

Trophic ecology of the ichthyofauna of a stretch of the Urucu River (Coari, Amazonas, Brazil)

Ecologia trófica da ictiofauna de um trecho do rio Urucu (Coari, Amazonas, Brasil)

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Abstract: Introduction: The floodplains of the large Amazonian rivers are very productive as a result of seasonal fluctuations of water levels. This favors the fishes as they are provided with a wide range of habitats and food resources; **Aim:** In this study, we identified the trophic structure of fish assemblages in the upper river Urucu area (State of Amazonas – Brazil), observing seasonal changes determined by the hydrological cycle; **Methods:** Samples were collected with the aid of gillnets, during the flood season (April/2008) and the dry season (August/2008) in areas upstream and downstream of ports of the Urucu river within the municipality of Coari, Amazonas, Brazil; **Results:** 902 individuals of seven orders, 23 families and 82 species were collected. Fishes were more abundant in the dry season than in the flood season, and the piscivores and carnivores (*Serrasalumus rhombeus* and *Osteoglossum bicirrhosum*) were the most significant trophic categories in the dry season whereas piscivores and insectivores (*Serrasalumus rhombeus*, *Bryconops alburnoides* and *Dianema urostriatum*) were more abundant in the flood season. The trophic diversity, dominance and evenness were very similar in all sampling periods and show lower values than taxonomic index patterns, except for the trophic dominance in the dry season. Taxonomic diversity and dominance were higher in the flood season if compared to the dry season, but figures were quite uniform and there were no great discrepancies between seasons. **Conclusion:** We found through our studies that the dry and flood seasons work as regulatory factors of abundance of fishes of certain trophic categories in the Urucu river, what can be possibly explained by the availability of resources and the food spectrum of each category.

Keywords: feeding habits, Amazon, fish, Urucu river, hydrological cycle.

Resumo: Introdução: As áreas inundáveis dos grandes rios amazônicos são muito produtivas, como resultado das flutuações sazonais no nível da água, favorecendo os peixes que passam a dispor de um amplo espectro de habitats e recursos alimentares; **Objetivos:** Neste estudo, identificamos a estrutura trófica das assembléias de peixes do curso superior do rio Urucu (Amazonas - Brasil), observando mudanças sazonais determinadas pelo ciclo hidrológico; **Métodos:** As coletas foram realizadas com auxílio de baterias de malhadeiras, no período de cheia (abril/2008) e seca (agosto/2008), em áreas a montante e jusante de portos localizados no rio Urucu, no município de Coari, Amazonas, Brasil; **Resultados:** Foram coletados 902 indivíduos compreendidos em sete ordens, 23 famílias e 82 espécies, a abundância de peixes no período da seca foi superior ao período da cheia. Piscívoros, onívoros e carnívoros foram as categorias com abundância mais elevada na seca; sendo essas mesmas categorias, incluso o grupo dos detritívoros, mais abundantes na cheia. *Bryconops alburnoides*, *Dianema urostriatum* e *Serrasalumus rhombeus* foram as mais abundantes no período da cheia e *Osteoglossum bicirrhosum*, *Serrasalumus rhombeus* e no período da seca; **Conclusão:** Constatamos através de nossos estudos a importância dos períodos de seca e cheia como fatores reguladores da abundância de peixes de determinadas categorias tróficas ocorrentes no rio Urucu, que possivelmente podem ser explicadas pela disponibilidade de recursos e espectro alimentar de cada categoria.

Palavras-chave: alimentação, Amazônia, peixes, rio Urucu, ciclo hidrológico.

1. Introduction

The floodplains of the large Amazonian rivers reach an area of about 200,000 km² and are known locally as várzeas and igapós (Junk, 1993). These areas are very productive and, when flooded, they increase the diversity of habitats that are colonized by several species of fishes. The fluctuation of water levels promotes an alternance of terrestrial and aquatic phases that results in drastic changes in environmental conditions, requiring specific adaptations of the ichthyofauna (Junk et al., 1983). During the falling water and dry seasons, the retraction of water limits the space, forcing fishes to migrate from the floodplain to the main channel of rivers or to permanent lakes (Goulding, 1980). During rising water and flood seasons, the expansion of flooded lands favors the exploration of various habitats and broadens the food spectrum of fishes (Claro-Junior et al., 2004). Abelha et al. (2001) describe that changes on fish diet could be ruled by seasonal spatial changes of the environment, taking into account that different places and seasons provide different abiotic conditions and availability of food. Diet, as well as reproduction and morphology, is one major component of fish ecology, and may be an important descriptor of the fish assemblage structure (Pouilly et al., 2006). The trophic structure in many studies on the ecology of fish is conceptually defined as a grouping of species into functional groups according to their feeding habits and/or ichthyotrophic categories (Gasalla and Soares, 2001). Thus, species with the same trophic position can be grouped into trophic guilds (Lake et al., 2001; Post, 2002), what can be defined as a grouping of species that exploit the same class of environmental resource in a similar way, without considering their taxonomic position (Fauth et al., 1996). From the knowledge of the diet of a fish community and its fish abundance it is possible to identify the different trophic categories, to infer the structure, evaluate the degree of importance of different trophic levels and understand the interrelationships among the components of that community (Agostinho et al., 1997) thus creating a base for a better understanding of the relationships between these components of the ichthyofauna and between these and other organisms of the aquatic community. Knowledge of food sources used by the fishes can provide data on the habitat, food availability in the environment and even on some aspects of behavior (Hahn et al., 1997). Thus, the objective of this work is to characterize the temporal trophic structure of fish species of a stretch of the Urucu River.

