MICROPHYTOPLANKTON OF THE MARAPANIM ESTUARY (PARÁ, NORTHERN BRAZIL)

Daniela dos Santos **SANTANA**¹

Rosildo dos Santos **PAIVA**¹

Luci Cajueiro Carneiro **PEREIRA**²

Rauquírio Marinho da **COSTA**^{2*}

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ABSTRACT

The present work was carried out to determine the composition and ecology of the microphytoplankton of the Marapanim River estuary (Amazon region, Pará-Brazil). Samples were collected quarterly during a period of one year from November/2002 to September/2003, in the flood and ebb neap tide at six different stations distributed along the estuary. Analyses were developed with samples collected through subsurface horizontal plankton net (64 μm mesh size) hauls. The microphytoplanktonic assemblages were represented by 180 taxa from which 18 species were new occurrences for Pará state. Tidal currents, salinity and sediment resuspension processes probably contributed to the presence of tycho planktonic (benthic and epiphytes), neritic and planktonic oceanic species.

KEY WORDS: Phytoplankton, estuary, Amazon region.

Microfitoplâncton do Estuário do Marapanim (Pará, Norte do Brasil)

RESUMO

O presente trabalho visou o estudo da composição florística e ecologia do microfitoplâncton do Estuário do Rio Marapanim (Região Amazônica, Pará - Brasil) durante o período de novembro/2002 a setembro/2003, em maré de quadratura de lua minguante. As amostras foram coletadas em seis estações distribuídas ao longo do estuário durante as condições de maré enchente e vazante por intermédio de arrastos horizontais realizados na subsuperfície através da utilização de redes de plâncton com abertura de malha de 64 μm . O microfitoplâncton esteve representado por 180 táxons, sendo relatadas 18 novas ocorrências para o estado do Pará. As correntes de marés, a salinidade e os processos de ressuspensão de sedimentos, possivelmente, contribuíram para o registro de um grande número de espécies ticoplanctônicas (bênticas e epífitas), neríticas e oceânicas planctônicas na área em estudo.

PALAVRAS-CHAVE: Fitoplâncton, estuário, região amazônica.

INTRODUCTION

Estuaries are environments characterized by a great variety of particles with dimensions and composition equally variable presenting a complex fluidic circulation pattern and are considered one of the most productive tropical ecosystems worldwide (Kremer *et al.*, 1994). These ecosystems are used as nursing grounds for a wide range of coastal nektonic species showing a high floristic and faunistic diversity of unchallenged value (Krumme & Liang, 2004).

Studies about the plankton communities in this kind of ecosystem as well as their interaction with different physical and chemical factors are very important to the better understanding of nutritional, productive and energy flux relationship processes among

Author for correspondence.¹Universidade Federal do Pará. Campus Universitário do Guamá. Departamento de Biologia – (CCB/ UFPA).

²Universidade Federal do Pará. Campus Universitário de Bragança – (CABRA/UFPA). Alameda Leandro Ribiro s/n, Aldeia, Bragança, Pará, Brasil.
E-mail: raucosta@ufpa.br

different organisms that live in these zones. On the other hand, information about the planktonic biomass could subsidize fish stock estimations in adjacent coastal zones which depend on the reproductive success and on the larval development that take place in the estuaries (Espírito Santo & Isaac, 1999; Xie & Yang, 2000).

The phytoplankton is considered one of the most important groups among organisms that live in the estuarine zones because they constitute the base of coastal aquatic food webs and are represented by primary producers whose development depends on their permanence in the photic zone (Brandini *et al.*, 1997).

Although the north region of Brazil is one of the priority areas for the recognition and conservation of the biodiversity of coastal ecosystems in the world little is known about the local phytoplanktonic communities (Melo *et al.*, 2006; Sousa *et al.*, 2008; 2009). Studies concerning the knowledge of the biotic and abiotic components of the estuarine zones of the Pará state could contribute to the understanding of the local planktonic community structure clarifying trophodynamic relationship aspects and offering data that permit the evaluation of fish stocks of their estuaries.

