

## ZOOPLANKTON FROM THE MARACAJÁ REEFS, NORTHEASTERN BRAZIL

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### ABSTRACT

This study was carried out to assess the diversity and the abundance of the reef zooplankton in the Maracajaú reefs. Samples were collected with two plankton nets (65 and 300 micrometers mesh size, each) from February to June/2000 at three stations in a transect perpendicular to coast. Plankton biomass in the 65  $\mu\text{m}$  fraction varied from 45.19  $\text{mg.m}^{-3}$  to 316.45  $\text{mg.m}^{-3}$ . In the 300  $\mu\text{m}$  fraction biomass varied from 9.33  $\text{mg.m}^{-3}$  to 43.16  $\text{mg.m}^{-3}$ . Zooplankton presented 61 taxa. Copepods were the most diverse taxa with 23 species. *Euterpina acutifrons*, *Oithona oswaldocruzi*, *Oithona hebes*, *Oithona* sp., *Parvocalanus crassirostris*, *Acartia lilljeborgi*, Bivalvia and Gastropoda larvae, *Trilocularina* sp., *Balanus* sp. larvae, *Spirillina* sp., Polychaeta larvae, Brachyura (zoea) and *Oikopleura longicauda* occurred in more than 75% of the samples. The zooplankton followed a seasonal pattern, with the highest numbers occurring during the rainy season (February). A high density of microzooplankton was found which varied from 1,917  $\text{ind.m}^{-3}$  to 47,620  $\text{ind.m}^{-3}$ . The macrozooplankton presented lower densities with a minimum of 92.4  $\text{ind.m}^{-3}$  and a maximum of 1,617  $\text{ind.m}^{-3}$ . Species diversity was intermediate ( $\sim 2 \text{ bits.ind}^{-1}$ ) and evenness relatively high ( $\sim 0.78$ ). Samples could be joined into 3 groups, mainly influenced by rainfall. Species similarity presented 5 groups: oceanic, neritic, a mixture of neritic and oceanic, reef and estuarine. Our data suggest a dynamic relationship between the zooplankton communities characteristic of inshore water trapped by the coastal boundary layer and more offshore plankton communities.

**Key words:** Zooplankton, reefs, distribution, diversity

### INTRODUCTION

Reefs constitute the very foundation of immensely complex marine coastal communities of fundamental value and are among the most productive marine ecosystems (New, 1995). Although geographically restricted to tropical seas and occupying only 0.1% of the earth surface, coral reefs have globally important implications for marine biodiversity. Reefs support unusually diverse animal communities with distinctive taxonomic structure and geographical distribution patterns (Kohn, 1997).

Generally, it is admitted that corals constitute an important part of the Brazilian reefs. However, it appeared that coral reefs of the Pacific type do not exist here (Mabesoone, 1967). All reefs in which corals grow or grew in Northeastern Brazil, have a base of sandstone or sometimes another rock type cropping out of the sea floor. Where corals occur, there is also a great influence of algae which may grow at the seaward side of the reef, where the wave action is strongest (Laborel,

1965). It seems that many reefs have reached their upward limit of growth. The base is now dead or grows only laterally (Mabesoone & Coutinho, 1970). Although the reefs are not completely of corals, they have important roles in protecting many low-lying shores from erosion, supporting fisheries, fostering tourism, and as sources of items for the souvenir and aquarium trades and of building material.

Reefs are also good environmental quality indicators because any impact results in community structure changes (New, 1995). The impact of increased sedimentation and eutrophication is probably the most common and serious influence on Brazilian reefs and their associated fauna and flora (Mabesoone & Coutinho, 1970).

Among the fauna, the reef zooplankton forms a specific community, which differs from the zooplankton communities of the surrounding pelagic areas of the open ocean in its species composition, in its behavior and in its abundance (Emery, 1968; Sale *et al.*, 1976; Sorokin, 1990). The zooplankton is a very important community to the reef fauna trophic web. According to Erez (1990) corals are well adapted to hunt small zooplankton using their arms and nematocysts. Many organisms of the reef community other than corals are active and passive filter-feeders, which concentrate plankton and particulate organic matter.

In the present paper the term “reef zooplankton” refers to the total zooplankton caught in nets close to and above the reefs of Maracajaú. This reef is a “table type”, formed by numerous pinnacles like mushroom. The reef is almost constituted by calcareous algae, corals and vermetids. Thus, it is hypothesized that much of the zooplankton in waters immediately adjacent to these reefs comes from the reef itself.

There are few studies in the Maracajaú area. Laborel (1967) was the first who mentioned coral occurrence besides other fauna and flora in this area. Mayal *et al.* (2001) presented the results of studies about five coral species in the area and Feitosa *et al.* (2003) studied the reef ichthyofauna.

