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Actinella species (Bacillariophyta) from an Amazon black water floodplain lake (Amazonas – Brazil)

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ABSTRACT
The genus *Actinella* Lewis was studied using planktonic samples from a black water floodplain lake in Central Amazon region. For species identification the taxa were morphological and morphometricaly analyzed on base in light microscope (LM) and scanning electronic microscope (SEM). Five species were registered: *Actinella brasiliensis* Grunow, *A. guianensis* Grunow, *A. gracile* Kociolek, *A. mirabilis* (Eulenstein ex Grunow) Grunow and *A. robusta* Hustedt. *A. gracile* is reported for the first time for Amazon State and black water systems and it is firstly documented with SEM. In addition, a review of geographic distribution of *Actinella* species in Brazilian Amazon region is given.

KEYWORDS: *Actinella*, diatoms; Amazon, black water, floodplain lakes

Espécies de *Actinella* (Bacillariophyta) de um lago de inundação amazônico de águas pretas (Amazonas – Brasil)

RESUMO
O gênero *Actinella* Lewis foi estudado a partir de amostras coletadas em um lago de inundação de águas pretas na Amazônia Central. Para a identificação das espécies as características morfológicas e morfométricas dos táxons foram analisadas em microscopia óptica (MO) e eletrônica de varredura (MEV). Cinco espécies foram identificadas: *Actinella brasiliensis* Grunow, *A. guianensis* Grunow, *A. gracile* Kociolek, *A. mirabilis* (Eulenstein ex Grunow) Grunow e *A. robusta* Hustedt. *A. gracile* é referida pela primeira vez para o estado do Amazonas e para ambientes de águas pretas, sendo documentada pela primeira vez em MEV. Em adição, uma revisão sobre a distribuição geográfica das espécies de *Actinella* na região da Amazônia brasileira é apresentada.

PALAVRAS-CHAVE: *Actinella*, diatomáceas, lagos de inundação, águas pretas, Amazônia

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INTRODUCTION

Actinella Lewis 1863 belongs to Eunotiaceae, the only family of raphids diatoms with rimoportulae. Due to both the presence of the rimoportulae and the rudimentar raphe, they constitute an intermediate group between the primitive araphids and the more advanced raphe-bearing (Kociolek, 2000; Kociolek and Spaulding, 2003; Novitski and Kociolek, 2005). This genus presents cells solitary or clustered, the frustules forming star-shaped colonies by the attachment of the smaller ends of the frustules (Patrick and Reimer, 1966). In valve view the valves are slightly curved, expanded at one end (headpole) with short spines on the margins of the valve, attached to solid substrata by the narrow end (footpole).

Actinella species are mainly found, in tropical region (Round *et al*., 1990) and the main centers of diversity are tropical South America and Africa (Sabbe *et al*., 2001). Actually, *Actinella* genus comprises around 60 species, from which around 50% of them were described in the last ten years: two species from Madagascar, twenty three from South America and six from the Australasian region (Kocioleck *et al*., 1997; 2001; Metzeltin and Lange Bertalot, 1998; 2002; 2007; Sabbe *et al.,*2001). In addition *A. punctata* var. *australis* Manguin was moved to *A. australis* according to Kociolek *et al*. (1997) and some *Eunotia* species were recently transferred to *Actinella* genus by Metzeltin and Lange Bertalot (2007).

In Amazon State, two *Actinella* species were described, recently: *A. disjuncta* Metzeltin and Lange-Bertalot and *A. rionegrenses* Metzeltin and Lange-Bertalot, found in Calado lake and Negro River, respectively. In the Negro River basin, ten *Actinella* species were registered in the literature: *A. pararobusta* Metzeltin et Lange-Bertalot, *A. pseudohantzschiana* Metzeltin and Lange-Bertalot, *A. brasiliensis*; *A. curvatula* Kociolek, *A. gessneri* Hustedt, *A. guianensis*, *A. mirabilis*, *A. punctata* Lewis, *A. rionegrenses, A. robusta* Hustedt*, A. siolii* Hustedt e *A. tasmaniensis* Hustedt (Uherkovich and Rai, 1979; Uherkovich and Franken, 1980; Furushima and Xavier, 1988; Souza-Mosimann *et al*., 1997; Putz, 1997; Putz and Junk, 1997; Metzeltin and Lange-Bertalot, 1998; 2007; Díaz-Castro *et al*., 2003, Melo *et al*., 2004; 2005, Ferrari *et al*., 2007).

