Ichthyofauna from tributaries of Urubu and Amazonas rivers, Amazonas State, Brazil

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Abstract: The Amazonas River basin comprises the world’s highest fish species diversity. Anthropogenic interferences in aquatic environments represent a pressure over the maintenance of ecological stability and biodiversity. We inventoried the ichthyofauna of 13 disturbed/modified tributaries of Urubu and Amazonas rivers in the region of the middle Amazon River, between June 2018 and March 2019. A total of 164 species were captured, represented by 11 orders, 37 families and 96 genera. Characiformes was the richest order, followed by Cichliformes and Siluriformes. The most representative families in number of species were Cichlidae, Serrasalmidae, and Characidae. Hemigrammus levis was the most abundant species, and Acarichthys heckelii the most common, registered in all sampled sites. In the present study, species with economic interest were collected, as well as many species recently described and one still waiting for formal description, identified provisionally as Moenkhausia aff. colletii. Therefore, the high fish diversity registered, even in disturbed environments in Middle Amazonas River, denotes the makeable ecological importance of this region for fishes resources and supports the necessity of evaluation of other aquatic environments in the region, as well as the potential impacts on composition, maintenance, and survival of ichthyofauna in environments directly affected by human activities.

Keywords: Amazon fish, Environmental impacts, Ichthyofauna diversity, Inventory.

Ictiofauna de afluentes dos rios Urubu e Amazonas, Estado do Amazonas, Brasil

Resumo: A bacia do rio Amazonas compreende a maior diversidade de espécies de peixes do mundo. Interferências antropogênicas em ambientes aquáticos representam uma pressão sobre a manutenção da estabilidade ecológica e da biodiversidade. Inventariamos a ictiofauna de 13 afluentes perturbados/modificados dos rios Urubu e Amazonas na região do médio do rio Amazonas, entre junho de 2018 e março de 2019. Foram capturadas 164 espécies no total, representadas por 11 ordens, 37 famílias e 96 gêneros. Characiformes foi a ordem mais rica, seguida por Cichliformes e Siluriformes. As famílias mais representativas em número de espécies foram Cichlidae, Serrasalmidae e Characidae. Hemigrammus levis foi a espécie mais abundante e Acarichthys heckelii a mais comum, registrada em todos os locais amostrados. No presente estudo foram coletadas espécies de interesse econômico, bem como muitas espécies recentemente descritas e uma ainda aguardando descrição formal, identificada provisoriamente como Moenkhausia aff. colletii. Portanto, a alta diversidade de peixes registrada, mesmo em ambientes perturbados no médio rio Amazonas, denota a importância ecológica marcante dessa região para os recursos pesqueiros e suporta a necessidade de avaliação de outros ambientes aquáticos da região, bem como os possíveis impactos na composição, manutenção e sobrevivência da ictiofauna em ambientes diretamente afetados pelas atividades humanas.

Palavras-chave: Diversidade da ictiofauna, Impactos ambientais, Inventário, Peixes amazônicos.
Introduction

The Amazonas River basin is the world’s largest watershed (Goulding et al. 2003), and has an area over 8,000,000 km² (Sioli 1984). The associated channels and wetlands support high values of primary and secondary productivity (Junk 2013). This complex landscape harbors the highest diversity of freshwater fishes in the world, with more than 2,700 species currently considered valid (Dagosta & Pinna 2019). During the rain forest annual flooded pulse, the combination of flat terrain and variable rivers and streams discharge allows the presence of large areas of wetlands and floodplain forest (Junk 1970), resulting in a dynamic complex of seasonally flooded areas with marked ecological importance (Junk et al. 2011).

Unfortunately, the structure and function of Amazon freshwater ecosystems are being increasingly impacted by crecent human activities and territorial modifications (Castello et al. 2013). The main impacts evidenced are roads construction and expansion (Jones et al. 2000, Barber et al. 2014, Smith et al. 2018), deforestation (Renó et al. 2011, Barber et al. 2014, Inomata et al. 2018), construction and installation of hydroelectric dams (Junk et al. 2007, Alho 2015, Hurd et al. 2016, Reis et al. 2016, Inomata et al. 2018), pollution (Castello et al. 2013), and overfishing (Alho 2015, Inomata et al. 2018).

