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## *Gomphonema* Ehrenberg (Bacillariophyceae) in a lotic environment of the Upper Paraná River floodplain, Brazil

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**ABSTRACT.** A taxonomic study of species of the genus *Gomphonema* Ehrenberg (Bacillariophyceae) was performed in lotic environment (Ipoitã Channel) of the Upper Paraná River Floodplain. Samplings were performed in June, September and December 2013 and February 2014. Two petioles of *Eichhornia azurea* (Sw) Kunth were sampled at three different sites in the channel. Twelve species and two taxonomic varieties were identified. All species identified were recorded at the sampling site 3, located close to the Ivinhema River. The lowest number of taxa occurred at the sampling site 1 (9 specific and infra specific taxa), in the confluence with the Paraná River. All taxa of *Gomphonema* were the first record for the Upper Paraná River Floodplain. Our results emphasize the lack of taxonomic studies for the region and the importance thereof to the knowledge of biodiversity.

**Keywords:** diatom, distribution area, periphyton, taxonomy.

## *Gomphonema* Ehrenberg (Bacillariophyceae) em ambiente lótico da planície de inundação do Alto Rio Paraná

**RESUMO.** Realizou-se o estudo taxonômico das espécies do gênero *Gomphonema* Ehrenberg (Bacillariophyceae) em um ambiente lótico (canal Ipoitã) da planície de inundação do alto rio Paraná. As coletas foram realizadas em junho, setembro e dezembro de 2013 e fevereiro de 2014. Dois pecíolos de *Eichhornia azurea* (Sw) Kunth foram amostrados em três pontos distintos do canal. Foram identificadas 12 espécies e duas variedades taxonômicas, sendo que todas foram registradas no ponto 3, situado próximo ao rio Ivinhema. O menor número de táxons ocorreu no ponto 1 (9 táxons específicos e infra específicos), na área de junção com o rio Paraná. Todos os táxons do gênero *Gomphonema* são primeiro registro para a planície de inundação do Alto Rio Paraná. Os resultados ressaltam a carência de trabalhos taxonômicos para a região e a importância destes para o conhecimento da biodiversidade.

**Palavras-chave:** diatomácea, área de distribuição, perifíton, taxonomia.

### Introduction

The Upper Paraná River floodplain is characterized by heterogeneous habitats that confer high biodiversity to this environment (Thomaz, Bini, & Bozelli, 2007, Agostinho, Pelicice, & Gomes, 2008). Periphytic algae are one of the aquatic communities found in this ecosystem, with a high proportion of diatoms (Bacillariophyceae), especially in lotic environments. These algae present morphological adaptations that favor their attachment to substrates (Wehr & Sheath, 2003).

The diatom genus *Gomphonema* Ehrenberg is well represented in aquatic environments, presenting high richness and abundance. *Gomphonema* species are characterized by cuneiform

cells in girdle view and hetero polar cells in valve view (Round, Crawford, & Mann, 1990). They generally attach to solid substrates through mucilage pads or stalks, secreted from the apical pore field located at the valve basis (Tremarin, Ludwig, Bertolli, Faria, & Costin, 2009a). In addition, cells possess a single H-shaped plastid with a central pyrenoid (Cox, 1996, Round et al., 1990). Several *Gomphonema* species are cosmopolitan. However, the morphological variability of frustules makes the taxonomy of this genus difficult (Krammer & Lange-Bertalot, 1986, 1991).

Approximately 90 *Gomphonema* species have been described for South America, 28 of which were recently proposed (Reichardt, 1995, Lange-Bertalot, Külbs, Lauser, Nörpel-Schempp, & Willmann, 1996,

Metzeltin & Lange-Bertalot, 1998, Rumrich, Lange-Bertalot, & Rumrich, 2000, Metzeltin, Lange-Bertalot, & Garcia-Rodrigues, 2005, Silva, Nogueira, & Souza, 2011). Approximately 40 of those species have been recorded in Brazil (Torgan, Becker, & Prates, 1999, Tremarin et al., 2009a, Santos, Tremarin, & Ludwig, 2011).

Almost 22 species of *Gomphonema* have been recorded for aquatic environments in Paraná (Tremarin, Freire, Bertolli, & Ludwig, 2009b), and only four species for Mato Grosso do Sul. The present study is the first floristic survey of *Gomphonema* in the Paraná River floodplain, contributing to the knowledge and characterization of aquatic biodiversity in this region, including ecology and biomonitoring studies, for which the correct identification of taxa is essential.

