

Stream ichthyofauna of the Tapajós National Forest, Pará, Brazil

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Abstract

The fish fauna of freshwater streams in the Tapajós National Forest was surveyed and a list of species is presented. The sampling was conducted from 2012 to 2013 during the dry season. Fish were collected with dip nets and seine nets in 22 streams of 1st to 3rd order. Sampling resulted in 3035 specimens belonging to 117 species, 27 families and six orders. The most abundant species were *Bryconops* aff. *melanurus*, *Hemigrammus belottii*, and *Hemigrammus analis*. Four undescribed species were recognized, one of which is known only from the area of this study. A significant dissimilarity was observed in fish species composition among drainage systems. This is the first survey of the stream ichthyofauna in the Tapajós National Forest, and it presents relevant information for future studies and decision-making in the management and conservation of fish fauna in this conservation unit.

Resumo

A ictiofauna de riachos na Floresta Nacional do Tapajós foi inventariada e uma lista de espécies é apresentada. As amostragens foram realizadas de 2012 a 2013 durante o período de águas baixas. Os peixes foram coletados com redes de arrasto e peneiras em 22 riachos de 1^a a 3^a ordem. As amostragens resultaram em 3035 espécimes pertencentes a 117 espécies, 27 famílias e seis ordens. As espécies mais abundantes foram

Bryconops aff. *melanurus*, *Hemigrammus belottii* and *Hemigrammus analis*. Quatro espécies novas foram reconhecidas, sendo uma conhecida apenas da área de estudo até o presente momento. Foi observada uma dissimilaridade significativa na composição de espécies de peixes entre os sistemas de drenagem. Esse é o primeiro inventário da ictiofauna de riachos na Floresta Nacional do Tapajós e apresenta informações relevantes para subsidiar estudos futuros e a tomada de decisões no gerenciamento da ictiofauna nessa Unidade de Conservação.

Keywords

Amazon, conservation, fish, Neotropical region, Tapajós River

Palavras-chave

Amazônia, conservação, peixes, região Neotropical, rio Tapajós

Introduction

The Neotropical region has the richest and most diverse fauna of freshwater fishes in the world, reaching a number of more than 5400 valid species (Reis 2013) and estimates of the final number of more than 8000 species (Reis et al. 2016). Among its watersheds, the highest species richness is located in the Amazon River basin (Santos and Ferreira 1999; Reis et al. 2003), where the number of fish species remains undefined, particularly those inhabiting small streams. In these environments, despite having low primary production (Walker 1990), a rich fish fauna is supported, composed mainly of small-sized fish species (Henderson and Walker 1986; Castro 1999).

Several studies have contributed to our knowledge of the Neotropical fish fauna in recent years. Most noteworthy are those aimed at surveying the ichthyofauna (e.g. De Oliveira et al. 2009; Barros et al. 2011; Raiol et al. 2012; Pedroza et al. 2012), studies with focus on ecology that have tested the influence of environmental factors on the assemblage structure (e.g. Mendonça et al. 2005; Espirito-Santo et al. 2008; Dias et al. 2009), studies on natural history (e.g. Zuanon and Sazina 2004; Zuanon et al. 2006), feeding ecology (e.g. Gonçalves et al. 2013), new distribution records (e.g. Dagosta et al. 2012), and descriptions of new species (e.g. Kullander and Ferreira 2005; Lima et al. 2009; Sousa et al. 2010; Ribeiro et al. 2011; Dutra et al. 2012; Teixeira et al. 2013; Espíndola et al. 2014; Román-Valencia et al. 2014; Silva-Oliveira et al. 2015).

The main objective of the Tapajós National Forest (FLONA Tapajós), founded in 1974, has focused on the multiple use of forest resources and scientific research (SNUC 2000). However, studies of the fish fauna in streams are still needed. Collecting data on species composition in restricted geographical areas, such as conservation units, is an important initial step in decision-making related to the management of fish communities and conservation. Thus, the present study aimed to provide a list of fish species and to test difference in fish species composition among different drainage systems in the Tapajós National Forest.

Materials and methods

Study area

The Tapajós National Forest (FLONA Tapajós), located in western Pará State, approximately 3°24'S, 55°03'W (Fig. 1), holds an area over 527,000 hectares encompassing part of the Aveiro, Belterra, Placas, and Rurópolis municipalities (ICMBio 2014). The FLONA Tapajós is bordered in the west by the Tapajós River, in the east by the highway BR-163, connecting Cuiabá (Mato Grosso State) to Santarém (Pará State), in the south by the Cupari River, and in the north its border is perpendicular to intersection 65 km on BR 163 North. Streams in the FLONA Tapajós streams flow directly in the Tapajós River or drain into two distinct river systems – Curuá-Una and Cupari rivers.

Data collection

Twenty-two streams of 1st to 3rd order were sampled (Fig. 2) during the dry season from September 2012 to November 2013. Nine streams belong to the Curuá-Una river system, six drain into the Cupari River, and seven flow directly in the Tapajós River (Table 1). Fish sampling followed a part of the protocol proposed by Mendonça et al. (2005), in which a 50-m section of each sampled stream was blocked with fine-mesh nets (5 mm between opposite knots). After blocking a section, two collectors were actively sampling for about two hours using dip nets and seine nets.

Specimens were anesthetized in a solution containing eugenol (clove oil), fixed in 10% formalin solution, and subsequently transferred to 70% ethanol. They were counted and identified to the lowest possible taxonomic level. Species were identified with the use of dichotomous keys for different taxonomic groups (e.g. Géry 1977; Kullander 1986; Vari 1992; Buckup 1993; Mago-Leccia 1994; Netto-Ferreira et al. 2009; Oyakawa and Mattox 2009; Caires and Figueiredo 2011; Peixoto et al. 2013) and diagnoses of species (e.g. Zanata et al. 2009; Marinho and Langeani 2010) as well as with the assistance of fish taxonomy experts. The use of the terms “cf.”, “aff.”, and “sp.” follows Bengtson (1988). Taxonomic classification follows Reis et al. (2003). Voucher specimens are deposited in the Fish Collection of Universidade Federal do Oeste do Pará (UFOPA-I) (Appendix 1). Fish were collected under ICMBio license number 35649-2.

Data analysis

An overall estimate of the fish species richness was calculated by means of the Jackknife 1 method (Krebs 1999), utilizing estimatS 8.2 (Cowel 2009). Alpha diversity was estimated by the Shannon-Wiener index (H') (Shannon and Weaver 1963). To test

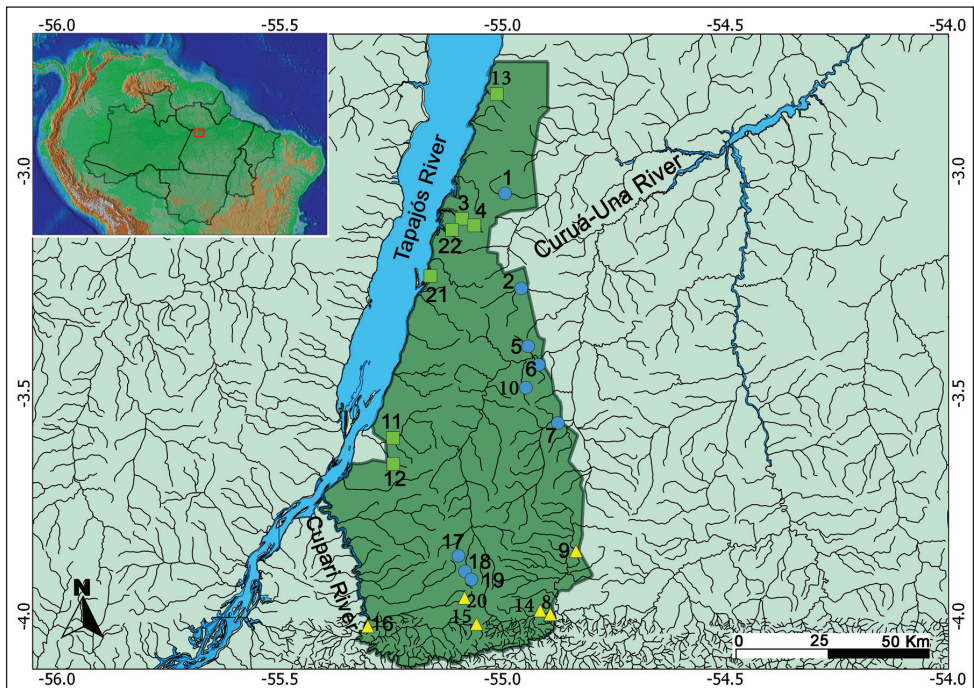


Figure 1. Map of the study area showing the collecting stations in drainage systems in the Tapajós National Forest, Pará State, Brazil. Green squares represent streams draining directly into the Tapajós River; blue dots represent streams draining into the Curuá-Una River, and yellow triangles represent streams draining into the Cupari River.