Itacoatiara is a municipality of Amazonas State, Brazil, situated on left bank of Amazon River, located downstream the confluences of Madeira and Urubu rivers, and upstream the confluence of Uatumã River. This region is drained by a complex fluvial system, composed of streams, channels, and lakes that integrate black and clearwater environments like igapós and campinaranas, as well as a vast area of floodplain enriched by alluvial deposits of rivers of white waters such as the Amazonas and Madeira (Cavallini 2014). The municipality is connected to Manaus by the road AM-010, which caused many impacts and even interrupted the course of some drainages of the region.

Despite the great diversity and the increase of anthropogenic pressures, studies on fish fauna of the region are usually concentrated on species with commercial interest. Smaller species, despite their high contribution of biomass and richness are subsampled, resulting in lack of knowledge to be filled with future studies (Barletta et al. 2010). Still, some rivers, like Urubu, remains poorly understood in terms of ichthyofauna composition, with few reports of species occurrence in the basin, rare cases of endemism and little information about species distribution (Dagosta & Pinna 2019). Thus, the aim of this investigation is to present an inventory of the ichthyofauna from watercourses from Urubu and Amazonas drainages near Itacoatiara.

Material and Methods

1. Study area

The city of Itacoatiara is drained by a complex fluvial system directly affected by the flood pulse (Figure 1). It is located in the left margin of...
Amazon River, upstream of the main connection between the Amazonas River and Canaçari Lake, and just downstream of the Amazonas-Madeira rivers confluence (Abril et al. 2014). The Canaçari Lake possesses clearwater and connects the Amazonas and Urubu rivers. It is disconnected from flooded forest most of the year, but during high water levels of Amazonas and Madeira rivers it is reconnected to these rivers (Polsenenare et al. 2013). Approximately 12 km from its confluence with the Amazonas River, the Urubu River suffers a 90° inflection and its main course becomes parallel to the Amazonas River. On left margin it receives two tributaries, Caru and Anebá rivers, that drain into the Canaçari Lake. This lake is, in turn, connected to Uatumã River (Cavallini, 2014) (Figure 1). Both the Urubu and Uatumã rivers are clearwater basins that originate from the old plateaus of Guyana Shield and carry a lighter sediment load, are more acid and less productive than whitewater rivers (Hurd et al. 2016).

The west border of urban area of Itacoatiara is also influenced upstream by Serpa Lake, which is a tributary of Amazonas River. However, most of the connections between Serpa Lake and Amazonas River were barred due to roads construction (AM-010 and local roads), and the main connection with Amazonas River was barred and limited to a small artificial channel (close to site 4, Figure 2). In the flooded season the water flows from Amazonas River to Serpa Lak through this channel, and in the dry season the water flow suffers an inversion. During flood season connections between Serpa and Canaçari lakes can also appear. Most of the lakeshore has steep edges and is occupied by rural population.

The sampling occurred in 13 sites in the rural area of Itacoatiara (Figures 2 and 3, and Table 1). Sites 1 to 4 are located in Serpa Lake. Site 1 is the farthest from Amazon River and the nearest from Urubu River. This site is isolated from other parts of the lake during dry season, by coverage of aquatic plants (*Montrichardia arborescens* Schott). Sites 2 and 3 represent intermediate portions of the lake, and site 4 is closer to the lake connection with Amazonas River and farthest from Urubu River.

The remaining seven sampled sites (5, 7, 9, 10, 11, 12, and 13) are watercourses dammed by AM0-010 road, since its construction in the late 1960s. Trees stumps and wood debris are found in the bottom of these sites, the margins are flat and are subject to different impacts, such as deforestation, pasture, overfishing and recreational use. All these sites are tributaries of Urubu River (5, 6, 9, 10, and 11) or Canaçari Lake (7, 8, 12, and 13). Sites 6 and 8 are stream stretches downstream the barrier from sites 5 and 7, respectively.

