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Larval fish assemblage in a tropical estuary in relation to tidal cycles, day/night and seasonal variations

FABIANA TEIXEIRA BONECKER[1,2], MÁRCIA SALUSTIANO DE CASTRO[1,3] & ANA CRISTINA TEIXEIRA BONECKER[1,4]

[1] *Universidade Federal do Rio de Janeiro, Instituto de Biologia, Departamento de Zoologia , CCS, Bloco A, Ilha do Fundão. 21941-590, Rio de Janeiro, Brasil. E-mail:* [2] *fabianabonecker@gmail.com,* [3] *mscastro@biologia.ufrj.br,* [4] *ana@biologia.ufrj.br*

Abstract. The Mucuri River estuary is a salt wedge ecosystem located in Northeast Brazil with an average depth of 4 m in the main channel and wide mangrove vegetation along its margins. This study aimed to analyze the occurrence and abundance of larval fish in relation to seasonal, day/night and tidal variations, and to verify the influence of temperature and salinity on this assemblage. Sampling was conducted at a fixed station located in the entrance of the estuary at every six hours along one tide cycle every three months from March 2002 to December 2004. Oblique hauls were done using a bongo net. A total of 7,230 larval fish from 22 families and 33 species were identified. The highest number of taxa was recorded during the flood tide and night sampling. The highest average densities occurred during the night sampling and in the rainy period, except by 2004 when the highest mean value was recorded in the dry season at night. The highest average densities and number of taxa obtained during flood tide suggested an important contribution of the adjacent coastal zone on the composition of larval assemblage. Larval fish assemblage did not change significantly between rainy and dry periods and it is also true for day/night variation. Larval assemblage of the Mucuri River estuary was dominated by Engraulidae, Gobiidae and Sciaenidae and was mainly influenced by tidal variation.

Keywords: Larval fish assemblage, seasonal variation, day/night variation, tidal variation, Mucuri estuary, Brazil.

Resumo. Assembléia de larvas de peixes em um estuário tropical em relação aos ciclos de marés e variações nictemerais e sazonais. O estuário do rio Mucuri é um ecossistema de cunha salina localizado no nordeste do Brasil, apresentando profundidades médias de 4 m no canal principal e vasta vegetação de mangue nas suas margens. Este estudo teve como objetivo analisar a ocorrência e a abundância das larvas de peixes em relação às variações sazonais, nictemerais e de maré e verificar a influência da temperatura e da salinidade sobre essa assembléia. As coletas foram trimestrais, em uma estação fixa localizada na entrada do estuário, a cada 6 horas, ao longo de um ciclo de maré, de março de 2002 a dezembro de 2004.Os arrastos oblíquos foram efetuados com rede bongô. Foi identificado um total de 7.230 larvas de peixes, incluindo 22 famílias e 33 espécies. O maior número de táxons foi registrado durante a maré enchente, nas amostragens noturnas. As maiores densidades médias ocorreram nas amostras noturnas na estação chuvosa, com exceção do ano de 2004 quando a maior densidade média ocorreu na estação seca durante a noite. As maiores densidades médias e número de táxons obtidas durante a maré enchente sugere uma importante contribuição da zona costeira adjacente sobre a composição da assembléia de larvas. A assembléia de larva de peixe não mudou significativamente entre o período chuvoso e o seco e o mesmo foi observado para a variação dia/noite. A assembléia de larvas do estuário do rio Mucuri foi dominada por Engraulidae, Gobiidae e Sciaenidae e foi principalmente influenciada pela variação de maré.

Palavras-chave: Assembléia de larvas de peixes, variação sazonal, variação dia/noite, estuário do rio Mucuri, Brasil.

Introduction

Estuaries have ecological value and have frequently been referred to as fish nursery areas (Franco-Gordo *et al.* 2003, Berasategui *et al.* 2004) and sustain many marine fish species mainly represented by larvae and juveniles (Duffy-Anderson *et al*. 2003, Castro *et al*. 2005).

