

Fish fauna of moderate altitude from first order stream in upper Rio Machado, Rondônia, Brazil

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Abstract. This study represents an inventory of fish collected in a first order tributary of the Igarapé Piracolina at Chapada dos Parecis, upper Rio Machado drainage, Rio Madeira basin, Vilhena, Rondônia, Brazil. The sampled stream is located in moderate altitudes (570-590) m above sea level and it is the type locality of five recently described species. Through fieldwork carried out in four fieldtrips between 2014 and 2015, 966 specimens were captured belonging to 18 species, distributed in nine families and four orders. Most of these species have a restricted distribution in the upper Rio Machado. Characidae was the most representative family both in number of species and specimens. One species is recognized as new and endemic to the region, and belong to the genus *Pyrrhulina* (Lebiasinidae), while five other species (*Ancistrus verecundus*, *Bryconops piracolina*, *Hypheobrycon lucenorum*, *Moenkhausia cambacica*, and *M. parecis*) are also possibly endemic to the upper Rio Machado basin. In this scenario, our results provide relevant data for the establishment of guiding policies, management decisions and bases for conservation actions in moderate altitude areas of the Amazon basin.

Keywords. Amazon basin; Restricted-range fishes; Inventory; Endemism.

INTRODUCTION

The Neotropic harbours the most diverse freshwater fish fauna in the world, including about 9,100 valid species (Reis *et al.*, 2016). Most of this ichthyofaunal diversity is located within the Amazon basin, where more than 2,400 valid fish species are included (Reis *et al.*, 2016; Jézéquel *et al.*, 2020). In the Rio Madeira, the largest tributary of the Rio Amazonas, about 1,000 fish species are registered (Queiroz *et al.*, 2013a, Ohara *et al.*, 2015) based on collecting efforts concentrated on the Brazilian territory, in the lower and middle portions of the basin and its main tributaries (Rapp Py-Daniel *et al.*, 2007; Perin *et al.*, 2007; Camargo & Giarrizzo, 2007; Pedroza *et al.*, 2012; Queiroz *et al.*, 2013a, b; Costa *et al.*, 2017; Anjos *et al.*, 2019; Oliveira *et al.*, 2020). However, the fish fauna of moderate altitude from headwaters of main rivers of Rondônia State remains practically unknown.

The Rio Machado, also known as Rio Ji-Paraná, is the main clear water tributary of the Rio Madeira in the state of Rondônia, where it drains an area of 75,400 km² (Casatti *et al.*, 2013). Its headwaters are located at the southeastern border of Rondônia at

Chapada dos Parecis, a watershed between three river basins (Madeira, Paraguay and Tapajós). This region is also the type locality of many recently described fish species (Fisch-Müller *et al.*, 2005; Wingert & Malabarba, 2011; Ohara & Lima, 2015; Ohara & Marinho, 2016; Ohara *et al.*, 2016; Bockmann & Reis, 2021; Marinho *et al.*, 2021). The majority of these species seem to have very restricted distribution, since they were not recorded during previous surveys in the Rio Machado basin (*e.g.*, Perin *et al.*, 2007; Casatti *et al.*, 2013; Costa *et al.*, 2017), in other rivers of the Rio Madeira basin (*e.g.*, Rapp Py-Daniel *et al.*, 2007; Araújo *et al.*, 2009; Pedroza *et al.*, 2012; Queiroz *et al.*, 2013a, b; Vieira *et al.*, 2016; Anjos *et al.*, 2019; Oliveira *et al.*, 2020), or in neighboring drainages (Ohara & Loeb, 2016; Ohara *et al.*, 2017). A similar pattern with restricted species has also been mentioned to the Chapada dos Parecis, regarding small fishes from the upper Rio Machado/Guaporé (Rio Madeira basin), upper Rio Juruena (Rio Tapajós basin), and upper Rio Paraguai (Ohara & Lima, 2015).