Figure 2. Map of the study area showing the sampled sites (black dots) on tributaries of Amazonas and Urubu rivers, in Middle Amazonas river basin, in Itacoatiara, Amazon State, Brazil.
Figure 3. Collecting sites (a) Serpa lake 1 (Site 1), (b) Serpa lake 2 (Site 2), (c) Serpa lake 3 (Site 3), (d) Serpa lake 4 (Site 4), (e) Km 24 stream (Site 5), (f) Km 24 stream (Site 6), (g) Km 8 lake (Site 7), (h) Km 8 stream (Site 8), (i) Km 13 lake (Site 9), (j) Km 13 lake (Site 10), (k) Km 13 lake (Site 11), (l) Almeida lake (Site 12) and (m) Km 6 lake (Site 13).
Table 1. Description of sampling sites on tributaries of Amazonas and Urubu rivers, in middle Amazonas river basin, Brazil.

| Site          | Local          | Coordinates          | Characteristics/ use of the margin areas                                      | Deep and extension                      |
|---------------|----------------|----------------------|-------------------------------------------------------------------------------|-----------------------------------------|
| 1             | Serpa lake     | 3°05'11.9”S 58°30'25.3”W | Lake’s northwest side; connection to Urubu river (water input); emerging aquatic macrophytes; subsistence fisheries; moderate humans impacts | 5.48 meters deep and 170 meters between the shores in samplings station |
| 2             | Serpa lake     | 3°04'55.6”S 58°29'47.2”W | Northwest-middle section of the lake; subsistence fisheries; marginal and floating habitations; intense navigation. | 5.90 meters deep and 270 meters between the shores in samplings station |
| 3             | Serpa lake     | 3°05'53.4”S 58°28'47.6”W | Middle section of the lake; subsistence fisheries; marginal and floating habitations. | 8.10 meters deep and 170 meters between the shores in samplings station |
| 4             | Serpa lake     | 3°07'12.3”S 58°28'12.6”W | Southeast section of the lake; connection to Amazonas river (water output in droughts and water input in floods). | 5.20 meters deep and 120 meters between the shores in samplings station |
| 5             | AM-010 km 24   | 3°02'39.1”S 58°35'40.8”W | Artificial lake connected to Caru river (stream dammed by AM-010 road). | 2.5 meters deep and 53,800 m² of surface area |
| 6             | AM-010 km 24   | 3°02'34.4”S 58°35'41.3”W | Tributary of Caru river; moderate human impacts. | 1.50 meters deep and 10 meters between the shores in samplings station |
| 7             | AM-010 km 8    | 3°04'03.3”S 58°28'05.4”W | Artificial lake connected to Canaçari lake (stream dammed for recreational use). | 1.7 meters deep and 12,700 m² of surface area |
| 8             | AM-010 km 8    | 3°03'30.2”S 58°27'35.9”W | Tributary of Canaçari lake; moderate human impacts. | 1.50 meters deep and 5 meters between the shores in samplings station |
| 9             | AM-010 km 13   | 3°02'49.1”S 58°29'53.5”W | Artificial lake connected to Urubu river (stream dammed by AM-010 road). | 3.1 meters deep and 336,700 m² of surface area |
| 10            | AM-010 km 13   | 3°02'53.3”S 58°29'47.4”W | Artificial lake connected to Urubu river (stream dammed by local road); disabled aquaculture site; pastures on lakeshore. | 2.9 meters deep and 59,900 m² of surface area |
| 11            | AM-010 km 13   | 3°02'41.6”S 58°29'44.5”W | Artificial lake connected to Urubu river (stream dammed by local road); suppressed riparian forest; pastures on lakeshore. | 2.2 meters deep and 20,600 m² of surface area |
| 12            | Almeida lake   | 3°04'27.6”S 58°26'27.7”W | Artificial lake connected to lake Canaçari (stream dammed by local road); recreational use. | 2.5 meters deep and 71,100 m² of surface area |
| 13            | AM-010 km 6    | 3°05'19.0”S 58°27'42.8”W | Artificial lake connected to lake Canaçari; seasonally connected to Serpa lake (on floods); suppressed riparian forest; pastures on lakeshore. | 4.5 meters deep and 96,000 m² of surface area |