The aim of this study is to describe *Actinella* species found in an Amazon black water floodplain lake based on the morphometric and morphologic features in optical and/or scanning electronic microscope. We also offer information about the geographic distribution of *Actinella* species in Brazilian Amazon region.

MATERIAL AND METHODS

This study was based on samples taken in ten stations in Cutiuaú Lake (Table 1), an floodplain lake located on the right bank of Jaú river, an affluent of the right bank of Negro river. These sites are situated in Jaú National Park in the middle Negro river basin. According to Sioli classification (Sioli, 1984), Cutiuaú lake is a typical black water systems, characterized by low pH and electrical conductivity and high concentrations of humic composts.

A total of 10 samples collected in November 2003 (low water period) were analyzed. The samples were collected by plankton net with mesh size of 25 µm, and fixed with Transeau solution. An aliquot of sample was concentrated and the frustules were cleaned according to the method of Stoch (1970). For analysis in LM the slides were mounted in Naphrax and examined in a Zeiss Axioplan photomicroscope. For SEM analysis the material was mounted on glass on stubs and metalized with gold-palladium and analized in Jeol JSM -5800 operated at 15-20 kV in the Federal University of Rio Grande do Sul.

The identifications of the taxa were based on Hustedt (1930,1952, 1965), Patrick and Reimer (1966), Krammer and Lange-Bertalot (1991), Metzeltin and Lange-Bertalot (1998, 2002, 2007), Kociolek *et al.* (2001). Classification system and terminology were based on Round *et al.* (1990). The analyzed material was stored at the Herbarium (INPA) of the Instituto Nacional de Pesquisas da Amazonia, Manaus, Amazonas, Brazil, numbers 222764-222773 (Table 1).

Table 1 - Sampling stations (SS) with geographic coordinates (GC) and Herbarium number (INPA) of samples collected in Cutiuaú Lake, Jaú National Park, Novo Airão, Amazonas, Brazil on 12/XI/2003

SS	GC	INPA
1	01º50'26''S; 61º37'40''W	222764
2	01º50'48''S; 61º37'16''W	222765
3	01º50'43''S; 61º36'53''W	222766
4	01º51'11''S; 61º37'17''W	222767
5	01º51'04''S; 61º36'54''W	222768
6	01º50'40''S; 61º35'51''W	222769
7	01º50'52''S; 61º37'03''W	222770
8	01º51'38''S; 61º37'01''W	222771
9	01º51'19''S; 61º36'13''W	222772
10	01º51'01''S; 61º35'54''W	222773

RESULTS AND DISCUSSION

TAXONOMICAL CONSIDERATIONS

Key for *Actinella* species identification

1. Valves with undulations on both dorsal and ventral margins *A. mirabilis*
2. Valves without undulations 3
   3. Headpole and footpole poorly distinct *A. robusta*
   3. Headpole and footpole clearly distinct from each other 4
4. Footpole cuneate *A. guianensis*
4. Footpole rounded 5
   5. Valves narrow, 2.8-4 µm wide *A. gracile*
   5. Valves broader, usually not less than 4 µm wide *A. brasiliensis*

Actinella brasiliensis Grunow in van Heurck, Synopsis des Diatomées de Belgique, Atlas, pl. 35, fig. 19. 1881.

(Figures 1-2)

Valves heteropolar, clavate, weakly arcuate, margins parallel. Headpole broadly spatulate- rounded. Footpole narrowly rounded. Punctate striae, parallel, continue from the valve mantle. Small spines present on the margin of the mantle in SEM view. Length 48-57 µm; breadth 4.8-5.5 µm; striae 16/ 10 µm; R l/b 10-14.

Studied material: INPA 222765, 222767, 222769, 222771, 222772

Actinella gracile Kociolek in Kociolek, Lyon and Spalding, Nova Hedwigia. Studies on Diatoms, p. 131-165. 2001.

(Figures 3-7)

Valves heteropolar, arched, narrow. Ventral margin of the valves concave, dorsal margin convex. Headpole barely swollen. Footpole narrowly rounded. Punctate striae, parallel, continue from the valve mantle, denser and radiate in the headpole. Small spines present on the margin of the mantle and two bigger spines at footpole in SEM view. Length 75-106.6µm; breadth 2.8-4µm; striae 16-18/ 10 µm.; R l/b 20.8-25.

