Check List the journal of biodiversity data

LISTS OF SPECIES

Check List 12(1): 1823, 6 January 2016 doi: http://dx.doi.org/10.15560/12.1.1823
ISSN 1809-127X

Checklist of periphytic diatoms in streams of the Pirapó River basin, Paraná state, Brazil

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Abstract: In lotic environments, diatoms have high richness and represent important elements of biodiversity and genetic resources of these sites. Given the impacts caused by urbanization and agriculture on streams and the responses of the periphytic diatom community, this study aims to provide a checklist of epilithic diatoms in two streams: one located in an urban area and the other in rural area. Bimonthly samples were taken along the longitudinal gradient of streams (headwaters, middle and mouth) from July 2007 through August 2008. Permanent slides were deposited in the Herbarium of the State University of Maringá. In the rural stream, we identified 124 species belonging to 47 genera and 26 families and in the urban stream, 79 species belonging to 34 genera and 20 families. The streams had 68 taxa in common. In both streams, the most representative family was Naviculaceae.

Key words: Bacillariophyceae; algae; urban stream; epilithon; water quality; bioindicator

INTRODUCTION

In rivers and streams, diatoms are among the communities with the highest number of species and represent important elements of biodiversity and genetic resources of these sites (Patrick 1961). This group may have significant biomass (Wehr and Sheath 2003; Azim and Asaeda 2005), contributing to the primary productivity of these ecosystems (Pan et al. 1999). Furthermore, diatoms have been used as biological indicators of water quality in many countries (Whitton and Kelly 1995; Kelly et al. 1998; Gómez and Licursi 2001; Ács et al. 2005; Potapova and Charles 2007; Delgado et al. 2012). In Brazil, most studies on this community are concentrated in the south. Much of the information about the diatom flora in lotic environments of the Paraná state is found in master›s theses (Brassac and Ludwig 2003). Considering the impacts caused by urbanization and agriculture on streams and the responses of the periphytic diatom community (Moresco and Rodrigues 2014), this study aims to provide a checklist of epilithic diatoms in two streams: one located in an urban area and the other in rural area.

MATERIALS AND METHODS

Study site

The Pirapó River basin is part of the large system of the Paraná River and it is an important left bank tributary (south bank) of the Paranapanema River (Maack 2002). This physiographic region is called the Third Plateau of Paraná, specifically in the polygon bounded by the longitudes 51°15′ and 52°15′ W and latitudes 22°30′ and 23°30′ S, with a drainage area of approximately 5,076 km^2. The climate in the region is subtropical, with average temperatures above 20°C. This basin has great importance in relation to abstraction of water for supply, development of agricultural activities and ecological tourism in most cities in the region (Peron et al. 2009).

The municipality of Maringá is located on the interfluve of Pirapó and Ivaí river basins and encompasses several springs in the urban area. The region is relatively industrialized and urbanized, and the city of Maringá is the most important urban center of the region, with about 390,000 inhabitants.

The microbasins of the sampled streams have different land use; the course of the Nazaré stream is entirely within the urban area, with residential occupation, and receives stormwater and sewage (Moresco and Rodrigues 2014). According to Moresco and Rodrigues (2014), the Remo stream is totally rural, with rotation of crops (corn, soybeans and wheat) along its course (Figure 1).

Data collection

Bimonthly collections were conducted at three sampling sites (headwaters, middle and mouth) of the streams Nazaré and Remo from July 2007 through August 2008.

