



## ***Staurastrum pantanale* sp. nov. (Zygnematophyceae, Desmidiaceae), a new desmid species from the Brazilian Pantanal**

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### **Abstract**

*Staurastrum pantanale* is proposed new to science and is characterized by its crenate cell wall and cell dimensions. The species was collected from the metaphyton of a shallow tropical lake (Salitrada Campo Dora Lake, 18° 58' 02" S, 56° 38' 59" W) with transparent water and pH 5, located in the Nhecolândia Pantanal, Mato Grosso do Sul State, Brazil. The new species' morphology and relationship with morphologically close species are discussed.

**Key words:** biodiversity, desmid, new species, Pantanal wetland, shallow lake

### **Introduction**

*Staurastrum* Meyen ex Ralfs includes from 800 (Gerrath 1993) to 1200 (Bicudo & Menezes 2006) known taxa, and represents approximately 20–30% of all known desmid species (Bicudo & Menezes 2006, Gontcharov 2008).

Traditionally, desmid taxonomy at the generic and infrageneric levels is based on morphological and metric characteristics, mainly those related to the cell wall and the semicell shape (Kouwets 2008). According to classical taxonomy, *Staurastrum* is considered largely polymorphic and polyphyletic (Prescott *et al.* 1982). However, recent molecular studies have suggested that this genus is in fact monophyletic (Gontcharov & Melkonian 2005, 2008).

Despite the already vast number of species found in the literature, new species and taxonomic varieties of *Staurastrum* are still being described, even for the temperate zone (Ricci 1990, Scharf 1995, Coesel & Joosten 1996, Kusber & Scharf 2009). This number tends, however, to be greater in the tropical region due to greater habitat differentiation and considerable lack of taxonomic studies (e.g. Yacubson 1977).

The Pantanal sub-region examined in this paper is known as Nhecolândia and it is mainly characterized by the presence of thousands of shallow lakes (up to 2 m deep) that may differ substantially in their limnological features (wide conductivity and pH spectra) (Calheiros & Oliveira 1999).

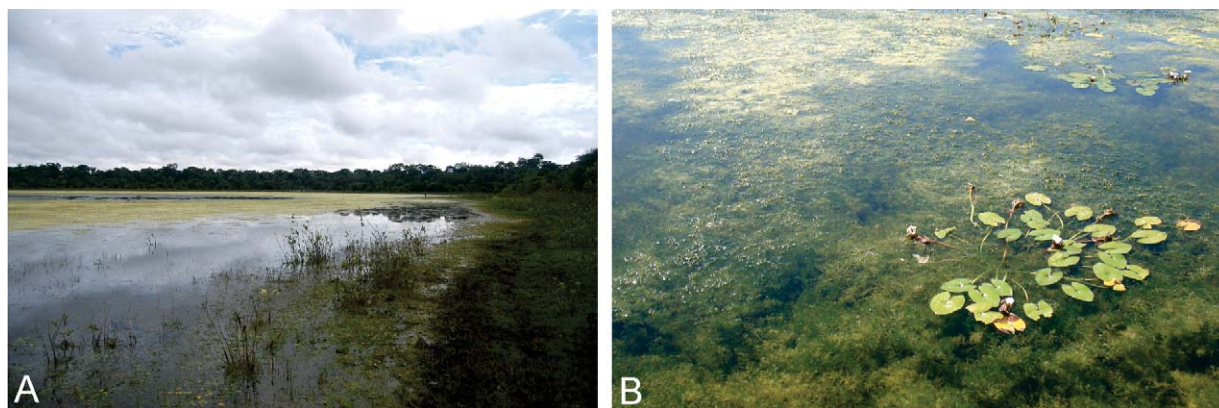
Taxonomic studies of the algae and cyanobacteria from such lakes started in 2004, unveiling its unique algal flora composition (Santos *et al.* 2004, Malone *et al.* 2007, Santos 2008, Santos & Sant'Anna 2010). During these studies, different populations of the *Staurastrum* species here described were studied, showing a set of very peculiar morphological characteristics that made it unique and distinct from all those previously described in literature. This paper aims to describe and propose a new *Staurastrum* species based on its morphological and metric features.

