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Composition of microphytoplankton of an estuarine Amazon River, Pará, Brazil

Bethânia Alves Sena[1], Vanessa Bandeira da Costa[2], Luiza Nakayama[3], Rossineide Martins da Rocha[4]

1. Mestre em Ecologia Aquática e Aquicultura no Programa Ciência Animal, Universidade Federal do Pará, Brasil. betalsena@yahoo.com.br
2. Doutoranda em Ecologia Aquática e Pesca, Universidade Federal do Pará. Pesquisador em Saúde Pública (Assistente), Instituto Evandro Chagas-Pará, Brasil. vanessacosta@iec.pa.gov.br
3. Doutora e chefe do Laboratório de Biologia e Organismos Aquáticos no Instituto de Ciências Biológicas (ICB), Universidade Federal do Pará, Brasil. lunaka@ufpa.br
4. Doutora em Aquicultura e chefe do Departamento de Histologia e Embriologia no Instituto de Ciências Biológicas (ICB), Universidade Federal do Pará, Brasil. mrocha@ufpa.br

ABSTRACT: This work aims to describe the composition, relative abundance and frequency of occurrence of microphytoplankton in the Arienga River, determined from the analysis of ten samples collected in the rainy and dry seasons (May and September 2009 respectively), during five stations, using a plankton net with a mesh size of 20m. In the period studied, the rainfall showed an atypical behavior, compared to the average of the last ten years for the region, as pH and temperature did not undergone changes. A total of 128 species were identified, belonging to divisions: Dinophyta (0.78%), Chrysophyta (0.78%), Cyanobacterium (12.50%), Chlorophyta (26.56%), and Bacillariophyta (59.38%). Of Genres found, 17 had 100% of representativeness at in both fenods. It was possible to confirm two large groups, suggesting that the rainfall regime was the main controller factor of phytoplankton composition and spatial variation of species along the Arienga River. The phytoplankton diversity was considered characteristic of the Amazon region; therefore, it is considered that the human action did not affect the phytoplankton community of the Arienga River to date.

Keywords: phytoplankton, estuary, Amazon, Bacillariophyta, *Polymyxus coronalis*.

Composição de microfitoplâncton de um estuário do Rio Amazonas, Pará, Brasil

RESUMO: Este trabalho teve como objetivo descrever a composição, abundância relativa e frequência de ocorrência do microfitoplâncton do rio Arienga, a partir da análise qualitativa de 10 amostras coletadas no período chuvoso e seco (respectivamente maio e setembro de 2009), em cinco estações, utilizando-se uma rede cônico-cilíndrica de plâncton com abertura de malha de 20m. No período estudado a precipitação pluviométrica apresentou um comportamento atípico, comparado à média dos últimos 10 anos para a região, o pH e a temperatura não sofreram variações. Foram identificadas 128 espécies pertencentes às divisões: Dinophyta (0,78%), Chrysophyta (0,78%), Cyanobactéria (12,50%), Chlorophyta (26,56%) e Bacillariophyta (59,38%). Dos gêneros encontrados, 17 apresentaram 100% de representatividade, nos períodos de coleta. Foi possível constatar dois grandes grupos, sugerindo que o regime pluviométrico foi o principal fator controlador da composição fitoplanctônica e da variação espacial de espécies do rio Arienga. A diversidade fitoplanctônica foi considerada característica para a região amazônica.

Palavras-chave: fitoplâncton, estuário, Amazônia, Bacillariophyta, *Polymyxus coronalis*.

1. Introduction

Estuaries are transition environments formed by the mixture of saltwater and freshwater, with different gradients of salinity and with fine sediments from seas and rivers, suffering influence of tidal regimes (CAMERON;PRITCHARD, 1963; KJERFVE, 1989b; MCLUSKY; ELLIOTT, 2004).

In these ecosystems, water is mainly related to the maintenance of communities responsible for primary production, which serve as food for the remaining links in the trophic chain (SCHIEWER, 1998; LOSADA et al., 2003; SILVA et al., 2005). Phytoplankton is within these communities and it consists of a set of diverse taxonomic groups, which are able to adapt their metabolic functions to different environmental and seasonal changes (GIANI; LEONARDO, 1988; CETTO, 2004). According to Reynolds (1997), the study of that community, its composition, primary production and distribution have fundamental importance for the knowledge of the main functioning mechanisms of aquatic ecosystems. Thus, among other factors, changes in this environment which are significant in biological communities correlate negatively to the diversity of phytoplankton organisms and they occur associated with the increase of urbanization activities in watersheds (MOREIRA-FILHO et al., 1974; PAIVA et al., 2006; COSTA et al., 2010). In addition, it is observed that there is a gradual growth of phycologists studying phytoplankton composition in a descriptive manner in the Amazon region (MELO; HUSZAR, 2000; RIBEIRO et al., 2008; SOUZA; MELO, 2010).

It should be noted that since 1970, the municipality of Barcarena has been receiving enterprises for the processing of aluminum, available by Alunorte and Albras industries besides kaolin processed by the companies Ymeris Rio Capim Caulim and Pará Pigmentos (BERREDO, 2001). Therefore, port activities are intense in the whole area, with heavy river traffic of small and large vessels, mainly around the Miramar terminal and SOTAVE Port (Guajará Bay) and Port of Vila do Conde (municipality of Barcarena), which are home to deposits of petroleum derivatives with environmental risk of accidental oil spilling or leaks (ARRUDA, 2003).