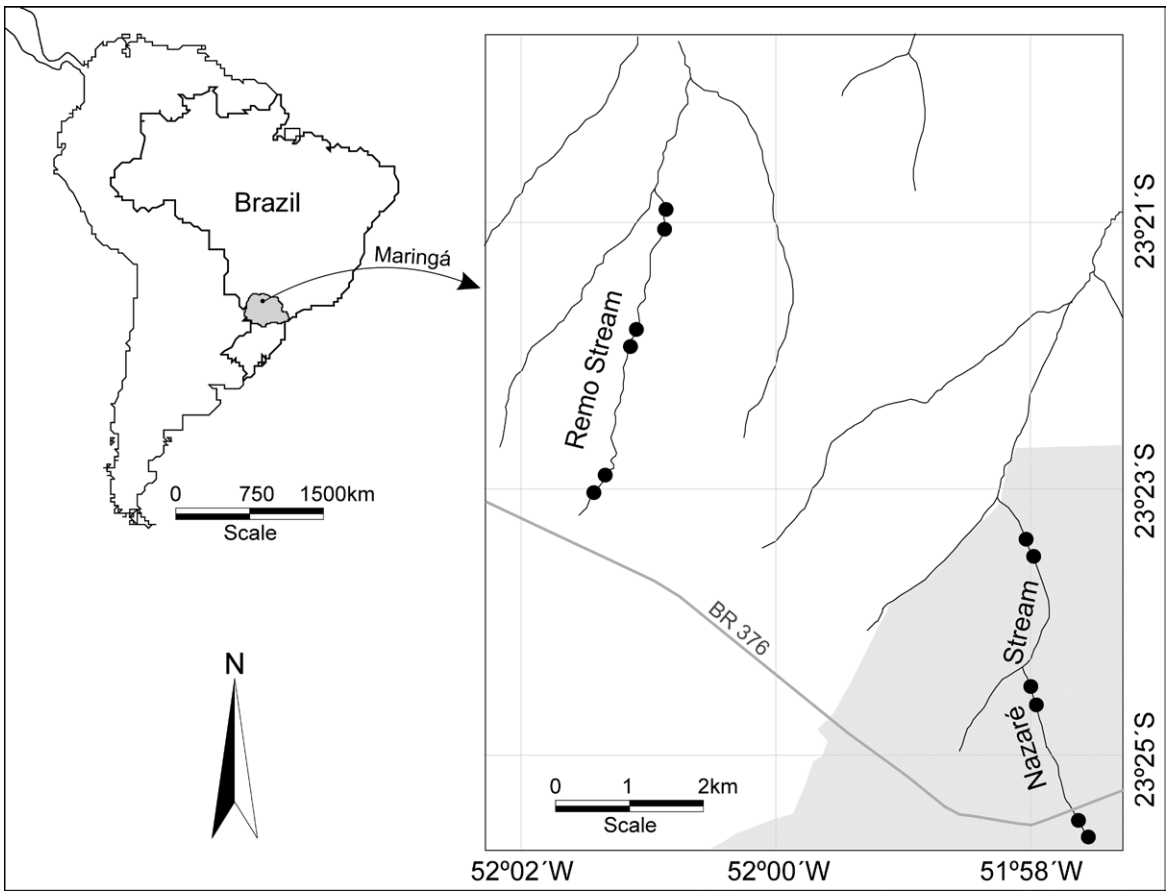

Figure 1. Location of the urban stream and the rural stream in Maringá Municipality, Paraná state, Brazil. White: rural area and grey: urban area.

For the qualitative analysis of the diatom community, we sampled three pebbles at each site, and the average of the total area scraped was 50cm². The choice of the substrate considered its abundance and frequency in all sampling sites. The surface opposite to the current flow was scraped with the aid of a brush and razor blade and the material collected was fixed in 4% formalin (1: 1 ratio). We measured the area scraped with a caliper. The material was oxidized with $KMnO_4$ and HCl according to the technique proposed by Simonsen (1974), modified by Moreira-Filho and Valente-Moreira (1981). Hyrax was used for mounting the permanent slides. The slides were deposited in the Herbarium of the State University of Maringá (HUEM 16508 to 16543). Diatoms were collected under license of *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* IBAMA process 02040.000093/06-45.

Individuals were identified under an optical microscope Olympus CX31 using specialized taxonomic literature (Patrick and Reimer 1966; Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Lange-Bertalot 2001; Krammer 2002; Metzeltin and Lange-Bertalot 1998, 2007; Metzeltin et al. 2005). The taxonomic classification used in this study followed the proposal of Round et al. (1990).