The present paper is the first contribution to the abundance and diversity of the reef zooplankton occurring in Maracajaú. These reefs are very important to the artisanal fisheries and for the diving tourism.

## MATERIALS AND METHODS

The Maracajaú area is located at the north of Rio Grande do Norte State (5°21'12S, 5°25'30"S and 35°14'30"W, 35°17'12"W), Northeastern Brazil (Fig. 1). In this area, there is an extensive reef formation, where a Environmental Protection Area was established in June 2001. During low tide, these reefs are generally at 0.5 to 1.0 meter depth from the surface and in some places at 1.5 meters depth. These formations are disposed in shallow waters and are nearly 10 km long and 4 km wide. These reefs are located 7 km offshore. The coast presents intense marine erosion and sharp cliffs that belong to the Barreiras Formation. Around 2 km from the coast, there is a channel 5 to 10 meters deep. Most of the bottom areas is covered with calcareous algae, except the channel which is covered by seagrasses (*Halodule wrightii* Aschers). The area is influenced by a small river (rio Maxaranguape).

There are six coral species: *Agaricia agaricites* (Linnaeus, 1758), *Siderastrea stellata* Verrill 1868, *Porites astreoides* Lamarck, 1816, *Porites branneri* Rathbun, 1887, *Favia gravida* Verrill, 1868 and *Mussismilia hispida* (Verrill, 1902) (Mayal *et al.*, 2000).

Plankton samples were collected from February to June/00, during diurnal low tide, at 3 fixed stations along a transect perpendicular to the coast of Maracajaú – RN. Station 1 was located over the reefs, station 2 on the channel that separates the reef area from the coast, and station 3 close to the coast (Fig. 1). Sampling was performed with two plankton nets (mouth of 30 cm diameter and 1 m length), one with 65 µm mesh size (for microzooplankton) and the other 300 µm mesh size

(for macrozooplankton), fitted with a Hydrobios flowmeter. Five minutes horizontal surface hauls were made at each station. After collections, samples were immediately preserved in 4% neutral saline formaldehyde. In the laboratory, a 1 ml sub-sample of the microzooplankton was placed in a Sedwick-Rafter chamber, identified and counted by species under a Zeiss compound microscope. A 4 ml sub-sample of the macrozooplankton was placed in a Bogorov chamber, identified and counted by species under a Zeiss stereomicroscope. Triplicate sub-samples of each sample were counted.

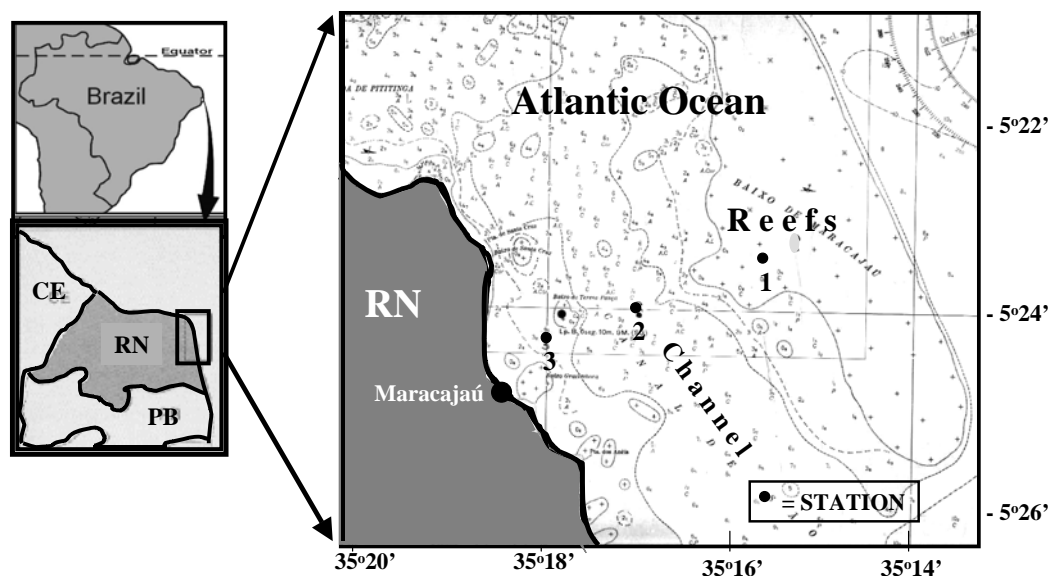


Figure 1 – Studied area and stations localization, Rio Grande do Norte, Brazil.