2. Material and Methods

This study was conducted in a stretch of the Urucu River, within the municipality of Coari, State of Amazonas (600 km west of Manaus, Brazil). The Urucu River (04° 53' S and 65° 11' W) is a tributary of the right bank of the Solimões River and one of the main tributaries of Lake Coari (Santos Junior, 2003). The region presents flat or mildly hilly relief, with acid soil (Vieira and Santos, 1987), presents lowland dense ombrophilous forest vegetation with a closed canopy, and is classified as a dense tropical region in the low plateaus sub-region of the Amazon (DNPM, 1978). Since the late 1980s oil and gas have been explored in the Urucu River basin and the sampling points are located near supply ports of oil and gas production facilities. The six sampling sites were located 1 km upstream and downstream of each port, and were all within a 94.5 km segment of the river. Fishes were collected during the flood season (April/2008) and dry season (August/2008) in the surroundings of Evandro 1, Evandro 2 and Evandro ports at the following points: control point (PCONT) (4° 51' 20,7" S and 65° 20' 53,2" W) located upstream of all ports; a point downstream of Port Urucu (PJU) (4° 50' 59,3" S and 65° 20' 37,4" W); a point just in front of Port Evandro 2 (PPE2) (4° 45' 47,9" S and 65° 02' 46,6" W); a point upstream of Port Evandro 2 (PME2) (4° 45' 42" S and 65° 20' 37,4" W) and a point downstream of the same port (PJE2) (4° 45' 26,4" S and 65° 02' 38,7" W) and a point downstream of Port Evandro 1 (PJE1) (4° 45' 02,2" S and 65° 02' 42,6" W) (Figure 1).

The sampling sites selected for this study were chosen near the docking ports of vessels, owing to the fact that the data for this study came from a larger study that aimed to examine the structure of fish assemblages which revealed, according to Costa (2009), that the assemblages studied in this stretch of river in both periods of the hydrological cycle were not modified as a result of port activities. To minimize the effects of selectivity, gillnets with different mesh sizes were used, organized in groups of eight nets with mesh sizes of 30, 40, 50, 60, 70, 80, 90 e 100mm between adjacent knots, each net with a standard size of 20m in length and 2m height. Overall, gillnets were set out between 06:00 PM and 12:00 AM, aiming to encompass one of the periods of maximum activity for fish (dawn and dusk), and the nets were checked each four hours. The fishes were sorted, identified as according to Nelson (1994), Ferreira et al. (1998) and by experts and fixed in 10% formalin and

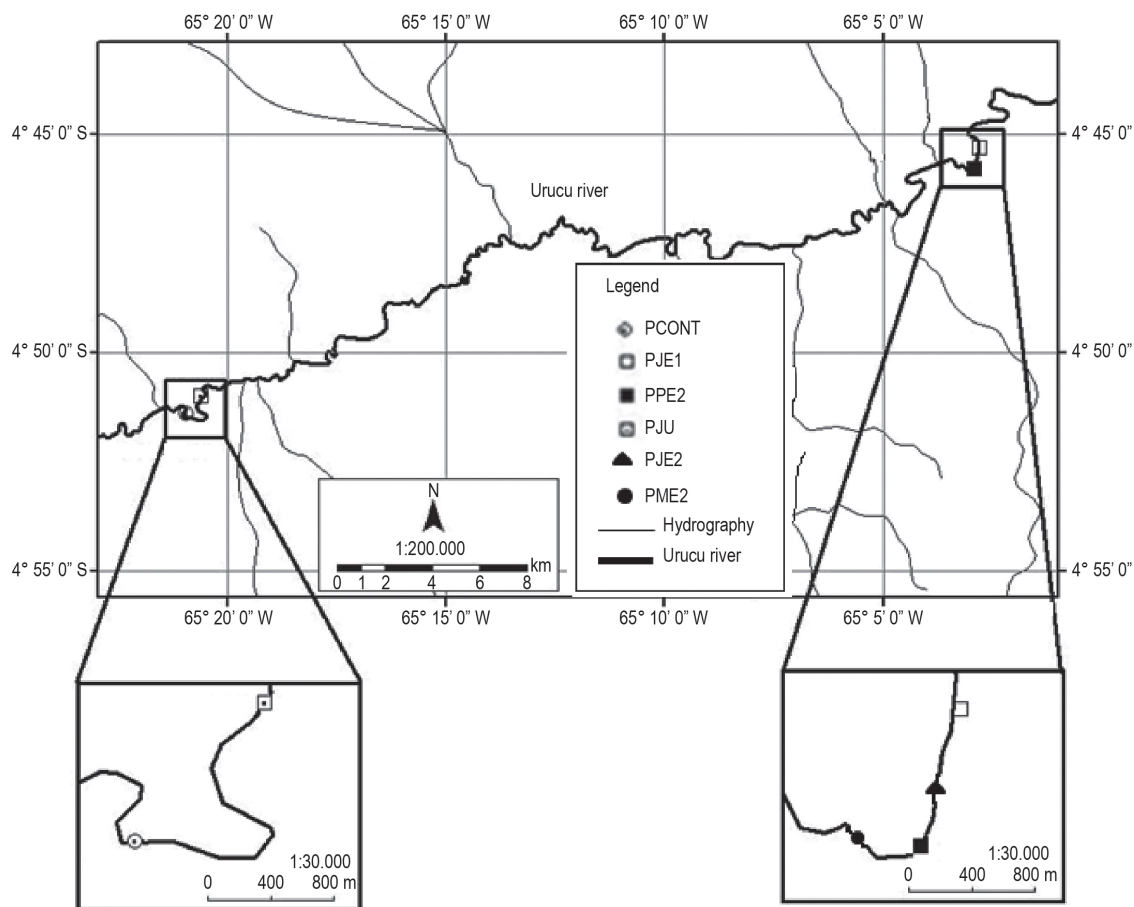


Figure 1. Study area with indication of the sampling points.

