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PENSOFT

Some interesting desmids (Desmidiaceae, Zygnematophyceae): first records, taxonomic notes, and distribution for the Amazon Brazilian flora

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Abstract. We report nine interesting desmid taxa, which five were recorded for the first time for the Amazon Brazilian flora, including first records of two infraspecific taxa from Brazil. The material was collected from an Amazon flooded area in the state of Amapá, Brazil. A description, geographical distribution in Brazil, water conditions, and frequency of occurrence are provided for each taxon. Our study expands the knowledge of desmids by providing taxonomic notes and information on geographic distribution.

Keywords. Desmidiaceae, floristic survey, green algae, microalgae, taxonomy, tropical flora

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Introduction

The family Desmidiaceae Ralfs is the largest, most diverse, and polyphyletic algal group belonging to the class Zygnematophyceae that occurs in freshwater habitats (Brook 1981; Gontcharov and Melkonian 2010). According to Guiry and Guiry (2022), the family nowadays comprises over 2,700 species, most of which were mostly proposed in 19th and 20th centuries exclusively on the basis on morphological grounds (Gontcharov 2008; Guiry and Guiry 2022).

The Amazon region has had a considerable number of studies carried out during the mid-20th century by foreign researchers such as Grönblad (1945), Thomasson (1955, 1971, 1977), Förster (1963, 1964, 1969, 1974), Scott et al. (1965), Schmidt and Uherkovich (1973), Uherkovich and Schmidt (1974), Uherkovich and Rai (1979), and Uherkovich (1981). Only since the 1980s have the main contributors been Brazilian, such as Martins (1980, 1982, 1986a, 1986b), Bittencourt-Oliveira (1990, 1993a, 1993b), Lopes (1992), Suarez-Mera (1995), Sophia and Huszar (1996), Ibañez (1998), Lopes and Bicudo (2003), Martins-da-Silva and Bicudo (2007), Souza et al. (2007), Souza (2008, 2012), Melo and Souza (2009), and Souza and Melo (2010, 2011). The most recent Brazilian researchers are Holanda et al. (2019), Araújo et al. (2020), and Saturnino et al. (2020).

Most studies on the desmid flora have focused mainly on the states of Amazonas and Pará and were

conducted in several aquatic ecosystems, including floodplains, shallow lakes, wetlands, and rivers. Especially for floodplains, the three types of water—clear, white, and black—are important in the dynamics and structure of the algal community (Junk et al. 1989; Souza and Melo 2010). In clear- and white-water floodplains there are more species reported in the literature as the result of the greater number of studies in these environments (Melo and Souza 2009).

Studies of the taxonomy and description of microalgae are still incipient for the state of Amapá. Even so, desmids constitute the best known and most recorded group of algae in the state's aquatic ecosystems. Förster (1963) was the pioneer in recording the occurrence of desmids in the aquatic ecosystems of Amapá. He reported five taxa belonging to the genera *Closterium* Nitzsch ex Ralfs, *Desmidium* C.Agardh ex Ralfs, and *Euastrum* Ehrenberg ex Ralfs.

Only about half a century later, the second taxonomic study was published by Souza and Melo (2011), who identified and illustrated 35 species and three varieties of Desmidiaceae—in the genera *Staurastrum* Meyen ex Ralfs, *Staurodesmus* Teiling, and *Xanthidium* Ehrenberg ex Ralfs—from Lake Novo, in coastal Amapá. Most recently, Araújo et al. (2020) published the third paper, this time on the pseudofilamentous desmids and including the descriptions and illustrations of 21 taxa.

To increase knowledge on the biodiversity and distribution of desmids from northern Brazil, we report on nine interesting taxa. Five taxa are recorded for the first time from the Amazon Brazilian flora. Two species are recorded from Brazil for the first time.

Methods

The state of Amapá is located in the eastern portion of the Brazilian Amazon. According to the Köppen climate classification, the dominant climate is Am (Tropical monsoon climate) (Alvares et al. 2013). The hydrological cycle is well defined, and there is seasonality and local rainfall; thus, there is a less-rainy period from July to December and a rainy or flood period from January to June (Araújo et al. 2020).

Our study was conducted at the permanently flooded station in Lake Curralinho (00°07′54″N, 051°06′50″W), that is within the Curiaú river basin and the Curiaú Environmental Protection Area, in the city of Macapá, Amapá, Brazil. We collected samples monthly between June 2007 and July 2008 (except in October 2007), using a 20 µm mesh plankton net. Samples were immediately preserved in Transeau solution (Bicudo and Menezes 2017).

Temporary slides were prepared for observation under a light microscope (Zeiss, Axio Lab A1). Photomicrographs were taken at 400× magnification with an image capture system coupled to the light microscope. Classic and contemporary literature, including taxonomic revisions, monographs, and floristic works were used for specific and infraspecific identification of the material. All samples are deposited at the Herbário Científico do Estado "Maria Eneyda P. Kauffmann Fidalgo" (SP), Municipality São Paulo, state of São Paulo, Brazil.

