Fishes from the Jaru Biological Reserve, Machado River drainage, Madeira River basin, Rondônia State, northern Brazil

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Abstract: This work assessed freshwater fishes collected at 12 stations located along the Tarumã River, middle Machado River, Madeira River basin. The fieldwork took place in May and September 2015 during the high and low water seasons, respectively. We gathered 1,482 specimens representing seven orders, 30 families, 54 genera and 74 species using seine, gill, and hand nets. The family Characidae was the most representative, exhibiting the highest number of species captured. The species with the greatest abundance were Hemigrammus vorderwinkleri, Hyphessobrycon bentosi, Hemigrammus cf. bellottii, Bryconella pallidifrons, and Apistogramma resticulosa. Two species that remained unidentified are probably a new species. This study represents the third fish survey totally conducted at a Conservation Unit in the Rondônia State, and will certainly provide valuable information for future investigations on biodiversity conservation in the Machado River.

Keywords: Amazon, freshwater, conservation, ichthyofauna, inventory.
ichthyofaunal inventory, which may eventually support future studies on fish biology and conservation.

**Material and Methods**

**1. Study area**

The Jarú Biological Reserve (Rebio Jarú) was established on July 11, 1979, under Federal Decree-law number 83,716, and is managed by the Instituto Chico Mendes de Conservação da Biodiversidade/Ministério do Meio Ambiente (ICMBio/MMA). Marked by the high degree of conservation, the rain forest of the Rebio Jarú is practically intact. The reserve has a humid tropical climate with temperatures varying between 23°C and 26°C, and the average annual rainfall ranges from 1,700 to 2,400 mm. The dry season occurs between May and October (Justina 2009).

The Rebio Jarú hydrographic network is part of the Machado River Basin located in eastern Rondônia State, northern Brazil. The Tarumã River, the main sub-basin of the Rebio Jarú, runs almost entirely (99%) within the Rebio Jarú. The average depth of the Tarumã River during the dry season was 2.8 ± 0.9 m; the average width, 32.8 ± 7.8 m; and the average water speed, 0.4 ms⁻¹. On the other hand, the average depth, width, and water flow values are 5.6 ± 1.2 m; 41.9 ± 4.0 m; and 0.3 ± 0.1 ms⁻¹ during the wet season, respectively. The Tarumã River has many rapids flowing across the granitic formation of the Serra da Providência and Jamari complex (Justina 2009). The high transparency of the water (average transparency \( \text{Tr}_{\text{DRY}} = 1.2 ± 2.1 \text{ m} \) and average transparency \( \text{Tr}_{\text{Wet}} = 1.1 ± 0.4 \text{ m} \) due to the low amount of sediment, characterizes the Tarumã as a clear water river.

**2. Data collection**

We performed collections of freshwater fish in the Tarumã River in May and September 2015. Each expedition lasted four days. Our samplings comprised 12 sites in two different aquatic environments: five in the main channel and seven in the small stream channels (igarapés) of the Tarumã River (Table 1, Figure 1).

The physical conditions of some sampling stations in the Tarumã River basin are shown in Figure 2.

Stream 4 (S4) – igarapé, 1.81 m wide and 0.26 m deep, preserved riparian vegetation, swift current, sand, pebbles, and dead leaves at the bottom (Figure 2a).

Stream 6 (S6) – igarapé, 1.39 m wide and 0.21m deep, preserved riparian vegetation, slow current, sand, pebbles, large branches and trunks, and dead leaves at the bottom (Figure 2b).

River 1 (R1) - stretch, 112 m wide and 6.2 m deep located near the mouth of the Tarumã River, preserved riparian vegetation and slow current (Figure 2c).

Stream 5 (S5) – igarapé, 0.70 m wide and 0.25 m deep, preserved riparian vegetation, slow current, sand, pebbles, large branches and trunks at the bottom (Figure 2d).

Stream 3 (S3) – igarapé, 1.00 m wide and 0.21 m deep, preserved riparian vegetation, swift current, sand, bare ravine, large branches and trunks at the bottom (Figure 2e).

River 4 (R4) - stretch, 30 m wide and 4.5 m deep located near the head of the Tarumã River, preserved riparian vegetation, slow current (Figure 2f).

