Fish communities of natural channels between floodplain lakes and Solimões-Amazonas River (Amazon-Brazil)

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ABSTRACT: Fish communities of natural channels between floodplain lakes and Solimões-Amazonas River (Amazon-Brazil). This work identified the assemblages that inhabit "furos", which are natural channels that make connections between floodplain lakes and rivers. Samplings were accomplished in the natural channels of connection between the Solimões River and lakes Cururu and Jacaré. A total of 1,107 specimens belonging to 78 species were caught. Characiformes was the most abundant and most diverse taxon. The fish assemblages are stochastically structured, probably due the transient nature of this environment.
Key-words: floodplain, channel, fish community, Amazonian.

RESUMO: Comunidades de peixes dos canais naturais entre os lagos de várzea e o rio Solimões-Amazonas (Amazonas-Brasil). Com o objetivo de identificar a ictiofauna que habita os canais de conexão "furos" entre os lagos de várzea e canal do rio Solimões foram efetuadas amostragens nos "furos" dos lagos Cururu e Jacaré, situados na margem direita do rio Solimões. Foram capturados 1.107 peixes representantes de 78 espécies. Characiformes foi o grupo mais abundante e mais diverso. A estruturação das assembléias de peixes é estocástica, provavelmente devido o caráter temporário deste tipo de ambiente.
Palavras-chave: várzea, canal, comunidade de peixes, Amazônia.

Introduction

The Solimões-Amazonas River and its main tributaries, including the floodplains, covers 300,000 square kilometers (Junk, 1993). The floodplains, including its lakes and igarapés, have fundamental importance to the life cycle of many fish species (Cox-Fernandes & Petry, 1991). This environment is used by several fish species to reproduction (Goulding, 1980), nursery (Araújo-Lima, 1985), feeding and refuge areas (Bayley, 1987; Lowe-McConnell, 1987).

The flood pulse couples and decouples the Amazonian floodplains to and from the aquatic systems with a moving littoral, in the case of the Solimões-Amazonas River to river channels and perennial floodplain lakes (Junk, 2000) and it is the major force which regulates the biota (Junk, 1999). Many fishes Amazonian floodplains exhibit morphological, physiological, and biochemical responses to survive during markedly different periods of the hydrological cycle (Saint-Paul, 1984). Some of these species developed migratory strategies and are commercially important to regional landings (Cox-Ferandes & Petry, 1991).

The connection between floodplain lakes and rivers are transient environments that markedly change between hydrological periods, alternating periods with strong unidirectional currents to stagnate waters. Several species colonize and explore these environments during the flood period of the hydrological cycle. Although its importance as a sideway to migratory species, these environments and its ecology are not very well studied (Cox-Fernandes, 1997). The aim of this study was to identify the migratory and non-migratory inhabitant fish species of the connection channels during two periods of the hydrological cycle and identify the main patterns of these communities.

Material and methods

This study was accomplished at two natural channels, chose as sampling sites, located in the right margin of Solimões-Amazonas river, indicated by furo of Cururu lake (03°34'37"S; 60°48'27"W) and furo of Jacaré lake (03°36'16"S; 60°49'06"W) (Fig. 1). These are transient environments that are quite dry during the dry season and show river flux toward lake during rising period and lake toward river at receding period.

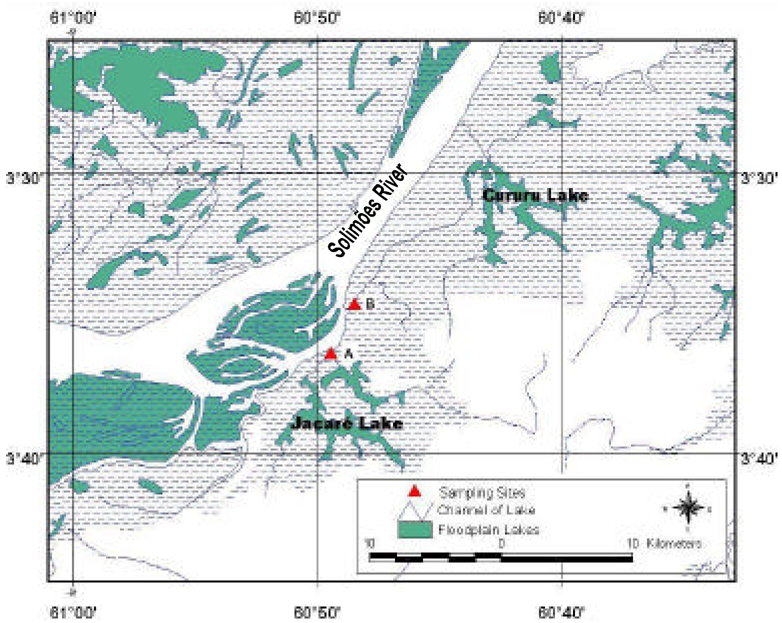

Figure 1: Study area, indicating the two sampling sites: (A) channel of Jacaré lake and (B) channel of Cururu lake. Manacapuru-Amazon-Brazil (PIATAM Project/ArcView program).