RESULTS

In the rural stream, 124 species were found, belonging to 47 genera and 26 families (Table 1). In the urban stream, 79 species were identified, belonging to 34 genera and 20 families. The streams had 68 (54.83%) taxa in common. The rural stream had 56 (45.16%) exclusive species and the urban stream only 11 (8.87%) exclusive species. In total, 135 species were identified.

In the rural environment, the most species-rich family was Naviculaceae (25 spp.), followed by Cymbellaceae (12 spp.), Bacillariaceae and Pinnulariaceae (10 spp. each), Sellaphoraceae (8 spp.), Gomphonemataceae (7 spp.), Diadesmidaceae (6 spp.). The other families presented five species or less (Eunotiaceae (5 spp.), Achnanthaceae, Amphipleuraceae and Surirellaceae (4 spp. each), Alaucoseiraceae, Fragillariaceae, Catenulaceae, Pleurosigmataceae and Stauroneidaceae (3 spp. each), Achanthidiaceae, Brachysiraceae, Cocconeidaceae and Diploneidaceae (2 spp. each) and Melosiraceae, Orthoseiraceae, Stephanodiscaceae, Triceratiaceae, Neidiaceae and Rhopalodiaceae (1 sp. each).

Regarding the urban stream, the family with the highest number of species identified was Naviculaceae (16 spp.), followed by Bacillariaceae (10 spp.), Pinnulariaceae (8 spp.), Cymbellaceae (7 spp.), Gomphonemathaceae (6 spp.), and Diadesmidadeceae and Sellaphoraceae (5 spp.

Table 1. Taxa of Bacillariophyta recorded in the R (rural) and U (urban) streams, municipality of Maringá, Paraná state. Periods 1 (July 2007), 2 (September 2007), 3 (December 2007), 4 (February 2008), 5 (April 2008), 6 (May–June 2008).

Taxa	R1	R2	R3	R4	R5	R6	U1	U2	U3	U4	U5	U6
COSCINODISCOPHYCEAE												
Alaucoseiraceae												
Aulacoseira ambigua (Grunow) Simonsen					x	x						
Aulacoseira granulata (Ehrenberg) Simonsen				x		x						
Aulacoseira sp.					x	x		x				
Melosiraceae												
Melosira varians Agardh					x	x						
Orthoseiraceae												
Orthoseira sp.					x							
Stephanodiscaceae												
Cyclotella meneghiniana Kützing		x			x				x	x	x	x
Triceratiaceae												
Pleurosira laevis (Ehrenberg) Compère		x			x							
FRAGILARIOPHYCEAE												
Fragilariaceae												
Fragilaria rumpens (Kützing) Carlson	x	x	x		x	x						
Synedra rumpens Kützing var. *familiaris* (Kützing) Grunow	x											
Ulnaria ulna (Nitzsch) Compère	x	x	x	x	x	x			x	x	x	
BACILLARIOPHYCEAE												
Achnanthaceae												
Achnanthes exigua Grunow	x	x	x	x	x	x	x		x	x	x	x
Achnanthes hungarica Grunow					x							
Achnanthes inflata Grunow									x	x	x	x
Achnanthes lanceolata (Brébisson ex Kützing) Grunow	x	x	x	x	x	x	x	x	x	x	x	x
Achnanthes rupestoides Hohn	x	x	x	x	x	x	x	x	x	x	x	x
Achnanthidiaceae												
Achnanthidium minutissimum (Kützing) Czarnecki	x	x	x	x	x	x	x	x	x	x	x	x
Planothidium conspicuum (Mayer) Aboal in Aboal	x											
Amphipleuraceae												
*Amphipleura lindheimeri*Grunow	x	x	x	x	x	x						
Frustulia crassinervia (Brébisson) Lange-Bertalot & Krammer	x		x	x	x	x						
Frustulia pumilio Lange-Bertalot & Rumrich	x	x	x	x	x	x	x	x	x	x	x	x
Frustulia vulgaris (Thwaites) De Toni	x	x	x		x	x				x	x	
Bacillariaceae												
Hantzschia amphioxys (Ehrenberg) Grunow	x	x		x	x							
Nitzschia amphibia Grunow	x	x	x	x	x	x	x	x	x	x	x	x
Nitzschia clausii Hantzsch				x				x	x	x		
Nitzschia frustulum (Kützing) Grunow	x	x	x			x	x					x
Nitzschia gandersheimiensis Krasske		x			x	x			x	x	x	
Nitzschia gracilis Hantzsch	x											
Nitzschia cf. *inconspicua* Grunow										x	x	x
Nitzschia linearis Smith	x	x	x	x	x	x	x	x	x	x	x	x
Nitzschia lorenziana Grunow											x	
Nitzschia palea (Kützing) Smith	x	x	x	x	x	x	x	x	x	x	x	x
Tryblionella debilis Arnot	x		x	x	x	x				x	x	x
Tryblionella levidensis Smith	x	x	x	x	x	x			x	x		
Brachysiraceae												
Brachysira neoexilis Lange-Bertalot	x		x									
Brachysira sp.			x									
Catenulaceae												
Amphora copulata (Kützing) Schoeman & Archibald	x	x	x	x	x	x						
Amphora montana Krasske	x	x	x	x	x	x	x	x	x	x	x	x
Amphora normannii Rabenhorst	x	x	x	x	x	x	x		x	x	x	x
Cocconeidaceae												
Cocconeis placentula var. *acuta* Meister		x	x			x						
Cocconeis placentula var. *euglypta* (Ehrenberg) Cleve	x	x	x	x	x	x	x	x	x	x	x	x
Cymbellaceae												
Cymbella microcephala Grunow	x			x			x					
Cymbella naviculiformis Auerswaldex Heiberg	x											

