**Nupela (Bacillariophyceae) in littoral rivers from south Brazil, and description of six new species of the genus**

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**Abstract:** The genus *Nupela* is characterized mainly by structure of the areola and raphe system. Many species were described from tropical regions; however, few studies have been conducted on Brazilian environments. The goal of this article is to identify and describe the morphology of *Nupela* species, under light and electron microscopy. A total of 12 species were identified, including six described as new: *Nupela amabilis* TREMARIN et T. LUDWIG, *N. difficilis* STRAUBE, TREMARIN et T. LUDWIG, *N. kocioleckii* TREMARIN et T. LUDWIG, *N. metzeltinii* TREMARIN et T. LUDWIG, *N. praecipuoides* TREMARIN et T. LUDWIG and *N. torganiae* TREMARIN et T. LUDWIG, and a new combination, *N. bicapitata* (Hustedt) TREMARIN et T. LUDWIG.

**Key words:** Atlantic Forest, diatom, freshwater, lotic, taxonomy, ultrastructure

**INTRODUCTION**

**VYVERMANN & COMPÈRE (1991)** established the genus *Nupela* based on *Nupela giluwensis* described as new to Papua New Guinea. *Nupela* comprises small freshwater diatoms with finely ornamented valves, difficult to resolve only by light microscopy. The areola with external opening covered by hymenes is larger than the internal aperture and is pointed as a areola with external opening covered by hymenes is difficult to resolve only by light microscopy. The areola with external opening covered by hymenes is larger than the internal aperture and is pointed as a very stable taxonomic and typical character (LANGE et al. 2007, 2010; KULIKOVSKY et al. 2009). The external proximal ends of raphe usually are slightly expanded and internally somewhat curved or T–shaped (SPAULDING & EDLUND 2008).

The genus *Nupela* has been expanded in the last decade including heterovalvar species beyond the isovallvar forms based on the type material, referring to the degree of raphe development in both valve faces of the frustule. The raphe may be fully developed on both valves or fully developed on one valve and lacks or shortened on the other valve (MONNIER et al. 2003; POTAPAPOVA et al. 2003; SIVER & HAMILTON 2005; SIVER et al. 2007). Light microscopy is often insufficient for identification (POTAPAPOVA et al. 2003). Distinctive valve features are generally only observed by electron microscopy.


This paper aims to expand knowledge about the taxonomy of *Nupela* species based on samples collected in rheophilic environments from Brazilian Atlantic Forest, and well document the morphology of the taxa under light and electron microscopy.

**MATERIAL AND METHODS**

Diatom samples were collected from fifteen rivers along the littoral basin of State of Paraná, located in the Atlantic Forest, Southern Brazil (Table 1). The headwaters of the selected rivers are located in the mountainous region or in
the plain, flowing toward the Atlantic Ocean. The upper courses, located at the Serra do Mar, have rapid and clear waters (São João, Mãe Catira, Colônia Pereira, Nhundiaquara, Nunes, Ipomoea, Caturité, Cachoeira, Nhanduquara, Serra do Salto and Colônia Pereira rivers). The lower courses are humic stained, and the rate of current is reduced (Guaraguá, Serticinho, do Onça, das Pombas, Cambará, do Salto and Colônia Pereira rivers) (Sarletta et al. 2001).

The samples were collected and fixed with TRANSEAU solution (1:1) (Sarletta et al. 1990), rinsed and mounted in Naphrax® (R.I. = 1.74). Samples and slides are stored at the Herbarium of Universidade Federal do Paraná (UPCB) and at the Academy of Natural Sciences of Philadelphia (ANSF). Illustrations were performed using an optical microscope Olympus BX40 equipped with Olympus DP71 digital camera. Cleaned samples were prepared and analysed at scanning electron microscopy–SEM (JEM JSM 6360LV and TESCAN VEGA3 LMU, 15 kV voltage and 8 mm working distance) and at transmission electron microscope–TEM (JEM microscope 1200EXII, voltage 80 kV), housed at the Electron Microscopical Center of Universidade Federal do Paraná. Abiotic variables (pH, electrical conductivity and water temperature) were measured using a Consort C535 equipment (Table 1). The terminology used in the descriptions followed Reis et al. (1990), Hendey (1964) and Poisson (2003).