Studied material: INPA 222770

Actinella guianensis Grunow in van Heurck, Synopsis des Diatomées de Belgique, Atlas, pl. 35, figs. 17, 20. 1881

(Figures 8-10)

Valves heteropolar, moderately arcuate. Headpole spatulate as cuneate. Footpole cuneate, less breadht than headpole. Spines around the valve mantle and footpole with two big spines on the apices visible externally in SEM. view. Punctuate striae, parallel, dense in the poles. Length 112-121.4 µm; breadth 6- 8.5 µm at the center of the valve; striae 7-13/ 10 µm; R l/b 14-18.

Studied material: INPA 222764, 222766, 222769, 222771, 222773

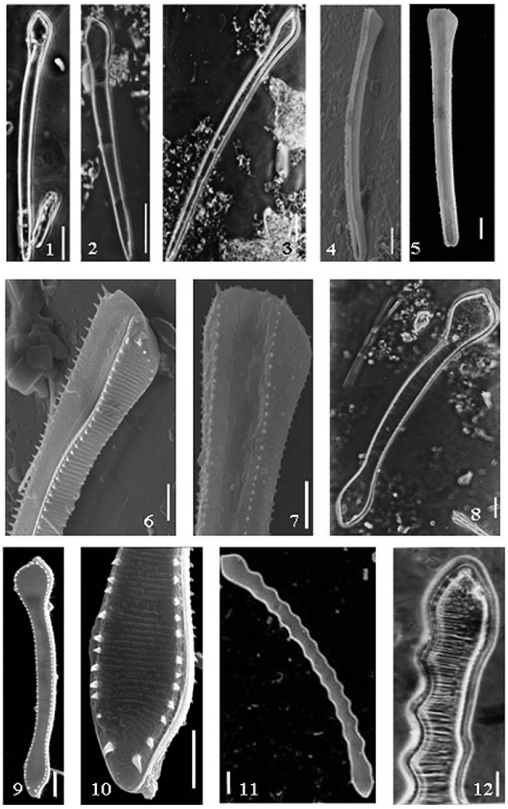
Actinella mirabilis (Eulenstein ex Grunow) Grunow in Van Heurck, Synopsis des Diatomées de Belgique, Atlas, pl. 35: figs. 16 a-c. 1881.

(Figures11-14)

Valves heteropolar, elongate, slightly heteropolar in valve view and arcuate. Apices pointed. Dorsal and ventral margin undulate. Punctuate striae, parallel, dense, continue from the valve face and radiate towards the apices. SEM: Helictoglossa and rimoportula are visible in internally valve view. Spines are present around the valve mantle and one big spine present on the apice of the valve in externally view. Short raphe curves from mantle onto valve face. Length 420-425 µm; breadth 16-20 µm; striae 9-13/ 10 µm, R l/b 21-26.

Studied material: INPA 222764, 222765, 222767, 222768, 222770, 222771, 222773

Actinella robusta Hustedt, Berichte der Deutschen Botanischen Gesellschaft, 65, p.135, pl.5: fig.6. 1952.



Figures 1-12 – 1, 2. *Actinella brasiliensis* valve view (LM). 3-7. *A. gracile*. 3. Valve view (LM). 4. Valve view (SEM). 5. Girdle view (SEM). 6. Detail of the head pole showing the spines (SEM). 7. Head pole with two bigger spines (SEM). 8-10 *A. guianensis*. 8. General valve view (LM). 9. General valve view (SEM). 10. Detail of the footpole showing the spines. 11,12. *A. mirabilis* (LM). 11. General valve view. 12. Detail of the foot pole. Scale bars: Figs. 1-4, 8-11 = 10μm . Figs 5, 12 = 5μm.

(Figures 15-20)

Valves heteropolar, elongate, slightly arcuate. Apices obtusely rounded, subcapitate in the dorsal margin. Dorsal margin moderately convex. Ventral margin moderately concave. Punctate striae, parallel, continue from the valve face, dense and radiate towards the terminal apices. Length 127.3- 216 µm; breadth 6.1- 7.2 µm; breadth in the headpole 6.7-8.3 µm; striae 8-12/ 10µm; R l/b: 19-34.

Studied material: INPA 222766, 222768, 222772

GEOGRAPHIC DISTRIBUTION IN BRAZILIAN AMAZON REGION

There are few published studies that list or describe *Actinella* species from the Brazilian Amazon region. In addition, they are concentrated in Amazonas and Pará States (Table 2). From 25 registered *Actinella* species in Brazilian Amazon region, 72% were described as new species (Table 2). This elevated number of *Actinella* species in Amazon region has led certain authors to suggest that the Amazon River is a center of diatom diversity (Kociolek *et al.* 2001).