preserved in 70% ethanol, and some specimens were stored in the ichthyologic collection of INPA (asset registration numbers: 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, INPA-32200, INPA-32175). As an exploratory analysis, we conducted a Nonmetric Multidimensional Scaling (NMDS) with numerical abundance and biomass data of each trophic category according to the seasons (dry vs. flood season) in order to reduce the data dimensionality of the fish assemblage. The dissimilarity matrix used in this ordination was constructed using the Bray-Curtis index. In order to verify the differences between dry and flood periods, we applied the Bifactor Analysis of Similarity (ANOSIM) proposed by Clarke and Green (1988) with data on numerical and biomass abundance. We used the quantitative similarity measure with the Morisita-Horn index (Magurran, 1988), recommended for being almost independent of sample size and species richness (Wolda, 1981). The

data was previously log-transformed ($\log x + 1$). To analyze the taxonomic structure of the assemblages in each period, the Alpha diversity was calculated by the Shannon-Wiener index, evenness by the Pielou index (e) (Ludwig and Reynolds, 1988) and to measure the overall species dominance we used the Berger-Parker index (d) (Magurran, 2004). The same indexes mentioned above were also calculated based on the number of trophic categories (richness categories) and number of individuals (abundance) belonging to each category for the sampling periods. Evisceration and analysis of stomach contents were not performed. The trophic categorization of the sampled species was described through the use of bibliographical references, and these were classified and described as detritivores, herbivores (more than 60% of the diet consists of Phanerogam plant structures); omnivores (when no feature of animal or vegetable origin alone reaches more than 60% of the diet), insectivores (over 60% of the diet consists of aquatic and terrestrial insects); invertivores (more than 60% of the diet is generally comprised of invertebrates, including insects, but

with no preference for the latter), carnivores (over 60% of the diet comprises various types of animal resources, such as vertebrates and invertebrates), piscivores (more than 60% of the diet is composed by fish, fish larvae or fins and scales) (Röpke, 2008), iliophagous (ingest silt or sand substrate looking for food of animal, plant or detritus origins) planktivores (predominantly feed on plankton) (Zavala-Camin, 1996). NMDS and ANOSIM were carried out with the help of the PAST 2.17 software. Inferential analyses were considered significant at $p \leq 0.05$. In order to better understand the state of those environments, we describe in Table 1 the physical conditions of each sampling point in the Urucu River. Environmental conditions at each sampling point were evaluated according to visual observation of the area; depth (m) with the aid of a measuring tape with a weight; transparency (cm) with a Secchi disk; width (m) of the river with the aid of a GPS; and water flow velocity with a model 2030 R mechanical flow meter that has a 6 digit odometer style counter and can indicate a minimum velocity of 10 cm/s.

3. Results

We collected 902 individuals distributed in seven orders, 23 families and 82 species making up a total biomass of 166.819 g. The species *Bryconops alburnoides* (Kner, 1858), *Dianema urostriatum* (Miranda Ribeiro, 1912) and *Serrasalumus rhombeus* (Linnaeus, 1766) were the most abundant during the flood season and *Osteoglossum bicirrhosum*

(Cuvier, 1829), *Serrasalumus rhombeus* (Linnaeus, 1766) in the dry season (Table 2).

The NMDS of samples based on abundance and biomass indicates a separation between the dry and flood seasons on axes 1 and 2, retained for interpretation ($Stress_{Abundance} = 0.2$; $Stress_{Biomass} = 0.2$) (Figures 2 and 3).

Analysis of Similarity (ANOSIM) performed for the periods of the hydrological cycle with numerical abundance and biomass data showed no significant difference between the dry and the flood seasons based on biomass ($r = 0.15$, $p = 0.10$; 9999 permutations). The dry season showed a greater variation in numerical abundance when compared to the flood season, and the two seasons differed significantly in terms of trophic composition ($r = 0.22$, $p = 0.04$, 9999 permutations) (Figure 4), mainly showing a greater abundance of piscivores ($n = 149$, 34%) and carnivores ($n = 94$, 21%).

A total of eight trophic categories were identified in both seasons. For the dry season the group of piscivores and carnivores were the most significant in abundance ($n = 243$; 55%) and biomass ($B = 84.066$ g; 78%). During the flood season these categories were also the ones that showed higher biomass ($B = 56.897$ g; 71%). Piscivores ($n = 160$; 34%) and insectivores ($n = 147$; 31%) were the categories with the highest number of individuals during the flood season. Piscivores showed higher abundance ($n = 160$, 34%) and biomass ($B = 38.430$ g; 51%) during the flood season if compared to the dry season ($n = 149$, 33%,

Table 1. Description of the conditions of each sampling point in the Urucu River, Coari municipality – AM/Brazil.

Points	Description
PCONT	Very steep river banks, narrow river, absence of rapids and macrophytes, river containing fairly closed canopy trees, absence of "igapós", local banks preserved (no fallen trees owing to the action of rafts or ferries), absence of ferry traffic, absence oil in the water. Transparency = 65cm, water flow velocity = 0.33 ± 0.50 m/s, river width = 14m and depth = 1.15 m.
PJU	Steep river banks with small portions of "igapós", absence of rapids and macrophytes, local banks showing fallen trees owing to the action of rafts or ferries, occurrence of ferry traffic, absence of oil in water; transparency = 53cm; water flow velocity = 0.33 ± 0.50 m/s; river width = 26.3m; river depth = 1.20m.
PME2	Steep river banks, "igapós" present, absence of rapids and macrophytes, local banks preserved, occurrence of ferry traffic, absence of oil in water; transparency = 54cm, water flow velocity = 0.25 ± 0.33 m/s, river width = 35m ; river depth = 4.32m.
PPE2	Wider river, presence of "igapó", absence of rapids and macrophytes, sampling point located next to the port, presence of docked ferries, local river banks preserved, moderate occurrence of ferry traffic, absence of oil in water, transparency = 54cm , water flow velocity = 0.33 ± 0.50 m/s; river width = 44m; river depth = 1.80 m.
PJE2	Steep river banks, "igapó" presence, absence of rapids and macrophytes, local banks preserved, moderate occurrence of ferry traffic, absence of oil in water, transparency = 72cm, water flow velocity = 0.33 ± 0.50 m/s; river width = 40m; depth = 7.78m
PJE1	Lower river banks, wider river, presence of "igapó", absence of rapids and macrophytes, local banks showing fallen trees owing to ferry action, occurrence of heavy ferry traffic, absence of oil in the water; transparency = 84cm; water flow velocity = 0.20 ± 0.33 m/s; river width = 38m ; river depth = 2.92m

