Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 11(3): 1633, April 2015 doi: http://dx.doi.org/10.15560/11.3.1633
ISSN 1809-127X 

# Phytoplankton in a tropical estuary, Northeast Brazil: composition and life forms

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**Abstract:** We aimed verify the composition of the phytoplankton community and this life forms that occur in the Capibaribe River estuary, Pernambuco, Brazil. This is a highly impacted ecosystem by anthropic activities. We collected samples of the phytoplankton community at three stations, during three months of each season: dry, from October to December 2010; rainy, from May to July 2011. We collected samples during the low and high tide, at the spring tide. We classified the species based on life forms. We identified 127 taxa, and the majority of species were freshwater planktonic form (FP; 30%), followed by marine oceanic planktonic (MOP; 25%), marine neritic tichoplanktonic (MNT; 22%) and planktonic (MNP; 19%,), and tichoplanktonic estuarine (TE; 3%) and freshwater (TF; 1%). The majority of species identified were diatoms, since it assumes the most variability of life forms, therefore enabling its presence in the different portions at the estuary.

**Key words:** diatoms; freshwater; marine; plankton; tichoplankton

## INTRODUCTION

Estuaries are high dynamic ecosystems affected by marine and limnetic conditions, such as changes in the river flow and marine tides, enabling different characteristic zones along the estuary. Thereby, it is observed great variations of the environmental parameters (Miranda et al. 2002). As a result, the phytoplankton community rapidly responds to these environmental changes (Cloern and Jassby 2010). Phytoplankton are one of the main primary producers in aquatic ecosystems, as well as is considered excellent bioindicators of environmental quality (Reynolds 2006).

The different life forms in the phytoplankton species are dependent, in general, on their response to the heterogeneity of habitats, besides the tolerance to oscillations in the environmental, which can resuspend or deposit cells on the bottom. The knowledge of composition and life forms of the biotic communities is a necessary tool to understand the mechanism and the ecological importance of aquatic ecosystems (Eskinazi-Leça et al. 2004; Cloern and Jassby 2010).

In this context, our study aimed to analyze the composition of the phytoplankton community and the main life forms of species occurring in the Capibaribe River estuary (Pernambuco), which is an important aquatic body in Northeast Brazil.

## MATERIALS AND METHODS

### Study Area

The Capibaribe River estuary is located in the downtown of the Recife City (Pernambuco state, Northeast Brazil; Figure 1). Because it is located in an area of high degree of urbanization, waters are eutrophized and strongly affected by anthropic activities, mainly due to discharge of domestic and industrial effluents. As consequence, occur high concentrations of ammonia, phosphorus, heavy metals, and thermotolerant coliforms, and turning the levels of dissolved oxygen undetectable (SRH 2010).

### Data sampling and analysis

We collected samples for phytoplankton analysis at three sites along the estuary: upstream (S1), downstream (S3), and one intermediate site (S2) along the river. We conducted sampling during three months of each climatic seasons, in the dry (October to December 2010) and rainy (May to July 2011) season, and during high and low tide in the same day, in spring tide.

We collected phytoplankton from the Capibaribe River estuary through superficial horizontal hauls (plankton net of 64 µm mesh size), for 3 minutes. We fixed samples ($n$ = 36) in neutral formaldehyde (Newell and Newell 1963), for subsequent identification and counting by optic microscopy.

