ZOOLOGIA 32(5): 351–359, October 2015
http://dx.doi.org/10.1590/S1984-46702015000500004

Factors determining the structure of fish assemblages in an Amazonian river near to oil and gas exploration areas in the Amazon basin (Brazil): establishing the baseline for environmental evaluation

Igor David Costa[1] & Carlos Edwar de Carvalho Freitas[2,*]

[1] *Departamento de Engenharia de Pesca, Fundação Universidade Federal de Rondônia. Rua da Paz 4376, 76916-000 Presidente Médici, RO, Brazil. E-mail: igorbiologia@yahoo.com.br*
[2] *Departamento de Ciências Pesqueiras, Universidade Federal do Amazonas. Avenida General Rodrigo Otávio 3000, 69077-000 Manaus, AM, Brazil.*
[*] *Corresponding author. E-mail: cefreitas@ufam.edu.br*

ABSTRACT. Determining the significance of biotic and abiotic factors in the structuring of fish assemblages in freshwater environments is an important question in ecology, particularly in view of environmental changes caused by man. In this paper we sought to identify the factors responsible for the composition and abundance of fish species collected with gill nets in six locations near ports in forest clearance areas opened up for oil and natural gas exploration (Petrobras Pedro Moura Base) in the Urucu River, during drought and flood cycles. In all, 923 individuals from 23 families and 82 species were collected, totalling a biomass of 182,244 g. The most abundant species during the flood season were *Bryconops alburnoides* (Kner, 1858) and *Dianema urostriatum* (Miranda Ribeiro, 1912); in the drought season, the predominant species were *Osteoglossum bicirrhosum* (Cuvier, 1829) and *Serrasalmus rhombeus* (Linnaeus, 1766). The species with the greatest biomass during the flood season were *Pellona castelnaeana* (Valenciennes, 1847), *S. rhombeus* and *Pellona flavipinis* (Valenciennes, 1847). During the drought season, the predominant species was *O. bicirrhosum*. When both periods were analysed together, electrical conductivity, water transparency and dissolved oxygen were the most important factors. The species *Hemisorubim platyrhynchos* (Valenciennes, 1840), *O. bicirrhosum*, *Chaetobranchus flavenscens* Heckel, 1840, *Geophagus proximus* (Castelnau, 1855) were strongly related to high values of conductivity, pH and water current velocity during the drought season, as well as *Serrasalmus altispinis* Merckx, Jégu & Santos, 2000, *Triportheus albus* Cope, 1872, *Triportheus angulatus* (Spix & Agassiz, 1829) and *Brycon melanopterus* (Cope, 1872) that were associated with less depth and width in the drought season whereas *P. castelnaeana*, *D. urostriatum*, *Rhytiodus argenteofuscus* Kner, 1858 and *Sorubim lima* (Bloch & Schneider, 1801) were mainly associated with high transparency and dissolved oxygen during the flood season.

KEY WORDS. Abiotic; floodplain; biological organization; hydrocarbons.

Elucidation of the processes that determine the composition and structure of natural communities and the prevalence of abiotic or biotic factors in these processes remains an important challenge in ecology (Chesson & Huntly 1997, Jackson et al. 2001). While some studies carried out in tropical rivers have identified non-random assemblage patterns that could be associated with abiotic factors (Rodrígues & Lewis 1997), others have shown the influence of biotic interactions, such as predation and competition, on assemblage structure (Freitas et al. 2010). In large tropical rivers, the importance of abiotic and biotic factors can vary depending on the scale considered (Freitas et al. 2013) and the period of the hydrological cycle (Winemiller 1989).

Aquatic ecosystems throughout the world are facing continuous threats from human activities. The resulting changes they suffer exert a detrimental influence on aquatic communities (Dudgeon et al. 2006) and may be responsible for the extinction of numerous species. According to Agostinho et al. (2005), the main causes of fish biodiversity loss in aquatic ecosystems can be grouped into five major categories: (1) competition for water and subsequent water abstraction; (2) habitat alteration; (3) pollution from different sources (heavy metals, pesticides and domestic and industrial wastewater); (4) the introduction of exotic species; and (5) commercial exploitation. Changes in the species richness and composition of fish communities in rivers with different levels of environmental impact can be determined in many ways. Fish community attributes (e.g., species richness and diversity) provide basic information about qualitative changes (Magurran 2003), but emergent attributes (structure, composition and organization) allow the effects of environmental changes on communities to be better assessed (Karr 1981).

