CLADOCERANS (BRANCHIOPODA) OF A TROPICAL ESTUARY IN BRAZIL

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ABSTRACT

The study was conducted in the Capibaribe river estuary in Recife (Brazil) to assess the role played by cladocerans in a eutrophic environment. Samplings were carried out monthly at 4 fixed stations along the estuary from July 1987 to June 1988. Collections were made with a plankton net of 65 micrometers mesh size. Six cladocerans species were registered: *Penilia avirostris, Diaphanosoma spinulosum, Chydorus barroisi, Ceriodaphnia rigaudi, Ilyocryptus spinifer*, and *Moina micrura.* The most frequent species was *Moina micrura* with 49%. The only true marine species was *Penilia avirostris,* which was registered at station 1 (close to the river mouth), during high and low tide and in the dry season. The Cladocera average density decreased from 329 ind.m^{-3} (August 1987, high tide) to 2 ind.m^{-3} (March 1988, high tide) due to the high load of organic and chemical pollution received by the estuary. At all stations, *D. spinulosum, M. micrura*, and *C. barroisi* occurred with a wide distribution, mainly during the rainy season. *C. rigaudi* and *I. spinifer* were rare, occurring only during the rainy season. Cladocerans played an important role in the food webs of the plankton community of the Capibaribe tropical estuary and the dominance of a few small species indicated a hypereutrophic environment. A high level of disturbance was indicated by the decline in diversity of specialized species and the increase in abundance of opportunistic species like *M. micrura*.

Key words: cladocerans, indicators, environmental quality, estuarine, zooplankton.

RESUMO

Cladoceras (Branchiopoda) de um estuário tropical no Brasil

O estudo foi realizado no estuário do rio Capibaribe em Recife (Brasil) para avaliar o papel desempenhado pelos cladóceras em um ambiente eutrófico. As amostragens foram feitas mensalmente em 4 estações fixas no período de julho de 1987 a junho de 1988. As coletas foram realizadas com uma rede de plâncton com 65 micrômetros de abertura de malha. Foram identificadas 6 espécies de cladóceras: *Penilia avirostris, Diaphanosoma spinulosum, Chydorus barroisi, Ceriodaphnia rigaudi, Ilyocryptus spinifer* e *Moina micrura.* A mais freqüente foi *Moina micrura*, com 49%. A única espécie marinha foi *Penilia avirostris,* registrada na estação 1 (próxima à desembocadura), durante as preamares e baixa-mares e no período seco. A densidade média dos cladóceros diminuiu de 329 ind.m^{-3} (agosto/87, preamar) para 2 ind.m^{-3} (março/88, preamar) em razão de uma forte carga de poluição química e orgânica recebida pelo estuário. *D. spinulosum, M. micrura* e *C. barroisi* ocorreram em todas as estações, apresentando ampla distribuição, principalmente no período chuvoso. *C. rigaudi* e *I. spinifer* foram raras, ocorrendo apenas durante o

período chuvoso. Os cladóceros tiveram importante papel na teia alimentar planctônica do estuário e a dominância de poucas espécies com pequenas dimensões indicou um ambiente hipereutrófico. O declínio da diversidade de espécies especializadas e o aumento de espécies oportunísticas como *M. micrura* indicam altos níveis de perturbações antropogênicas.

Palavras-chave: cladóceras, indicadores, qualidade ambiental, estuário, zooplâncton.

INTRODUCTION

Cladocerans are small crustaceans living almost exclusively in freshwater. Of the more than 600 described species, only eight species are known to be truly marine (Onbé, 1977, 1999). In the estuarine environment, marine and freshwater species occur.

Cladocerans play an important role in the food webs of the plankton community. The dominance of small cladocerans in eutrophic environments is thought to be directly related to their ability to effectively avoid typically abundant cyanobacteria and feed on smaller algal particles (Webster & Peters, 1978; Porter & McDonough, 1984; Hawkins & Lampert, 1989). On the other hand, it has been hypothesized that the larger cladocerans typical of oligothrophic conditions are unable to feed as efficiently in the presence of filamentous algae and are, thereby, excluded from eutrophic environments (Webster & Peters, 1978; Porter & McDonough, 1984; Hawkins & Lampert, 1989). Therefore, understanding the relationship between cladocerans and their spatial and temporal distribution is important to the understanding of trophic interactions within an estuary.