This study was conducted in the Arienga River, next to Pará Pigmentos Company, with the aim of expanding the information about the micro-phytoplankton community of the Amazon region.

2. Material and Methods

The municipality of Barcarena (Figure 1) - located at the mouth of the Pará River, in the metropolitan meso-region of Belém (IBGE, 2007) - is bounded by the Marajó Bay and cut by numerous rivers, water holes and creeks. It is characterized by specific natural conditions of little high topographic levels, especially on the islands which are partly subjected to flooding (SOUZA; LISBOA, 2005).

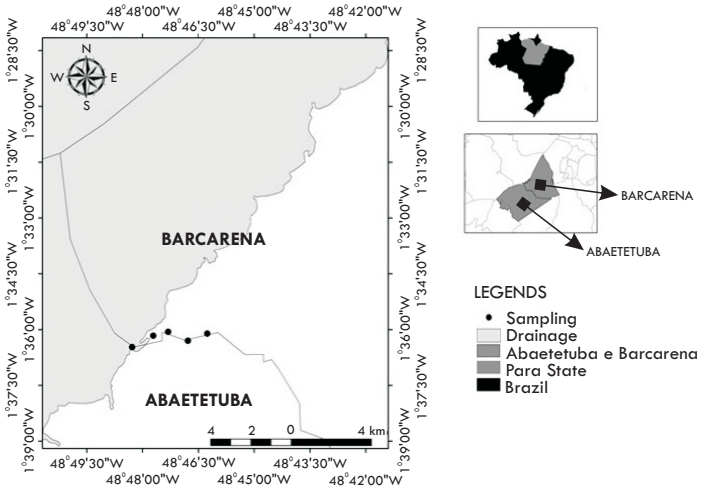

Figure 1. Area of study, with the collection points in the Arienga River, Amazon estuary. **Fonte:** Paulo Trindade.

Sample design

Collections were carried out in May (rainy) and September (dry) 2009 in five georeferenced sites (Table 1) along the Arienga River. The times and dates of the collections were selected with the aid of tide tables for the Port of Vila do Conde (DHN, 2011).

Table 1. Georeferenced collection sites along the Arienga River, Amazon estuary.

Points	Latitude N	Longitude W
1	01°36'30"	48°46'90"
2	01°36'70"	48°47'156"
3	01°36'07"	48°47'36"
4	01°36'25"	48°47'75"
5	01°36'39"	48° 49' 68"

Sampling

Rainfall data were obtained from the National Water Agency (2011) at Vila do Conde Station (Code: 148011), located in the municipality of Barcarena, State of Pará.

For the qualitative study of phytoplankton, we collected the sample using a planktonic net (mesh size: 20 µm) and subsequently stored in polyethylene flasks containing Transeau solution.

In each collection station, we measured temperature (Lutron DO-5519), pH (Lutron pH-221) and electrical conductivity (Lutron CD-4322).

Laboratory

The qualitative analysis of phytoplankton was performed by assembled cover slips and glass slides, which were observed in an optical microscope Olympus CX 40, preparing at least five slides for each sample. For diatom analysis, we used Müller Melchers & Ferrando's technique (1956) with a Zeiss scanning electron microscope, model LEO 1450 VP at Evandro Chagas Institute.

For the organization, identification and presentation of phytoplanktonic taxa, we used the following authors' classification: Bourrely (1972), Komárek and Anagnostidis (1989), Round et al. (1990), Bicudo and Menezes (2006).

The calculation of occurrence frequency of the taxa found was expressed in percentage, taking into consideration the number of samples in which each taxon occurred and the total number of samples tested, for which we applied the formula F = p x 100/P, where p is the number of samples containing the species studied and P the total number of samples collected. According to Mateucci and Colma's criteria (1982) for determination of species, the characteristics of the phytoplanktonic community were classified in the following categories: very common (≥ 80%), frequent (<80% and ≥ 50%), uncommon (<50% and ≥17%) and sporadic (<17%).

Relative abundance was calculated from counting the first 100 organisms observed in the blades. The results are expressed in accordance with Lobo and Leighton (1986) in the following categories: dominant (>70%), abundant (≤ 70% and >40%), little abundant (≤ 40% and >10%), and rare (≤ 10%).

Statistical analysis

The analysis of variance (ANOVA) was performed in order to compare the physicochemical and biological parameters (spatial and temporal), followed by Tukey's test. Multivariate analyses were carried out based on abundance matrices of the species and these values were transformed through the log (x+1). For cluster analysis, we used Bray-Curtis's similarity index (1957), and dendrogram construction was based on WPGMA (Weighted Pair Group Method with Arithmetic Mean). Similarity Percentage analysis (SIMPER) was applied to indicate which species contributed substantially to the formation of groups defined by cluster analysis. All analyses were performed through the statistical program Plymouth Routines in Multivariate Ecological Research, version 6.1.6 (PRIMER) and Statistics 7.

3. Results

Rainfall

Based on the average of the last 10 years (Figure 2), it was possible to differentiate two characteristic seasonal periods: the first from January to June and the second from July to December, which correspond to periods of higher and lower rainfall, respectively. In 2009, the total rainfall (3,144.20 mm) was 1.7 times higher than the average of the last 10 years (1,831.20 mm), with the minimum recorded in October 2009 (5.70 mm) and the maximum in April 2009 (637.40 mm).