The main aim of this study was to determine the composition of the microphytoplankton in the Marapanim estuary showing species occurrence and giving ecological data about the identified taxa contributing to the knowledge of the estuarine communities of the Amazon region.

STUDY AREA

Brazil has 8,500 km of coastline (Joyeux *et al.*, 2004) with the second largest continuous mangrove area on earth (Kjerfve *et al.*, 1997). The coast of Pará represents 7% of the state territory and holds almost 50% of the state population (Glaser & Diele, 2004).

The region is dominated by a humid tropical climate and a marked seasonality with most rainfall between January and June and mean annual precipitation of 2,500-3,000 mm (SUDAM, 1994). Mean air temperature is 27 °C and relative humidity presents annual average values oscillating from 80 to 85 %, directly associated to the pluviometric precipitation regime (Martorano *et al.*, 1993).

The Marapanim estuary is situated on the northeastern coast of Pará state, within a coastal Amazon sector constituted by a littoral submersion of Pará and Maranhão states located southeastern from the mouth of the Amazon River and limited by the coordinates: 00°32'30"S / 00°52'30"S and 47°28'45"W / 47°45'00"W (Berrêdo *et al.*, 2002 in Santana, 2004). According to Silva *et al.* (2009), this estuary is characterized by an embayed coastline sustained by Neogene and quaternary deposits of the Barreiras formation and post-Barreiras sediments, respectively.

The estuary presents funnel shape morphology with a high wide/depth relationship and a gradually width decrease towards the river (Silva & Mendes, 2001). It is characterized by semidiurnal macrotides with total heights of 4 m, local combined with the action of the waves. Tide currents penetrate 62 km inside the estuary during the dry period and 42 km in the rainy period. The vertical salinity gradient is discrete as a consequence of water mixtures and the action of tide currents and horizontal gradient is strongly marked with the highest salinities nearest the coast (Berrêdo *et al.*, 2002).

The pioneer vegetation, considered the first phase of the evolutive stage in the ecologic region, could be subdivided into other vegetable groups such as mangrove, salt marsh and grassland. The embraced area of the mangroves of the Marapanim estuary is about 130 km² and the principal arboreal species in these areas are: *Rhizophora mangle*, *Avicennia germinans* and *Laguncularia racemosa* (Costa Neto *et al.*, 2000). In zones of accretion *Spartina brasiliensis* could be found occupying the pioneer position in the mud-siltic plain.

MATERIAL AND METHODS

Samples were carried out in November/2002, March/2003, July/2003 and September/2003, during neap tides in the flood and ebb tides. Samplings were developed in four different stations distributed along the Marapanim estuary (1, 2, 3 and 4), one station

in the Cuiarana River (5) and one station in Araticum-Mirim creek (6). These last two are considered tide creeks of the Marapanim estuary.

Samples collected for the qualitative analysis were obtained through subsurface horizontal plankton net (64 μm mesh size) hauls carried out during a period of three minutes. Samples were fixed with neutral formaldehyde at 4% and transported to the laboratory.

The identification of microphytoplankton taxa were developed in the laboratory and organisms were identified until the low taxonomical possible level.

For the identification of the sampled material the works of Pérégallo & Pérégallo (1897-1908), Frenguelli (1928), Cupp (1943), Cleve-Euler (1951, 1952, 1953), Husted (1930, 1959, 1961/1966), Desikachary (1959), Hendey (1964), Wood (1968), Bourrelly (1972), Dodge (1982), Balech (1988), Silva-Cunha & Eskinazi-Leça (1990), Sournia (1986) and Tomas (1997) were used. Taxonomic position follows Desikachary (1959) for Cyanophyta, Round *et al.* (1990) for Bacillariophyta, Balech (1988) for Dinophyta and Bourrelly (1972) for Chlorophyta.