A ANOVA test was applied to verify differences among stations and months. The BIOSTAT program was used for this purpose.

Species diversity was based on the Shannon (1948) index and evenness on Pielou (1977). The calculations were made with the DIVERSITY program (CNPq and Mamirauá). A cluster analysis was performed based on the matrix of species abundance of the microzooplankton (most abundant) using the Bray-Curtis index (according to Legendre & Legendre, 1998). The classification used to build the dendrogram was the WPGMA (Rohlf & Fisher, 1968). The NTSYS-PC 2.1 program from Exeter Software was used for these calculations.

## RESULTS

Plankton biomass in the microzooplankton fraction varied from 45.19 mg.m<sup>-3</sup> (Station 1, June/2000) to 316.45 mg.m<sup>-3</sup> (Station 1, March/2000). In the macrozooplankton the biomass varied from 9.33 mg.m<sup>-3</sup> (Station 1, March/2000) to 43.16 mg.m<sup>-3</sup> (Station 1, February/2000) (Fig. 2). Average values were 117.01 mg.m<sup>-3</sup> (microzooplankton) and 15.71 mg.m<sup>-3</sup> (macrozooplankton).

Zooplankton was represented by 61 taxa (Table 1), with 50 taxa in the microzooplankton and 40 in macrozooplankton, and 20 taxa common to both. Copepod was the taxa with greatest diversity (23 species), followed by Tintinnina (8 species). Holoplankton predominated (65%) in the

microzooplankton samples while in the macrozooplankton both holo and merozooplankton were equally distributed.

Species diversity (Fig. 3) in the microzooplankton varied from 1.78 bits.ind<sup>-1</sup> (Station 1, March) to 2.75 bits.ind<sup>-1</sup> (Station 2, February), with an average of 2.23 bits.ind<sup>-1</sup>. Macrozooplankton diversity varied from 1.5 bits.ind<sup>-1</sup> (Station 2, June) to 2.0 bits.ind<sup>-1</sup> (Station 2, March), with an average of 2 bits.ind<sup>-1</sup>. Microzooplankton evenness varied from 0,64 (Station 3, May) to 0.87 (Station 2 February), with an average of 0.73 (Fig. 3). Macrozooplankton evenness varied from 0.62 (Station 2, February) to 0,97 (Station 3, June), with an average of 0.82 (Fi. 3).

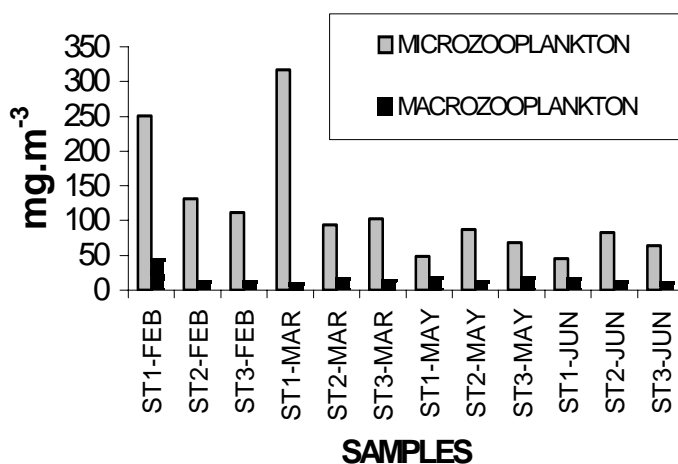


Figure 2 – Plankton biomass at the reefs of Maracajaú (Brazil).  
ST=Station.

Microzooplankton relative abundance showed the predominance of Copepoda in all samples followed by mollusk larvae (mainly bivalve) (Fig. 4). The macrozooplankton alternated the dominance between copepods and other crustacean, mainly brachyuran zoeae.

In the microzooplankton the following taxa were most frequent (more than 75% of the samples): *Euterpina acutifrons*, *Oithona oswaldocruzi*, *Oithona hebes*, *Oithona* sp., *Parvocalanus crassirostris*, Bivalve and gastropod larvae, *Trilocularina patensis*, *Balanus* sp. larvae, *Spirillina* sp. and polychaete larvae. In the macrozooplankton *Acartia lilljeborgi*, brachyuran zoeae and *Oikopleura longicauda* occurred in more than 75% of the samples.

The micro- and macrozooplankton followed a seasonal pattern, with the highest numbers occurring through the summer rainy season (February) (Fig. 5). A high density was found for the microzooplankton which varied from 1,917 ind.m<sup>-3</sup> (Station 3, June) to 47,620 ind.m<sup>-3</sup> (Station 2, February) with an average of 7,936 ind.m<sup>-3</sup>. Microzooplankton abundances were usually greatest at Station 3 and lowest at Station 2. An exception to this trend occurred in February/00, when Station 2 had markedly higher abundances than the other stations. The contribution of the inshore zooplankton community to these peaks is indicated by the abundances of the copepods (*Parvocalanus crassirostris*, *Euterpina acutifrons*, *Oithona hebes* and their nauplii) and bivalve larvae.