Continued

Table 1. *Continued.*

Taxa	R1	R2	R3	R4	R5	R6	U1	U2	U3	U4	U5	U6
Cymbella sp.	x											
Encyonema mesianum (Cholnoky) Mann	x	x	x	x	x	x			x			
Encyonema minutum (Hilse) Mann			x									
Encyonema silesiacum (Bleisch) Mann	x	x				x						x
Encyonema sp.						x						
Placoneis abundans Metzeltin, Lange-Bertalot & Garcia-Rodriguez			x									
Placoneis constans var. *symmetrica* (Hustedt) Kobayasi	x	x	x	x	x	x				x		
Placoneis disparilis (Hustedt) Metelzin & Krammer	x	x	x	x	x	x		x				
Placoneis hambergii (Hustedt) Bruder	x	x	x	x	x	x			x	x	x	x
Placoneis subplacentula (Hustedt) Cox	x				x							
Placoneis sp.							x					
Diadesmidaceae												
Diadesmis contenta (Grunow) Mann	x	x	x	x	x	x	x	x	x	x	x	
Diadesmis sp.	x	x										
Luticola dapalis (Frenguelli) Mann	x	x	x	x	x	x				x		
Luticola goeppertiana (Bleisch) Mann	x	x	x	x	x	x	x		x	x	x	x
Luticola mutica (Kützing) Mann	x			x	x	x	x					
Luticola cf. *saxophila* (Bock ex Hustedt) Mann							x					
Luticola sp.				x								
Diploneidaceae												
Diploneis cf. *elliptica* (Kützing) Cleve	x											
Diploneis subovalis Cleve	x	x	x	x	x	x			x			
Eunotiaceae												
Eunotia bilunaris (Ehrenberg) Mills					x	x						
Eunotia didyma Grunow var. *didyma*						x						
Eunotia paludosa Grunow	x		x	x								
Eunotia sp.						x	x					
Perinotia sp.	x	x	x	x	x	x						
Gomphonemataceae												
Gomphonema affine Kützing				x							x	
Gomphonema augur var. *turris* (Ehrenberg) Lange-Bertalot					x					x	x	
Gomphonema brasiliense Grunow	x	x	x	x	x	x						
Gomphonema clevei Fricke	x				x							
Gomphonema gracile Ehrenberg	x	x	x	x	x	x	x	x	x	x	x	x
Gomphonema cf. *insigne* Gregory										x		
Gomphonema lagenula Kützing	x	x	x	x	x	x	x	x	x	x	x	x
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot	x	x	x	x	x	x	x	x	x	x	x	x
Naviculaceae												
Adlafia drouetiana (Patrick) Metzeltin & Lange-Bertalot	x	x	x	x	x	x	x	x	x	x	x	x
Capartogramma crucicula (Grunow ex Cleve) Ross	x					x						
Eolimna minima (Grunow) Lange-Bertalot	x	x	x	x	x	x	x	x	x	x	x	x
Geissleria aikenensis (Patrick) Torgan & Oliveira	x	x	x	x	x	x	x	x	x	x	x	x
Geissleria neosubtropica Metzeltin, Lange-Bertalot & García-Rodriguez	x	x	x	x	x	x						
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metelzin & Witkowski	x	x	x									
Mayamaea atomus (Kützing) Lange-Bertalot var. permitis			x		x		x		x	x	x	x
*Navicula cryptotenella*Lange-Bertalot	x	x	x	x	x	x	x	x	x	x	x	x
Navicula erifuga Lange-Bertalot	x			x	x	x	x		x	x	x	x
Navicula gregaria Donkin	x	x	x	x	x	x	x	x	x	x	x	x
Navicula longicephala Hustedt	x					x						
Navicula paludosa Hustedt			x									
Navicula lohmannii Lange-Bertalot & Rumrich	x	x	x	x	x	x	x	x	x		x	x
Navicula rhynchocephala Kützing	x											
Navicula symmetrica Patrick	x	x	x	x	x	x	x	x	x	x	x	x
Navicula tenelloides Hustedt	x	x	x	x	x	x	x	x	x	x	x	x
Navicula viridula Kützing	x	x	x	x	x	x		x	x	x	x	x
Navicula viridula var. *rostellata* (Kützing) Cleve	x	x	x	x	x	x		x	x	x	x	x
Navicula sp.	x	x	x	x	x	x				x	x	
Navicula sp. 1							x	x	x	x	x	x
Navicula sp. 2	x											
Navicula sp. 3						x						

