

Mesozooplankton and Ichthyoplankton composition in two tropical estuaries of Bahia, Brazil

Catarina da Rocha Marcolin^{1*}, Bárbara Luciana da Conceição¹, Marcos Moura Nogueira², Paulo Mafalda Júnior² and Rodrigo Johnsson¹

¹ Universidade Federal da Bahia, Campus de Ondina, Instituto de Biologia, Departamento de Zoologia, LABIMAR (Crustacea, Cnidaria e Fauna Associada). CEP 40170-110 .Salvador, BA, Brazil.

² Universidade Federal da Bahia, Campus de Ondina, Instituto de Biologia, Departamento de Zoologia, Laboratório de Plâncton. CEP 40170-110. Salvador, BA, Brazil.

* Corresponding author. E-mail: crmarcolin@yahoo.com.br

ABSTRACT: The objective of this study was to describe the composition of two mesozooplankton and ichthyoplankton estuarine communities in Jandaíra, Bahia (Tabatinga River), impacted by a shrimp farm; and in Conde, Bahia (Itapicuru River), a pristine estuary. Samples were collected through horizontal hauls using a net (200 µm mesh size), coupled to a flowmeter, during the ebbing and flooding tides in April, August and December, 2007. In the Tabatinga and Itapicuru Rivers 76 and 92 taxa were registered. The most abundant groups were *Pseudodiaptomus richardii* and *Disco* sp. *Acartia lilljeborgi* was also dominant at Tabatinga, while *Temora* sp. and decapod larvae were predominant in Itapicuru River, which also presented higher densities for most planktonic taxa, particularly fish larvae. A descriptive analysis of the main taxa's spatial distribution and new geographical records of *Disco* sp., *P. richardi*, *Pontellopsis villosa*, *Macrosetella gracilis*, *Microsetella rosea*, *Gonyiopsillus brasiliensis*, *Agetus flaccus* and *Ergasilus caragatatubensis* were presented.

INTRODUCTION

The estuaries and mangroves are currently one of the world's most threatened ecosystems due to drastic encroachment of human activities despite their undeniable relevance (Barbier and Cox 2002; Singkran and Sudara 2005). According to Islam and Haque (2004), shrimp farming has been a great contributor to mangrove destruction, reducing biological resources such as habitats of crustaceans, mollusks and fish species of ecological and economic relevance.

Zooplankton plays a key role in the ecosystem structure due to its quick response to abiotic conditions, especially in impacted environments (Levinton 1995; Neumann-Leitão *et al.* 1999). It is, therefore, very important to describe the taxonomic diversity in tropical estuaries since there is no published information on the composition of zooplankton communities in the state of Bahia, only some unpublished academic works which focused mainly on ecological aspects.

This paper presents a description of the zooplankton and ichthyoplankton taxa density found in two similar tropical estuaries subjected to different sources of anthropogenic impact in the state of Bahia. It also highlights new records of some copepod species distribution.

MATERIAL AND METHODS

Study site

The Tabatinga River estuary is part of the Real River Basin located in the city of Jandaíra (11°32'45" S, 037°29'19" W) and the Itapicuru River estuary is part of the Itapicuru River Basin located in the city of Conde (11°47'38" S, 037°30'53" W), in the farthest north littoral in the state of Bahia, Brazil. They are under like climate regimes, varying from humid to sub-humid.

The Tabatinga River is adjacent to one of the largest

shrimp farms in the state of Bahia, which was implemented in 1993. The discharge of effluents occurs daily, after a 24 h treatment in sedimentation ponds.

In the Itapicuru River's basin, other sources of anthropogenic impacts can be found in the main course of the river, such as sewage and industrial effluents waste. However, close to the mouth of the Itapicuru River there is a small village where no industrial activities were observed. Tourism and artisanal fishery are the most important economic activities, but both are still poorly developed.

In both rivers, four sampling stations were chosen to collect data according to the decreasing salinity gradient (Figure 1).

Data collection

The sampling strategy was carried out in four stations in each estuary during the ebbing and flooding spring tides. This data was collected in the rainy (April and August months) and dry (December month) seasons of 2007, consisting of 48 samples. Salinity and temperature were estimated through a multi-parameter probe WTW 340i/SET.

Mesozooplankton samples were collected through horizontal hauls at 0.1 m from the surface, during 3 minutes, using a conical net (200 µm mesh size) coupled to a flowmeter for filtered volume determination. Plankton samples were preserved in 4 % formaldehyde seawater solution and transported to the laboratory.

Organisms were counted and identified to their lowest practical taxonomic level through an estereoscopic microscope (Leica MZ6), an optical microscope (Olympus CH30) and the pertinent bibliography (Smith 1982; Boxshall and Halsey 2004; Boltovskoy 2005; Richards 2006). The abundance of organisms was estimated through measuring 2, 10 or 50 mL aliquots, one aliquot per

sample, using a Stempel pipette. Rare taxa were counted in the whole sample and the density (D: individual per cubic meter) was calculated dividing the abundance by the total filtered volume.