Adults and larval fish occurrence and distribution in an estuary vary according to environmental changes like: precipitation regime, estuary morphology that determines the intensity and distance of the salt wedge inversion, tidal dynamic, current velocity and the availability of food resources (Camargo & Isaac 2003, Ré 2005). Temperature and salinity are important environmental factors influencing the occurrence, density and growth of eggs and larval fish in estuarine regions (Faria *et al*. 2006, Ramos *et al*. 2006a).

Larval fish assemblage can also be seasonally influenced in an estuarine region (Harris & Cyrus 2000) and seasonal variations have been well documented (Morais & Morais 1994, Barletta-Bergan *et al*. 2002, Ré 2005). However, most studies developed along the Brazilian coast on estuarine larval fish are limited to the north and south Brazil and few works developed in the southeast region (Barletta-Bergan *et al.* 2002, Joyeux *et al.* 2004).

The Mucuri River is a salt wedge estuary with a semi-diurnal regime situated in the Northeast of Brazil (18°06’02”S and 039°34’0”W). The rainy season extends from November to April and the dry period occurs from May to October (Castro & Bonecker 1996). Although the Mucuri estuary serves as repository for industrial waste, it is important for the local population because of the subsistence fishery activity. There is also a regionally important artisanal fishery upon blue crabs (Schwamborn & Bonecker 1996).

Previous studies in this ecosystem have focused on the zooplankton community variation (Aben-Athar & Bonecker 1996) and the meroplankton distribution (Castro & Bonecker 1996, Schwamborn & Bonecker 1996). However, neither the relationship between larval fish assemblage and environmental parameters, nor the short-term temporal variations on larval fish density have been studied. Therefore, this study analyzes the occurrence and abundance of larval fish in the Mucuri River estuary in relation to seasonal, day/night and tidal variations and verifies the influence of temperature and salinity on this assemblage.

Material and methods

Sampling. Samples were collected at a fixed point (18°05’45.7”S and 39°33’07.7W”) in the mouth of Mucuri River estuary (Figure 1). Sampling was performed at every three months, from March 2002 to December 2004, during the rainy (March and December) and dry periods (June and September). In each survey, sampling was done at every six hours during the flood and ebb tides.

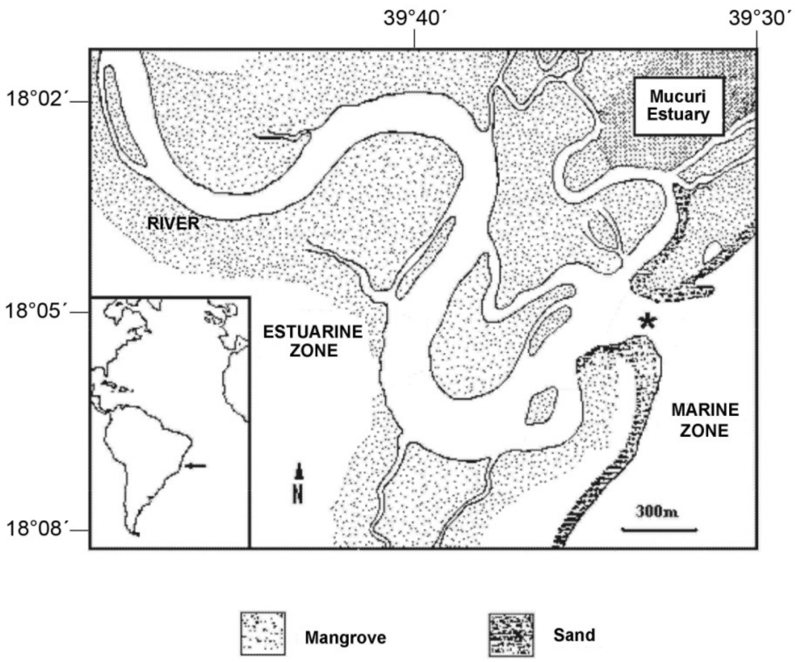

Figure 1. Sampling station location (*) in Mucuri River estuary.

Ichthyoplankton was collected through oblique hauls using a bongo net of 0.6 m diameter and 2.5 m length with 330 and 500 µm mesh sizes. Larval fish were more abundant and taxa number were greater in samples collected with the 500 µm mesh. Therefore, only samples obtained with this mesh were used. A flowmeter (General Oceanics Inc.) was used in order to quantify the volume of water filtered. Samples were fixed in 4% buffered seawater-formalin solution.