Table 2. Data of numerical abundance (A) during flood (dry) periods, trophic categorization (TC) (CAR=Carnivores, DET=Detritivores, HER=Herbivores, ILI=Iliophagous, INS=Insectivores, INV=Invertivores, ONI=omnivores, PIS=piscivores, PLA=planktivores) and references of the species collected in the Urucu River, municipality of Coari - AM / Brazil.

Order, Family, Genus and Species	A	TC	References*
Order Osteoglossiformes			
Family Osteoglossidae			
<i>Osteoglossum bicirrhosum</i> (Cuvier, 1829)	0(55)	CAR	Mérona and Rankin-de-Mérona (2004)
Order Clupeiformes			
Family Pristigasteridae			
<i>Pellona castelnaeana</i> Valenciennes, 1847	32(0)	PIS	Mérona and Rankin-de-Mérona (2004)
<i>Pellona flavipinnis</i> (Valenciennes, 1837)	22(4)	CAR	Mérona and Rankin-de-Mérona (2004)
Family Engraulidae			
<i>Lycengraulis batesii</i> (Günther, 1868)	7(1)	PIS	Mérona and Rankin-de-Mérona (2004) (<i>Lycengraulis grossidens</i>)
Order Beloniformes			
Family Belonidae			
<i>Potamorhaphis guianensis</i> (Jardine, 1843)	1(0)	CAR	Reis et al. (2003)
Order Characiformes			
Family Acestrorhynchidae			
<i>Acestrorhynchus falcirostris</i> (Cuvier, 1819)	1(28)	PIS	Santos et al. (2004)
<i>Acestrorhynchus falcatus</i> (Bloch, 1794)	3(0)	PIS	Reis et al. (2003)
<i>Acestrorhynchus microlepis</i> (Schomburgk, 1841)	1(0)	PIS	Pouilly et al. (2003)
Family Agoniatiidae			
<i>Agoniatas halecinus</i> Müller & Troschel, 1845	11(14)	PIS	Goulding et al. (1988)
Family Anostomidae			
<i>Abramites hypselonotus</i> (Günther, 1868)	0(2)	ONI	Santos and Rosa (1998)
<i>Leporinus agassizii</i> Steindachner, 1876	14(16)	ONI	Santos and Rosa (1998)
<i>Leporinus fasciatus</i> (Bloch, 1794)	0(2)	ONI	Santos et al. (2006)
<i>Schizodon fasciatus</i> Spix & Agassiz, 1829	0(1)	HER	Santos (1981)
<i>Rhytidodus argenteofuscus</i> Kner, 1858	3(0)	HER	Santos (1981)
Family Characidae			
<i>Brycon</i> cf. <i>pesu</i> Müller Troschel, 1845	16(6)	ONI	Arrington (2002)
<i>Brycon melanopterus</i> (Cope, 1872)	0(4)	ONI	Mérona and Rankin-de-Mérona (2004)
<i>Bryconops alburnoides</i> Kner, 1858	64(5)	INS	Silva (2008)
<i>Bryconops caudomaculatus</i> (Günther, 1864)	0(1)	INS	Silva (2008)
<i>Chalceus erythrurus</i> (Cope, 1870)	2(19)	INS	Arrington (2002)
<i>Moenkhausia lepidura</i> (Kner, 1858)	14(5)	INS	Moura et al. (2010)
<i>Myloplus rubripinnis</i> (Müller & Troschel, 1844)	4(5)	HER	Reis et al. (2003)
<i>Myleus</i> sp.	1(0)	HER	Reis et al. (2003)
<i>Myleus schomburgkii</i> (Jardine, 1841)	1(0)	HER	Reis et al. (2003)
<i>Poptella brevispina</i> Reis, 1989	1(0)	ONI	Santos et al. (2009) (<i>Poptella paraguayensis</i>)
<i>Pristobrycon striolatus</i> (Steindachner, 1908)	6(0)	PIS	Nico and Tarphon (1988)
<i>Pygocentrus nattereri</i> Kner, 1858	12(5)	PIS	Mérona and Rankin-de-Mérona (2004)
<i>Serrasalmus</i> sp.	0(2)	PIS	Reis et al. (2003)
<i>Serrasalmus altispinis</i> Merckx, Jégu & Santos, 2000	0(6)	PIS	Reis et al. (2003)
<i>Serrasalmus rhombeus</i> (Linnaeus, 1766)	54(44)	PIS	Santos et al. (2004)
<i>Tetragonopterus chalceus</i> Spix & Agassiz, 1829	1(0)	ONI	Ferreira and Santos (2006)
<i>Triportheus albus</i> Cope, 1872	0(6)	ONI	Pouilly et al. (2003)
<i>Triportheus angulatus</i> (Spix & Agassiz, 1829)	0(7)	ONI	Yamamoto et al. (2004)
<i>Triportheus elongatus</i> (Günther, 1864)	1(0)	ONI	Mérona and Rankin-de-Mérona (2004)
Family Chilodontidae			
<i>Caenotropus labyrinthicus</i> (Kner, 1858)	2(9)	ONI	Godoi (2004)