RESULTS AND DISCUSSION

Nupela amabilis Tremaén et T. Ludwig sp. nov. (Figs 1–12)
Description: Frustules isovalvar, slightly asymmetric about apical plane. Valves linear-lanceolate with subapertural apices, 11.5–12.2 µm long and 4.1–4.4 µm wide. Axial area linear. Central area asymmetric, reaching the margin on one side of valve, and limited by one or three areolae on the other side. Raphe slightly sinusous and complete on both valves. Proximal raphe externally expanded and internally hook-like. Terminal raphe ends curved to same side of the valve and externally ending in a small helictoglossa. Striae slightly radiate, ca. 44 in 10 µm.

Taxonomical remarks: The isovalvarity is not a common feature in the genus, only detected in some species, as N. gilberti Hendey, N. mutabilis Siver, Wolk et Edlund, N. postgigantea Biscaro, N. subinvicta (Krašké) Lange–Bertalot, N. tristis (Krašké) Lange–Bertalot, N. vitiosa (Schmid) et al. Hamilton, and for N. amabilis (Lange–Bertalot et al. 1996; Siver & Hamilton 2005; Siver et al. 2010; Balslev 2011). Among them, not only N. mutabilis has valve outline similar to N. amabilis, but differs in the rostrate apices and the T-shaped internal proximal raphe ends (Siver et al. 2010).

Nupela amabilis differs from most species of genus by the internal proximal raphe ends strongly curved in hook. Similar raphe was also described to N. vitiosa. N. epidotica (Krašké) Lange–Bertalot, N. neotropica (Hustedt) Lange–Bertalot, N. tenuicelphala (Hustedt) Lange–Bertalot, N. acaciensis Voigt et al. and N. catanambensis Voigt et al. and Siver & Hamilton 2005; Wogal 2009; Siver et al. 2014). Despite raphe ends coincidence among mentioned species, isovalvar feature is found only in N. acaciensis (Sala et al. 2014). The latter is distinguished from N. amabilis by lanceolate valve outline, cymbelloid symmetry, smaller central area and more elongated apices. Nupela styggermanni Lange–Bertalot illustrated by Wogal et al. 2004) has linear–lanceolate valve outline similar to Nupela amabilis, but has heterovalvar frustules with round central area, and its internal proximal ends of raphe are straight (Wogal & Lange–Bertalot 2004).

Thus, the proposition of Nupela amabilis is justified by a unique set of characters, mainly consisting of isovalvarity, linear-lanceolate valve outline and hook-shaped internal proximal raphe ends.

Nupela bicapitata (Hustedt) Tremaén et T. Ludwig comb. nov. (Figs 13–22)
Description: Frustules heterovalvar, slightly asymmetric about apical plane and transapically and slanting planes. Valves lanceolate with capitae apices, 19.2–22.9 µm long and 5.5–6.6 µm wide. Axial area lanceolate. Central area asymmetric, unilaterally expanded until the margin of the valve. Raphe slightly sinusous. One valve slightly convex, with long raphe slits. The other valve, slightly concave, with very short raphe slits, restricted to the apices, widely separated proximal endings, and with a linear depression along the axial area that resembles a raphe on LM. Proximal raphe ends externally simple. Terminal raphe ends curved to same side of the valve. Striae slightly radiate becoming convergent towards apices, ca. 44 in 10 µm.