The Amazon River basin harbours the world's greatest diversity of freshwater fish (Freitas et al. 2010). To date, most studies of the diversity of Amazonian fish have been concentrated in the floodplains adjacent to large rivers (Crampton 1999, Freitas & Garcez 2004, Siqueira-Souza & Freitas 2004), and there are few reports on the ichthyofauna of the middle and upper courses of tributaries of the Amazon River (Silvano et al. 2000).

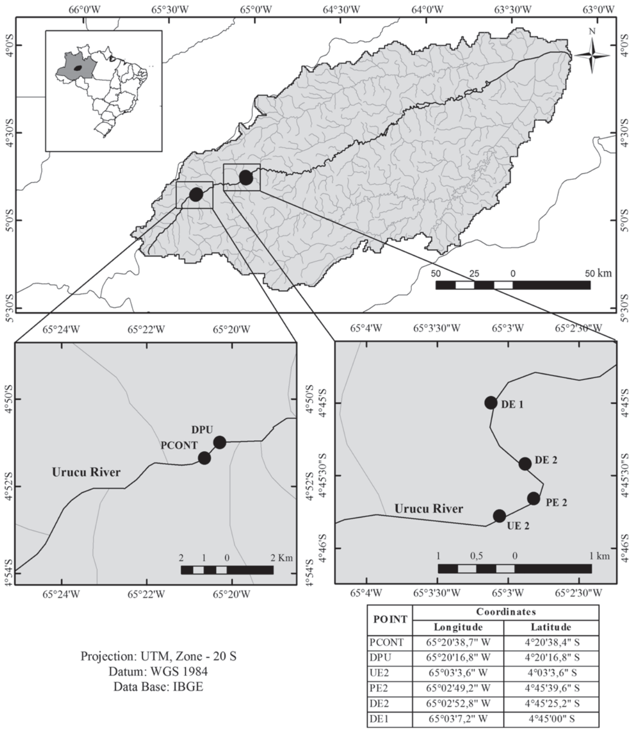
An oil and natural gas production facility was built on the upper stretch of the Urucu River, a tributary of the right bank of the Solimões River, in 1988, and a pipeline that crosses the forest in parallel with the Urucu River has connected the facility with a harbor in the Solimões River since the end of the 1980s. Taking into account the scarce information about fish fauna in the upper stretches of tributaries of the Amazonas River, and the complete inexistence of data from the Amazonian fish assemblages inhabiting the water bodies surrounding the oil and natural gas plant, we tested the hypothesis that the structure of fish assemblages differ among the studied periods due to the change of limnological variables from port activities over a stretch of that watershed.

This study evaluated the influence of environmental variables on the structure of fish assemblages in a stretch of the Urucu River during the drought and flood seasons and could constitute a baseline to identify changes due environmental pressures mediated by the oil and gas exploration plant.

MATERIAL AND METHODS

The study was conducted in the Urucu River, near the Evandro 1, Evandro 2, and Urucu harbors, which supply the Petrobras Pedro Moura Oil and Gas Exploration Base. The area is located in the municipality of Coari, in the state of Amazonas. The Urucu River (04°53'S,65°11'W) is a right-bank tributary of the Solimões River and one of the main tributaries of the Coari Lake. The water in the river is classified as black. However, during the flood season, it is almost white and is referred to locally as 'toldada'. The region is flat with gently rolling hills and acidic soil, and the climate is classified as tropical, with virtually no winter. Although rainfall is distributed throughout the year, the months of January to April and July to September have higher and lower rainfall, respectively.

Fish collections in the Urucu River were performed in April and August 2008, during the flood and drought season, respectively. The collection points, in a longitudinal (upstream-downstream) sequence, were: a control point (PCONT) (4°51'20.7"S, 65°20'53.2"W) located upstream of the three ports; a point downstream of Urucu port (DPU) (4°50'59.3"S, 65°20'37.4"W) located 500m from the port; a point opposite Evandro 2 port (PE2) (4°45'47.9"S, 65°02'46.6"W); a point upstream of Evandro 2 port (UE2) (4°45'42"S, 65°02'37.4"W); a point downstream of this same port (DE2) (4°45'26.4"S, 65°02'38.7"W); and a point downstream of Evandro 1 port (DE1) (4°45'02.2"S, 65°02'42.6"W) (Fig. 1). With the exception of DPU, all collection points were located 1 km upstream or downstream of their respective ports (Fig. 1). Eight sets of standardized 2 x 20 m fishing nets with mesh sizes varying from 30 to 100 mm (between opposite knots) were used. Sampling effort was standardized and collections were carried out for 13 hours continuously at each sampling point from 6:00 am to 7:00 pm. Fish were screened and identified according to Nelson (2006) and Ferreira et al. (1998) and by experts from the National Amazonian Research Institute (INPA). The biomass in grams of each species was calculated using a 0.01 g accuracy digital scale. All the fish were sorted, identified and fixed in 10% formalin and preserved in 70% ethanol. Some of the specimens were deposited in the ichthyological collection at the INPA (Vouchers: INPA-32193, INPA-32201, INPA-32186, INPA-32187, INPA-32188, INPA-32184, INPA-32190, INPA-32194, INPA-32195, INPA-32197, INPA-32199, INPA-32183, INPA-32178, 32200-INPA and INPA-32175).



