data: L = 9.0-13.0 µm; W = 3.0-4.0; De = 0.8-1.2 µm; T = 13.0-14.0 µm.
Paraná State citation: in the work of Lozovei & Luz (1976) still cited as *Scenedesmus quadricauda* Chod., Moresco & Bueno (2007), Biolo et al. (2009), Bortolini et al. (2010), Felisberto & Rodrigues (2010), Menezes et al. (2011), Felisberto & Rodrigues (2012), Aquino et al. (2014) and Aquino et al. (2022).
Taxonomic remarks: some specimens have smaller cell dimensions than those reported by Tucci et al. (2019), however they are in agreement with those found in Aquino et al. (2022).
Occurrence in samples: UNOPA 6805, 6995, 7005
Frequency of occurrence: rare

Desmodesmus brasiliensis (Bohlin) E.Hegewald, Algol. Stud., 96: 1-18, 2000.
Basionym: *Scenedesmus brasiliensis* Bohlin, Die Algen der ersten Regnell'schen Expedition, p.22, 1897.
Figure 3: H
Flat coenobium; formed by four cells arranged linearly; elliptical or oblong cells, up to cylindrical; attenuated ends with slightly rounded poles; ribs present in all cells, which can unite and form one to three teeth at the poles of the cells; parietal chloroplast with one pyrenoid.
Morphometric data: L = 15.0 µm; W = 7.9 µm; De = 2.0 µm.
Paraná State citation: Moresco & Bueno (2007); Biolo et al. (2009); Bortolini et al. (2010) and Aquino et al. (2022).
Taxonomic remarks: according to Biolo et al. (2009) and Tucci et al. (2019) the lateral projections are called teeth already in Bortolini et al. (2010) and Aquino et al. (2022) are called thorns, concluding that both denominations are correct.
Occurrence in samples: UNOPA 6831
Frequency of occurrence: rare

Desmodesmus communis **(**E.Hegewald) E.Hegewald, Algol. Stud., 96:1-18, 2000.
Basionym: *Scenedesmus communis* E.Hegewald, Algol. Stud., 151, 1977.
Figure 3: I
Flat coenobium; formed by four to eight cells arranged linearly; internal cells oblong, with rounded poles, without ornamentation; trapezoidal outer cells, with a slightly convex outer margin and a long spine at each pole; smooth cell wall; parietal chloroplast with one pyrenoid.
Morphometric data: L = 10.0-22.5 µm; W= 5.0-12.5 µm; T = 7.5-15.0 µm.