Taxonomical remarks: Based on LM microscopy, the Brazilian material is exactly coincident to Achnanthes
Nupela decipiens (Reimer) Potapova (Figs 23–42)

**Basionym:** Achnanthes decipiens Ruzin, Notulae Phycologicae, p. 2, pl.1, figs 2–3, 1966.

**Description:** Frustules heterovalvar, slightly asymmetric about apical plane. Valves lanceolate with narrowly rostrate to subrostrate apices, 8.9–18.5 µm long and 4.1–5.9 µm wide. One valve with long raphe slits and the other valve araphid. Raphe valve with axial area lanceolate, central area widely rounded. Proximal raphe ends externally expanded and internally simple. Terminal raphe ends curved to same side of the valve and internally ending in a small helictoglossa. Araphid valve with axial area widely lanceolate, externally ornamented by several irregular depressions and a longitudinal one that resembles a raphe in LM, internally with slits occluded near the apices. Central area widely lanceolate, not reaching the valvar margin. Transapical striae radiate, 36–40 in 10 µm, composed of openings of areolae small, round to oval. Transapical striae straight to slightly radiate, 38–40 in 10 µm, composed by discontinuous lines of areolae, ca. 50 in 10 µm. Inner openings of areolae small–round, oval.

**Taxonomical remarks:** The morphometric variation of *N. decipiens* in the Brazilian specimens agrees with that given by Potapova (2013) to USA. This register from Guanabara bay is the first record of the taxon to South America.

Nupela difficilis Straube, Tremarin et T. Ludwig sp. nov. (Figs 43–54)

**Description:** Frustules heterovalvar, slightly asymmetric about apical plane. Valves lanceolate with subrostrate apices, 8.8–14.8 µm long and 4.1–5.5 µm wide. Axial area lanceolate. Central area asymmetric, unilaterally reaching the valve margin. Raphe on both valves. One valve with long raphe slits. The other valve with shorter raphe slits and separated proximal endings. Proximal raphe ends internally simple. Terminal raphe ending in a small helictoglossa. Transapical striae slightly radiate, 40 in 10 µm, composed by continuous lines of areolae, 48–50 in 10 µm. Inner openings of areolae small–round.

**Holotype:** Slide UPCB 72984, Diatom collection of the Botany Department, Universidade Federal do Paraná, illustrated here in Figs 48–49.

**Isotype:** ANSP GC26823

**Type material:** Do Nunes river, Antonina, State of Paraná, Brazil, 25°20′43.2″S, 48°46′14.0″W, December 2011.

**Taxonomical remarks:** *Nupela difficilis* is similar to *N. decipiens* in valve dimensions, shape of apices and raphe ends, but the latter differs by the monoraphid frustule and central area shape (Potapova 2013). *Nupela vyvermanii* described and illustrated by Lange-Bertalot in Moser et al. (1998) differs of *N. difficilis* by the smaller central area and lower density of striae (32 in 10 µm), besides convergent striae at the apices (Ververman & Lange-Bertalot 2004, pl. 25, figs 3–6). *Nupela cf. vyvermanii* Lange-Bertalot found by Aizenštig & Lange-Bertalot (2013, figs 65, 66) from Sierra Leone resembles *N. difficilis* in the valve size (length 14–15 µm and width 4.5–5 µm) and apices shape, distinguishing by the lower number of striae (ca. 30 in 10 µm) and central area not reaching to valve margin. *Nupela difficilis* is mainly characterized by the valve outline, apices and central area contour, also by the straight proximal raphe ends in the inside valve.

Nupela amabilis Tremarin et T. Ludwig, LM (1–8) and SEM (9–12). (4–6) Holotype; (9) Detail of central region of valve in external view; (10) Overview of valves in external and internal view; (11) Distal end of raphe in internal view (12). Proximal ends of raphe in internal view. Scale bars 10 µm (1–8); 2 um (9), 1 µm (10–12).

**Nupela kociolekii Straube, Tremarin et T. Ludwig sp. nov.** (Figs 66–83)

**Description:** Frustules heterovalvar, slightly asymmetric about apical plane. Valves elliptical– lanceolate with rounded to subrostrate apices, 10.4–15.2 µm long and 4.4–5.2 µm wide. Axial area straight and narrow. Central area reduced. Raphe on both valves, slightly sinuous. Raphe slits well developed along one valve and shortened at the other. Proximal raphe ends externally expanded and internally simple. Terminal raphe ends curved to same side of the valve and internally ending in a small helictoglossa. Transapical striae straight to slightly radiate, 38–40 in 10 µm, composed by discontinuous lines of areolae, ca. 23 in 10 µm. Outer openings of areolae transapically elongate and inner openings small, round to oval.