The inventory of the fish fauna from a tributary of the Igarapé Piracolina, an important tributary of the headwaters of upper Rio Machado, is herein focused. This provides valuable information on

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endemic species, distribution, and altitudinal ichthyo-faunistic composition in a small stream at Chapada dos Parecis. Consequently, the available results will allow comparisons of the diversity of fishes from the headwaters of Amazonian rivers and provide information for the establishment of priority areas for conservation.

Rio Madeira basin, Vilhena, Rondônia, Brazil. It is a clear water stream (1-3 m wide, 0.3-1.5 m deep), swift current and bottom composed mainly of dead leaves and sand, at altitudes ranging about 570-590 meters above sea level (a.s.l.). The collection site is located near the Vilhena town and surrounded by large, cultivated farmlands (Fig. 1).

MATERIAL AND METHODS

Study Area

This survey was carried out in a first order stream, (12°48'57"S, 60°06'37"W) – tributary of the Igarapé Piracolina, located about 3 km from the border of Rondônia and Mato Grosso States, upper Rio Machado,

Fish sampling and species inventory

Two samples were taken in 2013 (July and September) and two in 2014 (September and November), all in a stretch of 50 m long. Fishes were collected with trapezoid hand-nets (1 m² of area and internode distance of 0.1 cm), and seine-nets (3 m wide, 2 m deep and internode distance of 1 cm).

