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Holocene diatoms from Xingu river: new records for the Brazilian Amazon and Brazil

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ABSTRACT – (Holocene diatoms from Xingu river: new records for the Brazilian Amazon and Brazil). Present study is the floristic survey and the distribution of diatoms observed in two sediment cores of the Xingu river, Pará State, north Brazil, and represents the past ~6,000 cal yr BP. Thirty-eight taxa distributed in twenty genera were recorded, among which five were new records for Brazil and nineteen new for the Brazilian Amazon. The most representative genus based on species number was *Gomphonema* Ehrenberg with six species. In brief, present new records represent a 75% increase in the total number of records for the Brazilian Amazon, and indicates that this region has not only been poorly investigated, but also suggests that its biodiversity assessment is underestimated. These findings highlight the efficacy of the paleolimnological approach as a tool for assessing biodiversity before the human impacts begin to affect the pristine conditions of the area.

Keywords: biodiversity, core, diatoms, floristic survey, paleolimnology

RESUMO – (Diatomáceas holocênicas do rio Xingu: novos registros para a Amazônia brasileira e o Brasil). O presente estudo visou ao levantamento florístico e à distribuição de diatomáceas obtidas de dois perfis sedimentares do rio Xingu, Estado do Pará, Brasil, e representa os últimos ~6.000 anos de idade. Trinta e oito táxons distribuídos em vinte gêneros foram documentados, entre os quais cinco são novos registros de ocorrência no Brasil e dezenove na Amazônia brasileira. *Gomphonema* Ehrenberg foi o gênero mais representado com seis espécies. Sintetizando, as novas ocorrências representam um aumento de 75% do número total de registros para a Amazônia brasileira e indicam que essa região ainda se encontra mal investigada, mas também sugere que a avaliação da biodiversidade está subestimada. Finalmente, os resultados destacam a utilidade da abordagem paleolimnológica como uma ferramenta de peso na avaliação da biodiversidade antes que os impactos humanos comecem a afetar as condições pristinas da área.

Palavras-chave: biodiversidade, diatomáceas, levantamento florístico, paleolimnologia, testemunho

Introduction

Holocene is the most recent interval of Earth history encompassing the present day. Together with the Pleistocene series it forms the Quaternary period, and possibly is the most intensively studied interval of recent geological time (Suguio 1999). Despite being a relatively short geological period, sedimentary evidence from the Holocene are sufficiently well preserved, thus enabling comparisons with data of the same nature in current processes (Walkers & Geissman 2009).

Paleolimnological studies have proved to be a valuable tool for the increase of environmental biodiversity and floristic changes reconstructions (*e.g.* Smol 2008, Bennion & Simpson 2011, Davidson & Jeppesen 2013, Wengrat *et al.* 2018). Moreover, past environmental communities are very often the only available source of information when researching biodiversity prior to human impacts (Smol 2002, Le Treut *et al.* 2007).

Diatoms have been widely used among the biological groups preserved in the sediments, because of their taxonomic distinction, abundance, preservation in the sediments, and rapid response to environmental changes (Reid 2005, Bennion & Simpson 2011). However, use of diatoms to indicate environmental changes requires high taxonomic precision (Birks 1994), since misidentifications may modify the interpretation in obtaining reliable data on modern diatom biodiversity (Buczko & Magyari 2007, Wetzel & Ector 2014).

In Brazil, floristic and taxonomical studies of sedimentary diatoms over a long timescale are still very scarce. In fact, at the present time there are only four contributions to the subject, a floristic survey and the spatial-temporal distribution of diatoms from surface sediments and core samples (ca. 90 years) of an urban reservoir located in the São Paulo Metropolitan Region (Faustino *et al.* 2016), a study on the water level variations based on the abundance and distribution of two diatoms in core samples (~830 years) of a marsh located on the Mutum Island, in the Upper Parana river floodplain (Ruwer & Rodrigues 2018), a study to reconstitute paleoenvironments of the lacustrine Pinguela- Palmital- Malvas system during the Holocene (Hermany *et al.* 2013), and a study to infer the paleoecological and paleohydrological changes in five sedimentary cores of Itupanema Beach, Pará State (Ribeiro *et al.* 2010).

We presently documented the floristic survey and the diatoms distribution over the past ~6.000 years from two sediment cores of the Xingu river, Pará State, Brazil. The Amazon Basin represents about 40% of the national territory, and contains more than 60% of the water available to the country (PNRH 2006). Occupying two-fifths of South America and 5% of the Earth surface, the Amazon Basin covers a total area of approximately 7 million km², and represents the largest drainage basin in the world, thus playing a vital role in maintaining biodiversity (Wetzel *et al.* 2011). Within this context, present study aimed at expanding the knowledge of tropical diatoms biodiversity before human impacts, and highlighting its biodiversity by providing new records for Brazil and the Brazilian Amazon.

Material and methods

The Xingu river basin, one of the main eastern Amazonian river systems (figure 1 a) has an area of 531,250 km² and an average flow between 2,582 and 9,700 $m^3 s^{-1}$. Climate is tropical with an average temperature between 25 ºC and 27 ºC (ISA 2012). The Xingu river downstream range is a region well known for its atypical river course and diversified morphology known as the Volta Grande do Xingu (*Xingu Great Bend*, Figure 1 c). Near to the mouth, the river shifts to a lowland Amazonian river with a single slack water channel under the influence of the tides (Sawakuchi *et al.* 2015). Samples used for the present investigation were collected in the lower Xingu river, in a floodplain lake (3°12’51.24”S, 52°11’24.25”W) located in the Arapujá island (Volta Grande do Xingu), in a Ria area (01°42’32.12”S, 52°16’47.42”W) near to Porto de Moz city.

During the dry season of 2014, the cores were collected by divers from a deep zone of both sites. The location was selected based on the water depth profile coupled with riverbed sediment sampling. Divers collected a 122 cm core (XC1-02) from the Arapujá island, and a 362 cm core (XC-03) from the *Ria*, using a 6 m long PVC tube sectioned at 2 cm intervals. Core chronology was determined by Optically Stimulated Luminescence (OSL) and ^{14}C dating. Two samples for quartz OSL dating were collected and prepared in the Luminescence and Gamma Spectrometry Laboratory of the Instituto de Geociências at the Universidade de São Paulo. Four samples were collected and prepared for ^{14}C dating at the Analytic Radiocarbon Dating in Miami and the Radiocarbon Laboratory at the Universidade Federal Fluminense (LAC-UFF). For more details, see Sawakuchi *et al.* (2015). Based on the OSL and ^{14}C dating, the base of the XC1-02 and XC-03 cores corresponded to about ~6.000 cal yr BP and 4.000 cal yr. BP, respectively, which covers the end of Mid-Holocene and the Late Holocene.

For diatom analyses, organic matter was oxidized to be removed, using hydrogen peroxide (H_2O_2 35%) and hydrochloric acid (HCl 37%), according to standard procedures (Battarbee *et al.* 2001). Permanent slides were prepared using Naphrax (R.I. 1.6) as the mounting medium. Optical observations, measurements and photomicrographs were taken at 1.000× magnification, with a Zeiss Axioskop 2 plus microscope equipped with an Axiocam ERc5s high-resolution digital camera. At least 400 valves per slide were counted (Battarbee *et al.* 2001). Species abundance was calculated by dividing the individual species count by the total count expressed as percentages for each slide (subsample). Taxonomy and nomenclature followed specific publications (*e.g.* Lange-Bertalot 1993, Metzeltin & Lange-Bertalot 1998, Morales & Manoylov 2006, Garcia 2010, Lange-Bertalot *et al.* 2011, Reichardt 2015, Almeida *et al.* 2015, Tyree & Vaccarino 2016, Costa *et al.*

2017b, Bartozek *et al.* 2018) and the valid names on-line catalog (Fourtanier & Kociolek 2011). Classification systems followed Medlin & Kaczmarska (2004) for supra-ordinal taxa and Round *et al.* (1990) for the subordinal ones, with the only exception of genera published after this work. After consulting the published literature (books and articles), the new records for Brazil and the Brazilian Amazon (Amazons, Amapá, Mato Grosso, western Maranhão, Pará, Rondônia, Roraima, Acre, and Tocatins States) were indicated. Furthermore, morphometric information is provided for the new records (M: valve mantle, D: diameter, L: length, W: width, L/W: length/width ratio, S: striae, A: areolae, and F: fibulae). Sediment samples are deposited at the "Herbário Científico do Estado Maria Eneyda P. Kauffmann Fidalgo" (SP) in the city São Paulo, Brazil (access numbers SP470331 to SP513834).