Continued

Table 1. *Continued.*

Taxa	R1	R2	R3	R4	R5	R6	U1	U2	U3	U4	U5	U6
Navicula sp. 4				x	x	x						
Navicula sp. 5		x										
Nupela praecipua (Reichardt) Reichardt	x	x	x	x	x	x	x		x	x	x	
Nupela sp.	x	x	x	x	x	x	x	x	x	x	x	x
Neidiaceae												
Neidium affine (Ehrenberg) Pfitzer									x			
Neidium sp.	x	x										
Pinnulariaceae												
Caloneis bacillum (Grunow) Cleve	x	x			x		x	x	x	x	x	x
Pinnularia doehringii Frenguelli	x	x	x		x			x	x	x	x	
Pinnularia dubitabilis (Hustedt) Hustedt						x						
Pinnularia gibba (Ehrenberg) Ehrenberg	x		x	x	x	x	x	x	x	x		x
Pinnularia latarea Krammer	x	x			x	x	x	x	x	x	x	
Pinnularia mesolepta (Ehrenberg) Smith		x	x	x						x		
Pinnularia obscura Krasske		x		x		x				x		x
Pinnularia subcapitata Gregory	x											
Pinnularia viridis (Nitzsch) Ehrenberg					x					x		
Pinnularia sp.			x	x	x	x				x		
Pleurosigmataceae												
Gyrosigma acuminatum (Kützing) Rabenhorst	x		x	x	x	x				x		
Gyrosigma nodiferum (Grunow) Reimer	x				x	x						
Gyrosigma scalproides (Rabenhorst) Cleve	x	x	x		x	x	x					
Rhopalodiaceae												
Rhopalodia gibberula var. *vanheurckii* (Van Heurck) Müller	x											
Sellaphoracea												
Fallacia ecuadoriana Lange-Bertalot & Rumrich	x	x	x	x	x	x					x	
Fallacia insociabilis (Krasske) Mann	x	x	x	x	x	x						
Fallacia monoculata (Hustedt) Mann	x			x			x	x	x	x	x	x
Sellaphora bacillum (Ehrenberg) Mann					x							
Sellaphora pupula (Kützing) Mereschkovsky	x	x	x	x	x	x	x	x	x	x	x	
Sellaphora seminulum (Grunow) Mann	x	x	x	x	x	x	x	x	x	x	x	x
Sellaphora sp.	x											
Sellaphora sp. 1.	x	x	x		x	x		x		x	x	
Stauroneidaceae												
Craticula ambigua (Ehrenberg) Mann					x	x						
Craticula submolesta (Hustedt) Lange-Bertalot								x				
Craticula sp.							x	x	x	x	x	x
Stauroneis cf. *kriegeri* Patrick	x	x	x	x	x	x						x
Stauroneis nana Hustedt	x	x				x						
Surirellaceae												
Stenopterobia schweickerdtii (Cholnoky) Brassac, Ludwig & Torgan	x	x			x	x						
Stenopterobia sp.	x	x	x	x	x	x	x	x	x	x	x	x
Surirella linearis Smith						x						
Surirella stalagma Hohn & Hellerman						x						
Surirella cf. *tenera* Gregory										x		