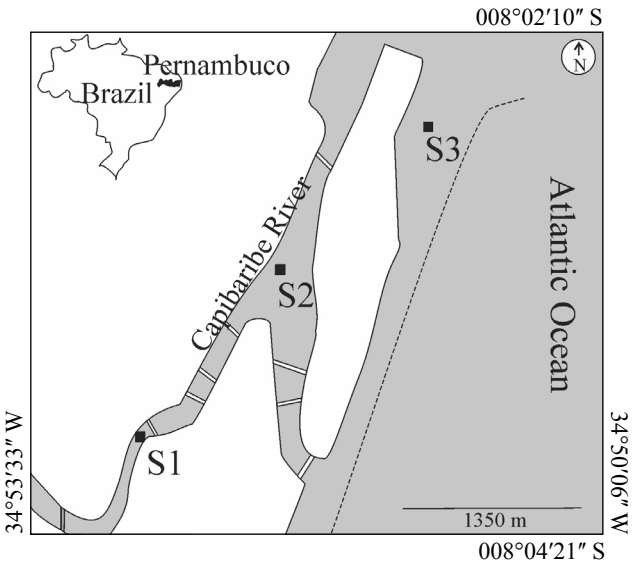


**Figure 1.** Capibaribe River estuary (Pernambuco state, Brazil), where is located the sampling sites (S1, S2, and S3).

We identified the species based on specific references, as Peragallo and Peragallo (1897-1908), Husted (1961–1966), Cupp (1943), Silva-Cunha and Eskinazi-Leça (1990), Tomas (1993), Sournia (1986), Balech (1988), Licea et al. (1995), Desikachary (1959), Mizuno (1968). When necessary, we observed the chloroplasts using a contrast phase system, and to better identification of the diatom frustule ornamentations we referenced Carr et al. (1986). We used the taxonomic classification system of Guiry and Guiry (2012).

We classified the life forms to only ones the organisms identified until species level. For diatoms, this classification was based on Torgan and Biancamano (1991), Moreira Filho et al. (1990; 1994/95; 1999), and Silva-Cunha and Eskinazi-Leça (1990). For the remaining groups we used the online database from Guiry and Guiry (2012) and Eskinazi-Leça et al. (2013). We considered the following classes: marine oceanic planktonic (MOP), marine neritic planktonic (MNP), marine neritic tichoplanktonic (MNT), tichoplanktonic estuarine (TE), tichoplanktonic freshwater (TF), and freshwater planktonic (FP).

## RESULTS

As result, we registered 128 taxa, overwhelming dominated by phylum Ochrophyta (diatoms), which formed 54% of the total, followed by the phyla Cyanobacteria (cyanobacteria, 18%), Chlorophyta (chlorophytes, 13%), Myzozoa (dinoflagellate, 7%), Euglenozoa (euglenophyte, 5%) and Charophyta (charophyte, 3%).

The majority of species identified showed the life forms compatible with FP, corresponding to 30% of the total and consisting mainly of species of chlorophytes and cyanobacteria. Species of MOP represented 25% of the total, followed by MNT and MNP, with 22% and 19%, respectively. Ultimately, species of TE and TF were represented with 3% and 1% of the total, respectively (Table 1). All dinoflagellates identified in the Capibaribe River estuary marine and planktonic life forms, and also other 26 species of diatoms (Table 1). Only *Fragilaria capucina* Desmazières were part of the FT category (Table 1). Two species of diatoms were part of the TE, *Terpsinoë musica* Ehrenberg and *Gyrosigma balticum* (E.) Rabenhorst.

**Table 1.** Taxa identified in the Capibaribe River estuary and this life form. Codes: (MNT) Marine Neritic Tichoplanktonic; (MNP) Marine Neritic Planktonic; (MOP) Marine Oceanic Planktonic; (FT) Freshwater Tichoplanktonic; (FP) Freshwater Planktonic; (TE) Tichoplanktonic Estuarine.