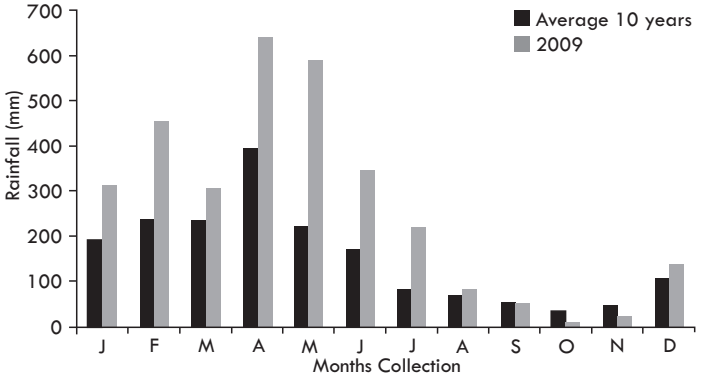

Figure 2. Monthly total rainfall (2009) and historical average monthly rainfall in the municipality of Barcarena, State of Pará (2000-2009) (Source: National Water Agency, 2011).

Physicochemical parameters

The temperature on the surface of the water remained

stable over the periods of collection with values that fluctuated between 28.0 °C (May 2009) and 29.4 °C (September 2009), showing an amplitude variation of 1.4 °C. There were no significant differences between collecting sites and seasonal periods.

The pH was acid with minimum value of 6.21 and maximum of 7.32 in May and October 2009, respectively; however, we did not observe significant differences between collecting sites and seasonal periods.

Electrical conductivity had a minimum value of 13.40 µS cm^{-1} and a maximum of 40 µS cm^{-1} in May and October 2009, respectively. This parameter was significantly higher ($p = 0.45$) in the rainy season (31.6 µS cm^{-1}) compared with the dry period (21 µS cm^{-1}).

Floristic composition

In the Arienga River, microphytoplankton was represented by 128 species distributed among the divisions Chrysophyta, Dinophyta, Cyanobacteria, Chlorophyta and Bacillariophyta (Table 2).

Tabela 2. Microphytoplankton composition in samples collected in 2009, in Arienga River, the Amazon estuary.

TÁXONS	CHU	SEC	ECOLOGIA	REFERÊNCIAS
DIVISÃO: DINOPHYTA				
Classe: DINOPHYCEAE				
Família: PERIDINIACEAE				
Gênero: *Peridinium* Ehrenberg				
Peridinium sp.		X		
DIVISÃO: CHRYSOPHYTA				
Classe: CHRYSOPHYCEAE				
Família: DINOBRYACEAE				
Gênero: *Dinobryon* Ehrenberg				
Dinobryon sp.	X			
DIVISÃO: CYANOPHYTA				
Classe: CYANOPHYCEAE				
Ordem: CHROOCOCCALES				
Família: MICROCYSTACEAE				
Gênero: *Microcystis* Kützing ex Lemmermann				
Microscystis aeruginosa (Kützing) Kützing	X	X	Dulcícola	Leão, 2004
Microcystis sp.	X			
Família: GOMPHOSPHAERIACEAE				
Gênero: *Gomphosphaeria* Kützing				
Gomphosphaeria sp.	X			
Ordem: SYNECHOCOCCALES				
Família: MERISMOPEDIACEAE				
Gênero: *Merismopedia* Meyen				
Merismopedia tenuissima Lemmermann	X	X		
Ordem: NOSTOCALES				
Família: NOSTOCACEAE				
Gênero: *Anabaena* Bory de St. Vicent				
Anabaena constricta Geitler	X	X	Dulcícola	Leão, 2004
Anabaena sp.	X			
Ordem: OSCILLATORIALES				
Família: OSCILLATORIACEAE				
Gênero: *Oscillatoria* Vaucher ex Gomont				
Oscillatoria agardhii Gomont	X	X		
Oscillatoria chlorina Kützing ex Gomont	X			
Oscillatoria geminata Schwabe	X	X		
Oscillatoria lacustris (Klebahn) Geitler	X			
Oscillatoria limnetica Lemmermann		X		
Oscillatoria limosa Agardh ex Gom.		X	Dulcícola	Leão, 2004
Oscillatoria rubescens Candolle ex Gomont	X	X	Dulcícola	Leão, 2004
Oscillatoria sp.	X	X		
Família: PHORMIDIACEAE				
Gênero: *Phormidium* Kützing ex Gomont				
Phormidium retzii Kützing ex Gomont	X	X		
Ordem: PSEUDANABAENALES				
Família: PSEUDOANABAENACEAE				
Gênero: *Pseudoanabaena* Lauterborn				
Pseudoanabaena sp.	X			
Gênero: *Spirulina* Turpin ex Gomont	X			
Spirulina abbreviata Lemmermann				
DIVISÃO: CHLOROPHYTA				
Classe: ZYGNEMAPHYCEAE				
Família: DESMIDIACEAE				
Gênero: *Closterium* Nitzsch ex Ralfs				
Closterium acutum	X			
Closterium leibleinii	X			
Closterium pronum	X	X		
Closterium tortum	X			
Closterium sp.		X		
Gênero: *Desmidium* C. Agardh ex Ralfs				
Desmidium sp.	X			
Gênero: *Cosmarium* Corda ex Ralfs				