For the ecological characterization of the registered taxa data obtained from Moreira-Filho (1961), Eskinazi-Leça (1967/69), Moreira-Filho *et al.* (1968, 1985, 1990, 1999), Eskinazi-Leça & Koenig (1985/86), Sardeiro & Eskinazi-Leça (1985), Mosimann (1985, 1988), Gomes (1989) and Ribeiro (1996) were used.

RESULTS AND DISCUSSION

The microphytoplankton of the Marapanim estuary was represented by 180 taxa (Table 1) distributed in five divisions. The Cyanophyta represented 2.8% of the identified organisms and was constituted by 5 taxa distributed in one class, two orders, three families and three genera. The Dinophyta occupied the third place in terms of qualitative composition presenting 6.6% of the registered taxa. This division was composed by 12 taxa distributed in one class, two orders, four families and 5 genera. The most represented genera in terms of number of species were *Ceratium* (6 spp.) and *Protoperidinium* (3 spp.). The Dictyophyta was the least represented division presenting only 0.6% of the identified taxa framed in one class, one order, one family and one species, *Dictyocha fibula*. The Bacillariophyta was the most represented division and it was constituted by one hundred forty taxa (77.3% of the observed organisms) distributed in three classes, nine sub classes, twenty two orders, thirty eight families and sixty four genera. Genera with the higher number of species were: *Chaetoceros* (23 spp.), *Coscinodiscus* (7 spp.) and *Nitzschia* (7 spp.). Chlorophyta was represented by twenty three taxa (12.7% of the registered taxa) distributed in two classes, three orders, four families and thirteen genera. The most represented genera were *Closterium* (4 spp.), *Xanthidium* (4 spp.) and *Staurostrum* (3 spp.).

The predominance of diatoms has been reported for the majority of the tropical and subtropical estuaries and it used to occur when the marine flux was more remarkable (Patrick, 1967). In the estuaries of Pernambuco state (northeast Brazil) diatoms contributed with more than 80% of the microphytoplanktonic identified species (Travassos, 1991; Silva - Cunha *et al.*, 1993; Flores - Montes, 1996 and Lacerda *et al.*, 2004). In the Amazon littoral, recent studies showed similar results, with diatoms representing between 84.4% (Sousa *et al.*, 2009) and 88.5% (Sousa *et al.*, 2008) of the identified species.

Although the Chlorophyta occupied second place in number of species (12.7%), the organisms of this division were observed only in the rainy season (March/2003), indeed in the stations situated at the mouth of the estuary. For this group, a similar number of species were observed by Travassos (1991) in the Capibaribe estuary (Pernambuco, northeast of Brazil) and in the harbour area of Suape, Pernambuco (Koenig, 1997). In the Marapanim estuary, as could be seen in other Brazilian northeast estuaries, the presence of Chlorophyta was related to the lowest salinity values. Smayda (1983) also observed the presence of Chlorophyta during the predominance of limnetic flux.

Table1. Microphytoplankton composition in Marapanim River estuary (Pará, Northern Brazil) during the flood and ebb tide (November/2002 to September/2003).