Results

The diatom flora of the Xingu river over the past ~6.000 cal yr BP includes 38 taxa (30 species and varieties, and eight at the genus level, distributed in 20 genera). Eight taxa were identified only to the genus level because no similar taxon was found in the literature, and they probably represent taxonomic novelties. Taxa preceded by one asterisk represent new records for the Brazilian Amazon, and those preceded by two asterisks are first citations for Brazil. All taxa above mentioned are listed below.

Aulacoseiraceae R.M.Crawford

Aulacoseira Thwaites

*****Aulacoseira crassipunctata*** Krammer, Nova Hedwigia 52(1-2): 490, figs 71-79. 1991.

Figures 2, 3

Morphometry: M: 12.6-16.6 µm; D: 5.4-7.1 µm; S: 5-10 in 10 µm; A. 2-8 in 10 µm.

The species differs from *Aulacoseira canadensis* (Hustedt) Simonsen (1979: 57) in the shape of the ringleist that is very solid and thick at the middle of the column. Another difference is in the areolae outline that is small and rounded in *Aulacoseira crassipunctata* Krammer (Bahls *et al.* 2009). It was present in only 2% of the core samples, and had a maximum abundance of 6%. The species is present in samples from the Late Holocene, ~2.200 cal. yr BP to ~320 cal. yr BP. This is the first record of the species occurrence in Brazil.

Material examined: BRASIL. PARÁ: Porto de Moz, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC-03 (SP513792).

Fragilariaceae Greville

Rimoneis M.Garcia

***Rimoneis* sp.**

Figures 4-6

Morphometry: L: 8-17µm; W: 2.5-7.1 µm.

Valves linear-lanceolate, hyaline, with rounded ends. Axial area wide, occupying all the valve face. Striae not observed in LM. This taxon resembles *Rimoneis inanis* M.Garcia (2010) in the valve shape, although its valve ends are more pronounced and less rounded. Moreover, *Rimoneis* sp. present smaller valve dimensions (*R. inanis*, L:17-25 µm, W:2.7-3.3 µm). Currently, the genus *Rimoneis* presents only two species registered in the world, being *R. inanis* restricted to freshwater/brackish waters in sandy beaches of the Lagoa dos Patos lagoon and Guaíba river, located in Southern Brazil. *Rimoneis* sp. occurred in 5% of the core samples, with maximum abundance of 4%. It is present in samples from the Late Holocene, ~3.750 cal. yr BP to 1.450 cal. yr BP.

Material examined: BRASIL. PARÁ: Porto de Moz, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC-03 (SP513824).

Staurosira Ehrenberg

***Staurosira* sp.**

Figures 7, 8

Morphometry: L: 12.0-16.0 µm; W: 8.0-12.0 µm; S: 16-17 in 10 µm.

The population found resembles *Staurosira construens* Ehrenberg (1843) in its valve outline. However, it is distinct by presenting narrower ends. *Staurosira* sp. was identified in 82% of the core samples, and had a maximum abundance of 24%. The species is present in samples from the end of the Mid-Holocene, ~6.000 cal. yr BP up to the core top.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470331 to SP470349, SP470351, SP470352, SP470354, SP470357, SP470358, SP470361 to SP470365, SP470368 to SP470375, SP470377 to SP470383, SP470386 to SP470392).

Staurosirella D.M.Williams & Round

******Staurosirella acidophila*** P.D.Almeida, C.E.Wetzel, E.A.Morales, L.Ector & D.C.Bicudo, Cryptogamie Algologie 36(3): 260, figs 2-41. 2015.

Figures 9, 10

Morphometry: L: 16.6-20.6 µm; W: 4.0-5.5 µm; S: 8-9 in 10 µm.

The species was proposed by Almeida *et al.* (2015) from material collected from the Cachoeira da Graça Reservoir (São Paulo state), and according to those authors, *S. acidophila* is similar to *Staurosirella confusa* E.A.Morales (2005: 54-58), however, there are some clear differences in the arrangement and density of the striae (ca. 11 in 10 µm). This species also differs from *Staurosirella oldenburgiana* (Hustedt) E.A.Morales (2005: 118) in the width of the valve center and the presence of small areolae. It was reported from 52% of the core samples, reaching 4% maximum abundance.

The species is present in samples corresponding to the end of the Mid-Holocene, from ~6.000 cal. yr BP up to the core top. Current study represents the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470335 to SP470342, SP470345 to SP470356, SP470358, SP470360 to SP470366, SP470377, SP470378, SP470379, SP470392).

Staurosirella* cf. *acutirostrata (Metzeltin & Lange-Bertalot) Almeida & Wetzel, Cryptogamie Algologie 36(3): 267. 2015.

Figure 11

Morphometry: L: 16.0-23.3 µm; W: 5.3-6.0 µm; S: 7-8 in 10 µm.

This species was identified as *Staurosirella* cf. *acutirostrata* (Metzeltin & Lange-Bertalot) Almeida & Wetzel (2015: 267) due to presenting less tapered extremities and shorter valve length (L: 22-36 µm) than the ones described in Metzeltin & Lange-Bertalot (1998: 89, pl. 1, fig. 18-19, pl. 2) It was reported in 48% of all core samples, thus reaching a 4.3% maximum abundance. The species is identified from samples collected toward the end of the Mid-Holocene, from ~5.760 cal. yr BP up the core top.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470331, SP470332 to SP470337, SP470352 to SP470356, SP470359, SP470362, SP470364 to SP470367, SP470371, SP470372, SP470375 to SP470380, SP470382, SP470383, SP470387 to SP470391).

****Staurosirella dubia*** (Grunow) E.A.Morales & K.M.Manoylov, Diatom Research 21(2): 348. 2006.

Figures 12, 13

Morphometry: L: 14.0-16.0 µm; W: 5.0-6.0 µm; S: 7-8 in 10 µm.

Staurosirella dubia (Grunow) E.A.Morales & K.M.Manoylov has a similar valve outline when compared to *Staurosirella pinnata* (Ehrenberg) D.M.Williams & Round (1988: 274). However, *S. dubia* differs by having larger valves, lanceolate valve outline in the greater specimens, elliptical in the smaller ones, and wider striae (Morales 2010). It was found in 56% of the core samples, reaching 6% maximum abundance. Current species were present in samples from the end of the Mid-Holocene (~6.000 cal. yr BP) up to the core top. Current survey is the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470332 to SP470336, SP470338, SP470339, SP470344 to SP470353, SP470356, SP470357, SP470360 to SP470364, SP470377, SP470378, SP470380 to SP470385, SP470387, SP470388, SP470392).

****Staurosirella subcapitata*** (Frenguelli) E.A.Morales, Diatom Research 21(2): 358, figs 57-79. 2006.

Figures 14, 15

Morphometry: L: 8.0-22.0 µm; W: 3.0-5.0 µm; S: 6-9 in 10 µm.

Present species resembles *S. dubia* (Grunow) Morales & Manoylov, however according to the authors *S. subcapitata* (Frenguelli) E.A.Morales has less lanceolate and silicified valves than the second species. It occurred in 98% of all core, with a maximum abundance of 15%. *S. subcapitata* was identified in all subsamples from the Late Holocene (~4.000 cal. yr BP) up to the core top (~300 cal. yr BP). Despite the species was already reported for Brazilian Amazon, in the Negro river (Wetzel 2011), the present is to be considered the first publish citation for the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Porto de Moz, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC-03 (SP513792, SP513824, SP513825, SP513826, SP513827, SP513828, SP513829, SP513830, SP513831, SP513832, SP513833, SP513834).