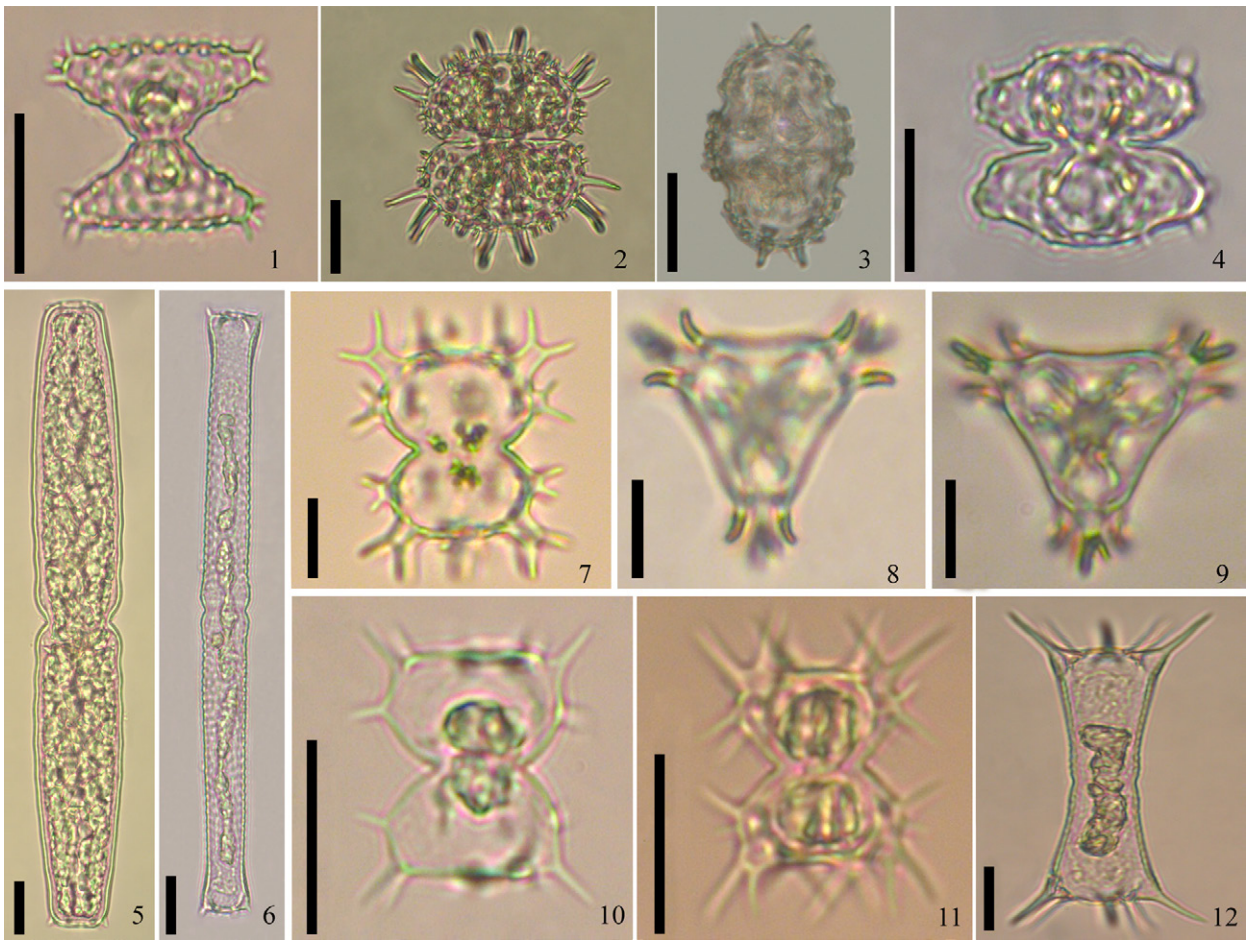
In the descriptions, all measurements are given in micrometers (µm) and the following abbreviations were used: cell length (CL), cell width (CW), and isthmus width (IW) for *Cosmarium* Corda ex Ralfs. For *Pleurotaenium* Nägeli, cell length (CL), cell width (CW), cell apex width (CAW), and isthmus width (IW) were measured. For the genera *Staurastrum* and *Staurodesmus*, we measured cell length with spines/processes (CLS) and without spines/processes (CLNS), cell width with spines/processes (CWS) and without spines/processes (CWNS), and isthmus width (IW).