The specimens referred to in this work are deposited at the Museu de Zoologia / Universidade Federal da Bahia (UFBA).

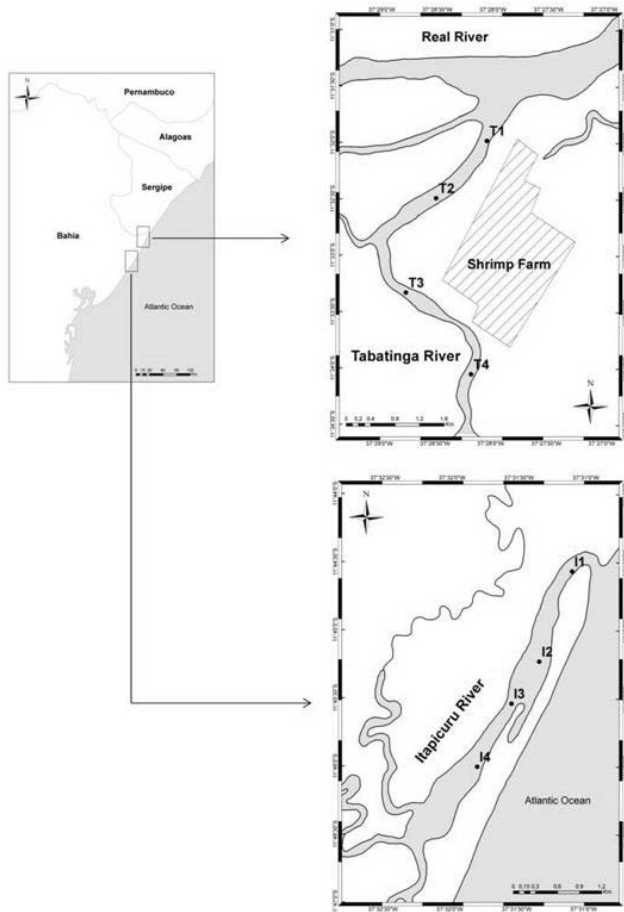


FIGURE 1. Sampling stations' disposition in the Tabatinga River estuary (1 to 4) surrounding a shrimp farm and in the Itapicuru River estuary (1 to 4). RR: Real River; TR: Tabatinga River; IR: Itapicuru River; P: ponds; I1-I4: stations 1 to 4 at Itapicuru River; T1-T4: stations 1 to 4 at Tabatinga River.

RESULTS AND DISCUSSION

The temperature was similar at all the sampling stations with smaller values in August. The salinity was a very variable parameter, which represented a decreasing gradient from station 1 to 4 in both estuaries (Tabatinga River: 5.90 to 26.30; Itapicuru River: 8.60 to 36.30). The higher values were found in December during the dry season. The T-S diagram shows the existence of only estuarine waters in the Tabatinga River (Figure 2), while estuarine and coastal waters were present in the Itapicuru River (Figure 3).

In the Tabatinga and Itapicuru Rivers, 65 and 73 zooplankton taxa were registered, respectively; 59 of them were found in both estuaries such as Foraminiferida, Cnidaria, Annelida, Mollusca, Echinodermata, Crustacea, Urochordata, Cephalochordata and Chaetognatha. Rotifera was solely recorded in the Tabatinga River while Thaliacea was only registered in the Itapicuru River. In relation to fish larvae, 11 and 19 species were found on these estuaries.

Considering both zooplankton and ichthyoplankton a total of 76 and 92 taxa were recorded in the Tabatinga and Itapicuru Rivers, and they are displayed on tables 1 to 4 with their respective density data. A total of 98 mesozoo- and 20 ichthyoplankton taxa were recorded taking into account both rivers.

The most relevant finding refers to the first register of Discoidae (Copepoda, Calanoida), represented by *Disco* sp. There are no previous records for *Disco* in the Southwestern Atlantic, nor in estuaries, being typically considered as an oceanic group (Boxshall and Halsey 2004). Currently the family is divided into three genera containing 29 species. However only two of them belong to *Prodisco* and four to *Paradisco*, the other 23 species are attributed to the genus *Disco*. Schulz (1993) proposed a subdivision of the *Disco* species according to the degree of mouth parts reduction. The specimens found in these estuaries represent a new species which is being described by the authors.

This study also represents the first record of other 7 copepod species in the state of Bahia: *Pseudodiaptomus richardi* Dahl, 1894, *Pontellopsis villosa* Brady, 1883, *Macrosetella gracilis* Dana, 1847, *Microsetella rosea* Dana, 1847, *Gonyiopsillus brasiliensis* Huys and Conroy-Dalton, 2000, *Agetus flaccus* Giesbrecht, 1891 and *Ergasilus caraguatatubensis* Amado and Rocha, 1995.

