

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

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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 undergo 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 microfítolâncton de um estuário do Rio Amazonas, Pará, Brasil

RESUMO: Este trabalho teve como objetivo descrever a composição, abundância relativa e frequência de ocorrência do microfítolâncton 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).

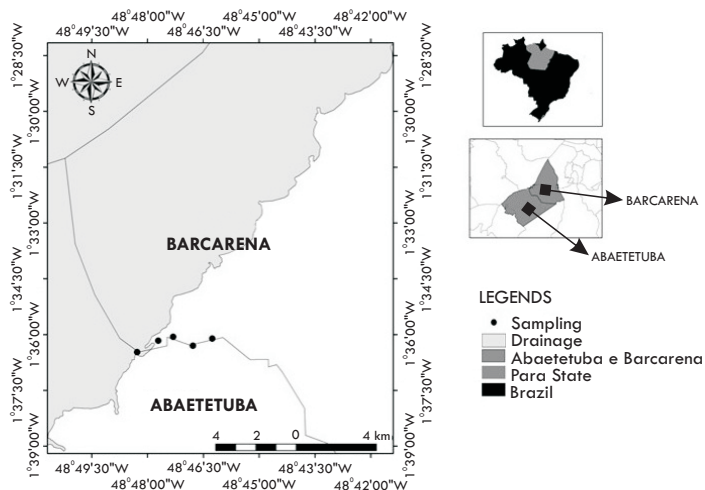


Figure 1. Area of study, with the collection points in the Arienga River, Amazon estuary. **Fonte:** Paulo Trindade.

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: Bourrelly (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 $F = p \times 100/P$, 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 ($\geq 80\%$), frequent ($<80\%$ and $\geq 50\%$), uncommon ($<50\%$ and $\geq 17\%$) 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 ($\leq 70\%$ and $>40\%$), little abundant ($\leq 40\%$ and $>10\%$), and rare ($\leq 10\%$).

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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).

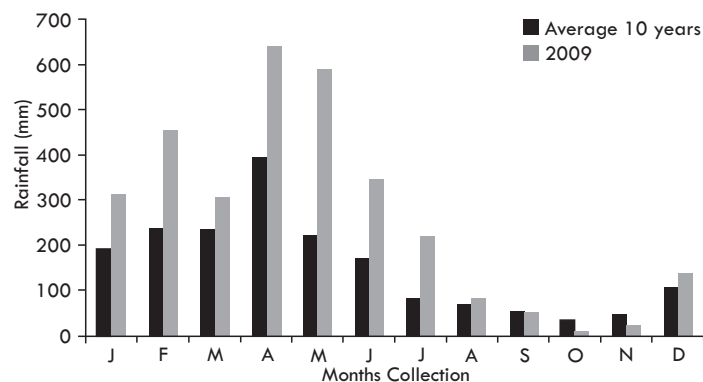


Figure 2. Monthly total rainfall (2009) and historical average monthly rainfall in the municipality of Barcarena, State of Pará (2000-2009) (Source: National Water Agency, 2011).

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 $\mu\text{S cm}^{-1}$ in May and October 2009, respectively. This parameter was significantly higher ($p = 0.45$) in the rainy season (31.6 $\mu\text{S cm}^{-1}$) compared with the dry period (21 $\mu\text{S cm}^{-1}$).