## Material and Methods

The Pantanal area is located in the central region of South America and has an estimated area of 200,000 km<sup>2</sup> distributed among three countries: Brazil (80%), Bolivia (15%), and Paraguay (5%) (Swarts 2000). Known as the Planet's largest wetland, it includes a mosaic of aquatic systems and a high biodiversity (Por 1995).

Climate in the Nhecolândia sub-region presents an annual mean temperature of 25.5° C and two very contrasting seasons, a dry (May–October) and a rainy one (November–April). The annual mean precipitation is 1,182.7 mm (Soriano 1999).

Lakes of the Nhecolândia sub-region may be classified into three types: “salinas”, permanent, alkaline (pH > 9), brackish (conductivity > 2,000  $\mu\text{S}\cdot\text{cm}^{-1}$ ) water bodies, isolated from all other systems; “baías”, permanent or temporary freshwater systems connected to adjacent water bodies during the rainy period (conductivity < 1,000  $\mu\text{S}\cdot\text{cm}^{-1}$  and pH 5–7.4) (Sakamoto *et al.* 1999); and “lagoas salitradas”, which are considered in between “baías” and “salinas” presenting characteristics of both types mentioned depending on the dry and rainy periods. Salitrada Campo Dora Lake (18° 58' 02" S, 56° 38' 59" W) is a shallow lake, with a maximum depth of 0.4 m (Table 1), surrounded by grass-like vegetation, and floating and submerged aquatic vegetation (SAVs) at its littoral zone (Fig 1). It is a temporary water body, since it frequently dries during the long drought period, whereas during the more intense rainy period it coalesces with adjacent systems making a single large lake (Rezende-Filho 2006). Its pH and water transparency values vary seasonally according to the flooding pulse: pH > 7.5 (up to 9) and reduced water transparency during the dry period, and pH < 7.5 (up to 5) with transparent water during the rainy one (Santos 2008, Silva & Sakamoto 2009). According to Santos (2008), the pond's algal flora mainly contains filamentous greens, desmids, cyanobacteria, and diatoms.



**FIGURE 1, A–B.** Pond studied, Salitrada Campo Dora: **A:** General view; **B:** Detail of submerged and floating macrophytes.

Samplings were performed during the high and low water periods from 2004 to 2009, using a 20  $\mu\text{m}$  mesh plankton net and a plastic sample bottle, both in the approximate center and at the SAV-dense margins of the pond. Material collected was fixed and preserved with a 4% formalin solution, and deposited at the Instituto de Botânica Herbarium (SP), São Paulo, Brazil. Over 100 individual specimens were studied using a binocular Zeiss Axioplan-2 microscope.

Scanning Electron Microscope (SEM): 1 ml of each sample unit was consecutively washed with 10%, 30%, 50%, 70%, and 100% alcohol to get rid of formalin and dehydrate the cells. A minimum of 3 hours interval was kept in between two consecutive washes to allow sedimentation of cells and the supernatant elimination. The concentrated sample was then transferred to a stub with double-faced adhesive tape, and placed in a sterilizer at 40°C for 12 hours. Stubs were finally gold coated and photomicrographs taken with a Phillips XL20 D777 Scanning Electron Microscope.

**TABLE 1:** Limnological features of the pond studied (“Salitrada Campo Dora”) (sampling 8 May 2005). Morphometric data according to Rezende-Filho (2006).

Variable	Measurement
Coalescence	during more intense flooding periods
Maximum length (m)	500
Maximum width (m)	250
Maximum depth (m)	0.44
Area (ha)	8
pH	5.02
Electrical conductivity ( $\mu\text{S}\cdot\text{cm}^{-1}$ )	648
Salinity (psu)	0
Water temperature ( $^{\circ}\text{C}$ )	23

## Results and Discussion

*Staurastrum pantanale* K.R.S. Santos, Malone, Sant’Anna & C.E.M. Bicudo, *sp. nov.* (Fig. 2 A–J; Fig. 3 A–C)  
**Type:**—BRAZIL. Mato Grosso do Sul: Corumbá, Pantanal da Nhecolândia, Lagoa Salitrada Campo Dora, 18° 58’ 02” S, 56° 38’ 59” W, 8 May 2005, K.R.S. Santos *s.n.* holotype SP390914!).

