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Ichthyofauna of the upper Juruena river on Chapada dos Parecis, Mato Grosso, Brazil

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Abstract: The fishes herein included were collected in four small streams of the upper rio Tapajós basin. Through fieldwork carried out in 2011, 2013 and 2014 during the low water season 1.728 specimens belonging to 22 species distributed in 11 families, and five orders were captured. Characidae was the most representative family both in number of species and specimens captured. The most abundant species were *Hyphessobrycon melanostichos*, *H. hexastichos*, and *H. notidanos*. Five species are recognized as new, and four as endemic to the upper rio Tapajós basin. This study represents the first fish inventory for the region and will provide valuable information for the conservation of the poorly known diversity of fishes of the Chapada dos Parecis, in the headwaters of the upper rio Tapajós basin.

Keywords: South America, Neotropical fish, Amazon, endemism.

Ictiofauna do alto rio Juruena na Chapada dos Parecis, Mato Grosso, Brasil

Resumo: Os peixes registrados aqui foram coletados em quatro igarapés da bacia do alto rio Tapajós. Expedições realizadas em 2011, 2013 e 2014 durante a estação de seca resultaram na coleta de 1.728 indivíduos pertencendo à 22 espécies distribuídas em 11 famílias e cinco ordens. Characidae foi a família com o maior número de espécies e espécimes capturados. As espécies com maior abundância foram *Hyphessobrycon melanostichos*, *H. hexastichos* e *H. notidanos*. Cinco espécies são reconhecidas como novas e quatro como endêmicas da bacia do alto rio Tapajós. Este trabalho representa o primeiro inventário sobre os peixes da região e fornecerá informações valiosas para a conservação da diversidade pouco conhecida de peixes da Chapada dos Parecis, nas cabeceiras da bacia do alto rio Tapajós.

Palavras-chave: América do Sul, peixe Neotropical, Amazônia, endemismo.

Introduction

The Neotropical region, that includes the South and part of Central America, harbours the most diverse freshwater fish fauna in the world including 5.400 registered species (Reis 2013), with estimates of a final number between 8.000–9.000 species (Schaefer 1998, Reis et al. 2016). Most of this ichthyofaunal diversity is located in the Amazon basin (Amazon, Orinoco and Guiana basins), in which 2.354 (Albert et al. 2011) or 2.411 (Reis et al. 2016) valid fish species are included. Most of the major tributaries of the Amazon river basin, still lack an inventory of their fish species, including the rio Tapajós.

Located in the Brazilian Shield the 1.784 km long, rio Tapajós is one of the largest tributaries of rio Amazonas (Costa 2007). Its upper portion was until recently virtually unknown by ichthyologist (Britski & Lima 2008). However, on the last decades, the collecting activity largely increased in the area, 97 of the 109 species presently known from the rio Tapajós basin having been described in the past 30 years. Currently, approximately 300 fishes are registered from the rio Tapajós basin (Ferreira et al. 1998, Camargo et al. 2005, Silva-Oliveira et al. 2016), but collecting efforts have mostly concentrated on the lower and middle portions of the basin, so that a catalogue of fishes of the upper rio Tapajós basin is still lacking. This contribution represents the first attempt to survey

the fish species of the upper rio Tapajós basin and will certainly provide valuable information for future studies especially on conservation of the poorly known diversity of fishes of the rio Tapajós basin.

Material and Methods

Study Area

The rio Tapajós is formed by the confluence of the Teles Pires and Juruena rivers. The rio Juruena is about 1.240 Km long and is formed by several tributaries draining from the Chapada dos Parecis, an important watershed between three river systems (Madeira, Paraguai and Tapajós river basins) with moderate altitude (750 m), located at the western border of the Brazilian Shield. The rivers in Chapada dos Parecis, tributaries of the rio Juruena (*i.e.* Mutum, 12 de Outubro, Primavera, Camararezinho, Sacre, Formiga, Juína, Sangue), where samples were obtained for this study, are generally rectilinear, embedded and deep, characterized by turbulent waters and presence of many waterfalls. The studied area is about 500 to 510 meters a.s.l., and is located between Comodoro and Vilhena towns, near BR 364 (Figure 1) on the Chapada dos Parecis and are considered headwater streams entering the upper rio Juruena, rio Tapajós basin.