**Taxonomical remarks:** The exemplars of *N. esoxica* analyzed in the Brazilian samples were wider than those recorded by Monnier et al. (2003, width 3.0–4.1 µm), however other frustule features were identical to the type material. The irregular striation pattern of *N. esoxica* resembles that of *N. pardinhoensis*, a recently species described to Southern Brazil. *Nupela pardinhoensis* differs to *N. esoxica* mainly by the shortened raphe slits on one valve and more separated proximal endings (Monnier et al. 2003, Bres et al. 2012). In Brazil, this species was cited by Tremarin et al. (2009).

**Holotype:** Slide UPCB 72984, Diatom collection of the Botany Department, Universidade Federal do Paraná, illustrated here in Figs 66–67.

**Isotype:** ANSP GC26823

**Type material:** Do Nunes river, Antonina, State of Paraná, Brazil, 25°20′43.2″S, 48°46′14.0″W, December 2011.

**Taxonomical remarks:** *Nupela kociolekii* is more closely related to *N. difficilis* with respect to the degree of development of the raphe and by the shape of apices. Although both species have occurred in the same samples, these can be differentiated by the proximal raphe ends, and number of striae. The striae of *N. kociolekii* are almost incomprehensive in LM because of its denser arrangement (40 in 10 µm), furthermore the internal proximal raphe ends are straight.

Etyymology: This species is dedicated to Dr. Patrick Kociolek, University of Colorado.

**Holotype:** Slide UPCB 72984, Diatom collection of the Botany Department, Universidade Federal do Paraná, illustrated here in Figs 66–67.

**Isotype:** ANSP GC26823.

**Type material:** Do Nunes river, Antonina, State of Paraná, Brazil, 25°20′43.2″S, 48°46′14.0″W, December 2011.

**Taxonomical remarks:** *Nupela kociolekii* is more closely related to *N. difficilis* with respect to the degree of development of the raphe and by the shape of apices. Although both species have occurred in the same samples, these can be differentiated by the proximal raphe ends, and number of striae. The striae of *N. kociolekii* are almost incomprehensive in LM because of its denser arrangement (40 in 10 µm), furthermore the internal proximal raphe ends are straight.
Figs 23–42. *Nupela decipiens* (Reimer) Tremarin et T. Ludwig, LM (23–36) and SEM (37–42): (37) Central area of valve in external view; (38) External view of distal end of raphe; (39) Central region of valve with raphe in internal view; (40) Distal end of raphe in internal view; (41) External view of valve without raphe; (42) Detail of extremities of valve showing occluded fissure in internal view. Scale bars 10 µm (23–36); 1 µm (37‒39, 41, 42); 0.5 µm (40).

*Nupela scissura* Silver, Hamilton et Morales resembles *N. kociolekii* in the shape of valves and apices, and by the central area unilaterally expanded until the margin with c-shaped area (Silver et al. 2007). However, *N. scissura* differs by the smaller central area, higher number of striae (48–58 in 10 µm), straight proximal raphe ends and monoraphid frustules (Silver et al. 2007).

*Nupela cf. matrioschka* Kulikovsky, Lange-Bertalot et Witkowski (Figs 84–86)  
**Description:** Frustules heterovalvar, slightly asymmetric about apical plane. Valves elliptical to elliptical-lanceolate with subrostrate to rounded apices, 9.3–10.3 µm long and 4.6–5.1 µm wide. Axial area linear and narrow. Central area reduced. Raphe on both valves, slightly sinuous. One valve with long raphe slits. The other valve with shorter raphe slits and slightly separated proximal endings. Proximal raphe ends externally expanded. Terminal raphe ends curved to the same side of the valve. Transapical striae radiate, ca. 35 in 10 µm, usually composed by discontinuous lines of areolae, ca. 39 in 10 µm. Outer openings of areolae transapically elongate.