2. Data collection and analysis

The samples were taken in June, September and November 2018, and March 2019. In sites 5, 7, 9, 10, 11, and 12 the fishes were collected using gill nets with different mesh sizes (20, 30, 40, 60, 80, 100, and 120 mm), and also a seine net (1.3 high and 10-meter-long, mesh size 5 mm) was used in the shallow littoral habitats of these sites. In sampling sites in Serpa lake (sites 1, 2, 3, and 4) only the gill nets were used, and in sample sites 6 and 8 (streams stretch) seine net and/or sieves with mesh size of 2 mm were used. All the specimens collected were anesthetized in benzocaine hydrochloride, fixed with formalin 10% solution and preserved in 70% ethanol for taxonomic identification. Voucher specimens were deposited in fish collection of Instituto National de Pesquisas da Amazônia (INPA).

Nomenclatural arrangement and classification of family and higher levels followed Betancur-R. et al. (2017). Sub-families of Acestrorhynchidae, Characidae, Auchenipteridae, and Loricariidae followed Oliveira et al. (2011), Mirande (2018), Birindelli (2014), and Armbruster (2004), respectively. The classification of families and subfamilies were presented in alphabetical order as consequence of incogluence between molecular and morphological phylogenetic proposes, or lack of resolution of relationships between them. Identification follows Géry (1960), Weitzman & Cobb (1975), Kullander (1986), Ploeg (1991), Vari (1992), Langeani (1996), Weitzman & Palmer (1997), Zarske & Géry (1999), Lasso & Machado-Allison (2000), Merckx et al. (2000), Toledo-Piza (2000), Machado-Allison (2002), Staeck (2003), López-Fernández & Taphorn (2004), Malabarba (2004), Chernoff & Machado-Allison (2005), Santos et al. (2006), Bleher et al. (2007), Sarmento-Soares & Martins-Pinheiro (2008), Sousa (2010), Costa (2011), Mendonça & Wosiacki (2011), Queiroz et al. (2013), Menezes & Lucena (2014), Peixoto et al. (2015), Walsh et al. (2015), Marinho & Langeani (2016), Ota et al. (2016), Marinho & Menezes (2017), Melo & Oliveira (2017), Ribeiro et al. (2017), Mateussi et al. (2018), and de Souza et al. (2019).
All collect individuals and species were listed and quantified for each sampling site. The relative abundance in percentage was estimated for each site through the percentage of fish collected in each site in relation of the total collected. Richness for each sampling site was defined by the total number of species registered in each site.

Results
A total of 164 species were captured (Table 2), distributed in 11 orders, 37 families and 96 genera. The orders with the highest number of species were Characiformes (56.7%, 93 species) followed by Cichliformes (17.1%, 28 species) and Siluriformes (16.4%, 27 species).

Table 2. Taxonomic classification of fishes collected in tributaries of Amazonas and Urubu rivers, in middle Amazonas river basin, Brazil. Localities: 1 – Serpa lake, 2 – Serpa lake, 3 – Serpa lake, 4 – Serpa lake, 5 – Km 24 stream, 6 – Km 24 stream, 7 – Km 8 lake, 8 – Km 8 stream, 9 – Km 13 lake, 10 – Km 13 lake, 11 – Km 13 lake, 12 – Almeida lake and 13 – Km 6 lake.