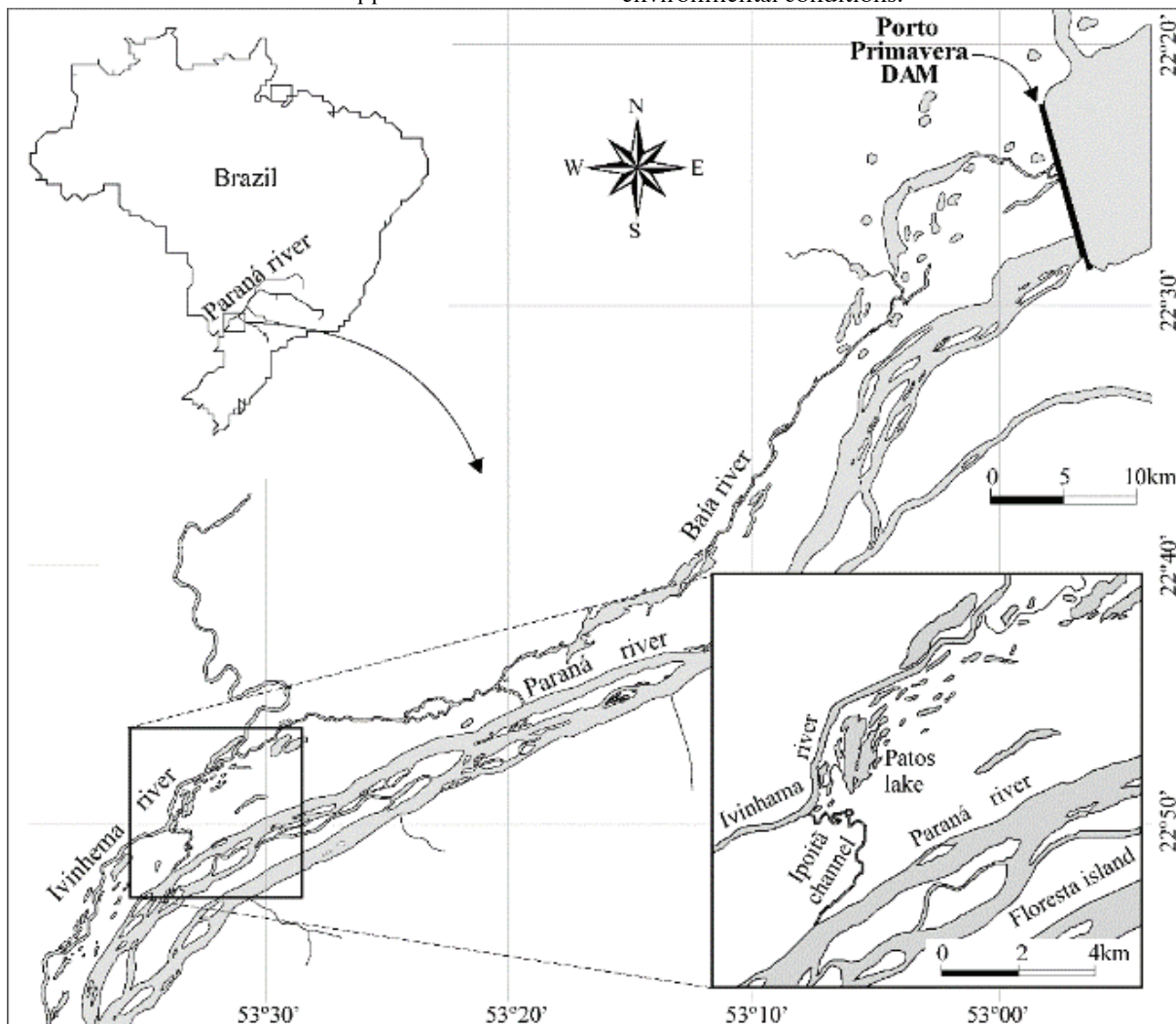
The goal of the present study was to perform a taxonomic analysis of species of the genus *Gomphonema* in a lotic environment of the Upper Paraná River

Floodplain, contributing to the knowledge regarding the distribution of these species.

### Material and methods

The study site is the Ipoitã Channel (22° 50'S; 53° 33'W), located in the Upper Paraná River floodplain, which connects the Ivinhema and Paraná rivers, with an average depth of 3.2 m. Samples were taken at three different sampling sites in this channel: site 1 at the connection with the Paraná River, site 2 in the middle of the channel, and site 3 at the connection with the Ivinhema River (Figure 1). This channel is inserted in the state of Mato Grosso do Sul, although it is practically on the border with the state of Paraná.

The substrates used were petioles of *Eichhornia azurea* (Sw) Kunth in the adult stage (Schwarzbold, 1990), selected from banks of this macrophyte of similar shape and size and under similar environmental conditions.



**Figure 1.** Upper Paraná River floodplain. The dashed line indicates the Ipoitã Channel.

Collections were performed in June, September and December 2013, and in February 2014. Periphytic algae were collected from the sixth or seventh plant internode of submerged mature petioles of *Eichhornia azurea* (Sw.) Kunth as recommended by Schwarzbold (1990). This macrophyte was selected to this research because it was the most abundant and is used as a standard plant for the PELD- Long Term Ecological Research. Two petioles were collected randomly at each site, placed in 150 mL Wheaton bottles, sprayed with distilled water, and kept in boxes with ice. The periphytic material was subsequently removed using stainless steel blades wrapped in aluminum foil and jets of distilled water. The resulting material was fixed in 1:1 Transeau solution (Bicudo & Menezes, 2006).

Part of the sample was oxidized with potassium permanganate and hydrochloric acid, according to Simonsen (1974) as modified by Moreira-Filho and Valente-Moreira (1981). Due to the high amount of organic matter in the blades, the material was oxidized again according to Hasle and Fryxell (1970). The resins used to mount permanent slides were Hyrax for the first method and Nafrax for the

second. One slide was mounted per site sampled in certain periods, resulting in 12 slides, in total. These slides were not quantified, but all of them were analyzed for species richness.

*Gomphonema* species were analyzed using a binocular microscope with amicometer ocular and 100x objective, and images were captured using an Olympus DP-071 camera. The terminology used for species description followed Round et al. (1990). Taxa identification was based, whenever possible, with the original literature referred to in the text. Samples were deposited in the Herbário of *Universidade Estadual de Maringá* (HUEM).

To record the occurrence of taxa distribution was conducted a review of literature with taxonomic approach.

## Results and discussion

A total 11 species and 3 taxonomic varieties belonging to genus *Gomphonema* were identified (Table 1). These taxa were distributed in one channel of the Upper Paraná River floodplain, located between the states of Mato Grosso do Sul and Paraná (Table 2).

**Table 1.** Taxa of *Gomphonema* (Gomphonemataceae) recorded in Ipoitã Channel in the Upper Paraná River floodplain. It occurs in different regions (1: connection with Paraná River, 2: middle of the channel; 3: connection with Ivinhema River) and months (Jun: June, Sep: September, Nov: November, 2013; and Feb: February, 2014).