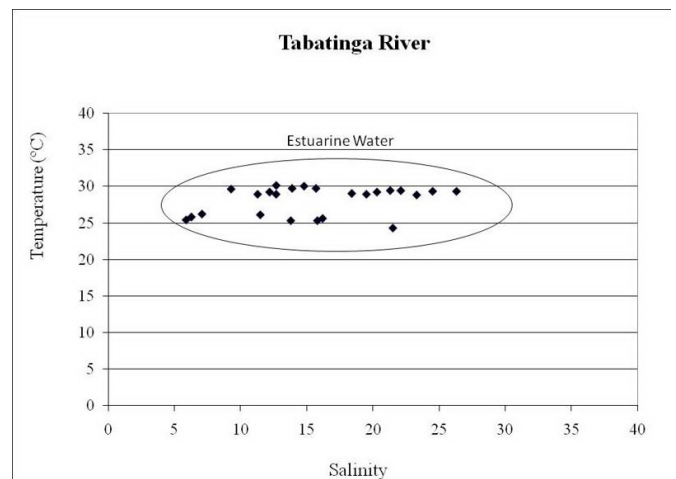


FIGURE 2. T-S Diagram at Tabatinga River during April, August and December, ebbing and flooding tides.

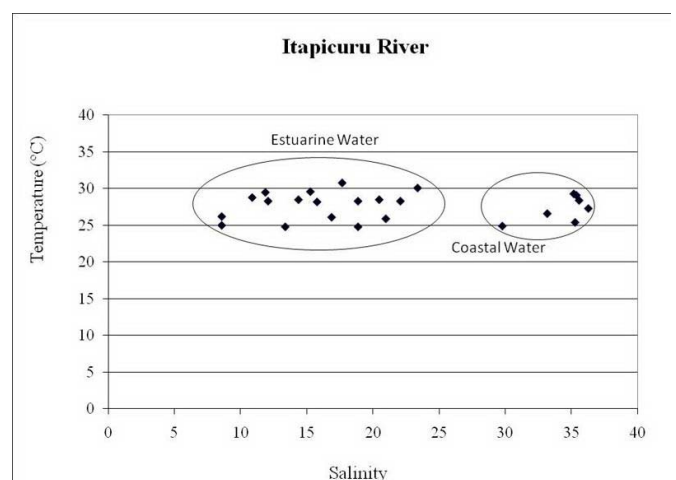


FIGURE 3. T-S Diagram at Itapicuru River during April, August and December, ebbing and flooding tides.

Ergasilidae is one of the most important families of copepods which are fish parasites. *Ergasilus caraguatatubensis* was first described by Amado and Rocha (1995) inhabiting the opercular cavity of Mugilidae collected in the states of Maranhão, Alagoas, São Paulo and Rio de Janeiro. Therefore the occurrence of *E. caraguatatubensis* and *Mugil liza* Valenciennes, 1836 (Mugilidae) may be linked, since both species were restricted to the Itapicuru River.

Caligus sp. (Caligidae) is also predominantly a fish parasite, including *M. liza*, but as it was found in both estuaries, its distribution may be also associated to other fish species.

Gonyiopsillus brasiliensis was described by Huys and Conroy-Dalton (2000) from samples collected in the state of Rio Grande do Sul, Brazil, on the outside opening of Lagoa dos Patos to the ocean. Huys and Conroy-Dalton (2000) also claimed that many South-American authors erroneously attributed this species to *Clytemnestra rostrata* Brady, 1883. So, our register of this species in the Itapicuru and Tabatinga Rivers confirms the hypothesis of previous misleading records along the Brazilian coast.

Among the 12 taxa exclusively reported in the Itapicuru River the distribution of some of them (*M. gracilis*, *Mecynocera clausi* Thompson, 1888, *Oithona plumifera* Baird, 1843, *Penilia avirostris* Dana, 1852 and Salpidae) was restricted to station 1, which may be explained by the higher salinity values due to the river's mouth proximity (Figure 1). On the other hand the exclusive occurrence of Augaptilidae, Paracalanidae (*Paracalanus* sp.), Centropagidae (*Centropages velificatus* Oliveira, 1947) and *P. villosa* along the entire estuary could not be associated to higher salinities and may reflect the existence of environmental differences probably related to water quality parameters, once the Tabatinga River is under the influence of shrimp farm effluent discharges.

A previously unpublished study dating from 1970 which took place in Baía de Todos os Santos (BTS), a coastal marine environment located approximately 200 kilometers away from our study area, registered the following species in common with our study site: *Liriope tetraphylla* Chamisso and Eysenhardt, 1821, *Pseudodiaptomus acutus* Dahl, 1894, *Calanopia americana* Dahl, 1894, *Acartia lilljeborgi* Giesbrecht, 1889, *Euterpina acutifrons* Dana, 1847 and *Lucifer faxoni* Borradaile, 1915. *Penilia avirostris* and *Oithona plumifera* were also found in BTS but were absent from the Tabatinga river due to lower salinity values in this estuary. The BTS study also registered species belonging to the *Microsetella*, *Centropages*, *Oithona*, *Oncaea*, *Temora*, *Labidocera* and *Oikopleura* genera, all of which were also identified in our sampling stations.

Some taxa (Rotifera, Stomatopoda and Caprellidae) occurred exclusively in the Tabatinga River, but these represent groups rarely found in mesozooplankton surface hauls and were collected due to uncommon factors such as their small size or hyperbenthic behavior.