Continua

Cosmarium sp.	X	X		
Gênero: *Micrasterias* Agardh ex Ralfs				
Micrasterias borgei	X	X		
Micrasterias radiata West e G.S.West		X		
Gênero: *Mougeotia* Agardh				
Mougeotia sp.	X	X		
Gênero: *Pleorotaenium* Nägeli				
Pleurotaenium sp.	X			
Gênero: *Staurastrum* Meyen ex Ralfs				
Staurastrum leptocladum Johnson		X	Planctônica	Bicudo *et al.*, 2007
Staurastrum pseudotetracerum West e G.S.West	X	X	Planctônica	Bicudo *et al.*, 2007
Staurastrum rotula Nordstedt	X		Planctônica, perifítica	Bicudo *et al.*, 2007
Gênero: *Sphaerozosma* Corda ex Ralfs				
Sphaerozosma laeve Thomasson	X	X		
Classe: OEDOGONIOPHYCEAE				
Família: OEDOGONIACEAE				
Gênero: *Oedogonium* Link ex Hirn				
Oedogonium sp.	X	X	Perifítica	Elkis e Bicudo, 2006
Família: SCENEDESMACEAE				
Gênero: *Scenedesmus* Meyen				
Scenedesmus ecornis (Ehrenberg) Chodat	X			
Scenedesmus javanesis Chodat		X		
Scenedesmus quadricauda Chodat	X	X	Dulcícola	Leão, 2004
Scenedesmus quadricauda var. *longispina* Smith	X			
Scenedesmus sp.	X			
Família: ULOTRICHACEAE				
Gênero: *Ulothrix* Kützing				
Ulothrix moniliformis Kützing	X	X		
Ulothrix sp.		X		
Família: CHLOROCOCCACEAE				
Gênero: *Schroederia* Lemmermann				
Schroederia sp.	X			
Família: VOLVOCACEAE				
Gênero: *Eudorina* Ehrenberg ex Ralfs				
Eudorina elegans Ehrenberg	X	X		
Gênero: *Pleudorina* Shaw				
Pleudorina illinoisensis Kofoid		X		
Gênero: *Volvox* Linnaeus				
Volvox aureus Ehrenberg	X			
Volvox sp.	X	X		
Família: HYDRODICTYACEAE				
Gênero: *Hydrodictyon* Roth				
Hydrodictyon sp.	X	X		
Gênero: *Pediastrum* Meyen				
Pediastrum duplex Meyen	X	X	Dulcícola	Cardoso, 2009
Pediastrum gracillimum (West e G.S.West) Thunmark	X	X		
Pediastrum simplex Meyen	X	X	Dulcícola	Cardoso, 2009
Pediastrum tetras (Ehrenberg) Ralfs	X			
Classe: SIPHONOCLADOPHYCEAE				
Família: CLADOPHORACEAE				
Gênero: *Cladophora* Kützing				
Cladophora sp.		X		
DIVISÃO: BACILLARIOPHYTA				
Classe: BACILLARIOPHYCEAE				
Família: ACANTHOCERATACEAE				
Gênero: *Achnantes* Bory				
Achnanthes sp.	X			
Família: ACHNANTIDIACEAE				
Gênero: *Achnanthidium* Kützing				
Achnanthidium exiguum (Grunow) D. B. Czarnecki	X			
Achnanthidium exiguum var. constrictum (Grunow) Andresen, Stoermer e Kreis	X			
Gênero: Psammothidium Buhtkiyarova e Round				
Psammothidium helveticum (Hustedt) Bukhtiyarova e Round	X			
Psammothidium sp.	X			
Família: AMPHIPLEURACEAE				
Gênero: *Frustulia* Rabenhorst				
Frustulia rhomboides (Ehrenberg) De Toni	X			
Família: AULACOSEIRACEAE				
Gênero: *Aulacoseira* Thwaites				
Aulacoseira cf. *distans* (Ehrenberg) Simonsen	X	X	Perifítica, planctônica, ticoplanctônica	Moro e Fursienberger, 1997
Aulacoseira granulata (Ehrenberg) Simonsen	X	X	Mesossapróbia, alcaliniófila, eutrófica, planctônica	Ribeiro *et al.*, 2007
Aulacoseira granulata var. *angustissima* (O.F.Müller) Simonsen	X	X	Marinho, plantônico	Moro e Fursienberger, 1997
Aulacoseira pseudogranulata (Cleve) Simonsen		X		
Família: BACILLARIACEAE				
Gênero: *Bacillaria* O. F. Müller				
Bacillaria paxillifera (O.F.Müller) T. Marsson	X	X	Marinha planctônica oceânica	Santiago, 2004
Gênero: *Nitzschia* Hassall				
Nitzschia acicularis (Kützing) W. Smith	X		Planctônica	Moro e Fursienberger, 1997
Nitzschia cf. *amphibia* Grunow	X			
Nitzschia cf. *brevissima* Grunow	X			
Nitzschia sigmoidea (Nitzsch) W. Smith	X	X	Marinho, perifítico, epifítico, planctônico	Moro e Fursienberger, 1997
Nitzschia sp.1	X			