The Capibaribe river receives nutrient-rich runoff from intense human activities. The rate and degree of human impact have accelerated over the past three decades as a result of increasing population, industrial development, and indiscriminate urbanization growth, all of which cause insidious alteration of the estuarine environment. Plankton biomass increase in this estuary as shown by Koening *et al.* (1995) is the major symptom of eutrophication and has resulted in reduced water clarity and oxygen levels (Macêdo *et al*., 1993) and fishery loss.

Freshwater or marine cladocerans have been cited in passing as becoming large-scale zooplankters in Brazilian estuaries during, respectively, the rainy and dry seasons (Montú, 1980; Montú & Gloeden, 1986; Paranaguá, 1995; Silva *et al*., 1996; Neumann-Leitão & Matsumura-Tundisi, 1998). However, no detailed studies have been carried out on this group of animals in estuaries of northeastern Brazil. Based on samples collected in a impacted estuary, the present study investigates some aspects of the role of cladocerans.

MATERIALS AND METHODS

Study area

The Capibaribe river estuary (Fig. 1) is located on the coast of Recife, Pernambuco State, Brazil 07º 54'-8º19'S, 34º54'-36º42'W; hydrographic basin: 7,716 km^2; maximum depth 8 m; tidal entry ~15 km from the Atlantic Ocean) (Ottmann & Ottmann, 1960). The climate is warm-humid, pseudo-tropical (Koppen As') with a mean annual temperature of 26ºC and a rainfall of 1500-2000 mm.yr^{-1}, concentrated from March to August. Humidity is generally higher than 80%. Southeast winds predominate. Water temperatures vary from 26.2ºC (rainy season) to 31.0ºC (dry season), salinity varies considerably (0.05 to 36.09), surface and bottom dissolved-oxygen saturation ranges from supersaturation to very low levels, with significant oxygen depletion during low tide (Travassos *et al*., 1993). Extensive mangrove areas have been destroyed although, distributed along the estuary, are small patches of *Rhizophora mangle*, *Laguncularia racemosa*, and *Avicennia schaueriana*.

Field and laboratory procedures

Samples for plankton were collected monthly at 4 fixed stations in the Capibaribe river estuary (Fig. 1), during consecutive diurnal high and low tides, from July 1987 to June 1988. Collections of the 96 samples were done with a plankton net (30 cm mouth diameter, 65 μm mesh size) fitted with a flowmeter. Three-minute horizontal surface hauls were made at each station. Samples were immediately preserved in 4% neutral saline formaldehyde. In the laboratory, all cladocerans were removed from these samples, placed in a Sedwick-Rafter chamber, identified, and counted by species under a Zeiss compound microscope.

The ANOVA test was applied to verify differences between tides, seasons, and stations.

A cluster analysis on the sample-species data matrix considering the total density for low and high tides was also performed using the Bray-Curtis index (Ibanez, 1976; Gros, 1981). The link method used to draw the dendrogram was the WPGMA (weighted pair group method, arithmetical averages) (Legendre & Legendre, 1998). A cophenetic test was applied to measure good fit of the cluster (Rohlf & Fisher, 1968).

RESULTS

Cladocerans were present in 62 samples and comprised from 12% to 64% (average: 32%) of the total zooplankton by numbers.

Six species in all were recorded in the present investigation: *Penilia avirostris* Dana, 1849; *Diaphanosoma spinulosum* Herst, 1975; *Chydorus barroise* (Richard, 1894); *Ceriodaphnia rigaudi* Richard, 1894; *Ilyocryptus spinifer* Herrick, 1884, and *Moina micrura* Kurz, 1874.