difference in fish species composition among drainage systems, an analysis of similarities (ANOSIM) was applied with 999 permutations, using Bray-Curtis as a distance metric to measure the degree of dissimilarity between sites based on quantitative data (abundance) and Jaccard index for qualitative data (presence/absence of species). The analyses were done with the software PAST (Hammer et al. 2001).

Results

A total of 3035 specimens belonging to 117 species, 27 families and six orders was sampled (Table 2; Appendix 2). The fish fauna was composed of 59 species of Characiformes (50.4%), 28 of Siluriformes (23.9%), 15 of Perciformes (12.8%), 11 of Gymnotiformes (9.4%), three of Cyprinodontiformes (2.6%) and one of Synbranchiformes (0.9%) (Fig. 3). The most representative families in number of species were Characidae with 38 species (32.5%), Cichlidae with 13 species (11.1%), and Loricariidae with ten species (8.5%) (Fig. 3).

The most abundant species were *Bryconops* aff. *melanurus* and *Hemigrammus belottii* (332 specimens each, 10.9% of the total species recorded), *Hemigrammus analis*

Table 1. Location of sampling stations in the Tapajós National Forest, Pará State, Brazil.

Station	Drainage	Locality	Geographical coordinates
1	Curuá-Una River	km 85 stream	03°02'50.9"S, 54°59'32.9"W
2	Curuá-Una River	unnamed stream	03°15'39.2"S, 54°57'22.7"W
3	Tapajós River	Corredor ecológico stream	03°15'39.2"S, 54°57'22.7"W
4	Tapajós River	unnamed stream	03°07'8.54"S, 55°03'42.4"W
5	Curuá-Una River	km 117 stream	03°23'26.2"S, 54°56'26.7"W
6	Curuá-Una River	unnamed stream	03°25'57.0"S, 54°55'01.8"W
7	Curuá-Una River	Onça stream	03°33'48.9"S, 54°52'26.3"W
8	Cupari River	Água preta stream	03°59'34.5"S, 54°53'27.5"W
9	Cupari River	unnamed stream	03°51'03.7"S, 54°50'00.0"W
10	Curuá-Una River	unnamed stream	03°29'02.1"S, 54°56'45.8"W
11	Tapajós River	Açu stream	03°35'49.4"S, 55°14'39.6"W
12	Tapajós River	Cachoeirinha stream	03°39'19.7"S, 55°14'37.1"W
13	Tapajós River	Maguari stream	02°49'26.9"S, 55°00'40.6"W
14	Cupari River	unnamed stream	03°59'04.3"S, 54°54'49.4"W
15	Cupari River	unnamed stream	04°00'52.5"S, 55°03'24.1"W
16	Cupari river River	unnamed stream	04°01'11.6"S, 55°18'02.7"W
17	Curuá-Una River	unnamed stream	03°51'41.7"S, 55°05'49.7"W
18	Curuá-Una River	unnamed stream	03°53'47.6"S, 55°04'56.7"W
19	Curuá-Una River	unnamed stream	03°54'53.3"S, 55°04'04.6"W
20	Cupari River	unnamed stream	03°57'21.5"S, 55°05'01.2"W
21	Tapajós River	unnamed stream	03°13'57.8"S, 55°09'36.9"W
22	Tapajós River	unnamed stream	03°07'44.8"S, 55°06'42.6"W

(220 specimens, 7.2%), *Apistogramma* cf. *agassizii* (154 specimens, 5.1%), *Aequidens tetramerus* (123 specimens, 4.1%), *Pyrrhulina* cf. *brevis* (108 specimens, 3.6%), *Bryconops munduruku* (107 specimens, 3.5%), and *Jupiaba* aff. *potaroensis* (105 specimens, 3.5%). The abundances of these species together represented 48.8% of all collected specimens. Same species, despite the highest values of abundance, were restricted to one sampling station (e.g. *Hemigrammus analis* and *Trichomycterus hasemani*, collected at a single station, stream 21). The values of abundance, richness and diversity of the streams sampled are presented in Table 3.

The distribution of most species was related to drainage basins; from 117 species recorded, 38 were restricted to streams flow directly into the Tapajós River, 47 were collected only in streams draining into the Cupari River basin, and 11 were recorded only in streams draining into the Curuá-Una River basin. Six species were common to streams of the Curuá-Una and Cupari river drainages. One species was shared among streams flow directly into the Tapajós River and streams draining into the Curuá-Una



Figure 2. Sampled streams in the Tapajós National Forest, Pará State, Brazil.

River; thirteen species were shared among streams flow into the Curuá-Una and Cupari rivers, as well as streams draining directly into the Tapajós River (Fig. 4).

The analysis of similarities revealed a significant dissimilarity in fish species composition to both qualitative and quantitative data among drainage system in the Tapajós National Forest, as follows: Curuá-Una *vs.* Tapajós (presence/absence $R = 0.32$, $p = 0.00$; abundance $R = 0.28$, $p = 0.01$); Curuá-Una *vs.* Cupari (presence/absence $R = 0.40$, $p = 0.01$; abundance $R = 0.36$, $p = 0.01$); and Cupari *vs.* Tapajós (presence/absence $R = 0.33$, $p = 0.02$; abundance $R = 0.23$, $p = 0.04$).

Table 2. List of fish species collected in streams of the Tapajós National Forest, Pará, Brazil.

