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Spawning areas, dispersion and microhabitats of fish larvae in the Anavilhanas Ecological Station, rio Negro, Amazonas State, Brazil

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The abundance and distribution of ichthyoplankton and their relationships to current velocity, temperature, dissolved oxygen, pH and electrical conductivity of the water in the Anavilhanas Ecological Station, Negro River, Amazonas State, Brazil, were analyzed. Preferred microhabitats for spawning, dispersion and nursery were also verified. Sampling was undertaken during the falling water period of 2001 and the rising water period of 2002, in a section of 100 km subdivided into 5 subsections, with a total of 20 stations (5 beaches, 5 ravines, 5 channels, and 5 lake channels) at night and during the day at the surface and at the bottom. 647 eggs and 4,187 larvae were captured, belonging to 10 families and four orders: Characiformes (6), Siluriformes (2), Perciformes (1), and Clupeiformes (1). Engraulidae (55.39%), Pimelodidae (30.45%), Auchenipteridae (5.23%) and Sciaenidae (5.13%) were the dominant families. The hierarchical statistical model (ANOVA) with three factors (microhabitat, depth and period) was applied to the environmental variables and the larval abundance, showing greater abundances of sciaenids in the ravines and lower abundances of engraulids in the channels. The highest captures were obtained at lower temperature values, at the bottom during the day and at the surface at night, suggesting an active larval behavior. The presence of the four larval development stages in all subsection for pimelodids and sciaenids, and in three subsections for engraulids, indicates that the Anavilhanas Ecological Station is an important spawning and nursery area for species of these groups in the Negro River. Larvae abundance of all characiform families was extremely low (from 0.1 to 1.17%), suggesting that they do not spawn in this system.

A abundância e distribuição do ictioplâncton e suas relações com a velocidade da corrente, temperatura, oxigênio dissolvido, pH e condutividade elétrica da água na Estação Ecológica Anavilhanas, rio Negro, Amazonas, Brasil, foram investigadas, bem como o uso de áreas e microhabitats preferenciais para desova, dispersão e criação. As coletas foram realizadas em dois períodos: vazante de 2001 e enchente de 2002, em um trecho de 100 km dividido em cinco subseções, e em cada um delas foram amostrados os microhabitats praia, barranco, canal e canal de lago, com um total de 20 pontos de coletas (cinco praias, cinco barrancos, cinco canais e cinco canais de lago). As coletas foram realizadas durante o dia e à noite na superfície e no fundo. 647 ovos e 4.187 larvas de peixes foram capturados, pertencentes a quatro ordens e dez famílias: Characiformes (6), Siluriformes (2), Perciformes (1) e Clupeiformes (1). As famílias dominantes foram Engraulidae (55,39%), Pimelodidae (30,45%), Auchenipteridae (5,23%) e Sciaenidae (5,13%). O modelo de estatística hierárquica (ANOVA) com três fatores (microhabitat, profundidade e período) foi aplicado às variáveis ambientais e às abundâncias de larvas, mostrando maior abundância de Sciaenidae nos barrancos e menor de Engraulidae nos canais. As maiores capturas foram obtidas em temperaturas mais baixas, no fundo durante o dia e na superfíc4ie à noite, sugerindo um comportamento ativo das larvas. A presença das quatro fases de desenvolvimento larval de Pimelodidae e Sciaenidae em todas as subseções, e de Engraulidae em três subseções, sugerem que a Estação Ecológica de Anavilhanas é uma área importante de desova e de desenvolvimento inicial para as espécies destes grupos no rio Negro. A abundância das larvas de todas as famílias de Characiformes foi extremamente baixa (0,1 a 1,17%) sugerindo que este sistema não é utilizado por membros desta ordem.

Key words: Ichthyoplankton, Black water, Reproduction, Protected Areas, Amazon.

Introduction

Fish requires specific areas for reproduction, and recruitment success depends on favorable environmental conditions for the survival of the larvae and juveniles (Urho, 1999). Water transportation affects larvae distribution in relation to space and time, and the distribution of food and predators have a positive or negative effect on their survival (Simpson, 1987). In rivers, current is the most decisive mechanism in the transportation of larvae to nursery areas (Hergenrader *et al*., 1982; Pavlov, 1994; Araújo-Lima & Oliveira, 1998; Bialetzki *et al*., 2004). Many Amazon migratory fish, including commercially important species, spawn in the main channel of the Amazon River and its tributaries (Balon, 1975; Oliveira & Araújo-Lima, 1998), where the larvae remain for a few days before

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they are carried into the floodplains (Araújo-Lima & Oliveira, 1998). However, few studies have considered the microhabitat diversity in rivers with different physicochemical properties.

Evaluation of larval density depends on the drift pattern of the larvae, which is influenced by photoperiod, current speed in the microhabitats, sampling depth, and investigated species (Pavlov, 1994; Gadomski & Barfoot, 1998; Araújo-Lima *et al.*, 2001). Considering these aspects, black water rivers of the Amazon basin, with its low-nutrient content, are very different from the whitewater rivers (Goulding *et al.*, 1988; Walker, 1990) and poorly studied (Oliveira & Ferreira, 2002).

This study aims to identify which fish species spawn and which microhabitats in open areas are used to spawning and nursery in the Anavilhanas Ecological Station (Anavilhanas ESEC). The hypothesis tested in this paper is that if many species spawn in the Anavilhanas Ecological Station, then high number of eggs and larvae should drift in different routes of dispersion, especially in specifics microhabitats that are considered nursery areas in the open waters of the Negro River.