Projection: UTM, Zone - 20 S
Datum: WGS 1984
Data Base: IBGE

POINT	Coordinates	
	Longitude	Latitude
PCONT	65°20'38,7" W	4°20'38,4" S
DPU	65°20'16,8" W	4°20'16,8" S
UE2	65°03'3,6" W	4°03'3,6" S
PE2	65°02'49,2" W	4°45'39,6" S
DE2	65°02'52,8" W	4°45'25,2" S
DE1	65°03'7,2" W	4°45'00" S

Figure 1. Study area showing the sampling areas and sampling points.

The following limnological variables were measured at the subsurface at each sampling point with a DIGIMED DM4P digital potentiometer: temperature (°C), electrical conductivity (µS/cm), pH and dissolved oxygen (mgO$_2$/L). The following measurements were also taken: river depth (m), with the aid of a weighted tape measure; water transparency (cm), with a Secchi disk; and river width (m), with a GPS. Water current velocity was measured at each sampling point with a General Oceanics 2030R mechanical flow meter with a 6-digit odometer-style counter and minimum velocity reading of 10 cm/s.

As aliphatic hydrocarbons (AHCs) are potential contaminants from oil and natural gas plants, the concentration and source (petrogenic or biogenic) of these pollutants in open water was determined using a specific technique for aliphatic hydrocarbons (n-alkanes from n-C_{12} to n-C_{40} and the two isoprenoids pristane and phytane). One liter of water was collected from each sampling point, and extraction was carried out by mechanical agitation using a funnel with dichloromethane. The extract was then cleaned up and fractionated using liquid chromatography and hexane as the mobile phase. Aliphatic hydrocarbon content was determined by gas chromatography with flame ionization detection (GC-FID). An internal/recovery standard was added before the samples were extracted to check the efficiency of the methodologies used – modified from EPA 8270 (1986).

The Shapiro-Wilks and Levene tests were used with the limnological variables to test for normality and homogeneity of variance, respectively, to determine whether parametric test t or non-parametric Mann-Whitney U test could be appropriate to compare the seasonal measures. To identify differences in fish fauna between periods of drought and flood, the analysis of similarities (ANOSIM) proposed by Clarke & Green (1988) was used for numerical abundance and biomass data. We used the Morisita-Horn index (Magurran 2003) as a quantitative similarity measure, as this is almost independent of sample size and species richness (Wolda 1981). Canonical correlation analysis (CCA) was used with species with abundance greater than three individuals to quantify the influence of environmental variables on the distribution of fish species in periods of drought and flood. The Monte Carlo test was also performed (5.999 permutations) to determine the significance of each environmental variable. The data were previously log-transformed (log x + 1). CCA and ANOSIM were performed with PAST 2.17 software (Hammer et al. 2001). Inferential analyses were considered significant when $p \leq 0.05$.

RESULTS

Temperature (U = 19.0; p = 0.48), transparency (U = 11.5; p = 0.09), dissolved oxygen (t = 1.77; p = 0.10), water current velocity (U = 17.5; p = 0.37), river width (t = 1.27; p = 0.22) and concentrations of aliphatic hydrocarbons (U = 21.0; p = 0.65) did not vary between the hydrological seasons. Conductivity was higher during the drought season (U = 0.001, p = 0.001) than during the flood season, and pH (t = -5.98, p = 0.0006) and river depth (t = 4.16, p = 0.001) were lower in the drought season than in the flood season (Table 1). Aliphatic hydrocarbon levels did not indicate contamination from petrogenic sources. The n-alkanes with the highest concentration [n-C_{29} (drought) and n-C_{31} (flood)] originated from the combustion of plant material.