Temperature (°C) and conductivity ($\mu S \cdot cm^{-1}$) were measured with a portable probe (Lutron MO-CD-4303) in the field. In the laboratory, dissolved oxygen ($mg \cdot L^{-1}$) was measured with an Instrutherm MO-880 digital probe, and pH with a Qualxtron 8010 pH meter.

The frequency of occurrence of each species for sample unit was calculated in terms of percentage according to the formula $F = n \cdot 100 / N$, where n is the number of samples in which the species was recorded, and N is the total number of samples analyzed ($N = 11$). Frequency categories were determined according to Matteucci and

Table 1. Abiotic variables and seasonal occurrence of desmid taxa at Curralinho lake from June 2007 to July 2008 . Abbreviations: EC = electric conductivity ($\mu S \cdot cm^{-1}$); T = temperature (°C); DO = dissolved oxygen ($mg \cdot L^{-1}$); FA = absolute frequency; and the number of each taxon recorded during the period of study; FR = relative frequency (%); U = uncommon; R = rare; BP = both rainy and less-rainy periods; RP = rainy period, LR = less-rainy period. *Mean (min.–max.) values.

Taxa	pH	EC	T	DO	FA	FR	Frequency	Seasonal occurrence
Cosmarium furcatum	5.2(5.1–5.3)*	9.2(8.6–9.7)*	29.1(29–29.1)*	4.3(1.9–6.6)*	2	18	U	BP
C. horridum	5.2(4.9–5.4)*	9.6(8.6–10.5)*	29.4(29–30.3)*	3.7(1.9–6.6)*	4	36	U	BP
C. ornatum var. *sublagoense*	5.4	9.4	29.2	2.6	1	9	R	R
Pleurotaenium coronatum var. *luetzelburgii*	5.2(5.1–5.4)*	8.8(8.5–9.4)*	29.7(29.1–30.9)*	5.2(2.6–6.6)*	3	27	U	R
P. sceptrum var. *sceptrum*	5.1(4.9–5.4)*	9.5(8.6–10.5)*	29.5(29.1–30.3)*	4.3(2.6–6.6)*	3	27	U	BP
Staurastrum furcatum var. *scaevum*	5.2(4.9–5.5)*	11.3(10.5–12.0)*	30.4(30.3–30.5)*	3.9(3.6–4.1)*	2	18	U	R
S. quadrispinatum var. *quadrispinatum*	4.85	10.5	30.3	3.6	1	9	R	LR
S. quadrispinatum var. *spicatum*	5.4(5.3–5.5)*	10.9(9.7–12.0)*	29.8(29.0–30.5)*	3.0(1.9–4.1)*	2	18	U	BP
Staurodesmus wandae var. *longissimus*	5.2(4.9–5.6)*	9.6(8.6–10.5)*	29.4(29.0–30.1)*	4.2(1.9–6.6)*	5	45	U	BP



Figures 1–12. Desmids from an Amazon flooded area (Lake Curralinho), Amapá, Brazil. **1.** *Cosmarium furcatum*. **2, 3.** *Cosmarium horridum*. **3.** Apical view. **4.** *Cosmarium ornatum* var. *sublagoense*. **5.** *Pleurotaenium coronatum* var. *luetzelburgii*. **6.** *Pleurotaenium sceptrum* var. *sceptrum*. **7–9.** *Staurastrum furcatum* var. *scaevum*. **8, 9.** Apical view. **10.** *Staurastrum quadrispinatum* var. *quadrispinatum*. **11.** *Staurastrum quadrispinatum* var. *spicatum*. **12.** *Staurodesmus wandae* var. *longissimus*. Scale bars: Figs. 1, 2, 4–6, 10–12 = 20 µm; Fig. 3 = 25 µm; Figs. 7–9 = 10 µm.

Colma (1982): very frequent (F > 70% occurrence), frequent (F > 40 < 70%), uncommon (F > 10 < 40%), and rare (F < 10%). The absolute frequency corresponds to the number of samples in which one species occurred (Table 1).

Results

Cosmarium Corda ex Ralfs

Cosmarium furcatum Kurt Förster

Figure 1

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 03.VII.2007; C.B. Araújo leg. (SP469218) • same locality; 15.IV.2008; C.B. Araújo leg. (SP469226).

Identification. Cells 1.1–1.3× broader than long. Semicells subtriangular. Apex slightly convex. Lateral margins concave and crenulate. Angles with 2 short spines, furcate and divergent. Median constriction deep. Sinus widely open. Cell wall granulate, granules distributed in series. Cell dimensions: CL 21.7–22.3 µm, CW 24.5–29.8 µm, IW 7.0–8.4 µm.

Geographic distribution in Brazil. Federal District (Estrela et al. 2011), Rio de Janeiro (Sophia 1999), and Tocantins (Förster 1964, as Goiás state).