We accomplished the collections in the river channels using a total of eight gill nets with standard size meshes of 2 x 20 m, and fishing nets with mesh sizes varying from 30 to 100 mm (between opposite knots). The fishing nets were set at each sampling site during the morning, from 8:00 am to 12:00 pm, and at night, from 8:00 pm to 5:00 am. For the same period, we used a trotline with four 5/0 hooks with ends tied either to the bank vegetation or to mooring spikes. We used some pieces of piranha, Serrasalmus rhombeus Linnaeus 1766, as baits attached to the trotline hooks.

In small streams, the fish collection in a stretch of 80 m lasted one hour during the daytime. Three collectors used hand gathering techniques with a seine net (1.5 x 2 m, 2 mm mesh) and a hand net (0.5 x 0.8 m, 2 mm mesh) along the entire stretch, selecting the best technique for each environment. Before the collections, the ends of the sampling sections were blocked with fine-mesh nets (5 mm between opposite knots) to prevent fish escapes, regardless of the capture method used. Abiotic data, such as depth, width, and soil were observed in situ. We sacrificed the specimens in a solution of clove oil (Eugenol, 2 drops per liter; cf. American Veterinary Medical Association 2001). After that, the fish were fixed in 10% formalin solution and then preserved in 70% ethanol. For species identifications, we consulted the most currently accepted taxonomic literature and identification keys (Queiroz et al. 2013b). The classification followed Nelson et al. (2016). The specimens were deposited in the Coleção de Peixes, Universidade Federal do Mato Grosso, Cuiabá, MT, Brazil (CPUFMT); Laboratório de Ictiologia de Ribeirão Preto da Universidade de São Paulo, Ribeirão Preto, SP, Brazil (LIRP) and Museu de Zoologia da Universidade de São Paulo, São Paulo, SP, Brazil (MZUSP) (Appendix 1). The fish sampling was authorized by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio, License: 48723–2/2015).

**Results**

Our sampling comprised 1,482 specimens representing seven orders, 33 families, 54 genera, and 74 species. A total of 1,263 specimens representing six orders, 20 families, and 50 species were collected in the streams and 219 specimens; five orders, 13 families, and 24 species were collected in the river (Table 2). Characiformes, Siluriformes, and Cichliformes represented 59% (47 species), 21% (17 species), and 10%

**Table 1. Sampling sites in the Tarumã River basin with environmental classification, geographic coordinates, and altitude.**

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Ichthyofauna from the Tarumã River basin

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http://www.scielo.br/bn

(eight species) of all species, respectively. Nevertheless, Cichliformes were the second most dominant regarding the abundance of capture (6%, n = 101). The Myliobatiformes, Beloniformes, and Synbranchiformes orders showed richness and abundance lower than 4% (n = 6) and 2% (n = 6), respectively (Figure 3). In the streams the Characiformes, Siluriformes, and Cichliformes represented 52% (26 species), 28% (14 species), and 10% (five species) of all species, respectively. Nevertheless, Cichliformes were the second most dominant regarding the abundance of capture (7%, n = 97).

In the river the results were similar to streams, where the Characiformes, Siluriformes, and Cichliformes represented 75% (18 species), 8% (two species), and 8% (two species) of all species, respectively. The other orders showed richness and abundance lower than 6% (Table 2). The families with the highest richness and abundance were Characidae (25 species, 31%; n = 874, 58%), Serrasalmidae (six species, 8%; n = 129, 9%), and Cichlidae (seven species, 9%; n = 100, 7%) (Figure 4). In the stream environment the families with the highest richness and abundance were Characidae (18 species, 36%; n = 1085, 78%), Cichlidae (five species, 10%; n = 97, 7%) and Crenuchidae (four species, 8%; n = 92, 6%), for the river environment the families Characidae (20 species, 5%; n = 208, 50%), Serrasalmidae (21 species, 5%; n = 127, 31%), and Cynodontidae (two species, 8%; n = 23, 5%) were the most representative in richness and abundance. The other families showed richness and abundance lower than 8% (Table 2). *Hemigrammus vorderwinkleri* Géry 1963 (n = 202), *Hyphessobrycon bentosi* Durbin 1908 (n = 196), *Hemigrammus cf. bellottii*

Figure 1. Map of the study area showing the collection stations in the drainage systems in the Jaru Biological Reserve (shaded area), Rondônia, Brazil. Triangles represent streams and circles represent collection points in the river channels of the Tarumã River.
Steindachner 1882 (n = 185), Bryconella pallidifrons Fowler 1946 (n = 147) (n = 100), and Apistogramma resticulosa Kullander 1980 (n = 86) were the most abundant species in the total of specimens collected and these species also were predominant in the stream environment. The species Serrasalmus rhombeus (n = 45), Serrasalmus compressus (n = 30) and Myloplus lobatus (n = 24) were the most abundant in the river environment.