| Taxa | Life form |
|---|---|
| **PHYLUM CYANOBACTERIA** | |
| **Class Cyanophyceae** | |
| **Order Nostocales** | |
| *Anabaena* sp. | |
| *Aphanizomenon* sp. | |
| *Cylindrospermopsis raciborskii* (W.) Seenayya & S. Raju | FP |
| Nostocales undertemined | |
| *Richelia intracellularis* J. Schmidt | MOP |
| **Order Chroococcales** | |
| **Chroococcales undertemined** | |
| *Chroococcus dispersus* (K.) Lemmermann | FP |
| *Microcystis aeruginosa* (K.) Kützing | FP |
| **Order Synechococcales** | |
| *Coelomoron* sp. | |
| *Merismopedia punctata* Meyen | FP |
| **Order Pseudanabaenales** | |
| *Geitlerinema unigranulatum* (R. N. S.) Komárek & Azevedo | FP |
| *Geitlerinema* sp. | |
| *Pseudanabaena* sp. | |
| *Spirulina subsalsa* Oersted | FP |
| *Spirulina* sp. | |
| **Order Oscillatoriales** | |
| *Lyngbya* sp. | |
| *Oscillatoria princeps* Vaucher ex Gomont | FP |
| *Oscillatoria* sp1 | |
| *Oscillatoria* sp2 | |
| *Phormidium* sp1 | |
| *Phormidium* sp2 | |
| *Phormidium* sp3 | |
| *Planktothrix agardhii* (G.) Anagnostidis & Komárek | F |
| *Planktothrix isothrix* (S.) Komárek & Komárková | F |
| **PHYLUM EUGLENOZOA** | |
| **Class Euglenophyceae** | |
| **Order Euglenophyceae** | |
| *Colacium* sp. | |
| **Order Eutreptiales** | |
| *Eutreptiella* sp. | |
| **Order Euglenales** | |
| *Euglena acus* (O. F. M.) Ehrenberg | FP |
| *Phacus* sp. | |
| *Phacus acuminata* Drezepolskiego | FP |
| *Trachelomonas* sp. | |