Taxa	1				2				3			
	Jun	Sep	Nov	Mar	Jun	Sep	Nov	Mar	Jun	Sep	Nov	Mar
<i>G. affine</i> var. <i>affine</i> Kützing												
<i>G. angustatum</i> (Kützing) Rabenhorst												
<i>G. brasiliense</i> Grunow												
<i>G. costei</i> D. Metzeltin & H. Lange-Bertalot												
<i>G. lagenula</i> Kützing												
<i>G. laticollum</i> Reichardt												
<i>G. mexicanum</i> Grunow												
<i>G. neonasutum</i> H. Lange-Bertalot & E. Reichardt												
<i>G. parvulum</i> (Kützing) Kützing												
<i>G. pumilum</i> Grunow Reichardt & Lange-Bertalot												
<i>G. salae</i> Lange-Bertalot & Reichardt												
<i>G. sphaerophorum</i> Ehrenberg												
<i>G. subtile</i> Ehrenberg												
<i>G. turris</i> var. <i>coarctata</i> (Frenguelli) Frenguelli												

**Table 2.** Taxa distribution of *Gomphonema* recorded in Ipoitã Channel in the Upper Paraná River floodplain, located between the states of Mato Grosso do Sul and Paraná.

Taxa	Taxa Occurrence
	Paraná
<i>G. affine</i> var. <i>affine</i> Kützing	Caetano (1984), Moreira (1990), Leandrini (1999), Rodrigues and Bicudo (2001), Cetto, Leandrini, Felisberto, and Rodrigues (2004), Bigunas (2005), Silva, Tavares, Aquino, and Wengrat (2007), Pires (2013)
<i>G. angustatum</i> (Kützing) Rabenhorst	Contin (1983), Cecy (1986), Shirata (1986), Contin (1990), Lozovei and Shirata (1990), Cetto et al. (2004), Moro, Bicudo, Melo, and Schmitt (2004), Tremarin et al. (2009a and b), Bertolli, Tremarin, and Ludwig (2010), Bertolli (2010), Faria (2010)
<i>G. brasiliense</i> Grunow	Ludwig (1987), Lozovei and Shirata (1990), Moreira (1990), Rodrigues (1991), Moro, Garcia, and Oliveira Júnior (1994), Brassac (1999), Atab (2000), Szawka (2001), Cetto et al. (2004), Bigunas (2005), Piccinini (2005), Aquino and Tavares (2006), Silva et al. (2007), Pires (2013), Marquardt, Furstemberger, Chaouiche, Caparica, and Carapanarla (2010)
<i>G. costei</i> D. Metzeltin & H. Lange-Bertalot	Brassac (1999), Ferrari (2004), Costin (2007), Pires (2013)
<i>G. lagenula</i> Kützing	Costin (2007), Santos (2007), Pavan (2008), Tremarin et al. (2009a and b), Bertolli et al. (2010), Bertolli (2010), Marquardt et al. (2010), Faria (2010), Silva, Ludwig, Tremarin, and Vercellino (2010), Moresco, Tremarin, Ludwig, and Rodrigues (2011), Pires (2013), Marra (2015)
<i>G. laticollum</i> Reichardt	Silva et al. (2007), Tremarin et al. (2009a and b), Bertolli et al. (2010), Bertolli (2010), Marquardt et al. (2010), Silva et al. (2010), Bartozek et al. (2013)

continuation...

... continuation	
<i>G. mexicanum</i> Grunow	Piccinini (2005), Costin (2007), Silva et al. (2007)
<i>G. neonasutum</i> H. Lange-Bertalot & E. Reichardt	First record Moreira-Filho and Momoli (1963), Moreira-Filho et al. (1973), Cecy, Valente-Moreira, and Hohmann (1976), Lozovei and Luz (1976), Moreira-Filho, Cecy, and Valente-Moreira (1976), Lozovei and Hohmann (1977), Stankiewicz (1980), Contin (1983), Caetano (1984), Cecy (1986), Shirata (1986), Ludwig (1987), Contin (1990), Lozovei and Shirata (1990), Moreira (1990), Moro (1991), Rodrigues (1991), Train (1991), Moro and Fürsternberg (1993), Moro et al. (1994), Tavares (1994), Momoli (1997), Brassac (1999), Leandrini (1999), Atab (2000), Tavares and Valente-Moreira (2000), Rodrigues and Bicudo (2001), Szawka (2001), Bittencourt-Oliveira (2002), Borges, Rodrigues, Pagioro, and Train (2003), Cetto et al. (2004), Ferrari (2004), Train and Rodrigues (2004), Bigunas (2005), Felisberto and Rodrigues (2005), Ludwig, Bigunas, Neiva, Coquemala, and Piccinini (2005), Neiva (2005), Piccinini (2005), Rodrigues et al. (2005), Costin (2007), Santos (2007), Silva et al. (2007), Borges, Train, and Rodrigues (2008), Pavan (2008), Tremarin et al. (2009a and b), Bertolli et al. (2010), Bertolli (2010), Marquardt et al. (2010), Faria (2010), Silva et al. (2010), Fontana and Bicudo (2012), Pires (2013), Marra (2015)
<i>G. parvulum</i> (Kützing) Kützing	Moreira (1990), Brassac (1999), Leandrini (1999), Atab (2000), Ferrari (2004), Bigunas (2005), Piccinini (2005), Costin (2007), Santos (2007), Silva et al. (2007), Pavan (2008), Bertolli et al. (2010), Bertolli (2010), Faria (2010), Moresco et al. (2011), Silva et al. (2010), Marra (2015)
<i>G. pumilum</i> Grunow Reichardt & Lange-Bertalot	Tremarin et al. (2009a and b)
<i>G. salae</i> Lange-Bertalot & Reichardt	Faria (2010)
<i>G. sphaerophorum</i> Ehrenberg	Train (1990), Moro and Fürsternberg (1993), Tavares (1994), Brassac (1999), Tavares and Valente-Moreira (2000), Rodrigues and Bicudo (2001), Ferrari (2004), Train and Rodrigues (2004), Aquino and Tavares (2006), Santos (2007), Silva et al. (2007), Pavan (2008), Marquardt et al. (2010), Fontana and Bicudo (2012), Marra (2015)
<i>G. subtile</i> Ehrenberg	Tremarin et al. (2009a and b)
<i>G. turris</i> var. <i>coarctata</i> (Frenguelli) Frenguelli	Tremarin et al. (2009a and b)

Theses and dissertations were included, since they register the species and this information was not published in scientific article.