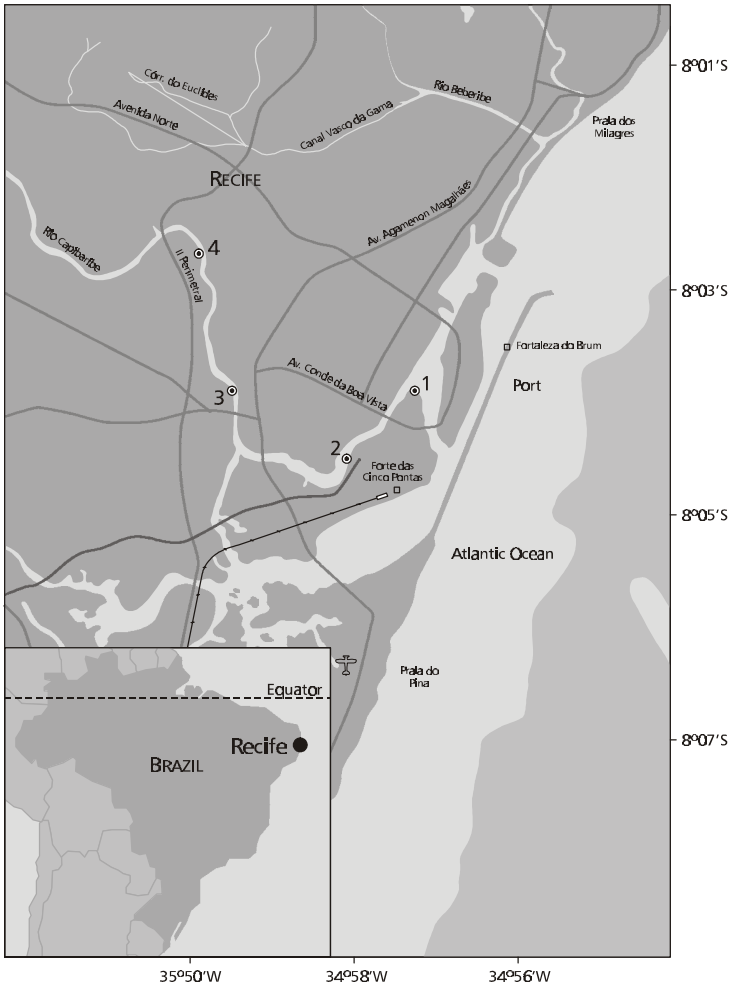

Fig. 1 — Location of the sampling stations in the Capibaribe river estuary, Recife, Pernambuco (Brazil). ⊙ = Station.

The most frequent species in all studied samples was *Moina micrura* with 49%, followed by *Diaphanosoma spinulosum* (38.5%), *Chydorus barroisi* (27.1%), and *Penilia avirostris* (8.3%), this last one occurring in station 1 only. Both *Ceriodaphnia rigaudi* and *Ilyocryptus spinifer* occurred in only 3.1% of the samples (Fig. 2).

During low tide, *Diaphanosoma spinulosum* presented 37% of relative abundance in station 1, while *Moina micrura* was more abundant in the other stations with a maximum of 60% at station 4 (Fig. 4). At high tide, *Penilia avirostris* attained 56% at station 1, *Diaphanosoma spinulosum* 73% (St. 2) and 59% (St. 3), and *Moina micrura* 92% at station 4 (Fig. 3). *Ceriodaphnia rigaudi* was not registered at high tide.

Density varied widely among stations (Fig. 4). When considering the samples containing cladocerans, average density increased from 2 ind.m^{-3} (March 1988, high tide) to 329 ind.m^{-3} (August 1987, high tide). Total average density was 47 ind.m^{-3} at low tide and 41 ind.m^{-3} at high tide. Rainy months and low tide resulted in higher abundance, except for the prominent peak of *Moina micrura* in August 1987, during high tide at station 4, with a density of 301 ind.m^{-3} (Fig. 5), turning it into an important zooplankter in the Capibaribe river.

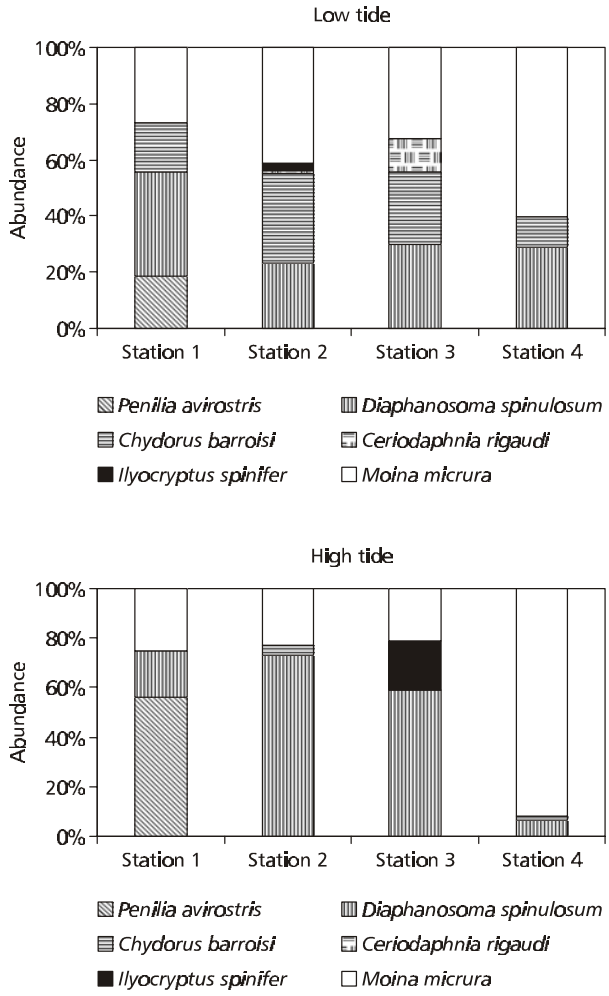

Fig. 2 — Spatial distribution of cladocerans in the Capibaribe river estuary, Recife, Pernambuco (Brazil), from July 1987 to June 1988.