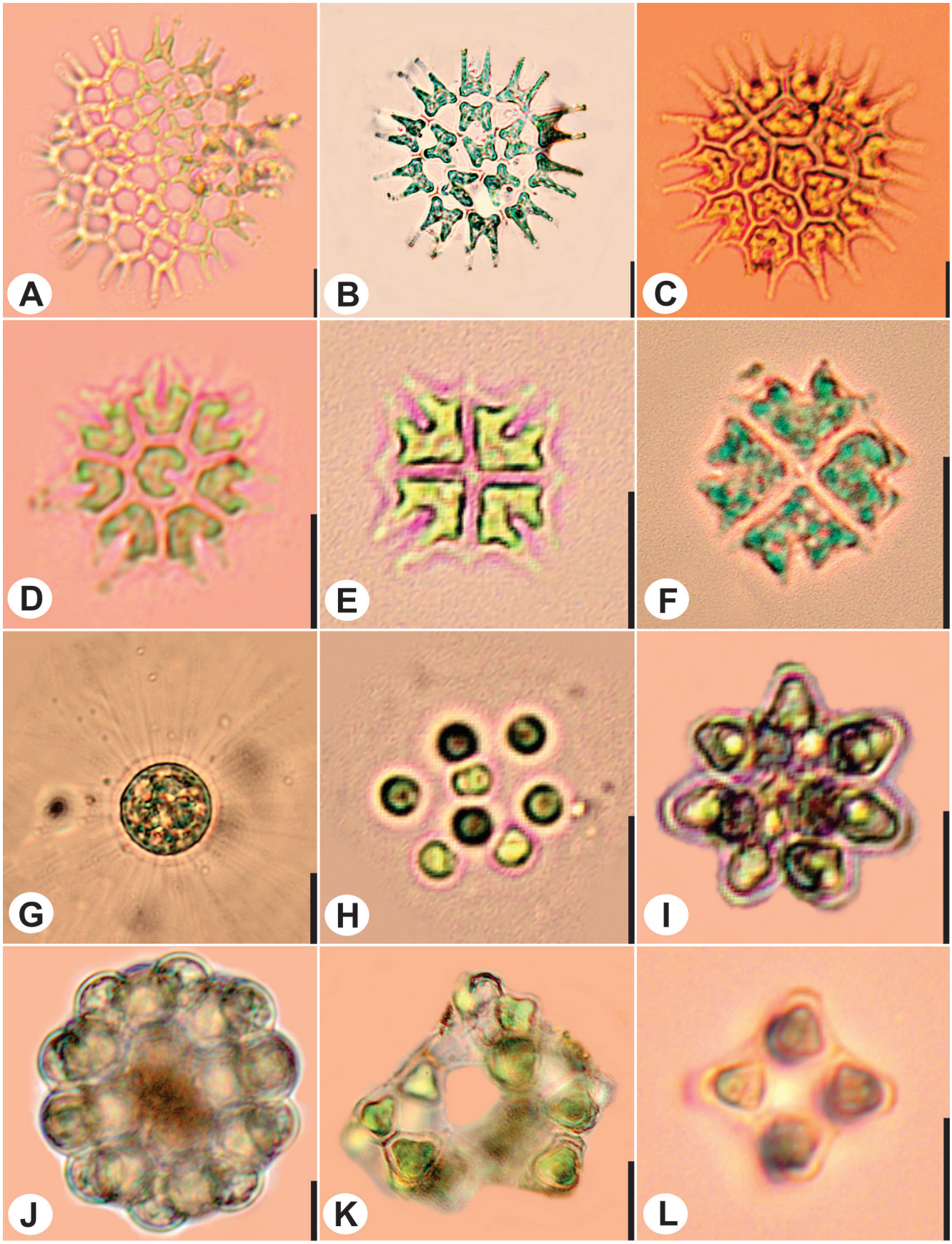

Figure 2. A. *Lacunastrum gracillimum.* B. *Pediastrum duplex.* C. *Pseudopediastrum boryanum* var. *longicorne.* D-F. *Stauridium tetras.* G. *Golenkinia radiata.* H. *Radiococcus skujae.* I. *Coelastrum astroideum.* J. *Coelastrum microporum.* K-L. *Coelastrum proboscideum.* Scales =10 µm.

Paraná State citation: Picelli-Vicentim (1985, 1987), Rodrigues & Train (1993), Oliveira et al. (1994), Picelli-Vicentim, (2001), Moresco & Bueno (2007), Biolo et al. (2009), Bortolini et al. (2010), Felisberto & Rodrigues (2010), Menezes et al. (2011), Aquino et al. (2014), Medeiros et al. (2021) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6819, 6829, 6831, 6833, 6987, 6995, 6997, 7001, 7074, 7094
Frequency of occurrence: sporadic

Desmodesmus denticulatus (Lagerheim) S.S.An, T.Friedl & E.Hegewald, Plant Biol., 1:427, 1999.
Basionym: *Scenedesmus denticulatus* Lagerheim, Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar Arg., 39(2): 47-81, 1882.
Figure 3: J
Flat coenobium; formed by four cells arranged alternately; oval inner cells, without ornamentation; outer cells elliptical, with one or two short spines at each pole; parietal chloroplast with one pyrenoid.
Morphometric data: L = 7.5-22.5 µm; W = 7.5-12.5 µm; De = 2.5 µm.
Paraná State citation: Moresco & Bueno (2007), Biolo et al. (2009), Bortolini et al. (2010), Felisberto & Rodrigues (2010), Menezes et al. (2011), Felisberto & Rodrigues (2012), Aquino (2014) and Aquino et al. (2022), still cited as *Scenedesmus denticulatus* (Lagerh) in the studies of Picelli-Vicentim (1987), Oliveira et al. (1994), Train et al. (2001), Train et al. (2003) and Algarte et al. (2006).
Occurrence in samples: UNOPA 6833, 6995, 7072
Frequency of occurrence: rare

Desmodesmus intermedius* var. *acutispinus (Roll) E.Hegewald, Algol. Stud., 96: 1-18, 2000.
Basionym: *Scenedesmus quadricauda* var. *acutispinus* Roll, Russkii Arkhiv Protistologii 4(3-4): 137-152, 1925.
Figure 4: B
Flat coenobium; formed by two to four oblong cells, arranged linearly; outer cells with a long spine on only one of the apices, distributed diagonally in the coenobium, parietal chloroplast with one pyrenoid.
Morphometric data: L = 6.6-7.0 µm; W = 2.5-3.0 µm; T = 6.0-8.0 µm.
Paraná State citation: Moresco & Bueno (2007) and Aquino et al. (2022).
Taxonomic remarks: the variety *acutispinus* differs from the type species in terms of the number and diagonal arrangement of spines at the apices of the outer cells. In the variety there are only two spines, and in the type species there are four spines.
Occurrence in samples: UNOPA 6981, 6983
Frequency of occurrence: rare

Desmodesmus opoliensis (P.G.Richter) E.Hegewald, Algol. Stud., 96: 1-18, 2000.
Basionym: *Scenedesmus opoliensis* P.G.Richter, S*cenedesmus opoliensis* P. Richt, nov. sp. Zeitschrift für angewandte Mikroskopie, 1: 3-7, 1895.
Figure 3: K
Flat coenobium; formed by four cells arranged linearly; internal fusiform cells, with attenuated and rounded poles, without ornamentation; trapezoidal outer cells, with truncated poles at the base of spine insertion and slightly convex outer margin; parietal chloroplast with one pyrenoid.
Morphometric data: L = 15.0-17.0 µm; W = 6.0 µm; T = 14.0-16.0 µm.
Paraná State citation: Moresco & Bueno (2007), Aquino et al. (2022), and still cited as *Scendesmus opoliensis* in the works of Rodrigues & Train (1993) and Picelli-Vicentim (2001).
Taxonomic remarks: the dimensions recorded in the specimens of this study are relatively smaller than those of Tucci et al. (2019), however they are in agreement with other works as in Aquino et al. (2022).
Occurrence in samples: UNOPA 6805
Frequency of occurrence: rare

Desmodesmus perforatus (Lemmermann) E.Hegewald, Algol. Stud., 96: 1-18, 2000.
Basionym: *Scenedesmus perforatus* Lemmermann, *Zeitschrift für Fischerei und deren Hilfswissenschaften* 11: 73-123, 1903.
Figure 3: L
Flat coenobium; formed by four biconcave cells in a linear arrangement; external cells with concave internal face and convex external face; curved spines, presence of microtubules and sometimes presence of frontal ribs; parietal chloroplast with one pyrenoid.
Morphometric data: L = 14.5-16.0 µm; W = 5.5-6.0 µm; T = 6.0-10.0 µm.
Paraná State citation: first record.
Taxonomic remarks: Tucci et al. (2019) have larger dimensions than those recorded in this study, but in Souza & Felisberto (2014) the specimens are also small, thus being in agreement with the population observed in our work.
Occurrence in samples: UNOPA 6827, 6829, 6981, 6983, 7094, 7270
Frequency of occurrence: rare