| Classification | Locality | Voucher INPA |
|----------------|----------|--------------|
| **TELEOSTEI**  |          |              |
| **ACTINOPTERI**|          |              |
| **OSTEOGLOSSIFORMES** | | |
| Osteoglossidae | | |
| Osteoglossum bicirrhosum (Cuvier, 1829) | 3,4 | 58811 |
| **CLUPEIFORMES** | | |
| Engraulidae | | |
| Anchoviella carrikeri Fowler, 1940 | 4 | 58810 |
| Anchoviella guianensis (Eigenmann, 1912) | 4, 5, 6, 9, 10, 11 | 57918 |
| Lycengraulis batesii (Günther, 1868) | 4 | 58883 |
| Pristigasteridae | | |
| Pellona flavipinnis (Valenciennes, 1837) | 4 | 58875 |
| **CHARACIFORMES** | | |
| Acestrorhynchiidae | | |
| Acestrorhynchinae | | |
| Acestrorhynchus falcatus (Bloch, 1794) | 8 | 58827 |
| Acestrorhynchus falcirostris (Cuvier, 1819) | 1, 2, 3, 4, 5, 12, 13 | 58971 |
| Acestrorhynchus salinae Menezes & Géry, 1983 | 8 | 58825 |
| Acestrorhynchus microlepis (Jardine, 1841) | 5, 6, 8, 13 | 58790 |
| Acestrorhynchus minimus Menezes, 1969 | 5, 6, 8, 9, 13 | 57902 |
| Acestrorhynchus cf. pantaneiro | 4 | 58850 |
| Heterocharacinidae | | |
| Gnathocharax steindachneri Fowler, 1913 | 6 | 58844 |
| Heterocharax macrolepis Eigenmann, 1912 | 12, 13 | 57882 |
| Heterocharax virgulatus Toledo-Piza, 2000 | 5, 8, 9, 10, 13 | 57922 |
| Hoplocharax goethei Géry, 1966 | 8 | 58834 |
| Anostomidae | | |
| Laemolyta taeniata (Kner, 1858) | 2, 3, 4 | 58817 |
| Leporinus fasciatus (Bloch, 1794) | 2, 3, 4, 6, 8 | 58814 |
| Leporinus friderici (Bloch, 1794) | 1, 2 | 58867 |
| Leporinus klausswitzi Géry, 1960 | 6, 8 | 58831 |
| Rhytiodus microlepis Kner, 1858 | 2, 3, 4 | 58880 |
| Schizodon fasciatus Spix & Agassiz, 1829 | 2, 3, 4 | 58881 |
| Bryconidae | | |
| Brycon amazonicus (Agassiz, 1829) | 3 | 58922 |
| Brycon melanopterus (Cope, 1872) | 3, 4 | 58857 |
| Chalceidae | | |
| Chalteaus erythrurus (Cope, 1870) | 2, 3, 4 | 58813 |
| Classification       | Locality | Voucher INPA |
|----------------------|----------|--------------|
| **Characidae**       |          |              |
| Characinae           |          |              |
| Charax condei (Géry & Knöppel, 1976) | 6, 8, 9 | 57921 |
| Roeboides myersii Gill, 1870 | 4, 6 | 58830 |
| **Stethaprioninae**  |          |              |
| Hemigrammus analis Durbin, 1909 | 5, 6, 8, 9, 12, 13 | 57891 |
| Hemigrammus bellottii (Steindachner, 1882) | 6, 8, 9, 10, 12 | 57917 |
| Hemigrammus coerules Durbin, 1908 | 5, 6, 7, 8 | 58826 |
| Hemigrammus diagonalis Mendonça & Wosiacki, 2011 | 5, 8, 12 | 57881 |
| Hemigrammus levis Durbin, 1908 | 5, 6, 7, 8, 9, 10, 11, 12, 13 | 57912 |
| Hemigrammus aff. melanochrous | 12 | 57880 |
| Hemigrammus ocellifer (Steindachner, 1882) | 12 | 58803 |
| Hemigrammus stictus (Durbin, 1909) | 6, 7, 8, 5, 9, 10, 12, 13 | 57915 |
| Hyphessobrycon bentosi Durbin, 1908 | 6 | 58836 |
| Hyphessobrycon eques (Steindachner, 1882) | 4 | 57924, 58846 |
| Moenkhausia aff. colletti | 12 | LBP 26690 |
| Moenkhausia cf. cotinho | 6 | 58835 |
| Moenkhausia lepidura (Kner, 1858) | 9 | 58805 |
| Moenkhausia mikia Marinho & Langeani, 2010 | 8 | 57932 |
| **Chilodontidae**    |          |              |
| Chilodus punctatus Müller & Troshel, 1844 | 6, 8 | 57930, 58824 |
| **Crenuchidae**      |          |              |
| Crenuchus spirarius Günther, 1863 | 8 | 58842 |
| **Ctenoluciidae**    |          |              |
| Boulengerella maculata (Valenciennes, 1850) | 3, 4, 5, 6 | 58792 |
| **Curimatidae**      |          |              |
| Curimatella alburnus (Müller & Troshel, 1844) | 6 | 58829 |
| Curimatopsis cryptica Vári, 1982 | 5 | 57933 |
| Curimatopsis evelynaes Géry, 1964 | 6, 7 | 58821 |