Temperature and salinity were measured at the surface, mid-water and bottom using a thermosalinometer (LabComp). Due to the shallow depth and low data variation (CV%) the average values of temperature and salinity were used. Numerical density was expressed as the number of specimens per 100 m^3. Some yolk-sac and damaged larvae could not be identified and were not considered in the analysis. The larval fish list was based on Nelson (2006).

Data analysis. Analysis of variance (ANOVA) was applied to verify if the differences among densities collected during the three years were significant. Student *t* test was used to test differences between samples collected during the dry and wet seasons, day and night, and in flood and ebb tides. In these analyses, the statistical program Statistica 6.0 was used.

One-way analysis of similarity (ANOSIM) and multidimensional scaling (MDS) were performed based on a matrix of 45 samples and taxa that occurred in more than five stations to determine the significance of seasonality, day/night and tidal cycle in the structure of the larval fish assemblage (Clarke & Gorley 2001). Three samples were excluded from the analyses because there were no larval fish. Density data were transformed to log(x+1) and the results were considered significant at significance level <5%.

Similarity percentages analyses (SIMPER) were used to identify taxon contribution to the factor that influenced significantly the assemblage formation. Species that accounted for more than 90% were considered key species. BIO-ENV, a correlation analysis between abiotic and biotic data, was employed using the Spearman correlation coefficient. The biotic matrix was the same used to ANOSIM and SIMPER and the abiotic matrix was based on temperature and salinity data. These analyses were done using the PRIMER 5.0 for Windows program.

Results

Environmental conditions. Temperature average values showed a similar pattern both in the flood and ebb tides, during the day and night sampling. During the flood tide water temperature varied between 23.13°C and 28.90°C; while in the ebb tide it ranged from 24.50°C to 29.70°C. The highest values were recorded during the rainy season and the lowest values occurred in the dry period.

Salinity average values varied greatly during this study especially in ebb tides when most values were lower than 20. During the flood tide salinity ranged from 29.35 to 37.63 and in the ebb tide varied between 0.13 and 27.90. The highest mean salinity values were recorded in the flood tide, while the lowest mean values were obtained during ebb tide (Figure 2). Salinity varied also seasonally and higher mean values were obtained during the dry period, both in the ebb and flood tides (Figure 2).

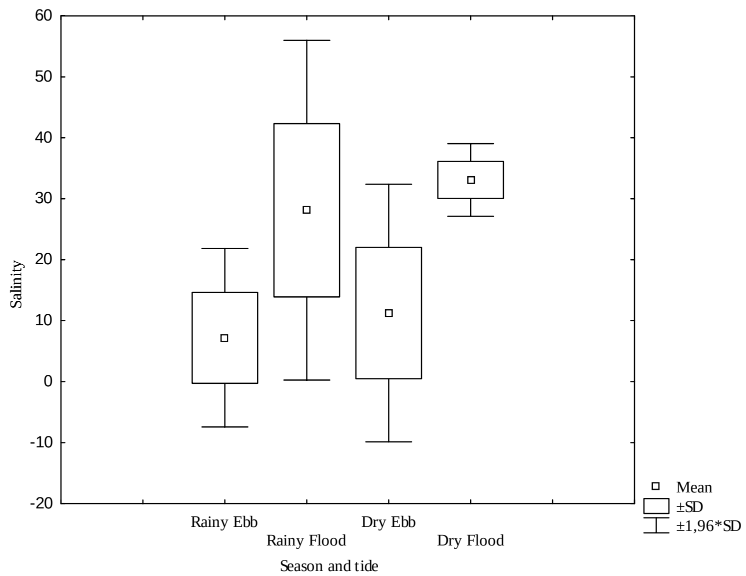

Figure 2. Box and whisker diagrams of salinity (seasonality and tide analyses).

Larval fish assemblage: Taxonomic composition and abundance. A total of 7,230 larval fish was identified along the study, comprising 22 families and 33 species (Table I).