Experimental fisheries were performed at two months belonging two seasons of hydrological cycle: May and June relative rising season; August and September relative receding season. In general, the rising season starts in December with a maximum in June, but the connection channel between lakes and rivers is restored in April. The receding season starts in July and is shorter (Fig. 2).

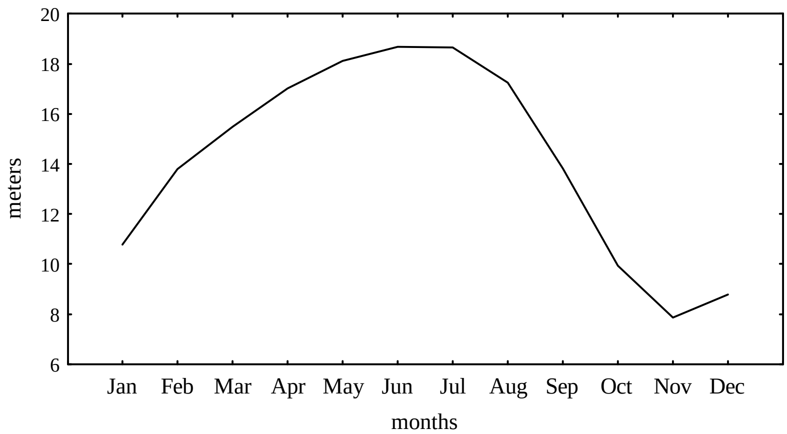

Figure 2: Water level variations of Solimões River (2001). Data obtained at ANA (National Water Agency).

To minimize the effects of selectivity, gillnets with different mesh size were used, organized in groups of five nets with mesh sizes of 30, 40, 50, 60 and 70 mm between adjacent knots, each net with a standard size of 30 m in length and 2 m height. Overall, gillnets stayed 18 hours in the water, were placed at 6:00 pm and collected at 12:00 am. At the same time, one gillnet with same dimensions and 30 mm between adjacent knots was used as a drift net for 30 minutes per day. A ring trap net with 20 mm between adjacent knots and 1 m of diameter was used in the channel two times per day, during 1 hour. Fishes were identified as according to Nelson (1994), Ferreira et al. (1998) and by experts.

To each channel and each period we estimated: Shannon index of diversity, Berger-Parker index of dominance and evenness (Magurran, 1988). To determine if fish communities are stochastic or deterministic structured we accomplished a co-occurrence analysis with 1000 iterations (Stone & Roberts, 1990). A principal component analysis (PCA) and a cluster analysis were accomplished to identify driving factors of patterns of community structure (Braak, 1995; Manly, 1994). The subjects are sample units composed by connection channel (C = furo of Cururu lake and J = furo of Jacaré lake) and period of experimental fishery (1, 2 = rising and 3, 4 = receding).

Results

A total of 1,107 specimens representing 6 orders, 20 families, 56 genera and 78 species were collected. Characiformes was the most abundant order with 744 specimens or 67.27%, followed by Siluriformes with 28.12%, Osteoglossiformes with 1.99%, Perciformes with 1.45%, Clupeiformes with 1.08% and Gymnotiformes with 0.09% (Tab. I). Also Characiformes was the most diverse group with 44 species or 56.41% of total.

Table I: List of species from Cururu and Jacaré lake channels.