Material and Methods

Study sites

The sites were located in the lower Negro River in Anavilhanas Ecological Station about 100 km upstream Manaus, in a section of 100 km subdivided into five subsections (A, B, C, D, and E), four microhabitats, characterized by depth near the margin, the current flow, and the patterns of sedimentation and/or erosion of the margins, in each subsection were considered: beach = the sedimentation margins, ravine = the erosion margins, channel = channel of the main river, and lake channel = channel connecting a lake to the main river, with a total of 20 stations (Fig. 1, Table 1). Samples were carried out at the surface (0.20 m) and at the bottom (2.0 to 9.0 m) during the day and at night, in two periods: November of 2001 (falling waters) and January of 2002 (rising waters), totalizing 80 samples. According to Araujo-Lima & Oliveira (1998) and Araujo-Lima *et al.* (2001) these are the times of year when the greatest densities of larvae are found drifting in the Central Amazon rivers.

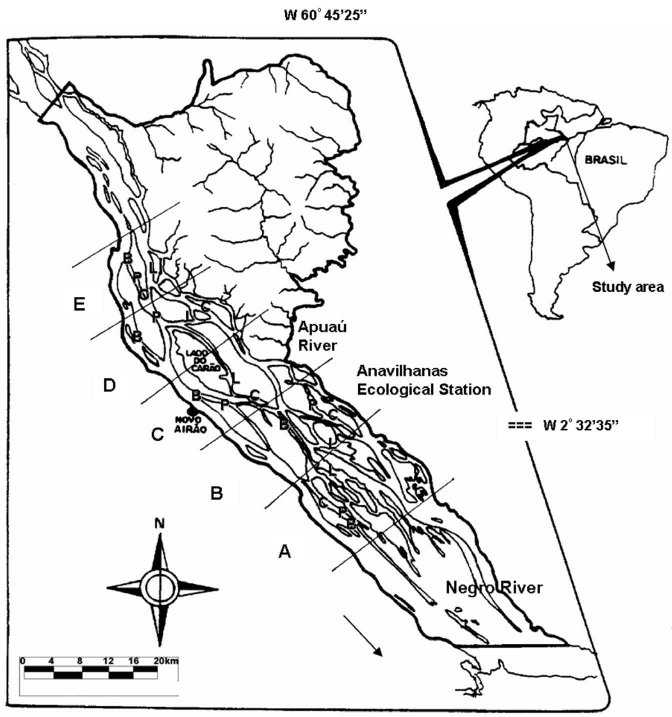

Fig. 1. Anavilhanas Ecological Station: A, B, C, D and E are the sub sections; beach (P). ravine (B) channel (C) and lake channel (L) are the microhabitats sampled; the arrow shows the direction of the flow.

Sampling

For the physicochemical data (temperature, dissolved oxygen, pH and electrical conductivity), water was collected at the surface (0.20 m) and at the bottom (2.0 to 9.0 m) with a Van Dorn type bottle; a conductivity/pH meter (OaktonTM 35630-00) and an Oxygen meter (YSI TM 55) were also used. The current speed was measured at the surface (0.20 m) with a standard flow meter (General Oceanics TM) at 5 to 20 m from the margin, and corrected by a calibration coefficient according to Nakatani *et al.* (2001). Ichthyoplankton samples were taken using a plankton net with 3.25 m, 0.1 m^2 mouth area and 0.4 mm mesh-size. The methodology to determine the volume of water filtered was used a standard flow meter (General Oceanics TM) according to Araújo-Lima & Oliveira (1998). The larvae and eggs were fixed with 10% formalin in the field and taken to the Núcleo de Pesquisas em Ictioplâncton (NUPIC) of the Universidade Federal do Amazonas (UFAM), in Manaus, where they were analyzed and identified according to the development stage such as: pre-flexion, flexion and post-flexion (Ahlstrom & Ball, 1954; Phonlor, 1984; Nakatani *et al.*, 2001) and number of myomeres (Araújo-Lima & Donald, 1988). Larvae were identified at the most precisely level possible (genus or species), but due to lack of taxonomic information on the larval forms of fish species from the Negro River not all larvae could be identified at these level, thus family level was used to standardize the analyses in this study. The identification of the eggs was not possible because they were in the early stages of cleavage and morula phase.

Data analysis

The abundance was calculated for 10 cubic meters (number of larvae or eggs/10 m^3), according to Nakatani *et al.* (2001). The densities of fish eggs and larvae were calculated for each microhabitat, with the data of the two hydrological periods together, but only the densities of fish larvae were calculated per family. Egg and larval densities were transformed to $\log_{10}(x+1)$ due to heterocedasticidy (Zar, 1984). The spatial distribution of the ichthyoplankton was tested with ANOVA model 1, a hierarchical type with two fixed factors (microhabitat and depth) and with measures repeated in time (day and night). This statistical design is hierarchical because the depth factor is within the microhabitat factor and the samples were taken in the same subsection at day and at night. The differences among microhabitats, depth and between day and night was also measured with a planned multiple comparison of means (LSD) applied to large samples ($n > 50$) as described by Elliott (1993). The effect of abiotic factors on the abundance of larvae in the microhabitat was measured using the residuals of these ANOVA analyses. In all tests, a significance level of 5% was used. To determine which subsection of Anavilhanas ESEC constitute areas of spawning, dispersion and/or nursery, the abundances of eggs and larvae in the subsections were compared using an ANOVA One-Way, considering that,

Table 1. Subsections, microhabitats, geographical location, hydrological and physicochemical data recorded in the Anavilhanas Ecological Station.