In relation to the macrozooplankton (Fig. 5), low densities were registered with a minimum of 92.4 ind.m<sup>-3</sup> (Station 3, June) and a maximum of 1,617 ind.m<sup>-3</sup> (Station 1, February), with an average value of 579 ind.m<sup>-3</sup>. Most individual taxa showed a seasonal cycle of abundance similar to that of total macrozooplankton, although meroplankton (mainly brachyuran zoeae) dominated Station 1 during all months and in June at all stations.

ANOVA test showed significant differences in density among stations ( $p=0.002$ ) and the months of February and June ( $p=0.001$ ) in both micro- and macrozooplankton.

Sample similarity presented 3 groups (Fig. 6). Group 1 joined the stations 1 and 3 of February, when highest rainfall was registered. In this month station 2 registered a extremely high peak of copepods placing this station alone in the dendrogram. Group 2 clustered all stations of March and May, except for station 2 of May, which was placed alone in the dendrogram due the exclusive presence of echinoderm larvae. Group 3 clustered the 3 stations of June when lowest rainfall was registered.

Species similarity presented 5 groups (Fig. 7). The first group clustered oceanic species such as *Creseis acicula* and Foraminifera (*Globigerinoides* spp.). The second, grouped some neritic species (*Tetromphallus bulloides*, *Tintinnopsis* spp., *Favella ehrenbergi*, *Temora stylifera*, *Oithona nana*, *Hemicyclops tallassius*, *Sagitta tenuis*, *Oikopleura dioica*, among others); the third group clustered a mixture of neritic and oceanic species (*Nannocalanus minor*, *Subeucalanus pileatus*, *Clausocalanus furcatus*, *Pontella atlantica*, *Lucifer faxoni*, besides other taxa at family or order level). The fourth group was characterized by the reef zooplankton, both holoplanktonic and meroplanktonic; in this group occurred, among others, *Convoluta* sp. (larvae), *Calanopia americana*, *Oithona oculata*, *Membranipora* sp. larvae, *Balanus* sp. larvae, echinoderms larvae, *Oikopleura longicauda*. The last group clustered the organisms under continental water influence (estuarine plume) among which *Parvocalanus crassirostris*, *Acartia lilljeborgi*, *Euterpina acutifrons*, *Oithona hebes*, *O. oswaldocruzi*, bivalve veliger and brachyuran zoeae.

Table 1 – Zooplankton composition at the Maracajaú (RN) reefs, from February to June/2000

FORAMINIFERA	<i>Labidocera fluviatilis</i> F. Dahl, 1894
<i>Bolivina</i> sp.	<i>Calanopia americana</i> F. Dahl, 1894
<i>Esponides</i> sp.	<i>Acartia lilljeborgi</i> Giesbrecht, 1892
<i>Remaneica</i> sp.	<i>Oithona nana</i> Giesbrecht, 1892
<i>Spirillina</i> sp.	<i>Oithona hebes</i> Giesbrecht, 1891
<i>Trilocularina</i> sp.	<i>Oithona oswaldocruzi</i> Oliveira, 1945
<i>Tetromphalus bulloides</i> d'Orbigny, 1826	<i>Oithona oculata</i> Farran, 1913
<i>Textularia</i> sp.	<i>Oithona</i> sp. (juvenile)
TINTINNINA	<i>Corycaeus giesbrechtii</i> F. Dahl, 1894
<i>Leprotintinnus nordqvisti</i> (Brandt, 1906)	<i>Hemicyclops tlassius</i> Vervoort and Ramirez, 1966
<i>Codonella amphorella</i> Biedermann, 1893	<i>Euterpina acutifrons</i> (Dana, 1847)
<i>Tintinnopsis compressa</i> Daday, 1887	<i>Tigriopus</i> sp.
<i>Tintinnopsis directa</i> Hada, 1932	<i>Caligus</i> sp.
<i>Tintinnopsis mortensenii</i> Schmidt, 1901	Copepoda (náuplio)
<i>Tintinnopsis tocaninensis</i> Kofoid and Campbell, 1929	CIRRIPEDIA
<i>Codonellopsis morchella</i> (Cleve, 1900)	<i>Balanus</i> sp. (larvae)
<i>Favella ehrenbergi</i> (Claparède and Laachmann, 1858)	ISOPODA (larvae)
CNIDARIA	STOMATOPODA
<i>Liriope tretraphylla</i> (Chamisso and Eysenhardt, 1821)	<i>Alima</i> sp. (larvae)
PLATYHELMINTHES	DECAPODA
<i>Convoluta</i> sp.	<i>Lucifer faxoni</i> Borraidaile, 1915
NEMATODA	<i>Farfantepenaeus</i> sp. (larvae)