The fish collections comprised 923 individuals distributed in 7 orders, 23 families and 82 species. Characiformes were the dominant group (61%), followed by Siluriformes (20%), while the orders Clupeiformes, Osteoglossiformes, Perciformes, Beloniformes and Pleuronectiformes accounted for less than 10% of the total captured. The most abundant species during the flood season were *Bryconops alburnoides* (Kner, 1858) (n = 64, 13%) and *Dianema urostriatum* (Miranda Ribeiro, 1912) (n = 63, 13%); in the drought season, the predominant species were *Osteoglossum bicirrhosum* (Cuvier, 1829) (n = 55, 12%) and *Serrasalmus rhombeus* (Linnaeus, 1766) (n = 44, 9%). The biomass in the flood season was 76,100g and in the drought season, 106,144g, totalling 182,244 g. The species with the greatest biomass during the flood season were *Pellona castelnaeana* (Valenciennes, 1847) (14,235 g, 20%), *Serrasalmus rhombeus* (11,680 g, 16%), *Pellona flavipinnis* (Valenciennes, 1836) (73,55 g, 10%) and *Calophysus macropterus* (Lichtenstein, 1819) (7,230 g, 10%). During the drought season, the predominant species was *Osteoglossum bicirrhosum* (45,506 g, 47%) (Appendix 1).

Table 1. Limnological data analyzed at collection points in the Urucu River in the flood and (drought) seasons. (T) Temperature, (Trans.) transparency, (CD) conductivity, (pH) Hydrogen potential, (O_2) dissolved oxygen, (Vel.) water current velocity, (Wid) width of the river, (Dpt) depth, (CAH) concentrations of Aliphatic hydrocarbons, (A) average collection points, (SD) standard deviation, (*) p < 0.05.

Limnological variables	Collection points						A	SD
	PCONT	DPU	UE2	PE2	DE2	DE1		
T (C°)	26.4(26.5)	25.9(25)	25(26.6)	25(25)	26(25)	26(25)	25.7(25.4)	0.5(0.7)
Trans (cm)	77(65)	72(53)	83(54)	78(54)	75(72)	83(84)	78.5(65.8)	4.2(12.8)
CD (µScm^{-1})*	8.4(34.7)	8.4(34.6)	9.5(35.2)	9.3(35.2)	9.6(34.6)	9.6(34.8)	9.1(34.8)	0.5(0.2)
pH*	5.7(6.2)	5.3(6.2)	5.9(6.4)	6.0(6.5)	5.8(6.3)	5.9(6.4)	5.7(6.3)	0.2(0.1)
O_2 (mgO_2/L)	5.8(6.1)	6.0(6.7)	5.8(5.4)	5.4(4.5)	6.0(4.3)	5.8(3.5)	5.7(5)	0.2(1.1)
Vel (m/s)	0.3(0.5)	0.3(0.5)	0.3(0.2)	0.3(0.5)	0.3(0.5)	0.3(0.2)	0.3(0.4)	0(0.1)
Wid (m)	20(15)	25(26)	62(35)	50(44)	50(42)	75(38)	48.8(34.7)	19.4(10.6)
Dpt (m)*	5.1(1)	5.9(1)	8.6(4.3)	7.5(2)	11.2(7.7)	8.5(2.9)	7.7(3)	1.9(2.3)
CHA (µg L^{-1})	0.1(2.9)	1.4(0)	0(0.3)	18.6(0.1)	7.0(0)	0.1(4.1)	3.9(1.1)	6.95(1.7)

ANOSIM based on biomass did not show significant differences between flood and drought seasons (r = 0.15, p = 0.10, 9999 permutations). However, ANOSIM based on abundance revealed a greater variation in this parameter in the drought season than in the flood season (r = 0.22, p = 0.04, 9999 permutations). The first two CCA axes for the flood and drought seasons explained 49.47% of the distribution of species (Fig. 2). CCA 1 explained 30.47% of the variance based on conductivity, transparency, pH, dissolved oxygen and water current velocity; and CCA 2 explained 19.90% of the variance associated with the variables width and depth. The Monte Carlo test indicated that the first two axes derived from the CCA were significant ($p < 0.05$) (Table 2). *Hemisorubim platyrhynchos* (Valenciennes, 1840), *Osteoglossum bicirrhosum*, *Chaetobranchus flavenscens* Heckel, 1840 and *Geophagus proximus* (Castelnau, 1855) were strongly related to high values of conductivity, pH and water current velocity during the drought season, as well as *Serrasalmus altispinis* Merckx, Jégu & Santos, 2000, *Triportheus albus* Cope, 1872, *Triportheus angulatus* (Spix & Agassiz, 1829) and *Brycon melanopterus* (Cope, 1872) that were associated with less depth and width in the drought season, whereas *P. castelnaeana*, *D. urostriatum*, *Rhytiodus argenteofuscus* Kner, 1858 and *Sorubim lima* (Bloch & Schneider, 1801) were mainly associated with high transparency and dissolved oxygen during the flood season (Table 3).