*Arrington (2002), Claro-Junior et al. (2004), Correa (2005), Duarte (2008), Ferraris Junior (1991), Ferreira and Santos (2006), Godoi (2004), Goulding et al. (1988), Gurgel et al. (2002), Marinelli et al. (1993), Mérona and Rankin-de-Mérona (2004), Nico and Tarphon, 1988), Pereira et al. (1996), Moura et al. (2010), Pouilly et al. (2003), Reis (1997), Reis et al. (2003), Rezende et al. (2005), Röpke (com. pess), Santos (1981, 1991), Santos and Rosa (1998), Santos et al. (2004, 2006, 2009), Silva (2008) and Yamamoto et al. (2004).

Table 2. Continued...

Order, Family, Genus and Species	A	TC	References*
Family Ctenoluciidae			
<i>Boulengerella cuvieri</i> (Spix & Agassiz, 1829)	2(0)	PIS	Duarte (2008)
<i>Boulengerella maculata</i> (Valenciennes, 1850)	3(22)	PIS	Goulding et al. (1988)
Family Curimatidae			
<i>Curimata</i> cf. <i>cisandina</i> (Allen, 1942)	1(0)	DET	Santos (1991) (<i>C. inornata</i>)
<i>Curimata inornata</i> Vari, 1989	0(33)	DET	Santos (1991)
<i>Curimata vittata</i> (Kner, 1858)	1(3)	DET	Santos (1991)
<i>Cyphocharax notatus</i> (Steindachner, 1908)	0(2)	DET	Santos et al. (2004)
<i>Psectrogaster amazonica</i> Eigenmann & Eigenmann, 1889	1(0)	DET	Mérona and Rankin-de-Mérona (2004)
<i>Psectrogaster rutiloides</i> (Kner, 1858)	4(0)	DET	Santos (1991)
<i>Steindachnerina bimaculata</i> (Steindachner, 1876)	0(1)	ILI	Godoi (2004)
Family Cynodontidae			
<i>Cynodon gibbus</i> (Agassiz, 1829)	3(0)	PIS	Santos et al. (2006)
<i>Rhaphiodon vulpinus</i> Agassiz, 1829	5(0)	PIS	Pouilly et al. (2003)
Family Erythrinidae			
<i>Hoplias malabaricus</i> (Bloch, 1794)	1(9)	PIS	Mérona and Rankin-de-Mérona (2004)
Family Hemiodontidae			
<i>Hemiodus semitaeniatus</i> Kner, 1858	2(6)	HER	Godoi (2004)
<i>Hemiodus unimaculatus</i> (Bloch, 1794)	7(36)	HER	Godoi (2004)
<i>Anodus orinocensis</i> (Steindachner, 1887)	1(0)	PLA	Santos et al. (2004)
Order Siluriformes			
Family Loricariidae			
<i>Ancistrus</i> sp.	0(1)	DET	Pereira et al. (1996)
<i>Dekeyseria amazonica</i> Rapp Py-Daniel, 1985	1(0)	HER	Rezende et al. (2005)
<i>Loricaria cataphracta</i> Linnaeus, 1758	0(1)	DET	Pereira et al. (1996)
<i>Rineloricaria</i> sp.	0(4)	DET	Pereira et al. (1996) (<i>Rineloricaria nigricauda</i>)
<i>Sturisoma</i> sp.	0(2)	DET	Pereira et al. (1996) (<i>Sturisoma robustum</i>)
<i>Hypoptopoma</i> cf. <i>gulare</i> Cope, 1878	24(1)	ILI	Santos et al. (2004)
Family Auchenipteridae			
<i>Ageneiosus inermis</i> (Linnaeus, 1766)	1(0)	CAR	Santos et al. (2006)
<i>Ageneiosus</i> gr. <i>vittatus</i> (Steindachner, 1908)	1(0)	CAR	Santos et al. (2006)
<i>Auchenipterichthys</i> sp.	2(0)	ONI	Marinelli et al. (1993) (<i>Auchenipterichthys thoracatus</i>)
<i>Auchenipterus ambyiacus</i> Fowler, 1915	2(0)	CAR	Pouilly et al. (2003)
<i>Auchenipterus nuchalis</i> (Spix & Agassiz, 1829)	2(0)	INS	Mérona and Rankin-de-Mérona (2004)
<i>Centromochus heckelli</i> (De Felippi, 1853)	2(0)	CAR	Röpke (com. pess)
<i>Trachelyopterus galeatus</i> (Linnaeus, 1766)	5(0)	ONI	Claro-Junior et al. (2004)
<i>Tatia intermedia</i> (Steindachner, 1877)	2(0)	INS	Ferraris Junior (1991)
Family Callichthyidae			
<i>Dianema urostriatum</i> (Miranda Ribeiro, 1912)	63(0)	INS	Correa (2005) (<i>D. longibarbis</i>)
Family Pimelodidae			
<i>Calophysus macropterus</i> (Lichtenstein, 1819)	28(15)	CAR	Santos et al. (2004)
<i>Hemisorubim platyrhynchos</i> (Valenciennes, 1840)	0(8)	CAR	Duarte (2008)
<i>Hypophthalmus edentatus</i> Spix & Agassiz, 1829	2(0)	PLA	Santos et al. (2006)
<i>Hypophthalmus marginatus</i> Valenciennes, 1840	2(0)	PLA	Santos et al. (2006)
<i>Pimelodus blochii</i> Valenciennes, 1840	5(4)	CAR	Mérona and Rankin-de-Mérona (2004)
<i>Pinirampus pirinampu</i> (Spix & Agassiz, 1829)	4(0)	PIS	Rezende et al. (2005)
<i>Pseudoplatystoma fasciatum</i> (Linnaeus, 1766)	1(0)	PIS	Lowe-McConnel (1975)
<i>Sorubim lima</i> (Bloch & Schneider, 1801)	4(0)	CAR	Santos et al. (2006)