### Identification key for *Gomphonema* species and varieties included the following observations:

1. Presence of stigma ..... 2
1. Absence of stigma ..... *Gomphonema brasiliense*
2. Inconspicuous areolation ..... 3
2. Conspicuous areolation ..... 4
3. Valvelength 35 µm or longer ..... 5
3. Valvelength 26 µm or shorter ..... 6
4. Valve width 10.5 µm or lower ..... 9
4. Valve width 12.5 µm or higher ..... 10
5. Valves slightly lanceolate ..... *Gomphonema affine* var. *affine*
5. Valves clavate ..... *Gomphonema salae*
6. Valves lanceolatetoelliptic-lanceolate ..... 7
6. Other valve shapes ..... 8
7. Apices subcapitate to subrostrate; bases subcapitate ..... *Gomphonema lagenula*
7. Apices subrostrate; bases attenuate-rounded ..... *Gomphonema parvulum*
8. Central area unilateral formed by a shortened median stria .....  
..... *Gomphonema angustatum*
8. Central area rounded ..... *Gomphonema pumilum*
9. Number of striae in 10 µm 13 or fewer ..... 10
9. Number of striae in 10 µm 14 or more ..... *Gomphonema latcollum*
10. Axial area linear ..... 11
10. Axial area slightly undulate ..... *Gomphonema neonasutum*
11. Valves thin and narrow, lanceolate, with expanded center .....  
..... *Gomphonema subtile*
11. Other valve shapes ..... 12
12. Raphe sternum wide ..... *Gomphonema costei*
12. Raphe sternum narrow ..... 13
13. Raphe filiform ..... *Gomphonema sphaerophorum*
13. Raphe slightly sinuous ..... 14
14. Valvelength longer than 54 µm ..... *Gomphonema turris* var. *coarctata*
14. Valvelength shorter than 35 µm ..... *Gomphonema mexicanum*

*Gomphonema affine* var. *affine* Kützing, Bacill. Nordhausen. p. 86, pl. 30, fig. 54, 1844 (Figure 2/ 1-19).

Valves slightly heteropolar, lanceolate, with apices rounded and bases attenuate-rounded. Raphe sternum

narrow and linear. Raphe lightly sinuous with proximal ends slightly bent towards the stigma. Central area is asymmetrical, expanding until the valve margin is on one side of the valve due to the wider spacing of the median striae. Stigma located close to the median stria. Striae straight to radiate, with one shortened stria on one side of the central nodule. Areola inconspicuous. Length: 35.8-51.7 µm; width: 7.6-10.5 µm; 9-13 striae in 10 µm.

*Gomphonema affine* is similar to *Gomphonema amoenum* Lange-Bertalot in its dimensions and valve outline. However, *G. amoenum* presents subrostrate apices and more radiate striae (Reichardt, 1999). The results of the analyzed population are in agreement with the morphometric data (length 36-88 µm, width 9-13.6 µm, 8-11 striae in 10 µm) of the tropical species material analyzed by Reichardt (1999).