At both estuaries there was a strong predominance of holoplanktonic organisms in relation to meroplanktonic ones and this pattern was more evident during ebbing tides (Figure 4).

Crustacean's predominance was striking for both estuaries where the highest density and dominance (%) (Tables 2 and 3) were recorded especially for calanoid copepods (*Pseudodiaptomus richardi* Dahl, 1894, *Disco* sp., *Temora* sp. and *Acartia lilljeborgi*) and decapod larvae (*Ucides cordatus* Linnaeus, 1763). This trend was congruent with most studies carried out in estuarine and coastal zooplanktonic communities (Fonseca and Klein 1976; Vega-Pérez 1993; Gaughan and Potter 1995; Neumann-Leitão et al. 1996; Falkenhaus et al. 1997; Froneman 2000; 2001; Lawrence et al. 2004; Kibirige et al. 2006; Feike et al. 2007).

Among the total 59 common zooplankton taxa found, only few of them were more abundant in the Tabatinga River: Cnidaria, Nematoda, Cirripedia, *A. lilljeborgi*, *Oithona* spp., *E. acutifrons*, Ostracoda, Gammaridae, Isopoda, Tanaidacea, Cumacea, *L. faxoni*, *L. typus* and *Oikopleura* spp. All the others were more abundant in the Itapicuru River. These results coincide with Champalbert and Patruti (1982), Arfi and Patruti (1987), Soetaert and Van Rijswijk (1993), Park and Marshall (2000), Uriarte and Villate (2004; 2005), and Kibirige et al. (2006) who found a total abundance reduction in the main zooplankton groups in sites subjected to organic pollution.

The same pattern was identified in ichthyoplankton groups. Regarding the 10 common species, 7 were more abundant in the Itapicuru River and 3 (*Harengula* aff. *jaguana* Poey, 1865, *Hypsoblennius invemar* Smith-Vaniz and Acero, 1980 and *Trinectes* sp.) in the Tabatinga River (Tables 4 and 5). *Anchoa* sp. was one of the most abundant groups in both rivers, while *Harengula* aff. *jaguana* and *Ctenogobius boleosoma* Jordan and Gilbert, 1882 also presented high density values in the Tabatinga and Itapicuru Rivers, respectively.

This work brings new and relevant taxonomic information on planktonic fauna of tropical estuaries. The lower number of taxa and the lower density of most taxa, concerning zooplankton and ichthyoplankton, in the Tabatinga River may reflect poor water quality conditions in this estuary due to organic pollution caused by shrimp farm effluents disposal.

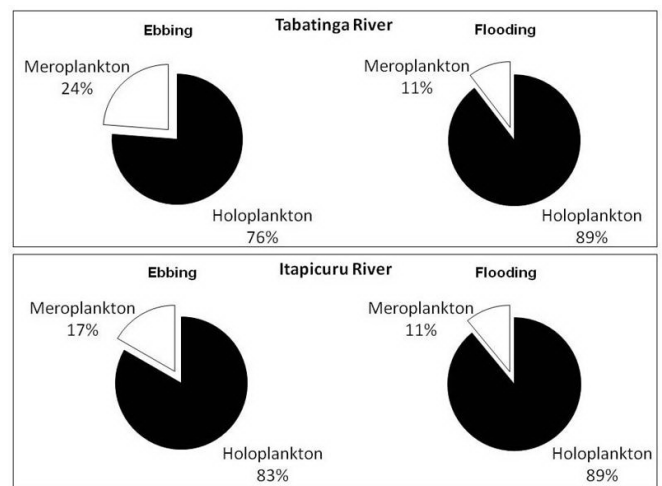


FIGURE 4. Relative abundance of meroplankton and holoplankton during ebbing and flooding tides.

TABLE 1. Average density, standard deviation (s), total density and percentage of main zooplankton groups in the Tabatinga River during April, August and December.