**Taxonomical remarks:** *Nupela matrioschka* was described to *Sphagnum* bogs from Russia and has no subsequent records yet (Kulikovsky et al. 2009). Few exemplars found in the Brazilian samples were similar to *Nupela matrioschka* in shape and size of the valves.
Fig. 55–65. *Nupela exotica* MOYER, LANGE-BERTALOT & BERTRAND, LM (55–61) and SEM (62–65): (62) Internal view of valve with longer raphe; (63) Central region of valve in internal view; (55) Internal view of valve with shortened raphe; (64, 65) Distal end of raphe in internal view. Scale bars 10 µm (55–61); 5 µm (63); 1 µm (62, 64, 65).

valves and somewhat discontinuous striae. However the valves have lower density of radiate striae (non 42–48 in 10 µm), not convergent at the apices (KULIBOGO et al. 2009).

We did not find other *Nupela* species with similar features among the individuals studied. The scarce exemplars found in Brazilian material did not allow detailed analysis of the frustules and a possible proposal of a new taxon.

*Nupela metzeltinii* TREMARIN et T. LUDWIG sp. nov. (Figs 87–92)

**Description:** Frustules heterovalvar, slightly asymmetric about apical plane. Valves narrowly lanceolate with subcapitate apices, 14.8–18.9 µm long and 3.7–4.1 µm wide. Axial area linear and narrow, with impressions along the raphe slits. Central area rounded. Raphe on both valves, straight. One valve with very short raphe slits and separated proximal endings. Proximal raphe ends externally simple and straight. Terminal raphe ends curved to same side of the valve. Transapical striae radiate to slightly convergent at the apices, 50 in 10 µm.

**Etymology:** This species is dedicated to the diatomist Ditmar Metzel from Germany.

**Holotype:** Slide UPCB 47494, Diatom collection of the Botany Department, Universidade Federal do Paraná, illustrated here in Figs 89–90.

**Isotype:** ANSP GC26822.

**Type material:** Guarajaçu river, Pontal do Paraná, State of Paraná, Brazil, 25°43’5.77’S, 48°33’26.81’W, October 2003.

**Taxonomical remarks:** *Nupela metzeltinii* is similar in shape and dimensions of the valves, apices and number of striae to *N. neotropica* LANGE-BERTALOT & MOYER (1994). *Nupela marvanii* MOYER also have lanceolate valves and heterovalvar frustules as *N. metzeltinii*, however the former have wider valves (5–6 µm), capitate apices and a very short raphe on one of the valves (MOYER 2009). *Nupela metzeltinii* was scarce in the analyzed samples. Although it has not been possible a detailed description of the internal valve, no similar known species was found. The proposition of *Nupela metzeltinii* is justified by a set of characteristics, as heterovalvarity, lanceolate valves, subcapitates ends, raphe slits little shorter on one of the valve, and delicate depressions in the axial area.

*Nupela neglecta* PONADER, LOWE et POTAPOV (Figs 93–96)

**Description:** Frustules heterovalvar, slightly asymmetric about apical and transapical planes. Valves lanceolate with subrostrate apices, 10.4–10.7 µm long and width 4.1 µm wide. Axial area linear and narrow. Central area small. One valve with long raphe slits. The other valve with very short raphe slits and widely separated proximal endings. Proximal raphe ends simple. Terminal raphe ends curved to same side of the valve and internally ending in a small helictoglossa. Transapical striae slightly radiate, 40 in 10 µm, composed by discontinuous lines of areolae, 2–4 per striae. Inner openings of areolae small, round or oval.