*Continued*

**Table 1.** *Continued.*

| Taxa | Life form |
|---|---|
| **PHYLUM MYZOZOA** | |
| **Class Dinophyceae** | |
| **Order Dinophysiales** | |
| *Dinophysis caudata* Saville-Kent | MNP |
| **Order Gonyaulacales** | |
| *Neoceratium extensum* (G.) Gomez, Moreira & Garcia | MNP |
| *Neoceratium furca* (E.) Gomez, Moreira & Garcia | MNP |
| *Neoceratium fusus* (E.) Gomez, Moreira & Garcia | MOP |
| *Neoceratium macroceros* (E.) Gomez, Moreira & Garcia | MOP |
| *Neoceratium trichoceros* (E.) Gomez, Moreira & Garcia | MOP |
| *Neoceratium tripos* (M.) Gomez, Moreira & Garcia | MOP |
| **Order Peridiniales** | |
| *Protoperidinium* sp1 | |
| *Protoperidinium* sp2 | |
| **PHYLUM OCHROPHYTA** | |
| **Class Coscinodiscophyceae** | |
| **Order Aulacoseirales** | |
| *Aulacoseira granulata* (E.) Simonsen | FP |
| **Order Coscinodiscales** | |
| *Actinoptychus splendens* (S.) Ralfs ex Pritchard | MNT |
| *Coscinodiscus centralis* Ehrenberg | MOP |
| *Coscinodiscus kutzing* Grunow | MOP |
| *Coscinodiscus nitidus* W.Gregory | MNP |
| *Coscinodiscus oculus-iridis* (E.) Ehrenberg | MNP |
| *Coscinodiscus* sp1 | |
| *Coscinodiscus* sp2 | |
| *Coscinosdiscus* sp3 | |
| **Order Chaetocerotales** | |
| *Bacteriastrum delicatulum* Cleve | MOP |
| *Chaetoceros atlanticus* Cleve | MOP |
| *Chaetoceros brevis* F.Schütt | MNP |
| *Chaetoceros compressus* Lauder | MOP |
| *Chaetoceros curvisetus* Cleve | MNT |
| *Chaetoceros lorenzianus* Grunow | MNP |
| *Chaetoceros peruvianus* Brightwell | MOP |
| *Chaetoceros* sp1 | |
| *Chaetoceros* sp2 | |
| **Order Hemiaulales** | |
| *Bellerochea malleus* (B.) Van Heurck | MNP |
| **Order Triceratiales** | |
| *Odontella aurita* (L.) Agardh | MNT |
| *Cerataulus turgidus* (E.) Ehrenberg | MNT |
| *Dimerogramma* sp. | |
| *Triceratium pentacrinus* (E.) Wallich | MNT |
| *Triceratium broeckii* G. Leuduger-Fortmorel | MNT |
| **Order Biddulphiales** | |
| *Biddulphia biddulphiana* (S.) Boyer | MNT |
| *Terpsinoë musica* Ehrenberg | TE |
| **Class Fragilariophyceae** | |
| **Order Fragilariales** | |
| *Asterionellopsis glacialis* (C.) Round | MNP |
| *Fragilaria capucina* Desmazières | FT |
| *Fragilaria* sp. | |
| *Synedra* sp. | |
| **Order Thalassiosirales** | |
| *Cyclotella glomerata* Bachmann | FP |
| *Cyclotella* sp. | |
| *Lauderia* sp. | |
| *Skeletonema costatum* (G.) Cleve | MNP |
| *Thalassiosira eccentrica* (E.) Cleve | MNT |
| *Thalassiosira* sp. | |
| **Thalassiosirales undertemined** | |
| **Order Lithodesmiales** | |
| *Ditylum* sp. | |
| *Helicotheca tamesis* (S.) Ricard | MNP |
| **Order Rhizosoleniales** | |
| *Guinardia flaccida* (C.) Peragallo | MOP |
| *Guinardia striata* (S.) Hasle | MOP |
| *Proboscia alata* (B.) Sundström | MOP |
| *Rhizosolenia setigera* Brightwell | MOP |
| *Rhizosolenia styliformis* T.Brightwell | MOP |
| **Order Leptocylindrales** | |
| *Leptocylindrus danicus* Cleve | MNP |
| **Order Paraliales** | |
| *Paralia sulcata* (E.) Cleve | MNT |
| **Class Bacillariophyceae** | |
| **Order Bacillariales** | |
| *Bacillaria paxillifera* (O. F. M.) Marsson | MOP |
| *Cylindrotheca closterium* (E.) Reimann & Lewin | MNT |
| *Nitzschia insignis* Gregory | MNT |
| *Nitzschia lorenziana* Grunow | MNT |
| *Nitzschia sigma* (K.) W.Smith | MNT |
| *Nitzschia* sp. | |
| *Pseudo-nitzschia pungens* (Grunow ex Cleve) Hasle | MNP |
| **Order Surirellales** | |
| *Campylodiscus clypeus* (E.) Ehrenberg ex Kützing | MNT |
| *Entomoneis alata* (E.) Ehrenberg | MOP |
| *Surirella febigerii* Lewis | MNT |
| **Order Naviculales** | |
| *Gyrosigma balticum* (E.) Rabenhorst | TE |
| *Navicula* sp. | |
| *Pinnularia* sp. | |
| *Pleurosigma* sp1 | |
| *Pleurosigma* sp2 | |
| **Naviculales undertemined** | |
| **Class Fragilariophyceae** | |
| **Order Licmophorales** | |
| *Licmophora abbreviata* Agardh | MNT |
| *Licmophora* sp. | |
| **Order Thalassionematales** | |
| *Thalassionema frauenfeldii* (G.) Hallegraeff | MOP |
| *Thalassionema* sp. | |
| **Order Melosirales** | |
| *Melchersiella hexagonalis* Kützing | MNP |
| **Order Rhabdonematales** | |
| *Rhabdonema punctatum* (Harvey & Barley) Stodder | MNT |
| Order Striatellales | |
| *Grammatophora marina* (L.) Kützing | MOP |
| **PHYLUM CHLOROPHYTA** | |
| **Class Chlorellaceae** | |
| **Chlorellaceae undertemined** | |
| **Class Trebouxiophyceae** | |
| **Order Chlorellales** | |
| *Actinastrum hantzschii* Lagerheim | FP |
| *Micractinium pusillum* Fresenius | FP |
| *Oocystis* sp. | |
| **Order Trebouxiophyceae** | |
| *Crucigenia tetrapedia* (K.) Kuntze | FP |