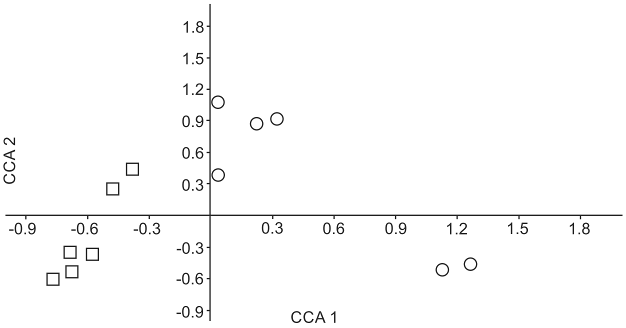


Figure 2. Scores for sampling points on the first two axes of the Canonical Correlation Analysis (CCA) in the drought/flood period: (□) flood period and (○) drought period.

Table 2. Results of the Canonical Correlation Analysis for the occurrence of fish species and key environmental variables in periods of drought and flood in the Urucu River, Municipality of Coari, AM, Brazil.

Environmental variables	Drought/Flood	
	CCA1	CCA2
Temperature (C°)	-0.37	0.27
Transparency (cm)	-0.52	-0.26
Electrical conductivity (μScm^{-1})	0.82	0.44
pH	0.75	0.12
Dissolved oxygen (mgO$_2$/L)	-0.59	0.05
Water velocity (m/s)	0.51	-0.05
River width (m)	-0.12	-0.81
Depth (m)	-0.52	-0.73
Concentration of hydrocarbons (μg L^{-1})	-0.39	-0.06
% Explained variance	30.47	19.90
% Accumulated variance	39.47	49.47
Monte Carlo simulation (5999 permutations) – p	0.01	0.00

DISCUSSION

Several studies have shown that the composition, structure and diversity of fish assemblages in flooded areas are correlated with abiotic factors such as dissolved oxygen (Saint-Paul & Soares 1987), temperature, pH, conductivity and habitat complexity; geomorphological features such as depth (Stewart et al. 2002, Freitas et al. 2013), transparency (Rodrígues & Lewis 1997, Súarez et al. 2001), lake area (Súarez et al. 2001), connectivity and distance between water bodies (Freitas & Garcez 2004); and biotic factors such as predation and competition (Saint-Paul et al. 2000).

Predictably, changes in fish community structure associated with flood and drought events are related to variations in transparency and depth, which are strongly correlated variables, primarily because of the increase in turbidity resulting from the resuspension of sediment from the river bottom to the water column (Hamilton & Lewis 1990). Water transparency, a variable that governs the visibility of the water column, determines the dominance of a large number of taxa and types of piscivorous animals in lakes during the drought season (Rodríguez & Lewis 1997). In general, Characiformes and cichlids use visual orientation towards the daylight: they have large eyes and live in well-lit places such as surface waters (Lowe-McConnell 1999). Similarly, Clupeiformes reduce their dependence on the optical system in the water column by adapting to life on the surface, which they do by taking advantage of a number of body features, such as silvery scales, a laterally compressed body, upturned jaws and a flat dorsal profile. In contrast, several species of Siluriformes and Gymnotiformes have nocturnal habits, as well as sensorial adaptations to low light (Lowe-McConnell 1999), and are found predominantly in turbid waters.

The association of *H. platyrhynchos* with conductivity during the drought season is explained by the increase in ion concentration during this period. This is due to the high turbidity (low light intensity) in the water column caused by the decrease in the volume of water (Esteves 1998). Siluriformes have sensory adaptations to low light levels and are found predominantly in turbid waters (Lowe-McConnell 1999), while species such as *O. bicirrhosum*, *C. flavenscens* and *G. proximus* are more related to water current velocity. Kikuchi & Uieda (1998) observed that the highest rates of water current velocity are found in the flood season, and the lowest during the drought.

Table 3. Scores on axis 1 and axis 2 based on the matrix of species assemblage composition and the matrix of habitat variables in periods of drought and flood in the Urucu River, Municipality of Coari, AM, Brazil.