Desmodesmus serratus (Corda) S.S.An, Friedl & E.Hegewald, Plant Biol., 1: 418-428, 1999.
Basionym: *Arthrodesmus serratus* Corda, Almanach de Carlsbad, 9: 213-244, 1839.
Figure 4: A
Flat coenobium; formed by four cells arranged linearly, without main spines; oblong cells, punctuated rib running through each cell; frequent presence of one to three teeth at the cell poles; outer cells with a row of spinules along their entire length; parietal chloroplast with one pyrenoid.
Morphometric data: L = 7.0-15.0 µm; W = 2.5-5.0 µm T = 2.0-3.0 µm.
Paraná State citation: Moresco & Bueno (2007), Bortolini et al. (2010) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6831, 6833, 7094
Frequency of occurrence: rare

Desmodesmus subspicatus (Chodat) E.Hegewald & A.W.F.Schmidt, Algol. Stud., 96: 1-18, 2000.
Basionym: *Scenedesmus subspicatus* Chodat, Schweizerische Zeitschrift für Hydrologie, 3: 71-258, 1926.
Figure 4: C
Flat coenobium; formed by two or four oblong cells arranged linearly; frequent presence of secondary spine on inner cells and one or two lateral spines on outer cells; main spines in linear arrangement; parietal chloroplast with one pyrenoid.
Morphometric data: L = 7.0 µm; W = 2.0 µm; T = 4.0-6.0 µm.
Paraná State citation: first record.
Taxonomic remarks: *D. subspicatus* can be found in older literature (Rosini et al. 2013), as *Scenedesmus quadricauda* (Turpin) Brébisson,

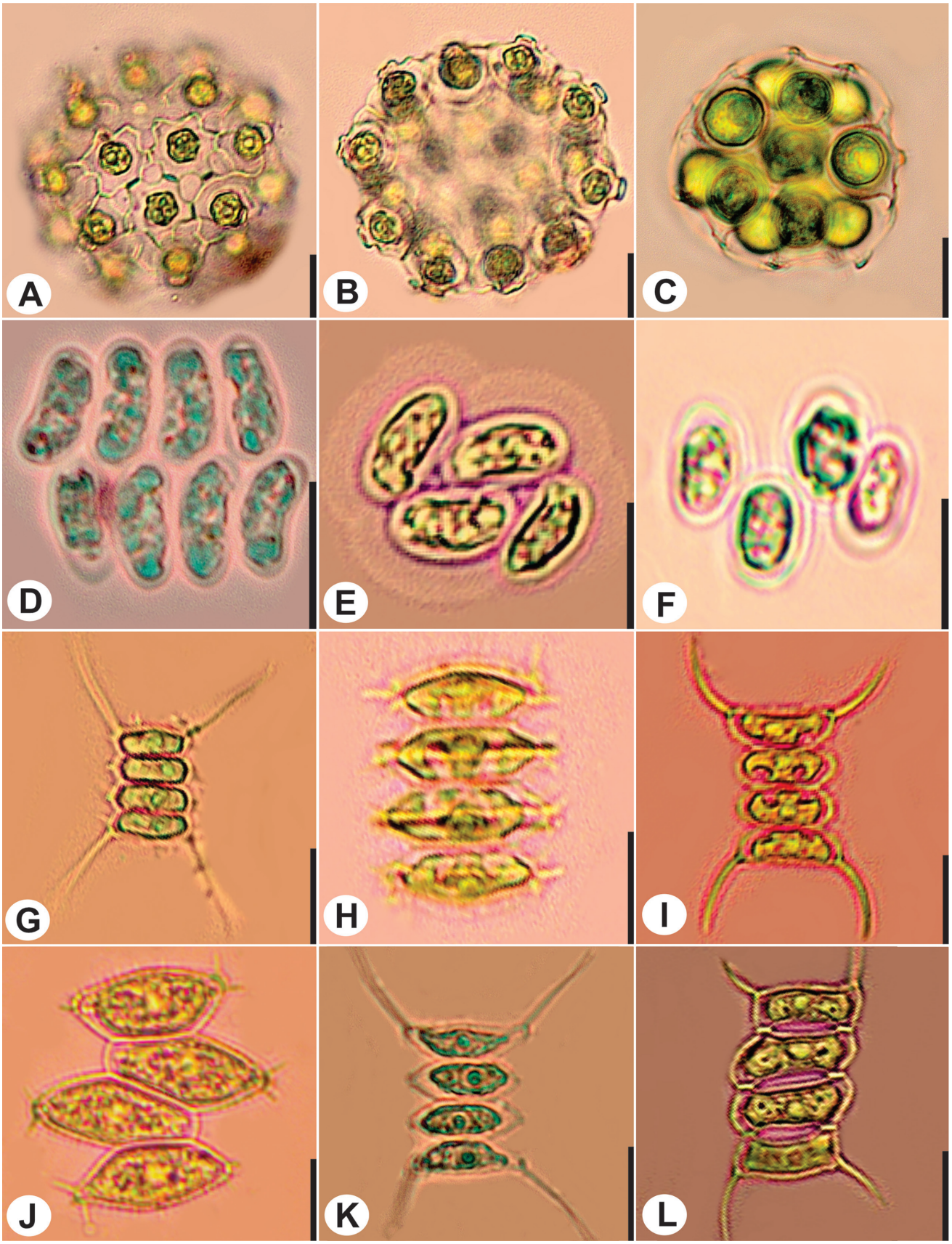

Figure 3. A-B. *Coelastrum pulchrum*. C. *Coelastrum reticulatum* var. *cubanum*. D-E. *Comasiella arcuata* var. *platydisca*. F. *Scenedesmus obtusus*. G. *Desmodesmus armatus*. H. *Desmodesmus brasiliensis*. I. *Desmodesmus communis*. J. *Desmodesmus denticulatus*. K. *Desmodesmus opoliensis*. L. *Desmodesmus perforatus*. Scales =10 µm.