Sub-sections	Microhabitats	Stations	Longitude/Latitude	Mean Velocity (m/s)	Mean Depth (m)	Mean Dissolved Oxygen (ppm)	Mean Temperature (ºC)	Mean pH	Mean Electrical Conductivity (uS.cm-1)
A	Beach	A1	60º44'46"W/02º46'41"S	0.09	1.70	4.24	30.48	4.56	14.94
	Ravine	A2	60º44'26"W/02º46'42"S	0.12	5.68	4.28	30.63	4.57	10.83
	Channel	A3	60º44'23"W/02º45'27"S	0.08	8.24	4.21	30.42	4.54	10.97
	Lake Channel	A4	60º43'25"W/02º44'22"S	0.18	6.57	4.28	31.03	4.57	11.10
B	Beach	B1	60º47'48"W/02º37'01"S	0.03	1.64	4.24	31.80	4.51	11.17
	Ravine	B2	60º48'23"W/02º37'16"S	0.08	5.18	4.44	31.28	4.59	11.17
	Channel	B3	60º45'10"W/02º41'02"S	0.26	7.04	4.34	31.75	4.44	9.85
	Lake Channel	B4	60º44'25"W/02º42'35"S	0.22	7.24	4.21	30.75	4.58	11.14
C	Beach	C1	60º53'06"W/02º36'34"S	0.19	2.40	4.35	30.57	4.55	11.98
	Ravine	C2	60º55'15"W/02º35'42"S	0.05	8.23	4.47	30.52	4.62	11.63
	Channel	C3	60º52'33"W/02º37'13"S	0.21	10.33	4.11	30.67	4.55	12.15
	Lake Channel	C4	60º52'08"W/02º35'46"S	0.06	4.51	4.50	30.27	4.61	11.16
D	Beach	D1	60º59'31"W/02º29'02"S	0.11	2.64	4.35	30.22	4.58	11.66
	Ravine	D2	61º00'11"W/02º28'45"S	0.14	5.15	4.57	30.25	4.62	13.16
	Channel	D3	60º54'32"W/02º28'00"S	0.09	9.16	4.58	30.27	4.63	11.49
	Lake Channel	D4	60º57'09"W/02º27'49"S	0.28	4.22	4.21	29.82	4.63	11.13
E	Beach	E1	61º01'38"W/02º25'18"S	0.08	2.58	4.35	30.42	4.62	13.13
	Ravine	E2	61º03'07"W/02º22'31"S	0.12	6.49	4.53	30.55	4.62	13.08
	Channel	E3	61º00'16"W/02º24'47"S	0.10	8.10	4.29	30.32	4.70	11.94
	Lake Channel	E4	61º02'21"W/02º22'40"S	0.21	5.41	3.44	30.53	4.60	12.69

those which present a larger percentage of eggs and of larvae in precocious stages of development (larval vitelline and preflexion), constitute probable places of spawning, and those with larvae in more advanced stages (flexion and postflexion) can be classified as nursery and dispersion places.

Results

Physical and chemical data

The mean values of the hydrological and physicochemical characteristics of microhabitats are showed on Table 1.

The slowest current speed recorded in the microhabitats of the Negro River was at the beach (0.03 m/s) and the fastest in the channel (0.69 m/s). The electrical conductivity ranged from 6.13 $\mu S.cm^{-1}$ (ravine) to 25.1 $\mu S.cm^{-1}$ (beach) but did not show significant differences between microhabitats and periods. Dissolved oxygen varied among the microhabitats and ranged from 2.05 to 5.82 ppm, the highest value occurred in the ravines (ANOVA; F=3.44; n=80; d.f.= 3; P=0.019) and at the surface (ANOVA; F=33.39; n=80; d.f.= 3; P=0.000). The water temperature ranged from 28.4 to 34.7 ºC, being lower at the bottom (ANOVA; F=28.97; n=80; d.f.= 3; P=0.000) and at night (ANOVA; F=30.73; n=80; d.f.=3; P=0.000). The pH oscillated around 4.4 ±0.25, being lower in the lake channels and ravines (ANOVA; F=3.52; n=80; d.f.= 3; P=0.019).

Eggs and larvae data

In the 20 stations sampled the eggs densities were low, with 647 eggs captured in the initial phases of cleavage and morula (Table 2). However, the density of eggs was higher on the bottom (ANOVA; F=3.50; n=80; d.f.= 3; P=0.01) and at night (ANOVA; F=6.87; n=80; d.f.= 3; P=0.01). Higher densities occurred between 29.3 and 31.5 ºC (ANOVA; F=4.91; n=80; d.f.= 5; P=0.002) and between 8.9 and 14.2 $\mu S.cm^{-1}$ (ANOVA; F=4.91; n=80; d.f.= 5; P=0.014) (Fig. 2).