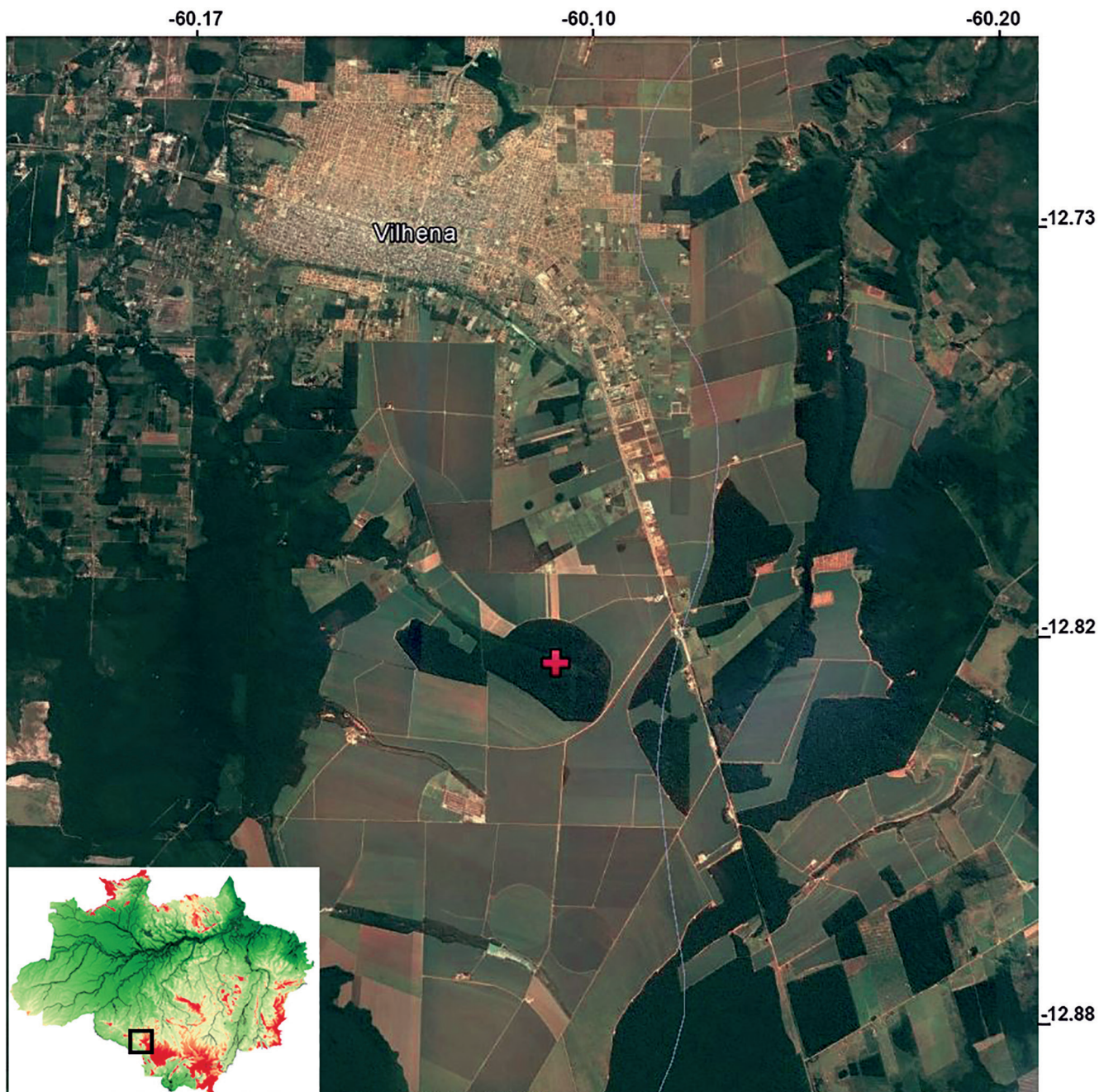


Figure 1. Map of the study area from the upper Rio Machado, Rio Madeira basin, Rondônia, Brazil. The sampled station is indicated by the red plus symbol.

Photographs of habitats were taken in four different places (Fig. 2). Photographs of recently collected fishes were taken in the field, with exception of *Erythrinus erythrinus* (Bloch & Schneider, 1801), *Creagrutus petilus* Vari & Harold, 2001 and *Brachyhypopomus degy* Dutra, Peixoto, Ochoa, Ohara, de Santana, Menezes & Datovo, 2021, which photos were taken from preserved specimens. *Hoplias malabaricus* (Bloch 1794) was not photographed.

Fishes were anesthetized with clove oil (Eugenol, 10 mg per liter, as indicated by the AVMA, 2013), fixed in 10% formalin, and posteriorly transferred to 70% ethanol. Fishes were then counted and identified according Queiroz *et al.* (2013a), Ohara *et al.* (2017) and original description of species (*e.g.*, Wingert & Malabarba, 2011; Fisch-Müller *et al.*, 2005; Ohara & Lima, 2015; Ohara *et al.*, 2016; Ohara & Marinho, 2016). Higher-rank taxonomic classification follows Fricke *et al.* (2022).

Voucher specimens were deposited in the fish collections at the Museu de Zoologia da Universidade de São Paulo (MZUSP) and the Universidade Federal

de Rondônia (UFRO-I), with catalog numbers given in Table 1. The single captured specimen of *Rhamdia quelen* (Quoy & Gaimard, 1824) was not preserved, and consequently, there is no deposited voucher for this species. Collection permit was granted by Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (registration number IBAMA 83/2012, May 2012-September 2013).

The map herein included was generated using Google Earth 7.3.3.7786 and QGIS 3.22.1 softwares.

RESULTS

The species recorded from the first order tributary of the Igarapé Piracolina are listed in Table 1 and corresponding photos are provide in Fig. 3. A total of 966 specimens, belonging to 18 species, distributed in nine families, and four orders were recorded.



Figure 2. Habitats of the sampled station in the upper Rio Machado, Rio Madeira basin, Rondônia, Brazil.

Characiformes was the most representative order with ten species (55.6%), followed by Siluriformes (six species = 33.3%), and Cichliformes and Gymnotiformes (both with one species = 5.6%) (Fig. 4A). Charcaiformes prevailed again with 832 specimens captured (86.1%), followed by Siluriformes with 82 (8.5%), Cichliformes with 41 (4.2%), and Gymnotiformes with 11 specimens (1.1%) (Fig. 4B).