which refers to its holotype, however, currently the current name is *Desmodesmus subspicatus* as seen in Tucci et al. (2019).
Occurrence in samples: UNOPA 6833
Frequency of occurrence: rare

Scenedesmus indicus Philipose ex Hegewald, Engelberg & Paschma, Nova Hedwig., 47 (3/4): 497-533, 1988.
Figure 4: I
Flat and linear coenobium; formed by four cells arranged alternately; outer cells arcuate with rounded, dilated or swollen poles; oblong inner cells with swollen poles; parietal chloroplast with one pyrenoid.
Morphometric data: L = 11.0 – 15.0 µm; W = 3.5 – 4.0 µm.
Paraná State citation: first record.
Taxonomic remarks: *Scenedesmus indicus* is easily differentiated from the other species due to the morphology of the coenobium, in which the cells are arranged in an alternating manner.
Occurrence in samples: UNOPA 6805, 6995, 7276
Frequency of occurrence: rare

Scenedesmus obtusus Meyen, Nova Acta Phys.-Med. Acad. Caes. Leop. -Carol. Nat., 14: 768-778, 1829.
Figure 3: F
Flat coenobium; formed by four or eight alternating cells; ovate-cylindrical cells with rounded poles; outer cells usually oblique; straight inner cells; slightly thickened cell wall; parietal chloroplast with one pyrenoid.
Morphometric data: L = 11.0-13.0 µm; W = 7.0 µm.
Paraná State citation: Picelli-Vicentim (1987); Bortolini et al. (2010) and cited as *Scenedesmus graevenitzii* in Moresco & Bueno (2007).
Occurrence in samples: UNOPA 7082
Frequency of occurrence: rare

Tetradesmus dimorphus (Turpin) M.J.Wynne, Feddes Repert., 126: 83-86, 2016.
Basionym: *Achnanthes dimorpha* Turpin, Mém. Mus. natl. hist. nat., 16: 313, 1828.
Figure 4: D
Flat coenobium; formed by four to eight fusiform cells with acute poles; arranged in a linear or alternating manner; external cells markedly concave, reaching straight or slightly convex; almost straight inner cells; parietal chloroplast; pyrenoid not observed.
Morphometric data: L = 19.0-22.0 µm; W= 3.0-5.0 µm; Co = 18.0 – 22.0 µm.
Paraná State citation: cited as *Tetradesmus dimorphus* in Aquino et al. (2022), cited as *Scenedesmus obliquus* var. *dimorphus* (Turpin) Hansgirg in Bortolini et al. (2010), Menezes et al. (2011), Aquino et al. (2014), and cited as *Scenedesmus acuminatus* (Lagerh.) and/or *Scenedesmus acutus* (Meyen) in Picelli-Vicentim (1987), Rodrigues & Train (1993), Oliveira et al. (1994), Bittencourt-Oliveira (1997), Train et al. (2001), Borges et al. (2003), Train et al. (2003), Algarte et al. (2006), Moresco & Bueno (2007), Borges et al. (2008), Felisberto & Rodrigues (2010) and Felisberto & Rodrigues (2012).
Occurrence in samples: UNOPA 6827, 6981, 7272
Frequency of occurrence: rare

Tetrallantos lagerheimii Teiling, Svensk Bot. Tidskr., 10 (1):59-66, 1916.
Figure 4: K
Coenobium formed by up to four cells; two are in the same plane and two are arranged vertically, joined by the poles; lunate or approximately reniform cells with rounded apices; parietal chloroplast with one pyrenoid.
Morphometric data: L = 10.0-12.5 µm; W = 5.0-7.5 µm.
Paraná State citation: Rodrigues & Train (1993).
Occurrence in samples: UNOPA 7015, 7274, 7276
Frequency of occurrence: rare

Westella botryoides (West) De Wildeman, Bull. Herb. Boissier., 5:532, 1897.
Basionym: *Tetracoccus botryoides* West, J. R. Microsc. Soc., 735, 1892.
Figure 4: J
Quadrangular coenobium; formed by four cells arranged in a cruciate manner; these cells form sincenobia with eight or 16 cells joined by the rest of the maternal cell wall by threads of mucilage; globular to subtriangular cells; parietal chloroplast with one pyrenoid.
Morphometric data: Co = 15.0 µm; D = 5.0 -7.5 µm.
Paraná State citation: Picelli-Vicentim (1987).
Occurrence in samples: UNOPA 6991, 6995
Frequency of occurrence: rare

FAMILY SELENASTRACEAE

Ankistrodesmus bernardii Komárek, Nova Hedwigia 37: 65-180, 1983.
Figure 4: E
Fasciculate colony; formed by approximately eight to 10 spindle cells with a sigmoid curve in the median region; longer than wide; united and intertwined in the middle region of the colony, tapering gradually towards the apex; pyrenoid not observed.
Morphometric data: L = 60.0 µm; W = 1.8-2.6 µm.
Paraná State citation: first record.
Taxonomic remarks: *Ankistrodesmus bernardii* Komárek can be confused with *Ankistrodesmus densus* Korshikov, as both form colonies with many cells that are variable in length but differ in that *A. densu*s has curved or sigmoid cells throughout.
Occurrence in samples: UNOPA 6827
Frequency of occurrence: rare