A total of 4,187 larvae were captured belonging to ten families and four orders: Characiformes (6), Siluriformes (2), Perciformes (1) and Clupeiformes (1). Most of the larvae caught were small (< 6mm) and in undeveloped stage (preflexion) (Table 2). Engraulidae (55.39%), Pimelodidae (30.45%), Auchenipteridae (5.23%) and Sciaenidae (5.13%) were the dominant groups (Table 2). 2,324 larvae of Clupeiformes were caught, belonging to Engraulidae with lower abundances in the channels (ANOVA; F=3.31; n=80; d.f.= 3; P <0.02) (LSD; P=0,002), higher at the bottom (ANOVA; F=10.80; n=80; d.f.= 1; P <0.0017), at night (ANOVA; F=16.01; n=80; d.f.= 1; P <0.0002) (Fig. 3); and with higher abundances occurring between 29.2 and 31.2 ºC (ANOVA; F=5.39; n=80; d.f.= 5; P <0.003).

The most abundant siluriform family was Pimelodidae with 1,275 larvae (Table 2), being higher at the bottom (ANOVA; F=35.30; n=80; d.f.= 1; P <0.0000), at night (ANOVA; F=11.94; n=80; d.f.= 1; P <0.001) (Fig. 4), and with temperatures between 29 to 32 ºC (ANOVA; F=3.43; n=80; d.f.=5; P=0.000). The occurrence of larvae of genera other than *Hypophthalmus* was very low in both periods, therefore, for analysis effect, only this genus was considered. The abundance of the Auchenipteridae was higher at the bottom (ANOVA; F=27.54; n=80; d.f.= 1; P <0.0000) (Fig. 5), with higher abundances occurring in temperatures between 29.3 and 31.1 ºC (ANOVA; F=1.70; n=80; d.f.= 5; P=0.007).

Sciaenidae was the only family in Perciformes, with all larvae belonging to *Plagioscion* (Table 2). It was higher in the ravines (ANOVA; F=3.14; n=80; d.f.= 3; P <0.02) (LSD; P=0,001) and at night (ANOVA; F=18.95; n= 80; d.f.= 1; P <0.0000), there were no differences between surface and bottom (Fig. 6), with higher densities occurring in temperatures from 28.8 to 31.2 ºC (ANOVA; F=5.64; n= 80; d.f.= 5; P=0.014) and electrical conductivity from 8.5 to 13.5 $\mu S.cm^{-1}$. There was not any correlation between the variables pH and dissolved oxygen with egg abundance nor with the larvae abundance of the families captured.

Larval densities for Characiformes were very low in all sampling sites representing 0.10% to 1.17% of total capture (Table 2). Therefore it was not possible to use the proposed

Table 2. Number of fish eggs, larvae and juveniles caught at the Anavilhanas Ecological Station. Larvae % by family and ontogenetic stage (LV=larval viteline; PRE=preflexion; FLE=flexion; POS=postflexion; JUV=juvenile).

Order/Family	Subsections	Eggs Total	LV	PRE	FLE	POS	Larvae Total	by family (%)	JUV	Total
Clupeiformes										
Engraulidae	A, B, C, D, E	-	123	2040	133	28	2324	55.39	0	2324
Siluriformes										
Pimelodidae	A, B, C, D, E	-	424	522	227	102	1275	30.45	0	1275
Auchenipteridae	A, B, C, D, E	-	33	186	0	0	219	5.23	0	219
Perciformes										
Sciaenidae	A, B, C, D, E	-	57	94	52	12	215	5.13	1	216
Characiformes										
Characidae	A, B, C, D, E	-	7	26	4	7	44	1.17	5	49
Prochilodontidae	B, C, D, E	-	8	29	2	0	39	0.93	0	39
Hemiodontidae	A, B, C, D, E	-	0	33	1	0	34	0.81	0	34
Curimatidae	A, B, C, D, E	-	5	19	4	0	28	0.67	0	28
Cynodontidae	A, B, C, D	-	0	4	1	0	5	0.12	0	5
Anostomidae	C, D, E	-	0	4	0	0	4	0.10	0	4
Total	A, B, C, D, E	647	657	2957	424	142	4187	100%	6	4834
% per larval stage			15.69	70.62	10.12	3.55	100%			

statistical model of distribution for these groups.

Analysis of the abundances of eggs and larvae comparing the five subsections of the total area using an ANOVA One-Way, was not significant for any family considered. There also was no significant differences between the subsections.

Discussion

Distribution of eggs

The highest abundance of eggs at the bottom in all microhabitats, but mainly on the channels and lake channels, would be the result of spawning that occurred close to these sites, and suggests a drift close to the bottom (Bialetzki *et al.*, 1999; Baumgartner *et al.*, 2004). According to Balon (1975), the eggs of migratory Characiformes tend to be buoyant, because of its form as well as the presence of a large perivitellinic space; several species of siluriforms also present this characteristic (Nakatani *et al.*, 2001; Leite *et al.*, 2007; Oliveira *et al.*, 2008). On the other hand, the captured eggs may also belong to Engraulidae and Sciaenidae species, which possess pelagic eggs (Matsuura, 1977; Phonlor, 1984; Bialetzki *et al.*, 2004). Considering all groups caught in this study and a mean velocity of the current of 0.35 m/s, depending on the adhesiveness of the corium to small grains of sand, the density of these eggs would increase, keeping them in the inferior half of the water column (Araújo-Lima & Oliveira, 1998). In that case, this accumulation and egg transportation close to the bottom is probably the result of the interaction of physical factors, such as turbulence, associated to characteristics of adhesiveness of the eggs of species of these families (Rizzo *et al.*, 2002).