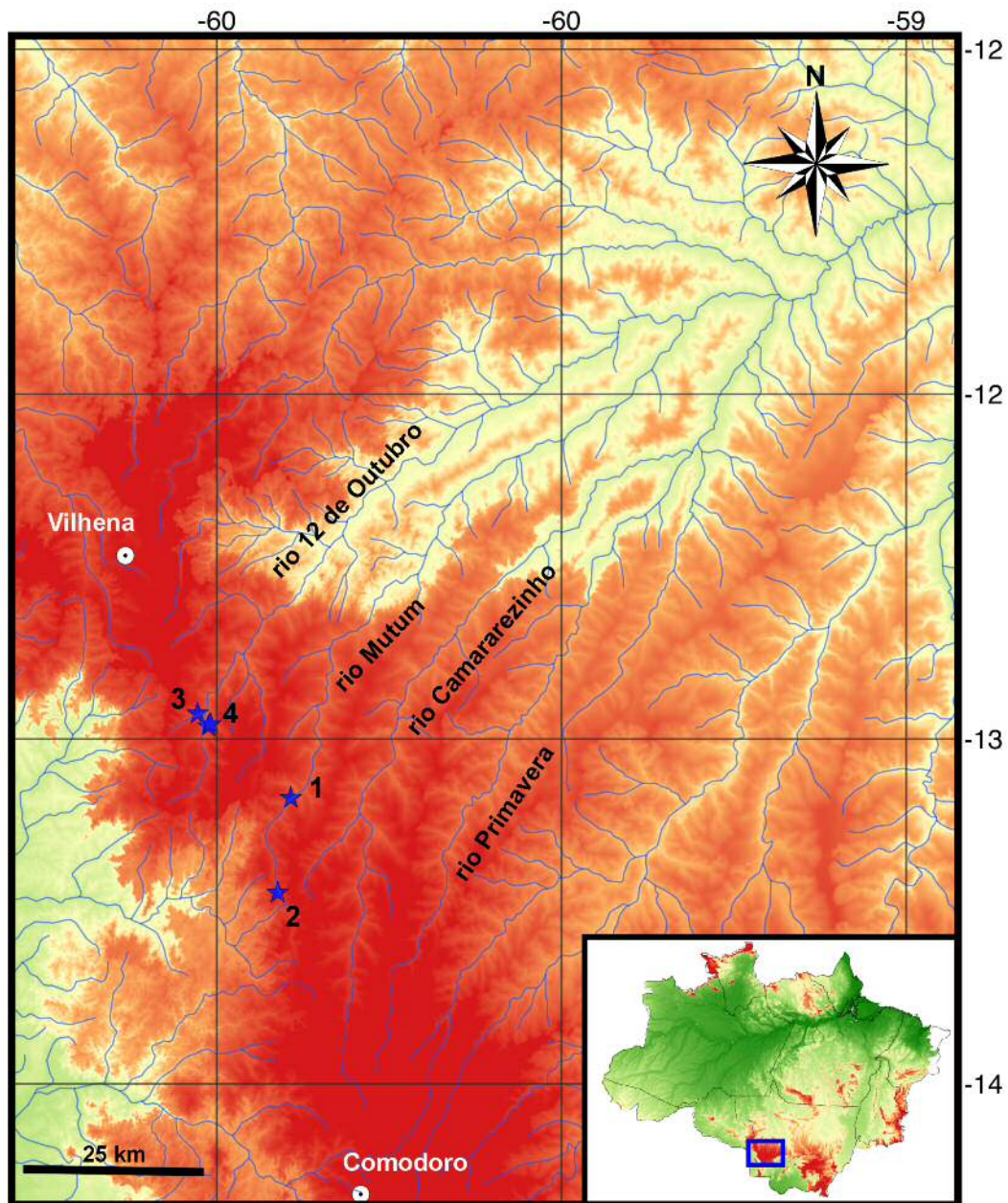


Figure 1. Map of the study area showing the four stations sampled (indicated by number) from the upper rio Juruena, rio Tapajós basin, Mato Grosso, Brazil.

Station 1 (13°05'08"S, 59°53'32"W) - igarapé Mutum located near BR 364, 3-6 m wide and 0.5-2.5 m deep, preserved riparian vegetation, swift current, and sand, pebbles and dead leaves on the bottom (Fig. 2a).

Station 2 (13°13'23"S, 59°54'42"W) - Headwater of igarapé Mutum in flooded portions of the stream due to damming caused by road, 6-8 m wide and 0.5-1.5 m deep, lentic environment, mud and decomposed organic matter on the bottom.

Station 3 (12°58'41"S, 60°00'34"W) - igarapé 12 de Outubro located near BR 364, 2-4 m wide and 0.5-2 m deep, few preserved riparian vegetation, swift current, and sand and dead leaves on the bottom (Fig. 2b).

Station 4 (12°57'50"S, 60°01'40"W) - Tributary of 12 de Outubro located near BR 364, 1-2 m wide and 0.5-1.7 m deep, preserved riparian vegetation, swift current, subaquatic vegetation and sand on the bottom (Fig. 2c).