| Curimatopsis macrolepis (Steindachner, 1876) | 5, 6, 7, 8, 12 | 57883 |
| Curimatopsis pallida Melo & Oliveira, 2017 | 8 | 58833 |
| Cyphocharax abramoides (Kner, 1858) | 9, 5, 10, 11 | 57900 |
| Cyphocharax leucostictus (Eigenmann & Eigenmann, 1889) | 4 | 58860 |
| Cyphocharax plumbeus (Eigenmann & Eigenmann, 1889) | 5, 6, 8 | 57927 |
| Cyphocharax spiluros (Eigenmann & Eigenmann, 1889) | 8, 9 | 58804, 58849 |
| Potamorhina latior (Spix & Agassiz, 1829) | 4 | 58877 |
| Psectrogaster essequibensis (Günther, 1864) | 2, 3, 4 | 58878 |
| **Cynodontidae**     |          |              |
| Rhaphiodon vulpinus Spix & Agassiz, 1829 | 2, 3, 4 | 58812 |
| **Erythrinidae**     |          |              |
| Hoplias malabaricus (Bloch, 1794) | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 58795 |
| **Gasteropelecidae** |          |              |
| Carnegella strigata (Günther, 1864) | 8 | 58843 |
| Classification        | Locality | Voucher INPA |
|-----------------------|----------|--------------|
| **Hemiodontidae**     |          |              |
| Anodus elongatus      | 2, 4     | 58852        |
| Hemiodus argenteus    | 4        | 58867        |
| Hemiodus gracilis     | 6, 8, 9, 13 | 57919     |
| Hemiodus immaculatus  | 2, 3, 4  | 58815        |
| Hemiodus unimaculatus | 6, 9     | 58802        |
| Hemiodus sp. 1        | 2, 3, 4  | 58864        |
| Hemiodus sp. 2        | 4        | 58865        |
| **Iguanodictidae**    |          |              |
| Bryconops caudomaculatus | 5, 6, 7, 8 | 57895    |
| Bryconops giacopinii  | 4        | 58808        |
| Bryconops melanurus   | 6, 7, 8, 9, 13 | 57896    |
| Iguanodectes spilurus | 8        | 58846        |
| **Lebiasinidae**      |          |              |
| Copella callolepis    | 12       | 57894        |
| Copella nattereri     | 5, 6, 7, 8 | 58807    |
| Nannostomus digrammus | 5, 6, 8, 9, 10, 12, 13 | 57892    |
| Nannostomus eques     | 5, 6, 8, 9, 10, 12, 13 | 57901    |
| Nannostomus harrisoni | 6, 8, 10, 12 | 57893    |
| Pyrrhulina cf. australis | 5, 6, 8, 9, 10, 11, 12, 13 | 57885    |
| **Prochilodontidae**  |          |              |
| Semaprochilodus       | 2, 4     | 58927        |
| Semaprochilodus       | 2, 3     | 58928        |
| **Serrasalmidae**     |          |              |
| Catoprion mento       | 3, 4, 5, 8, 9, 10, 13 | 57920    |
| Colossoma macropomum  | 12       | 58793        |
| Metynnis altidorsalis | 3, 4     | 57911        |
| Metynnis guaporensis  | 3        | 58938        |
| Metynnis hypsauchen   | 3        | 57910        |
| Metynnis lippincottianus | 1, 3, 4, 7, 8, 9, 10, 12, 13 | 57884, 58818 |
| Metynnis luna         | 4        | 57909        |
| Metynnis maculatus    | 7, 8     | 58818        |
| Metynnis melanogrammus | 6, 8, 9  | 57925        |
| Myloplus aff. asterias| 3        | 58873        |
| Mylossoma albiscopum  | 3, 4     | 58874        |
| Pygocentrus nattereri | 2, 3, 4  | 58879        |
| Pygopristis denticulata | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 57899    |
| Serrasalmus altispinis | 3, 4     | 58929        |
| Serrasalmus compressus | 2, 3, 4  | 58931        |
| Serrasalmus eigenmanni | 4, 8     | 58820        |
| Serrasalmus maculatus | 4        | 58933        |
| Serrasalmus rhombeus  | 2, 3     | 58932        |
| Serrasalmus spilopleura | 3, 4    | 58930        |
| **Triportheidae**     |          |              |
| Triportheus albus     | 3, 4     | 58935        |
| Triportheus auritus   | 2, 3, 4  | 58937        |
| Triportheus rotundatus | 3, 4     | 58936        |
### Classification