Engraulidae, *Anchoa spinifer*, Clupeidae, Syngnathidae, Gerreidae, Sciaenidae, *Stellifer stellifer*, *Stellifer* sp. and Gobiidae were recorded in all samples (Table I). However, some species occurred exclusively in one tidal or sampling period (Table I). The greatest number of taxa (36) was recorded during the nocturnal flood tide, while the lowest number of taxa (18) was collected during the diurnal ebb tide (Table I).

Engraulidae was most abundant in 2002 and 2004, and represented more than 40% of the total catch. In 2003, Gobiidae dominated and contributed with more than 30%. Sciaenidae was the third in abundance (> 8 %) in the study period. Other families that represented more than 1% in at least one study year were Clupeidae, Pristigasteridae, Syngnathidae, Gerreidae, Eleotridae and Achiridae.

ANOVA analysis showed no significant differences among larval fish densities obtained along the years (p = 0.5). Therefore, the other analyses were done considering the three years together. Average larval densities were significantly greater in the nocturnal samples than in the diurnal ones (p = 0.01) and during the flood tide ($p << 0.05$). However, there was no significant difference between dry and rainy season (p = 0.2) in relation to larval densities.

Larval fish composition in relation to seasonality, day/night and tidal cycles. The ANOSIM analysis indicated that larval fish assemblages during the rainy and dry seasons were similar to one another (R = 0.032; p = 0.12), as were during the day and night sampling (R = 0.009; p = 0.56). Significant differences on larval assemblage were observed during the flood and ebb tides (R = 0.46; p = 0.001) and it was also revealed in MDS plot (Figure 3).

During the flood tide Engraulidae was the discriminating taxon representing 41% followed by Gobiidae (20%) and Sciaenidae (15%); while in the ebb there was greater contribution of Syngnathidae (38%), Engraulidae (21%) and Sciaenidae (16%). According to BIO-ENV analysis, changes on larval fish assemblages were more correlated with salinity than with temperature, as was expected since assemblages in the Mucuri estuary were determined by tide variation.

Discussion

The Mucuri River estuary is under a seasonal regime typically tropical, which is defined by two seasons: rainy (summer), when precipitation is very frequent and intense; and dry period (winter) when there is a critical decline of rain (Nimer 1989). This pattern described in the literature was also found during the present study. Unsurprisingly, the salinity pattern varied in accordance to seasonality being typical of tropical humid regions that are influenced by precipitation and tide, as previously reported for other tropical estuaries (Barletta *et al*. 2005, Castro *et al*. 2005).

The number of taxa recorded during this study (45) was higher than the previous study developed in the same ecosystem (24) (Castro & Bonecker 1996). Other studies developed in different estuaries showed a higher taxa number, e.g. in Lima estuary (50) (Ramos *et al*. 2006b); Caeté River estuary (63) (Bartella-Bergan *et al*. 2002); in the French Guiana (59) (Morais & Morais 1994). However, it is important to stress that when one compares larval fish assemblages of estuarine regions one should considerate the methodology used, sampling effort, the extension of water bodies and environmental conditions (Barletta *et al*. 2005, Ramos *et al*. 2006b). The greater number of sampling stations defined in other estuaries listed above and monthly sampling contributed to increase the number of taxa collected when compared with the present study. Probably, the number of taxa would be higher in Mucuri estuary if larvae were collected in more than one station and if samples were taken monthly. The majority of taxa recorded in this study had already been cited to the Mucuri River estuary (Castro & Bonecker 1996) except by the Atherinopsidae (*A. brasiliensis*), Carangidae (*C. chysurus* and *Oligoplites* sp.) and Haemulidae. Only Ophichthidae (*Myrophis punctatus*) that had already been recorded from this estuary (Castro & Bonecker 1996) was not collected in this study.

The larval fish assemblage of the Mucuri estuary is composed by few species with high abundance, like Engraulidae, Gobiidae and Sciaenidae. According to Joyeux *et al*. (2004), larval fish assemblages in Brazilian estuaries are structured around Gobiidae, Sciaenidae and Engraulidae or Clupeidae. Dominance of these species was also recorded in different estuarine and coastal regions (Grijalva-Chon *et al*. 1992, Bartella-Bergan *et al*. 2002, Castro *et al*. 2005, Faria *et al*. 2006). According to the literature the dominance of engraulids at lower latitudes is common while clupeids are less abundant (Bartella-Bergan *et al*. 2002).