The only marine species, *Penilia avirostris*, in a characteristic pattern, occurred from September 1987 to March 1988 (dry season) with a small peak (40 ind.m^{-3}) in December 1987 (Fig. 5). *Moina micrura, Diaphanosoma spinulosum*, and *Chydorus barroise* showed also a characteristic pattern, occurring during the rainy season, a period of relatively high river flow. These species were absent in the driest months.

Ceriodaphnia rigaudi and *Ilyocryptus spinifer* occurred very sparsely in low densities in the samplings and only in a few months of the year.

The ANOVA test showed differences between tides ($p = 0.01$), seasons ($p = 0.03$) and stations 1 and 4 ($p = 0.04$).

Similarity analysis of samples (Fig. 6) presented two groups. The first clustered all low tide samples (when a freshwater flux flushes over the area); and the second clustered the high tide samples of stations 2 and 3, which present a mixture of fresh and saltwater fluxes. High tides at station 1 and 4, which are independent of one another, produced differences between these stations: station 1 is characteristically marine, whereas freshwater conditions prevail in station 4.

Species similarity analysis (Fig. 7) presented one group that clustered *Diaphanosoma spinulosum, Chydorus barroisi*, and *Moina micrura*, the most abundant species.

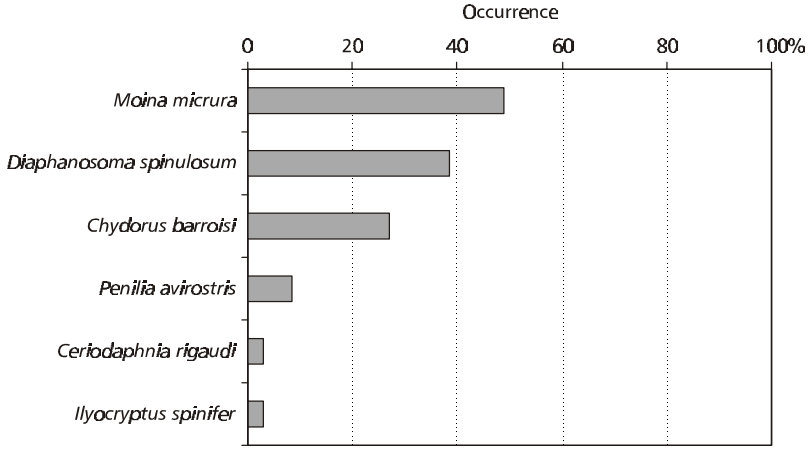

Fig. 3 — Frequency of occurrence of six species of cladocerans in the Capibaribe river estuary, Recife, Pernambuco (Brazil), from June 1987 to July 1988.

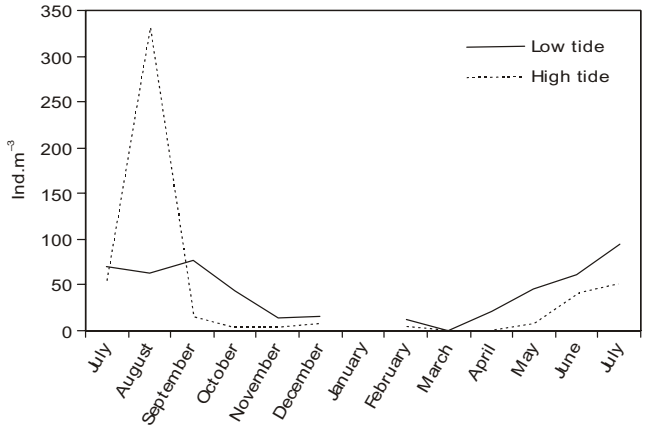

Fig. 4 — Total density of cladocerans at high and low tides in the Capibaribe river estuary, Recife, Pernambuco (Brazil), from July 1987 to June 1988.