Continua

Nitzschia sp.2	X			
Nitzschia sp.3	X			
Nitzschia sp.4	X			
Família: CATENULACEAE				
Gênero: *Catenula* Meresch Kowsky				
Catenula adhaerens (Mereschkowsky) Mereschkowsky	X			
Gênero: *Amphora* Ehrenberg ex Kützing				
Amphora sp.	X			
Família: COSCINODISCACEAE				
Gênero: *Cyclotella* (Kütz.) Bréb.				
Cyclotella cf. *atomus* Hustedt	X			
Gênero: *Coscinodiscus* Kützing				
Coscinodiscus apiculatus Ehrenberg	X			
Coscinodiscus cf. *concinnus* W.Smith	X			
Coscinodiscus oculus-iridis (Ehrenberg) Ehrenberg	X		Marinha planctônica nerítica	Santiago, 2004
Coscinodiscus sp.1	X	X		
Coscinodiscus sp.2	X			
Gênero: *Hemediscaceae* Ehrenberg				
Actinocyclus normanii (Gregory) Hustedt	X	X		
Actinicyclus normanii cf. *subsalsus* (Juhlin-Dannfelt) Hustedt		X		
Família: COCONEIDACEAE				
Gênero: *Cocconeis* Ehrenberg				
Cocconeis sp.1	X			
Cocconeis sp.2	X			
Família: CYMATOSIRACEAE				
Gênero: *Cymatosira* Grunow				
Cymatosira belgica Grunow	X			
Família: NAVICULACEAE				
Gênero: *Caloneis* P. Cleve				
Caloneis sp.	X			
Gênero: *Navicula* Bory de St. Vincent				
Navicula sp.1	X	X		
Gênero: *Hippodonta* Witkowski e Metzeltin				
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin e Witkowski	X			
Família: MELOSIRACEAE				
Gênero: *Melosira* Agardh				
Melosira. granulata (Ehrenberg) Ralfs	X	X	Planctônica	Moro e Fursienberger, 1997
Melosira varians Agardh	X		Perifítica, epifítica, epilítica, planctônica, ticoplanctônica	Moro e Fursienberger, 1997
Melosira sp.		X		
Família: PARALIACEAE				
Gênero: *Paralia* Ehrenberg				
Paralia sulcata (Ehrenberg) Cleve	X			
Família: PINNULARIACEAE				
Gênero: *Pinnularia* Ehrenberg				
Pinnularia braunii (Grunow) Cleve	X	X	Planctônica	Moro e Fursienberger, 1997
Pinnularia braunii var. *amphicephala* (Mayer) Hustedt		X		
Pinnularia viridis (Nitzsch) Ehrenb.	X	X	perifítica, epilítica, planctônica	Moro e Fursienberger, 1997
Família: HELIOPELTACEAE				
Gênero: *Polymyxus* Bailey				
Polymyxus coronalis Bailey	X	X		
Família: EUNOTIACEAE				
Gênero: *Eunotia* Ehrenberg				
Eunotia serra Ehrenberg		X	Perifítica	Moro e Fursienberger, 1997
Eunotia cf. *zygodon* Ehrenberg		X		
Eunotia sp.1	X	X		
Eunotia sp.2	X			
Eunotia sp.3	X			
Família: SELLAPHORACEAE				
Gênero: *Fallacia* Stickle e Mann				
Fallacia sp.	X			
Família: PLEUROSIGMATACEAE				
Gênero: *Gyrosigma* Hassall				
Gyrosigma sp.1		X		
Gyrosigma sp.2		X		
Família: CYMBELLACEAE				
Gênero: *Cymbella* Agardh				
Cymbella sp.	X			
Gênero: *Placoneis* Mereschkowsky				
Placoneis sp.	X			
Família: RHIZOSOLENIACEAE				
Gênero: *Rhizosolenia* Brightwell				
Rhizosolenia setigera Brightwell	X	X	Marinha planctônica oceânica	Santiago, 2004
Família: SELLAPHORACEAE				
Gênero: *Sellaphora* Mereschowsky				
Sellaphora sp.	X			
Família: STAUROSIRELLACEAE				
Gênero: *Staurosirella* Wiliams e Round				
Staurosirella leptostauron (Ehrenberg) Williams e Round		X		
Staurosirella sp.	X			
Família: GOMPHONEMATACEAE				
Gênero: *Gomphonema* Ehrenberg				
Gomphonema sp.		X		