Division Cyanophyta	Family Hyalodiscaceae	<i>Cymatosira belgica</i> Grunow
Class Cyanophyceae	<i>Hyalodiscus laevis</i> Ehrenberg	<i>Cymatosira lorenziana</i> Grunow
Order Chroococcales	<i>Podosira hormoides</i> (Mont.) Kützing	SubClass Rhizosoleniophycidae
Family Chroococcaceae	Family Paraliaceae	Order Rhizosoleniales
<i>Microcystis</i> sp.	<i>Paralia sulcata</i> (Ehrenberg) Cleve	Family Rhizosoleniaceae
Order Nostocales	Order Coscinodiscales	<i>Dactyliosolen fragilissimus</i> (Bergon) Hasle
Family Oscillatoriaceae	Family Coscinodiscaceae	<i>Guinardia delicatula</i> (Cleve) Hasle
<i>Oscillatoria</i> sp.1	<i>Coscinodiscus apiculatus</i> Ehrenberg	<i>Guinardia flaccida</i> (Castr.) Peragallo
<i>Oscillatoria</i> sp.2	<i>Coscinodiscus centralis</i> Ehrenberg	<i>Pseudosolenia calcar-avis</i> (Schultze) Sündström
<i>Oscillatoria</i> sp.3	<i>Coscinodiscus concinnus</i> W. Smith	<i>Rhizosolenia hebetata</i> f. <i>semispina</i> (Hensen) Gran
Family Nostocaceae	<i>Coscinodiscus jonesianus</i> (Greville) Ostenfeld	<i>Rhizosolenia imbricata</i> Brightwell
<i>Anabaena</i> sp.	<i>Coscinodiscus oculus-iridis</i> Ehrenberg	<i>Rhizosolenia longiseta</i> Zach.
Division Dinophyta	<i>Coscinodiscus perforatus</i> Ehrenberg	SubClass Chaetocerophycidae
Class Dinophyceae	<i>Coscinodiscus rothii</i> (Ehrenberg) Grunow	Order Chaetocerales
Order Gymnodiniales	<i>Palmeria hardmaniana</i> Greville	Family Chaetoceraceae
Family Gymnodiniaceae	Family Hemidiscaceae	<i>Chaetoceros affinis</i> Lauder
<i>Gymnodinium splendens</i> Lebour	<i>Actinocyclus octonarius</i> Ehrenberg	<i>Chaetoceros atlanticus</i> Cleve
Order Peridinales	Family Heliopeltaceae	<i>Chaetoceros borealis</i> (Bailey) Smithson
Family Peridiniaceae	<i>Actinoptychus senarius</i> (Ehrenberg) Ehrenberg	<i>Chaetoceros brevis</i> Schütt
<i>Diplopsalis</i> sp.	<i>Actinoptychus splendens</i> (Shabd.) Ralfs	<i>Chaetoceros curvisetus</i> Cleve
<i>Protoperidinium depressum</i> (Bailey) Balech	<i>Actinoptychus trilingulatus</i> (Brightwell) Ralfs	<i>Chaetoceros constrictus</i> Gran
<i>Protoperidinium leonis</i> (Pavillard) Balech	<i>Polymyxus coronalis</i> L. W. Bailey	<i>Chaetoceros decipiens</i> Cleve
<i>Protoperidinium steinii</i> (Jorgensen) Balech	Order Asterolamprales	<i>Chaetoceros densus</i> Cleve
Family Gonyaulaceae	Family Asterolampraceae	<i>Chaetoceros diadema</i> (Ehrenberg) Gran
<i>Lingulodinium polyedrum</i> (Stein) Dodge	<i>Asterolampra marylandica</i> Ehrenberg	<i>Chaetoceros didymus</i> Ehrenberg
Family Ceratiaceae	SubClass Biddulphicidae	<i>Chaetoceros distans</i> Cleve
<i>Ceratium candelabrum</i> (Ehrenberg) Stein	Order Triceratiales	<i>Chaetoceros eibenii</i> Grunow
<i>Ceratium extensum</i> (Gourret) Cleve	Family Triceratiaceae	<i>Chaetoceros furcellatus</i> Bailey
<i>Ceratium furca</i> (Ehrenberg) Claparede & Lachmann	<i>Cerataulus smithii</i> Ralfs	<i>Chaetoceros gracilis</i> Schütt
<i>Ceratium fusus</i> (Ehrenberg) Dujardin	<i>Cerataulus turgidus</i> Ehrenberg	<i>Chaetoceros laciniosus</i> Schütt
<i>Ceratium lineatum</i> (Ehrenberg) Cleve	<i>Odontella aurita</i> (Lyngbye) C. A. Agardh	<i>Chaetoceros lauderi</i> Ralfs
<i>Ceratium teres</i> Kofoid	<i>Odontella mobiliensis</i> (Bailey) Grunow	<i>Chaetoceros lorenzianus</i> Grunow
Division Dictyochophyta	<i>Odontella regia</i> (Schultze) Ostenfeld	<i>Chaetoceros mitra</i> (Bailey) Cleve
Class Dictyochophyceae	<i>Odontella rhombus</i> (Ehrenberg) Kützing	<i>Chaetoceros peruvianus</i> Brightwell
Order Dictyochaes	<i>Odontella sinensis</i> (Greville) Grunow	Division Bacillariophyta
Family Dictyochaceae	<i>Triceratium favus</i> Ehrenberg	Class Coscinodiscophyceae
<i>Dictyocha fibula</i> Ehrenberg	<i>Triceratium favus</i> f. <i>quadrata</i> Grunow	SubClass Chaetocerophycidae
Division Bacillariophyta	Order Biddulphiales	Order Chaetocerales
Class Coscinodiscophyceae	Family Biddulphiaceae	Family Chaetoceraceae
SubClass Thalassiosirophycidae	<i>Biddulphia tridens</i> Ehrenberg	<i>Chaetoceros radians</i> Schütt
Order Thalassiosirales	<i>Terpsinoe musica</i> Ehrenberg	<i>Chaetoceros teres</i> Cleve