*Arrington (2002), Claro-Junior et al. (2004), Correa (2005), Duarte (2008), Ferraris Junior (1991), Ferreira and Santos (2006), Godoi (2004), Goulding et al. (1988), Gurgel et al. (2002), Marinelli et al. (1993), Mérona and Rankin-de-Mérona (2004), Nico and Tarphon, 1988), Pereira et al. (1996), Moura et al. (2010), Pouilly et al. (2003), Reis (1997), Reis et al. (2003), Rezende et al. (2005), Röpke (com. pess), Santos (1981, 1991), Santos and Rosa (1998), Santos et al. (2004, 2006, 2009), Silva (2008) and Yamamoto et al. (2004).

Table 2. Continued...

Order, Family, Genus and Species	A	TC	References*
Order Perciformes			
Family Cichlidae			
<i>Biotodoma cupido</i> (Heckel, 1840)	0(6)	CAR	Reis (1997)
<i>Chaetobranchius flavescens</i> Heckel, 1840	0(7)	INV	Mérona and Rankin-de-Mérona (2004)
<i>Cichla</i> sp.	0(10)	PIS	Mérona and Rankin-de-Mérona (2004)
<i>Cichla monoculus</i> Spix & Agassiz, 1831	0(2)	PIS	Mérona and Rankin-de-Mérona (2004)
<i>Crenicichla cincta</i> Regan, 1905	1(0)	PIS	Gurgel et al. (2002) (<i>Crenicichla menezesi</i>)
<i>Geophagus proximus</i> (Castelnaud, 1855)	0(9)	ONI	Santos et al. (2006)
<i>Satanoperca jurupari</i> (Heckel, 1840)	0(1)	ONI	Santos et al. (2004)
Family Scianidae			
<i>Plagioscion squamosissimus</i> (Heckel, 1840)	8(6)	CAR	Santos et al. (2004)
Order Pleuronectiformes			
Family Achiridae			
<i>Hypoclinemus mentalis</i> (Günther, 1862)	0(1)	CAR	Reis et al. (2003)

*Arrington (2002), Claro-Junior et al. (2004), Correa (2005), Duarte (2008), Ferraris Junior (1991), Ferreira and Santos (2006), Godoi (2004), Goulding et al. (1988), Gurgel et al. (2002), Marinelli et al. (1993), Mérona and Rankin-de-Mérona (2004), Nico and Tarphon, 1988), Pereira et al. (1996), Moura et al. (2010), Pouilly et al. (2003), Reis (1997), Reis et al. (2003), Rezende et al. (2005), Röpke (com. pess), Santos (1981, 1991), Santos and Rosa (1998), Santos et al. (2004, 2006, 2009), Silva (2008) and Yamamoto et al. (2004).

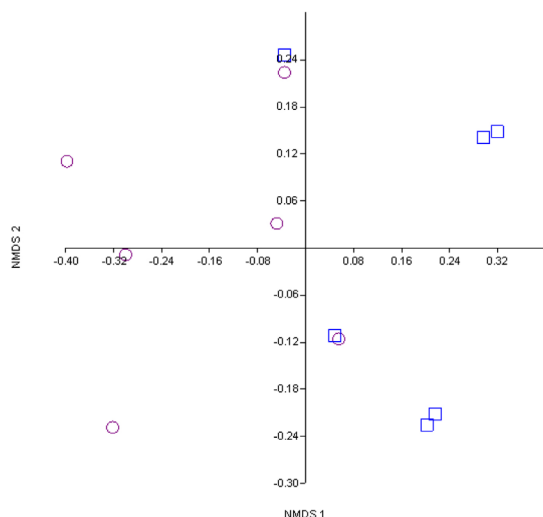


Figure 2. NMDS graphics for the sampling periods based on abundance of trophic categories. □ = flood season and ○ = dry season.

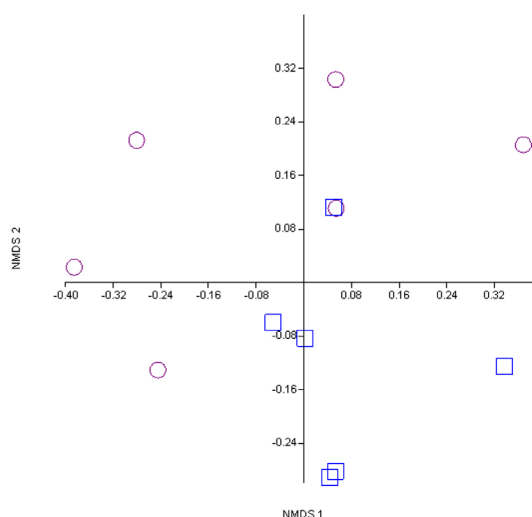


Figure 3. NMDS graph for the sampling periods based on biomass of trophic categories. □ = flood season and ○ = dry season.

B = 23,138; 22%), and the group of carnivores were the most significant in terms of biomass in the dry season (B = 60.928g; 57%) (Table 3).

Seasonal analysis showed that the taxonomic diversity and dominance were higher in the flood season if compared to dry season, and evenness showed no significant difference between seasons. The trophic diversity, dominance and evenness (trophic indexes) were very similar in the dry and flood seasons, but were lower than taxonomic levels, except for the trophic dominance in the dry season (Table 4).