TABATINGA RIVER								
	DENSITY (ind.m ⁻³)				AVERAGE	s	TOTAL DENSITY	DOMINANCE (%)
	T1	T2	T3	T4				
Foraminiferida	7.8	1.2	0.1	0.1	2.0	4.71	19.8	0.004
Cnidaria	64.0	48.4	0.8	0.3	28.4	75.60	681.2	0.123
<i>Bougainvillia muscus</i> Allman, 1863	0.0	0.0	0.0	0.3	0.3	-	0.3	0.000
<i>Liriope tetraphylla</i> Chamisso and Eysenhardt, 1821	41.5	42.4	0.2	0.01	21.0	58.98	505.0	0.091
Family Diphyidae	0.1	0.5	0.0	0.0	0.3	0.27	0.6	0.000
Class Scyphozoa	0.2	0.0	0.0	0.0	0.2	-	0.2	0.000
Rotifera	1.5	0.1	0.0	0.0	0.8	0.99	1.7	0.000
Nematoda	2.7	5.3	0.2	0.3	2.1	5.12	33.7	0.006
Polychaeta (larvae)	0.5	1.0	0.3	0.2	0.6	0.61	9.5	0.002
Family Spionidae	0.0	0.2	0.0	0.0	0.2	0.06	0.3	0.000
Family Nereididae	0.0	0.3	0.0	0.0	0.3	0.20	0.7	0.000
Gastropoda (larvae)	40.6	171.1	26.4	10.1	64.8	151.89	1230.4	0.222
<i>Creseis</i> sp.	0.0	0.0	0.0	0.3	0.3	-	0.3	0.000
Bivalvia (larvae)	12.5	41.7	15.4	72.5	35.5	69.28	852.6	0.154
Class Ophiuroidea	0.0	0.0	0.2	0.0	0.2	-	0.2	0.000
Cirripedia (nauplii)	872.1	653.3	450.1	161.7	538.0	889.57	12373.3	2.236
<i>Pseudodiaptomus richardi</i> Dahl, 1894	268.2	389.8	2534.3	5530.6	2258.6	4556.54	51947.5	9.386
<i>P. acutus</i> Dahl, 1894	0.0	0.0	0.0	5.4	5.4	-	5.4	0.001
<i>Acartia negligens</i> Dana, 1849	22.0	0.0	0.0	0.0	22.0	-	22.0	0.004
<i>A. lilljeborgi</i> Giesbrecht, 1889	2033.9	2772.7	496.3	1530.1	1708.2	1843.18	40997.8	7.408
<i>Labidocera</i> sp.	1.0	4.0	0.0	0.1	2.2	4.16	15.2	0.003
<i>Calanopia americana</i> Dahl, 1894	0.0	0.0	0.0	0.1	0.1	-	0.1	0.000
<i>Temora</i> sp.	799.4	525.2	13.3	19.5	485.9	989.50	5344.4	0.966
<i>Disco</i> sp.	811.4	199.7	1195.5	3544.8	1503.0	2478.44	28557.3	5.160
Arietellidae	0.3	0.1	0.0	0.0	0.2	0.10	0.7	0.000
<i>Oithona</i> spp.	936.4	1247.3	6.2	7.1	549.3	1396.81	13182.6	2.382
<i>Halyciclops</i> sp.	7.9	2.6	3.3	5.1	4.6	6.56	92.3	0.017
Corycaeidae	0.2	0.3	0.1	0.0	0.2	0.22	1.2	0.000
<i>Oncaea</i> sp.	0.0	0.0	0.8	0.0	0.8	-	0.8	0.000
<i>Ergasilus</i> sp.	0.0	0.0	0.2	0.4	0.3	0.16	1.6	0.000
<i>Euterpina acutifrons</i> Dana, 1847	427.9	308.2	2.2	0.7	204.9	426.61	3073.4	0.555
<i>Microsetella rosea</i> Dana, 1847	1.2	0.6	0.2	0.2	0.5	0.49	4.4	0.001
<i>Gonyopsillus brasiliensis</i> Huys and Conroy-Dalton, 2000	0.3	0.0	0.0	0.7	0.5	0.29	1.1	0.000
<i>Caligus</i> sp.	0.0	0.1	0.1	0.0	0.1	0.04	0.4	0.000
Ostracoda	28.8	43.9	28.0	22.9	31.0	51.88	588.9	0.106
Stomatopoda	0.0	0.6	0.0	0.0	0.6	-	0.6	0.000
Mysida	0.3	0.0	0.1	0.1	0.2	0.14	0.5	0.000
Gammaridae	1.6	5.0	5.1	31.6	11.1	28.30	254.7	0.046
Isopoda	1.0	0.9	1.2	2.0	1.3	1.41	29.2	0.005
Tanaidacea	0.0	0.2	0.2	0.1	0.2	0.06	0.8	0.000
Cumacea	0.3	0.1	0.2	1.1	0.6	0.89	6.4	0.001
<i>Lucifer faxoni</i> Borradaile, 1915	18.9	4.4	0.2	0.0	6.9	14.27	117.2	0.021
<i>L. typus</i> Milne Edwards, 1837	44.0	22.0	0.5	0.2	18.5	41.20	333.1	0.060
<i>Acetes americanus</i> Ortmann, 1893	0.05	0.0	0.0	0.02	0.04	0.02	0.1	0.000
<i>Sergestes</i> sp.	0.2	0.0	0.0	0.1	0.1	0.07	0.3	0.000
<i>Penaeus</i> sp.	0.2	0.0	0.1	0.1	0.1	0.06	0.5	0.000
<i>Alpheus</i> spp.	8.3	7.9	3.2	4.8	6.0	8.31	120.7	0.022
<i>Synalpheus fritzmuelleri</i> Coutière, 1909	1.6	0.9	0.2	1.1	0.9	0.95	10.7	0.002
<i>Callichirus major</i> Say, 1818	0.3	0.0	0.0	0.0	0.3	-	0.3	0.000
<i>Petrolisthes armatus</i> Gibbes, 1850	0.3	0.0	0.0	0.1	0.2	0.18	0.4	0.000
<i>Clibanarius scolopetarius</i> Herbst, 1796	1.5	0.7	1.7	2.7	1.7	2.25	29.4	0.005
<i>Callinectes sapidus</i> Rathbun, 1896	1.0	0.7	0.4	0.3	0.7	0.48	9.5	0.002