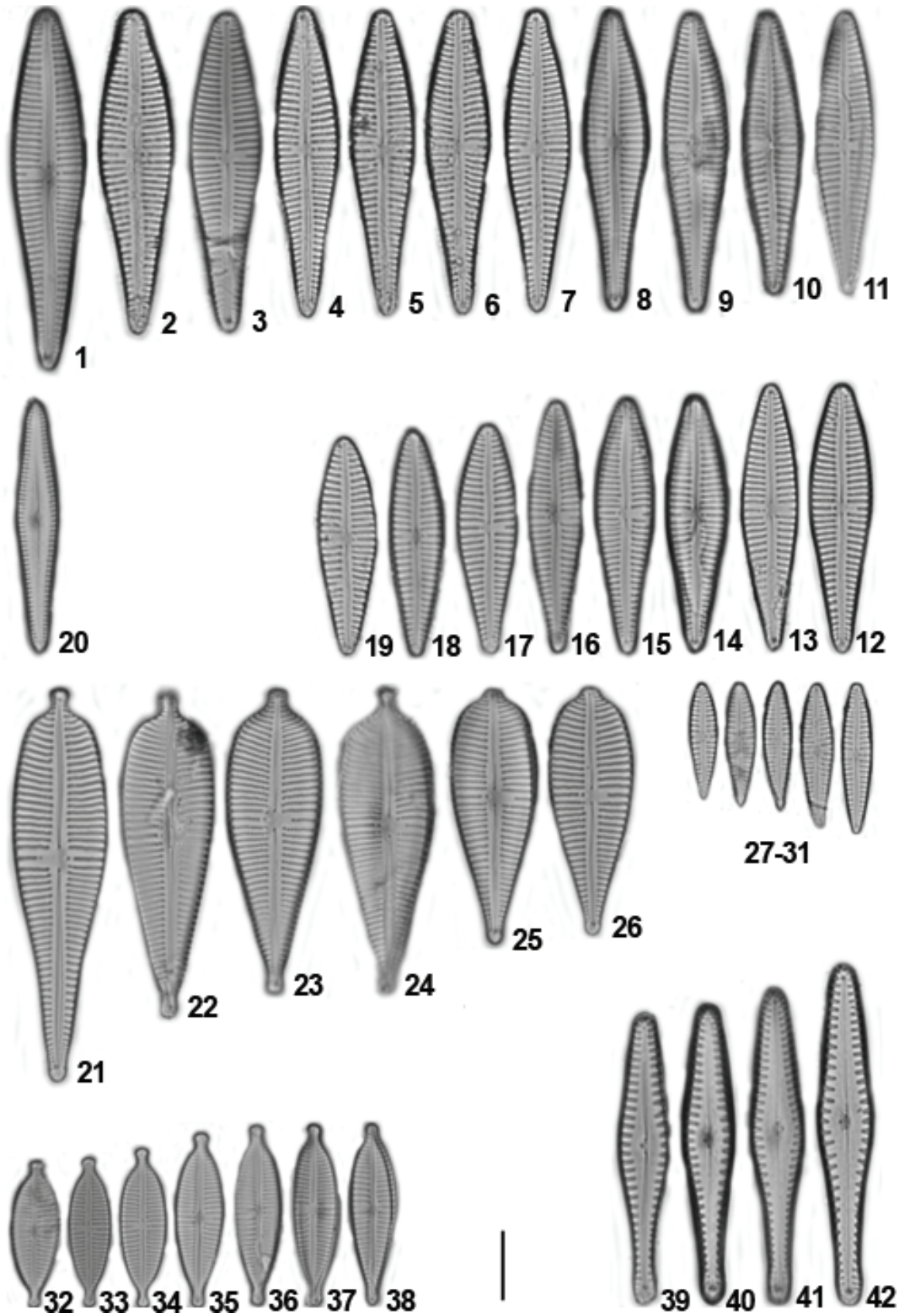
Occurrence in samples: Huem-24354, 24355, 24356 collected on June 15<sup>th</sup>, 2013; Huem-24357, collected on August 30<sup>th</sup>, 2013.

*Gomphonema angustatum* (Kützing) Rabenhorst, Fl. Eur. Alg. I, p. 283, 1864.

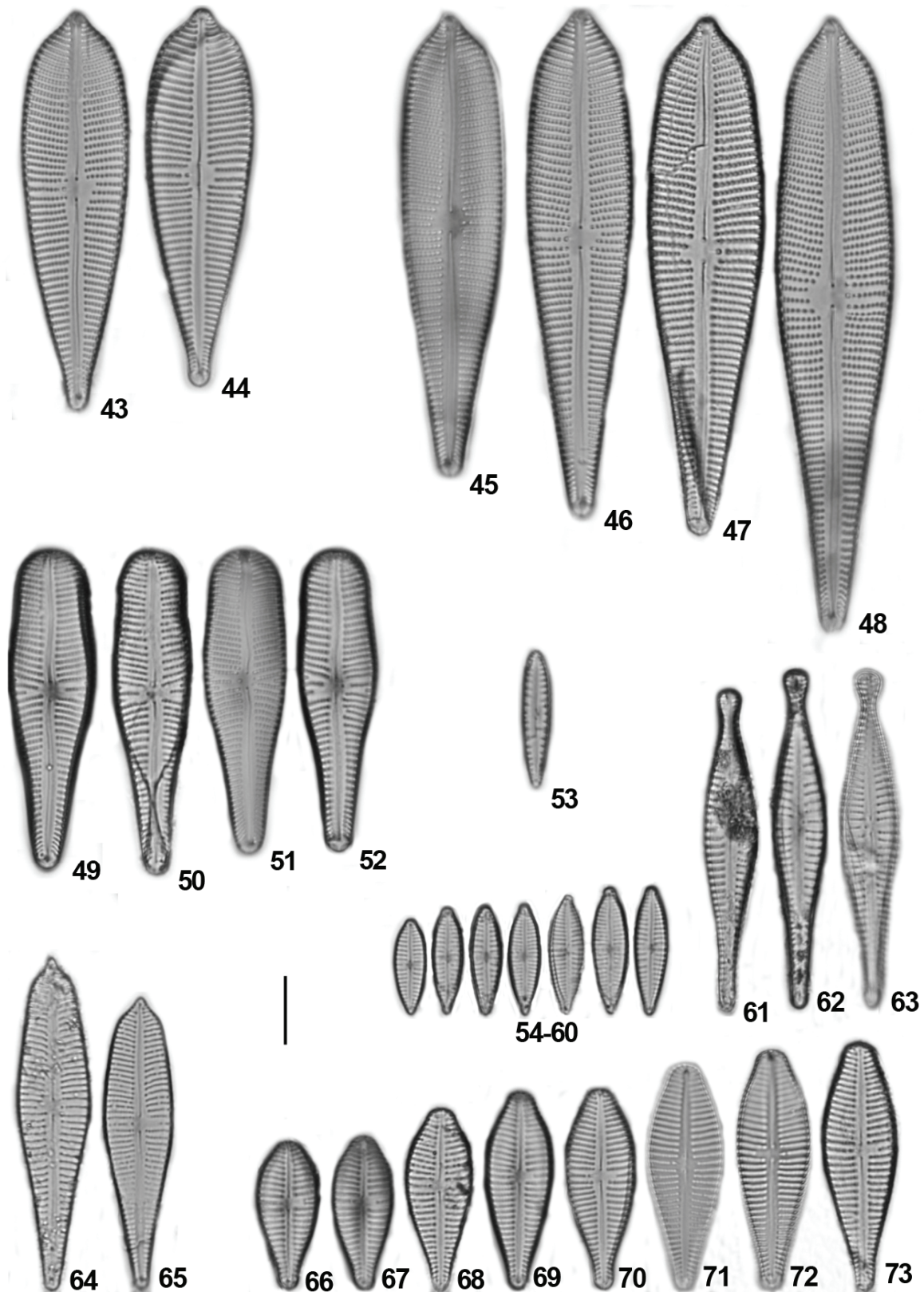
Basionym: *Sphenella angustata* Kützing, Kies. Bacill. Diat., p. 83, pl. 8, fig. 4, 1844 (Figure 2/ 27-31).