4. Discussion

The predominance of the Otophysi group fishes found in our research is consistent with what was expected for the Amazon region (Nelson, 1994), as it is characterized by the dominance of Characiformes (43%), Siluriformes (36%) and Gymnotiformes (3%) representing approximately 82% of the Amazon fish fauna (Lowe-McConnell, 1999). This dominance is well reported for various rivers in the Neotropical region (Robertson, 1972; Sabino and Zuanon, 1998; Lowe-McConnell, 1999; Castro, 1999;

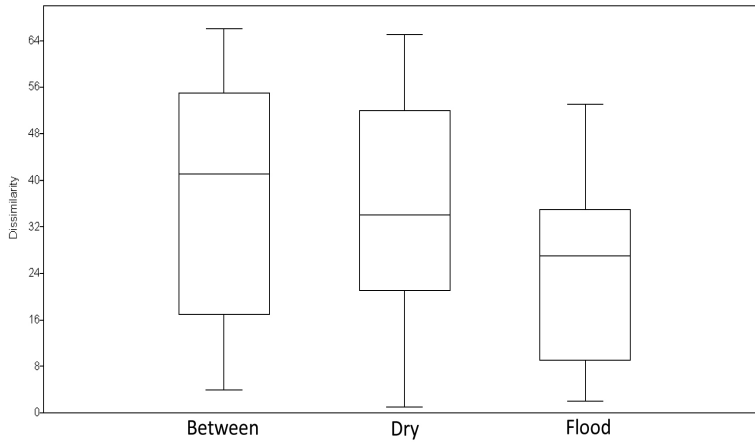


Figure 4. Dissimilarity of abundance of trophic groups in the dry and flood seasons.

Table 3. Data of numerical abundance (N), abundance percentage (%N), biomass (B) and biomass percentage (%B) for each trophic rank (TR) (CAR=Carnivores, DET=Detritivores, HER=Herbivores, ILI=Iliophagous, INS=Insectivores, INV=Invertivores, ONI=omnivores, PIS=piscivores, PLA=planktivores) during dry and flood seasons in the Urucu River, municipality of Coari - AM / Brazil.

Dry						Flood					
Abundance			Biomass (g)			Abundance			Biomass (g)		
TR	N	%N	TR	B	%B	TR	N	%N	TR	B	%B
PIS	149	33.9	CAR	60.928	57.4	PIS	160	33.9	PIS	38.430	50.9
CAR	94	21.4	PIS	23.138	21.8	INS	147	31.1	CAR	18.467	24.5
ONI	62	14.1	ONI	11.288	10.6	CAR	76	16.1	ONI	10.665	14.1
HER	54	12.3	HER	4.815	4.5	ONI	46	9.75	HER	3.78	5
DET	46	10.5	DET	2.685	2.5	ILI	24	5.08	INS	1.77	2.3
INS	25	5.7	INS	1.595	1.5	HER	12	2.54	PLA	873	1.2
INV	7	1.6	INV	1.58	1.5	DET	4	0.85	DET	590	0.8
ILI	2	0.5	ILI	115	0.1	PLA	3	0.636	ILI	475	0.6

Table 4. Taxonomic diversity index (H'_{Tax}), taxonomic dominance index (d_{Tax}), Pielou's taxonomic evenness index (e_{Tax}), trophic diversity index (H'_{Trof}), trophic dominance index (d_{Trof}) and Pielou's trophic evenness index (e_{Trof}) for the six sampled stretches of the Urucu River during the dry and flood seasons.

Season	H'_{Tax}	H'_{Trof}	d_{Tax}	d_{Trof}	e_{Tax}	e_{Trof}
Dry	4.70	2.40	0.20	0.32	0.83	0.80
Flood	4.80	2.43	0.60	0.30	0.81	0.80

Pouilly et al., 2004). The most abundant families in the sampled stretches and seasons were Characidae and Loricariidae, groups widely distributed throughout the Amazon basin (Britski, 1999; Ferreira et al., 1998; Santos et al., 2006).

An important factor for the structuring of fish communities in the tropics is related to the mobility of species, since many of these migrate from rivers into and out of lakes, flooded forests and tributaries according to the changes of water levels and physical/chemical variables (Goulding, 1980). In the flood plain areas, the diversity and density of fishes are determined by the flow regime; flooding increases

homogenization of limnological characteristics of the environment (Thomaz et al., 1997) while dry season makes the environments respond to regional factors independently, increasing fauna heterogeneity as microhabitats become isolated (Teixeira et al., 2005). Our exploratory analysis identified a segregation between dry and flood seasons based on the abundance and biomass of trophic categories, and greater variability between sites in the dry season (see Figure 4). Thus, we infer that the contribution of each trophic group, for each sample season, acts in a distinct way in the Urucu River. Such condition corroborates scientific literature. For example, based only on information about piscivore guilds, studies indicate that this category is the most significant in abundance and biomass during dry season because there is a higher density of prey in the river channels (Saint-Paul et al., 2000; Claro-Junior, 2003; Júlio Junior et al., 2003; Siqueira-Souza and Freitas, 2004; Doria et al., 2005; Correa, 2008; Sousa and Freitas, 2008). As well as to the flood season, where Pompeu (1997) describes that river bank areas are

flooded supplying a greater amount of food and prey, which in turn supports higher densities of fish. Röpke (2008), in a study of temporal variation of trophic structure in aquatic herbaceous biotopes, points to a higher number of individuals and high piscivore biomass in dry and receding waters periods. Our results showed high contribution of carnivore and piscivore species (e.g. *O. bicirrhosum*, *S. rhombeus*) in both periods, and insectivores (e.g. *D. urostriatum* e *B. alburnoides*) in the flood period. The flood season offers a wide range of food items, favoring insectivore and omnivore relations, whereas the dry season favors carnivore relations (Santos et al., 2009) owing to the increase of fish density, what intensifies the biotic interactions in tropical aquatic ecosystems, such as predation (Layman and Winemiller, 2004).