TABLE 1. (CONTINUED)

TABATINGA RIVER								
	DENSITY (ind.m ⁻³)				AVERAGE	s	TOTAL DENSITY	DOMINANCE (%)
	T1	T2	T3	T4				
<i>Panopeus americanus</i> Saussure, 1857	41.7	27.2	23.3	0.0	34.0	55.26	271.7	0.049
<i>Hexapanopeus caribbaeus</i> Stimpson, 1871	126.0	99.2	18.8	0.1	75.1	177.63	1426.4	0.258
<i>Pinnixa chaetopterana</i> Stimpson, 1860	0.1	0.1	0.0	0.0	0.1	0.03	0.4	0.000
<i>Ocypode quadrata</i> Fabricius, 1787	0.3	0.0	0.0	0.0	0.3	-	0.3	0.000
<i>Ucides cordatus</i> Linnaeus, 1763	1406.5	798.5	159.9	460.2	706.3	1517.51	16950.4	3.063
<i>Parasagitta tenuis</i> Conant, 1896	11.7	3.6	0.2	0.2	5.9	14.48	89.1	0.016
<i>Flaccisagitta enflata</i> Grassi, 1881	0.0	0.1	0.0	0.0	0.1	-	0.1	0.000
<i>Oikopleura</i> spp.	136.6	149.0	2.5	0.3	90.8	251.56	1724.7	0.312

TABLE 2. Average density, standard deviation (s), total density and percentage of main zooplankton groups in the Itapicuru River during April, August and December.

ITAPICURU RIVER								
	DENSITY (ind.m ⁻³)				AVERAGE	s	TOTAL DENSITY	DOMINANCE (%)
	I1	I2	I3	I4				
Foraminiferida	194.8	78.1	6.7	7.0	74.5	165.0	1712.8	0.311
Cnidaria	10.0	8.5	1.9	38.8	13.1	34.0	276.0	0.050
<i>Bougainvillia muscus</i>	0.0	0.2	0.0	0.0	0.2	0.09	0.3	0.000
<i>Liriope tetraphylla</i>	0.1	0.0	0.0	0.1	0.1	0.02	0.3	0.000
Diphyidae	0.0	0.0	0.0	0.1	0.1	0.01	0.2	0.000
Nematoda	0.2	0.6	0.4	0.8	0.5	0.5	8.2	0.001
Polychaeta (larvae)	5.0	35.4	5.4	5.9	12.3	29.0	269.7	0.049
Spionidae	0.0	0.2	0.2	0.6	0.4	0.4	2.3	0.000
Nereididae	0.2	0.0	0.1	0.1	0.1	0.1	0.5	0.000
Gastropoda (larvae)	28.0	120.7	342.3	760.1	312.8	673.1	7506.4	1.362
<i>Creseis</i> sp.	0.0	0.0	0.0	265.5	265.5	276.4	796.4	0.145
Bivalvia (larvae)	215.1	537.4	91.0	221.7	266.3	515.0	6391.1	1.160
Ophiuroidea	12.3	0.6	0.1	0.0	5.7	10.9	51.4	0.009
<i>Penilia avirostris</i> (Dana, 1852)	0.9	1.7	0.3	0.1	0.9	1.3	6.9	0.001
Cirripedia (nauplii)	0.3	214.8	842.4	998.1	383.6	678.2	5754.6	1.044
<i>Pseudodiaptomus richardi</i>	721.8	1749.4	20752.5	30772.6	13499.1	20590.0	323977.7	58.788
<i>P. acutus</i>	0.0	2.4	0.0	26.9	14.7	17.3	29.3	0.005
<i>Acartia lilljeborgi</i>	102.1	1580.4	646.2	1514.2	930.8	1709.4	14893.6	2.703
<i>Labidocera</i> sp.	34.7	36.6	6.1	0.3	26.2	30.0	183.7	0.033
<i>Pontellina</i> sp.	242.7	14.5	0.0	49.8	102.3	122.9	307.0	0.056
<i>Pontellopsis vilosa</i> Brady, 1883	8.3	34.8	0.0	0.0	21.5	32.3	129.2	0.023
<i>Calanopia americana</i>	17.0	18.2	0.0	19.4	18.2	1.2	54.6	0.010
<i>Temora</i> sp.	1468.2	8359.8	877.5	29.6	2978.7	9100.9	53616.1	9.729
Augaptilidae	93.1	132.9	3424.1	27.1	573.7	1776.5	8032.3	1.458
<i>Centropages velificatus</i> Oliveira, 1947	0.0	114.9	0.0	0.0	114.9	-	114.9	0.021
<i>Paracalanus</i> sp.	0.0	229.9	0.0	0.0	229.9	-	229.9	0.042
<i>Disco</i> sp.	679.8	2893.4	2893.7	5588.0	3278.4	3937.1	62289.3	11.303
<i>Mecynocera clausi</i> Thompson, 1888	13.9	0.5	0.2	0.0	5.7	10.3	28.7	0.005
<i>Oithona</i> spp.	133.2	47.8	57.6	429.7	167.1	281.1	4009.8	0.728
<i>O. plumifera</i> Baird, 1843	0.5	0.0	0.0	0.0	0.5	-	0.5	0.000
<i>Halyciclops</i> sp.	1.1	150.4	22.1	30.9	54.7	168.7	1203.7	0.218
Corycaidae	44.1	269.3	8.7	1.4	96.4	329.6	1928.5	0.350
<i>Oncaea</i> sp.	1.1	3.4	0.4	0.0	1.6	2.9	16.3	0.003
<i>Agetus flaccus</i> Giesbrecht, 1891	0.1	0.0	0.0	0.0	0.1	-	0.1	0.000
<i>Ditrichocorycaeus africanus</i>	0.1	0.0	0.0	0.0	0.1	-	0.1	0.000
<i>Ergasilus</i> sp.	0.2	0.1	0.4	1.0	0.6	0.5	7.4	0.001
<i>E. caragatatubensis</i>	0.0	0.2	0.1	0.0	0.1	0.02	0.3	0.000
<i>Euterpina acutifrons</i>	20.1	170.0	0.3	0.0	71.4	233.3	1141.9	0.207
<i>Microsetella rosea</i>	0.1	0.2	0.2	0.2	0.2	0.1	2.2	0.000
<i>Macrosetella gracilis</i> Dana, 1847	0.0	0.1	0.2	0.0	0.1	0.0	0.3	0.000
<i>Gonyiopsillus brasiliensis</i>	0.9	0.2	0.2	0.5	0.4	0.3	1.9	0.000
<i>Caligus</i> sp.	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.000
Ostracoda	1.1	18.9	5.4	20.7	11.5	20.1	276.5	0.050
Mysida	0.4	0.5	0.0	0.1	0.4	0.2	1.5	0.000
Gammaridae	1.5	7.4	10.3	9.6	7.3	9.4	160.7	0.029
Isopoda	0.6	0.5	0.2	0.5	0.5	0.5	10.2	0.002
Tanaidacea	0.0	0.0	0.2	0.1	0.1	0.1	0.2	0.000
Cumacea	0.2	0.2	0.2	0.2	0.2	0.1	2.1	0.000
<i>Lucifer faxoni</i>	4.6	14.3	0.9	0.9	5.2	12.5	103.5	0.019
<i>L. typus</i>	15.3	24.0	3.1	3.1	11.4	24.9	227.6	0.041
<i>Acetes americanus</i>	0.0	0.4	0.8	0.8	0.7	0.2	2.8	0.001
<i>Sergestes</i> sp.	1.0	0.5	0.7	0.5	0.7	0.5	8.3	0.002