Remarks. This species was described by Förster (1964) based on material collected in "Rio das Femmeas, Porta Azul", now considered as state of Tocantins. Our material has larger cell dimensions than reported by Förster (1964) and by Estrela et al. (2011). Our measurements were, however, smaller than those reported by Sophia (1999).

Cosmarium horridum Borge

Figures 2, 3

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 02.VI.2007; C.B. Araújo leg. (SP469217) • same locality; 03.VII.2007; C.B. Araújo leg. (SP469218) • same locality; 15.IV.2008; C.B. Araújo leg. (SP469226) • same locality; 15.VII.2008; C.B. Araújo leg. (SP469228).

Identification. Cells 1.1–1.3× longer than broad. Semicells ellipsoid to oblong. Apex widely round, with a series of short slightly curved spines. Lateral margins concave, with 8 longer spines and several small ones.

Median constriction deep. Median sinus narrow. Lateral and median regions ornamented with rings of 10–12 short spines; central region ornamented with 3 or 4 spines. Cell wall granulate or punctuate. Chloroplast axial. Cell dimensions: CL 45.8–57.8 µm, CW 38.2–42.9 µm, IW 13.2–24.4 µm.

Geographic distribution in Brazil. Bahia (Oliveira et al. 2016), Federal District (Senna et al. 1998; Estrela et al. 2011), Mato Grosso (Borge 1903, 1918) and São Paulo (Borge 1918; Bicudo et al. 2019).

Remarks. This species was described based on material collected in French Guiana (Borge 1899). It has long cells, longer than they are wide, with the central region ornamented with 16 circular tubercles, and the apex ornamented with 1–4 teeth. This species is highly variable and includes several transitional forms. According to Borge (1918), *Xanthidium ornatum* O.Borge proposed by Borge (1903) from material collected in Mato Grosso should be a taxonomic form or even a synonym of *Cosmarium horridum*. Although Grönblad (1945) mentioned the occurrence of *C. horridum* (as *Cosmarium lagoense* Nordstedt var. *horridum* Borge) in Pará, no detailed information such as a description, measurements, or an illustration was provided, nor was such information provided later by Costa et al. (2014). We, therefore, are the first to report the occurrence of this species in northern Brazil and to provide a description, measurements, and illustration.

***Cosmarium ornatum* Ralfs ex Ralfs var. *sublagoense* Kurt Förster & Eckert**

Figure 4

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 02.VI.2007; C.B. Araújo leg. (SP469217).

Identification. Cells 1.1× longer than broad. Semicells kidney-shaped. Basal angles and most of the lateral margins form a continuous broad curve with the upper margins slightly retuse below the apex in the mid-region. Apical margins with 2 short spines in the mid-region and 2 short ones on the extremities of the apex. Lateral margins with spines. Face of semicell protuberant, with rings of granules in various positions. Median constriction deep. Median sinus open. Cell wall smooth. Chloroplast axial. Cell dimensions: CL 26.7–27.6 µm, CW 30.9–32.0 µm, IW 10.6–11.1 µm.

Geographic distribution in Brazil. Tocantins (Förster 1964, as Goiás state).

Remarks. *Cosmarium ornatum* Ralfs var. *sublagoense* Kurt Förster & Eckert was proposed from material collected from Rio das Femmeas, state of Tocantins, Brazil. According to the authors, the variety is similar to *C. ornatum* var. *lagoense* Nordstedt described by Nordstedt (1870), which was elevated to a species level (*Cosmarium lagoense* Nordstedt) by Nordstedt (1877). The differences between *C. ornatum* var. *sublagoense* and *C. lagoense* lies in the median sinus, which is acutely angled and deeper, and the apex smooth, in the var. *sublagoense*. Moreover, this variety differs from the typical variety in having two short spines at the tips of the apical margin, two short spines on the cell median intumescence, and a shallow median constriction with the median sinus broad. *Cosmarium ornatum* Ralfs var. *ornatum* f. *ornatum* has spines along the entire margin, a deep median constriction, and a narrow median sinus, which may be open near the isthmus.

Pleurotaenium Nägeli

***Pleurotaenium coronatum* (Brébisson) Rabenhorst var. *luetzelburgii* Kurt Förster**

Figure 5

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 02.VI.2007; C.B. Araújo leg. (SP469217) • same locality; 15.IV.2008; C.B. Araújo leg. (SP469226) • same locality; 13.V.2008; C.B. Araújo leg. (SP469227).

Identification. Cells 7.4–7.8× longer than broad. Semicells cylindrical. Apex rounded truncate, 4 visible granules. Lateral margins slightly undulate towards the apex. Basal intumescence replaced by a well-defined deep incision. Median sinus open. Cell wall smooth, brownish, punctate. Cell dimensions: CL 246.8–254.2 µm, CW 31.5–34.1 µm, CAW 21.8–24.0 µm, IW c. 23.6 µm.