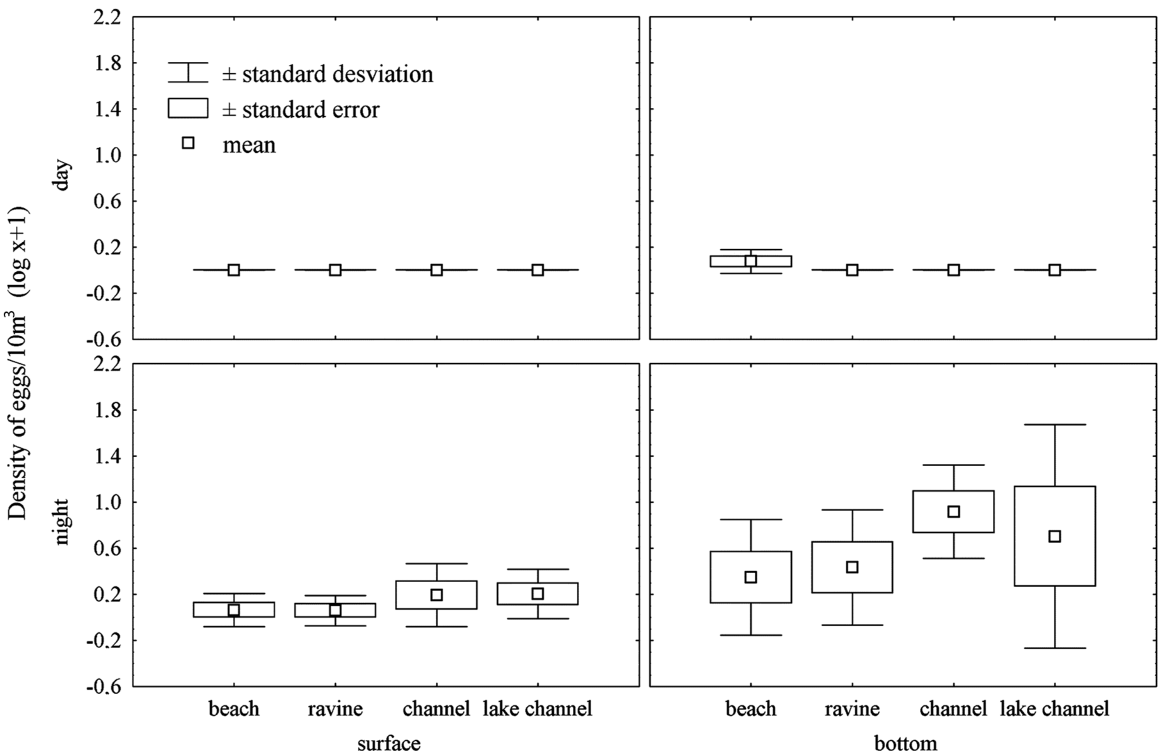

Fig. 2. Abundance of eggs in different microhabitats in the surface and bottom in the Anavilhanas Ecological Station.

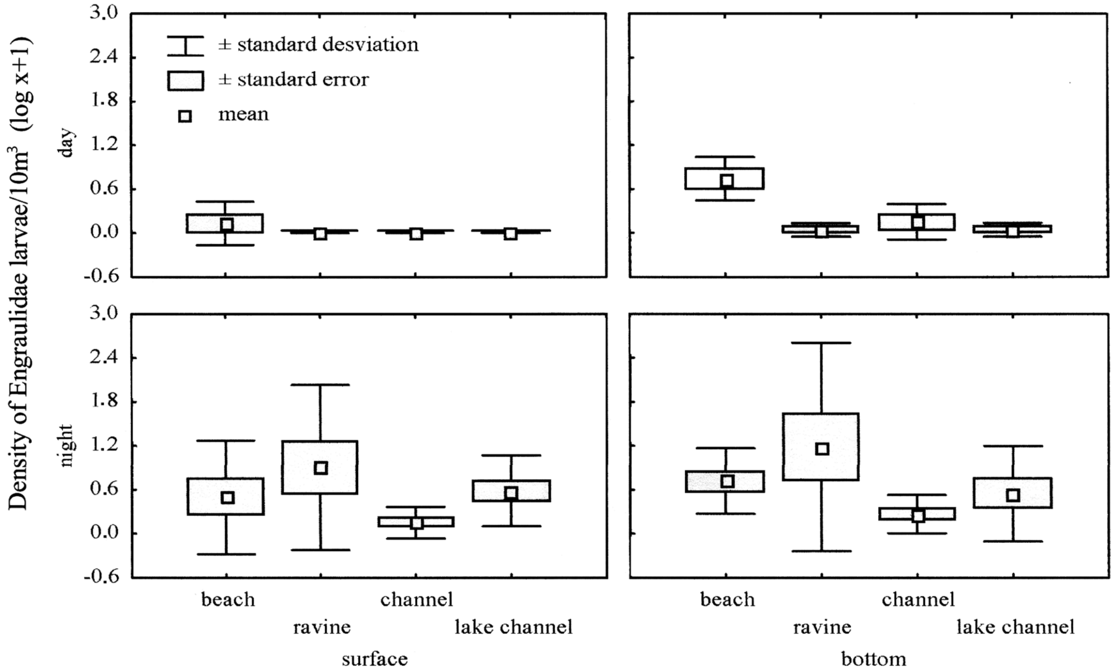

Fig. 3. Abundance of Engraulidae larvae in different microhabitats in the surface and bottom in the Anavilhanas Ecological Station.