Scientific Name	Common Name	Cururu Lake	Jacaré Lake	Migratory
OSTEOGLOSSIFORMES				
Arapaimidae				
Arapaima gigas (Schinz, 1822)	Pirarucu	-	4	yes
Osteoglossidae				
Osteoglossum bicirrhosum Cuvier, 1829	Aruanã	3	15	yes
CLUPEIFORMES				
Pristigasteridae				
Ilisha amazonica (Miranda Ribeiro, 1923)	Apapá	1	-	yes
Pellona castelnaeana Valenciennes, 1847	Apapá branco	-	2	yes
Pellona flavipinnis (Valenciennes, 1836)	Apapá amarelo	3	8	yes
CHARACIFORMES				
Anostomidae				
Anostomoides laticeps (Eigenmann, 1912)	Aracu	2	-	yes
Leporinus fasciatus (Bloch, 1794)	Aracu flamengo	-	5	yes
Leporinus friderici (Bloch, 1794)	Aracu	9	-	yes
Leporinus trifasciatus (Steindachner, 1876)	Aracu c	10	1	yes
Rhytiodus argenteofuscus (Kner, 1858)	Aracu pau-de-nego	2	-	yes
Rhytiodus microlepis (Kner, 1858)	Aracu	9	2	yes
Schizodon vittatus (Valenciennes, 1850)	Aracu pororoca	1	-	yes
Schizodon fasciatus Spix & Agassiz, 1829	Aracu	57	2	yes
Characidae				
Acestrorhynchus falcatus (Bloch, 1794)	Dentudo	19	-	yes
Acestrorhynchus falcirostris (Cuvier, 1819)	Dentudo	5	5	yes

Table 1: cont.

Brycon cephalus (Günther, 1869)	Matrinchã	6	5	yes
Chalceus macrolepidotus (Cuvier, 1817)	Arari	10	-	yes
Roeboides myersii (Gill, 1870)	Zé-do-ó	3	2	yes
Tetragonopterus chalceus Spix & Agassiz, 1829	Sardinha matupiri	15	-	yes
Triportheus albus Cope, 1872	Sardinha	5	-	yes
Triportheus elongatus (Günther, 1864)	Sardinha comprida	1	-	yes
Triportheus flavus Cope, 1871	Sardinha papuda	14	13	yes
Curimatidae				
Potamorhina altamazonica (Cope, 1878)	Branquinha	15	-	yes
Potamorhina latior Spix & Agassiz, 1829	Branquinha	21	2	yes
Potamorhina pristigaster (Steindachner, 1876)	Branquinha	53	47	yes
Psectrogaster amazonica (Eigenmann & Eigenmann, 1889)	Branquinha	7	1	yes
Psectrogaster rutiloides (Kner, 1858)	Branquinha	42	5	yes
Cynodontidae				
Hydrolycus scomberoides (Cuvier, 1816)	Peixe cachorro	3	4	yes
Rhaphiodon vulpinus Agassiz, 1829	Peixe cachorro	16	-	yes
Erythrinidae				
Hoplerythrinus unitaeniatus (Agassiz, 1829)	Jeju	-	11	not
Hoplias malabaricus (Bloch, 1794)	Traíra	29	2	not
Hemiodontidae				
Anodus melanopogon Spix,1829	Cubiu	2	-	yes
Hemiodus sp	Charuto	2	-	yes
Prochilodontidae				
Prochilodus nigricans Spix & Agassiz,1829	Curimatã	5	-	yes
Semaprochilodus insignis (Jardine & Schomburgb, 1841)	Jaraqui escama grossa	17	1	yes
Semaprochilodus taeniurus Valenciennes, 1817	Jaraqui escama fina	9	15	yes
Serrasalmidae				
Colossoma macropomum (Cuvier, 1818)	Tambaqui	3	36	yes
Metynnis argenteus (Ahl, 1923)	Pacu marreca	-	1	yes
Myleus torquatus (Kner, 1858)	Pacu branco	-	1	yes
Mylossoma duriventre (Cuvier, 1818)	Pacu	30	6	yes
Mylossoma aureum (Agassiz, 1829)	Pacu manteiga	11	8	yes
Piaractus brachypomus (Cuvier, 1818)	Pirapitinga	1	4	yes
Pygocentrus nattereri (Kner, 1858)	Piranha caju	16	66	not
Serrasalmus eigenmanni Norman, 1829	Piranha branca	12	2	not
Serrasalmus elongatus Kner, 1858	Piraña mucura	5	2	not
Serrasalmus rhombeus (Linnaeus, 1766)	Piranha preta	11	-	not
Serrasalmus spilopleura Kner, 1858	Piranha mafurá	12	7	not
Serrasalmus sp	Piranha	1	-	not
GYMNOTIFORMES				
Gymnotidae				
Gymnotus sp.	Sarapó	1	-	unknown
SILURIFORMES				
Ageneiosidae				
Ageneiosus brevifilis Valenciennes, 1840	Mandubé	11	12	unknown
Auchenipteridae				
Parauchenipterus galeatus (Linnaeus, 1766)	Cangati	107	-	unknown
Parauchenipterus sp.	Cangati	2	1	unknown
Callichthyidae				

Table I: cont.