POLYCHAETA (larvae)	Alpheidae (larvae)	Continua...
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Table 1 – Zooplankton composition at the Maracajaú (RN) reefs, from February to June/2000

MOLLUSCA	Porcellanidae (larvae)
<i>Creseis acícula</i> (Rang, 1828)	Brachyura (zoeae)
Gastropoda (veliger)	Brachyura (megalopa)
Bivalvia (veliger)	Paguridae (larvae)
COPEPODA	BRYOZOA
<i>Nannocalanus minor</i> (Claus, 1863)	<i>Membraniphora</i> sp. (larvae)
<i>Subeucalanus pileatus</i> (Giesbrecht, 1888)	ECHINODERMATA (larvae)
<i>Parvocalanus crassirostris</i> (F. Dahl, 1894)	CHAETOGNATHA
<i>Paracalanus quasimodo</i> Bowman, 1971	<i>Sagitta tenuis</i> Conant, 1896
<i>Clausocalanus furcatus</i> (Brady, 1883)	LARVACEA
<i>Temora stylifera</i> (Dana, 1849)	<i>Oikopleura dioica</i> Fol, 1872
<i>Centropages velificatus</i> (Oliveira, 1947)	<i>Oikopleura longicauda</i> Vogt, 1854
<i>Pseudodiaptomus acutus</i> (F. Dahl, 1894)	TELEOSTEI (eggs and larvae)
<i>Pontella atlantica</i> (Milne-Edwards, 1840)	

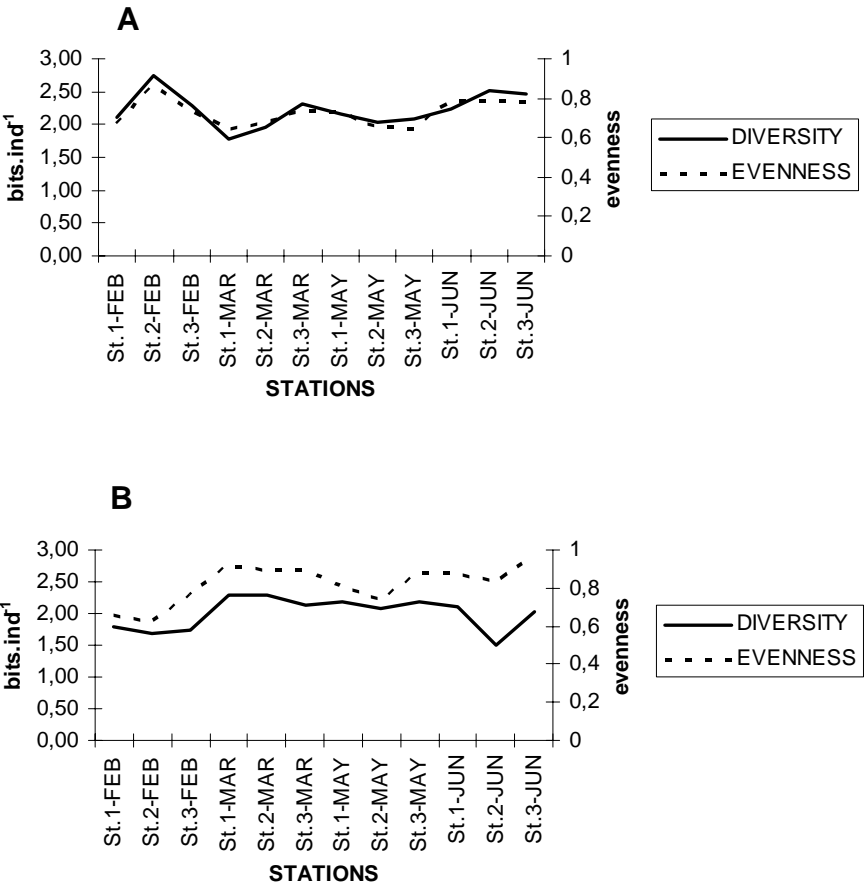


Figure 3 – Species diversity and evenness of the zooplankton in the reefs of Maracajaú (Brazil). A= microzooplankton, B= macrozooplankton. ST=Station.