*A Staurastro crenulato viso vertice 3-angulari, aspectu frontali processibus distincte convergentibus, marginibus profunde crenatis, processibus in 4 spinas breves desinentibus (ad 2  $\mu\text{m}$  longas) differt. Dimensiones: Cellulae 22.4–28.0  $\mu\text{m}$  longae, 10.8–12.6  $\mu\text{m}$  latae processibus exclusis, 27.5–42.6  $\mu\text{m}$  latae processibus inclusis, isthmus 6.5–8.9  $\mu\text{m}$  latus, processus 8–17  $\mu\text{m}$  longi. Zygospora globosa, 2–3(–4)-processibus furcatis, 45–49  $\mu\text{m}$  diam. processibus inclusis, 22–30  $\mu\text{m}$  processibus exclusis, processus 6.4–12.8  $\mu\text{m}$  longi.*

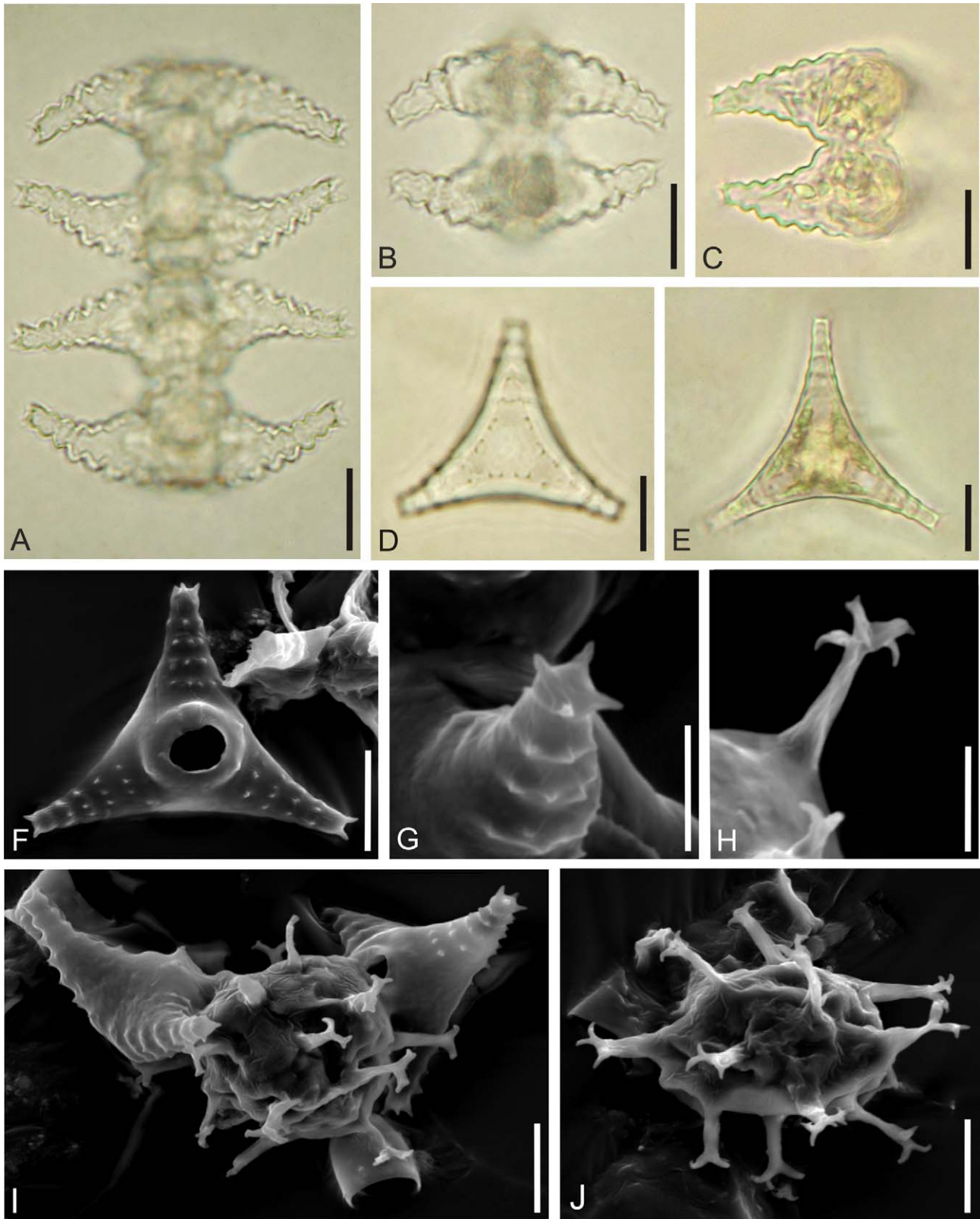
Cells 3-radiate, 22.4–28.0  $\mu\text{m}$  long, 10.8–12.6  $\mu\text{m}$  wide without processes, 27.5–42.6  $\mu\text{m}$  broad with processes, isthmus 6.5–8.9  $\mu\text{m}$  wide, processes 8–17  $\mu\text{m}$  long; median constriction deep, sinus acutangular; semicell irregularly rectangular without processes, basal margin slightly convex, apical margin broadly convex; lateral angles are produced to form rather stout, distinctly convergent processes, tipped with 4 short teeth (up to 2  $\mu\text{m}$  long); all margins deeply crenate; cell wall provided with minute acute granules in concentric series on the processes; vertical view cell 3-angular, margins regularly concave, sometimes almost straight at the mid portion, with a pair of emarginate verrucae within the margin; chloroplasts axial, 1 per semicell, 2-furcate in each angle in vertical view; zygospore globose, with several 2–3(–4)-furcate processes, wall slightly rugose, 45–49  $\mu\text{m}$  diam. with processes, 22–30  $\mu\text{m}$  without processes, processes 6.4–12.8  $\mu\text{m}$  long.