TAXON	DRAINAGE			
	Cupari	Curuá-Una	Tapajós	Total
CHARACIFORMES				
Curimatidae				
<i>Cyphocharax gangamon</i> Vari, 1992	-	-	17	17
<i>Cyphocharax gouldingi</i> Vari, 1992	8	-	-	8
Anostomidae				
<i>Leporinus granti</i> Eigenmann, 1912	1	-	-	1
<i>Leporinus frederici</i> (Bloch, 1794)	1	-	-	1
Chilodontidae				
<i>Chilodus punctatus</i> Müller & Troschel, 1844	8	-	-	8
Crenuchidae				
<i>Characidium</i> sp. 1	-	-	7	7
<i>Characidium</i> sp. 2	-	19	-	19
<i>Characidium</i> cf. <i>zebra</i> Eigenmann, 1909	41	-	-	41
<i>Elachocharax junki</i> (Géry, 1971)	-	-	38	38
<i>Crenuchus spilurus</i> Günther, 1863	-	-	20	20
Gasteropelecidae				
<i>Carnegiella strigata</i> (Günther, 1864)	1	-	-	1
Characidae				
<i>Astyanax bimaculatus</i> (Linnaeus, 1758)	9	-	-	9
<i>Bryconops</i> aff. <i>caudomaculatus</i> (Günther, 1864)	1	-	-	1
<i>Bryconops</i> cf. <i>imitator</i> Chernoff & Machado-Allison, 2002	36	-	-	36
<i>Bryconops</i> aff. <i>melanurus</i> (Bloch, 1794)	19	14	299	332
<i>Bryconops munduruku</i> Silva-Oliveira, Canto & Ribeiro, 2015	-	-	107	107
<i>Bryconops</i> sp.	1	-	-	1
<i>Creagrutus petilus</i> Vari & Harold, 2001	12	-	-	12
<i>Hemigrammus analis</i> Durbin, 1909	-	-	220	220
<i>Hemigrammus belottii</i> (Steindachner, 1882)	332	-	-	332
<i>Hemigrammus</i> sp.	-	-	13	13
<i>Hemigrammus levis</i> Durbin, 1908	-	-	1	1
<i>Hemigrammus hyanuary</i> Durbin, 1918	-	-	3	3
<i>Hemigrammus ocellifer</i> (Steindachner, 1882)	52	2	-	54
<i>Hemigrammus stictus</i> (Durbin, 1909)	-	-	1	1
<i>Hemigrammus vorderwinkleri</i> Géry, 1963	-	-	59	59
<i>Hyphessobrycon heterorhabdus</i> (Ulrey, 1894)	57	2	-	59
<i>Hyphessobrycon</i> sp. n.	-	16	-	16
<i>Hyphessobrycon</i> cf. <i>agulha</i> Fowler, 1913	-	-	2	2
<i>Iguanodectes variatus</i> Géry, 1993	-	-	25	25
<i>Jupiaba acanthogaster</i> (Eigenmann, 1911)	3	-	-	3
<i>Jupiaba apenima</i> Zanata, 1997	8	-	-	8
<i>Jupiaba</i> cf. <i>potaroensis</i> (Eigenmann, 1909)	105	-	-	105
<i>Jupiaba zonata</i> (Eigenmann, 1908)	2	-	-	2
<i>Knodus</i> cf. <i>heteresthes</i> (Eigenmann, 1908)	16	21	-	37
<i>Knodus</i> sp.	56	-	-	56
<i>Knodus</i> cf. <i>shinabota</i> Ferreira & Carvajal, 2007	-	2	-	2
<i>Microscembrycon</i> sp.	1	-	-	1
<i>Moenkhausia celibela</i> Marinho & Langeani, 2010	-	-	6	6

TAXON	DRAINAGE			
	Cupari	Curuá-Una	Tapajós	Total
<i>Moenkhausia colletti</i> (Steindachner, 1882)	7	-	-	7
<i>Moenkhausia hasemani</i> Eigenmann, 1917	4	-	-	4
<i>Moenkhausia comma</i> Eigenmann, 1908	5	6	3	14
<i>Moenkhausia oligolepis</i> (Günther, 1864)	54	-	-	54
<i>Moenkhausia</i> sp. n.	-	55	-	55
<i>Moenkhausia pirauba</i> Zanata, Birindelli & Moreira, 2009	4	-	-	4
<i>Moenkhausia</i> sp.	3	-	-	3
<i>Phenacogaster calverti</i> (Fowler, 1941)	96	-	-	96
<i>Phenacogaster</i> sp.	3	-	-	3
<i>Poptella compressa</i> (Günther, 1864)	13	-	-	13
Serrasalminidae				
<i>Catoprion mento</i> (Cuvier, 1819)	-	-	1	1
<i>Myloplus rubripinnis</i> (Müller & Troschel, 1844)	3	-	-	3
Acestrorhynchidae				
<i>Acestrorhynchus falcatus</i> (Bloch, 1794)	1	-	1	2
Erythrinidae				
<i>Erythrinus erythrinus</i> (Bloch & Schneider, 1801)	1	16	9	26
<i>Hoplias malabaricus</i> (Bloch, 1794)	12	2	3	17
<i>Hoplias curupira</i> Oyakawa & Mattox, 2009	-	1	-	1
Lebiasinidae				
<i>Copella nigrofasciata</i> (Meinken, 1952)	-	-	88	88
<i>Pyrrhulina</i> cf. <i>brevis</i> Steindachner, 1876	34	59	15	108
<i>Nannostomus eques</i> Steindachner, 1876	-	-	7	7
<i>Nannostomus</i> sp.	-	-	2	2
SILURIFORMES				
Cetopsidae				
<i>Denticetopsis seducta</i> Vari, Ferraris & de Pinna, 2005	1	-	-	1
<i>Denticetopsis</i> sp.	1	-	-	1
<i>Helogenes marmoratus</i> Günther, 1863	1	40	29	70
Aspredinidae				
<i>Bumocephalus coracoideus</i> (Cope, 1874)	-	1	-	1
<i>Bumocephalus knerii</i> Steindachner, 1882	1	-	-	1
Trichomycteridae				
<i>Ituglanis amazonicus</i> (Steindachner, 1882)	1	-	-	1
<i>Trichomycterus hasemani</i> (Eigenmann, 1914)	-	-	91	91
Callichthyidae				
<i>Aspidoras</i> sp. n.	2	-	-	2
<i>Callichthys callichthys</i> (Linnaeus, 1758)	1	1	-	2
<i>Corydoras</i> cf. <i>aprouaguensis</i> Nijssen & Isbrücker, 1983	3	-	-	3
<i>Corydoras</i> sp.	4	-	-	4
<i>Megalechis picta</i> (Müller & Troschel, 1848)	-	-	1	1
Loricariidae				
<i>Ancistrus</i> sp. 1	3	-	-	3
<i>Ancistrus</i> sp. 2 “bolinha”	1	-	-	1
<i>Curculionichthys</i> sp. n.	10	-	-	10
<i>Farlowella smithi</i> Fowler, 1913	3	-	-	3
<i>Farlowella</i> sp. 1 “juvenile”	1	-	-	1

TAXON	DRAINAGE			
	Cupari	Curuá-Una	Tapajós	Total
<i>Farlowella</i> sp. 2	-	5	-	5
<i>Harttia dissidens</i> Rapp Py-Daniel & Oliveira, 2001	2	-	-	2
Hypostominae sp. "juvenile"	2	-	-	2
<i>Rineloricaria lanceolata</i> (Günther, 1868)	1	-	-	1
<i>Sturisoma</i> sp.	1	-	-	1
Pseudopimelodidae				
<i>Batrochoglanis raninus</i> (Valenciennes, 1840)	-	2	-	2
Heptapteridae				
<i>Brachyglanis microphthalmus</i> Bizerril, 1991	-	2	-	2
<i>Phenacorhamdia</i> sp.	6	-	-	6
<i>Pimelodella cristata</i> (Müller & Troschel, 1848)	2	-	-	2
<i>Pimelodella</i> sp.	5	-	-	5
<i>Rhamdia quelen</i> (Quoy & Gaimard, 1824)	1	2	-	3
GYMNOTIFORMES				
Gymnotidae				
<i>Gymnotus coatesi</i> La Monte, 1935	5	6	18	29
<i>Gymnotus coropinae</i> Hoedeman, 1962	11	15	1	27
Sternopygidae				
<i>Eigenmannia trilineata</i> López & Castello, 1966	-	4	-	4
<i>Sternopygus macrurus</i> (Bloch & Schneider, 1801)	-	3	-	3
Rhamphichthyidae				
<i>Gymnorhamphichthys petiti</i> Géry & Vu-Tân-Tuê, 1964	-	12	8	20
<i>Gymnorhamphichthys hypostomus</i> Ellis, 1912	1	-	-	1
Hypopomidae				
<i>Brachyhypopomus</i> aff. <i>beebei</i> (Schultz, 1944)	-	-	3	3
<i>Hypopygus lepturus</i> Hoedeman, 1962	6	51	14	71
<i>Hypopygus benoneae</i> Peixoto, Dutra, Santana & Wosiacki, 2013			2	2
<i>Microsternarchus</i> cf. <i>bilineatus</i> Fernández-Yépez, 1968	-	-	11	4
<i>Steatogenys duidae</i> (La Monte, 1929)	-	-	4	4
CYPRINODONTIFORMES				
Rivulidae				
<i>Rivulus urophthalmus</i> Günther, 1866	6	13	12	31
<i>Rivulus</i> sp.	-	-	6	6
Poeciliidae				
<i>Fluviophylax</i> sp.	-	-	3	3
SYNBRANCHIFORMES				
Synbranchidae				
<i>Synbranchus marmoratus</i> Bloch, 1795	3	10	7	20
PERCIFORMES				
Polycentridae				
<i>Monocirrhus polyacanthus</i> Heckel, 1840	-	-	2	2
Cichlidae				
<i>Aequidens</i> sp.	3	-	-	3
<i>Aequidens tetramerus</i> (Heckel, 1840)	25	91	7	123
<i>Acaronia nassa</i> (Heckel, 1840)	-	-	1	1
<i>Apistogramma</i> cf. <i>agassizii</i> (Steindachner, 1875)	-	-	154	154
<i>Apistogramma</i> sp. 1	1	33	1	35