Table I. Total number and percentage of contribution of family and species of fish larvae collected in flood and ebb tide, during day and night, along the study period in the Mucuri River estuary.

Taxa	Flood				Ebb			
	Day	%	Night	%	Day	%	Night	%
Elopidae								
Elops sp.	11	1.08	14	0.24	-	-	3	1.49
Engraulidae	609	59.53	2492	42.84	43	22.40	53	26.37
Anchoa spinifer	18	1.76	225	3.87	1	0.52	1	0.50
Achoviella lepidentostole	3	0.29	-	-	-	-	-	-
Clupeidae	3	0.29	21	0.36	-	-	3	1.49
Opisthonema oglinum	-	-	-	-	1	0.52	1	0.50
Pristigasteridae								
Pellona harroweri	-	-	63	1.09	2	1.04	1	0.50
Ariidae	1	0.10	3	0.05	2	1.04	-	-
Mugilidae								
Mugil curema	-	-	4	0.07	-	-	2	1.00
Atherinopsidae								
Atherinella brasiliensis	-	-	2	0.03	-	-	-	-
Hemiramphidae								
Hyporhamphus unifasciatus	-	-	1	0.02	-	-	3	1.49
Syngnathidae	2	0.20	11	0.19	98	51.04	32	15.92
Microphis brachyurus lineatus	-	-	1	0.02	-	-	-	-
Pseudophallus mindii	-	-	-	-	2	1.04	-	1.49
Syngnathus pelagicus	-	-	1	0.02	-	-	2	1.00
Scorpaenidae	1	0.10	-	-	-	-	-	-
Carangidae								
Chloroscombrus chrysurus	-	-	1	0.02	-	-	-	-
Oligoplites sp.	3	0.29	4	0.07	1	0.52	-	-
Gerreidae	49	4.79	274	4.71	2	1.04	12	5.97
Diapterus sp.	-	-	7	0.12	-	-	-	-
Diapterus auratus	-	-	1	0.02	-	-	-	-
Diapterus rhombeus	-	-	4	0.07	-	-	1	0.50
Haemulidae	-	-	2	0.03	1	0.52	-	-
Sciaenidae	46	4.50	161	2.77	1	0.52	19	9.45
Cynoscion leiarchus	-	-	5	0.09	-	-	-	-
Macrodon ancylodon	-	-	1	0.02	-	-	-	-
Menticirrhus americanus	1	0.10	-	-	-	-	1	0.50
Micropogonias furnieri	-	-	25	0.43	-	-	-	-
Stellifer sp.	67	6.55	106	1.82	11	5.73	2	1.00
Stellifer rastrifer	1	0.10	116	1.99	-	-	-	-
Stellifer stellifer	3	0.29	241	4.14	6	3.13	19	9.45
Ephippidae								
Chaetodipterus faber	2	0.20	1	0.02	-	-	-	-
Blenniidae			1	0.02	1	0.52	7	3.48
Parablennius pilicornis	1	0.10	-	-	1	0.52	-	-
Gobiidae	59	5.77	1537	26.42	17	8.85	31	15.42
Eleotridae								
Dormitator maculatus	-	-	16	0.28	-	-	1	0.50
Microdesmidae								
Microdesmus carri	-	-	6	0.10	-	-	-	-
Achiridae								
Achirus declives	-	-	6	0.10	-	-	-	-
Achirus lineatus	90	8.80	241	4.14	-	-	-	-
Trinectes microphthalmus	-	-	-	-	-	-	3	1.49
Trinectes paulistanus	51	4.99	222	3.82	1	0.52	-	-
Cynoglossidae								
Symphurus plagusia	-	-	-	-	-	-	1	0.50
Tetraodontidae	1	0.10	1	0.02	-	-	-	-
Sphoeroides greeleyi	1	0.10	-	-	1	0.52	-	-