Sampling

Samples were taken in November 2011, July and August 2013, September and November 2014 in four stations. Sampling took one hour long, and four were undertaken during the day and one during the nocturnal period. The following gears were used: trapezoid hand-nets with area of 1 m² and internode distance of 0.1 cm, seine-nets 3-5 m wide, 1.5-2.5 m deep and internode distance of 1 cm and casting-nets 2.5 m deep, 22 m of circumference and internode distance of 1.5 cm. Photographs were taken in three stations that were georeferenced with a GPS device. Abiotic data such as depth, water transparency and soil were observed *in situ*. No sazonal differences were detected in the abiotic data. Collection permit was granted by Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (registration number IBAMA 83/2012, May 2012-September 2013).

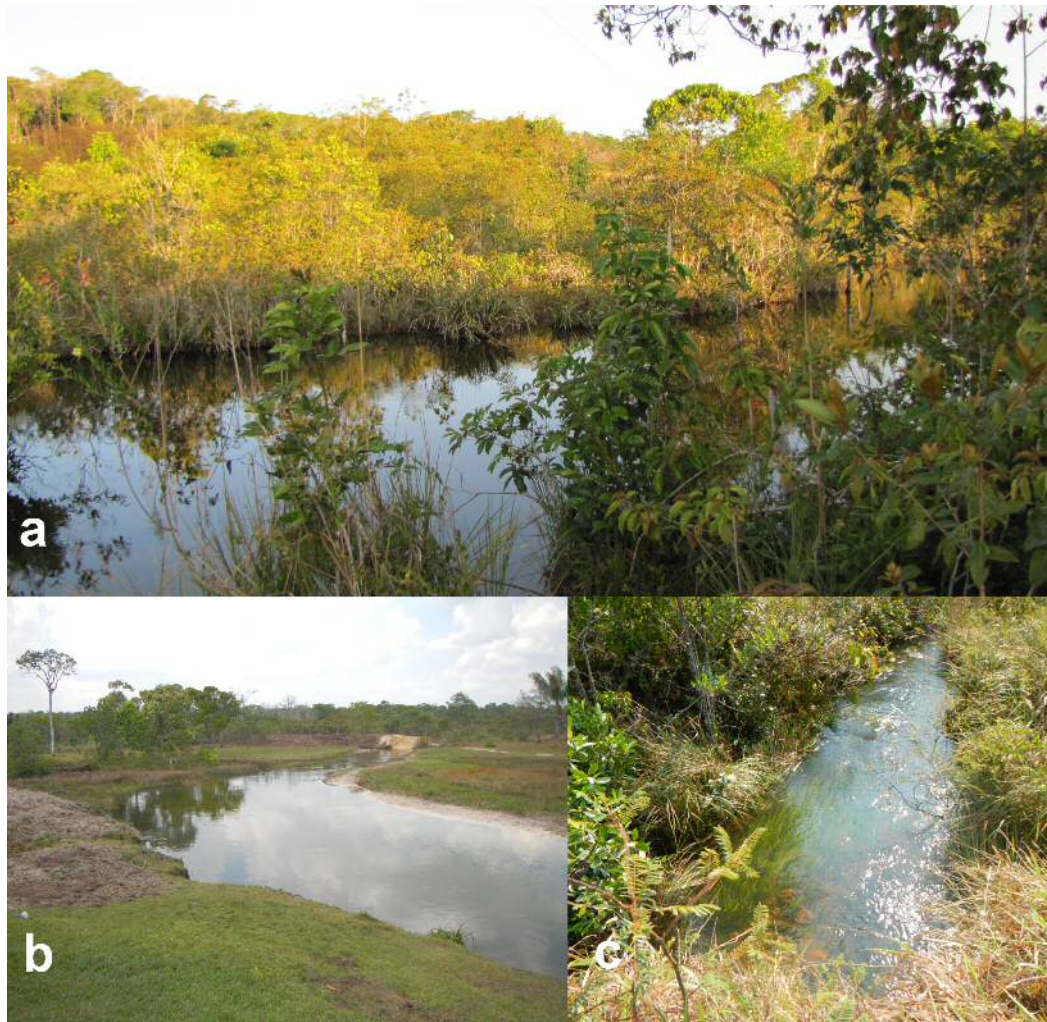


Figure 2. Habitats of three stations sampled from the upper rio Juruena, rio Tapajós basin, Mato Grosso, Brazil. (a) igarapé Mutum; (b) headwaters of igarapé Mutum; (c) igarapé 12 de Outubro; (d) tributary of 12 de Outubro.

The sampled fishes were anesthetized with clove-oil (1ml/liter), put in plastic bags, fixed in 10% formalin for 48 hours and transferred to 70% ethanol. The material was then counted and identified to the lowest possible level using revisionary studies by Bertaco & Malabarba (2007), Bertaco & Carvalho (2005 a, b), Carvalho & Bertaco (2006), Costa (2001), Queiroz et al. (2013), Reis et al. (2005), and comparisons with identified material deposited in the fish collections whenever needed. The classification adopted follows Reis et al. (2003), Wiley & Jonson (2010), and Van Der Laan et al. (2014), with genera listed in alphabetical order within each family. Voucher specimens were deposited in the fish collections of the Museu de Zoologia da Universidade de São Paulo (MZUSP) and the Universidade Federal de Rondônia, Ictiologia (UFRO-I). Species and specimens were counted for each registered species with data organized in Table 1 and Figures 3 and 4.