TAXON	DRAINAGE			
	Cupari	Curuá-Una	Tapajós	Total
<i>Apistogramma</i> sp. 2	-	-	4	4
<i>Crenicichla regani</i> Ploeg, 1989	-	-	14	14
<i>Crenicichla inpa</i> Ploeg, 1991	6	23	-	29
<i>Crenicichla pellegrini</i> Ploeg, 1991	-	-	1	1
<i>Dicrossus maculatus</i> Steindachner, 1875	-	-	4	4
<i>Hypselecara coryphaenoides</i> (Heckel, 1840)	-	-	1	1
<i>Satanoperca jurupari</i> (Heckel, 1840)	-	-	1	1
<i>Taeniacara candidi</i> Myers, 1935	-	-	3	3
Gobiidae				
<i>Microphilypnus acangaquara</i> Caires & Figueiredo, 2011	-	-	26	26
TOTAL	1130	529	1376	3035

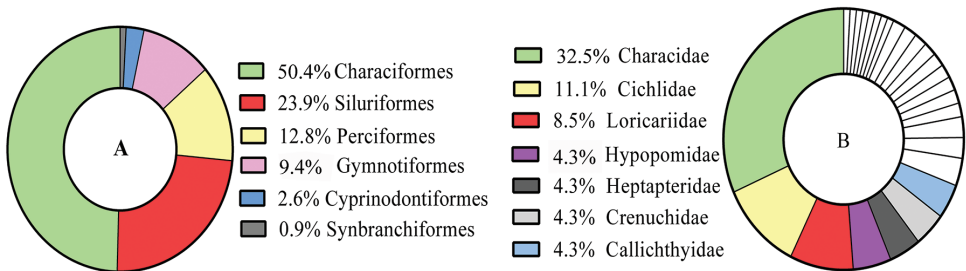


Figure 3. Representativeness of species for orders (A) and most diverse families (B) in streams of the Tapajós National Forest, Pará, Brazil.

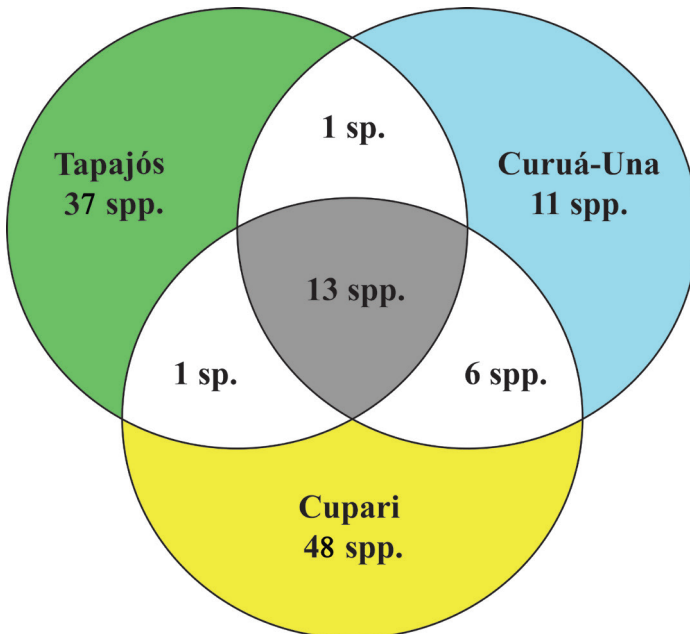


Figure 4. Distribution of fish species recorded in different drainage systems in the Tapajós National Forest.

Table 3. Values of abundance, richness and diversity (Shannon) of the sampled stations in streams in the Tapajós National Forest, Pará, Brazil.

STATION	ABUNDANCE	RICHNESS	DIVERSITY
IG1	87	14	2.11
IG2	23	8	1.67
IG3	422	21	1.61
IG4	59	9	1.83
IG5	39	10	1.93
IG6	63	10	1.82
IG7	125	21	2.53
IG8	99	23	2.53
IG9	438	30	2.43
IG10	148	14	1.99
IG11	82	10	1.37
IG12	108	8	0.56
IG13	0	0	0.00
IG14	51	15	1.51
IG15	403	8	0.81
IG16	78	15	2.36
IG17	13	7	1.73
IG18	0	0	0.00
IG19	24	5	1.28
IG20	64	10	1.69
IG21	566	28	1.91
IG22	142	11	2.03

Discussion

The fish fauna of Tapajós National Forest, as well as the lower Tapajós River, is one of the most understudied and undersampled among aquatic systems in the Amazon drainage and so far all species found during the survey represent new records for the studied area. The number of species recorded (117) is one of the highest among known fish faunas in streams of the 1st to 3rd order in the Amazon drainage (e.g. Mendonça et al. 2005; Montag et al. 2008; De-Oliveira et al. 2009; Dias et al. 2009; Barros et al. 2011). However, the richness of species should be higher and reach up to 183 species. Therefore, more efforts should be employed in surveying the fish fauna of streams in the FLONA Tapajós.

The Neotropical fish faunas are characterized by the predominance of species from the orders Characiformes and Siluriformes (e.g. Angermeier and Karr 1983; Arbeláez 2004; Baumgartner et al. 2006; Arbeláez 2008; Scarabotti et al. 2011; Pedroza et al. 2012; Raiol et al. 2012; Claro-García and Shibatta 2013; Volcan et al. 2013, Ramos et al. 2014). Characiformes is one of the largest orders of fishes with at least 2000 valid species (Eschmeyer 2015). In the Neotropical region, Characiformes, Siluriformes, and Gymnotiformes, or Ostariophysi, constitute about 77% of the freshwater fish

fauna; however the order Perciformes has over 515 freshwater species, in some cases alternating with Gymnotiformes as the third richest order (Albert et al. 2011). In the present study, Perciformes presented three species more than Gymnotiformes.

If families are concerned, the largest number of species in the Neotropical region is contained in Characidae and Loricariidae (Schaefer 1998); however, similar to this study, other faunistic surveys in small streams of the Amazon drainage revealed an inversion in the number of species in the families Cichlidae and Loricariidae (e.g. Mendonça et al. 2005; Barros et al. 2011).

The highest values of richness were observed at sampling stations 8, 9 and 21 (Table 3). Stations 8 and 9 were at river sections characterized by the greatest depth and width. In streams, studies indicate that an increase in species richness is positively related to the habitat complexity and shelter availability as well as current velocity and stream size (Garutti 1988; Meffe and Sheldon 1988; Abes and Agostinho 2001; Suárez and Lima-Junior 2009). In the Neotropical region, substrate, depth and current speed are among the most important physical features, and a combination of such environmental features produces a mosaic of microhabitats, which can explain the downstream increase in species richness (Casatti 2005).