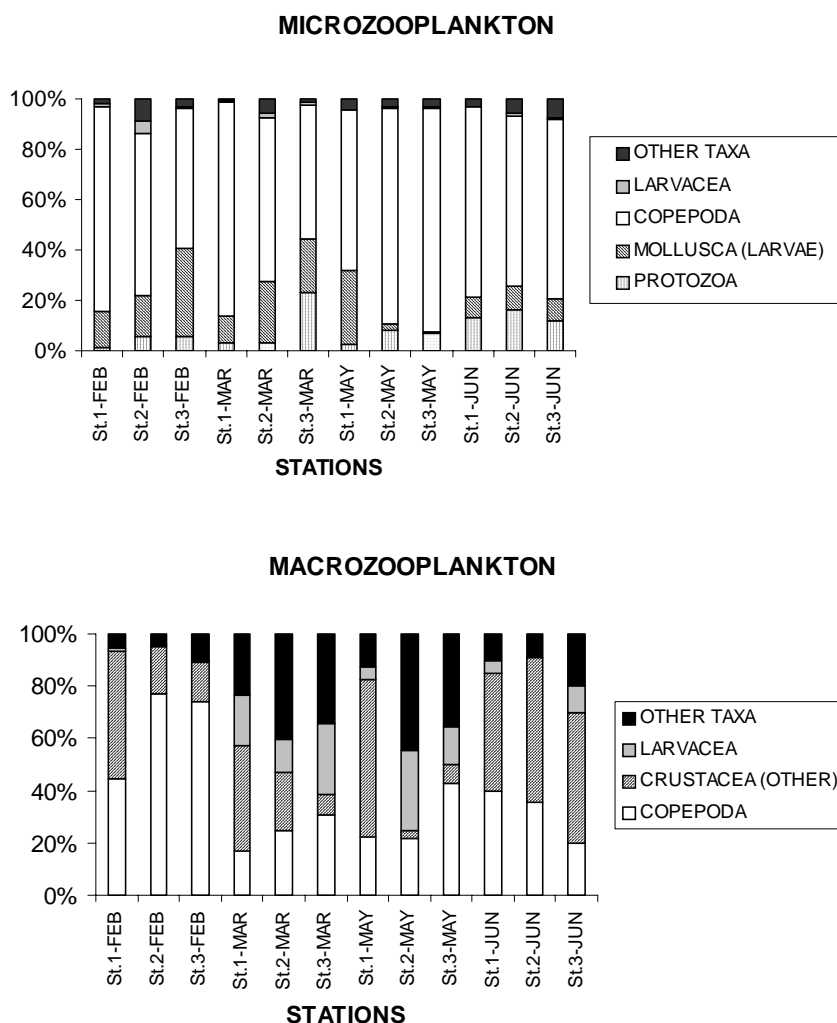


Figure 4 – Zooplankton relative abundance of the reefs of Maracajaú (Brazil). A= microzooplankton, B= macrozooplankton. ST=Station.

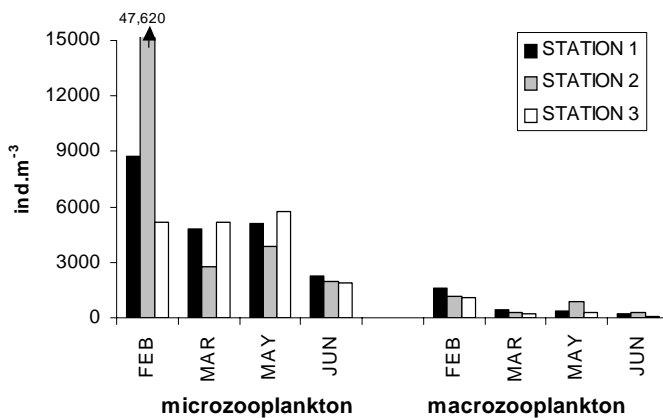


Figure 5 – Density of the zooplankton in the reefs of Maracajaú (Brazil).