Ankistrodesmus densus Korshikov, The Freshwater Algae of the Ukrainian SSR. p. 300, 1953.
Figure 4: F
Colony with many fasciculate cells; usually formed by 16 densely packed cells; cells longer than wide, fusiform, curved or sigmoid throughout their length; gradually taper towards the apex; superimposed on each other; parietal chloroplast without pyrenoids.
Morphometric data: L = 35.0-55.0 µm; W = 2.5 µm.
Paraná State citation: Picelli-Vicentim (1987), Rodrigues & Train (1993), Oliveira et al. (1994), Biolo et al. (2009), Bortolini et al. (2010) and Aquino et al. (2022).
Occurrence in samples: UNOPA 6829, 7082
Frequency of occurrence: rare

Ankistrodesmus falcatus (Corda) Ralfs, The British Desmidieae, p. 180, 1848.
Basionym: *Micrasterias falcatus* Corda, Almanach de Carlsbad, 5: 206, 1835.
Figure 4: G
Starry colony formed by one to four fascicles; cells arranged irregularly; cells are long, fusiform, slightly curved, falcate, longer than wide, joined by the medial convex region, gradually tapering towards the apex; parietal chloroplast without pyrenoids.
Morphometric data: L = 37.5-50.0 µm; W = 2.5µm.
Paraná State citation: Andrade & Rachou (1954), Picelli-Vicentim (1986), Rodrigues & Train (1993), Oliveira et al. (1994), Bittencourt-Oliveira (1997), Train et al. (2001), Bittencourt-Oliveira (2002), Algarte et al. (2006), Felisberto & Rodrigues (2010), Aquino et al. (2014) and Aquino et al. (2022).
Taxonomic remarks: the specimens in this work have larger dimensions than those recorded in Aquino et al. (2022), however they are in agreement with the specimens observed in Ramos et al. (2012).
Occurrence in samples: UNOPA 6829, 6981
Frequency of occurrence: rare

Ankistrodesmus fusiformis Corda, Almanach de Carlsbad, 8: 179-198, 1838.
Figure 4: H
Starry colony formed by two to four cells; cells cruciate, fusiform, from straight to arcuate; tapered towards the apex, crossing over each other; pointed poles, longer than wide; pyrenoid not observed.
Morphometric data: L = 30.0 µm; W = 1.4-2.5 µm.
Paraná State citation: Picelli-Vicentim (1987), Rodrigues & Train (1993), Train et al. (2001), Algarte et al. (2006), Bortolini et al. (2010), Felisberto & Rodrigues (2010), Menezes et al. (2011), Felisberto & Rodrigues (2012), Aquino et al. (2014) and Aquino et al. (2022).
Taxonomic remarks: in Aquino et al. (2022) the registered specimens with four cells, whereas those observed in this study have only two, but they are in agreement with Ramos et al. (2012) who also recorded this morphological variation in their population.
Occurrence in samples: UNOPA 7082, 7268
Frequency of occurrence: rare

Kirchneriella lunaris (Kirchner) Möbius, Abh. Senckenb. Nat. Gesell., 18: 309-350, 1894.
Basionym: *Rhaphidium convolutum* var. *lunare* Kirchner, Kryptogamen-Flora von Schlesien, 114, 1878.
Figure 4: L
Colonies formed by four to 16 cells, sickle-shaped lunate; wrapped in a mucilaginous sheath; sometimes lonely; parietal chloroplasts close to the cell wall; pyrenoid not observed.
Morphometric data: L = 5.0-10.0 µm.
Paraná State citation: Picelli-Vicentim (1987), Rodrigues & Train (1993) and Oliveira et al. (1994).
Occurrence in samples: UNOPA 6981, 6995, 7005, 7082
Frequency of occurrence: rare

Monoraphidium capricornutum (Printz) Nygaard, Biol. Skr., 21(1): 1-107, 1977.
Basionym: *Selenastrum capricornutum* Printz, Skr. Norske Vidensk. -Akad. Oslo, Mat. -Naturvidensk. Kl., 6:92, 1914.
Figure 4: N
Spindle cells; arched in semicircles, slightly tapered at the ends; parietal chloroplast without pyrenoids.
Morphometric data: L = 10.0-12.5 µm; W = 2.5 µm.
Paraná State citation: first record.
Taxonomic remarks: the specimens in this study have relatively larger dimensions than those recorded in Ramos et al. (2012) and Nandi et al. (2017) with regard to the length of the cells, however the width, description and illustration are in agreement with the works.
Occurrence in samples: UNOPA 6827
Frequency of occurrence: rare

Monoraphidium caribeum Hindák, Algol. Stud., 1:7-32, 1970.
Figure 4: O
Solitary cells, arcuate in a semicircle, slightly tapering at the ends; parietal chloroplast without pyrenoids.
Morphometric data: L = 17.5 µm; W = 2.5 µm.
Paraná State citation: first record.
Taxonomic remarks: *M. caribeum* can be confused with *Ankistrodesmus arcuatus* Korshikov, however the species differ by the size of the cells, where *A. arcuatus* has larger dimensions.
Occurrence in samples: UNOPA 7100
Frequency of occurrence: rare