*Continued*

**Table 1.** *Continued.*

| Taxa | Life form |
|---|---|
| **Class Ulvophyceae** | |
| **Order Cladaphorales** | |
| *Cladophora* sp. | |
| **Class Chlorophyceae** | |
| **Order Sphaeropleales** | |
| *Desmodesmus maximus* (West & West) Hegewald | FP |
| *Monoraphidium* sp. | |
| Pediastrum boryanum | FP |
| *Pediastrum duplex* Meyen | FP |
| *Pediastrum* sp. | |
| *Scenedesmus acutus* Meyen | FP |
| *Scenedesmus dimorphus* (T.) Kützing | FP |
| *Scenedesmus obliquus* (T.) Kützing | FP |
| *Scenedesmus quadricauda* Chodat | FP |
| **Order Chlamydomonadales** | |
| *Pandorina morum* (O.F.M.) Bory de Saint-Vincent | FP |
| **PHYLUM CHAROPHYTA** | |
| **Class Charophyceae** | |
| **Order Charales** | |
| *Chara* sp. | |
| **Class Conjugatophyceae** | |
| **Order Desmidiales** | |
| *Closterium* sp. | |
| *Staurastrum* sp. | |
| **Order Zygnematales** | |
| *Spirogyra* sp. | |

## DISCUSSION

In tropical estuary ecosystems diatoms are the main components of the planktonic flora (Fujita and Odebrecht 2007; Masuda et al. 2011; Borges et al. 2012). Studies with phytoplankton species demonstrated that the predominance of diatoms in estuarine ecosystems is not only due to its high rate of division, but also to its euryhaline ability (Ribeiro et al. 2003).

More recent approaches focusing the phytoplankton community in ecosystems nearby of the Capibaribe River have shown that diatoms are the main organisms of the community. It is explained by the higher levels of silicate in these waters and thus, its benefits the diatom population (Santiago et al. 2010; Borges et al. 2012). In addition, our results suggest that the greater occurrence of diatoms in estuaries, comparing with other groups, is due to the different life forms that this population can assume (Table 1).

Many species that are present in estuaries are originally from the freshwaters, such as chlorophyceans and cyanobacteria species. These species are transported downstream by the river's flow (Masuda et al. 2011). The occurrence of some freshwater cyanobacteria species in our study show that these species are present in some freshwater ecosystems in Northeast Brazil, mostly in rivers and reservoirs that are components of the watershed of the Capibaribe River (Dantas et al. 2012).

On the other hand, dinoflagellates identified during our study were essentially marine and planktonic. These organisms are present in the estuarine environment due to the tide regime, which is responsible for their transport into the estuary (Trigueros and Orive 2000). *T. musica* and *G. balticum* are tycoplanktonic estuarine diatoms. Both species are present in other tropical estuaries in Brazil (Fujita and Odebrecht 2007; Leão et al. 2008; Santiago et al. 2010; Masuda et al. 2011), while *F. capucina* is the only tycoplanktonic freshwater form in the present study, commonly reported in other benthonic substrates (Roberts et al. 2004; Antoniades et al. 2005). The three diatoms mentioned are in water column due to the high dynamism of the estuarine ecosystem, which induces mixture and resuspension of organisms from the bottom (Fujita and Odebrecht 2007).

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**Authors' contribution statement:** EPA identified the species, its life forms and wrote the text, GCPB identified the species and its life forms, MHS and JZOP collected the data, and MGGSC wrote the text.

**Received:** May 2014
**Accepted: February 2015**
**Editorial responsibility:** Luciana Gomes Barbosa