Results

The species recorded from the upper rio Tapajós basin are listed in Table 1 and the corresponding photos are provided in Figures 3 and 4. A total of 1.728 specimens representing 22 species distributed in 11 families, and five orders were collected in four stations in both the igarapé Mutum and the igarapé 12 de Outubro. Characiformes (55%, 12 species) was the

predominant group, followed by Siluriformes (28%, 6 species), Gymnotiformes (9%, 2 species), Labriformes (4%, 1 species) and Cyprinodontiformes (4%, 1 species) in number of recorded species (Figure 5).

The most representative families considering number of species collected were Characidae (seven species), and Heptapteridae (five species). In terms of captured specimens Characiformes prevailed again (1.498 specimens collected = 86%), followed by Siluriformes (129 specimens collected = 7%), Gymnotiformes and Labriformes (49 specimens each = 3%) and Cyprinodontiformes (3 specimens = 1%) (Figure 6). Characidae includes the three most abundant species recorded from the upper rio Tapajós basin: *Hyphessobrycon melanostichos* Carvalho & Bertaco, 2005, *Hyphessobrycon hexastichos* Bertaco & Carvalho, 2005, and *Hasemania nambiquara* Bertaco & Malabarba, 2007, with 610, 305 and 205 captured specimens respectively, representing 65% of the total captured specimens. On the other hand one single specimen of *Hoplerethrinus unitaeniatus* and *Pimelodella* sp. were recorded. *Moenkhausia* sp. and *Melanorivulus modestus* (Costa, 2001) also presented low abundance, with two and three captured specimens, respectively.

A total of 1.104 specimens belonging to 20 species were recorded from the igarapé Mutum (Stations 1 and 2). The fish fauna is composed by Characiformes (12 species, 913 specimens), Siluriformes (6 species,