In general, abundance levels are lower in the flood season owing to the dispersion of fish in the environment, making it difficult to capture them with fishing equipment. In addition, in the dry season fish are more concentrated owing to the reduction of the water body area, what makes fish catching easier (Lowe-McConnell, 1999). However, in contradiction with literature, greater absolute abundance and biomass of piscivores were sampled during flood season when compared to dry season. According to Jepsen (1997), in studies on the Cinaruco river (Venezuela), during the dry season larger prey (> 110 mm) are less abundant apparently due to intense predation during the period of flood and receding waters, confirming our results in that relates to the high number of piscivores in the flood season.

The stability of the environment is an important condition for predator species of specialized feeding habits while there is a greater number of species that have broader feeding habits in environments that are more variable, which are subject to disturbances and to a rich range of piscivore species in stable environmental conditions (Kushlan, 1976; Poff and Allan, 1995; Hoeinghaus et al., 2006), as in the environment we studied. The occurrence of a high level of piscivory in certain tropical systems has been attributed to the abundance of detritivore habit prey in floodplains (Winemiller and Jepsen, 1998; Winemiller, 2004). Seasonal changes in the composition of the ichthyofauna were also observed in the floodplains of the Rupunini River (Lowe-McConnell, 1975), the Machado and Madeira rivers (Goulding, 1980), Lake Inácio (Saint-Paul et al., 2000), Lago do Rei (Mérona and Bittencourt, 1993), Catalão Lake (Vale, 2003) and

Lakes Samaúma, Sacambú and Maracá in Central Amazon (Siqueira-Souza and Freitas, 2004).

In the studied area the diversity values obtained can be considered high, considering that index values above 3.0 indicate high diversity (Goulding, 1980). Corroborating our results, Kushlan (1976), Saint-Paul et al. (2000), Ferreira and Casatti (2006), Cunico et al. (2006), Ferreira and Petrere (2007), Silva (2008) and Correa (2008) found higher values of taxonomic diversity in the flood season. The dynamics of flooding promotes increased production and high diversity of fishes, and this plays an important ecological role in the whole basin (Silva et al., 2007). The diminishing richness and diversity that happens from the flood season to the dry season is due to the reduction of water space (Saint-Paul et al., 2000). A greater number of species occur in larger areas, emphasizing the species-area relationship (Ricklefs, 2001). Along with this, the rise of water level - that floods the vegetation of the river banks - makes available a greater number of shelters and structurally more complex habitats as well as food resources that are not available in the dry season, supporting greater diversity in the flood season (Teixeira et al., 2005).

An important component of species diversity is evenness (Begon et al., 2007), which is the opposite of species dominance. Under natural conditions of the tropical ecosystems, rare species are distributed evenly, that is, numerous species are found with a small number of individuals. Contrary to our results, Silva et al. (2007) and Cunico et al. (2006) obtained lower evenness in the dry season, and reported the piscivores *P. nattereri* and *H. malabaricus*, respectively, as dominant species. In our research, the lower taxonomic evenness in the flood season is evidenced by the high abundance of insectivore species as *B. alburnoides* e *D. urostriatum*, which because of their feeding habits, show a strict relation with the period of high water owing to the greater availability of allochthonous insects in this period (Winemiller, 1990; Zavala-Camin, 1996; Junk, 1997; Yamamoto et al., 2004).

Assemblages can be viewed both in taxonomic or in functional terms (Poff and Allan, 1995). The use of functional groups allows us to infer more directly on the ecological responses of species to environmental variation (Hoeinghaus et al., 2006). The presence of greater diversity of trophic categories, richness of species (especially those from the top of the chain as piscivores, and basal as detritivores and herbivores) and number of trophic elements have been suggested as resulting from natural or ecological factors such

as productivity (Giller, 1984; DeAngelis, 1992; Lowe-McConnell, 1999; Townsend et al., 1998) and stability of environments (Lowe-McConnell, 1999; Poff and Allan, 1995; Hoeninghaus et al., 2006). The type and number of trophic categories present in a community vary with the species therein, with the density of prey and with the taxonomic resolution adopted by the authors for the classification of guilds (Angermeier and Karr, 1983; Moyle and Senanayake, 1984). Studies in temperate and tropical environments reported similar results to ours, with figures ranging from five to eight guilds (Peretti and Andrian, 2004; Casseiro et al., 2005; Rayner, 2006; Ximenes et al., 2011). Similar to the results obtained by Ximenes et al. (2011), changes in the number of trophic categories were not observed between the dry and flood seasons, suggesting that the species that were included in the community over time were grouped into the existing categories, while the available food resources in the environment are possibly exploited by both, the resident and the visitor species, and there was no variation in the number of trophic categories over time, but there were changes in their composition as changes in the water cycle allow the inclusion of new species to the community and to the categories present there. The high similarity between the trophic index values of the periods analyzed, together with the fact that these were lower than taxonomic index patterns, point to a high redundancy in the use of feeding niches by species belonging to the studied stretch in each period, indicating that, in the absence of a given species, it can be replaced by an equivalent one. Thus, our results may be related to an assembly rule proposed by Fox (1987) and Fox and Brown (1993) which is based on functional groups and that suggests that new species added to communities tend to belong to less occupied functional groups, so that a reasonably uniform species distribution among groups is achieved. We also point to evidence of the influence of seasonal changes on the qualitative and quantitative contribution of the trophic categories analyzed, possibly explained by the availability of food and food spectrum of each category.

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