Floristic composition

In the Arienga River, microphytoplankton was represented by 128 species distributed among the divisions Chrysochyta, 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: <i>Peridinium</i> Ehrenberg				
<i>Peridinium</i> sp.		X		
DIVISÃO: CHRYSOPHYTA				
Classe: CHRYSOPHYCEAE				
Família: DINOBRYACEAE				
Gênero: <i>Dinobryon</i> Ehrenberg				
<i>Dinobryon</i> sp.	X			
DIVISÃO: CYANOPHYTA				
Classe: CYANOPHYCEAE				
Ordem: CHROCOCCALES				
Família: MICROCYSTACEAE				
Gênero: <i>Microcystis</i> Kützing ex Lemmermann				
<i>Microcystis aeruginosa</i> (Kützing) Kützing	X	X	Dulcícola	Leão, 2004
<i>Microcystis</i> sp.	X			
Família: GOMPHOSPHAERIAACEAE				
Gênero: <i>Gomphosphaeria</i> Kützing				
<i>Gomphosphaeria</i> sp.	X			
Ordem: SYNECHOCOCCALES				
Família: MERISMOPEIDIAACEAE				
Gênero: <i>Merismopedia</i> Meyen				
<i>Merismopedia tenuissima</i> Lemmermann	X	X		
Ordem: NOSTOCALES				
Família: NOSTOCAEAE				
Gênero: <i>Anabaena</i> Bory de St. Vincent				
<i>Anabaena constricta</i> Geitler	X	X	Dulcícola	Leão, 2004
<i>Anabaena</i> sp.	X			
Ordem: OSCILLATORIALES				
Família: OSCILLATORIAEAE				
Gênero: <i>Oscillatoria</i> Vaucher ex Gomont				
<i>Oscillatoria agardhii</i> Gomont	X	X		
<i>Oscillatoria chlorina</i> Kützing ex Gomont	X			
<i>Oscillatoria geminata</i> Schwabe	X	X		
<i>Oscillatoria lacustris</i> (Klebahn) Geitler	X			
<i>Oscillatoria limnetica</i> Lemmermann		X		
<i>Oscillatoria limosa</i> Agardh ex Gom.		X	Dulcícola	Leão, 2004
<i>Oscillatoria rubescens</i> Candolle ex Gomont	X	X	Dulcícola	Leão, 2004
<i>Oscillatoria</i> sp.	X	X		
Família: PHORMIDIACEAE				
Gênero: <i>Phormidium</i> Kützing ex Gomont				
<i>Phormidium retzii</i> Kützing ex Gomont	X	X		
Ordem: PSEUDANABAENALES				
Família: PSEUDOANABAENACEAE				
Gênero: <i>Pseudoanabaena</i> Lauterborn				
<i>Pseudoanabaena</i> sp.	X			
Gênero: <i>Spirulina</i> Turpin ex Gomont				
<i>Spirulina abbreviata</i> Lemmermann	X			
DIVISÃO: CHLOROPHYTA				
Classe: ZYGNEMAPHYCEAE				
Família: DESMIDIACEAE				
Gênero: <i>Closterium</i> Nitzsch ex Ralfs				
<i>Closterium acutum</i>	X			
<i>Closterium leibleinii</i>	X			
<i>Closterium pronum</i>	X	X		
<i>Closterium tortum</i>	X			
<i>Closterium</i> sp.		X		
Gênero: <i>Desmidium</i> C. Agardh ex Ralfs				
<i>Desmidium</i> sp.	X			
Gênero: <i>Cosmarium</i> Corda ex Ralfs				