In this study the highest egg abundances were correlated with a range of electrical conductivity and water temperature. A decrease followed by an increase in the values of the temperature and electrical conductivity of the water are pointed out as "triggers" for spawning in tropical rivers (Nakatani *et al*., 1993; Vazzoler, 1996; Baumgartner *et al*., 1997; Bialetzki *et al*., 2004). Nevertheless, another factor that could influence the decrease in the capture of eggs is the short time between incubation and eclosion. The time of incubation for most of the species that disperse eggs and larvae is relatively short, 12 to 18 hours (Araújo-Lima, 1994; Cardoso *et al*., 1995; Nakatani *et al*., 2001). If spawning occurred in Anavilhanas at the end of the afternoon, and if recently fertilized eggs are accumulated close to the bottom during the drift, from the night through the following morning, the eggs would be submitted to light and temperature conditions considered ideal for their development up to larvae (Curiacos, 1999) and this strategy should act as a protection against visual predators.

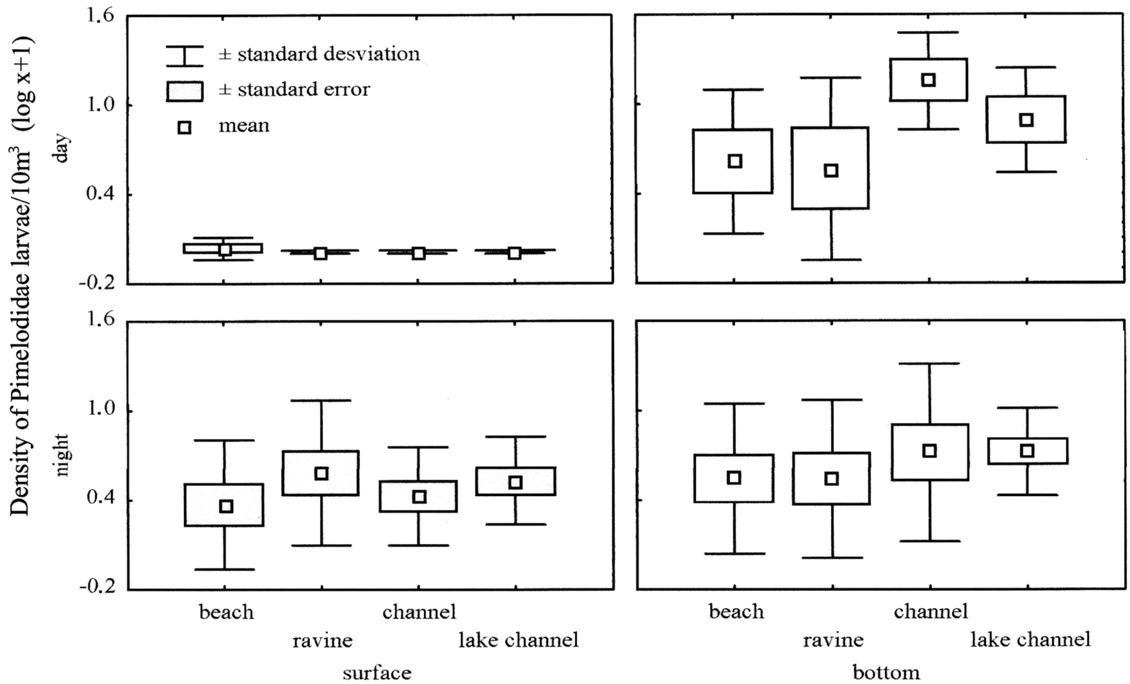

Fig. 4. Abundance of Pimelodidae larvae in different microhabitats in the surface and bottom in the Anavilhanas Ecological Station.