Geographic distribution in Brazil. São Paulo (Bicudo et al. 2014) and Tocantins (Förster 1964, as Goiás state).

Remarks. Förster (1964) described this species from material collected in Conceição, Tocantins, Brazil. Later on, Bicudo et al. (2014) proposed *Pleurotaenium coronatum* (Brébisson) Rabenhorst var. *latereodulatum* Azevedo and C.E.M.Bicudo based on some specimens previously identified as *P. coronatum* var., which have lateral margins strongly tapered towards the apex of the semicell. However, according to the AlgaeBase (Guiry and Guiry 2022) and based on the International Code of Nomenclature for Algae, Fungi, and Plants (Turland et al. 2018), *P. coronatum* var. *latereodulatum* is not a valid name because its original description was not in Latin or English. The size of the granules at the apex of each semicell may be quite variable, and sometimes only poorly developed (Förster 1964; Bicudo et al. 2014). We observed specimens with large granules at the extremities of the semicells and comparatively smaller granules at the mid-region of the apex of semicells in our material.

Pleurotaenium sceptrum* (Roy) West & G.S. West var. *sceptrum

Figure 6

Basionym. *Docidium sceptrum* Roy (1883): 39.

Material examined. BRAZIL– Amapá • Macapá, Lake Curralinho; 00°07′54″N, 51°06′50″W; 02.VI.2007; C.B. Araújo leg. (SP469217) • same locality; 15.IV.2008; C.B.

Araújo leg. (SP469226) • same locality; 15.VII.2008; C.B. Araújo leg. (SP469228).

Identification. Cells 12.4–13.9× long than broad. Semicells cylindrical, slightly tapered towards the apex. Semicell apex with 4 or 5 sharp spines in front view. Lateral margins parallel to each other, with a slight intumescence near the isthmus region. Median constriction shallow. Median sinus open. Cell wall smooth, finely punctate. Chloroplasts axial. Cell dimensions: CL 81.2–237.1 µm, CW 14.5–17.0 µm, CAW 10.2–17.2 µm, IW 11.1–15.3 µm.

Geographic distribution in Brazil. Bahia (Oliveira et al. 2014), Mato Grosso (Freitas and Loverde-Oliveira 2013, as *Pleurotaenium tridentulum*), and São Paulo (Bicudo et al. 2014).

Remarks. The species is commonly cited as *Pleurotaenium tridentulum* (Wolle) W. West var. *tridentulum*. However, *P. sceptrum* was described by Roy (1883: 37) as *Docidium sceptrum*, whereas *Docidium tridentulum* Wolle (the basionym of *P. tridentulum*) was described by Wolle (1884: 52). Therefore, following the International Code of Nomenclature for Algae, Fungi, and Plants (Turland et al. 2018), the first published valid name has precedence. Thus, *P. sceptrum* is the earliest valid published name for this species and *P. tridentulum* described in West (1892: 120) must be considered a taxonomic synonym. It is important to mention that *P. sceptrum* was only cited by Nägeli (1849: 104), with no description or illustration included. Furthermore, *P. tridentulum* was erroneously described by Wolle (1884) as having three apical teeth, although there are always four teeth.

Staurastrum Meyen ex Ralfs

***Staurastrum furcatum* Brébisson var. *scaevum* Scott & Grönblad**

Figures 7–9

Material examined. BRAZIL– **Amapá** • Macapá, Lake Curralinho; 00°07'54″N, 51°06″50″W; 14.I.2008; C.B. Araújo leg. (SP469223) • same locality; 15.VII.2008; C.B. Araújo leg. (SP469228).

Identification. Cells small to medium-sized, 1.2× long than broad with processes. Semicells transversally oval to subglobose. Apical margin broadly convex to domed-shaped, a pair of stout, 2-spinate processes at each apical angle. Dorsal and ventral margins about equally convex. Basal margins convex to lateral angles, each with a short, stout, 2-spinate process. Median constriction relatively deep. Sinus with an acute notch at apex. Isthmus fairly broad. Cell wall smooth. Chloroplasts axial. Cell dimensions: CLS 30–40 µm, CLNS 26 µm, CWS 33 µm, CWNS 22–23 µm, IW 15.0–15.5 µm.

Geographical distribution in Brazil. Our records are the first of this species from Brazil.

Remarks. According to Prescott et al. (1982), *S. furcatum* var. *scaevum* differs from the typical variety by having a supernumerary asymmetrical 2-spinate process on the left side of each angle in vertical view. In some specimens, such processes may have degenerated into a long, simple spine (Scott and Grönblad 1957). Our measurements and illustrations are similar to those by Scott and Grönblad (1957) and Prescott et al. (1982) from material collected in the United States.

Staurastrum quadrispinatum* W.B.Turner var. *quadrispinatum

Figure 10

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 15.VII.2008; C.B. Araújo leg. (SP469228).

