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.

Introdução

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, Juina, 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.
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 m$^2$ 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 saisonal 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).
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 *Hoplerythrinus 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, 191 specimens), Gymnotiformes (2 species, 84 specimens), Labriformes (1 species, 14 specimens) and Cyprinodontiformes (2 species, 79 specimens).
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.

<table>
<thead>
<tr>
<th>Ordem</th>
<th>Family</th>
<th>Species</th>
<th>Sampling Stations</th>
<th>N</th>
<th>Vouchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characiformes</td>
<td>Characidae</td>
<td><em>Hasemania nambiquara</em></td>
<td>198</td>
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<td>0</td>
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<tr>
<td></td>
<td></td>
<td><em>Hemigrammus skloplatus</em></td>
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<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Hyphessobrycon hexastichos</em></td>
<td>356</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Hyphessobrycon melanostichos</em></td>
<td>180</td>
<td>9</td>
<td>404</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Hyphessobrycon notidianos</em></td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Knodus sp.</em></td>
<td>11</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Moenkhausia sp.</em></td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Hemigrammus skolioplatus</em></td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Hyphessobrycon hexastichos</em></td>
<td>356</td>
<td>2</td>
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<tr>
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<td><em>Hyphessobrycon melanostichos</em></td>
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<td><em>Hyphessobrycon notidianos</em></td>
<td>5</td>
<td>0</td>
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</tr>
<tr>
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<td></td>
<td><em>Knodus sp.</em></td>
<td>11</td>
<td>9</td>
<td>9</td>
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<tr>
<td>Erythrinidae</td>
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<td><em>Erythrus erythrus</em></td>
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<td>1</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td><em>Hoploberythus unitaeniatus</em></td>
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<tr>
<td>Anostomidae</td>
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<td><em>Leporinus aff. granti</em></td>
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</tr>
<tr>
<td>Lebiasinidae</td>
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<td><em>Pyrhulina aff. marilynae</em></td>
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<td>37</td>
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<td>Callichthyidae</td>
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<td><em>Megalobrama thoracata</em></td>
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<td>Heptapteridae</td>
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<td><em>Cetopsorhamdia sp.2</em></td>
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<td></td>
<td><em>Cetopsorhamdia sp.3</em></td>
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<tr>
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<td><em>Pimelodella sp.</em></td>
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</tr>
<tr>
<td></td>
<td></td>
<td><em>Phenacorhamdia sp.</em></td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Labriformes</td>
<td>Cichlidae</td>
<td><em>Aequidens cf. rondoni</em></td>
<td>32</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Gymnotiformes</td>
<td>Hypopomidae</td>
<td><em>Brachyhypopomus sp.n.</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Sternoptygidae</td>
<td><em>Eigenmannia sp.n.</em></td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cyprinodontiformes</td>
<td>Cynolebiidae</td>
<td><em>Melanorivulus modestus</em></td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total number of specimens</td>
<td></td>
<td></td>
<td>1068</td>
<td>36</td>
<td>463</td>
</tr>
<tr>
<td>Total number of species</td>
<td></td>
<td></td>
<td>20</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

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: "Hypheossobrycon 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), "Brachyhypopomus" 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. "Melanorirulus modestus", and "H. nambiquara" are only known from the igarapé Mutum and "Hypheossobrycon 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.

**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.

Discussion


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 namibiiquara*, *Hamigrammus skolioplatus* Bertaco & Carvalho, 2005, *Hyphessobrycon notidans* 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 (13º14'43"S 59º54'26"W), rio Madeira basin and in the igarapé Piracolima (12º49'58"S 60º06'34"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 Juruna 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 Juruna indicates it as a hotspot area for fish diversity, and as such 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

References


Ohara, W.M & Loeb, M.V.


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