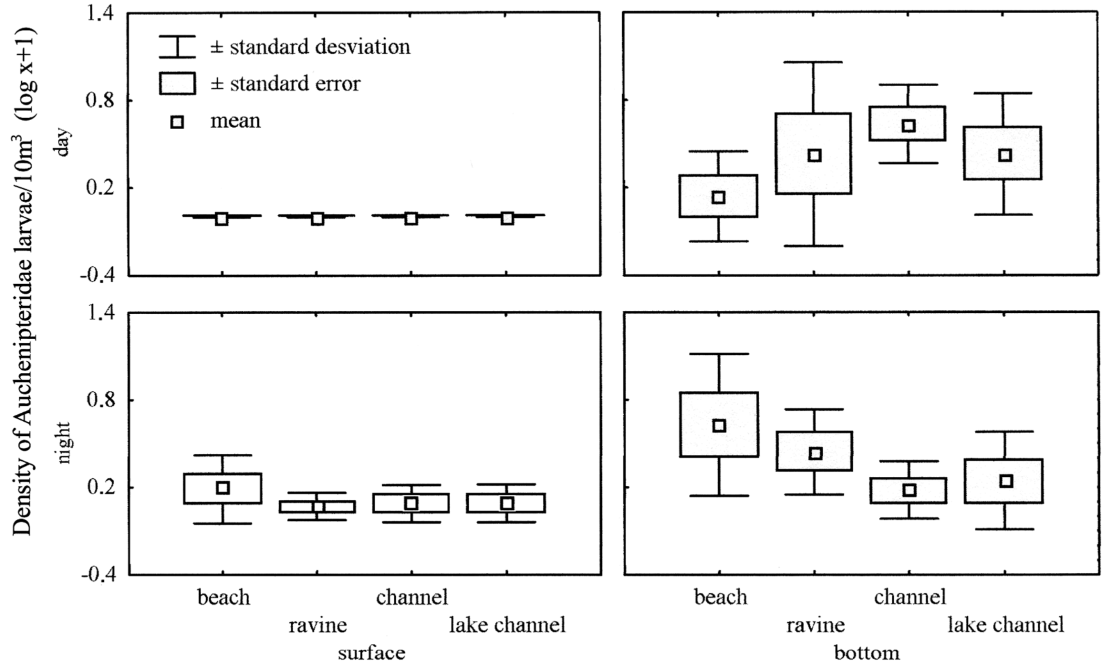

Fig. 5. Abundance of Auchenipteridae larvae in different microhabitats in the surface and bottom in the Anavilhanas Ecological Station.

Vertical distribution of larvae

The highest captures of larvae at night and lowest captures in the daytime indicate a probable vertical migration to the surface at night. These results are similar to many others of diurnal distribution and abundance of ichthyoplankton in tropical rivers (Baumgartner *et al*., 1997; Araújo-Lima *et al*., 2001; Bialetzki *et al*., 2004) and in temperate regions (Gale & Mohr, 1978; Hergenrader *et al*., 1982; Gallagher & Conner, 1983; Corbet & Powles, 1986; Gadomski & Barfoot, 1998).

Baumgartner *et al*. (2004) studying larvae of *Hypophthalmus edentatus*, *Plagioscion squamosissimus* and species of Characiformes in the upper Paraná River mentioned the interaction of several factors that act in the highest capture at the surface at night, but they affirm that the feeding activity would trigger the whole process of vertical distribution. Possible explanations for the differences between day and night

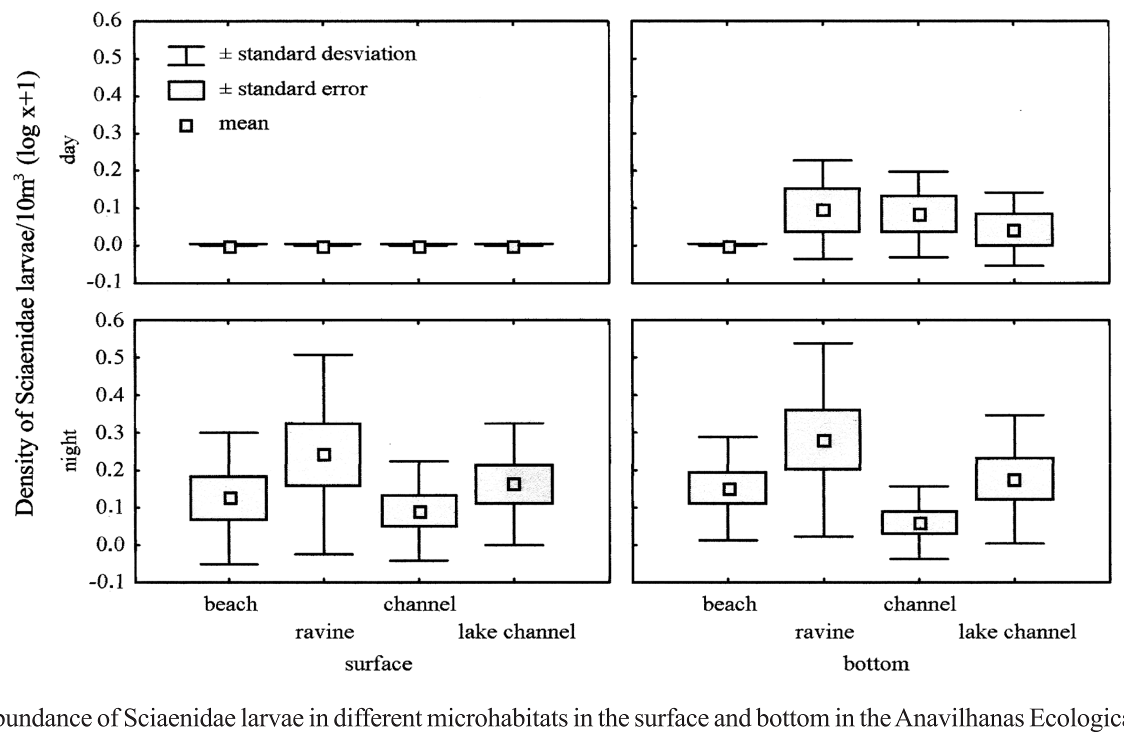

Fig. 6. Abundance of Sciaenidae larvae in different microhabitats in the surface and bottom in the Anavilhanas Ecological Station.

catches in the Negro River might be related to larval vision, especially for the more developed and visually active ones (Katsuragawa & Matsuura, 1990; Araújo-Lima *et al*., 2001). In this study 87.12% of the larvae caught were in larval vitelline and preflexion stages, with standard length between 2.0 and 6.8 mm, with initial ontogenetic development. So, considering the active method of capture in the counter flow of the current at speeds always superior to 0.03 m/s, it can be deduced that this factor would have interfered very little in the low occurrences at the surface during the day.