Continua

<i>Cosmarium</i> sp.	X	X		
Gênero: <i>Micrasterias</i> Agardh ex Ralfs				
<i>Micrasterias borgei</i>	X	X		
<i>Micrasterias radiata</i> West e G.S.West				X
Gênero: <i>Mougeotia</i> Agardh				
<i>Mougeotia</i> sp.	X	X		
Gênero: <i>Pleurotaenium</i> Nägeli				
<i>Pleurotaenium</i> sp.	X			
Gênero: <i>Staurastrum</i> Meyen ex Ralfs				
<i>Staurastrum leptocladum</i> Johnson			X	Planctônica
<i>Staurastrum pseudotetracerum</i> West e G.S.West	X	X		Planctônica
<i>Staurastrum rotula</i> Nordstedt	X			Planctônica, perifítica
Gênero: <i>Sphaeroszma</i> Corda ex Ralfs				
<i>Sphaeroszma laeve</i> Thomasson	X	X		
Classe: OEDOGONIOPHYCEAE				
Família: OEDOGONIACEAE				
Gênero: <i>Oedogonium</i> Link ex Hirn				
<i>Oedogonium</i> sp.	X	X		Perifítica
Família: SCENEDESMACEAE				
Gênero: <i>Scenedesmus</i> Meyen				
<i>Scenedesmus ecornis</i> (Ehrenberg) Chodat	X			
<i>Scenedesmus javanesis</i> Chodat			X	
<i>Scenedesmus quadricauda</i> Chodat	X	X		Dulcícola
<i>Scenedesmus quadricauda</i> var. <i>longispina</i> Smith	X			
<i>Scenedesmus</i> sp.	X			
Família: ULOTRICHACEAE				
Gênero: <i>Ulothrix</i> Kützting				
<i>Ulothrix moniliformis</i> Kützting	X	X		
<i>Ulothrix</i> sp.				X
Família: CHLOROCOCCACEAE				
Gênero: <i>Schroederia</i> Lemmermann				
<i>Schroederia</i> sp.	X			
Família: VOLVOCEAE				
Gênero: <i>Eudorina</i> Ehrenberg ex Ralfs				
<i>Eudorina elegans</i> Ehrenberg	X	X		
Gênero: <i>Pleodorina</i> Shaw				
<i>Pleodorina illinoisensis</i> Kofoid				X
Gênero: <i>Volvox</i> Linnaeus				
<i>Volvox aureus</i> Ehrenberg	X			
<i>Volvox</i> sp.	X	X		
Família: HYDRODICTYACEAE				
Gênero: <i>Hydrodictyon</i> Roth				
<i>Hydrodictyon</i> sp.	X	X		
Gênero: <i>Pediastrum</i> Meyen				
<i>Pediastrum duplex</i> Meyen	X	X		Dulcícola
<i>Pediastrum gracillimum</i> (West e G.S.West) Thunmark	X	X		
<i>Pediastrum simplex</i> Meyen	X	X		Dulcícola
<i>Pediastrum tetras</i> (Ehrenberg) Ralfs	X			
Classe: SIPHONOCLODOPHYCEAE				
Família: CLADOPHORACEAE				
Gênero: <i>Cladophora</i> Kützting				
<i>Cladophora</i> sp.				X
DIVISÃO: BACILLARIOPHYTA				
Classe: BACILLARIOPHYCEAE				
Família: ACANTHOCERATACEAE				
Gênero: <i>Achnanthes</i> Bory				
<i>Achnanthes</i> sp.	X			
Família: ACHNANTIDIACEAE				
Gênero: <i>Achnanthyidium</i> Kützting				
<i>Achnanthyidium exiguum</i> (Grunow) D. B. Czarnecki	X			
<i>Achnanthyidium exiguum</i> var. <i>constrictum</i> (Grunow) Andresen, Stoermer e Kreis	X			
Gênero: <i>Psammothidium</i> Bukhtiyarova e Round				
<i>Psammothidium helveticum</i> (Hustedt) Bukhtiyarova e Round	X			
<i>Psammothidium</i> sp.	X			
Família: AMPHIPLEURACEAE				
Gênero: <i>Frustulia</i> Rabenhorst				
<i>Frustulia rhomboides</i> (Ehrenberg) De Toni	X			
Família: AULACOSEIRACEAE				
Gênero: <i>Aulacoseira</i> Thwaites				
<i>Aulacoseira</i> cf. <i>distans</i> (Ehrenberg) Simonsen	X	X		Perifítica, planctônica, tico-planctônica
<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen	X	X		Mesosapróbica, alcalinófila, eutrófica, planctônica
<i>Aulacoseira granulata</i> var. <i>angustissima</i> (O.F.Müller) Simonsen	X	X		Marinho, planctônico
<i>Aulacoseira pseudogranulata</i> (Cleve) Simonsen			X	
Família: BACILLARIACEAE				
Gênero: <i>Bacillaria</i> O. F. Müller				
<i>Bacillaria paxillifera</i> (O.F.Müller) T. Marsson	X	X		Marinha planctônica oceânica
Gênero: <i>Nitzschia</i> Hassall				
<i>Nitzschia acicularis</i> (Kützting) W. Smith	X			Planctônica
<i>Nitzschia</i> cf. <i>amphibia</i> Grunow	X			
<i>Nitzschia</i> cf. <i>brevissima</i> Grunow	X			
<i>Nitzschia sigmoidea</i> (Nitzsch) W. Smith	X	X		Marinho, perifítico, epifítico, planctônico
<i>Nitzschia</i> sp.1	X			

Continua

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

Continua

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

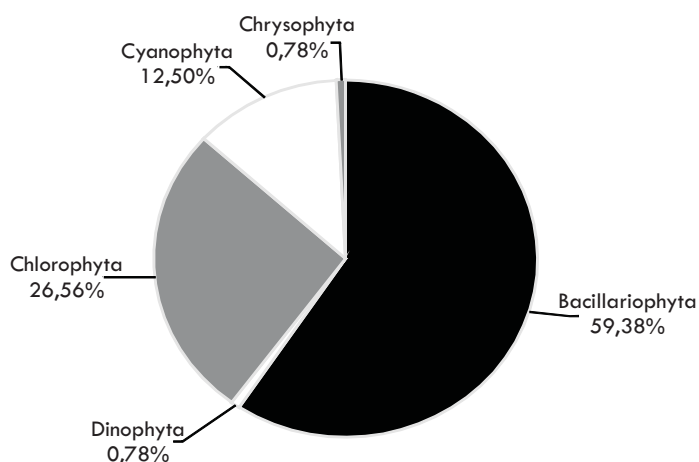


Figure 3. Percentage distribution of microphytoplanktonic divisions identified in samples collected in 2009 in the Arienga River, Amazon estuary.

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*, *Coscinodiscus* 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*.