Family Thalassiosiraceae	Order Hemiaulales	<i>Chaetoceros tortissimus</i> Gran
<i>Thalassiosira angulata</i> (Gregory) Hasle	Family Hemiaulaceae	<i>Chaetoceros</i> sp.
<i>Thalassiosira eccentrica</i> (Ehrenberg) Cleve	<i>Climacodium frauenfeldianum</i> Grunow	<i>Bacteriastrum delicatulum</i> Cleve
<i>Thalassiosira leptopus</i> (Grunow) Hasle & G. Fryxell	<i>Cerataulina pelagica</i> (Cleve) Hendey	<i>Bacteriastrum hyalinum</i> Lauder
<i>Thalassiosira subtilis</i> (Ostenfeld) Gran	<i>Hemiaulus membranaceus</i> Cleve	Order Leptocylindrales
Family <i>Skeletonemataceae</i>	<i>Hemiaulus sinensis</i> Greville	Family Leptocylindraceae
<i>Skeletonema costatum</i> (Greville) Cleve	Family Bellerocheaceae	<i>Leptocylindrus danicus</i> Cleve
Family Lauderiaceae	<i>Bellerochea malleus</i> (Brightwell) Van Heurck	<i>Leptocylindrus minimus</i> Gran
<i>Lauderia annulata</i> Cleve	Family Streptothecaceae	Class Fragilariophyceae
<i>Lauderia compressa</i> Peragallo	<i>Helicotheca tamesis</i> (Shrubsole) Ricard	SubClass Fragilariophycidae
<i>Detonula pumila</i> (Castracane) Gran	Family Plagiogrammaceae	Order Fragilariales
Family Stephanodiscaceae	<i>Dimerogramma fulvum</i> Gregory	Family Fragilariaceae
<i>Cyclotella meneghiniana</i> Kützing	SubClass Lithodesmiophycidae	<i>Asterionellopsis glacialis</i> (Castracane) F.E. Round
<i>Cyclotella planctonica</i> Brunth.	Order Lithodesmiales	<i>Fragilaria vitrea</i> (Kützing) Grunow
<i>Cyclotella socialis</i> Schütt	Family Lithodesmiaceae	<i>Opephora schwartzii</i> (Grunow) Petit
<i>Cyclotella stylum</i> Brightwell	<i>Ditylum brightwellii</i> (West) Grunow	<i>Synedra cristalina</i> var. <i>typica</i> Lyngbye
SubClass Coscinodiscophycidae	<i>Ditylum sol</i> Grunow	<i>Synedra longissima</i> Smith
Order Melosirales	<i>Lithodesmium undulatum</i> Ehrenberg	<i>Synedra robusta</i> Ralfs
Family Melosiraceae	SubClass Cymatosiropycidae	<i>Tabellaria flenestrata</i> (Lyngbye) Kützing
<i>Melosira arctica</i> (Ehrenberg) Dickie	Order Cymatosirales	Order Thalassionematales
<i>Melosira nummuloides</i> Agardh	Family Cymatosiraceae	Family Thalassionemataceae