TABLE 2. (CONTINUED)

ITAPICURU RIVER								
	DENSITY (ind.m ⁻³)				AVERAGE	s	TOTAL DENSITY	DOMINANCE (%)
	I1	I2	I3	I4				
<i>Penaeus</i> sp.	0.6	0.1	0.5	0.3	0.4	0.5	3.1	0.001
<i>Alpheus</i> spp.	1.3	14.4	3.7	10.3	7.4	16.4	148.4	0.027
<i>Synalpheus fritzmuelleri</i>	1.6	0.7	0.0	0.2	1.0	0.8	4.9	0.001
<i>Callichirus major</i>	0.1	0.3	0.0	0.3	0.2	0.1	1.5	0.000
<i>Petrolisthes armatus</i>	0.3	1.7	0.1	0.0	0.6	0.7	2.2	0.000
<i>Pagurus</i> sp.	0.7	13.5	0.2	0.0	2.5	4.9	17.8	0.003
<i>Clibanarius scolopetarius</i>	37.7	62.2	36.2	29.7	41.8	70.8	920.7	0.167
<i>Callinectes sapidus</i>	0.4	3.5	27.6	3.8	12.0	37.9	192.2	0.035
<i>Panopeus americanus</i>	0.0	0.0	8.8	15.1	12.0	14.4	47.9	0.009
<i>Hexapanopeus caribbaeus</i>	87.6	25.5	7.8	8.1	34.0	102.5	611.5	0.111
<i>Pinnixa chaetoptera</i>	2.2	15.3	2.2	4.3	6.3	10.6	87.5	0.016
<i>Ocyropsis quadrata</i>	0.3	15.6	0.5	1.7	4.3	12.6	55.9	0.010
<i>Uca cordatus</i>	1718.7	998.1	3822.8	2103.5	2160.8	3183.3	51858.7	9.410
<i>Parasagitta tenuis</i>	58.9	147.6	11.4	2.2	62.1	165.5	1304.8	0.237
<i>Flaccisagitta enflata</i>	0.2	0.1	0.0	0.0	0.1	0.1	0.6	0.000
<i>Oikopleura</i> spp.	16.0	3.5	0.1	0.0	7.8	13.7	85.4	0.015
<i>Salpidae</i>	0.5	0.0	0.4	0.0	0.5	0.4	1.4	0.000

TABLE 3. Average density, standard deviation (s), total density and percentage of main ichthyoplankton groups in the Tabatinga River during April, August and December.