Continua

Família: HELIOPELTACEAE				
Gênero: *Actinoptychus* Ehrenberg				
Actinoptychus senarius (Ehrenberg) Ehrenberg	X	X	Marinho e Planctônico	Moro e Fursienberger, 1997
Actinoptychus splendens (Shadbolt) Ralfs ex Pritchard	X	X	Marinha planctônica nerítica	Santiago, 2004
Família: SURIRELLACEAE				
Gênero: *Surirella* Turpin				
Surirella biseriata Brébisson	X	X	Perifítica, planctônica	Moro e Fursienberger, 1997
Surirella guatimalensis Ehrenberg	X			
Surirella ovata Kützing	X	X	Ticoplanctônica, planctônica	Moro e Fursienberger, 1997; Santiago, 2004
Surirella robusta var. *splendida* (Ehrenberg; Ehremberg) Van Heurck	X	X	Perifítica, epilítica, planctônica, ticoplanctônica,	Moro e Fursienberger, 1997
Surirella tenuissima Hustedt		X		
Surirella sp.	X	X		
Família: BIDDULPHIACEAE				
Gênero: *Terpsinoe* Ehrenberg				
Terpsinoe musica Ehrenberg	X			
Família: THALASSIOSIRACEAE				
Gênero: *Thalassiosira* Ehrenberg				
Thalassiosira sp.	X	X		
Família: THALASSIONEMATACEAE				
Gênero: *Thalassionema* Grunow ex Mereschkowsky				
Thalassionema sp.1	X			
Thalassionema sp.2	X			
Família: TRICERATIACEAE				
Gênero: *Triceratium* Ehrenberg				
Triceratium favus Ehrenberg	X	X	Marinha, estuarina, euralina	Cardoso, 2009
Família: THALASSIONEMATACEAE				
Gênero: *Tryblionella* Smith				
Tryblionella sp.	X			
Família: TABELLARIACEAE				
Gênero: *Tabellaria* Ehrenberg ex Kützing				
Tabellaria sp.	X	X		
Classe: FRAGILLARIOPHYCEAE				
Família: FRAGILARIACEAE				
Gênero: *Diatoma* Bory de St.-Vincent				
Diatoma tenuis Agardh		X	Epifítica, epilítica, planctônica	Moro e Fursienberger, 1997
Diatoma sp.	X			
Gênero: *Fragilaria* Lyngbye				
Fragilaria sp.	X	X		

The division Bacillariophyta was the most representative with a total of 76 taxa, distributed in one order, two classes, 27 families, 40 genera. Among them, the following outstood: *Nitzschia* Hassall, *Coscinodiscaceae* Kützing, *Eunotia* Ehrenberg, *Surirella* Turpin, who had more than five taxa; followed by Chlorophyta with eight families, 18 genera and 38 taxa. The most representative genres were: *Closterium* Nitzsch ex Ralfs, *Scenedesmus* Meyen and *Pediastrum* Meyen. *Cyanobacteria* were represented by seven families, eight genera and 16 taxa, and the genus *Oscillatoria* Vaucher ex Gomont stood out by presenting eight taxa. Divisions *Chrysophyta* and *Dinophyta* had lower occurrence with one taxon each (Figure 3).

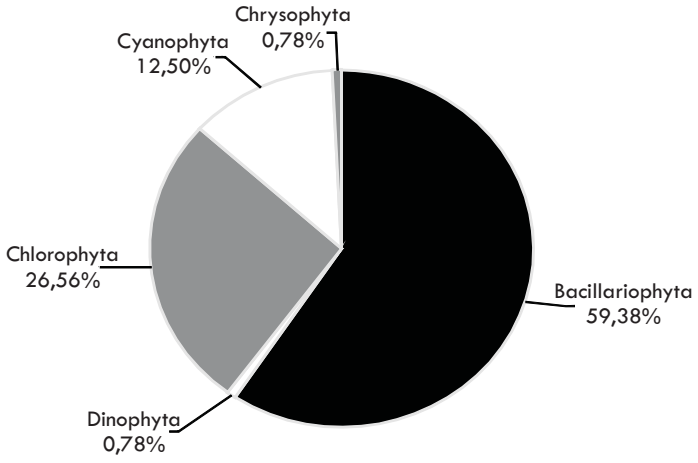

Figure 3. Percentage distribution of microphytoplanktonic divisions identified in samples collected in 2009 in the Arienga River, Amazon estuary.

Based on frequency of occurrence, we observed the presence of sporadic planktonic microalgae, followed by those infrequent, frequent and very common (Figure 4). The following species occurred in 100% of the samples: *Actinoptychus splendens*, *Aulacoseira granulata*, *Coscinosdiscus* sp., *Polymyxus coronalis, Surirella robusta* var *splendida, Eudorina elegans, Staurastrum leptocladum, Volvox* sp., *Microcystis aeruginosa*, *Fragilaria* sp., *Navicula* sp., *Pinnularia braunii*, *Hydrodictyon* sp., *Pediastrum simplex, Rhizosolenia setigera, Tabellaria* sp., *Thalassiosira* sp., and *Ulothrix moniliformis*.

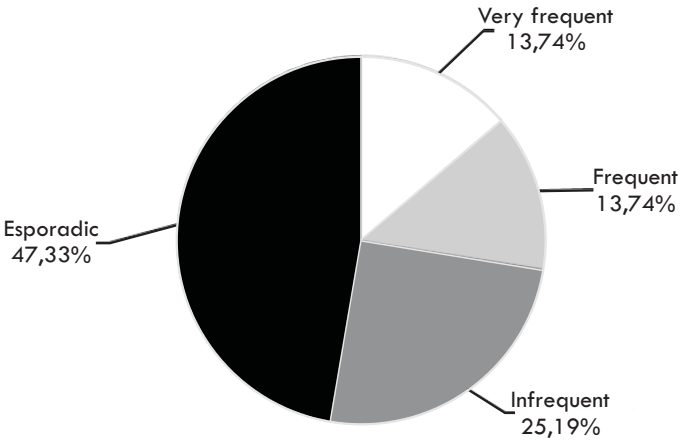

Figure 4. Frequency of microphytoplankton occurrence in samples collected in 2009 in the Arienga River, Amazon estuary.