Eunotiaceae Kützing

Eunotia Ehrenberg

Eunotia camelus Ehrenberg, Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich-Preussischen Akademie der Wissenschaften zu Berlin 1841: 413 [125], pl. 2/1, fig. 1. 1843.

Figure 16

Morphometry: L: 22.0-62.5 µm; W: 6.0-7.0 µm; S: 9-12 in 10 µm.

According to Costa *et al*. (2017b), the type material of *Eunotia camelus* Ehrenberg illustrated in Reichardt (1995) included a population composed of two different species, a fact that brings some confusion regarding the classification of the species. In the southeastern Brazil, most of the populations identified as *E. camelus* actually are *Eunotia longicamelus* L.F.Costa, D.C.Bicudo & C.E.Wetzel. It was reported in 15% of the core samples, and reached 3% maximum abundance. The species is found in samples from the early Late Holocene (~1.514 cal. yr BP) to the core top.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470348, SP470350 to SP470355, SP470357 to SP470360).

****Eunotia longicamelus*** L.F.Costa, D.C.Bicudo & C.E.Wetzel, Bibliotheca Diatomologica 64: 32, pl. 73, pl. 74, figs 1-8, pl. 75, pl. 76. 2017.

Figure 17

Morphometry: L: 35.0-48.0 µm; W: 6.0-7.3 µm; S: 10-14 in 10 µm, A: 20-22 in 10 µm.

Eunotia longicamelus L.F.Costa, D.C.Bicudo & C.E.Wetzel was established by Costa *et al.* (2017b) on the basis of material gathered from the Ponte Nova Reservoir (Southeastern Brazil). *E. longicamelus* is widely identified and cited as *E. camelus* Ehrenberg, however, the first species shows narrower valves, dorsal margin with two or four major undulations, and less concave ventral margin (Costa *et al.* 2017b). The species was reported from 11% of the core samples, reaching 2.5% maximum abundance, and occurring since the end of the Mid-Holocene, from ~5.192 cal. yr BP up to the core top. Current survey is the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470352, SP470356, SP470357, SP470359, SP470384, SP470385, SP470388).

****Eunotia rabenhorstii*** Cleve & Grunow var. ***monodon*** Cleve & Grunow, Synopsis des Diatomées de Belgique Atlas. pl. 35, fig. 12 [A-B]. 1881.

Figures 18, 19

Morphometry: L: 18.0-22.0 µm; W: 5.3-6.0 µm; S: 15-16 in 10 µm.

This variety is quite similar to *Eunotia rabenhorstii* Cleve & Grunow var. *triodon* Cleve & Grunow (1881: 12a), but, having a single undulation on the dorsal margin is unique for the var. *monodon* Cleve & Grunow (Patrick & Reimer 1966, Costa *et al.* 2017b). The species was rare, occurring in just 2% of the core samples, reaching 1% maximum abundance. It is found in samples from the Late Holocene (~408 cal. yr BP). This is the first report of the occurrence of the variety *monodon* in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.,* core XC1-02 (SP470334).

***Eunotia superbidens** Lange-Bertalot, Diatoms of Europe 6: 229, pl. 81, figs 1-10, pl. 82, figs 1-6. 2011.

Figure 20

Morphometry: L: 57.0-67.0 µm; W: 11.0-11.9 µm at the swellings, 6.0-10.0 µm at the apices ; S: 8-12 in 10 µm.

Eunotia superbidens Lange-Bertalot is very similar to *Eunotia praerupta* Ehrenberg (1843: 414), regarding their size, but differ in the presence of a single undulation on the dorsal margin, and the greater striae density. The species also differs from *Eunotia bigibba* Kützing (1849: 6) mainly by the more depressed undulations and its larger valves. This species was rarely met during the present investigation, being distributed in 2% of the core samples and reaching 1% maximum abundance. It is present in samples from the Late Holocene (~1.514 cal. yr BP). Current investigation is the first report of the presence of the species in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470360).

***Eunotia* sp.**

Figures 21, 22

Morphometry: L: 119-137 µm; W: 12-13 µm; S: 8-11 in 10 µm.

Eunotia sp. resembles *Eunotia myrmica* Lange-Bertalot (2011), but the latter has narrower and cuneate apices, as well as smaller valve dimensions (Pavlov & Levkov 2013: L: 58.8-67 µm). The taxon was rarely observed, occurring in 2 % of the core samples and reaching 1% maximum abundance. It is present in samples from the Late Holocene (~811 cal. yr BP).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470342).

Placoneis Mereschkowsky

* ***Placoneis exigua*** (Gregory) Mereschkowsky, Beihefte zum Botanischen Centralblatt 15(1), p. 1-30, pl.1, 1903.

Figure 23

Morphometry: L: 33-34 µm; W: 10.6-11.3 µm; S: 11-13 in 10 µm.

Present species resembles *Placoneis constans* (Husted) Cox var. *symmetrica* (Hustedt) Kobayasi in its valves and rostrate ends. However, *P. exigua* differs by having larger valves than *P. constans* and presents a central area with a shorter striae surrounded by longer striae (Bartozek *et al.* 2018). The species was reported for 6% of the core samples, thus reaching 1.5% maximum abundance. This taxon is met in samples from the end of the Mid-Holocene to the core top (~5.479 cal. yr BP to the present day).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC-03 (SP470346, SP470352, SP470372, SP470388).

Gomphonemataceae F.T.Kützing

****Gomphonema auritum*** A.Braun *ex* Kützing, Species algarum. 68. 1849.

Figures 24, 25

Morphometry: L: 18-22 µm; W: 4.9-5.1 µm; L/W: 3.6-4.3; S: 13-15 in 10 µm.

The species was found in 21% of the core samples surveyed, and reached 2.5% maximum abundance. The species is found in samples from the end of the Mid-Holocene to the core top (~5.479 cal. yr BP to the present day). Current study represents the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core

XC1-02 (SP470351, SP470354 to SP470356, SP470365, SP470375, SP470377, SP470378, SP470382, SP470384 to SP470386, SP470390).

*__*Gomphonema acuminatum*__ Ehrenberg, Abhandlungen der Königlichen Akademie Wissenschaften zu Berlin, Physikalische Klasse 1831: 88. 1832

Figure 26

Morphometry: L: ca. 44.0 µm; W: ca. 8.0 µm at the center; ca. 12 µm at apices; L/W: ca. 5.5; S: ca. 11 in 10 µm.

Based on the valve outline, *Gomphonema acuminatum* C.G.Ehrenberg is extremely similar to *Gomphonema brebissonii* F.T.Kützing (1849: 66) and *Gomphonema coronatum* C.G.Ehrenberg (1841: 211). However, *G. brebissoni* has a well reduced apical inflation, and *G. coronatum* a smaller inflation near the headpole (Kociolek 2011). Occurrence of *G. acuminatum* was rare, since it is found in only 2% of the core samples, reaching 1% maximum abundance. The species is found in samples from the Late Holocene up to the core top (~1.757 cal. yr BP to the present day). Present research is the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470362).

*__*Gomphonema brasiliensoides*__ Metzeltin, Lange-Bertalot & García-Rodríguez, Iconographia Diatomologica 15: 80, pl. 149, figs 1-10. 2005

Figures 27, 28

Morphometry: L: 32.0-40.0 µm; W: 5.3-7.3 µm; L/W: 5.7-6.0; S: ca. 11 in 10 µm.

Dimensions of *Gomphonema brasiliensoides* Metzeltin, Lange-Bertalot & García-Rodriguez are greater than those of *Gomphonema brasiliense* Grunow (Metzeltin *et al.* 2005: L: 24.0-60.0 µm, W: 6.6-9 µm and L: 22.0-44.0 µm, W: 5.5-6.7 µm; respectively). It was found in 13% of the core samples and reached 2% maximum abundance. The species is identified from samples from the end of the Mid-Holocene to the core top (~3.774 cal. yr BP to the present day). Present investigation represents the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470342, SP470349, SP470350, SP470352, SP470353, SP470359, SP470362, SP470377).