Hoplosternun litoralle (Hancock, 1828)	Tamaotá	1	37	unknown
Doradidae				
Megalodoras uranoscopus (Eigenmann & Eigenmann, 1888)	Rebeca	1	4	unknown
Nemadoras sp.	Reco-reco	-	13	unknown
Oxydoras niger (Valenciennes, 1821)	Cuiu-cuiu	3	-	unknown
Platydoras costatus (Linnaeus, 1758)	Bacu	18	-	unknown
Pterodoras lentiginosus (Valenciennes, 1817)	Bacu barriga mole	1	-	
Hypophthalmidae				
Hypophthalmus edentatus (Spix & Agassiz,1829)	Mapará	2	-	yes
Loricariidae				
Hypostomus emarginatus (Valenciennes, 1817)	Acari pedra	12	2	not
Limatolichthys sp.	Acari	-	1	not
Liposarcus pardalis (Castelnau, 1855)	Acari-bodó	25	31	not
Loricariichthys maculatus (Bloch, 1794)	Acari-bodó	3	2	not
Reganella sp.	Acari-bodó	1	-	not
Pimelodidae				
Calophysus macropterus (Lichtenstein, 1819)	Piracatinga	6	-	yes
Hemisorubim platyrhynchos (Valenciennes, 1840)	Braço-de-moça	1	-	yes
Pimelodus blochii (Valenciennes, 1840)	Mandi	-	4	unknown
Pinirampus pirinampu (Spix & Agassiz,1829)	Piranambu	3	-	yes
Pseudoplatystoma tigrinum (Valenciennes, 1840)	Caparari	2	1	yes
Sorubim lima (Bloch & Schneider, 1801)	Bico-de-pato	1	1	yes
PERCIFORMES				
Cichlidae				
Chaetobranchopsis orbicularis (Steindachner, 1875)	Cará cascudo	3	-	not
Cichla monoculus Spix & Agassiz, 1831	Tucunaré	-	1	not
Crenicichla aff. Ornata	Jacundá	7	-	not
Crenicichla reticulata (Heckel, 1840)	Jacundá	2	-	not
Scianidae				
Plagioscion squamossissimus (Heckel, 1840)	Pescada branca	1	-	yes
Plagioscion sp.	Pescada	1	-	yes
Satanoperca jurupari (Heckel, 1840)	Acará bicudo	-	1	not

(www.fishbase.org/search.cfm; Ribeiro & Petrere, 1990; Cox-Fernandes, 1997; Issac et al., 1999; Araújo-Lima & Ruffino, 2004).

The greater diversity was observed at Cururu lake channel during receding period and the smaller at the same channel during rising period (Tab. II). The greater dominance was noticed at Cururu lake channel during rising period and the smaller at Jacaré lake channel during receding period (Tab. II). Evenness was smaller at Cururu lake channel during receding period and greater at Jacaré lake during rising period. The c-scores estimate was 0.55012 (p = 0.4988), indicating that communities are stochastically structured.

The principal component analysis allowed the identification of three groups of composed units (Fig. 3). The first group is composed by samplings developed at channel

Table II: Estimates of fish diversity index (S), dominance index (H) and evenness (E) to each channel and season (S = number of species; H'- Shannon index; D - Berger-Parker index and E – Evenness)

	Lake (Season)			
Fish Assemblage Attributes	**Cururu (rising)**	**Cururu (receding)**	**Jacaré (rising)**	**Jacaré (receding)**
S	27	59	28	28
H'	2.6425	3.2403	2.9783	2.6738
D	0.2680	0.1897	0.1354	0.1871
E	0.0978	0.0549	0.1064	0.0922

of Cururu lake during rising period (C1 and C2 units). The second group is composed by samplings accomplished at channel of Cururu Lake during receding period (C3 and C4). The last group is composed by samplings accomplished at channel of Jacaré lake in both periods (J1, J2, J3 and J4).

Assessing the factor scores in the PCA, the species driving groups formation are: Psectrogaster rutiloides, Potamorhina latior and Semaprochilodus insignis that were abundant at channel of Cururu lake during the high water period. At the same place, Parauchenipterus galeatus, Mylossoma duriventre, Schizodon fasciatum and Rhaphiodon vulpinus are determinants to group composed by samples obtained during the receding period. The samples of Jacaré lake channel were jointed mainly by Colossoma macropomum, Hoplosternum littorale, Prochilodus nigricans, Potamorhina pristigaster and Triportheus flavus.

The same pattern of PCA was obtained by cluster analysis (Fig. 4), with three clusters. The first composed by samplings accomplished at Cururu lake channel during receding period; the second composed by samplings developed at Jacaré lake channel in both periods of the hydrological cycle; and the third composed by samplings accomplished at Cururu lake channel during rising water period.