Station 21 is near to the mouth of a stream draining into a lake, and its high values of richness is resulted of the presence of species typically recorded near lakes such as *Catoprion mento*, *Hemigrammus analis*, *H. levis*, *H. hyanuary*, *H. stictus* and *Dicrossus maculatus* (Siqueira-Souza and Freitas 2004; Lima et al. 2013; Kullander 2011). Four new species were recorded, *Curculionichthys* sp. n., *Aspidoras* sp. n., *Hyphessobrycon* sp. n., and *Moenkhausia* sp. n, the *Aspidoras* being known only from the present study. Some specimens received provisional identification with the use of “cf. “, “aff.”, or “sp.”, which may be indicative of the recognition of other new species after more refined analysis, or may even indicate insufficient research for some taxonomic groups (e.g. *Ancistrus* and *Apistogramma*).

The existence of dissimilarity in fish species composition of different, however geographically close, drainage systems within the Tapajos National Forest indicates that geographic isolation coupled with environmental characteristics is responsible for the structuring of fish communities, in accordance with observed by Schleuter et al. (2012) in temperate regions and Barros et al. 2013, in tropical streams. Furthermore the smaller drainage basins can significantly influence the stream fish assemblages composition (Mendonça et al. 2005; Barros et al. 2013) since headwaters streams often support exclusive species that do not occur in the river system, allowing constitute single assemblages that are fundamental to compose the regional fish diversity (Paller 1994; Meyer et al. 2007) and must be priority included in units conservation planning for freshwater systems.

Authors' contribution statement

CSO, ACC and FRR collected the data, identified the species, filled the database and wrote the text.

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References

- Abes SS, Agostinho AA (2001) Spatial patterns in fish distribution and structure of the ichthyocenosis in the Água Nanci stream, upper Paraná River basin, Brazil. *Hydrobiologia* 445: 217–227. doi: 10.1023/A:1017538720502
- Albert J, Petry P, Reis RE (2011) Major Biogeographic and Phylogenetic Patterns. In: Albert J, Reis RE (Eds) *Historical biogeography of neotropical freshwater fishes*. University of California Press, Berkeley and Los Angeles, California, 21–58. doi: 10.1525/california/9780520268685.003.0002
- Angermeier PL, Karr JR (1983) Fish communities along environmental gradients in a system of tropical streams. *Environmental Biology of Fishes* 9: 117–135. doi: 10.1007/BF00690857
- Arbeláez F, Duivenvoorden JF, Maldonado Ocampo JÁ (2008) Geological differentiation explains diversity and composition of fish communities in upland streams in the southern Amazon of Colombia. *Journal of Tropical Ecology* 24: 505–515. doi: 10.1017/S0266467408005294
- Arbeláez F, Gálvis G, Mojica JI, Duque S (2004) Composition and richness of the ichthyofauna in a terra firme forest stream of the Colombian Amazonia. *Amazoniana* 17: 95–107.
- Barros DF, Zuanon J, Mendonça FP, Espírito-Santo HVM, Galuch AV, Albernaz ALM (2011) The fish fauna of streams in the Madeira-Purus. *Check List* 7: 768–773. <http://www.checklist.org.br/getpdf?SL009-11>
- Barros DF, Albernaz ALM, Zuanon J, Espírito-Santo HVM, Mendonça FP, Galuch AV (2013) Effects of isolation and environmental variables on fish community structure in the Brazilian Amazon Madeira-Purus interfluvium. *Brazilian Journal Biology* 73(3): 491–499. doi: 10.1590/S1519-69842013000300005
- Baumgartner D, Baumgartner G, Pavanelli CS, Silva PRL, Frana VA, Oliveira LC, Michelin MR (2006) Fish, Salto Osório Reservoir, Iguaçú River basin, Paraná State, Brazil. *Check List* 2: 1–4. doi: 10.15560/2.1.1

- Bengtson P (1988) Open nomenclature. *Paleontology* 31: 223–227.
- Böhlke JE, Weitzman SH, Menezes NA (1978) Estado atual da sistemática dos peixes da água doce da América do Sul. *Acta Amazônica* 8: 657–677.
- Buckup PA (1993) Review of the characidiini fishes (Teleostei: Characiformes) with descriptions of four new genera and ten new species. *Ichthyological Exploration of Freshwaters* 4: 97–154.
- Caires RA, Figueiredo JL (2011) Review of the genus *Microphilypnus* Myers, 1927 (Teleostei: Gobioidae: Eleotridae) from the lower Amazon basin, with description of one new species. *Zootaxa* 3036: 39–57.
- Castro RMC (1999) Evolução da ictiofauna de riachos sul-americanos: padrões gerais e possíveis processos causais. In: Caramaschi EP, Mazzoni R, Peres-Neto PR (Eds) *Ecologia de peixes de riachos. Série Oecologia Brasiliensis. volume VI, PPGE-UFRJ, Rio de Janeiro*, 139–155. doi: 10.4257/oeco.1999.0601.04
- Claro-García A, Shibatta OA (2013) The fish fauna of streams from the upper rio Tocantins basin, Goiás State, Brazil. *Check List* 9: 28–33. doi: 10.15560/9.1.28
- Colwell RK (2009) EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.2. User's guide and application. <http://purl.oclc.org/estimates>
- Dagosta FCP, Pastana MNL, Esguícero ALH (2012) New records of fishes (Actinopterygii: Ostariophysi) from the Upper Tapajós River Basin. *Check List* 8: 592–594. <http://www.checklist.org.br/getpdf?NGD159-11>
- De Oliveira RR, Rocha MS, Anjos MB, Zuanon J, Rapp Py-Daniel LH (2009) Fish fauna of small streams of the Catua-Ipixuna Extractive Reserve, State of Amazonas, Brazil. *Check List* 5: 154–172. <http://www.checklist.org.br/getpdf?SL125-08>
- Dias MS, Magnusson WE, Zuanon J (2009) Effects of Reduced-Impact Logging on Fish Assemblages in Central Amazonia. *Conservation Biology* 24: 278–286. doi: 10.1111/j.1523-1739.2009.01299.x
- Dutra GM, Wosiacki WB, de Pinna MCC (2012) *Trichomycterus anbinga*, a new species of miniature catfish related to *T. hasemani* and *T. johnsoni* (Siluriformes: Trichomycteridae) from the Amazon basin, Brazil. *Neotropical Ichthyology* 10: 225–231. doi: 10.1590/S1679-62252012000200001
- Eschmeyer WN (2015) *Catalog of Fishes*, California Academy of Sciences. <http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>
- Espíndola VC, Spencer MRS, Rocha LR, Britto MRA (2014) New species of *Corydoras* Lacépède (Siluriformes: Callichthyidae) from the rio Tapajós basin and its phylogenetic implications. *Papéis avulsos de zoologia* 54: 25–32. doi: 10.1590/0031-1049.2014.54.03
- Espirito-Santo HMV, Magnusson WE, Zuanon J, Mendonça FP, Landeiro VL (2008) Seasonal variation in the composition of fish assemblages in small Amazonian forest streams: evidence for predictable changes. *Freshwater Biology* 54: 536–548. doi: 10.1111/j.1365-2427.2008.02129.x
- Géry J (1977) *Characoids of the world*. T.F.H. Publications, Inc. Ltd., Neptune City, New Jersey, 672 pp.
- Gonçalves AFG, Prudente BS, Filho FSC, Montag LFA (2013) Feeding ecology of Dash-dot Tetra *Hemigrammus belottii* (Steindachner 1882) (Characiformes: Characidae) in the