Valves heteropolar, narrow ly clavate-lanceolate, with apices subrostrate and bases attenuate. Raphe sternum linear and narrow. Raphe straight or slightly sinuous, with proximal ends slightly bent towards the stigma. Central area unilateral formed by a shortened median stria. Stigma located close to the median stria. Striae straight, slightly radiate at the ends and with wider spacing at the median region of the valve. Areolae inconspicuous. Length: 16.4-21.1 µm; width: 3.5-4.7 µm; 11-15 striae in 10 µm.





**Figure 2.** 1-19: *Gomphonema affine* var. *affine*. 20: *Gomphonema brasiliense*. 21-26: *Gomphonema sphaerophorum*. 27-31: *Gomphonema angustatum*. 32-38: *Gomphonema lagenula*. 39-42: *Gomphonema costei*. Scale: 10  $\mu$ m.



**Figure 3.** *Gomphonema turris* var. *coarctata*. 45-48: *Gomphonema neonasutum*. 49-52: *Gomphonema laticollum*. 53: *Gomphonema pumilum*. 54-60: *Gomphonema parvulum*. 61-63: *Gomphonema subtile*. 64-65: *Gomphonema salac*. 66-73: *Gomphonema mexicanum*. Scale: 10  $\mu$ m.

This species was found in others studies conducted in the state of Paraná. In Tremarin et al. (2009a), this species was found in the macrophyte *Potamogeton polygonus* and the individuals were larger than observed in our study.

Occurrence in samples: Huem-24354, 24355, 24356 collected on June 15<sup>th</sup>, 2013; Huem-24361, collected on November 29<sup>th</sup>, 2013.

*Gomphonema brasiliense* Grunow in Schneider, Naturw. Beitr. Kenntn. Kauk., p. 110, 1878 (Figure 2/ 20).

Valves slightly heteropolar, lanceolate, with apices cuneate-rounded and bases narrowly rounded. Raphe sternum wide and lanceolate. Rapses lightly sinuous with proxima lends bent towards the stigma. Central area rounded. Stigma absent. Striae short, straight toradiate along the length of the valve. Areolae inconspicuous. Length: 36.4 µm; width: 6.4 µm; 15 striae in 10 µm.

*Gomphonema brasiliense* ssp. *pacificum* Moser, Lange-Bertalot and Metzeltin can be differentiated from *Gomphonema brasiliense* by its narrower valves (3.6-5.2 µm) (Moser, Lange-Bertalot, & Metzeltin, 1998).

Occurrence in samples: Huem-24354, collected on June 15<sup>th</sup>, 2013; Huem-24363, collected on February 18<sup>th</sup>, 2014.

*Gomphonema costei* Metzeltin and Lange-Bertalot in Lange-Bertalot, Iconogr. Diatomol. 5: 115, pl. 154, fig. 7-12, 1998 (Figure 2/ 39-42).

Valves heteropolar, lanceolate, slightly swollen at the median region, with rounded apices and bases. Raphe sternum lanceolate. Raphe sinuous with proxima lends bent towards the stigma. Stigma rounded located close to the central nodule. Striae straight toradiate at the ends, coarse and shortened long the full length of the valve. Areolae conspicuous, difficult to observe. Length: 41.7-48.8 µm; width: 7.0-8.2 µm; 9-10 striae in 10 µm.

*Gomphonema costei* and *Gomphonema evexus* Hohn has very similar valve outline as well as identical dimensions and density of striae, suggesting that the species may be synonymized in the future (Patrick et al., 1966).

Occurrence in samples: Huem-24354, 24355, 24356 collected on June 15<sup>th</sup>, 2013; Huem-24357, collected on August 30<sup>th</sup>, 2013; Huem-24360, collected on November 29<sup>th</sup>, 2013; Huem-24365, collected on February 18<sup>th</sup>, 2014.

*Gomphonema lagenula* Kützing, Kies. Bacill. Diat., p. 85, pl. 30, fig. 60, 1844 (Figure 2/ 32-38).

Valves heteropolar, lanceolate to elliptic-lanceolate, with apices subcapitate to subrostrate and bases subcapitate. Raphe sternum narrow and linear.

Raphe straight with proxima lends bent towards the stigma. Central area unilaterally expanded, delimited by shortened median striae. Stigma located at the end of the median stria. Striae uniseriate, straight to slightly radiate, with central striae more widely spaced than the others. Areola inconspicuous. Length: 21.1-25.8 µm; width: 5.8-6.4 µm; 14-16 striae in 10 µm.

Occurrence in samples: Huem-24354, 24355, 24356 collected on June 15<sup>th</sup>, 2013; Huem-24357, 24358, 24359 collected on August 30<sup>th</sup>, 2013; Huem-24360, 24361, 24362, collected on November 29<sup>th</sup>, 2013; HUEM-24363, 24364, 24365, collected on February 18<sup>th</sup>, 2014.

*Gomphonema laticollum* Reichardt (2001) in Jahn et al., Studies on Diatoms, p. 199, pl. 5, fig. 1-14, 2001 (Figure 3/ 49-52).

Valves clavate, swollen at the median region and with little pronounced constriction between the median region and the apex. Apices widely rounded and bases attenuate-rounded. Raphe sternum narrow and linear. Raphe sinuous with proxima lends dilated in a pore shape, bent towards the stigma. Central area irregular delimited by shortened median striae. Stigma present. Striae uniseriate and radiate, formed by conspicuous areolae. Length: 21.1-25.8 µm; width: 5.8-6.4 µm; 14-16 striae in 10 µm.