Discussion

Most of the several studies conducted in different portions of the Madeira River Basin in the Brazilian territory have focused either on a relatively small area or on specific tributaries. These investigations identified 122 species from the Jamari River (Santos 1996), 133 from the Marmelos River (Camargo & Giarrizzo 2007), 447 from the Aripuanã and middle Madeira rivers (Py-Daniel et al. 2007), 74 from the Belmont Stream (Araújo et al. 2009), 160 from the Guariba and Roosevelt Rivers (Pedroza et al. 2012), 189 from the Cuniã Lake (Queiroz et al. 2013a), and 174 from the middle Madeira River (Torrente-Vilara et al. 2011). A more comprehensive inventory identified 820 species along the Madeira River Basin (Queiroz et al. 2013b), and 140 species in different tributaries (Casatti et al. 2013). However, contrary to the previously mentioned works, only the present study and the assays of Queiroz et al. (2013a) and Vieira et al. (2016) were conducted entirely in a Conservation Unit in the Rondônia State, resulting in the identification of 74, 189, and 141 species, respectively. The current work contributed 24 species to the general inventory of the Machado River and 26 species to the inventory conducted in Conservation Units in the Rondônia State. Additionally, the material deposited in the Brazilian collections enabled the accomplishment of recent taxonomic studies, which contributed to enhancing the knowledge of the ichthyofauna of both the Madeira River (Rocha et al. 2008a, Rocha et al. 2008b, Zanata & Ohara 2009, Ribeiro et al. 2011, Ohara 2012, Marinho & Ohara 2013, Zanata & Ohara 2015, Ohara & Lima 2015a, Tencatt & Ohara 2016a, Ohara & Neuhaus 2016, Tencatt & Ohara 2016b, Ohara et al. 2016a, Pastana & Ohara 2016), and the Machado River (Ohara & Lima 2015b, Ohara & Marinho 2016, Ohara et al. 2016b).

Figure 2. Habitats of some collection stations in the drainage systems in the Jaru Biological Reserve, Tarumã River Basin, Rondônia, Brazil. (a) stream 4; (b) stream 6; (c) stretch 1 of the river channels; (d) stream 5; (e) stream 3; (f) stretch 4 of the river channels.
Table 2. Fish captured in the Tarumã River, Rondônia, in May and September 2015. Method of collection: T – Trotline, G – Gillnets and S/H – Seine nets (picarés) and hand net (puçá). * Potential for the ornamental fish trade (Brasil 2012), † species additional to species list to studied watershed. Systematic positions were based on Nelson et al. (2016).

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**SILURIFORMES**

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<td>Nemuroglanis furcatus Ribeiro, Pedroza &amp; Rapp Py-Daniel, 2011*</td>
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<td>Pimelodella howesi Fowler 1940</td>
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<td>Pseudopimelodidae</td>
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<td>Doradidae</td>
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<td>Physopyxis lyra Cope 1871</td>
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<td>Loricariidae</td>
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<td>Pimelodidae</td>
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<tr>
<td>Platyneumathlyths notatus Jardine 1841*</td>
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**GYMNOTIFORMES**

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<td>Hypophyglea leptura Hoedeman 1962*</td>
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<td>Beloniformes</td>
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<td>Potamophis guianensis Jardine 1843*</td>
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**SYNBRANCHIFORMES**

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**CICHLIFORMES**

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<td>Crenicara punctulatum Günther 1863*</td>
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<td>Crenicichla regani Ploeg 1980*</td>
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<td>Crenicichla santosi Ploeg 1991*</td>
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<td>Cichla pleiozona Kulander &amp; Ferreira 2006</td>
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<td>Satanoperca jurupari Heckel 1840*</td>
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**ACANTHURIFORMES**

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<td>Sciaenidae</td>
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<tr>
<td>Petiilipinnis grunniens Jardine &amp; Schomburgk 1843*</td>
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</table>

Some rare species, considered as such due to their absence in most major ichthyological collections, were recorded in the Tarumã River. These included the Characiformes *Axelrodia stigmatias* Fowler 1913, *Bario steindachneri* Eigenmann 1893, *Clupeocharax guaporensis* Zanata & Toledo-Piza 2004, *Creagrutus anary* Fowler 1913, and *Hemigrammus melanochrous* Fowler 1913, the Siluriformes, *Nemuroglanis furcatus* Ribeiro, Pedroza & Rapp Py-Daniel, 2011, and the Cichliformes, *Crenicichla santosi* Ploeg 1991. Two taxa were provisionally identified, due to their uncertain taxonomic status. They may be records of new species, such as *Microcharacidium* sp. (Crenuchidae) and *Ancistrus* sp. (Loricariidae). We emphasize that none of the sampled species are on the IUCN Red List.