Raphidocelis danubiana* var. *elegans (Playfair) Taşkin & Alp, Türkiye suyosunlari listei [Turkey algae list]. p.804, 2019.
Basionym: *Kirchneriella elegans* Playfair, Proc. Linn. Soc., 41: 838, 1917.
Figure 4: M
Colony formed by four cells irregularly arranged in mucilage; curved cylindrical cells with rounded apices, in the same plane; parietal chloroplast without pyrenoid.
Morphometric data: L = 4.0 µm (distance between apexes); W = 2.0 µm.
Paraná State citation: first record.
Taxonomic remarks: recently the genus *Kirchneriella contorta* var. *elegans* (Playfair) Komárek changed to the taxon *Raphidocelis danubiana* var. *elegans*, which can be found in the literature in the first way.
Occurrence in samples: UNOPA 7005
Frequency of occurrence: rare

Selenastrum bibraianum Reinsch, Abh. Senckenb. Nat. Gesell., 3(2): 1- 238, 1866.
Figure 4: P
Coenobium formed by four to 16 lunate or semicircular cells; ventral margins strongly convex towards the center of the colony, tapering towards the cell apex; single parietal chloroplast occupying the entire intercellular space; pyrenoid not observed.
Morphometric data: L = 15.0 µm; W = 4.0 µm.
Paraná State citation: Cited as *Ankistrodesmus bibraianus* (Reinsch) Koršikov in Bortolini et al. (2010); Aquino et al. (2014).
Occurrence in samples: UNOPA 6827
Frequency of occurrence: rare

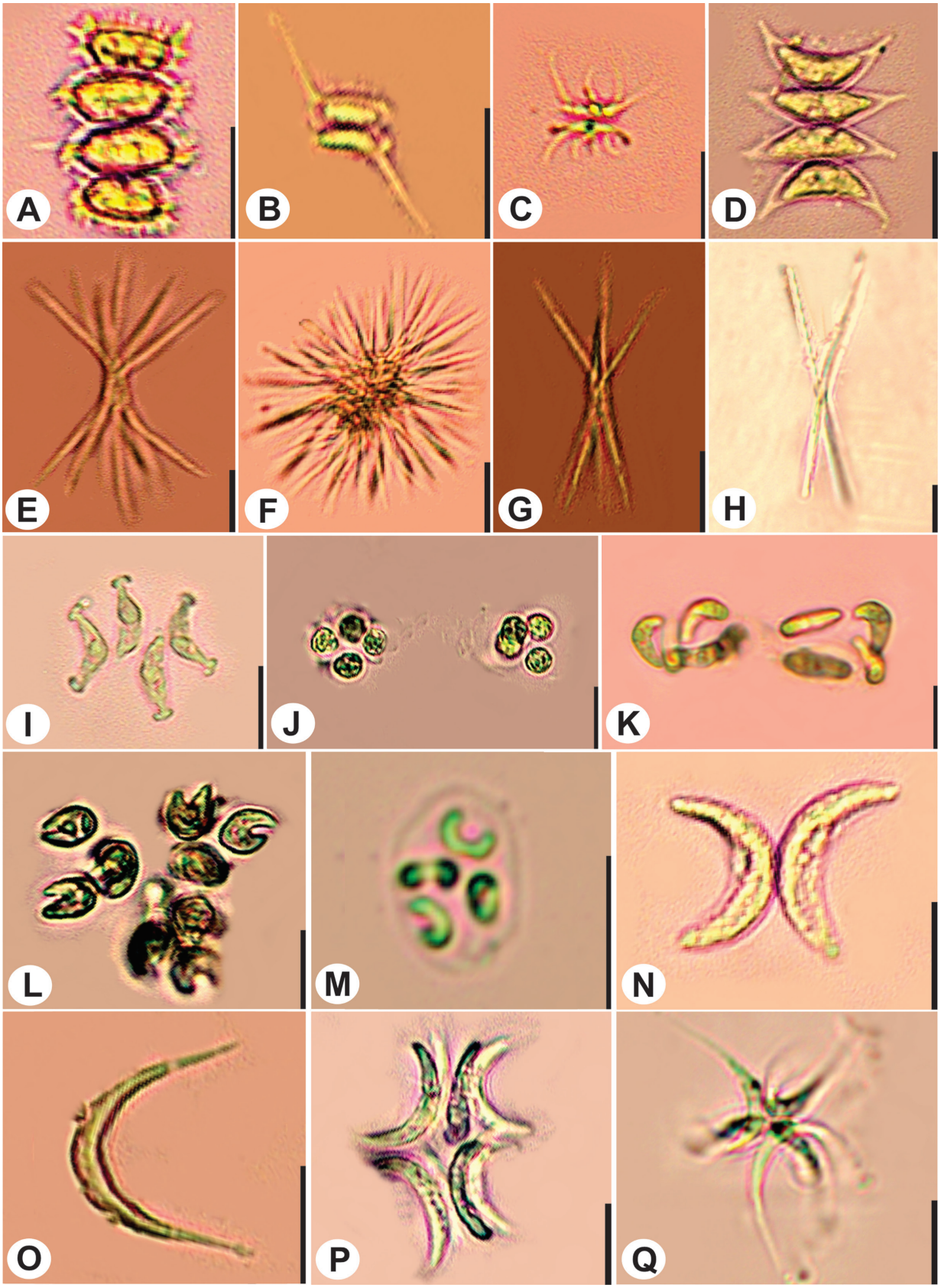

Figure 4. A. *Desmodesmus serratus.* B. *Desmodesmus intermedius* var. *acutispinus.* C. *Desmodesmus subspicatus.* D. *Tetradesmus dimorphus.* E. *Ankistrodesmus bernardii.* F. *Ankistrodesmus densus.* G. *Ankistrodesmus falcatus.* H. *Ankistrodesmus fusiformis.* I. *Scenedesmus indicus.* J. *Westella botryoides.* K. *Tetrallantos lagerheimii.* L. *Kirchneriella lunares.* M. *Raphidocelis danubiana* var. *elegans.* N. *Monoraphidium capricornutum.*O. *Monoraphidium caribeum.* P. *Selenastrum bibraianum.* Q. *Selenastrum rinoi.* Scales =10 µm.