Species	CCA 1	CCA 2
Pellona castelnaeana (Valenciennes, 1847)	-1.344080	-1.411710
Dianema urostriatum (Miranda Ribeiro, 1912)	-1.256870	-1.349400
Rhytiodus argenteofuscus kner, 1858	-1.250630	-1.057100
Sorubim lima (Bloch & Schneider, 1801)	-1.187530	-0.727260
Pristobrycon striolatus (Steindachner, 1908)	-1.176140	-0.413100
Raphiodon vulpinus Spix & Agassiz, 1829	-1.168580	-0.509860
Lycengraulis batesii (Günther, 1868)	-1.162720	-1.060510
Hypoptopoma cf. *gulare* Cope, 1878	-1.140400	-0.887850
Cynodon gibbus Spix & Agassiz, 1829	-1.105250	-0.003700
Pinirapus pirinanpus (Spix & Agasiz, 1829)	-1.072580	-0.029480
Pygocentrus nattereri Kner, 1858	-0.909090	-0.273610
Pellona flavipinnis (Valenciennes, 1836)	-0.898830	0.036199
Bryconops alburnoides (Kner, 1858)	-0.770940	-0.943670
Brycon cf. *pesu* Müller Troschel, 1845	-0.631250	0.951399
Serrasalmus rhombeus (Linnaeus, 1766)	-0.459250	0.409816
Hemiodus semitaeniatus (Kner, 1858)	-0.421950	0.394312
Myleus rubrypinnis (Müller & SchomburgK, 1841)	-0.404910	1.042980
Moenkhausia lepidura (Kner, 1858)	-0.331460	1.575480
Leporinus agassizi Steindacherner, 1876	-0.226540	0.894908
Calophysus macropterus (Lichtenstein, 1819)	-0.101490	-0.279850
Plasgioscion squamosissimus (Heckel, 1840)	-0.052310	0.363431
Pimelodus blochii (Valenciennes, 1840)	-0.049800	0.542570
Chalceus erythrurus (Cope, 1870)	0.047424	1.774320
Rineloricaria sp.	0.159718	1.669650
Agoniates halecinus (Müller & Troschel, 1845)	0.292889	-0.682450
Brycon melanopterus (Cope, 1872)	0.315085	2.866150
Serrasalmus altispinis Merckx, Jégu & Santos, 2000	0.376206	3.238450
Triportheus albus Cope, 1872	0.502797	2.690570
Triportheus angulatus (Spix & Agassiz, 1829)	0.595742	2.746460
Hemiodus unimaculatus (Bloch, 1794)	0.622580	-0.878750
Caenotropus labyrinthicus (Kner, 1858)	0.632348	0.648210
Boulengerella maculata (Valenciennes, 1850)	1.025970	-0.335890
Curimata inornata Vari, 1989	1.238580	0.507683
Curimata vittata (Kner,1858)	1.238580	0.507683
Cichla sp.	1.420020	-0.000190
Acestrhorhynchus falcirostris (Cuvier, 1819)	1.516500	-0.199120
Hoplias malabaricus (Bloch, 1794)	1.594580	-0.406270
Geophagus proximus (Castelnau, 1855)	1.905290	-0.727420
Chaetobranchus flavenscens Heckel, 1840	1.987890	-0.658540
Osteoglossum bicirrhosum (Cuvier,1829)	2.420040	-1.484380
Hemisorubim platyrhynchos (Valenciennes, 1840)	2.444300	-1.470070

Thus, we infer that the association of these species with water current velocity is a consequence of their sedentary habits, as the various collection points analyzed are transformed into large backwater areas during the drought season.

Clupeiformes, such as *Pellona flavipinis* (Valenciennes, 1847), are morphologically specialized for foraging near the surface (Goulding 1980). The distribution of species associated with transparency can be interpreted based on the following evolutionary adaptations: (1) extremely good visual orientation in non-piscivorous species in environments with low transparency, specifically at the surface of the water column because of the higher luminosity. *Dianema urostriatum*, one insectivorous species (Reis 2003), can be resident on this floodplain, colonizing the flooded forest adjacent during flood season.

The association of *T. albus* and *T. angulatus* with less depth and width during the drought season could be related to the seasonal feeding patterns of these species. *Triportheus angulatus* remains into the lakes during flood period. However, when the water level is reducing, almost adults start coming out of the lake before the total isolation, performing lateral migration out of the floodplain (Yamamoto et al. 2004) resulting that the highest abundance occurs during receding waters and drought period (Soares & Junk 2000). According to Yamamoto et al. (2004) in the drought season there is a clear reduction in the availability of food, insects and plant material being the most consumed by the species thus *T. angulatus* eat such food items that are more available in this lean period (Yamamoto et al. 2004). As well as the species of *Triportheus*, *B. melanopterus* presents omnivorous habit (Santos et al. 2006), demonstrating a considerable range of food items consumed by the group, which involves consumption this from plant debris, terrestrial and aquatic insects to fish and small vertebrates (Albrecht et al. 2009). The Piranha *S. altispinis*, like most members of this group, consumes fish however fruits, seeds and invertebrates are part of the diet of constant or occasional basis (Santos et al. 2006). According to Yamamoto et al. (2004) that the environmental seasonality controlled by the variation in water level may alter the richness and the abundance of resources in the environment, influencing the food intake and dietary composition of predator fish. During the flood, the rising river level increases the abundance of food derived from the more different sources, providing better conditions for the fish to feed abundantly. In the dry season, the decrease in the water level leads to a scarcity of food (Resende et al. 1996). For carnivorous/piscivorous fishes this pattern may be inverted: during the flood stage, fodder fish species disperse over the floodplain in search of different food sources and shelter, which decreases their accessibility to predators. During the dry season, prey concentrate in the restricted water bodies and become more available to potential predators, thus increasing not only the diversity, but also the abundance of these items (Ferreira et al. 2014).