Several species were discriminated with the use of “cf” or “aff”, indicating that the number of new species may be higher. For example, the species identified herein as *Brycon* cf. *pesu* Müller & Troschel 1845 belongs to a complex of species, where new species are undergoing a description process (Zanata & Lima pers. comm.). Several species, namely, *Hemigrammus bellottii*, *Phenacogaster retropinnus* Lucena & Malabarba 2010, *Characidium* cf. *pellucidum* Eigenmann 1909, *Characidium aff. zebra* Eigenmann 1909, *Corydoras armatus* Günther 1868, and *Corydoras* cf. *trilineatus* Cope 1872, belong either to poorly known taxonomic groups or represent still undescribed species, meaning that further taxonomic studies will be necessary.

Our work highlights the importance of conducting studies within protected areas and strengthens the role of territorial spaces with relevant environmental characteristics in a context where only three inventories within 14 Conservation Units in Rondônia have taken place. The presence of protected areas may help mitigate environmental impacts and maintain the biological integrity of a region surrounded by a long history of anthropogenic
disturbances (deforestation, gold mining, the construction of the BR 364 road and, more recently, the building of large hydroelectric dams).

Appendix 1
Voucher specimens.

**MYLIOBATIFORMES:** Potamotrygon falkneri*; **CHARACIFORMES:** Aicestrorhynchus falcatus (MZUSP 118769, MZUSP 118812), Aicestrorhynchus falcicostris (UFRO-I 5523, UFRO-I 18313), Axelorichia stigmatias (MZUSP 118772, MZUSP 118786), Bario steindachneri (MZUSP 118734), Bryconella pallidifrons (MZUSP 118744, MZUSP 118791, MZUSP 118874, MZUSP 118759), Brycon amazonicus (MZUSP 14017), Brycon cf. pesu (LIRP 11773, UFRO-I 14213, UFRO-I 15506), Brycon falcatus (LIRP 13045, 10269), Chalcus guaporensis (UFRO-I 4321, UFRO-I 17475), Creagrutus anary (MZUSP 118745, MZUSP 118779), Hemigrampus ocellifer (MZUSP 118738, MZUSP 118767, MZUSP 118798, MZUSP 118725), Hemigrampus cf. bellottii (MZUSP 118765, MZUSP 118790, MZUSP 118733), Hemigrampus melanochrous (MZUSP 118743, MZUSP 118802, MZUSP 118726), Hemigrampus analis (MZUSP 118581, MZUSP 118788), Hemigrampus vorderwinkleri (MZUSP 118766, MZUSP 118794), Hyphessobrycon aguilha (MZUSP 118785, MZUSP 118742, MZUSP 118970), Hyphessobrycon copeandi (MZUSP 118763), Hyphessobrycon bentoixi (MZUSP 118764, MZUSP 118972), Hyphessobrycon svegesi (MZUSP 118732), Jiaparia zonata (MZUSP 118762), Moenkhausia oligolepis (MZUSP 118753), Moenkhausia mikia (MZUSP 118755), Moenkhausia colletti (MZUSP 118770), Phenacogaster cf. retropinnus (MZUSP 118754, MZUSP 118789), Roeboideus affinis (CPUFMT 3393), Triportheus albus (CPUFMT 3398), Carnegiella strigata, Roeboides affinis

**ACANTHIDIFORMES:** Hyphessobrycon bentosi, Phenacogaster caribensis, Prochilodus nigricans, Triportheus albus

**HYMODONIDAE:** Heteropneustes fossilis (MZUSP 118767, MZUSP 118798, MZUSP 118736, MZUSP 118721, MZUSP 118805), Microcharacidium aff. aff. (MZUSP 118758, MZUSP 118788), Microcypris brevis (MZUSP 118735, MZUSP 118767, MZUSP 118798, MZUSP 14017), Microglanis poecilus

**CICHLIFORMES**

**BONY»


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