- streams of the Urucu River basin, central Amazonia, Brazil. *Biota Neotropica* 13: 141–147. <http://www.biotaneotropica.org.br/v13n3/pt/abstract?article+bn03113032013>
- Hammer Ø, Harper DAT, Ryan PD (2001) Past: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica* 4(1): 1–9.
- Henderson PA, Walker I (1986) On the leaf litter community of the Amazonian black water stream Tarumázinho. *Journal of Tropical Ecology* 2: 1–16. doi: 10.1017/S0266467400000547
- ICMBio (2014) A Floresta Nacional do Tapajós. <http://www.icmbio.gov.br/flonatapajos/>
- Kullander SO (1986) Cichlid fishes of the Amazon River drainage of Peru. Stockholm. Swedish Museum of Natural History, Stockholm, 431 pp.
- Kullander SO, Ferreira EJG (2005) Two new species of *Apistogramma* Regan (Teleostei: Cichlidae) from the rio Trombetas, Pará State, Brazil. *Neotropical Ichthyology* 3: 361–371. doi: 10.1590/S1679-62252005000300003
- Kullander SO (2011) A review of *Dicrossus foirni* and *Dicrossus warzeli*, two species of cichlid fishes from the Amazon River basin in Brazil (Teleostei: Cichlidae). *aqua, International Journal of Ichthyology* 17: 73–94.
- Lima FCT, Pires THS, Ohara WM, Jerep FC, Carvalho FR, Marinho MMF, Zuanon J (2013) Charadidae. In: Queiroz LJ, Torrente-Vilara G, Ohara WM, Pires THS, Zuanon J, Doria CRC (Eds) Peixes do rio madeira (Vol. 1). Dielato Latin American Document, São Paulo, 213–294.
- Lima FCT, Wosiacki WB, Ramos CS (2009) *Hemigrammus arua*, a new species of characid (Characiformes: Characidae) from the lower Amazon, Brazil. *Neotropical Ichthyology* 7: 153–160. doi: 10.1590/S1679-62252009000200004
- Mago-Leccia F (1994) Electric fishes of the continental waters of America. Ed. Clemente, Venezuela, 206 pp.
- Marinho MMF, Langeani F (2010) *Moenkhausia celibela*: a new species from the Amazon basin, Brazil (Characiformes: Characidae). *Journal of Fish Biology* 77: 879–889. doi: 10.1111/j.1095-8649.2010.02719.x
- Meffe GK, Sheldon A (1988) The influence of habitats structure on fish assemblage composition in southeastern blackwater streams. *American Midland Naturalist* 120: 225–241. doi: 10.2307/2425994
- Mendonça FP, Magnusson WE, Zuanon J (2005) Relationships between habitat characteristics and fish assemblages in small streams of Central Amazonia. *Copeia* 2005: 750–763. doi: 10.1643/0045-8511(2005)005[0751:RBHCAF]2.0.CO;2
- Meyer JL, Strayer DL, Wallace JB, Eggert SL, Helfman GS, Leonard NE (2007) The contribution of headwater streams to biodiversity in river networks. *Journal of the American Water Resources Association* 43: 86–103. doi: 10.1111/j.1752-1688.2007.00008.x
- Montag LFA, Freitas TM, Wosiacki WB, Barthem RB (2008) The fishes of National Forest of Caxiuaná (Melgaço and Portel municipality, Pará State - Brazil). *Boletim do Museu Paraense Emílio Goeldi* 3: 11–34.
- Netto-Ferreira A, Zanata AM, Birindelli JLO, Sousa LM (2009) Two new species of *Jupiaba* (Characiformes: Characidae) from the rio Tapajós and rio Madeira drainages, Brazil, with an identification key to species of the genus. *Zootaxa* 2262: 53–68.

- Oyakawa OT, Mattox GMT (2009) Revision of the Neotropical trahiras of the *Hoplias lacerdae* species-group (Ostariophysi: Characiformes: Erythrinidae) with descriptions of two new species. *Neotropical Ichthyology* 7: 117–140. doi: 10.1590/S1679-62252009000200001
- Paller MH (1994) Relationships between fish assemblage structure and stream order in South Carolina Coastal plain streams. *Transactions of the American Fisheries Society* 123: 150–161. doi: 10.1577/1548-8659(1994)123<0150:RBFASA>2.3.CO;2
- Pedroza WS, Ribeiro FRV, Teixeira TF, Ohara WM, Rapp Py-Daniel LH (2012) Ichthyofaunal survey of stretches of the Guariba and Roosevelt rivers, in Guariba State Park and Guariba Extractive Reserve, Madeira River basin, Amazonas, Brazil. *Check List* 8: 8–15. <http://www.checklist.org.br/getpdf?SL024-10>
- Peixoto LAW, Dutra GM, Santana CD, Wosiacki WB (2013) A new species of the electric fish genus *Hypopygus* (Gymnotiformes: Hypopomidae) from the lower Amazon Basin, Brazil. *Copeia* 2013: 232–237. doi: 10.1643/CI-12-087
- Raiol RDO, Wosiacki WB, Montag LFA (2012) Fish of the Taiassuí and Benfica river basins, Benevides, Pará (Brazil). *Check List* 8: 491–498.
- Ramos TPA, Ramos RTC, Ramos SAQA (2014) Ichthyofauna of the Parnaíba river basin, northeastern Brazil. *Biota Neotropica* 14: 1–8. doi: 10.1590/S1676-06020140039
- Reis RE (2013) Conserving the freshwater fishes of South America. *International Zoo Yearbook* 47: 65–70. doi: 10.1111/izy.12000
- Reis RE, Kullander SO, Ferraris Jr. CJ (2003) Check list of the freshwater fishes of South and Central America. Edipucrs, Porto Alegre, Brazil, 729 pp.
- Reis RE, Albert JS, Di Dario F, Mincarone MM, Petry P, Rocha LA (2016) Fish biodiversity and conservation in South America. *Journal of Fish Biology*, *in press*.
- Ribeiro FRV, Pedroza WS, Rapp Py-Daniel LH (2011) A new species of *Nemuroglanis* (Siluriformes: Heptapteridae) from the rio Guariba, rio Madeira basin, Brazil. *Zootaxa* 2799: 41–48. doi: 10.13140/2.1.2286.4645
- Roberts TR (1972) Ecology of fishes in the Amazon and Congo Basins. *Bulletin of the Museum of Comparative Zoology* 143: 117–147.
- Román-Valencia C, Ruiz-C RI, Taphorn DC, García-Alzate CA (2014) A new species of *Hemibrycon* (Characiformes, Characidae) from the upper San Juan River drainage, Pacific versant, Colombia. *ZooKeys* 454: 109–125. doi: 10.3897/zookeys.454.6954
- Schleuter D, Daufresne M, Veslot J, Mason NWH, Lanoiselée C, Brosse S, Beauchard O, Argillier C (2012) Geographic isolation and climate govern the functional diversity of native fish communities in European drainage basins. *Global Ecology and Biogeography* 21: 1083–1095. doi: 10.1111/j.1466-8238.2012.00763.x
- Santos GM, Ferreira EJJG (1999) Peixes da bacia Amazônica. In: Lowe-McConnell RH (Ed.) *Estudos ecológicos de comunidades de peixes tropicais*. Edusp, São Paulo, Brazil, 345–354.
- Scarabotti PA, López JA, Pouilly M (2011) Flood pulse and the dynamics of fish assemblage structure from neotropical floodplain lakes. *Ecology of Freshwater Fish* 20: 605–618. doi: 10.1111/j.1600-0633.2011.00510.x
- Schaefer SA (1998) Conflict and resolution: impact of new taxa on phylogenetic studies of the Neotropical cascudinhos. In: Malabarba LR, Reis RE, Vari RP, Lucena ZMS, Lucena CAS