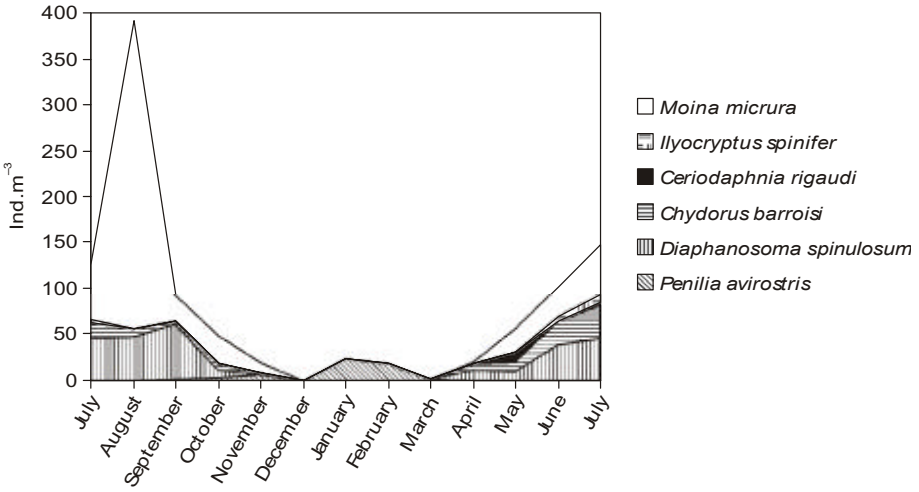

Fig. 5 — Seasonal variation of the density of cladocerans in the Capibaribe river estuary, Recife, Pernambuco (Brazil), from July 1987 to June 1988.

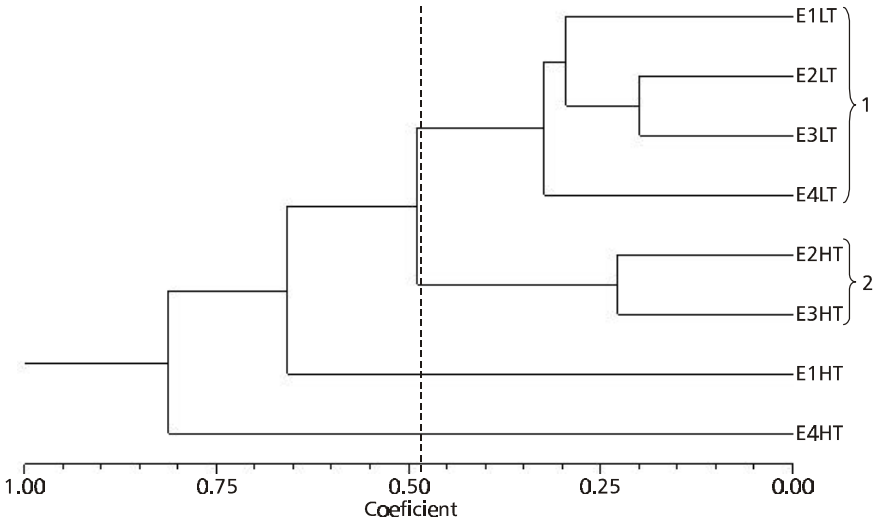

Fig. 6 — Dendrogram showing samples similarity in the estuary of the Capibaribe river, Recife, Pernambuco (Brazil), based on Braycurtis index. Linkage: WPGMA (Weighted Pair Group Method, Arithmetical Averages).