**Taxonomical remarks:** *Nupela lesothensis* (SCHOEMAN) LANGE-BERTALOT and *N. jahniae-reginae* LANGE-BERTALOT are the most similar species to *N. neglecta* in relation to size and shape of the valves and development of raphe, with long raphe slits on one
valve and shorter on the other. These species differ mainly by the shape of apices, disposition of the areolae in the stria and number of longitudinal rows of areolae on each side of the raphe. *Nupela neglecta* presents slightly protracted apices, discontinuous striae and 3–4 rows of areolae while the other two species have rounded obtuse apices, continuous striae and more than 4 rows of areolae (METZLETT & LANGE-BERTALOT 1998; RUMBIK et al. 2000; POTAPOVA et al. 2003).

*Nupela neglecta* was described by epilithic samples from New Jersey (USA). This is the first record of *N. neglecta* to South America.

**Nupela praecipuoides Tremarin et T. Ludwig sp. nov.** (Figs 97–111)

**Description:** Frustules heterovalvar, slightly asymmetric about apical plane. Valves lanceolate with slightly protracted to subrostrate apices, 9.2–21.5 µm long and 4.1–5.5 µm wide. One valve with long raphe slits and the other valve araphid. Raphid valve with axial area linear and narrow, central area rounded. Proximal raphe ends externally expanded and internally simple. Terminal raphe ends curved to same side of the valve and internally ending in small helictoglossa. Araphid valve with lanceolate axial area, smooth or generally with irregular depressions visible or not under LM. Valve araphid sometimes with internal slits occluded by silica, near the apices. Transapical striae radiate to straight at the apices, 36–38 in 10 µm, composed by continuous lines of areolae, 35–39 in 10 µm.

Outer openings of areolae transapically elongate and occluded by delicate hymenate layer. Inner openings of areolae small, round to oval.

**Etymology:** This species name was given due to its morphological resemblance to *Nupela praecipua*.

**Holotype:** Slide UPCB 47494, Diatom collection of the Botany Department, Universidade Federal do Paraná, illustrated here in Fig. 103.

**Isotype:** ANSP GC26822.

**Type material:** Guaraguaçu river, Pontal do Paraná, State of Paraná, Brazil, 25°43'5.77"S, 48°33'26.81"W, October 2003.

**Taxonomical remarks:** The exemplars of *Nupela praecipuoides* were similar to the type material of *N. praecipua* (REICHARDT) REICHARDT described to Mexico. However, striae and areolae of *N. praecipua*...
Figs 112–128. *Nupela torganiae* Tremarin et T. Ludwig, LM (112–121), SEM (122, 125, 127, 128) and TEM (123, 124, 126): (120) Holotype; (122) External view of valve with longer raphe; (123, 124) Overview of valve with longer and shortened raphe, respectively; (125) Distal end of raphe in external view; (126) Detail of areolae with hymenate occlusions; (127) Central region of valve showing the proximal ends of raphe in internal view; (128) Distal end of raphe in internal view. Scale bars 10 µm (Figs 112–121); 2 µm (122–124); 1 µm (125, 127, 128); 0.2 µm (126).

Figs 97–111. *Nupela praecipuoides* Tremarin et T. Ludwig, LM (97–103); SEM (105–111) and TEM (104): (103) Holotype; (104) Detail of areolae with hymenate occlusions; (105, 106) Central region of valve showing the proximal ends of raphe in external and internal view, respectively; (107–108) Distal end of raphe in external and internal view, respectively; (109) Extremity of valve without raphe in internal view; (110–111) Valves without raphe in external and internal view, respectively. Scale bars 10 µm (97–103); 2 µm (105, 111); 1 µm (105–109); 100 nm (104).
Nupela torganiae TREMAVIN et T. LUDWIG sp. nov.  
(Figs 112–128)  
Description: Frustules heterovalvar, slightly asymmetric about apical and transapical planes. Valves lanceolate with subcapitate apices, 9.2–13.7 µm long and 3.3–4.8 µm wide. Axial area lanceolate. Central area asymmetric, broadly elliptical, unilaterally reaching the valve and presenting similarities in the size of valves and shape of apices, but differed in the expansion of the axial area, shape of valves and raphe. We do not find other similar species to Nupela torganiae. The new species is characterized mainly by the wide central area and the presence of raphe in both valves, being one of this slightly shorter than the other.