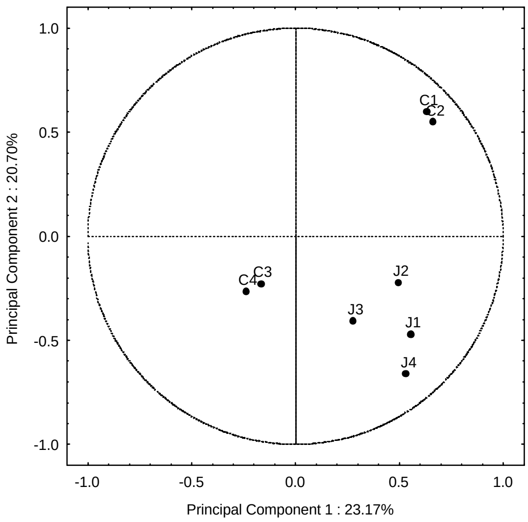

Figure 3: Ordination of composed units: C = channel of Cururu lake; J = channel of Jacaré lake; 1 and 2 = rising; 3 and 4 = receding

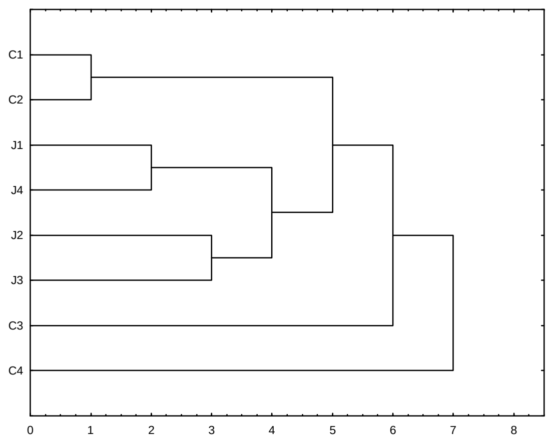

Figure 4: Dendogram of the composed units: C = channel of Cururu lake; J = channel of Jacaré lake;1 and 2 = rising; 3 and 4 = receding.

Discussion

Taxonomic composition is similar to prior studies accomplished in the Amazon basin, mainly floodplain lakes. In lakes at Marchantaria Island (Solimões River) Characiformes were also dominant, as showed by Bayley (1983) and Junk et al. (1983) that found 43% and 37% respectively. Yamamoto (2004) studied the fishes in lakes at Risco Island (Amazonas River) and found that 83% of fish communities are constituted by Characiformes.

The Characiformes were also the most diverse group according to Siqueira-Souza & Freitas (2004) who studied the fishes of floodplain lakes of the lower stretch of Solimões River and found that 57% of all species are comprised by these group.

Despite the absence of diversity studies of the fishes that live in Amazonian connection channels, the diversity measures are slightly lower than estimated for prior studies accomplished at Amazonian floodplain lakes, the environments most studied in the Amazon basin. Using Shannon Index, Saint-Paul et al. (2000) found an estimate of 2.9 at Ignacio Lake and Siqueira-Souza & Freitas (2004) found values between 3.686 and 4.822 sampling floodplain lakes at the lower stretch of Solimões river.

Possibly, the stochastic pattern was a result of environment transience. In the Amazonian basin, the channels connecting floodplain lakes and rivers can dry out during the low water phase, staying without connection with the river until the next rising period. It also constitutes a sideway to migratory fish species (Cox-Fernandes & Petry, 1991). Thus, we theorize that these assemblages are composed of (i) little resident species (e.g. Chaetobranchopsis orbicularis, Cichla monoculus, Plagioscion squamossissimus) which exhibit seasonal changes of abundance; (ii) opportunistic species that quickly colonize these environments after dry periods (e.g. Pygocentrus nattereri, Serrasalmus calmoni and S. eigenmanni); and (iii) migratory species which use it as a sideway (e.g. Prochilodus nigricans, Semaprochilodus insignis and S. taenirus).

Once Cururu lake channel exhibit differences of species composition between rising and receding period, while Jacaré lake channel showed similar composition in both periods, the discrepancies between lake's channel are due, probably, to differences in landscape characteristics of these channels that determine changes in colonization timing. A key factor for these arrangements is probably the connectivity with river. The Jacaré lake channel is parallel to the river, while Cururu lake channel route is more orthogonal to the Solimões river. Thus, the Jacaré lake channel is probably more influenced by the stable environment of river.

Acknowledgements

We thank Dra. Maria G. M. Soares for helpful comments on the manuscript and to PIATAM project FINEP/PETROBRAS and PYRA Program for support the research.

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Received: 26 April 2004
Accepted: 05 July 2004