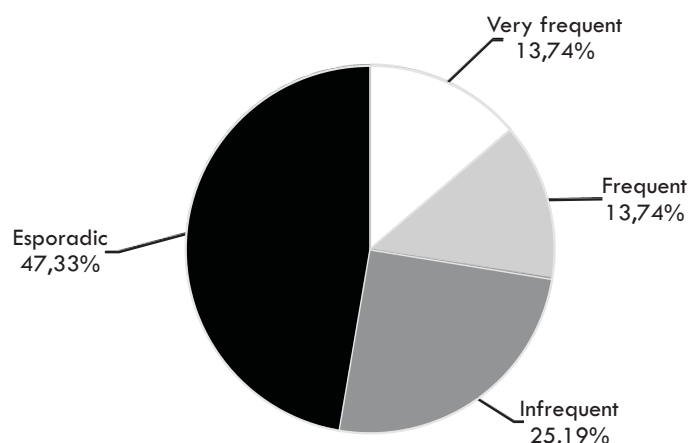


Figure 4. Frequency of microphytoplankton occurrence in samples collected in 2009 in the Arienga River, Amazon estuary.

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).

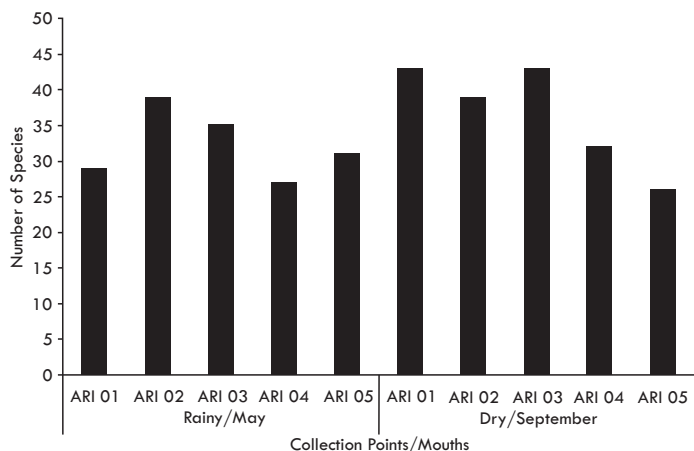


Figure 5. Number of species by collection site in the Arienga River, Amazon estuary, from May to August 2009.

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).

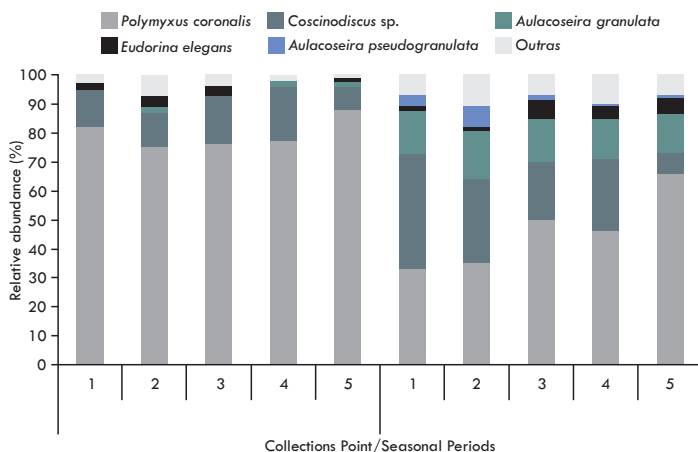


Figure 6. Distribution of the relative abundance of phytoplanktonic species identified in the Arienga River, Amazon estuary, in the rainy (May 2009) and dry (September 2009) seasons.

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 ($p = 0.51$).

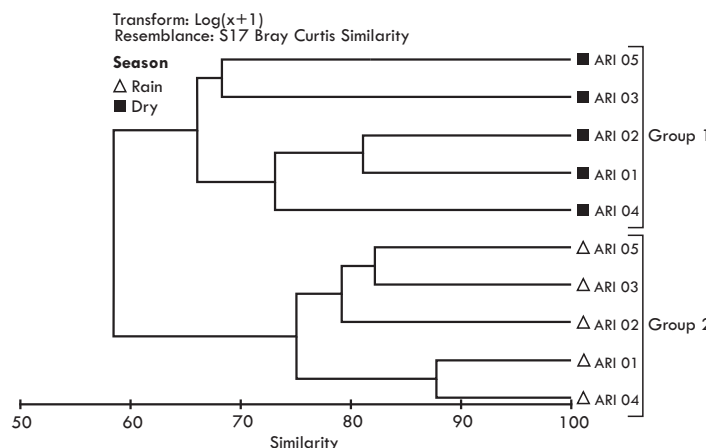


Figure 7. Dendrogram of samples association collected in the Arienga River, Amazon estuary, from May to September 2009.

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

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