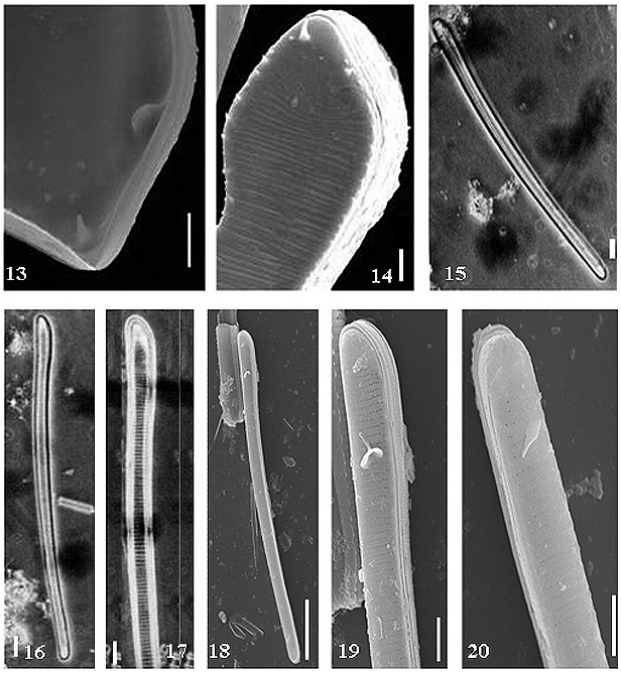
Actinella is usually found in extremely acid and humic waters, and most of the species are in semitropical or tropical waters (Patrick and Reimer, 1966; Round *et al.*, 1990) with an elevated occurrence in black water systems: environments characterized by low pH and electrical conductivity and high concentration of humic composts (Sioli, 1984).

This study registers five *Actinella* species in a black water floodplain lake. *A. mirabilis* was most frequent, registered in 70% of analyzed samples, followed by *A. guianensis* and *A. brasiliensis*. In fact, these species are the most common species in Brazilian Amazon region (Table 2). On the other hand, *A. gracile* was registered only twice in Pará State and now is documented for first time to Amazon State and black waters systems. In addition it is firstly documented in SEM showing small spines on the margin of the mantle and two bigger spines at footpole.

Table 2 - List of *Actinella* species found in Brazilian Amazon region. 1= Species found in Amazon State, 2= Species found in Pará State; 3= Species found in undefined state. Species in bold type are described based on Brazilian Amazon samples.

Species/Authors*	a	b	c	d	e	f	g	h	i	j	l	m	n	o	p
A. amazoniana										2					2
A. brasiliensis			1	1	1	1		1	1	2	1	1	1	1	
A. crawfordii										2,3					2
A. curvatula										2				1	2
A. disjuncta															1
A. eunotioides	1									2					
A. falcifera															2
A. gracile										2					2
A. gessneri		1,2								2					2
A. guianensis				1				1	1,2	2	1	1	1		
A. hustedtii										2					2
A lange-bertalotti										2					
A. lima										3					2
A. kociolekii															3
A. mirabilis			1	1			1	1	1,2	2	1	1	1	1	1
A. pararobusta									1	?1					1
A. peroniodes	1									2,3				1	2
A. pseudohanttzschiana									1	1,2					
A. punctata			1	1											
A. rionegrensis															1
A. robusta	1			1				1	3	2,3	1			1	
A. siolii		1,2								2				1	2
A. superperonioides															2
A.tasmaniensis				1											
A. thelma															2

*Authors: a) Hustedt (1952); b) Hustedt (1965); c) Uherkovich and Rai (1979); d) Uherkovich and Franken (1980); e) Uherkovich (1981); f) Furushima and Xavier (1988); g) Putz (1997) and Putz and Junk (1997); h) Souza-Mosimann *et al*. (1997); i) Metzeltin and Lage-Bertalot (1998); j) Kociolek *et al* (2001); l) Díaz-Castro *et al*. (2003); m) Melo *et al.* (2004); n) Melo *et al*. (2005); o) Ferrari *et al.* (2007), p) Metzeltin and Lage-Bertalot (2007).



Figures 13-20 – 13, 14. *Actinella mirabilis* (SEM). 13. Internal view of the headpole showing the helictoglossa and rimoportula. 14. External view of the headpole with a large apical spine. 15-20. *A. robusta*. 15-17. General valve view (LM). 18. general view (SEM). 19, 20. Detail of the pole showing the raphe on the mantle (SEM). Scale bars: Figs. 14, 17= 10 μm. Figs. 13, 15,16,18-19 = 5μm.

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