Identification. Cells 1.1× longer than broad. Semicell quadrangular. Apical margin straight. Basal margins concave and smooth. Apices ornamented with 2 marginal pointed, slightly curved, robust spines, 1 submarginal spine, curved to the opposite semicell. Margins between angles concave. Median constriction deep. Median sinus open and acute. Cell wall hyaline and smooth. Chloroplast axial. Cell dimensions: CLS 29.3 µm, CLNS 23.1 µm, CWS 24.9 µm, CWNS 19.7 µm, IW 9.1 µm.

Geographic distribution in Brazil. Mato Grosso (Paula et al. 2014) and Paraná (Dunck et al. 2018, just a citation).

Remarks. The cell dimensions of our material are in accordance with those presented by Paula et al. (2014) for specimens from Mato Grosso. According to Šťastný (2010), this is a rather rare species in oligotrophic, strongly acidic environments with pH values of 3.7–4.1 and electrical conductivity of 37–93 $\mu S \cdot cm^{-1}$. However, the pH was acidic (4.9), and the electrical conductivity was very low (10.5 $\mu S \cdot cm^{-1}$) in our study.

***Staurastrum quadrispinatum* W.B.Turner var. *spicatum* (West & G.S.West) Scott & Grönblad**

Figure 11

Basionym. *Staurastrum spicatum* West & G.S.West (1895): 69.

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 03.VII.2007; C.B. Araújo leg. (SP469218) • same locality; 14.I.2008; C.B. Araújo leg. (SP469223).

Identification. Cells medium-sized, 1.1–1.4× longer than broad, including the processes. Semicells rectangular. Apical margin straight. Apical angles ending in 2 spines. Lateral margins straight to slightly convex, divergent. Angles decorated with 1 strong spine. Median constriction moderate. Median sinus open, acutangular. Cell wall hyaline, smooth. Cell dimensions: CLS 36.0 µm, CLNS 21.8–27.0 µm, CWS 33.7 µm, CWNS 14.8–24.0 µm, IW: 9.9–10.6 µm.

Geographical distribution in Brazil. Our records are the first of this species from Brazil.

Remarks. This variety was proposed by Scott and Grönblad (1957) from material collected in the United States. According to these authors, *S. quadrispinatum* var. *spicatum* is identical to individuals belonging to *Staurastrum spicatum* West & G.S.West, and it was also not possible to easily differentiate it from the various morphological expressions they identified as *Staurastrum quadrispinatum* Turner. Thus, according to Scott and Grönblad (1957), it was more correct to propose a new combination and transfer *S. spicatum* to *S. quadrispinatum* as a variety. Specimens of the latter variety have rectangular semicells with simple basal angles, strong spines, and apical angles with two spines. Measurements of our Amapá material are similar to those recorded by Scott and Grönblad (1957) and Prescott et al. (1982) of North American specimens.

Staurodesmus Teiling

***Staurodesmus wandae* (Raciborski) Willi Krieger & Bourrelly var. *longissimus* (Borge) Teiling**

Figure 12

Basionym. *Staurastrum longissimum* Borge (1918): 47.

Material examined. BRAZIL – Amapá • Macapá, Lake Curralinho; 00°07′54″N, 051°06′50″W; 02.VI.2007; C.B. Araújo leg. (SP469217) • same locality; 03.VII.2007; C.B. Araújo leg. (SP469218) • same locality; 12.II.2008; C.B. Araújo leg. (SP469224) • same locality; 15.IV.2008; C.B. Araújo leg. (SP469226) • same locality; 15.VII.2008; C.B. Araújo leg. (SP469228).

Identification. Cells 1.7–3.0× long than wide without spines. Semicells obtrapeziform-elongate. Apical and basal margins slightly convex. Median constriction shallow. Median sinus open, obtuse. Angles retuse ornamented with 1 medium-sized, divergent spine inserted in the upper third of semicell. Cell wall smooth. Apical view 5-angled. Cell dimensions: CLS 68.5–100.0 µm, CLNS 48.3–82.2 µm, CWS 30.2–47.9 µm, CWNS 16.0–26.4 µm, IW 12.0–16.2 µm.

Geographical distribution in Brazil. Federal District (Leite 1990), São Paulo (Borge 1918; Godinho 2005), Tocantins (Förster 1964, as Goiás state).