***Gomphonema curvipedatum** H.Kobayasi *ex* Osada, Atlas of Japanese diatoms based on electron microscopy 1: 10, pl. 122, figs 1-13. 2006.

Figure 29

Morphometry: L: 24.5-34.0 µm; W: 4.5-6.0 µm; L/W: 5.4-5.6; S: ca. 14 in 10 µm.

It differs from *Gomphonema hawaiiense* Reichardt (2005: 119) by having smaller valves dimensions (L: 24.5-34.0 µm; W: 4.5-6.0 µm and L: 32.6-55.0 µm; W:6.3-9.5 µm respectively). (Tremarin *et al.* 2009) and curved subcapitate apices. The taxon was found in 5% of the core samples, reaching 1% maximum abundance. This species is present in samples from the end of the Mid-Holocene (~4.345 cal. yr BP). Current investigation represents the first report of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470337, SP470355, SP470381).

****Gomphonema pseudosphaerophorum** H.Kobayasi, Proceedings of the International Diatom Symposium 9: 452, pl. 1, figs 1-10. 1988.

Figure 30

Morphometry: L: 50-62.6 µm; W: 8.6-9.3 µm; S: 10-12 in 10 µm.

Gomphonema pseudosphaerophorum H. Kobayasi has slightly narrower valves than *Gomphonema sphaerophorum* Ehrenberg (1845: 78, Tyree & Vaccarino 2016: W: 8.1-9.4 µm and W: 12.8-13.2 µm, respectively). Additionally, *G. pseudosphaerophorum* has dimly punctate striae radiating throughout the valve, whereas *G. sphaerophorum* has nearly parallel striae at the mid-valve, becoming radiate toward the apices. Occurrence of representative specimens of this species was rare and only found in 2% of the core samples, reaching 1% maximum abundance. It is present in samples corresponding to the Late Holocene (~456 cal. yr BP). Current study is the first citation of the occurrence of this species in Brazil.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470342).

***Gomphonema* sp.**

Figures 31, 32

Morphometry: L: 43.8-55.8 µm; W: 7.8-8.3 µm; L/W: 5.6-6.7 µm, S: 11-12 in 10 µm.

Valves lanceolate to rhombic-lanceolate, apices rostrate, axial area narrow, linear, and slightly widened in the central area. Raphe slightly curved. Striae parallel, slightly radiating towards the ends. Stigma positioned at the end of the longest central striae.

This taxon presents morphological features similar to *Gomphonema naviculoides* W.Smith, regarding the valve shape. However, both species differ in valve dimensions and striae density. According to Reichardt (2015), *G. naviculoides* presents 35-45 µm in length, and 7.8-9.5 µm in width, with 12-14 striae in 10 µm. Due to the absence of ultrastructural details (SEM), we decided to retain *Gomphonema* sp. as a distinct taxon. It was present in 8% of the core samples, and reached 2.3% maximum abundance. It occurs during the Late Holocene from ~1.322 cal. yr BP.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470350, SP470352, SP470353, SP470355, SP470359).

Achnanthidiaceae D.G.Mann

Gogorevia Kulikovskiy, Glushchenko, Maltsev & Kociolek

****Gogorevia exilis*** (Kützing) Kulikovskiy & Kociolek, Journal of Phycology 56(5): 2020

Figures 33, 34

Morphometry: L: 14.0-15.0 µm; W: 7.3-8.0 µm; S: 22-23 in 10 µm.

This species was described by Grunow (1880: 21) as *Achnanthes exigua* and later on transferred to *Achnanthidium exiguum* by Czarnecki (1994: 157). However, according to Taylor *et al.* (2014) the type of *A. exiguum* have significant morphological differences as compared with members of *Achnanthidium,* suggesting that the transfer based on the structure of the raphe was not correct. Due to the presence of morphological features, such as sigmoid raphe, where the distal raphe ends curve to the different sides, uniseriate striae, and shape of the valves the species was transferred to *Gogorevia* by Kulikovskiy *et al.* (2020). The species is present in 5% of all core samples, reaching 1.5% maximum abundance. It occurred in the Late Holocene (~1.514 cal. yr BP). The species was already reported for Brazilian Amazon, in the Negro river, as *Achnanthidium exiguum* (Grunow) Czarnecki, however, the present is to be considered the first report for the country using its correct name.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi, et al.*, core XC1-02 (SP470350, SP470351, SP470360), Porto de Moz, core XC-03 (SP513827, SP513829).

Planothidium Round & Bukhtiyarova

****Planothidium pulcherrimum*** (Hustedt) Coste, Essai de biotypologie et application au diagnostic du bon état écologique. 9, fig. 6. 2010.

Figures 35, 36

Morphometry: L: 23.3-30.0 µm; W: 10.0-14.0 µm; S: 9-10 in 10 µm.

This species was described by Hustedt (1952: 392, fig. 99-100) as *Cocconeis pulcherrima* and later on transferred to *Achnanthes pulcherrima* by Metzeltin & Lange-Bertalot (1998: 18, pl. 69, fig. 9-14, pl. 70, fig. 1, 4, p. 366, pl. 66, fig. 1-9). However, that transference was considered not valid because the basionym was not mentioned (Coste *et al.* 2010). Due to the presence of a cavum (rimmed depression at the valve central area), which is a distinguishing character for species in the genus, it was later transferred to *Planothidium* by Coste *et al.* (2010). It was present in just 2% of the core samples, and reached 1% maximum abundance. It occurred in samples that corresponded to the end of the Mid-Holocene (~5.479 cal. yr BP). This is the first record of the presence of this species in Brazil using its correct name, and the first citation for the species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470389).

Achnanthaceae Kützing

Achnanthes* cf. *inflata (Kützing) Grunow *in* Fenzl, E. *et al.* Reise der österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859 unter den Befehlen des Commodore B. von Wüllerstorf-Urbair. Botanischer Theil. Erster Band. Sporenpflanzen. 7. 1868.

Figures 37, 38

Morphometry: L: 54.0-57.0 µm; W: 13.0-14.0 µm; S: 12-13 in 10 µm; A: 10-13 in 10 µm

This material is identified as *Achnanthes* cf. *inflata* (Kützing) Grunow due to its representative specimens show slightly less rounded ends than the ones described by Grunow (1868). However, other morphological characteristics coincided with Grunow (1868) original description. Our specimens have wider valve ends than *Achnanthes inflata* var. *elata* (Leuduger-Fortmorel) Hustedt (1937: 206), and differ from *Achnanthes coarctata* (Brébisson *ex* W.Smith) Grunow (1880: 20) by the presence of a central inflation at the valve margin and by being not constricted as is the latter. The species was found in just 2% of the core samples, and reached 1% maximum abundance in samples corresponding to the Late Holocene (~625 cal. yr BP). This is the first report for the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470348).

Diadesmidaceae D.G.Mann

Luticola D.G.Mann

****Luticola intermedia*** (Hustedt) Levkov, Meltzeltin & A.Palov, Diatoms of Europe 7: 138, pl. 20, figs 1-16, pl. 21, figs 28-40. 2013.

Figures 39, 40

Morphometry: L: 27.0-28.0 µm; W: ca. 8.0 µm; S: 17-20 in 10 µm.

Present species resembles *Luticola acidoclinata* Lange-Bertalot (1996) in its valve outline and dimensions (L: 10-30 µm, W: 5.0-8.5 µm). However, *Luticola intermedia* (Hustedt) Levkov, Meltzeltin & A.Palov exhibits a narrow and linear axial area, with 4-5 isolate areolae at the valve margin (Levkov *et al*. 2013). It was present in only 3% of the core samples, and reached 1% maximum abundance. The species is present in samples corresponding to the Late Holocene (~689 cal. yr BP). Current inventory is the first report of this species presence in the Brazilian Amazon.