Table1. (continued)

<i>Thalassionema nitzschioides</i> (Grunow) Mereschkowsky	<i>Pleurosigma speciosum</i> Smith	<i>Surirella</i> sp.
Order Rhabdonematales	<i>Rhoicosigma oceanicum</i> H. F.	Division Chlorophyta
Family Rhabdonemataceae	Family Plagiotropidaceae	Class Eucchlorophyceae
<i>Rhabdonema punctatum</i> (Harvey & Bailey) Stodder	<i>Tropidoneis elegans</i> Smith	Order Volvocales
Order Striatellales	<i>Tropidoneis vitrea</i> Smith	Family Volvocaceae
Family Striatellaceae	Family Stauroneidaceae	<i>Eudorina</i> sp.
<i>Grammatophora oceanica</i> (Ehrenberg) Grunow	<i>Stauroneis</i> sp.	Order Chlorococcales
Family Eunotiaceae	Order Thalassiophysales	Family Radiococcaceae
<i>Eunotia flexuosa</i> (Brébisson) Kützing	Family Catenulaceae	<i>Eutetramorus planctonica</i> (Korch.) Bourr.
Class Bacillariophyceae	<i>Amphora arenaria</i> Donk	Class Zygnophyceae
SubClass Bacillariophycidae	<i>Amphora elegans</i> H. Peragallo	Order Zygnematales
Order Lyrellales	<i>Amphora inflexa</i> Brébisson	Family Desmidiaceae
Family Lyrellaceae	<i>Amphora quadrata</i> (Greville) Pers.	<i>Bambusina brebissonii</i> Kützing
<i>Petroneis humerosa</i> (Brébisson) Stick & Mann	<i>Amphiprora angustata</i> Hendey	<i>Closterium gracile</i> Brébisson
Order Achnanthes	<i>Amphiprora pulchra</i> var. <i>pulchella</i> H. Peragallo	<i>Closterium johnsonii</i> W & G.S. West
Family Cocconeidaceae	<i>Entomoneis alata</i> Ehrenberg	<i>Closterium kuetzingii</i> Brébisson
<i>Cocconeis fluminensis</i> Grunow	Order Bacillariales	<i>Closterium macilentum</i> Brébisson
<i>Campyloneis grevillei</i> (Smith) Grunow	Family Bacillariaceae	<i>Cosmarium ornatum</i> var. <i>pseudolagoense</i> Förster & Eckert
Order Naviculales	<i>Bacillaria paxillifera</i> (O. F. Müller) Hendey	<i>Desmidium baileyi</i> (Ralfs) de Bary
Family Pinnulariaceae	<i>Cylindrotheca closterium</i> (Ehrenberg)	<i>Desmidium cylindricum</i> Greville