Reichardt (2001) reviewed the species *Gomphonema truncatum* Ehrenberg and proposed *G. laticollum* Reichardt because it presents striae less pronounced constriction close to the valve apices.

Occurrence in samples: Huem-24354, 24355, 24356 collected on June 15<sup>th</sup>, 2013; Huem-24357, collected on August 30<sup>th</sup>, 2013.

*Gomphonema mexicanum* Grunow in Van Heurck, Syn. Diat. Belg., pl. 24; fig. 3, 1880. (Figure 3/ 66-73).

Valves heteropolar, lanceolate, with apices broadly rostrate and bases attenuate-rounded to subcapitate. Raphe sternum narrow and linear. Raphe weakly undulate, with proxima lends dilated in a pore shape. Central area unilaterally expanded, delimited by a shortened median stria. Stigma punctiform located close to the median stria. Striae straight to radiate close to the valve ends. Areola conspicuous, difficult to observe. Length: 20-34.7 µm; width: 8.8-10.5 µm; 12-13 striae in 10 µm.

*Gomphonema mexicanum* is very similar to *G. affinopsis* Metzeltin, Lange-Bertalot and García-Rodríguez, differentiated by the punctiform shape of the stigma, whereas in *G. affinopsis*, the stigma is elongated (Metzeltin & Lange-Bertalot, 1998).



Occurrence in samples: Huem-24354, collected on June 15<sup>th</sup>, 2013; Huem-24357, collected on August 30<sup>th</sup>, 2013.

*Gomphonema neonasutum* Lange-Bertalot and Reichardt in Lange-Bertalot, Iconogr. Diatomol. 5: 121, pl. 156, figs. 1-4, 1998 (Figure 3/ 45-48).

Valves heteropolar, lanceolate, slightly swollen at the median region, with apices cuneate-apiculate to cuneate-subrostrate and bases attenuate-rounded. Raphe sternum narrow and linear. Raphe sinuous with proxima lends dilated in a pore shape, bent towards the stigma. Central area irregular delimited by shortened median striae. Stigma located close to the median stria. Striae uniseriate, radiate. Areola conspicuous. Length: 67-89.4  $\mu\text{m}$ ; width: 14.7-17  $\mu\text{m}$ ; 9-10 striae in 10  $\mu\text{m}$ .

*Gomphonema neonasutum* is similar to *G. turris* in valve morphology and size but differs in the apiculate shape of the apices (Metzeltin & Lange-Bertalot, 1998).

Occurrence at the samples: Huem-24354, collected on June 15<sup>th</sup>, 2013; Huem-24357, 24358, collected on August 30<sup>th</sup>, 2013; Huem- 24361, 24362, collected on November 29<sup>th</sup>, 2013; Huem-24363, collected on February 18<sup>th</sup>, 2014.

*Gomphonema parvulum* (Kützing) Kützing, Spec. Alg., p. 65, 1849. Basionym: *Sphenella parvula* Kützing, Kies. Bacill. Diat., p. 83, pl. 30, fig. 63, 1844 (Figure 3).

Valves heteropolar, lanceolate to elliptic-lanceolate, with apices subrostrate and bases attenuate-rounded. Raphe sternum linear, narrow. Raphe straight to slightly sinuous with proxima lends bent towards the stigma. Central area irregular and narrow, delimited by a shortened median stria. Stigma present. Striae uniseriate, straight to slightly radiate at the ends. Areola inconspicuous. Length: 14.1-19.4  $\mu\text{m}$ ; width: 4.7  $\mu\text{m}$ ; 14-17 striae in 10  $\mu\text{m}$ .

*Gomphonema micropus* Kützing is morphologically similar to *Gomphonema parvulum* var. *parvulum*. However, the two species can be differentiated according to their differently organized apices and striae (Krammer & Lange-Bertalot, 1986, Reichardt, 1999). *Gomphonema micropus* also differs by being longer (19-44  $\mu\text{m}$ ) and wider (6.3-9  $\mu\text{m}$ ), and by its lower density of striae (11-14 in 10  $\mu\text{m}$ ) (Reichardt, 1999).

Occurrence in samples: Huem-24355, 24356, collected on June 15<sup>th</sup>, 2013; Huem-24357, collected on August 30<sup>th</sup>, 2013; Huem- 24361, 24362, collected on November 29<sup>th</sup>, 2013.

*Gomphonema pumilum* (Grunow) Reichardt and Lange-Bertalot, Nova Hedwigia 53(3-4): 528, pl. 6, figs. 4-11, 1991.

Basionym: *Gomphonema intricatum* Kützing var. *pumila* Grunow in Van Heurck, Syn. Diat. Belg., pl.24, figs. 35-36, 1880 (Figure 3/ 53).

Valves clavate, with apices rounded and bases attenuate. Raphe sternum linear, narrow. Raphe filiform with proxima lends dilated in a pore shape, bent towards the stigma. Central area rounded. Stigma present. Striae straight to radiate. Areola inconspicuous. Length: 19.4  $\mu\text{m}$ ; width: 4.1  $\mu\text{m}$ ; 10 striae in 10  $\mu\text{m}$ .

Occurrence in samples: Huem-24354, 24355, 24356, collected on June 15<sup>th</sup>, 2013; Huem-24357, 24359, collected on August 30<sup>th</sup>, 2013; Huem-24360, 24361, 24362, collected on November 29<sup>th</sup>, 2013; Huem-24363, 24364, 24365, collected on February 18<sup>th</sup>, 2013.