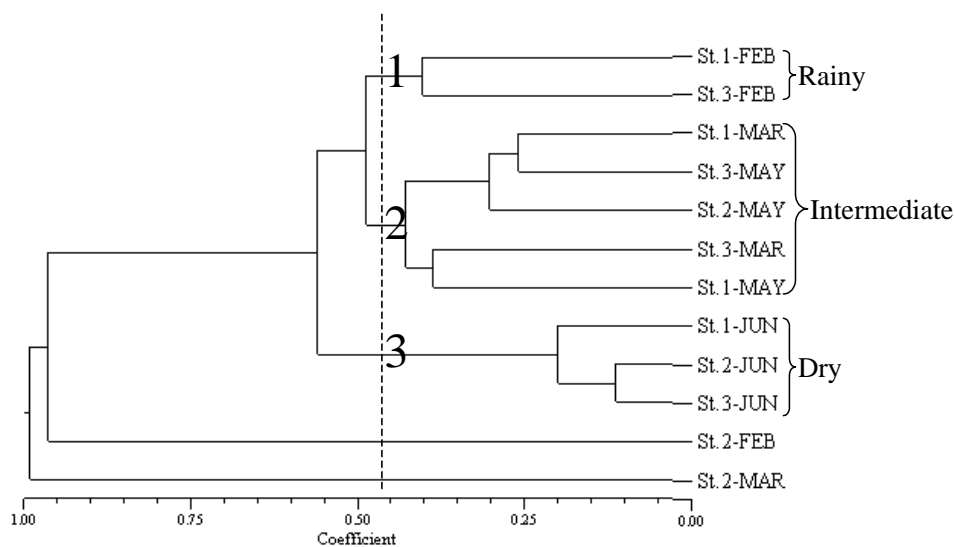


Figure 6 – Samples dendrogram generated using the Bray-Curtis coefficient to the microzooplankton data in the reefs of Maracajaú (Brazil). ST=Station.



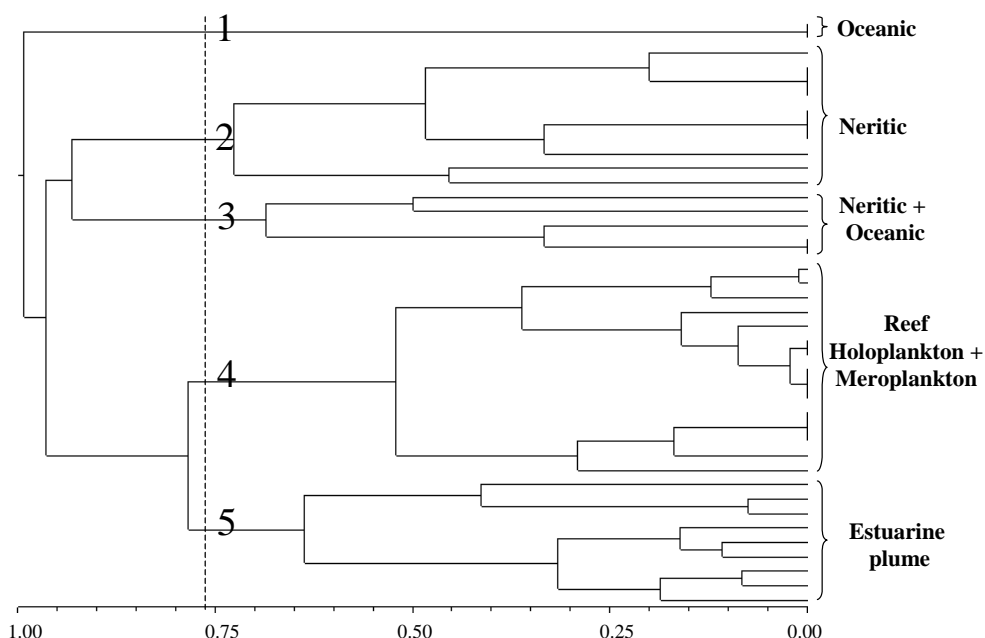


Figure 7 – Species dendrogram generated using the Bray-Curtis coefficient to the microzooplankton data in the reefs of Maracajaú (Brazil).

## DISCUSSION

The plankton is an important component of the reef ecosystem as can be seen in conspicuous abundance of planktivorous animals in many reef communities. Among the reef animals feeding on plankton, there are numerous planktonic and benthic filtering invertebrates, benthic sediment feeders (including corals), abundant populations of planktonivorous fishes, and all fish larvae (Sorokin, 1990). Nevertheless, the reef zooplankton in northeastern Brazil has been less studied than the plankton of open oceanic waters.

Several plankton abundance studies all over the world have shown that coral reefs remove 20 to 80% of the holoplankton from water passing over reef crests and flats (Tranter and George, 1972; Glyn, 1973; Johannes and Geber, 1974; Lefreve, 1985). If these filtration efficiencies are realistic, the coral reef may be regarded as a huge sieve capable of differential filtration, and thus their study in Brazil is of great importance.

Our sampling period in the Maracajaú reef area spanned successive months from the rainy to dry season, the rainfall being an important physical regulator of the plankton dynamics in the Maracajaú reef. The summer of 2000 was characterized by high rainfall (>250 mm) according to data from INMET (Institute of Meteorology), and considerable riverine discharge (seen by the visible turbid plume of the Maxaranguape River). In contrast, the dry season brought very little rainfall (< 50 mm), and was characterized by some intrusion from the oligotrophic South Equatorial Current.