Nupela wellneri (LANGE-BERTALOT) LANGE-BERTALOT (Figs 129–139)  
Description: Frustules heterovalvar, slightly asymmetric about apical plane. Valves elliptical to lanceolate with rostrate to subrostrate apices, 11.8–16.6 µm long and 3.7–4.4 µm wide. Axial area linear and narrow. Central area asymmetric, limited by short marginal striae. Raphe on both valves, straight. One valve with long raphe slits. The other valve with shorter raphe slits and separated proximal endings. Proximal raphe ends externally simple and internally deflected. Terminal raphe ends curved to same side of the valve and externally ending in small helicoglossa. Transapical striae slightly radiate to converging in the apices, ca. 42 µm in length, composed by continuous lines of areolae, 40–50 in 10 µm. Inner openings of areolae small, round to oval.

Taxonomical remarks: Nupela wellneri can be easily confused with N. deformis, N. pallavicini (KRAMMER) LANGE-BERTALOT in LM, but the higher density of striae (ca. 60 in 10 µm), some small depressions in axial area and one valve with very shortened raphe slits distinguish N. deformis from N. wellneri (POITOU et al. 2003; LANGE-BERTALOT & MOSHI 1994). Nupela pallavicini seems to have smaller central area than N. wellneri, more pronounced apices and lower density of striae (30 in 10 µm), discernible in LM (LANGE-BERTALOT et al. 1996). Nupela wellneri and N. bicapitata are similar concerning valve outline, but the latter have larger valves, axial area more expanded and shorter raphe fissures.

The exemplars analyzed here agrees with the protologue (length 12–14 µm, width 4.0–4.8 µm, 45 striae/10 µm and 50 areolae/10 µm) (LANGE-BERTALOT & KRAMMER 1987). Nupela wellneri was proposed to Germany, and recorded in Andes and United States (LANGE-BERTALOT & KRAMMER 1987; RUMREICH et al. 2000; POITOU 2003).

Nupela amabilis, N. bicapitata, N. decipiens, N. metzeltini, N. neglecta, N. torganiae and N. wellneri co-occurred only in the Guaraguacu river. The high Nupela richness was especially found in this river, probably due to greater number of collected samples (six points and two different periods – autumn and spring). In those samples we found high richness Eunotia Eirenb erg & Pinndallia Eirenb erg (see TREMAVIN et al. 2008, 2010), and also some estuarine taxa [e.g. Cyclotella sutorium BRIEGSWILL, Staurosira obtusa (HUSTEDT) GARCIA, Catenula adhaerens (MERESCHOWSKY) MERESCHOWSKY, Delphineis surirella (EIRENBerg) ANDREWS and Seminavis striogosa (HUSTEDT) DANIELIUS et EISEMANN–AMILLI]. Among all the rivers studied, only the Guaraguacu river presented salinity zero to 14 along the sampling points, explaining the records of estuarine taxa (TREMAVIN et al. 2010).

Nupela praecpuoides was the most common taxon, occurring in eight rivers. Nupela cf. matriochka, N. neglecta and N. metzeltini were considered rare in the samples, less than 10 valves were analyzed during the study. The Nupela taxa co-occurred with other periphytic freshwater diatoms, as Melosira varia ns C. AGARDEN, Fragillaria fragilaroides (GRUNOW) CHIRINOSKY, Ubaria ulna (NITIZSKY) P. COMPTE, Epistoiopsis sp., Gomphonema spp., Encyonema sp. and Cocconeis sp.

Nupela species were found in all rivers located at Serra do Mar, but we have not detected them in four (da Orca, Serra do Azinhó, das Pombas e do Salto rivers) from the seven analyzed lowland rivers. Generally, fast rivers with clean waters, low conductivity and neutral pH seem to facilitate the development of these poorly known species.

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