**Habitat:**—Metaphyton in a shallow pond with filamentous green algae and macrophytes (pH = 5).

**Etymology:**—The epithet *pantanale* is based on the name of the geographic region, the Pantanal, where it was found.

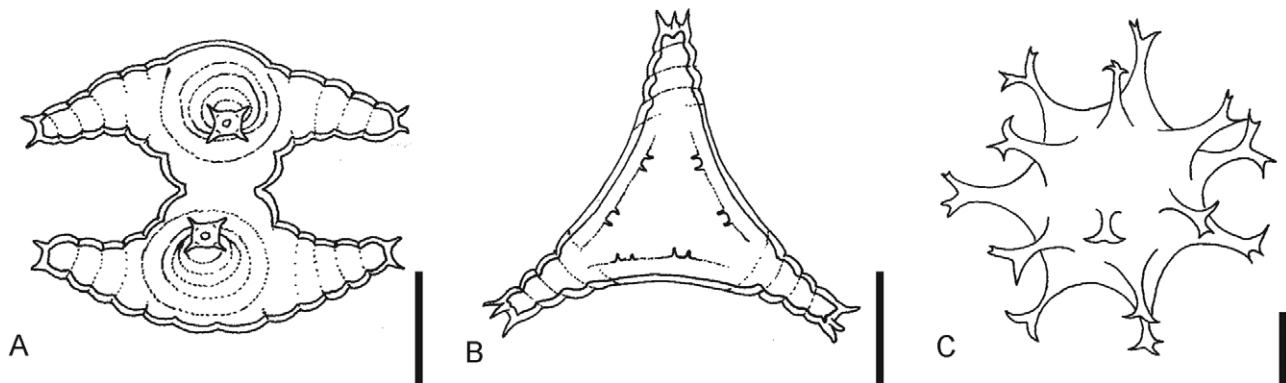
**Observations:**—*Staurastrum pantanale* differs morphologically from previously described taxa in its distinctly convergent processes (in frontal cell view) with a deeply crenate outline (Fig. 2 A–C; Fig. 3 A–B) and cell dimensions (Table 2).

*Staurastrum pantanale* is characterized by a subcylindric base of the semicell body (Fig. 3 A). In this feature it resembles representatives of the *Staurastrum manfeldtii* Delponte (1877: 160) species group (Coesel 1992), in particular *S. manfeldtii* var. *parvum* Messikommer (1942: 173). However, it differs from *S. pantanale* by the short and slightly convergent apical processes (in frontal view), by the straight margins between the processes (in vertical view), which are tipped with 3 spines, and by the undulate-serrulate cell wall (West *et al.* 1923).