The most representative family was Characidae, with seven species (38.9%), followed by Erythrinidae (11%), Callichthyidae (11%) and Heptapteridae (11%), each with two species (Fig. 5A). Auchenipteridae, Cichlidae, Hypopomidae, Lebiasinidae and Loricariidae were represented each by one species. The most abundant species were: *Hyphessobrycon* aff. *notidanos* Carvalho & Bertaco, 2006, *Moenkhausia parecis* Ohara & Marinho, 2016 and *Bryconops piracolina* Wingert & Malabarba, 2011, with 288,

238 and 123 specimens, respectively (67.2% of all specimens captured). In contrast, a single specimen of *Hoplias malabaricus*, *Moenkhausia cambacica* Marinho, Ohara & Dagosta 2021, *Rhamdia quelen* and *Megalechis thoracata* were recorded (Fig. 5B). *Erythrinus erythrinus* (Bloch & Schneider, 1801), *Creagrutus petilus*, *Brachyhypopomus degy* and *Corydoras hephaestus* Ohara, Tencatt & Britto, 2016 also presented low abundance, each with 12 or less specimens. A full list of collected taxa and the number of individuals for each species is shown on Table 1.

One species was identified is herein indicated as new and awaits a formal description, i.e., *Pyrrhulina* **sp. nov.** (Lebiasinidae) (Ohara, *pers. comm.*), and a preliminary examination indicates that could also represent a new species endemic for the Rio Machado basin. In addition, the taxonomic status of *Aequidens* aff. *rondoni* (Miranda Ribeiro, 1918), and *Hyphessobrycon* cf. *melanostichos*



Figure 3. Fishes registered from the tributary of Igarapé Piracolina, upper Rio Machado, Vilhena, Rondônia. *Bryconops piracolina* (1-2); *Creagrutus petilus* (3); *Hyphessobrycon* aff. *notidanos* (4-5); *H. lucenorum* (6-7); *Hyphessobrycon* cf. *melanostichos* (8); *Moenkhausia parecis* (9); *M. cambacica* (10); *Erythrinus erythrinus* (11); *Pyrrhulina* **sp. nov.** (12-13); *Ancistrus verecundus* (14-15); *Tatia intermedia* (16); *Corydoras hephaestus* (17); *Megalechis thoracata* (18); *Cetopsorhamdia clathrata* (19); *Rhamdia quelen* (20); *Aequidens* aff. *rondoni* (21); *Brachyhypopomus degy* (22); *Hoplias malabaricus* not represented herein.

Table 1. List of species and vouchers registered in the tributary of the Igarapé Piracolina, upper Rio Machado, Rio Madeira basin, Rondônia, Brazil. N = number of registered specimens.