each), Achnanthaceae (4 spp.), Stauroneidaceae (3 spp.), Amphipleuraceae, Catenulaceae, Pleurosigmataceae and Surirellaceae (2 spp. each), Aulacoseiraceae, Stephanodiscaceae, Fragilariaceae, Achnanthidiaceae, Cocconeidaceae, Diploneidaceae and Neidiaceae (1 sp. each) (Table 1). Some of the species found are shown in Figure 2.

DISCUSSION

The assemblages of the periphytic diatoms studied were different between the urban stream and the rural stream. Studies on streams draining urban centers have shown a decline in the diatom richness associated with organic pollution (Lobo et al. 1995; Sonneman et al. 2001). While both agriculture and urbanization cause impacts on rivers and streams, the pollution derived from urban areas is more intense than that registered in rural areas (Odum 1983; Kannel et al. 2007). These way susceptible organisms to pollution will decline and may disappear.

In a study conducted in these streams Moresco and Rodrigues (2014) detected that the effect of urbanization on periphytic diatoms in the urban stream was evident. This stream showed low richness values. On the other hand, in the rural stream, richness presented higher values. According to Moresco and Rodrigues (2014), the distinction in periphytic diatom assemblages among urban and rural streams were associated to the

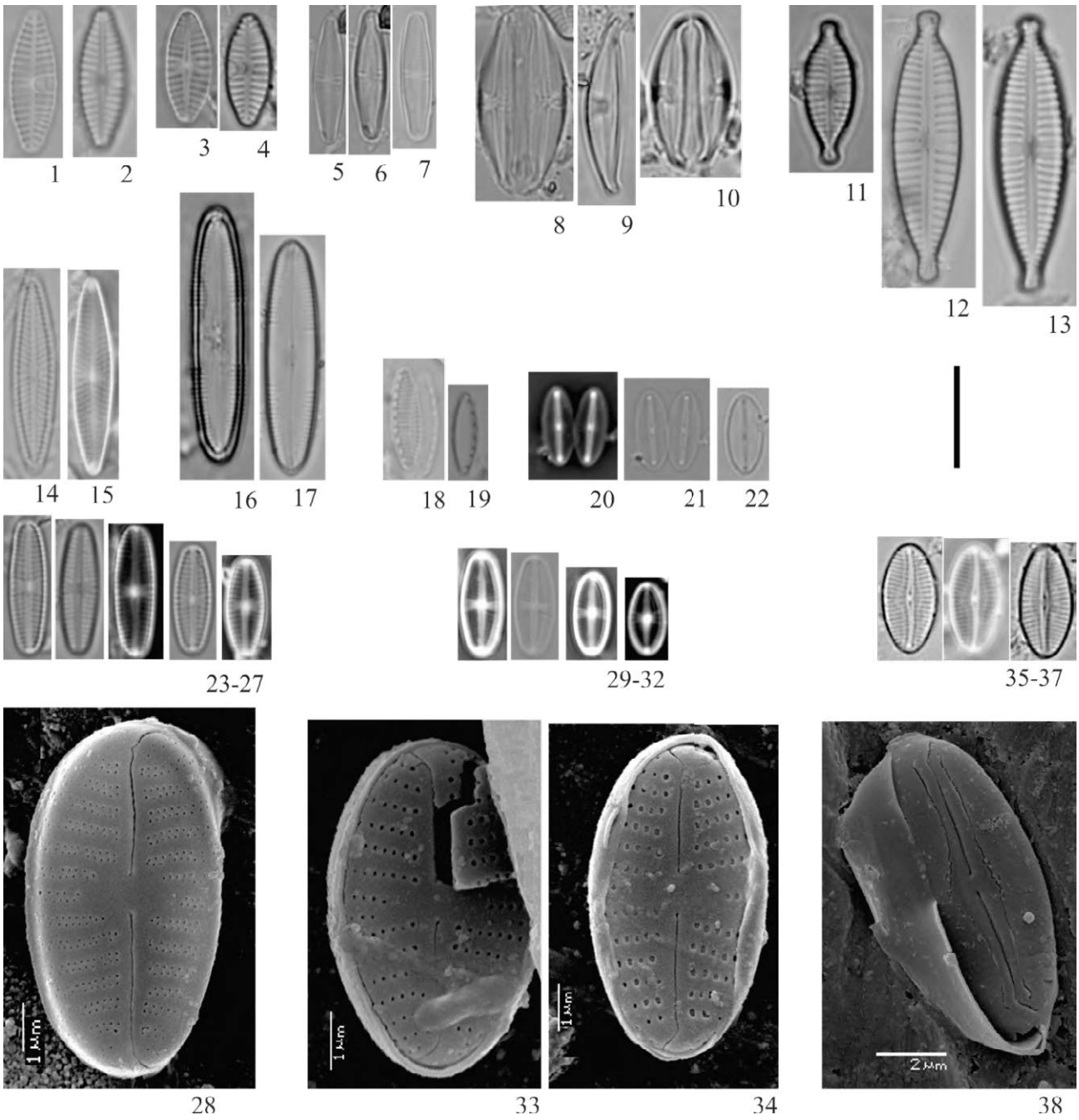