**FIGURE 2, A–J:** *Staurastrum pantanale* sp. nov. **A–E:** LM images. **A:** Cell division; **B:** Frontal view; **C:** Detail of cell wall showing a crenate outline and acuminate isthmus; **D:** Vertical view and cell wall ornamentation detail; **E:** Detail of 2-furcate chloroplast toward the process apex; **F–J:** SEM images: **F:** Detail of cell wall ornamentation; **G:** Detail of process with 4 spines at the apex; **H:** Zygospore with 2–4-furcate processes; **I:** Zygospore formation; **J:** Zygospore general view. Scale bars: A–F, I–J = 10  $\mu\text{m}$ ; G–H = 5  $\mu\text{m}$ .

*Staurastrum crenulatum* (Nägeli 1849: 129) Delponte (1877: 68) differs from *S. pantanale* by the short and straight or slightly divergent processes, by the vertical view 3–5-angular with a deeply concave margin among the processes tipped with 2–3 spines, and the cell wall is crenate-denticulate (Table 2). *Staurastrum pantanale* presents distinctly convergent processes tipped with 4 spines and a straight or slightly concave margin between the processes (in vertical view) (Fig. 3 A–B; Table 2).



**FIGURE 3, A–C:** *Staurastrum pantanale* sp. nov. **A:** Frontal view of the cell; **B:** Vertical view of the cell; **C:** Zygospore. Scale bars: A–C = 10 µm.

**TABLE 2:** Comparison among *Staurastrum pantanale* sp. nov., *S. manfeldtii* var. *parvum* and *S. crenulatum*.

Feature	<i>S. pantanale</i>	<i>S. manfeldtii</i> var. <i>parvum</i>	<i>S. crenulatum</i>
Length (µm)	22–28	32	20–25
Width with processes (µm)	27–43	52	20–33
Length of processes (µm)	7.8–17.0	-	-
Isthmus (µm)	6.5–8.9	8.5–8.6	5–7
Nº. of spines at tip of processes	4	3	2-3
Median constriction	deep	relatively shallow	shallow
Wall undulations	crenate	undulate-serrulate	crenate-denticulate
Vertical view	3-angular	3-angular	3–5-angular
Margins between processes (vertical view)	concave to almost straight	straight	deeply concave
Semicell shape without processes	irregularly rectangular	broadly bowl	broadly oval or subfusiform
Habitat	metaphyton	-	-
Distribution	tropical	temperate	worldwide

All studied populations ( $n = 100$ ) showed either immature (Fig. 2 I) or mature (Fig. 2 J; Fig. 3 C) zygospores, allowing the description of their morphological details under SEM, such as their 2–4-furcate processes at the apex (Fig. 2 H) and the slightly rugose wall (Fig. 2 I–J). Both *S. manfeldtii* var. *parvum* and *S. crenulatum* never had their zygospores described, making the comparison with *S. pantanale* impractical. It is worth emphasizing that the occurrence of zygospores is seldom documented in the desmid literature, and that their description is extremely important since it may help to differentiate infrageneric taxa within desmids (Ricci 1990). According to Cushman (1905), a detailed study of the zygospore of a considerable number of species is needed to evaluate its use for separation at the species and infraspecific levels in desmids. Although Cushman’s statement dates from 1905, the question still remains open without a solution.

*Staurastrum manfeldtii* var. *parvum* and *S. crenulatum* are quite common in temperate regions and only the latter is considered to have a worldwide distribution (Prescott *et al.* 1982). Nevertheless, *S. crenulatum*

was never referred to Brazil, and even for South America there is only one citation for Argentina (Tell 1980). *Staurastrum pantanale* was collected from a very typical tropical environment. Despite having collected material in 40 sample units from different ponds in the Nhecolândia Pantanal, including “salinas”, “salitradas” and “baías”, the species was exclusively from “salitrada” ponds. *Staurastrum pantanale* was extremely abundant in the latter systems towards the end of the rainy season (May 2005), living in acidic (pH = 5) and relatively low electrical conductivity (648  $\mu\text{S}\cdot\text{cm}^{-1}$ ) conditions that are favorable for the growth of many desmid species (Brook 1981, Coesel 1996). The present species occurred in the metaphyton among dense populations of filamentous green algae, mainly *Oedogonium subdissimile* Jao (1979: 325), *O. punctatum* Wittrock (1878: 142), *Oedogonium* sp., *Chara* spp. and *Spirogyra* spp.

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