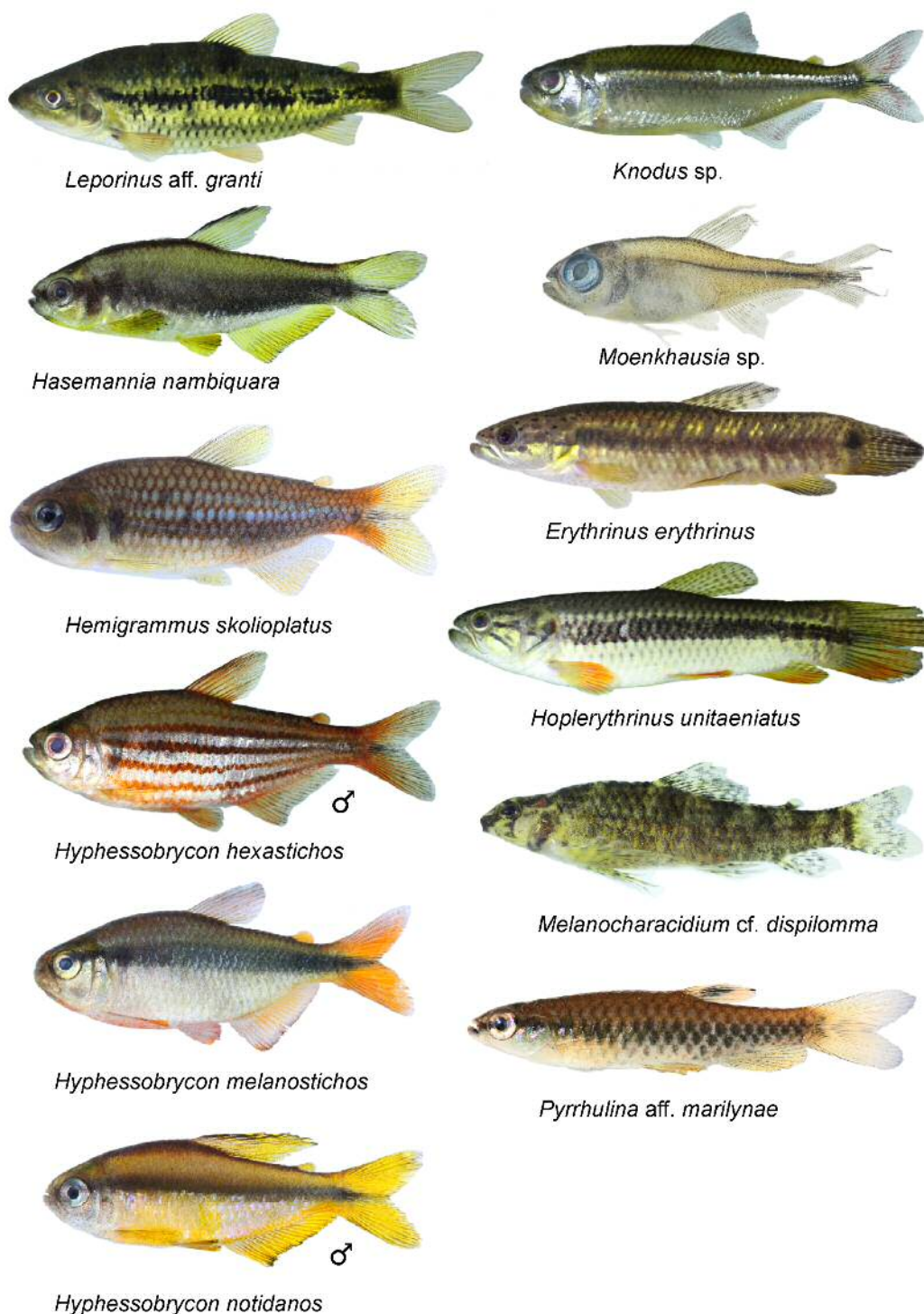


Figure 3. Characiformes registered from the upper rio Juruena, rio Tapajós basin, Mato Grosso, Brazil.

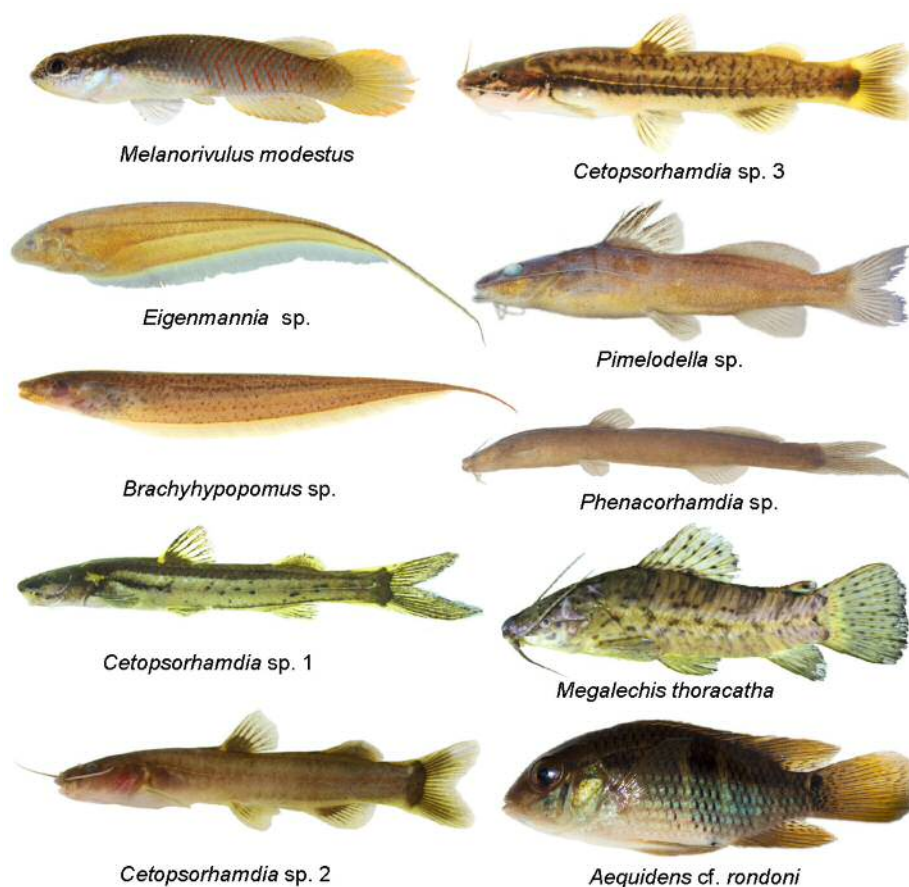
118 specimens), Gymnotiformes (1 species, 40 specimens) and Labriformes (1 species, 33 specimens). No Cyprinodontiformes species was captured in the igarapé Mutum. The most representative families in number of species and specimens were Characidae (seven species), and Heptapteridae (five species). Characidae includes the three most abundant species registered in the igarapé Mutum, *Hyphessobrycon hexastichos*, *Hasemania nambiquara*, and *Hyphessobrycon melanostichos*, with 358, 205 and 189 captured specimens respectively.