Order/Family/species	Fieldwork				N	Voucher
	1	2	3	4		
Characiformes						
Characidae						
<i>Bryconops piracolina</i> Wingert & Malabarba 2011	69	44	3	7	123	MZUSP 115519, 117061; UFRO-I 22726, 22912
<i>Creagrutus petilus</i> Vari & Harold 2001	5			3	8	MZUSP 115517; UFRO-I 22916
<i>Hyphessobrycon lucenorum</i> Ohara & Lima 2015	28	14	11	17	70	MZUSP 115522, 115556, 117060; UFRO-I 22724, 22909
<i>Hyphessobrycon</i> cf. <i>melanostichos</i> Carvalho & Bertaco 2006	49	6		7	62	MZUSP 115518; UFRO-I 22722, 22908
<i>Hyphessobrycon</i> aff. <i>notidanos</i> Carvalho & Bertaco 2006	200	17	45	26	288	MZUSP 115521, 117068; UFRO-I 22725, 22907
<i>Moenkhausia parecis</i> Ohara & Marinho 2016	167	16	8	47	238	MZUSP 115509, 117066, UFRO-I 22721, 22906
<i>Moenkhausia cambacica</i> Marinho, Ohara & Dagosta 2021	1				1	MZUSP 115277
Erythrinidae						
<i>Erythrinus erythrinus</i> (Bloch & Schneider 1801)			2	3	5	MZUSP 115513, 117069
<i>Hoplias malabaricus</i> (Bloch 1794)				1	1	MZUSP 115514
Lebiasinidae						
<i>Pyrrhulina</i> sp. nov.			13	23	36	MZUSP 115523, 117067; UFRO-I 22917
Siluriformes						
Callichthyidae						
<i>Corydoras hephaestus</i> Ohara, Tencatt & Britto 2016	7	1	4		12	MZUSP 117059; UFRO-I 22728, 22914
<i>Megalechis thoracata</i> (Valenciennes 1840)					1	MZUSP 115515
Loricariidae						
<i>Ancistrus verecundus</i> Fisch-Muller, Cardoso, da Silva & Bertaco 2005	15	1	1	4	21	MZUSP 115516, 117062; UFRO-I 22719, 22915
Heptapteridae						
<i>Cetopsorhamdia clathrata</i> Bockmann & Reis 2021	21		1	8	30	MZUSP 117063, 115512; UFRO-I 22918
<i>Rhamdia quelen</i> (Quoy & Gaimard 1824)	1				1	photo
Auchenipteridae						
<i>Tatia intermedia</i> (Steindachner 1877)	10			7	17	MZUSP 115510; UFRO-I 22723
Gymnotiformes						
Hypopomidae						
<i>Brachyhypopomus degy</i> Dutra, Peixoto, Ochoa, Ohara, de Santana, Menezes & Datovo 2021	8	1	1	1	11	MZUSP 117064, 115520; UFRO-I 22913, 22727
Cichliformes						
Cichlidae						
<i>Aequidens</i> aff. <i>rondoni</i> (Miranda Ribeiro 1918)	26		3	12	41	MZUSP 115511, 117065; UFRO-I 22720
Total number of specimens	607	100	92	167	966	

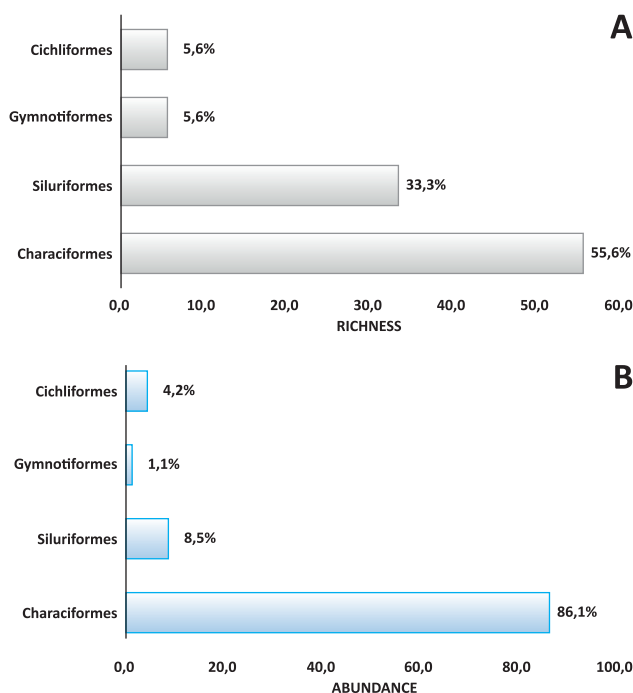


Figure 4. Relative diversity of species (A), and relative abundance of specimens (B) per order registered in the upper Rio Machado basin.

A Carvalho & Bertaco, 2006 still requires taxonomic revision, and *Hyphessobrycon* aff. *notidanos* is currently under taxonomic revision by one of authors (WMO).