It is of critical importance to understand the mechanisms that regulate the structure of fish assemblages, not only to acquire basic information, but also to anticipate the effect of environmental changes on the integrity of communities. As well as many studies in the Neotropics (e.g., Junk et al. 1983, Saint-Paul & Soares 1987, Rodrígues & Lewis 1997, Tejerina-Garro et al. 1998, Saint-Paul et al. 2000, Súarez et al. 2001, Hoeinghaus et al. 2003, Siqueira-Souza & Freitas 2004, Súarez et al. 2004, 2011, Freitas & Garcez 2004, Freitas et al. 2013), our results suggest that fish assemblages are influenced by seasonal variations and are ruled by the flood pulse, which causes changes in transparency, depth, water current velocity and dissolved oxygen. Although not detected evidence of environment changes associated to the activities of oil extraction, this study represents a baseline for future studies associated with evaluation of eventual or cronic environmental impacts in the area.

ACKNOWLEDGMENTS

We wish to thank the National Institute for Amazonian Research and in particular J. Zuanon and H.M. Espírito-Santo for their help with the identification of the taxonomic material. T.C. Oliveira for guidance and support in the chemical analysis of the water.

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Appendix 1. Numerical abundance and biomass data of the species collected during the flood and (drought) seasons in the Urucu River, Municipality of Coari – AM/Brazil.

Taxa	Abundance	Biomass (g)
Osteoglossiformes		
Osteoglossidae		
Osteoglossum bicirrhosum (Cuvier,1829)	0(55)	0(45506)
Clupeiformes		
Pristigasteridae		
Pellona castelnaeana (Valenciennes, 1847)	32(0)	14235(0)
Pellona flavipinnis (Valenciennes, 1836)	22(4)	7355(1985)
Engraulidade		
Lycengraulis batesii (Günther, 1868)	7(1)	385(25)
Beloniformes		
Belonidae		
Potamorrhaphis guianensis (Jardine, 1843)	1(0)	40(0)
Characiformes		
Acestrorhynchidae		
Acestrhorhynchus falcirostris (Cuvier, 1819)	1(28)	0(4289)
Acestrorhynchus falcatus (Bloch, 1794)	3(0)	700(0)
Acestrorhynchus microlepis (Schomburgk, 1841)	1(0)	115(0)

Continues

Appendix 1. Continued

Taxa	Abundance	Biomass (g)
Agoniatidae		
Agoniates halecinus (Müller & Troschel, 1845)	11(14)	510(505)
Anostomidae		
Abramites hypselonotus (Günther, 1868)	0(2)	0(75)
Leporinus agassizi Steindacherner, 1876	14(16)	5300(5920)
Leporinus fasciatum (Bloch, 1794)	3(2)	810(270)
Schizodon fasciatus Spix & Agassiz, 1829	0(1)	0(585
Rhytiodus argenteofuscus Kner, 1858	3(0)	710(0)
Characidae		
Brycon cf. *pesu* Müller Troschel, 1845	16(6)	1210(55)
Brycon melanopterus (Cope, 1872)	0(4)	0(800)
Bryconops alburnoides (Kner, 1858)	64(5)	2195(145)
Bryconops caudomaculatos (Günther, 1864)	8(1)	235(45)
Chalceus erythrurus (Cope, 1870)	2(19)	145(1370)
Moenkhausia lepidura (Kner, 1858)	14(5)	245(180)
Myleus rubrypinnis (Müller & SchomburgK, 1841)	4(5)	1045(465)
Myleus sp.	1(0)	135(0)
Mylesinus schomburgkii Valenciennes, 1850	1(0)	745(0)
Poptella brevispina Reis, 1989	1(0)	35(0)
Pristobrycon striolatus (Steindachner, 1908)	6(0)	935(0)
Pygocentrus nattereri Kner, 1858	12(5)	1830(1330)
Serrasalmus altispinis Merckx, Jégu & Santos, 2000	0(2)	0(320)
Serrasalmus sp.	0(6)	0(7775)
Serrasalmus rhombeus (Linnaeus, 1766)	54(44)	11680(245)
Tetragonopterus chalceus Spix & Agassiz, 1829	1(0)	90(0)
Triportheus albus Cope, 1872	16(6)	570(645)
Triportheus angulatus (Spix & Agassiz, 1829)	0(7)	0(678)
Triportheus elongatus (Günther, 1864)	1(0)	150(0)
Chilodontidae		
Caenotropus labyrinthicus (Kner, 1858)	2(9)	240(80)
Ctenoluciidae		
Boulengerella cuvieri (Agassiz, 1829)	2(0)	630(0)
Boulengerella maculata (Valenciennes, 1850)	3(22)	410(3729)
Curimatidae		
Curimata cf. *cisandina* (Allen, 1942)	1(0)	95(0)
Curimata inornata Vari, 1989	0(33)	0(2195)
Curimata vittata (Kner,1858)	1(3)	135(200)
Cyphocharax notatus (Steindachner, 1908)	0(2)	0(70)
Psectrogaster amazonica Eigenmann & Eigenmann, 1889	1(0)	150(0)
Psectrogaster rutiloides (Kner, 1858)	4(0)	590(0)
Steindachnerina bimaculata (Steindachner, 1876)	0(1)	0(95)
Cynodontidae		
Cynodon gibbus Spix & Agassiz, 1829	3(0)	260(0)
Raphiodon vulpinus Spix & Agassiz, 1829	5(0)	2440(0)
Erytrinidae		
Hoplias malabaricus (Bloch, 1794)	1(9)	40(400)
Hemiodontidae		
Hemiodus semitaeniatus (Kner, 1858)	2(6)	150(390)
Hemiodus unimaculatus (Bloch, 1794)	7(36)	900(3745)
Anodus orinocensis (Steindachner, 1887)	1(0)	145(0)