Material examined: BRASIL, PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470340, SP470350).

Caloneis Cleve

***Caloneis* sp.**

Figures 41, 42

Morphometry: L: 33.0-49.0 µm; W: 8.0-9.0 µm; S: 19-20 in 10 µm.

Caloneis sp. resembles *Caloneis* sp. Nº. 163/14 in Metzeltin & Lange-Bertalot (1998: 560, pl. 163, fig. 14). However, the specimens from Xingu river present slightly panduriform valves. Further studies are required to confirm if this taxon is a new species. During the present study, the taxon was present in 11% of the core samples, and reached 2.5% maximum abundance, occurring in samples corresponding to the end of the Mid-Holocene (~5.192 cal. yr BP).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470336, SP470350, SP470354, SP470357, SP470358, SP470380, SP470387).

Diploneidaceae D.G.Mann

****Diploneis elliptica*** (Kützing) Cleve var. ***elliptica***, Kongliga Svenska Vetenskapsakademiens Handlingar, séries 4, 26(2): 92. 1894.

Figures 43-45

Morphometry: L: 18.3-30.0 µm; W: 13-18 µm; S: 9-11 in 10 µm, A: ca. 14 in 10 µm.

The population of *Diploneis elliptica* (Kützing) Cleve var. *elliptica* showed valve morphology and striae density similar to the ones illustrated by Krammer & Lange-Bertalot (1986: fig. 108: 1-4). However, samples analyzed from the Xingu river showed specimens smaller than those described for the species (L: 20-130 µm). It was present in 2.6% of the core samples, and reaches

3% maximum abundance. *D. elliptica* var. *elliptica* was identified from samples corresponding to the Late Holocene (~1.730 to 560 cal. yr BP). This is the first citation of the species presence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Porto de Moz, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP513826).

Naviculaceae Kützing

Navicula Bory

****Navicula notha*** Wallace, Notulae Naturae Bacillarien order Diatomeen. 4, pl. 1, fig. 4A-D. 1960.

Figures 46, 47

Morphometry: L: ca. 26.9 µm; W: ca. 5.0 µm; S: ca. 15 in 10 µm.

Considering the valve shape, *Navicula notha* Wallace resembles *Navicula cryptocephala* Kützing (1844: 95), but differs in having smaller valves, with an inconspicuous central area in the smaller specimens, and rhombic shape in the larger ones (Potapova 2011). The species occurred only in 3% of the core samples, and reaches 1.3% maximum abundance. It is present in samples corresponding to the Late Holocene (~2.909 cal. yr BP). This is the first report of its occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470358, SP470371).

Sellaphoraceae Mereschkowsky

Sellaphora Mereschkowsky

*****Sellaphora emilia*** Metzeltin & Lange-Bertalot, Iconographia Diatomologica 18: 234, pl. 159, figs 3-6. 2007.

Figure 48

Morphometry: L: 52.0-55.0 µm; W: 12.0-12.6 µm; S: 19-20 in 10 µm.

Sellaphora emilia Metzeltin & Lange-Bertalot belongs to the group *bacillum* of genus *Sellaphora* (Mann *et al.* 2008). Differs from *Sellaphora renata* Metzeltin & Lange-Bertalot in having valves with consistently straight margins, less broadly rounded ends and by the smaller valve dimensions (2007: L: 45.0-124.0 µm, W: 12.0-14.0 µm and L: 45.0-140.0 µm, W: 15.0-21.0 µm; respectively). The species was present in only 2% of the core samples, and reaches 1% maximum abundance. It is also present in samples corresponding to the Late Holocene (~1.757 cal. yr BP). Current study is the first report of the species occurrence in Brazil.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470363).

***_Sellaphora rectangularis_** (Gregory) Lange-Bertalot & D.Metzeltin, Iconographia Diatomologica 2: 102, pl. 25, figs 10-12, pl. 125, fig. 7. 1996.

Figures 49, 50

Morphometry: L: 29.0-36.0 µm; W: 7.0-8.0 µm; S: ca. 23 in 10 µm.

This species belongs to the group "*pupula*" of *Sellaphora* and differs from *Sellaphora pupula* (Kützing) Mereschkovsky (1902: 187) in its linear elliptical valves, with broadly rounded poles (Mann *et al.* 2008). It was present in 35% of the core samples, reaching 6% maximum abundance. The species was identified from samples corresponding to the end of the Mid-Holocene to the core top (~6.000 cal. yr BP to the present day). Current study is the first communication of this species occurrence in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470332 to SP470340, SP470342 to SP470344, SP470348, SP470351, 470358, SP470371, SP470377, SP470382, SP470390, SP470392).

Sellaphora renata Metzeltin & Lange-Bertalot, Iconographia Diatomologica 18: 1-877, incl. 296 pl. 2007.

Figures 51, 52

Morphometry: L: 76.0-88.0 µm; W: 10.0-14.0 µm; S: 19-20 in 10 µm.

Based on the valve outline, *Sellaphora renata* Metzeltin & Lange-Bertalot is quite similar to *Sellaphora lambda* (Cleve) Metzeltin & Lange-Bertalot (1998: 206). However, *S. renata* lack of marginal spines present in *S. lambda* (Metzeltin & Lange-Bertalot 2007). The species was found in 5% of the core samples and reached 1.5% maximum abundance. It was identified in samples corresponding to the early Late Holocene (~1.322 cal. yr BP).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470342; SP4703587; SP470358).

*****Sellaphora sassiana*** (Metzeltin & Lange-Bertalot) C.E.Wetzel, Fottea 15(2): 228. 2015.

Figures 53, 54

Morphometry: L: 14.0-15.0 µm; W: 1.2-1.3 µm; S: ca. 30 in 10 µm.

According to Wetzel *et al.* (2015), *Naviculadicta sassiana* Metzeltin & Lange-Bertalot (1998) was first described for the Amazonian region (Tapajós river, Brasil), and was later on transferred to *Sellaphora* based on the LM illustrations in Metzeltin & Lange-Bertalot (1998). *Sellaphora sassiana* was present in 5% of the core samples, reaching 9.6% maximum abundance. It occured in samples corresponding to the Late Holocene (~408 cal. yr BP). The species was already reported for Brazil, from the Tapajós river, as *Naviculadicta sassiana* (*e.g*., Metzeltin & Lange-Bertalot 1998), however, the present is to be considered the first report for the country using its correct name.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470331 to SP470333).

****Sellaphora ventraloconfusa*** (Lange-Bertalot) Metzeltin & Lange-Bertalot, Iconographia Diatomologica 5: 212. 1998.

Figure 55

Morphometry: L: ca. 21.0 µm; W: ca. 6.0 µm.

In a review of several *Sellaphora* materials, Mann *et al.* (2004) mentioned that *Sellaphora ventraloconfusa* (Lange-Bertalot) Metzeltin & Lange-Bertalot should be included in the *Sellaphora seminulum* (Grunow) D.G.Mann group, but all information available to date is still insufficient to confirm it. This species was present at only 2% of the core samples, and reached 1% maximum abundance. It occurred from samples corresponding to the Late Holocene (~408 cal. yr BP). Current investigation is the first document of the occurrence of the species in the Brazilian Amazon.

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470341).

Lacuneolimna Tudesque, Le Cohu & Lange-Bertalot

*****Lacuneolimna novagallia*** Tudesque & Le Cohu, Phytotaxa 231(1): 24, figs 43-71. 2015.

Figure 56

Morphometry: L: 16.2-16.6 µm; W: 7.7-8.6 µm; S: 15-18 in 10 µm.

Lacuneolimna novagallia Tudesque & Le Cohu is distinguished from *Lacuneolimna zalokariae* Tudesque & Le Cohu (2015: 21) in its continuous depressions in valve face, wider costae, and more expanded "cross-bar network" (Tudesque *et al.* 2015). It was present in 0.6% of the core samples, reaching 2% maximum abundance. The species was identified from samples corresponding to the Late Holocene (~1.790 cal. yr BP). This is the first citation of the species presence in Brazil.