Twenty species (90%) with 1.068 captured specimens (62%) were registered in the Station 1. A low number of species and specimens were registered in all the other three stations. The Station 2, the headwater of igarapé Mutum, was represented by eight species (38%) and 36 captured specimens (2%), the lowest values of captured species and specimens herein recorded. Stations 3 and 4 are located in the igarapé 12 de Outubro basin. A total of 624 specimens belonging to 11 species were collected. The fish fauna is composed by Characiformes (6 species, 585 specimens), Siluriformes

Table 1. List of species registered in four stations from the upper rio Juruena, rio Tapajós basin, Mato Grosso, Brazil.

Ordem	Family	Species	Sampling Stations				N	Vouchers	
			1	2	3	4			
Characiformes	Characidae	<i>Hasemania nambiquara</i>	198	7	0	0	205	UFRO-I 12346, 12392, 22736	
		<i>Hemigrammus skolioplatus</i>	1	0	0	11	12	MZUSP 115497	
		<i>Hyphessobrycon hexastichos</i>	356	2	0	0	358	UFRO-I 12297, 12318, 12681	
		<i>Hyphessobrycon melanostichos</i>	180	9	404	17	610	UFRO-I 12281, 12657, 22884	
		<i>Hyphessobrycon notidianos</i>	5	0	2	97	104	MZUSP 115505, 115501	
		<i>Knodus</i> sp.	11	9	9	1	30	UFRO-I 12305, 22844, 22905	
		<i>Moenkhausia</i> sp.	2	0	0	0	2	UFRO-I 22881	
		Erythrinidae	<i>Erythrinus erythrinus</i>	1	1	1	4	7	UFRO-I 22738, 22846
			<i>Hoplerethrinus unitaeniatus</i>	1	0	0	0	1	UFRO-I 22846
		Anostomidae	<i>Leporinus</i> aff. <i>granti</i>	11	0	0	0	11	UFRO-I 12300, 22717
		Crenuchidae	<i>Melanocharacidium</i> cf. <i>dispilomma</i>	113	0	0	0	113	UFRO-I 12656, 22734,
		Lebiasinidae	<i>Pyrrhulina</i> aff. <i>marilynae</i>	1	5	37	2	45	UFRO-I 22718
Siluriformes	Callichthyidae	<i>Megalechis thoracata</i>	11	2	3	2	18	UFRO-I 12684, 22732, 22847	
	Heptapteridae	<i>Cetopsorhamdia</i> sp.1	81	0	0	0	81	UFRO-I 12343, 12682, 22733	
		<i>Cetopsorhamdia</i> sp.2	11	0	0	0	11	UFRO-I 22716	
		<i>Cetopsorhamdia</i> sp.3	4	0	0	6	10	MZUSP 115498, 115478	
		<i>Pimelodella</i> sp.	1	0	0	0	1	UFRO-I 22885	
		<i>Phenacorhamdia</i> sp.	8	0	0	0	8	UFRO-I 22887	
		<i>Aequidens</i> cf. <i>rondoni</i>	32	1	4	12	49	UFRO-I 12277, 12673, 22843	
Labriformes	Cichlidae	<i>Aequidens</i> cf. <i>rondoni</i>	32	1	4	12	49	UFRO-I 12277, 12673, 22843	
	Gymnotiformes	Hypopomidae	<i>Brachyhypopomus</i> sp.n.	0	0	0	9	9	MZUSP 115496
Gymnotiformes	Sternopygidae	<i>Eigenmannia</i> sp.n.	40	0	0	0	40	UFRO-I 12275, 12683, 22737	
	Cyprinodontiformes	Cynolebiidae	<i>Melanorivulus modestus</i>	0	0	3	0	3	MZUSP 115507
Total number of specimens			1068	36	463	161	1728		
Total number of species			20	8	8	10	22		

N = number of registered specimens.

**Figure 4.** Cyprinodontiformes, Gymnotiformes Siluriformes, and Labriformes registered from the upper rio Juruena, rio Tapajós basin, Mato Grosso, Brazil.

(2 species, 11 specimens), Gymnotiformes (1 species, 9 specimens), Labriformes (1 species, 16 specimens) and Cyprinodontiformes (1 species, 3 specimens). The most representative family in number of species and specimens was Characidae, with four recorded species, including the two most abundant species registered in the igarapé 12 de Outubro basin:

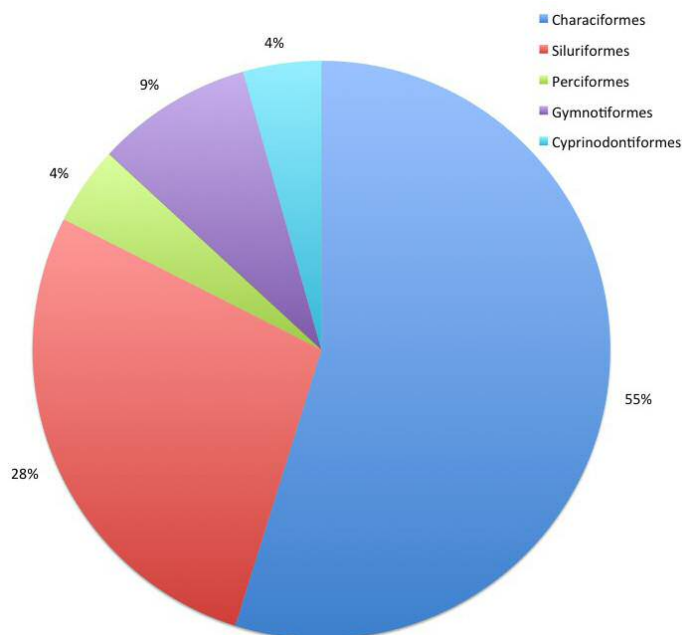


Figure 5. Relative diversity of species among the five orders registered from the upper rio Tapajós basin.

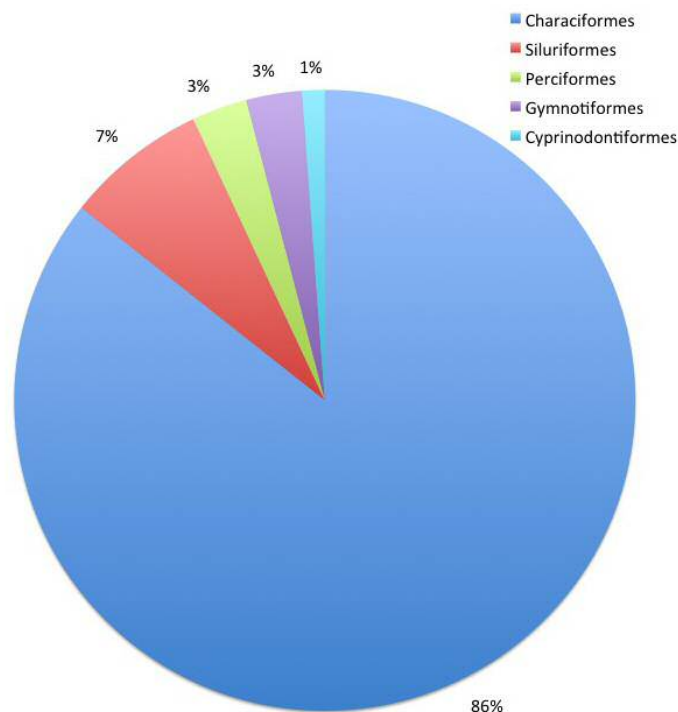


Figure 6. Relative abundance of number of species and number of individuals registered in each sample station in the four stations sampled, upper rio Tapajós basin.

Hyphessobrycon melanostichos and *H. notidanos*, with 421 and 99 captured specimens respectively.

Nine captured species (43%) were identified as “sp.,” including two Characiformes, five (all) Heptapteridae and two (all) Gymnotiformes. Three of the Heptapteridae species, and the two Gymnotiformes species were herein recognized as undescribed species, however more undescribed species herein registered could be recognized in the future with additional research. Moreover, *Cetopsorhamdia* sp.1, *Cetopsorhamdia* sp.2 (Heptapteridae), *Brachyhyopomus* sp.n. and *Eigenmannia* sp.n. (Gymnotiformes) are currently under taxonomic revisions and preliminary examination indicates that they could represent new species endemic for the rio Juruena (Bockmann pers. communication for Heptapteridae and Ohara. personal observation for Gymnotiformes). Other four species (19%) were tentatively identified indicating that more taxonomic studies on the neotropical ichthyofauna are needed.

No threatened species were found, however four endemic species to the upper rio Tapajós basin were recorded. *Melanorivulus modestus*, and *H. nambiquara* are only known from the igarapé Mutum and *Hyphessobrycon notidanos* is only known from the igarapé 12 de Outubro. Even though *Hemigrammus skolioplatus* is known from both the igarapé Mutum and the igarapé 12 de Outubro, it occurs only in a small restricted area.