<i>Caloneis</i> sp.	Reimann & Lewin	<i>Groenbladia neglecta</i> (Raciborski) Teiling
<i>Pinnularia</i> sp.	<i>Nitzschia insignis</i> var. <i>smithii</i> Ralfs	<i>Hyalotheca dissiliens</i> (Smith) Brébisson
Family Diploneidaceae	<i>Nitzschia longissima typica</i> Brébisson	<i>Pleurotaenium trabecula</i> (Ehrenberg) Nägeli
<i>Diploneis bombus</i> Ehrenberg	<i>Nitzschia lorenziana</i> Grunow	<i>Staurostrum cerastes</i> var. <i>pulchrum</i> Scott & Grönblad
<i>Diploneis crabo</i> Ehrenberg	<i>Nitzschia maxima</i> Grunow	<i>Staurostrum hystrix</i> var. <i>brasiliense</i> Grönblad
<i>Diploneis splendida</i> Gregory	<i>Nitzschia obtusa</i> Smith	<i>Staurostrum stelliferum</i> Borge
Family Naviculaceae	<i>Nitzschia scalaris</i> (Ehrenberg) W. Smith	<i>Triploceras verticillatum</i> Bailey
<i>Navicula cuspidata</i> (Kützing) Kützing	<i>Nitzschia</i> sp.	<i>Xanthidium amazonense</i> Scott & Croasdale
<i>Navicula</i> sp.	<i>Pseudo-nitzschia seriata</i> (Cleve) H. Peragallo	<i>Xanthidium canadense</i> var. <i>borgei</i> Först
Family Pleurosigmataceae	Order Surirellales	<i>Xanthidium fragile</i> Borge
<i>Gyrosigma balticum</i> (Ehrenberg) Cleve	Family Surirellaceae	<i>Xanthidium trilobum</i> Nordstedt
<i>Pleurosigma delicatum</i> Smith	<i>Petrodictyon gemma</i> (Ehrenberg) Mann	Family Zygnemataceae
<i>Pleurosigma decorum</i> Smith	<i>Surirella elegans</i> Ehrenberg	<i>Mougeotia</i> sp.
<i>Pleurosigma spencerii</i> Smith	<i>Surirella fastuosa</i> Ehrenberg	<i>Zygne</i> sp.

Dinoflagellates (Dinophyta) represented 6.6 % of the identified taxa. These organisms are more representative of coastal areas and may be found preferable in oceanic waters and entering in the estuaries during seasons of high salinity (dry season) which make environmental conditions favorable to their survival (Balech, 1988). For this reason only few species are reported for estuarine regions (Feitosa, 1988; Lacerda, 1994; Lacerda *et al.*, 2004). In the present study, dinoflagellates showed remarkable importance during the dry season, principally in the stations situated in the mouth of the estuary. However, they were also sporadically observed in the inner stations and during the ebb tide.

Barros – Franca & Batista (1991) observed the presence of *Ceratium furca* and *Dinophysis caudata* in samples of the harbour of Suape (Pernambuco, Brazil) during the flood tides and showed the importance of the currents in the transport of these species to the referred ecosystem. Maia (1995) observed the presence of ten species of dinoflagellates in the Pina Basin (Pernambuco-Brazil) from which *Ceratium furca*, *C. fusus* and *C. massiliense* presented considerable occurrence during the flood tides of the dry season. In Northern Brazil, previous studies performed in the surf zone of Canela Island (Bragança, Pará), showed that species of this group accounted for 10% of the local microphytoplankton (Sousa *et al.*, 2008).

Another algae group that is common in the estuarine environment is the group of the Cyanophyta represented in the Marapanim estuary by five taxa (2.8%). Samayda (1983) reported that blue-green algae became more important when salinity values decreased and that they were very adapted to freshwater environments. However, in the present work, the Cyanophyta just occurred during the dry season, when the highest salinity values were observed, and principally in the stations closer to the mouth of the estuary. Although this group has been reported as a freshwater species for the studied area they might be considered euryhaline species. The same observation was carried out by Koenig (1997) and Koenig *et al.* (2002), in the Ipojuca estuary (Pernambuco-Brazil) and by Sousa *et al.* (2008; 2009) in the Amazon littoral.

The number of identified taxa in the present study was higher than that registered by other authors in different ecosystems of Pará state (Amazon region, north Brazil) in which it was observed lower specific diversity than that found in the Marapanim estuary (Paiva, 1991; Sousa *et al.*, 2008, 2009). However, in these studies as it could be seen in a previous study developed in the Marapanim estuary, the diatoms were the group most represented.