Material examined: BRASIL. PARÁ: Porto de Moz, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC-03 (SP513828).

Pinnulariaceae D.G. Mann

Pinnularia Ehrenberg

Pinnularia* cf. *liyanlingae Metzeltin & Lange-Bertalot, Iconographia Diatomologica 18. p.207, pl. 238-239, figs 1-4; 1-3. 2007.

Figure 57

Morphometry: L: 86.0 µm; W: 22.0 µm; S: 9 in 10 µm.

In the present study, this taxon was identified as *Pinnularia* cf. *liyanlingae*, because the specimens presented smaller dimensions than those described by Metzeltin & Lange-Bertalot (2007, L: 94-200 µm, W: 24-32 µm). The taxon was found in 15% of the core samples and reached 1.5% maximum abundance. It was identified in samples corresponding to the early Late Holocene to the core top (~1.322 cal. yr BP to the present day).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470340 to SP470342; SP470344; SP470347; SP470356 to SP470359).

Stauroneidaceae D.G.Mann

Stauroneis Ehrenberg

Stauroneis sp.

Figures 58, 59

Morphometry: L: 84.0-88.0 µm; W: 17.0-18.0 µm; S: 19-20 in 10 µm; A: 21-22 in 10 µm.

This taxa resembles *Stauroneis sylviabonillae* Metzeltin, Lange-Bertalot & García-Rodríguez in regard to the lanceolate valve shape, however, *Stauroneis* sp. has smaller valves dimensions and higher striae density than those described in Metzeltin *et al.* (2005: L:103-120 µm, W:20-22 µm, S:15-16 in 10µm).Moreover, *S. sylviabonillae* has proximal raphe fissures slightly deflected, such feature isn't observed *Stauroneis* sp. Material examined also differs from *Stauroneis anceps* Ehrenberg (1843: 291-445 105) due to its narrow, rostrate, and long apices (Bahls 2011). In the present study, *Stauroneis* sp.1 was present in 5% of the core samples, reaching 2% maximum abundance. It occurred in samples corresponding to the Late Holocene (~2.909 cal. yr BP).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470378, SP470380, SP470388).

Stauroneis sp.1

Figures 60-62

Morphometry: L: 108.0-124.0 µm; W: 14.0-15.0 µm; S: 18-19 in 10 µm.

This material resembles that of *Stauroneis schinzii* (Brun) Cleve (1894: 146), however, the latter has very broadly rounded valve apices and greater cell dimensions (Patrick & Reimer 1966: L: 130-221 µm, W: 17-19 µm, S: 15-18 in 10 µm) than *Stauroneis* sp.1. The latter material is further characterized by having linear valves, obtusely rounded subrostrate apices, broad linear slightly irregular axial area that suddenly turns ovoid at the terminal ends, relatively small fascia that slightly expands toward the margin, broad raphe that somewhat narrows near by the proximal and distal ends, branched distal raphe ends that form semicircular hooks bending to the same direction, and radiate striae at the valve center that become parallel toward the ends. It is present in 35% of the core samples, and reached 2.6% maximum abundance. The taxon was identified from samples corresponding to the end of the Mid-Holocene to the core top (~5.760 cal. yr BP to present).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470331, SP470332, SP470336, SP470339, SP470342, SP470345, SP470349, SP470350, SP470352 to SP470357, SP470359, SP470362, SP470364, SP470375, SP470376, SP470382, SP470388, SP470390).

Bacillariaceae Ehrenberg

****Nitzschia pusilluhasta*** E.A.Lehmkhul & C.E.M.Bicudo, Phytotaxa 339(1): 86, figs 2-21, 53-58. 2019.

Figures 63, 64

Morphometry: L: ca. 20 µm; W: ca. 3 µm; F: ca. 11 in 10 µm, S: ca. 20 in 10 µm.

Nitzschia pusilluhasta E.A.Lehmkhul & C.E.M.Bicudo differs from *Nitzschia amphibia* Grunow (1862: 574) because the latter species has lanceolate valves with slightly protracted ends, and a gap between the central fibulae (Lehmkuhl *et al*. 2019: 25-26). It can be also misidentified as *Nitzschia semirobusta* Lange-Bertalot (1993: 149), however, *N. pusilluhasta* has greater valve dimensions and rectangular, short to slightly extend fibulae. It was present in 0.6% of the core samples and reaches 3% maximum abundance. In the current study, *N. pusilluhasta* was identified from samples corresponding to the Late Holocene (~2.400 cal. yr BP). This is the first report of the species occurrence in the Amazon basin.

Material examined: BRASIL. PARÁ: Porto de Moz, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC-03 (SP513827).

Surirellaceae Kützing

Surirella Turpin

***Surirella* sp.**

Figure 65, 66

Morphometry: L: 40.0-45.0 µm; W: 10.0-10.6 µm; S: 25-27 in 10 µm; AC: 3-4 in 10 µm.

Surirella sp. resembles *Surirella terryi* D.B.Ward *ex* W.A.Terry (1907: 127) in its heteropolar valves and the cuneate valve apices. However, the latter species has a more pronounced central area along the apical axis and greater valve dimensions (Ferreira & Bicudo 2017: L: 67-176 µm, W: 23-35 µm). The species is also characterized by its asymmetric linear valves with a rounded headpole and a cuneate footpole, a narrow hyaline axial area, lack of costae, non visible fibulae, and low keel and alar canals parallel to each other. This taxon was present in 5% of the core samples, reaching 1% maximum abundance. It was identified from samples corresponding to the Late Holocene (~973 cal. yr BP).

Material examined: BRASIL. PARÁ: Altamira, Rio Xingu, 2014, *A.O. Sawakuchi et al.*, core XC1-02 (SP470331, SP470332, SP470343).

Discussion

Overall, 38 taxa from 20 genera were recorded along the study period (~6.000 cal yr BP). Moreover, five new records of diatom species were added for Brazil as well as nineteen new records for the Brazilian Amazon.

Gomphonema was the most represented genus in species number (six species), followed by *Eunotia* (five species), *Sellaphora* (five species) and *Staurosirella* (four species).

Considering the studied period, only three species exclusively occurred during the end of the Mid-Holocene reaching 4.5% maximum abundance. This low abundance of diatoms species during the end of the Mid-Holocene may be related to the deeper waters with hydrological flow. This finding is consistent with the results in studies in the Amazon Basin (*e.g.,* Cordeiro et al., 2008, Moreira et al. 2013, Brugger et al. 2016, Fontes et al. 2017).

In the Late Holocene, 20 species were reported reaching 45.2% maximum abundance, of which five are new records or the Brazilian territory (*Aulacoseira crassipunctata*, *Gomphonema pseudosphaerophorum*, *Sellaphora emilia*, *S. sassiana* e *Lacuneolimna novagallia*). In this period, the diatom assemblage was composed by benthic species suggesting a shallower water condition with with low conductivity, oligotrophic and acidic waters (Moro & Fürstenberger 1993, Van Dam et al. 1994, Metzeltin & Lange-Bertalot 2007, Bahls et al. 2009, Tudesque et al. 2015).Similar result was registered by Cardozo et al. (2014), in Lake Tota, Colombia during the Late Holocene and was attributed to a drier period with high temperatures and low precipitation.

An additional 14 species were indistinctly distributed throughout the core, reaching 75.3% maximum abundance. The results showed that this variation in diatoms species can indicate water level changes in the Xingu river, so that at the end of the Mid-Holocene the system presented deep waters that gave way to shallower waters in the Late Holocene.

In the last years, the Brazilian amazon basin has been experiencing a great number of new species (Wetzel et al. 2010a, 2010b, 2011, 2012a, 2012b, Burliga et al. 2013, Tremarin et al. 2013a, 2014a, 2014b, Pereira et al. 2014, 2015, 2017, Almeida et al. 2017, Almeida et al. 2018, Canani et al. 2018) demonstrating how scant is the knowledge of the diatoms in this region. Furthermore, the present new records for the Brazilian Amazon represent a 75% increase in the total number of records for the region, and strengthen that the region remains poorly investigated and its biodiversity assessment is considerably underestimated. Finally, the present study highlights the importance of a paleolimnological approach as an available tool to assess changes in biodiversity over a long time scale and increase the knowledge of diatoms, especially in amazonian ecosystems.