Microhabitat distribution of larvae

The engraulid larvae were less abundant in the channels, suggesting a pattern of spawning and drifting preferentially close to the beaches, ravines and lake channels. The biological reason for this pattern of greater larvae abundance in a specific place can be related to the favorable conditions for spawning such as food supply and protection against predators (Nikolsky, 1978; Lowe-McConnell, 1987; Munro, 1990; Copp, 1993), and it probably constitutes an adaptive strategy of differentiated dispersion to occupy vacant habitats (Krebs, 1994). Scheidegger & Bain (1995) analyzing the relationship between the preference for microhabitat and the taxonomic composition of larvae in the Tallopoosa River, with regulated flow, and in the Cahaba River, not regulated, in Alabama (USA), verified that it is possible to identify, at a family level, significant differences among the nursery areas. The largest abundance of engraulid larvae in flexion and postflexion stages at the beaches suggests that this microhabitat is a nursery area for the species of this family.

The sciaenid larvae (*Plagioscion* spp.) were more abundant in the ravines, which are areas of erosion, similar to that described for the fish larvae of the Missouri River in microhabitats with these characteristics (Hergenrader *et al*., 1982), and for *Mylossoma aureum* and *M. duriventre* in the margins of the Amazon River (Oliveira & Araújo-Lima, 1998; Oliveira, 2000). This pattern probably gives advantages to the species of *Plagioscion* that would be more easily transported to the nursery areas, such as lake channels and lakes. This hypothesis is reinforced by the presence of greater larvae abundances in flexion and postflexion stage in the lake channel, where they would find shelter and food.

Some authors suggest that the beginning of the larvae displacement downstream is not totally passive (Gale & Mohr, 1978; Corbett & Powles, 1986; Pavlov, 1994; Oliveira & Araújo-Lima, 1998). In turbulent and unidirectional river systems, when the moment is favorable, the larvae that move close to the margin, should actively reach the radial secondary currents (Potter *et al*., 1978). These currents are regulated by the relief at the bottom of the channels, and act as cells in helix form which, after reaching the erosion margins and the sedimentation areas, return to the longitudinal main current (Thorne *et al*., 1985; Carling, 1992). This would result in an accumulation of larvae in the erosion and sedimentation areas that constitute transition environments between the spawning and nursery areas (Oliveira & Araújo-Lima, 1998; Bialetzki *et al*., 2004).

Thus, the tendency of higher engraulid larvae abundances in the beaches, and of sciaenid larvae in the ravines, are the results of the interaction of the spawning and nursery areas, swimming behavior of the species of these groups and interaction with the hydraulic conditions of the system. These patterns differed from the one observed for the larvae of Auchenipteridae and Pimelodidae, which besides being more abundant at the bottom and at night, did not present differences in the distribution between microhabitats.

Longitudinal distribution of larvae

Considering all sub-areas, engraulid larvae in preflexion stage were the most abundant. Until this stage, about 96 hours have elapsed from the spawning (personal obs.). At an average speed of 0.25 m/s, we can estimate a drift between 40 and 50 km, thus we can affirm that the spawning activity of this family occurred along the whole extension of the area studied. The capture of the four larval development stages of Sciaenidae in all sub-areas, and of the larval vitelline and preflexion stage in three sub-areas for the families Auchenipteridae and Pimelodidae, suggests that these groups use the entire Anavilhanas ESEC as area for spawning and nursery. This increase the chances of larvae reach areas with better survival conditions (Simpson, 1987; Oliveira & Araújo-Lima, 1998; Urho, 1999; Bialetzki *et al*., 2004).

The behavior of these groups reveals that the whole extension of the Anavilhanas ESEC constitutes an important refuge in the life cycle of the local fish fauna, functioning as an area of spawning and nursery of non-migratory and short distance migratory resident species of the Negro River. On the other hand, the low abundance of larvae of the migratory fish represented by Characidae, Curimatidae and Prochilodontidae, and of the short distance migratory fish by Cynodontidae, Anostomidae and Hemiodontidae, suggests that the archipelago does not constitute a preferential reproduction area for these groups. Lima & Araújo-Lima (2004) also noted that larval and juveniles of these species of Characiformes were found in nutrient-rich rivers only, for example the Amazon River, indicating that spawning activity was restricted to rivers with this water type. But, on that case Anavilhanas ESEC would function as feeding area for these species (Vieira *et al*., 2002).

Gymnotiform and synbranchiform larvae did not occur in Anavilhanas, but in others studies, when caught, showed only negligible numbers (Araújo-Lima & Oliveira, 1998; Nakatani *et al*., 2001; Baumgartner *et al*., 2004; Bialetzki *et al*., 2004) indicating that they showed spawning strategy other than dispersing eggs and larvae in open waters.

Ravines and lake channels are the principle microhabitats used for spawning and also serve as nurseries by those fish families that disperse eggs and larvae in the Anavilhanas ESEC area. There were no significant differences in terms of egg and larvae abundance among the Anavilhanas ESEC subsections. Thus, the whole area of the Anavilhanas ESEC is of extreme importance for the maintenance of the fishing stocks and of the diversity of the fish fauna in the lower Negro River and its conservation and management is vital.

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