Figure 2. Taxa of diatoms. **1–4**: *Achnanthes lanceolata*. **5–7**: *Achnanthidium minutissimum*. **8–10**: *Amphora montana*. **11–13**: *Gomphonema lagenula*. **14–15**: *Navicula tenelloides*. **16–17**: *Caloneis bacillum*. **18–19**: *Nitzschia* cf. *inconspicua*. **20–22**: *Mayamaea atomus* var. *permitis*. **23–28**: *Sellaphora seminulum*. **29–34**: *Eolimna minima*. **35–38**: *Fallacia monoculata*. Scale bar = 10 µm. For figures 28, 33 and 34 the scale is 1 µm and for figure 38 the scale is 2 µm. Photos by C. Moresco and Priscila I. Tremarin.

increased conductivity and total nitrogen values found in urban stream and the upper dissolved oxygen, COD, BOD5, and flow in rural stream.

ACKNOWLEDGEMENTS

To the CNPq for the financial support to the project "Identification of possible bioindicators in urban aquatic ecosystems: the response of the groups of organisms to stress gradients" and to CAPES for scholarship. To PEA/UEM and Nupélia/UEM for logistic support. To Priscila I. Tremarin and Thelma A.V. Ludwig for the help in identifying diatoms.

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Author contributions: CM collected the data, CM identified the specimens, and CM and LR wrote the text.

Received: 11 June 2015
Accepted: 19 December 2015
Academic editor: Sandra Costa-Böddeker