DISCUSSION

The survey conducted herein indicates that Characiformes and Siluriformes are the most species-rich orders of the ichthyofauna of the analyzed tributary of the Igarapé Piracolina. This agrees with the Neotropical pattern of composition proposed by Lowe-McConnell (1987), Castro (1999) and Reis *et al.* (2016) in terms of the predominance of Characiformes and Siluriformes in neotropical streams. However, a low number of species of Cichliformes and Gymnotiformes was herein registered in contrast to results obtained by Lowe-McConnell (1987), Castro (1999) and Reis *et al.* (2016). A similar result was obtained by Ohara & Loeb (2016), in a headwater stream of the upper Rio Juruena (Rio Tapajós basin), also situated in the Chapada dos Parecis, indicating that altitudinal streams can have different fish composition and diversity in comparison to the lowland river channels and streams in the Amazon basin.

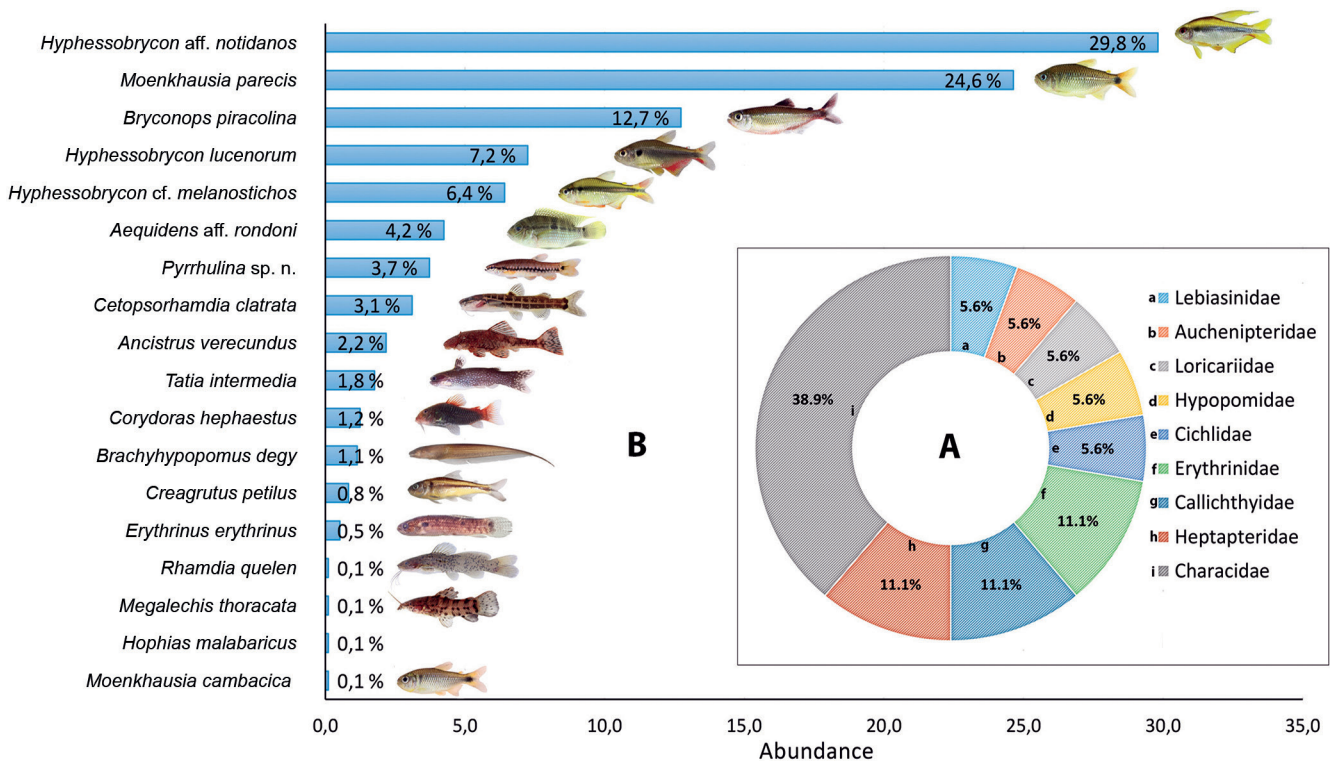


Figure 5. Richness per family (A) and relative abundance of species (B) registered in the upper Rio Machado basin.