Remarks. *Staurastrum longissimum* was originally described by Borge (1918: 47) from material collected in São Paulo state, Brazil. Later, this species was transferred by Teiling (1967) to *Staurodesmus wandae* as a variety of that species. This variety differs from the typical species in having cells approximately 3× longer than wide, which makes it unique and easily identifiable. Förster (1964: pl. 33, figs. 11–13, pl. 49, fig. 10) identified some material collected from Rio das Femmeas, Tocantins, Brazil (previously reported as Goiás by him), which served as the basis for the new variety: *Staurastrum longissimum* Borge var. *macroporosum* Kurt Förster. However, this variety must be considered a heterotypic synonym of *S. wandae* (Raciborski) Willi Krieger & Bourrelly var. *longissimus* (Borge) Teiling. Measurements of our Amapá material are almost similar to those reported by Godinho (2005) from material from São Paulo state.

The predominantly acidic (pH < 5.5) and low conductivity of the water in our study area is favorable for the development of desmids. In addition, high temperatures and low dissolved oxygen (<5.5 mg·L^{-1}) were dominant (Table 1). Acidity and low conductivity of water are very common in the aquatic ecosystems of the Amazon region (Melo and Souza 2009; Souza and Melo 2010), especially during the rainy season.

In terms of their frequency of occurrence, we found all taxa to be uncommon or rare, probably due to their intrinsic characteristics and ecological preferences at the time of year of the study. Seven taxa are considered uncommon or less frequent. *Staurodesmus wandae* var. *longissimus* (45%) was recorded in five of the 11 months of our study, followed by *Cosmarium horridum* in four months (36% of frequency). In contrast, *Cosmarium ornatum* var. *sublagoense* and *Staurastrum quadrispinatum* var. *quadrispinatum* were rare (9%), present only during the rainy and the less-rainy periods, respectively (Table 1).

Discussion

We report nine taxa in four genera of Desmidiaceae. We identified two taxa to the species level and seven others to an infraspecific category. Of the infraspecific taxa, two are typical and five are non-typical varieties of their respective species. The most representative genera were *Cosmarium* and *Stautasrum* (three taxa each one), followed by *Pleurotaenium* (two taxa) and *Staurodesmus* (a single taxon).

Our analysis of the seasonal occurrence of desmids during our study from June 2007 to July 2008 showed that most taxa occurred during both rainy and less-rainy periods (Table 1). However, three taxa were exclusively recorded during the rainy period (*C. ornatum* var. *sublagoense*, *P. coronatum* var. *luetzelburgii*, and *S. furcatum* var. *scaevum*), and *S. quadrispinatum* var. *quadrispinatum* was only recorded for the less-rainy period.

The taxa reported here are distributed in seven Brazilian states: Amapá (present study), Bahia, Mato Grosso, Paraná, Rio de Janeiro, São Paulo, and Tocantins (previously as Goiás state), as well as the Brazilian Federal District (Fig. 13). The states of São Paulo and Tocantins showed the greatest number of taxa (four each). *Cosmarium horridum* is well distributed in Brazil (in five states), followed by *C. furcatum*, *P. sceptrum* var. *sceptrum* and *Staurodesmus wandae* var. *longissimum* in four states (Fig. 13).

The number of desmid taxa (Zygnematophyceae) currently recorded from northern Brazil is 331 distributed into 23 genera (Flora e Funga do Brasil 2022). However, this number is probably underestimate. According to the Flora do Brazil (Flora e Funga do Brasil 2022) database, the microalgae flora of Amapá comprises just 18 taxa belonging to the two genera *Staurastrum* and *Staurodesmus*. Although there are still few studies and information is lacking on the microalgal