The broad zooplankton community patterns we observed were similar to those described by Nascimento-Vieira (2000) and Porto Filho *et al.* (2000) in the reef area of Tamandaré in the south of

Pernambuco State (northeastern Brazil). In our study, total plankton biomass increased at the flood time, as a result of an increase in numbers of nauplii and juvenile copepods, mainly *Oithona* sp. Under SE winds influence in June, longshore velocities were sluggish and appeared to favor the movement of offshore zooplankton communities toward the coast.

Our data suggest a dynamic relationship between the zooplankton communities characteristic of inshore water trapped by the coastal boundary layer and more offshore plankton communities. The extent of the inshore plankton community changes under the influence of both meteorological and hydrographic forcing events, primarily wind speed and direction, and terrestrial run-off.

Information on seasonal fluctuations in the biomass of reef zooplankton is scarce. The data available indicate that these fluctuations may be quite significant. In the lagoon of the Great Barrier Reef, according to data of day tows, the maximum biomass in the winter (200-300 mg.m<sup>-3</sup>) was several times more than during the summer minimum (50-60 mg.m<sup>-3</sup>). The maximum was directly connected with the input of river waters into the lagoon (Sammarco and Crenshaw, 1984). In lagoon waters of the ring reef of Heron Island, which were not subjected to the influence of river waters, the maximum of zooplankton was documented to be in summer. The same was observed in the lagoon of Takapoto atoll (Sale *et al.*, 1976; McWilliam *et al.*, 1981). The total biomass of microzooplankton ranged in different reef areas between 20 and 300 mg.m<sup>-3</sup>. In our study biomass varied from 45mg.m<sup>-3</sup> to 316 mg.m<sup>-3</sup> (microzooplankton) and from 9 mg.m<sup>-3</sup> to 43 mg.m<sup>-3</sup> (macrozooplankton), showing the important role of the smaller fraction for the reef food webs.

Thus, the microzooplankton was numerically much more abundant than the macrozooplankton and this is a common feature in reef zooplankton (Sammarco & Crenshaw, 1984; Sorokin, 1990). The microzooplankton was represented mainly by tintinnids, copepod nauplii, juveniles and adults of smaller species, mollusks veligers and young appendicularians. The macrozooplankton was represented by copepods (larger species), other crustacean larvae (mainly Brachyura), chaetognaths, echinoderms larvae and fish eggs and larvae.

Species diversity at Maracajaú area was relatively low for both zooplankton fractions when considering an area under coral reef influence. Similar results were obtained by Nascimento-Vieira (2000) for the Tamandaré reef area and it was attributed to the impacts due to tourism, mangrove destruction and a higher influx of organic pollution.

The wet summertime maximum observed for copepods is consistent with that described for the northern Great Barrier reef region by Farran (1949) and Sammarco & Crenshaw (1984). This trend is typical on a world-wide scale for plankton of tropical inshore waters near rivers during the summer wet season (Wickstead, 1963; Binet, 1979; Pati, 1980; Sammarco & Crenshaw, 1984). The data presented here support the hypotheses that marine plankton communities near rivers are primarily under the control of the physical environment.

A main specific feature of the reef zooplankton which differentiates it from the zooplankton of the open ocean, is the domination of its population by species connected with the bottom biotopes. Among the latter there are holoplanktonic forms which live permanently in the water column, but during the day are swarming near the bottom close to possible shelters. Among these are some copepods (e.g. *Calanopia americana*, *Oithona oculata* in our study), mysids and amphipods (Emery, 1968; Henting, 1971; Sorokin, 1990), although these last two taxa were not registered in the present research, due to the sampling methods used. Among the holoplanktonic species of the Maracajaú reef zooplankton, the cyclopoid and calanoid copepods were dominant. Chaetognaths and appendicularians were also numerous. Although, according to Sorokin (1990) most of the reef zooplankters associated with the bottom are species of the demersal zooplankton, not studied here.

Another important group of reef zooplankton connected with the bottom biotopes which was well represented in our samples is the meroplankton. This includes species which, at early

stages of their ontogenetic development, are living as true plankters and feed in the water column. These included the larvae and juvenile stages of flatworms, mollusks (veligers), crustaceans (zoeae), of echinoderms (pluteus), polychaetes (larvae) and bryozoans (cyphonauta). Larval stages of corals (planulae) and of hydroids (hydromedusae) were not registered in our research. The meroplankton is an usual component of the pelagic zooplankton and could be partially brought into the reef area with passing waters.

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