TABATINGA RIVER								
	DENSITY (ind.100m ⁻³)				AVERAGE	s	TOTAL DENSITY	DOMINANCE (%)
	T1	T2	T3	T4				
<i>Anchoa</i> sp.	16.7	56.5	20.2	150.3	60.9	62.2	243.7	61.94
<i>Harengula</i> aff. <i>jaguana</i> Poey, 1865	6.0	2.2	16.0	26.0	12.5	10.7	50.2	12.75
<i>Ctenogobius boleosoma</i> Jordan and Gilbert, 1882	0.0	0.0	1.4	6.8	2.1	3.2	8.24	8.2
<i>Microdesmus</i> cf. <i>longipinnis</i> Weymouth, 1910	0.0	3.9	3.1	1.6	2.2	1.7	8.69	8.6
<i>Microphis lineatus</i> Bleeker, 1853	0.0	0.0	5.1	6.5	2.9	3.4	11.6	2.94
<i>Stellifer rastrifer</i> Jordan, 1889	0.0	4.0	0.0	1.6	1.4	1.9	5.6	1.41
<i>Hypsoblennius invemar</i> Smith-Vaniz and Acero, 1980	5.4	2.0	0.0	4.2	2.9	2.4	11.6	2.93
<i>Hyporhamphus unifasciatus</i> Ranzani, 1842	3.0	0.0	1.8	0.0	1.2	1.5	4.8	1.21
<i>Trinectes</i> sp.	0.0	0.0	0.0	11.6	2.9	5.8	11.6	2.96
<i>Achirus lineatus</i> Linnaeus, 1758	9.6	1.1	0.0	3.2	3.5	4.3	13.9	3.55
<i>Sphoeroides</i> sp.	0.0	0.0	0.0	1.3	0.3	0.6	1.3	0.33
Eggs	1.0	0.6	0.1	10.0	2.2	3.4	243.7	5.69

TABLE 4. Average density, standard deviation (s), total density and percentage of main ichthyoplankton groups in the Itapicuru River during April, August and December.

ITAPICURU RIVER								
	DENSITY (ind.100m ⁻³)				AVERAGE	s	TOTAL DENSITY	DOMINANCE (%)
	I1	I2	I3	I4				
<i>Lycengraulis grossidens</i>	6.2	0.0	0.0	13.7	5.0	6.5	19.9	0.81
<i>Anchoa</i> sp.	31.9	103.7	355.9	186.3	169.5	139.4	677.8	27.67
<i>Harengula</i> aff. <i>jaguana</i>	7.4	5.6	2.6	16.5	8.0	6.0	32.1	1.31
<i>Ctenogobius boleosoma</i>	123.1	397.9	298.8	209.0	257.2	118.1	1028.8	41.99
<i>Microdesmus</i> cf. <i>longipinnis</i>	0.0	8.9	19.5	1.8	7.5	8.8	30.2	1.23
<i>Eucinostomus</i> sp.	0.0	3.7	2.5	0.0	1.5	1.8	6.2	0.25
<i>Microphis lineatus</i> Bleeker, 1853	6.4	13.0	4.2	10.0	8.4	3.9	33.6	1.37
<i>Mugil liza</i> Valenciennes, 1836	0.0	0.0	0.0	1.2	0.3	0.6	1.2	0.05
Sparidae	6.5	36.0	99.4	3.0	36.2	44.6	144.9	5.92
<i>Stellifer rastrifer</i>	0.9	5.1	13.1	1.2	5.1	5.7	20.3	0.83
<i>Hypsoblennius invemar</i>	0.0	0.0	0.0	3.2	0.8	1.6	3.2	0.13
Haemulidae	5.8	0.0	1.3	0.0	1.8	2.8	7.1	0.29

TABLE 4. (CONTINUED)

ITAPICURU RIVER								
	DENSITY (ind.100m ⁻³)					s	TOTAL DENSITY	DOMINANCE (%)
	I1	I2	I3	I4	AVERAGE			
<i>Oligoplites</i> sp.	1.5	0.0	0.0	0.0	0.4	0.8	1.5	0.06
Atherinopsidae	1.5	0.0	2.5	0.0	1.0	1.2	4.0	0.16
Labrizomidae	0.0	1.3	0.0	0.0	0.3	0.6	1.3	0.05
<i>Hirundichthys</i> sp.	0.0	1.7	0.0	0.0	0.4	0.9	1.7	0.07
<i>Trinectes</i> sp.	3.1	0.0	2.6	0.0	1.4	1.6	5.7	0.23
<i>Achirus lineatus</i>	6.8	4.3	2.6	1.3	3.7	2.4	15.0	0.61
<i>Spherooides</i> sp.	0.0	9.6	1.4	31.3	10.6	14.5	42.3	1.73
Eggs	41.4	17.1	2.7	1.0	15.5	31.9	19.9	15.23

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