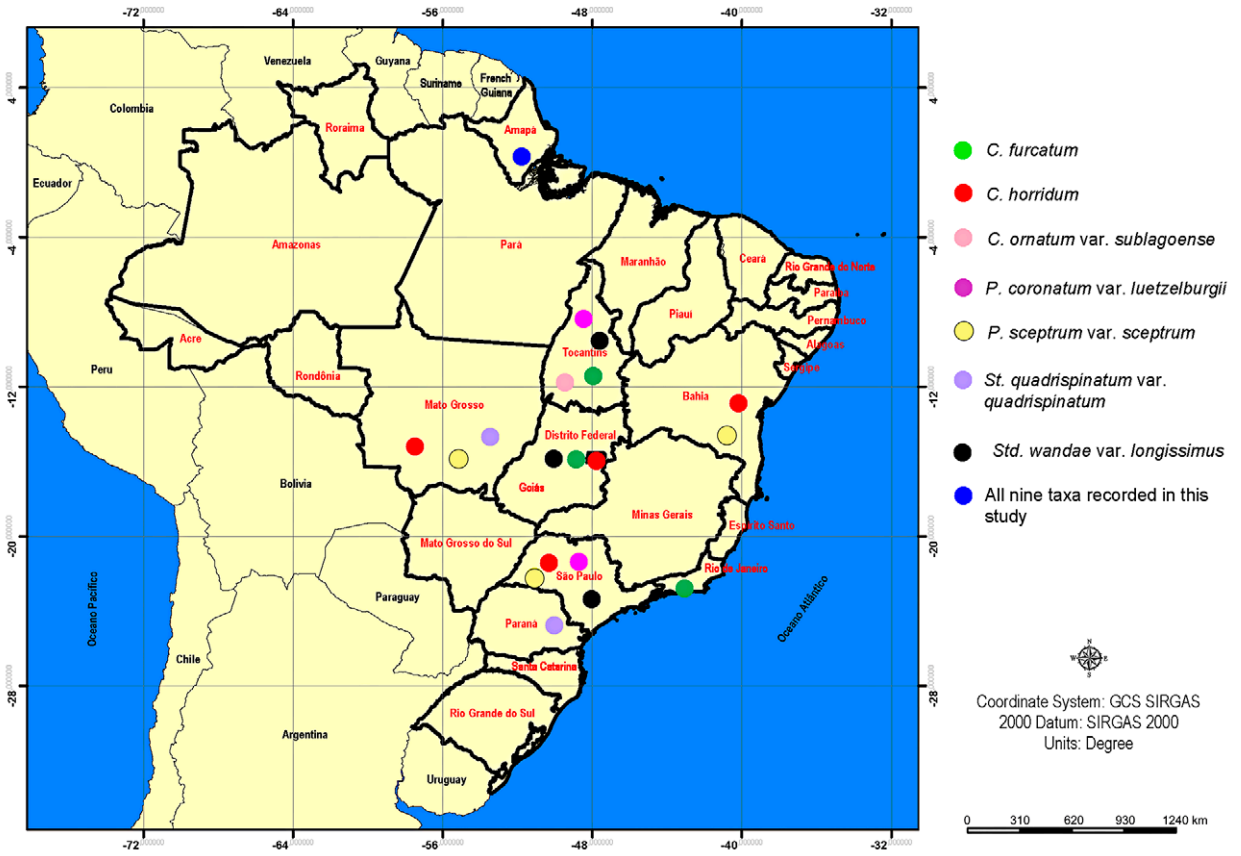


Figure 13. Geographic distribution of nine desmids taxa in Brazil. All nine taxa reported in this study are recorded for the first time from Amapá (blue circle), and *Staurastrum furcatum* var. *scaevum* and *St. quadrispinatum* var. *spicatum* are recorded for the first time from Brazil.

flora of this state, other genera have been reported from aquatic ecosystems in Amapá, including *Closterium* and *Euastrum* (Förster 1963), *Desmidium* (Förster 1963; Araújo et al. 2020), some other pseudofilamentous genera (Araújo et al. 2020), and *Xanthidium* (Souza and Melo 2011).

All taxa that we found are reported here for the first time from Amapá. The following five taxa are additions to the desmid flora of the Amazon region: *C. horridum*, *P. sceptrum* var. *sceptrum*, *Staurastrum quadrispinatum* var. *quadrispinatum, S. quadrispinatum* var. *spicatum* and *S. furcatum* var. *scaevum*. The last two are also reported for the first time from South America and Brazil.

Four taxa were recorded by Förster (1964) from Rio das Femmeas, Porta Azul (*Cosmarium furcatum*, *C. ornatum* var. *sublagoense* and *Staurodesmus wandae* var. *longissimus*) and Conceição (*Pleurotaenium coronatum* var. *luetzelburgii*). In 1964, prior to the formation of Tocantins, these localities belonging northern of state of Goiás, but nowadays, since the separation of these both Brazilian states, they are within the state of Tocantins. After 58 years, we can report these four taxa for only the second time from the Amazon Brazilian flora.

Both species newly reported from Brazil by us were descripted from material collected in North America by Scott and Grönblad (1957), and there is currently no detailed information available on their distribution in the AlgaeBase database (Guiry and Guiry 2022). Some other taxa reported here are of common or may be endemic to tropical South America, such as *C. furcatum* and *C. horridum* (Coesel 1996), *C. ornatum* var. *sublagoense* (Förster 1964; Biolo and Bicudo 2018), and *S. wandae* var. *longissimum* (Borge 1918; Bicudo et al. 2018). Three taxa, *P. coronatum* var. *luetzelburgii*, *P. sceptrum* var. *sceptrum*, and *S. quadrispinatum* var. *quadrispinatum*, are widely distributed around the world (Guiry and Guiry 2022).

Finally, we emphasize the need for more taxonomic revision and investigations on desmids, as well as other microalgae groups, especially in Amapá, where knowledge is still poor compared to other Brazilian states.

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Authors' Contributions

Conceptualization: CBA. Formal analysis: CBA. Funding acquisition: LRT, PCC. Investigation: CBA. Resources:

LRT, SM. Supervision: CEMB, LRT, SM. Visualization: CBA, PCC. Writing – original draft: CBA, CEMB. Writing – review and editing: SM, LRT, PCC, CEMB, CBA, MFMF.

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