The richness of microphytoplankton species in the Arienga River was represented by 107 species in the rainy season (May 2009) and 69 in the dry season (September 2009). The rainy season was characterized by chrysophyta (1.75%), dinoflagellata (1.75%), cyanobacteria (22.81%), chlorophyceae (19.30%) and diatoms (54.39%). The dry season was characterized by cyanobacteria (15.79%),

chlorophyceae (38.60%) and diatoms (45.61%). However, no significant differences were observed regarding richness of species between the different seasonal periods and sampling sites, which were represented by one cyanophyceae (0.94%), ten dinoflagellata (9.44%) and 95 diatoms (89.62%) (Figure 5).

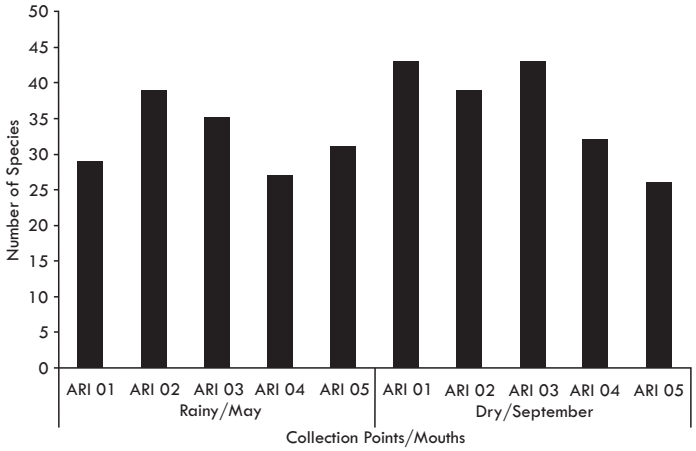

Figure 5. Number of species by collection site in the Arienga River, Amazon estuary, from May to August 2009.

Relative abundance

In the rainy season (May 2009), *Polymyxus coronalis* was classified as dominant (80% average of relative abundance) and *Coscinodiscus* sp. as little abundant (14% average of relative abundance) and the others were considered rare. In the dry season (September 2009), *Polymyxus coronalis* was abundant (45.4% average of relative abundance), *Aulacoseira granulata* was little abundant (average of 14.8%) and *Coscinodiscus* sp. (average of 14%) and the others were considered rare (Figure 6).

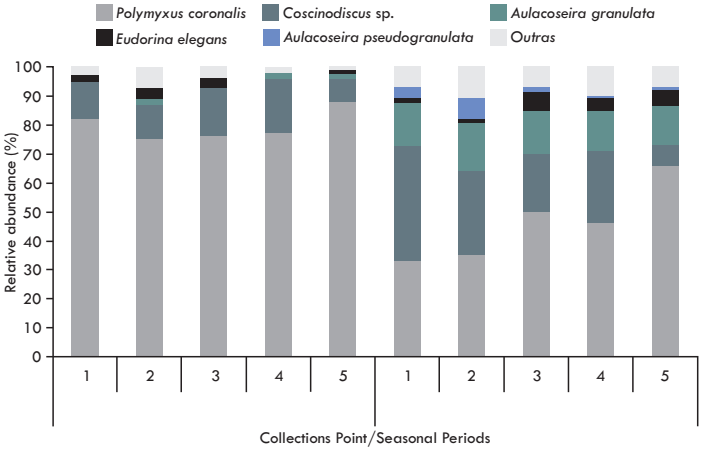

Figure 6. Distribution of the relative abundance of phytoplanktonic species identified in the Arienga River, Amazon estuary, in the rainy (May 2009) and dry (September 2009) seasons.

Association of samples

The association of samples (Figure 7) allowed to highlight two groupings at 65% similarity level. Group I consisted only of dry season samples (September) and group II included samples of the rainy season (May).

Through Similarity Percentage analysis (SIMPER), it was possible to identify the species that contributed most to the configuration of the two major groups formed in the association of samples (Table 3). Through variance analysis, it was found that the species *Actinoptychus splendens* showed abundance significantly higher in the dry period ($p = 0.90$) and *Coscinodiscus* sp. in the rainy season ($p = 0.51$).

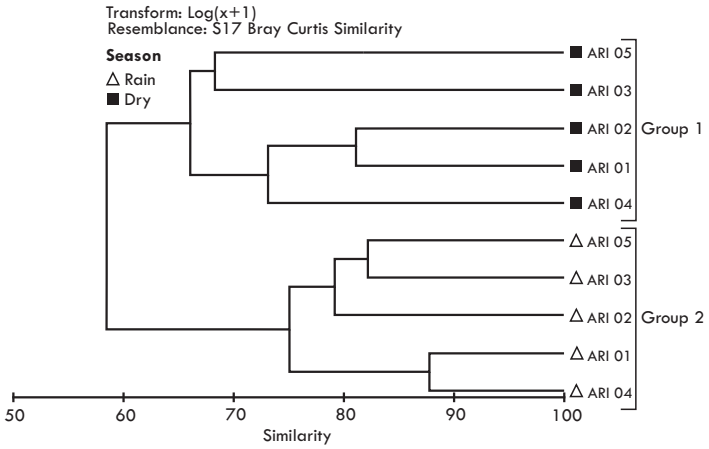

Figure 7. Dendrogram of samples association collected in the Arienga River, Amazon estuary, from May to September 2009.

Tabela 3. Species similarity analysis between the wet and dry seasons 2009.