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Author Contributions

Samantha B. Faustino: Contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.

Krysna S. de Morais: Contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.

Carlos Eduardo de Mattos Bicudo: Contribution to critical revision, adding intellectual content.

Denise C. Bicudo: Contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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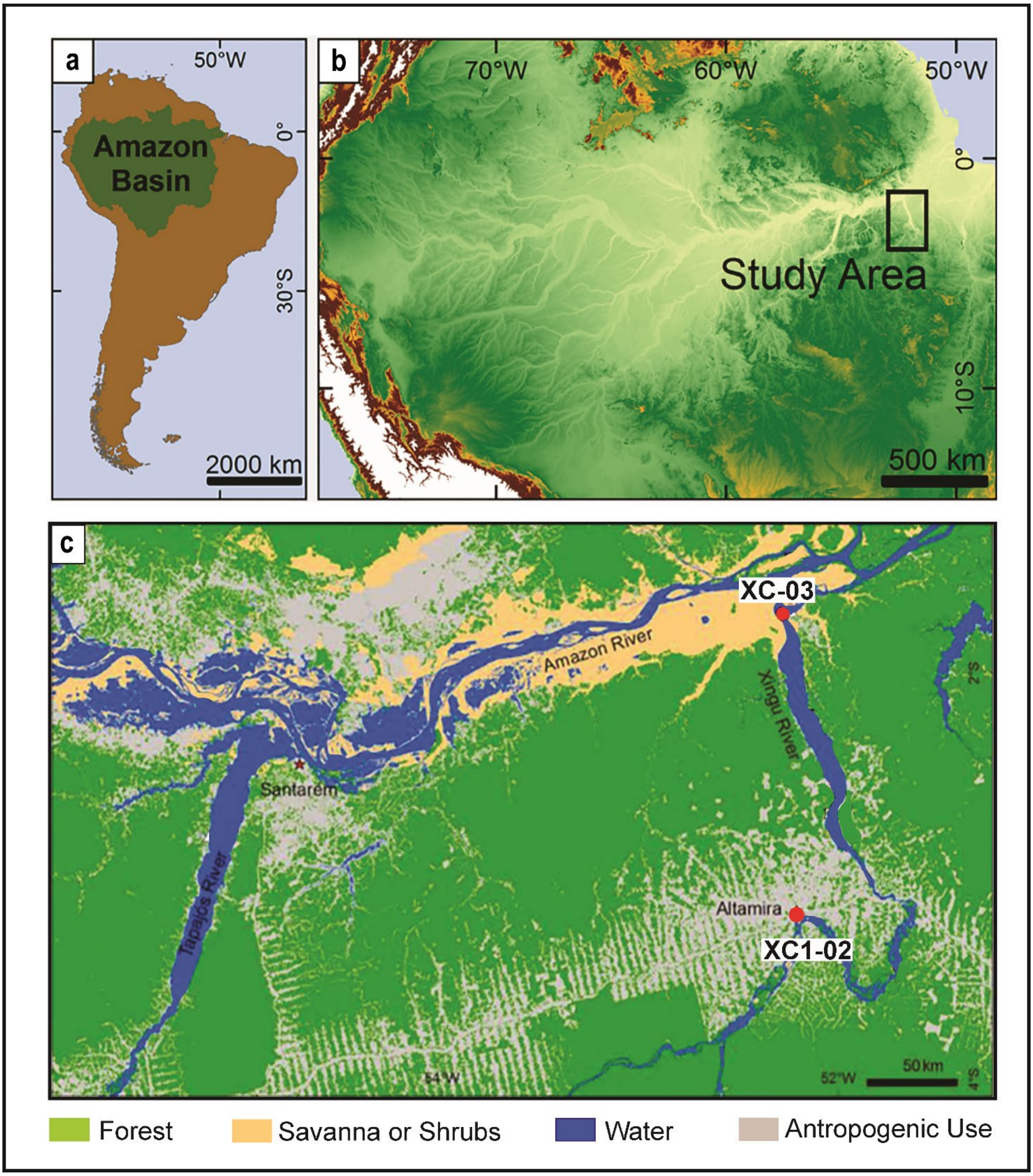
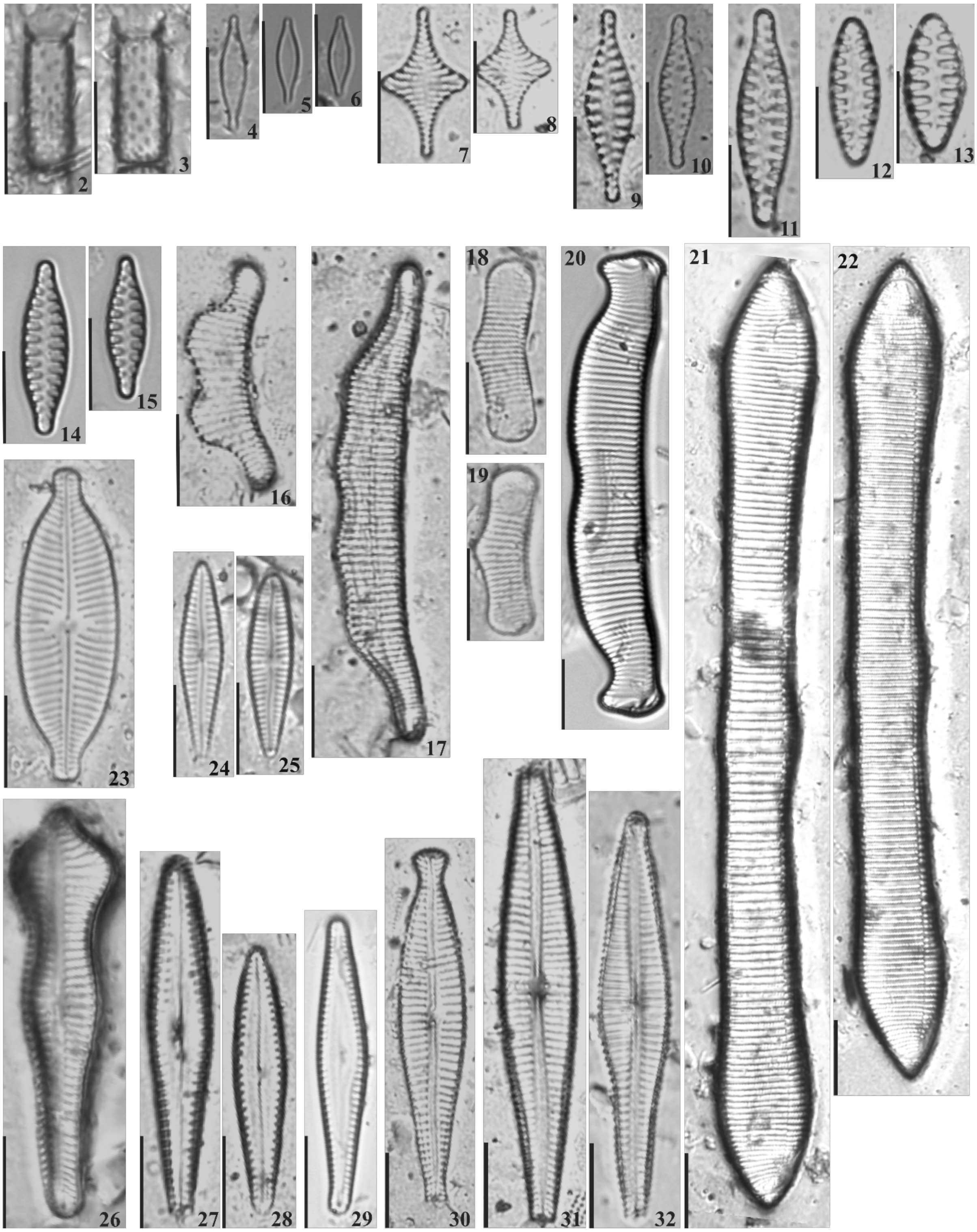