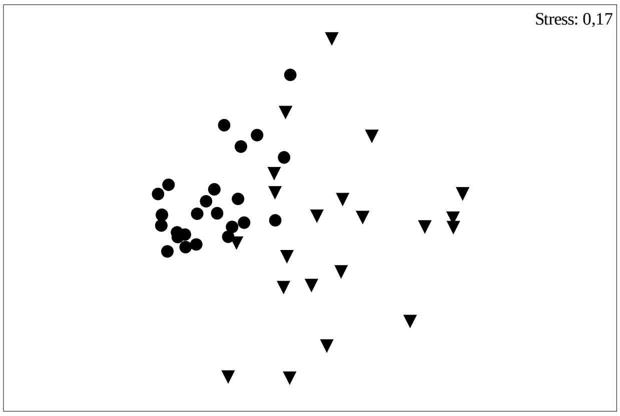

Figure 3. MDS ordination showing differences between ebb and flood assemblages. Each individual point represents a sample. Closed circles: flood; closed triangles: ebb.

According to Mc Lusky (1981) estuaries are characterized by presence of few species that are very abundant and many species rare, normality originated from the adjacent coastal region. In this study marine-estuarine species were dominants (*A. lepidentostole*, *P. harroweri, M. ancylodon, M. americanus, C. leiarchus, M. furnieri*, *Stellifer rastrifer, S. stellifer*), but were also recorded amphidromous species (*Dormitator maculatus*) and freshwater-estuarine species (*Microphis brachyurus lineatus*, *Pseudophallus mindii*).

Seasonality and day/night variations seem to play an important role on larval fish abundance and composition (Sanvicente-Añorve *et al.* 2000). Many larval fish studies showed a tendency of higher densities and taxa number to be recorded during the hottest months (Ramos *et al*. 2006b, Faria *et al.* 2006, Aceves-Medina *et al.* 2008). Generally, larval fish peaks are observed during nocturnal sampling in opposition to lower densities found in diurnal samples (Ramos *et al*. 2006b). This was also true for the Mucuri estuary where larval fish densities were significantly higher during the night comparing with daylight sampling. Although, seasonality is an important factor influencing larval fish, in the present study larval fish density and composition did not vary significantly between the rainy and dry seasons. Different results were obtained by Barletta-Bergan *et al* (2002) in the Caeté River estuary, where the authors found significant differences in density of the most abundant species in relation to season. In Rio da Prata estuary was also observed strong association between larval fish assemblage distribution and salinity structure taken with seasonality (Berasategui *et al.* 2004).

The significant difference observed in larval density and composition between assemblages collected in the flood and ebb tides along this study stresses the importance of tidal cycles in the maintenance of larval fish within the Mucuri estuary. Aben-Athar & Bonecker (1996) attested that tidal cycles with seasonal variations are the main factors influencing plankton distribution in the Mucuri River estuary. Previous studies developed in the Mucuri River estuary observed higher larval densities during flood tide (Castro & Bonecker 1996). In Australia the number of species collected in the flood tide was six times higher than found during the ebb (Neira & Potter 1992). On the other hand, a study conducted at the Guanabara Bay entrance showed that higher densities were obtained during the ebb tide (Castro *et al.* 2005).

Low correlation between water temperature and larval assemblage observed in this study is probably associated with the tropical climate of this region. According to Camargo & Isaac (2003), water temperature in estuarine and coastal ecosystems located in the north Brazil (tropical climate) does not change greatly during the year, and is not the main factor influencing adult fish distribution. Otherwise, salinity changes along the year in tropical regions and in this study had the greatest correlation with larval fish assemblage. In Caeté estuary, situated in the Brazilian north region, seasonal salinity variations was the principal factor influencing the fish assemblage structure (Barletta *et al*. 2005). Changes in salinity probably also influenced the dominance of Engraulidae during the flood tide and of Syngnathidae in the ebb tide in the Mucuri River estuary.

The results obtained in this study suggest that larval assemblage in Mucuri River estuary is mainly influenced by tidal variance. However, further works considering sampling stations distributed along the estuary and adjacent coast, as discussed earlier, would give more information on larval assemblage variability and confirm the importance of this estuary as a nursery area.

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