SPECIES	MEDIUM DENSITY	MEDIUM SIMILAR	SIM/SD	CONTRIB%	CUM.%
Grupo I					
Polymyxus coronalis	4,39	40,47	9,67	51,97	51,97
Coscinodiscus sp.	2,66	22,86	8,59	29,36	81,32
Eudorina elegans	0,96	5,05	1,10	6,48	87,81
Microcystis aeruginosa	0,55	3,79	1,15	4,87	92,68
Grupo II					
Polymyxus coronalis	3,82	21,58	18,19	31,20	31,20
Coscinodiscus sp.	3,10	16,13	5,07	23,32	54,52
Aulacoseira granulata	2,77	16,13	29,41	23,32	77,84
Eudorina elegans	1,35	5,84	2,05	8,44	86,29
Aulacoseira pseudogranulata	1,23	5,12	2,80	7,40	93,69

4. Discussion

In the period studied, rainfall had an atypical behavior, having been registered values 1.7 times higher than the average of the last 10 years for the northern region of Pará and 1.1 to 1.4 times higher than the estimated by Moraes et al. (2005) for northeastern Pará (2,300 to 2,800 mm).

Other physicochemical factors analyzed (pH and temperature) did not show large variations and these data are in accordance with findings by other authors in the Amazon region (PAIVA et al., 2006; RIBEIRO et al., 2008; COSTA et al., 2010). For this reason, authors who carry out researches relating physicochemical factors to the phytoplanktonic community (ESKINAZI-LEÇA et al., 1984; KOENING; MACEDO, 1999; AGAWIN; DUARTE, 2002) consider that these factors neither exercise control over growth and abundance of phytoplankton nor determine an annual pattern in tropical waters.

In the estuary, we observed differences in composition, frequency and relative abundance of species between the two seasonal periods studied. These differences are in accordance with studies carried out in estuaries and other coastal areas of the State of Pará (SANTOS-FERNANDES et al., 1998; SHAH et al., 2008, 2009; COSTA et al., 2011). This seasonal variation pattern can be found in other tropical coastal regions with small terrigenous influence, where the density of phytoplankton increases during the rainy season, depending on the amount of nutrients washed down from the mainland (SANTOS-FERNANDES et al., 1998; ESKINAZI-LEÇA et al., 2004). The microphytoplankton of the Arienga River was composed of

diatoms, chlorophyceae, cyanobacterias and dinoflagellates.

Estuarine and coastal environments are often associated with regions with high stress, turbulence and under the influence of coastal currents (TILSTONE et al., 2000; SMAYDA, 2002), similar to water bodies found in this study and common to other Amazonian ecosystems, such as the Guamá River (PAIVA et al., 2006) and Xingu River (COSTA et al., 2009). In addition, Koening et al. (2003), Almeida et al. (2005) and Carmona et al. (2009) found the predominance of Bacillariophyta representatives, which have euryhaline character; therefore, bacillariophyta is the best adapted to the conditions prevailing in the Arienga River.

The division Bacillariophyta had 78 species, being 10 with 100% frequency in the two collection periods. Similar results were observed in the mouth of Guamá River by Moreira Filho et al. (1974), Paiva et al. (2006) and Monteiro (2009). *Polymyxus coronalis* should be highlighted, since according to Navarro and Peribonio (1993) and Paiva et al. (2006), it is an indicative species of brackish waters in the Amazon region.

The Division Chlorophyta was the second group of greater representativeness in terms of number of species, and in the rainy season, the species was more abundant. These green algae have high morphometric variability and can develop in almost all environments (HAPPEY-WOOD, 1988; TANIGUCHI et al., 2005; COSTA et al., 2010) and they are expressive regarding primary productivity in tropical aquatic ecosystems (COESEL, 1996). In addition, it was the second division with the highest species richness.

Through Similarity Percentage analysis (SIMPER), it was possible to confirm two large groups: (I) samples of the dry season (September) showing great mean similarity, and (II) samples of the rainy season (May), which also showed great mean similarity. Therefore, in general terms, the rainfall regime was the main determinant factor of the composition and frequency of occurrence in the Arienga River, being responsible for the variation of electrical conductivity. These data are in accordance to some authors' findings (AMOROS; BORNETTE, 2002; SILVA et al., 2009) which point out that seasonality in tropical and subtropical areas interferes directly in the hydrological regime, influencing water physicochemical variables and, consequently, the biologic communities.

The similarity between the two collections of biological material in May and September 2009, respectively, was 41.61%, confirming spatial variation in species distribution along the Arienga River. In this environment, Santiago (2004) found that the seasonal variation can be influenced by rainfall and electrical conductivity.

5. Conclusion

Carrying out this study in the Arienga River, we observed differences in composition, frequency and abundance of species between the different seasonal periods studied and this seasonal variation pattern is considered to be characteristic of tropical coastal regions.

The phytoplanktonic biodiversity of the Arienga River was considered to be characteristic of the Amazon region, and the diatoms as the more important qualitatively, with considerable presence of euryhaline marine species, which predominate over the other groups throughout the year.

Through Similarity Percentage analysis (SIMPER), it was possible to confirm two large groups, suggesting that the rainfall regime was the main control factor of phytoplanktonic composition. The similarity between the two collections carried out in 2009 confirmed spatial variation in species distribution along the Arienga River.

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