- (Eds) Phylogeny and Classification of Neotropical Fishes. Edipucrs, Porto Alegre, Brazil, 375–400.
- Shannon CE, Weaver W (1963) The mathematical theory of communication. Illinois University Press, Urbana, 177 pp.
- Silva-Oliveira C, Canto ALC, Ribeiro FRV (2015) *Bryconops munduruku* (Characiformes: Characidae), a new species of fish from the lower Tapajós River basin, Brazil. *Zootaxa* 3994(1): 133–141. doi: 10.11646/zootaxa.3994.1.7
- Siqueira-Souza FK, Freitas CEC (2004) Fish diversity of floodplain lakes on the lower stretch of the Solimões River. *Brazilian Journal of Biology* 64: 501–510. doi: 10.1590/S1519-69842004000300013
- SNUC- (Sistema Nacional de Unidades de Conservação da Natureza) (2000) Lei nº 9.985 de 18 de Julho de 2000; decreto nº 4.340 de 22 de agosto de 2002 5ª ed. aum. Brasília MMA/SBF, 2004, 56 pp.
- Sousa LM, Netto-Ferreira AL, Birindelli JLO (2010) Two new species of *Moenkhausia* Eigenmann (Characiformes: Characidae) from Serra do Cachimbo, Pará Northern Brazil. *Neotropical Ichthyology* 8: 255–264. doi: 10.1590/S1679-62252010000200003
- Suárez YR, Lima-júnior SE (2009) Spatial and temporal variation in stream fish assemblages of Guirai River basin, upper Paraná Basin. *Biota Neotropica* 9: 102–111. doi: 10.1590/S1676-06032009000100012
- Teixeira TF, Lima FCT, Zuanon J (2013) A New *Hyphessobrycon* Durbin from the Rio Teles Pires, Rio Tapajós basin, Mato Grosso State, Brazil (Characiformes: Characidae). *Copeia* 2013: 612–621. doi: 10.1643/CI-13-026
- Vari RP (1992) Systematics of the Neotropical Characiform genus *Cyphocharax* Fowler (Pisces, Ostariophysi). *Smithsonian Contributions to Zoology* 529: 1–137. doi: 10.5479/si.00810282.529
- Volcan MV, Lanés LEK, Gonçalves ÂC, da Fonseca AP, Cirne MP (2013) The fish fauna of the Corrientes stream basin, Patos lagoon system, state of Rio Grande do Sul, southern Brazil. *Check List* 8: 77–82. doi: 10.15560/8.1.077
- Walker I (1990) Ecologia e biologia dos igapós e igarapés. *Ciência Hoje* 11: 46–52.
- Zanata AM, Birindelli JLO, Moreira CR (2009) New species of *Moenkhausia* Eigenmann (Characiformes: Characidae) from Rio Xingu and Rio Tapajós basins, Brazil, with comments on a putative case of polymorphic Batesian mimicry. *Journal of Fish Biology* 75: 2615–2628. doi: 10.1111/j.1095-8649.2009.02455.x
- Zuanon J, Bockmann FA, Sazima I (2006) A remarkable sand-dwelling fish assemblage from central Amazonia, with comments on the evolution of psammophily in South American freshwater fishes. *Neotropical Ichthyology* 4: 107–118. doi: 10.1590/S1679-62252006000100012
- Zuanon J, Sazima I (2004) Natural history of *Stauroglanis gouldingi* (Siluriformes: Trycomycetidae), a miniature sand-dwelling candiru from central Amazonian streamlets. *Ichthyological Exploration of Freshwaters* 15: 201–208.

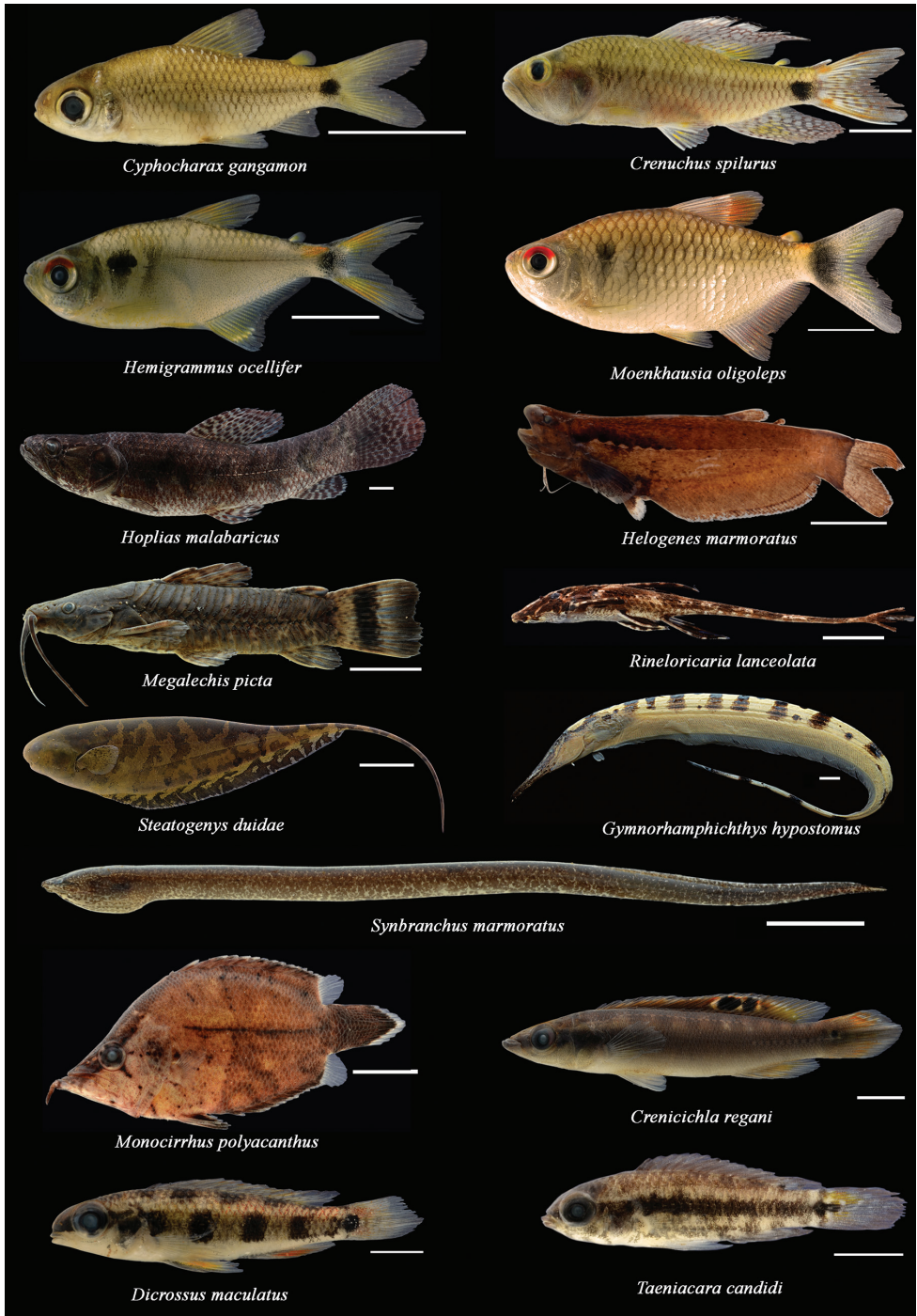
Appendix I

Voucher specimens.