Up to the present date, the only previous records of fishes from the upper parts of Rio Machado are those resultants from new species descriptions from the area (Vari & Harold, 2001; Fisch-Müller *et al.*, 2005; Wingert & Malabarba, 2011; Ohara & Lima, 2015; Ohara & Marinho, 2016; Ohara *et al.*, 2016). Some of these species are found exclusively in headwaters of the upper Rio Machado in the Chapada dos Parecis, such as *Ancistrus verecundus* Fisch-Muller, Cardoso, da Silva & Bertaco, 2005, *Bryconops piracolina* Wingert & Malabarba, 2011, *Hyphessobrycon lucenorum* Ohara & Lima, 2015, *Moenkhausia parecis* Ohara & Marinho, 2016, and *M. cambacica* Marinho, Ohara & Dagosta, 2021. Moreover, few species are common to both the upper (Igarapé Piracolina) and the middle Rio Machado, suggesting a different fish composition (see list of species in Perin *et al.*, 2007; Casatti *et al.*, 2013; Costa *et al.*, 2017). The only species shared between upper and middle/lower sections of this river are widespread taxa in the Neotropical region (*Hoplias malabaricus*, *Erythrinus erythrinus*, *Rhamdia quelen*). A similar pattern was found between the upper and lower Rio Tapajós (see Ohara & Loeb, 2016).

As mentioned by Ohara & Loeb (2016), some species with restricted distribution occur exclusively in neighboring hydrographical systems in the Chapada dos Parecis (e.g., in Igarapé Piracolina/Rio Machado and upper Rio Juruena/Rio Tapajós), as *Hyphessobrycon cf. melanostichos* and *Hyphessobrycon aff. notidanos*. *Corydoras hephaestus* described from Igarapé Piracolina was also found in the Rio 12 de Outubro, upper Rio Juruena (MCP 35617), and represent another case of species shared by the Madeira and Tapajós rivers. More recently, *Brachyhypopomus degy* described from upper Rio Juruena (tributaries of 12 de Outubro) and upper Rio

Machado (Igarapé Piracolina) seems to provide additional evidence corroborating a pattern of shared species between Chapada dos Parecis and neighboring drainages (Dutra *et al.*, 2020).

Studies focusing the Amazonian ichthyofaunal diversity are mostly concentrated next to urban areas (e.g., Ferreira *et al.*, 1998; Santos *et al.*, 2006; Mendonça *et al.*, 2005), Conservation Units (cf., Camargo & Giarrizzo, 2007; Oliveira *et al.*, 2020 Pedroza *et al.*, 2012; Vieira *et al.*, 2016; Costa *et al.*, 2017), in the floodplains (cf., Lowe-McConnell, 1999) or in large rivers (Mérona *et al.*, 2004; Queiroz *et al.*, 2013a; Ohara *et al.*, 2017). In addition, some studies have been mentioned high endemism of fish species in Amazon areas at altitudes ranging 500-800 m at Chapada dos Parecis (Ohara & Lima, 2015; Dagosta & de Pinna, 2019), or at Serra do Cachimbo (Birindelli *et al.*, 2009), with the description of new species of restricted distribution. However, the fish fauna composition of altitudes in the Amazon remains little known. In this scenario, additional data on the ichthyofaunal diversity of moderate altitudes of the Chapada dos Parecis are offered herein, bringing new data for establishing guiding policies, management decisions and basis for conservation actions.

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