Continues

Appendix 1. Continued.

Taxa	Abundance	Biomass (g)
Siluriformes		
Loricariidae		
Ancistrus sp.	0(1)	0(35)
Dekeyseria amazonica (Rapp Py-Daniel, 1985)	1(0)	95(0)
Loricaria cataphracta Linnaeus, 1758	0(1)	0(20)
Rineloricaria sp.	0(4)	0(100)
Sturisoma sp.	0(2)	0(100)
Hypoptopoma cf. *gulare* Cope, 1878	24(1)	170(20)
Auchenipteridae		
Ageneiosus brevifilis (Linnaeus, 1766)	1(0)	375(0)
Ageneiosus gr. *vittatus* (Steindachner, 1908)	1(0)	10(0)
Auchenipterichthys sp.	2(0)	30(0)
Auchenipterus ambyacus (Fowler,1915)	2(0)	70(0)
Auchenipterus nuchalis (Spix & Agassiz, 1829)	2(0)	205(0)
Centromochus heckelli (De Felippi, 1853)	2(0)	35(0)
Parauchenipterus galeatus (Linnaeus, 1758)	5(0)	200(0)
Tatia intermedia (Steindachner, 1877)	2(0)	70(0)
Callichthyidae		
Dianema urostriatum (Miranda Ribeiro, 1912)	63(0)	1030(0)
Pimelodidae		
Calophysus macropterus (Lichtenstein, 1819)	28(15)	7230(325)
Hemisorubim platyrhynchos (Valenciennes, 1840)	0(8)	0(5022)
Hypophtalmus edentatus Spix & Agassiz, 1829	2(0)	533(0)
Hypophtalmus marginatus Valenciennes,1840	2(0)	195(0)
Pimelodus blochii (Valenciennes, 1840)	5(4)	490(285)
Pinirapus pirinanpus (Spix & Agasiz, 1829)	4(0)	1320(0)
Pseudoplatystoma fasciatum (Linnaeus, 1766)	1(0)	1085(0)
Sorubim lima (Bloch & Schneider, 1801)	4(0)	550(0)
Perciformes		
Cichlidae		
Biotodoma cupido (Heckel, 1840)	0(6)	0(155)
Chaetobranchus flavenscens Heckel, 1840	0(7)	0(1580)
Cichla sp.	0(10)	0(1760)
Cichla monoculus (Spix & Agassiz, 1831)	0(2)	1765(225)
Crenicinchla cincta Regan, 1905	1(0)	460(0)
Geophagus proximus (Castelnau, 1855)	0(9)	0(1185)
Satanoperca Jurupari (Heckel, 1840)	0(1)	0(190)
Scianidae		
Plasgioscion squamosissimus (Heckel, 1840)	8(6)	2340(1140)
Pleuronectiformes		
Achiridae		
Hypoclinemus mentalis (Günther, 1862)	0(1)	0(30)

Submitted: 3 December 2014
Received in revised form: 22 June 2015
Accepted: 6 October 2015
Editorial responsibility: Vinicius Abilhoa