Selenastrum rinoi Komárek & Comas, 272, 276, figure 10, 1982.
Figure 4: Q
Colonies formed by four moon cells; convex side of cells oriented towards the center; apexes tapered; chloroplast without pyrenoid.
Morphometric data: L= 16.0 µm; W = 5.0 µm.
Paraná State citation: first record.
Taxonomic remarks: *Selenastrum rinoi* can be confused with *Monoraphidium capricornutum*, however, it differs in that it has smaller cells, with more distant apices, in addition to having an irregular arrangement of cells in the colony.
Occurrence in samples: UNOPA 6827
Frequency of occurrence: rare

The trophic state index indicated that seven of the nine sampled municipalities fall into oligotrophic conditions, while the remaining two are considered mesotrophic. Regarding the limnological conditions we observed a variation in the flow of the sampled rivers, where the lowest flow recorded is in Rio Tamanduá (0.09 m³ s) and the highest is in Rio Toledo (1.39 m³ s). Water temperature varied from 15°C to 20°C in Baú and Jacutinga Rivers respectively. The pH value in all sampled rivers was considered neutral (6). The electrical conductivity varied from (0.02 mS cm^{-1}) in the Toledo River to (0.08 mS cm^{-1}) in the Baú River. As for turbidity, the lowest value recorded was in Rio Baú (6.41 NTU) and the highest in Rio Jacutinga (23.35 NTU). Dissolved oxygen varied from (6.39 mg L^{-1}) in Gonçalves Dias River to (14.95 mg L^{-1}) in Baú River. The lowest value of ammonia nitrogen (0.01 mg L^{-1}) was constant in four rivers, namely Baú, Itaguaçu, Gonçalves Dias, and Jacutinga, while the highest value (0.14 mg L^{-1}) was registered in the Cascavel River. The values of total phosphorous were similar in all sampled rivers. Nitrate varied from (0.53 mg L^{-1}) at Gonçalves Dias to (1.83 mg L^{-1}) at Toledo River (Table 2). All sampled rivers had at least two species recorded, however, approximately 70% of the occurrences were in oligotrophic environments. The rivers with higher occurrences recorded were Cascavel (31%), Passo Liso (23%) and Toledo (17%), the first two being oligotrophic and the third mesotrophic.

Table 2. Occurrence of species, ecological data and trophic state. GUAR: Guaraniaçu, MED: Medianeira, TOL: Toledo, TBP: Três Barras do Paraná, CVEL: Cascavel, FOZ: Foz do Iguaçu, STO: Santa Tereza do Oeste, CTD: Catanduvas, BVA: Boa Vista da Aparecida. OLIG: oligotrophic, MESO: mesotrophic.

Watershed	**Piquiri**	**Paraná III**			**Lower Iguaçu River**				
River	**Baú**	**Alegria**	**Toledo**	**Itaguaçu**	**Cascavel**	**Tamanduá**	**Gonçalves Dias**	**Passo Liso**	**Jacutinga**
Occurrence in samples	**GUAR**	**MED**	**TOL**	**TBP**	**CVEL**	**FOZ**	**STO**	**CTD**	**BVA**
Family Hydrodictyaceae									
Lacunastrum gracillimum			x					x	x
Pediastrum duplex			x		x				
Pseudopediastrum boryanum var. *longicorne*						x		x	
Stauridium tetras	x				x			x	
Family Neochloridaceae									
Golenkinia radiata	x	x						x	
Family Radiococcaceae									
Radiococcus skujae					x				
Family Scenedesmaceae									
Coelastrum astroideum				x	x			x	
Coelastrum microporum					x			x	
Coelastrum proboscideum			x					x	
Coelastrum pulchrum					x				
Coelastrum reticulatum var. *cubanum*			x		x	x		x	
Comasiella arcuata var. *platydisca*					x			x	
Desmodesmus armatus						x		x	
Desmodesmus brasiliensis			x						
Desmodesmus communis		x	x	x	x			x	x
Desmodesmus denticulatus			x		x			x	
Desmodesmus intermedius var. *acutispinus*					x				
Desmodesmus opoliensis								x	
Desmodesmus perforatus					x				
Desmodesmus serratus			x		x				
Desmodesmus subspicatus			x						
Scenedesmus indicus			x					x	
Scenedesmus obtusus						x			
Tetradesmus dimorphus					x				
Tetrallantos lagerheimii			x				x		
Westella botryoides	x							x	

Continue...