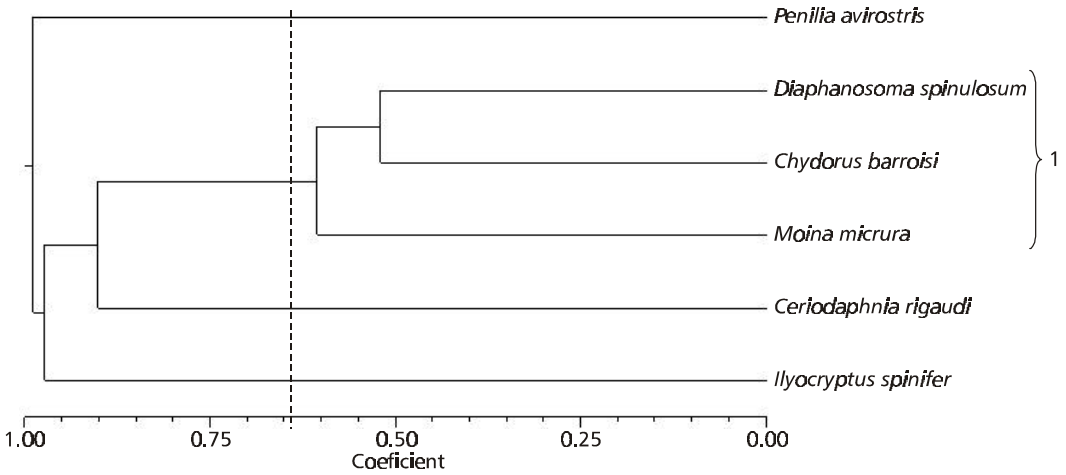

Fig. 7 — Dendrogram showing species similarity of cladocerans in the estuary of the Capibaribe river, Recife, Pernambuco (Brazil) based on Braycurtis index. Linkage: WPGMA (Weighted Pair Group Method, Arithmetical Averages).

DISCUSSION

The composition, abundance, species diversity, and spatial distribution of the cladocerans at the Capibaribe estuary was related to the salinity regime and trophic state of the environment, in addition to the degree of biological interaction. Cladocerans were an important fraction of the total zooplankton, comprising 32% of all samples and, according to Korínek (2002), in the tropics they are of smaller size than those in the temperate zone. Previous studies have demonstrated that oligotrophic systems are dominated by copepods, whereas more eutrophic systems are dominated by rotifers and cladocerans (Gannon & Stemberger, 1978; Blancher, 1984). It seems that the cladocerans at Capibaribe estuary have negatively affected the rotifer population through interference competition, predation, or both as has been demonstrated in laboratory experiments and in natural plankton (MacIsaac & Gilbert, 1989; Jack & Gilbert, 1994; Wickham & Gilbert, 1991; Onbé, 1999).

Increased sewage loading from the expanding population in Recife has caused a progressive increase in algal bloom occurrence and oxygen depletion in the Capibaribe estuary (Travassos *et al*., 1993). Changes in the structure and processes of the estuarine ecosystem were registered in a previous study (Macêdo *et al*., 1993). Due to algal blooms and enrichment of organic matter, high zooplankton density could be expected. However, a low zooplankton density was found, probably because of excessive chemical effluents and high ammonia levels related to eutrophic conditions (Macêdo *et al*., 1993) and causing growth inhibition and disappearance of zooplankton species.

The species composition of cladocerans changes with salinity, as was seen in the cluster analysis of samples. During high tide, the marine species *Penilia avirostris* was present close to the river mouth during the dry season. According to Onbé & Ikeda (1995), among seven species of marine cladocerans occurring in Toyama Bay (southern Japan Sea), *Penilia avirostris* was one of the important members of the plankton in summer.

Penilia avirostris is the only marine cladoceran that is cosmopolitan and frequently abundant in warm and productive nearshore waters of the tropics and subtropics (Della Croce & Venugopal, 1972; Grahame, 1976; Moore & Sander, 1979; Wong *et al*., 1992). In temperate waters, *P. avirostris* occurs seasonally in large numbers in polluted estuaries (Yoo & Kim, 1978). The occurrence of this species in the Capibaribe estuary shows that it occurs also in polluted waters of the tropics.

Information in the literature on feeding behavior of *Penilia avirostris* suggests that a preference exists for small particles, including small diatoms, microflagellates, and bacteria (Gore, 1980; Paffenhöfer & Orcutt, 1986; Turner *et al*., 1988; Kim *et al*., 1989), which were abundant in the Capibaribe estuary (Koening *et al*., 1995).

At low tide, the Capibaribe estuary is dominated by freshwater and there is a freshwater group comprising *Moina micrura, Diaphanosoma spinulosum, Chydorus barrois, Ceriodaphnia rigaudi*, and *Ilyocryptus spinifer.* The first three of these species formed a group of the most abundant species in the cluster analysis.

Diaphanosoma spinulosum, together with *Ceriodaphnia cornuta* and *Moina minuta* (Neumann-Leitão & Matsumura-Tundisi, 1998) were important zooplankters during low tide in the Ipojuca river estuary, a heavy polluted environment on the southern coast of Pernambuco State.

Ilyocryptus spinifer is cosmopolitan, benthic, and commonly found in muddy bottoms and dense vegetation while rare in plankton (Montú & Gloeden, 1986; Dussart *et al*., 1994), which explains its low occurrence in the polluted environment of the studied estuary.

The peak in population abundance of *Moina micrura* at the inner station in August 1987 might reflect short-term changes in reproductive potential for parthenogenesis, depending primarily on the changes in abundance of food. Further information on the reproductive biology of this species will throw some light on this issue.

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