Figure 1. Location of the sampling site. a. Amazon basin, b. Xingu river basin, c. Location of the floodplain lake on Arapujá island (XC1-02) and Xingu Ria (XC-03). Maps adapted from Sawakuchi *et al*. (2015), Almeida *et al*. (2016) and Bertassoli *et al*. (2017).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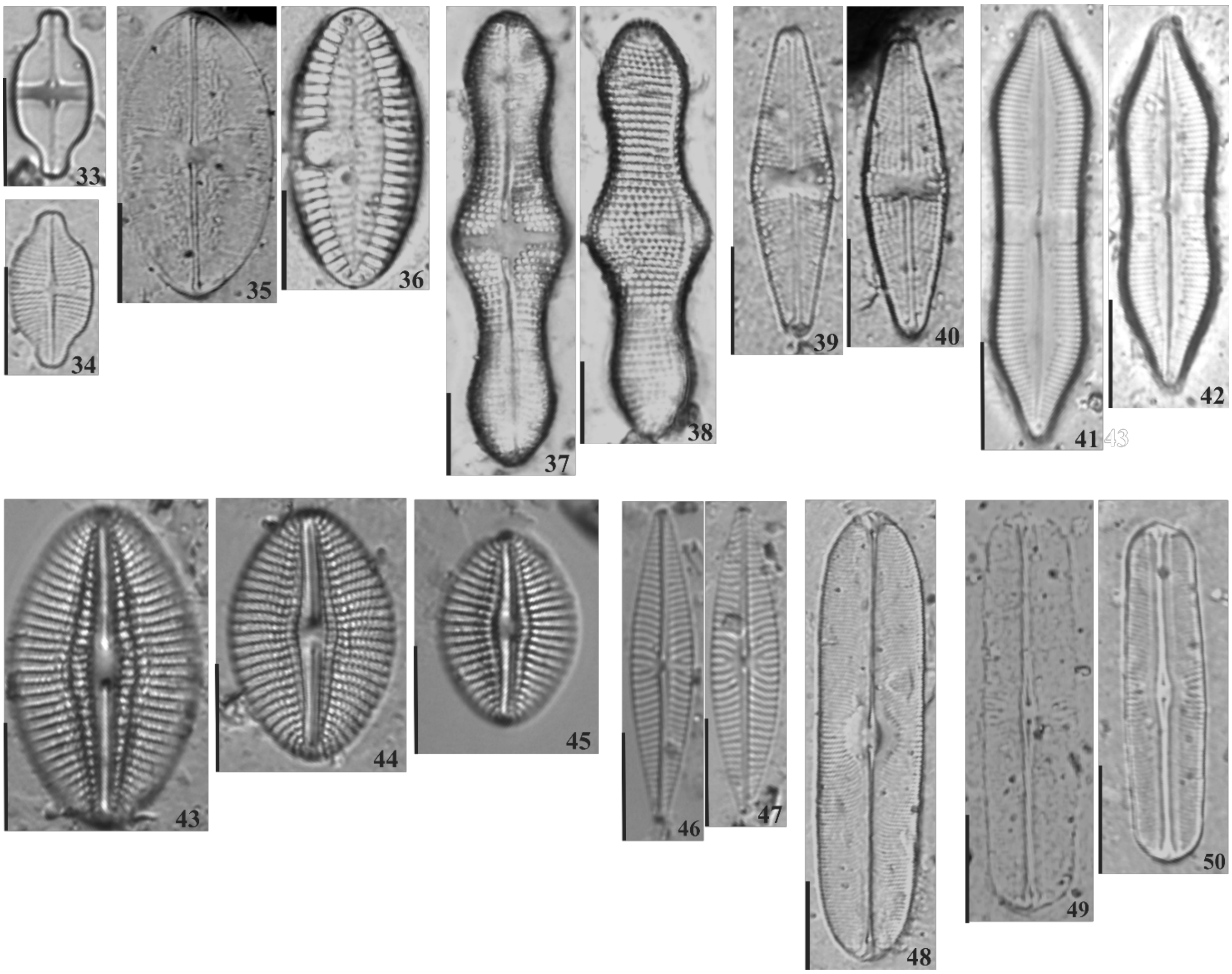

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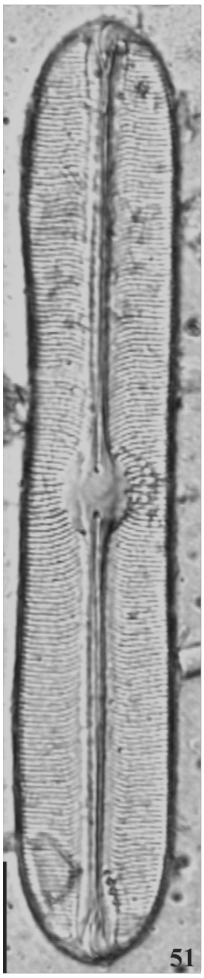
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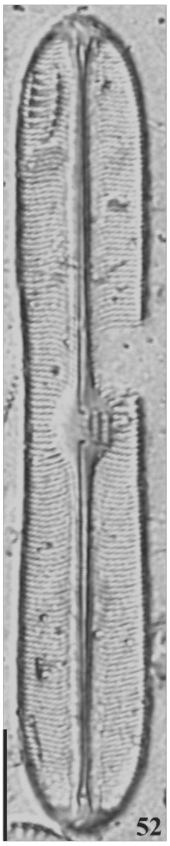
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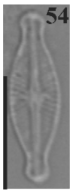
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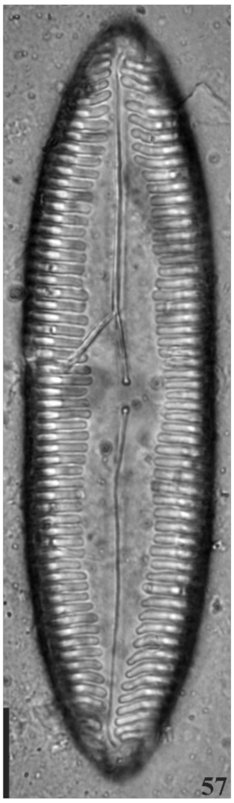
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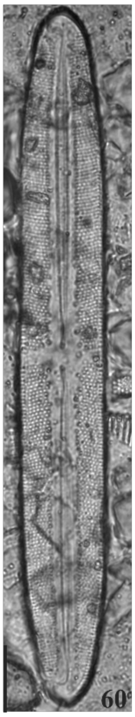
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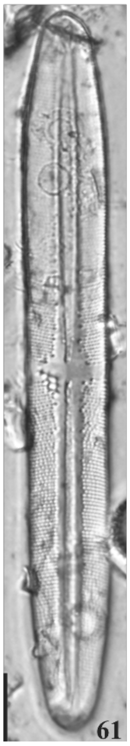
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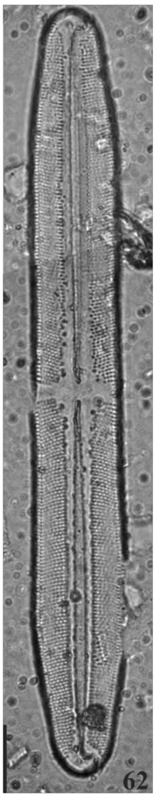
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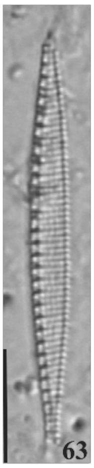
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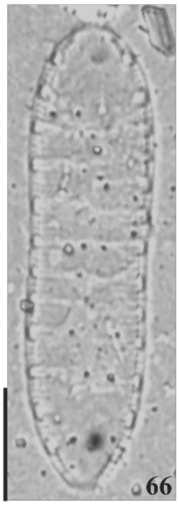
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