For the ecological frame of the identified taxa four categories were established: planktonic oceanic, planktonic neritic, tycho planktonic and freshwater species (Figure 1). In the Marapanim estuary planktonic neritic species were dominant (33.1%), followed by neritic littoral (tycho planktonic-30.9%) and planktonic oceanic species (21.5%). In the

studied area, as it could be observed for other Brazilian estuaries, the planktonic oceanic and planktonic neritic species were predominant and species such as *Coscinodiscus apiculatus*, *C. centralis*, *Chaetoceros atlanticus*, *C. peruvianus*, *C. lorenzianus*, *C. curvisetus*, *Odontella regia*, *Skeletonema costatum* and *Thalassiosira* spp. were the most commonly represented (Kutner, 1972; Silva – Cunha & Almeida, 1987/89; Sassi, 1991; Moura, 1992; Lacerda *et al.*, 2004). The fact that the tychoplanktonic species were ranked second in number of identified taxa might be associated to the force of tide currents and the shallowness of the estuary which are responsible for sediment resuspension and the presence of benthic and epiphyte species in the plankton. Hendey (1964) also observed that many neritic littoral (tychoplanktonic) species could be maintained in the water column during a large part of their life cycle when removed from their natural environment. For this reason they could be frequently sampled in plankton net hauls.

Figure 1: Ecological categories representation (%) of the different species registered in the Marapanim estuary (November/2002 to September/2003).

Bustillos – Gusmán (1986) verified that in three different rich organic matter mangrove ecosystems in La Paz bay (Mexico), which also presented high levels of sedimentation, benthic diatoms and epiphytes were more adapted to the environment and *Amphora* and *Pleurosigma* were the predominant genera. Schreiber & Pennock (1995) also reported the importance of benthic microalgae in the primary production of shallow waters of Weeks Bay estuary (Alabama). These studies, and other performed in the Amazon coast (Sousa *et al.*, 2008; 2009), showed that the introduction of benthic and epiphyte species in the plankton is very common in estuarine zones despite being tropical or subtropical regions and that these organisms contributed to the enrichment of the species' inventory and their high primary production.

The presence of oceanic and neritic species must be attributed to tidal currents and as it was observed by Frenguelli (1928) it is difficult to establish exact boundaries between neritic and oceanic forms because many species may be found in the ocean or next to coastal regions due to their ecological ability to colonize marine and estuarine environments. Guillard and Rilham (1977) also suggested the inclusion of the term "type species" for the characterization of planktonic populations. They referred to *Skeletonema costatum*, *Leptocilyndrus danicus*, *Chaetoceros curvisetus* and *C. didymus* as coastal forms of the setentrional Atlantic, while *Rhizosolenia imbricata* would characterize the oceanic plankton. Frenguelli (1928) also considered this last species as characteristic of the Atlantic Ocean.

Silva – Cunha & Eskinazi – Leça (1990), discussed that for the determination of the "type species" methodical studies in different sample stations and seasonal periods are

necessary. The distribution of sample stations in the Marapanim River were limited to the estuarine region and although different seasonal periods were sampled in the present study (November/2002 – dry season; March/2003 – rainy season; July/2003 beginning of the rainy/dry transition season; and September/2003 – dry season), it was not possible to characterize “type species”. For this reason it was more appropriate to use the terms oceanic planktonic, neritic oceanic, ticoplanktonic and freshwater species as was commonly used by Gomes (1989), Silva-Cunha & Eskinazi-Leça (1990) and other to designate species whose habitats are in oceanic or coastal environments.

In the present study 18 new occurrences were reported for Pará state which are: *Amphiprora angustata*, *A. pulchra* var. *pulchella*, *Amphora elegans*, *A. inflexa*, *A. quadrata*, *Ceratium lineatum*, *C. teres*, *Chaetoceros eibonii*, *C. furcellatus*, *C. radians*, *C. tortissimus*, *Cocconeis fluminensis*, *Cyclotella planctonica*, *C. socialis*, *Cymatosira belgica*, *Diploneis splendida*, *Fragilaria vitrea* and *Gymnodinium splendens*; showing its relevance for the knowledge of planktonic communities composition of estuaries from the Amazon region.

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