Discussion

Available literature records about the ichthyofauna of the rio Tapajós basin are primarily concerned with the description of new species (Bertaco & Malabarba 2007, Bertaco & Carvalho 2005a, b, Bertaco & Garutti 2007, Birindelli et al. 2008, Birindelli & Britski 2013, Birindelli et al. 2013, Britski & Garavello 1980, 1993, 2005, 2007, Britski & Lima 2008, Caires & Figueiredo 2011, Caires 2013, Calegari et al. 2013, Carvalho & Bertaco 2006, Castro 1993, Carvalho & Datovo 2012, Campos-da-Paz 2002, Costa 1991, 1994, 2007, Dagosta & Pastana 2014, Dagosta & Netto-Ferreira 2015, Dagosta et al. 2016, Eigenmann 1908, 1917, de Oliveira et al. 2010, 2016, Dutra et al. 2012, Espindola et al. 2014, Fink 1979, Feitosa et al. 2011, Ferreira & Netto-Ferreira 2010, Fichberg et al. 2014, Fink 1979, Fisch-Muller et al. 2005a, b, Géry 1980, Hollanda-Carvalho & Weber 2005, Isbrücker & Nijssen 1989, Kullander 1988, Kullander 1990, Kullander & Ferreira 2006, Langeani 1999, Lima et al. 2007, 2009, 2014, Lima & Flausino 2016, Loeb 2012, Lucena 2003, Lujan et al. 2010, Lundberg & Mago-Leccia 1986, Marinho & Langeani 2010, Marinho & Lima 2009, Marinho et al. 2016a, b, Mendonça et al. 2016, Menezes 1987, 2006, Miranda-Ribeiro 1918, 1920, 1937, Moreira et al. 2002, Netto-Ferreira et al. 2009, Netto-Ferreira & Marinho 2013, Netto-Ferreira, Marinho & Vari 2011, Netto-Ferreira et al. 2014, Nijssen & Isbrücker 1976, 1987, Nijssen 1972, Oyakawa & Mattox 2009, Oliveira & Marinho 2016, Pastana & Dagosta 2014, Pereira & Castro 2014, Roberts 2013, Römer et al. 2010, Sabaj-Pérez & Birindelli 2013, Sarmento-Soares et al. 2013, Silva et al. 2014, Silva et al. 2015, Sousa et al. 2010, Scharcansky & Lucena 2007, Teixeira et al. 2014, 2016, Toledo-Piza et al. 1999, Varella et al. 2012, Vari 1989, Vari & Calegari 2014, Vari 1992, Vari et al. 2005, 2012, Vari & Goulding 1985, Weitzman et al. 2005, Weitzman 1978, Zanata 1997, Zanata et al. 2010, Zawadzki et al. 2015). However, a recent unpublished survey of the fishes from the lower and middle rio Teles Pires basin, recorded 355 species (Ohara & Lima pers. obs.). According to the authors, based on the available literature and the analyses of fish specimens deposited in museums at least 620 species may occur in the rio Tapajós basin, 12% of which are probably endemic.

A comparison of the species herein recorded and the fish assemblage from the lower portion of the rio Tapajós basin was performed based on the available literature (Ferreira et al. 1998, Camargo et al. 2005, Silva-Oliveira et al. 2016) and no common species between two portions was observed. The headwater streams seem to harbor a unique species assemblage

due to observed differences in abiotic factors such as temperature, light, hydrologic regime, water chemistry, substrate type, food resources and species pool influenced by small-scale differences in local conditions (Meyer et al. 2007).

A high number of species and specimens were captured in the igarapé Mutum, with the highest values obtained for the survey undertaken in Station 1, and the lowest values in Station 2. On the other hand, a low number of species and specimens were captured in the igarapé 12 de Outubro. Differences on environmental heterogeneity and presence of riparian vegetation were herein registered, however, the number of species and specimens captured should not be compared within this survey due to the non-standardization of the sampling effort in the field trips.

Four endemic species to the upper rio Tapajós basin were herein registered, including *Hasemania nambiquara*, *Hemigrammus skolioplatus* Bertaco & Carvalho, 2005, *Hyphessobrycon notidanus* and *Melanorivulus modestus*. Although, *Hyphessobrycon hexastichos* and *H. melanostichos* have distribution range apparently restricted to the Chapada dos Parecis, they also were collected in the upper rio Guaporé (13°14'43"S 59°54'26"W), rio Madeira basin and in the igarapé Piracolina (12°49'58"S 60°06'34"W), upper rio Machado, rio Madeira basin (cf. Ohara & Lima 2015, Ohara & Marinho 2016, Ohara et al. 2016), respectively. So *Hyphessobrycon hexastichos* and *H. melanostichos* are not herein considered as endemic species for the upper rio Tapajós. According to Ohara & Lima (2015) a large number of fish species from the upper rio Juruena are found exclusively in the headwater rivers of the Chapada dos Parecis, which suggests that the area has apparently an endemic ichthyofauna that differs from rest of the rio Tapajós basin, including the rio Teles Pires.

Additionally, as stated by Meyer et al. (2007) fish fauna from headwater streams can make a significant contribution to regional fish diversity. The presence of a high number of endemic fish and at least five new species in a small portion of the upper rio Juruena indicates it as a hotspot area for fish diversity, and as such as having potential priority for conservation measures (Carvalho & Bertaco 2006, Britski & Lima 2008, Ohara & Lima 2015).

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Author Contributions

Substantial contribution in the concept and design of the study: WMO

Contribution to data collection: WMO

Contribution to data analysis and interpretation: ML

Contribution to manuscript preparation: WMO; ML

Contribution to critical revision, adding intellectual content: WMO; ML

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