CHARACIFORMES: *Cyphocharax gangamon* (UFOPA-I 00574), *Cyphocharax gouldingi* (UFOPA-I 00459); *Leporinus granti* (UFOPA-I 00444); *Leporinus frederici* (UFOPA-I 00536); *Chilodus punctatus* (UFOPA-I 00455); *Characidium* sp.1 (UFOPA-I 00366); *Characidium* sp. 2 (UFOPA-I 00360, 00424); *Characidium* cf. *zebra* (UFOPA-I 00435, 00454, 00530); *Elachocharax junki* (UFOPA-I 00370); *Crenuchus spilurus* (UFOPA-I 00369, 00595); *Carnegiella strigata* (UFOPA-I 00529); *Astyanax bimaculatus* (UFOPA-I 00511, 00554); *Bryconops* aff. *caudomaculatus* (UFOPA-I 00431); *Bryconops* aff. *melanurus* (UFOPA-I 00365, 00384, 00402, 00432, 00494, 00571); *Bryconops munduruku* (UFOPA-I 00495, 00504); *Bryconop* cf. *imitator* (UFOPA-I 00453, 00606) *Bryconops* sp. (UFOPA-I 00433); *Creagrutus petilus* (UFOPA-I 00437, 00458); *Hemigrammus analis* (UFOPA-I 00577); *Hemigrammus belottii* (UFOPA-I 00521, 00532); *Hemigrammus* sp. (UFOPA-I 00498); *Hemigrammus levis* (UFOPA-I 00579); *Hemigrammus hyanuary* (UFOPA-I 00578); *Hemigrammus ocellifer* (UFOPA-I 00346, 00522, 00533, 00545, 00557); *Hemigrammus stictus* (UFOPA-I 00580); *Hemigrammus vorderwinkleri* (UFOPA-I 00373, 00599), *Hyphessobrycon heterorhabdus* (UFOPA-I 00419, 00464); *Hyphessobrycon* sp. n. (UFOPA-I 00347, 00359, 00407, 00420); *Hyphessobrycon* cf. *agulha* (UFOPA-I 00500); *Iguanodectes variatus* (UFOPA-I 00377, 00389); *Jupiaba acanthogaster* (UFOPA-I 00468); *Jupiaba apenina* (UFOPA-I 00467); *Jupiaba* cf. *potaroensis* (UFOPA-I 00441, 00466); *Jupiaba zonata* (UFOPA-I 00442); *Knodus heteresthes* (UFOPA-I 00395, 00408, 00422, 00443); *Knodus* sp. (UFOPA-I 00514, 00559); *Knodus* cf. *shinahota* (UFOPA-I 00423); *Microscembrycon* sp. (UFOPA-I 00470); *Moenkhausia celibela* (UFOPA-I 00584); *Moenkhausia collettii* (UFOPA-I 00537); *Moenkhausia* cf. *hasemani* (UFOPA-I 00445; 00515); *Moenkhausia comma* (UFOPA-I 00350, 00397, 00426, 00490, 00501, 00509, 00560); *Moenkhausia oligolepis* (UFOPA-I 00446, 00472, 00516, 00538); *Moenkhausia* sp. n. (UFOPA-I 00349, 00396, 00409, 00425, 00489); *Moenkhausia pirauba* (UFOPA-I 00471); *Moenkhausia* sp. (UFOPA-I 00539); *Phenacogaster calverti* (UFOPA-I 00474); *Phenacogaster* sp. (UFOPA-I 00475); *Poptella compressa* (UFOPA-I 00477); *Catoprion mento* (UFOPA-I 00572); *Myloplus rubripinnis* (UFOPA-I 00473); *Acestrorhynchus falcatus* (UFOPA-I 00363, 00451); *Erythrinus erythrinus* (UFOPA-I 00344, 00356, 00386, 00404, 00404, 00404, 00415, 00483, 00555, 00596, 00603); *Hoplias malabaricus* (UFOPA-I 00374, 00418, 00463, 00499, 00513, 00523, 00534); *Hoplias curupira* (UFOPA-I 00604); *Copella nigrofasciata* (UFOPA-I 00367, 00385, 00505, 00594); *Pyrrhulina* cf. *brevis* (UFOPA-I 00398, 00491, 00510, 00524, 00540, 00546, 00551, 00561, 00588); *Nannostomus eques* (UFOPA-I 00586); *Nannostomus* sp. (UFOPA-I 00587); **SILURIFORMES:** *Denticetopsis seducta* (UFOPA-I 00414); *Denticetopsis* sp. (UFOPA-I 00355); *Helogenes marmoratus* (UFOPA-I 00341, 00358, 00362, 00383, 00394, 00406, 00417, 00487, 00497, 00508, 00542, 00549); *Bunocephalus coracoideus* (UFOPA-I 00343); *Bunocephalus knerii* (UFOPA-I 00434);

Ituglanis amazonicus (UFOPA-I 00558); *Trichomycterus hasemani* (UFOPA-I 00592); *Aspidoras* sp. n. (UFOPA-I 00430), *Callichthys callichthys* (UFOPA-I 00512, 00543); *Corydoras* cf. *aprouaguensis* (UFOPA-I-00436, 00456); *Corydoras* sp. (UFOPA-I 00457); *Megalechis picta* (UFOPA-I 00581); *Ancistrus* sp.1 (UFOPA-I 00429); *Ancistrus* sp.2 (UFOPA-I 00452); *Farlowella smithi* (UFOPA-I 00438, 00460); *Farlowella* sp. 1 “juvenile” (UFOPA-I 00461); *Farlowella* sp. 2 (UFOPA-I-00605); Hypostominae sp. “juvenile” (UFOPA-I 00465); *Harttia dissidens* (UFOPA-I 00469); *Curculionichthys* sp. n. (UFOPA-I 00479); *Rineloricaria lanceolata* (UFOPA-I 00606); *Sturisoma* sp. (UFOPA-I 00448); *Batrochoglanis raninus* (UFOPA-I 00411); *Brachyglanis microphthalmus* (UFOPA-I 00401, 00412); *Phenacorhamdia* sp. (UFOPA-I 00439, 00462); *Pimelodella cristata* (UFOPA-I 00447); *Pimelodella* sp. (UFOPA-I 00476); *Rhamdia quelen* (UFOPA-I 00351, 00517); **GYMNOTIFORMES:** *Gymnotus coatesi* (UFOPA-I 00372, 00388, 00485, 00507, 00531, 00597); *Gymnotus coropinae* (UFOPA-I 00345, 00486, 00496, 00520, 00550, 00556); *Eigenmannia trilineata* (UFOPA-I 00393); *Sternopygus macrurus* (UFOPA-I 00428); *Gymnorhamphichthys petiti* (UFOPA-I 00357, 00405, 00416, 00484); *Gymnorhamphichthys hypostomus* (UFOPA-I 00440); *Brachyhyopomus* aff. *beebei* (UFOPA-I 00569); *Hypopygus lepturus* (UFOPA-I 00348, 00375, 00421, 00488, 00535); *Hypopygus benoneae* (UFOPA-I 00381); *Microsternarchus bilineatus* (UFOPA-I 00378, 00570); *Steatogenys duidae* (UFOPA-I 00380, 00601); **CYPRINODONTIFORMES:** *Rivulus urophthalmus* (UFOPA-I 00379, 00390, 00399, 00427, 00502, 00518, 00547, 00552); *Rivulus* sp. (UFOPA-I 00589, 00600); *Fluviphylax* sp. (UFOPA-I 00576); **SYNBRANCHIFORMES:** *Synbranchus marmoratus* (UFOPA-I 00352, 00478, 00492, 00525, 00562, 00591, 00602); **PERCIFORMES:** *Monocirrhus polyacanthus* (UFOPA-I 00585); *Aequidens* sp. (UFOPA-I 00541); *Aequidens tetramerus* (UFOPA-I 00339, 00353, 00361, 00382, 00391, 00400, 00410, 00449, 00480, 00481, 00503, 00519, 00526, 00548, 00553, 00563); *Acaronia nassa* (UFOPA-I 00564); *Apistogramma* cf. *agassizii* (UFOPA-I 00364, 00493, 00565, 00593); *Apistogramma* sp. 1 (UFOPA-I 00342, 00528, 00567); *Apistogramma* sp. 2 (UFOPA-I 00568); *Crenicichla inpa* (UFOPA-I 00340, 00354, 00392, 00403, 00413, 00450, 00482, 00527, 00544); *Crenicichla pellegrini* (UFOPA-I 00506); *Crenicichla regani* (UFOPA-I 00368, 00573); *Dicrossus maculatus* (UFOPA-I 00575); *Hypselecara coryphaenoides* (UFOPA-I 00376); *Satanoperca jurupari* (UFOPA-I 00590); *Taeniacara candidi* (UFOPA-I 00566); *Microphilypnus acanaguara* (UFOPA-I 00582, 00583).

Appendix 2



Some fish species collected in the streams of the Tapajós National Forest, Pará, Brazil. Scale bar 1 cm.