...Continuation

Watershed	Piquiri	Paraná III			Lower Iguaçu River				
River	Baú	Alegria	Toledo	Itaguaçu	Cascavel	Tamanduá	Gonçalves Dias	Passo Liso	Jacutinga
Occurrence in samples	GUAR	MED	TOL	TBP	CVEL	FOZ	STO	CTD	BVA
Family Selenastraceae									
Ankistrodesmus bernardii					x				
Ankistrodesmus densus					x	x			
Ankistrodesmus falcatus					x				
Ankistrodesmus fusiformis						x	x		
Kirchneriella lunaris					x	x		x	
Monoraphidium capricornutum					x				
Monoraphidium caribeum			x						
Raphidocelis danubiana var. elegans						x			
Selenastrum bibraianum					x				
Selenastrum rinoi					x				
Ecological data									
Flow (m^3 s)	0.14	0.14	1.39	0.20	0.41	0.09	0.29	0.22	0.51
Water Temperature (°C)	15.83	19.23	17.87	18.18	18.27	19.46	19.54	17.22	20.36
pH	6.8	6.99	6.33	6.74	6.27	6.40	6.89	6.71	6.95
Conductivity (mS cm^{-1})	0.08	0.03	0.02	0.07	0.05	0.04	0.03	0.07	0.07
Turbidity (NTU)	6.41	9.30	19.63	9.44	8.29	18.18	9.84	7.40	23.35
Dissolved oxygen (mg L^{-1})	14.95	6.77	8.88	7.84	8.77	7.19	6.39	8.09	9.97
Ammoniac nitrogen (mg L^{-1})	0.01	0.02	0.03	0.01	0.14	0.08	0.01	0.02	0.01
Total phosphorous (mg L^{-1})	0.02	0.02	0.04	0.03	0.02	0.04	0.02	0.03	0.02
Nitrate (mg L^{-1})	0.74	1.02	1.86	1.7	1.3	1.51	0.53	1.1	1.07
Trophic state	OLIG	OLIG	MESO	OLIG	OLIG	MESO	OLIG	OLIG	OLIG

Discussion

In our study we recorded 36 taxa of chlorophyceans belonging to the order Sphaeropleales. The Scenedesmaceae family was the most representative with 20 taxa (55%), followed by Selenastraceae with 10 taxa (27.7%) and Hydrodictyaceae with 4 taxa (11%). We also highlight the record of 10 new citations for the State of Paraná, thus expanding the knowledge of the flora of Chlorophyceae for lotic environments: *Ankistrodesmus bernardii*, *Desmodesmus perforatus*, *Desmodesmus subspicatus*, *Monoraphidium capricornutum*, *Monoraphidium caribeum*, *Pseudopediastrum boryanum* var. *longicorne*, *Raphidocelis danubiana* var. *elegans*, *Radiococcus skujae*, *Scenedesmus indicus* and *Selenastrum rinoi*. The class Chorophyceae develops in wide environmental variation, but they are important in oligotrophic aquatic environments and described as cosmopolitan, being bioindicators of water quality (D'Alessandro & Nogueira 2017).

The genus with the highest number of taxa was *Desmodesmus* with 9 species (25%), followed by *Coelastrum* with 5 species (13%) and *Ankistrodesmus* with 4 species (11%). The higher occurrence of *Desmodesmus* compared to the others may be associated with the fact that this genus is common in most aquatic environments, from eutrophic to oligotrophic (Borges et al. 2008, Hentschke & Torgan 2010, Domingues & Torgan 2012, Rosini et al. 2012, Aquino et al. 2014), which can be observed in the Cascavel (Municipality of Cascavel) and Arroio Passo Liso (Municipality of Catanduvas) rivers, both in the watershed of the lower Iguaçu River, considered oligotrophic where high contributions of the genera *Coelastrum* sp. and *Desmodesmus* sp. were observed.

Among the 36 taxa identified in this study, five species occurred only under mesotrophic conditions, namely: *Desmodesmus brasiliensis, Desmodesmus subspicatus, Scenedesmus obtusus, Monoraphidium caribeum*, and *Raphidocelis denubiana* var. *elegans*. The occurrence of *Desmodesmus* in nutrient-rich environments, as mentioned earlier, is due to it being a genus adaptable to diverse environmental conditions, being common at all trophic levels (Phinyo et al. 2017). The genus Scenedesmus has already been associated with sites with mild to moderate organic pollution, warning for environments with tendencies to elevate their trophy (Sabkie et al. 2020). We can also mention *Monoraphidium caribeum*, which, although cosmopolitan, is found mostly in eutrophic aquatic environments. The other occurrences were in oligo to mesotrophic conditions, which is in accordance with what is expected for the group (Comas 1996).

The Cascavel River showed the highest species richness (21 taxa). This environment was related to one of the lowest values of turbidity (8.29 NTU) in the area sampled. The Jacutinga River had the highest value for this variable (23.35 NTU), represented by only two species. The correlation of turbidity with Chlorophyceae representatives has been reported previously, where this variable negatively influenced the diversity of the group (Gogoi et al. 2019; Kumar et al. 2020). This relationship is due to the limitation of light penetration into the water, which reduces phytoplankton photosynthesis, in addition to altering the other limnological conditions (Nunes et al. 2022).

In our study, 94% of the taxa found had a rare frequency of occurrence, and only 6% were classified as sporadic. The rarity of the species in lotic environments may be related to the local hydrodynamics,

where the greater flow of water prevents the establishment and development of potamoplankton, promoting a constant transport of taxa downstream (Medeiros et al. 2020). Phytoplankton is considered a group of key organisms to indicate changes in aquatic environments due to changes in the structure of biota, in response to physical and chemical factors in water bodies (Wojciechowski et al. 2017).

Since 2007, 91 taxa have been recorded for the Chlorophyceae class in the State of Paraná, and according to the flora of Brazil (2020), 362 species were recorded throughout the country, with publications in São Paulo and Rio de Janeiro predominating, thus showing the need for further studies in Paraná. In conclusion, we can emphasize the importance of taxonomic studies, which serve as a basis for knowledge of biodiversity, providing essential information for ecological, bioindicator and conservation approaches.

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Margaret Seghetto Nardelli: contributed to data analysis and interpretation; critical revision and manuscript preparation, all adding intellectual content.

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Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Data Availability

The data used in our analysis is available at https://collectory.sibbr.gov.br/collectory/public/show/co468?lang=pt_B

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