*Gomphonema salae* Lange-Bertalot and Reichardt in Lange-Bertalot, Iconogr. Diatomol. 5: 548, pl. 157, figs. 3-5, 1998 (Figure 3/ 64-65).

Valves clavate, swollen at the median region and with slightly pronounced constriction between the median region and the apex. Apices cuneate-subrostrate and bases attenuate-rounded. Raphe sternum slightly linear, narrow. Raphe weakly sinuous with proxima lends bent towards the stigma. Central area unilateral, delimited by a shortened median stria. Stigma located close to the median stria. Striae uniseriate, straight to radiate close to the apices, with wider spacing at the median region. Areola inconspicuous. Length: 42.3-48.2  $\mu\text{m}$ ; width: 10-10.5  $\mu\text{m}$ ; 12-13 striae in 10  $\mu\text{m}$ .

*Gomphonema neonasutum* differs from *G. salae* in size, and the apiculate shape of the apices. Furthermore, the number of striae in *G. salae* is greater than in *G. neonasutum* and *G. turris* (Metzeltin & Lange-Bertalot, 1998).

Occurrence in samples: Huem-24354, 24356, collected on June 15<sup>th</sup>, 2013.

*Gomphonema sphaerophorum* Ehrenberg, Ber. Bek. Verh. Königl. Preuss. Akad. Wiss. Berl., p. 78, 1845 (Figure 2/ 21-26).

Valves heteropolar, lanceolate, with apices rostrate-capitate to subrostrate and bases capitate to subcapitate. Raphe sternum linear and narrow. Raphe filiform with proximal ends simple and rounded. Central area unilateral formed by a shortened median stria. Stigma located close to the median stria. Striae slightly radiate. Areolae rounded. Length: 43.5-56.4  $\mu\text{m}$ ; width: 12.9-13.5  $\mu\text{m}$ ; 9-12 striae in 10  $\mu\text{m}$ .

Occurrence in samples: Huem-24354, 24355, 24356 collected on June 15<sup>th</sup>, 2013; Huem-24363, 24364, 24365, collected on February 18<sup>th</sup>, 2014.

*Gomphonema subtile* Ehrenberg, Abh. Königl. Akad. Wiss. Berl. 1841: 416, 1843 (Figure 3/ 61-63).

Valves heteropolar, lanceolate, with apices capitate and bases rounded. Raphe sternum narrow, linear. Raphe straight with proximal end dilated in a pore shape. Central area unilateral formed by a shortened median stria. Stigma located close to the median stria. Areolae conspicuous but difficult to observe. Length: 46.4-49.4  $\mu\text{m}$ ; width: 7.6-8.2  $\mu\text{m}$ ; 9-10 striae in 10  $\mu\text{m}$ .

Occurrence in samples: Huem-24354, collected on June 15<sup>th</sup>, 2013; Huem-24360, collected on November 29<sup>th</sup>, 2013; Huem-24363, 24365, collected on February 18<sup>th</sup>, 2014.

*Gomphonema turris* var. *coarctata* (Frenguelli) Frenguelli, Rev. Mus. La Plata, Sec. Bot. 3: 275, 1941.

Basionym: *Gomphonema turris* f. *coarctata* Frenguelli, An. Mus. Nac. Hist. Nat. 4: 423, pl. 4, figs. 35-36, 1933 (Figure 3/ 43-44).

Valves clavate, lanceolate, with apices cuneate-subrostrate and bases attenuate-rounded. Raphe sternum linear, narrow. Raphe slightly sinuous with proximal ends dilated in a pore shape and bent towards the stigma. Central area elliptic or asymmetric, delimited by irregular shortening of the median striae. Stigma located close to the median stria. Striae uniseriate, straight to radiate near the ends. Areolae conspicuous. Length: 54.7-58.2  $\mu\text{m}$ ; width: 15.2-15.8  $\mu\text{m}$ ; 10 striae in 10  $\mu\text{m}$ ; 18-22 areolae in 10  $\mu\text{m}$ .

Occurrence in samples: Huem-24354, 24356 collected on June 15<sup>th</sup>, 2013.

In this study, only *Gomphonema neonasutum* is the first record to the state of Paraná (Table 1). The species that have been widely distributed was *G. lagenula* and *G. parvulum*. Only *Gomphonema lagenula* Kützing, a species with cosmopolitan distribution, occurred in all sampling sites and in all months.

The Ipoitã Channel is influenced hydrologically by Paraná and Ivinhema rivers. The sampling site 3, located close to the Ivinhema River, was the most species-rich area (Table 2). This can be explained by the characteristics of the Ivinhema River, which has natural hydrodynamics, and because it is located in a protected area where there is still marginal vegetation and many flood areas (Souza Filho & Stevaux, 1997).

The lowest number of taxa occurred in the sampling site 1, at the connection with the Paraná River (Table 2). Paraná River is strongly impacted by dams and has higher water transparency and lower nutrient concentrations (Agostinho et al., 2008, Roberto, Santana, & Thomaz, 2009). The differences between these rivers may help to explain the distribution of species in the floodplain, and even the success of some species in certain

habitats. Fluctuations in the water level of the Ivinhema River are independent from levels in the Paraná River (Souza Filho, Comunello, & Rocha, 2005), and this pattern also contributes to increase habitat heterogeneity among different riverine habitats in the floodplain (Roberto et al., 2009), elevating the biodiversity in this area. Higher periphyton biomasses, for example, are usually found in the Ivinhema River, which carries more phosphate than the Paraná River (Leandrini, Fonseca, & Rodrigues, 2008).

## Conclusion

The present study contributes to the knowledge regarding diatom biodiversity in this region, and it provides support to future ecological and biomonitoring studies in the Upper Paraná River Floodplain. The results emphasize the lack of taxonomic studies for the region and the importance thereof to the knowledge of biodiversity.

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