| Classification          | Locality | Voucher INPA |
|-------------------------|----------|--------------|
| **GYMNOTIFORMES**       |          |              |
| **Hypopomidae**         |          |              |
| *Brachyhypopomus brevirostris* (Steindachner, 1868) | 5, 7, 8, 10 | 57929 |
| *Brachyhypopomus* sp.   | 1, 3, 4  | 58934 |
| **Sternopygidae**       |          |              |
| *Eigenmannia mairapinima* Peixoto, Dutra & Wosiacki, 2015 | 7, 8, 9, 10, 11 | 57907 |
| **SILURIFORMES**        |          |              |
| **Auchenipteridae**     |          |              |
| **Auchenipterinae**     |          |              |
| *Ageneiosus dentatus* Kner, 1858 | 4 | 58855 |
| *Ageneiosus inermis* (Linnaeus, 1766) | 4 | 58863 |
| *Ageneiosus lineatus* Ribeiro, Rapp Py-Daniel & Walsh, 2017 | 1, 2, 3, 4 | 58882 |
| *Auchenipterichthys coracoideus* (Eigenmann & Allen, 1942) | 9, 11 | 58800 |
| *Auchenipterus nuchalis* (Spix & Agassiz, 1829) | 4 | 58853 |
| *Trachelyichthys exilis* Greenfield & Glodek, 1977 | 5, 6, 9, 13 | 57923 |
| *Trachelyopterichthys taeniatua* (Kner, 1858) | 3 | 58868 |
| *Trachychoristis porosus* Eigenmann & Eigenmann, 1888 | 2, 3, 4 | 58876 |
| *Tympanopleura atronasus* (Eigenmann & Eigenmann, 1888) | 4 | 58854 |
| *Tympanopleura rondoni* (Miranda Ribeiro, 1914) | 2, 4 | 58862 |
| **Centromochilinae**    |          |              |
| *Tatia nigra* Sarmento-Soares & Martins-Pinheiro, 2008 | 2 | 57906 |
| *Tatia strigata* Soares-Porto, 1995 | 58840 |
| **Callichthyidae**      |          |              |
| *Hoplosternum litorale* (Hancock, 1828) | 2, 4 | 58816 |
| **Doradidae**           |          |              |
| *Anadoras grypus* (Cope, 1872) | 3 | 58856 |
| *Oxydoras niger* (Valenciennes, 1821) | 9, 11 | 58787 |
| **Heptapteridae**       |          |              |
| *Rhamdia quelen* (Quoy & Gaimard, 1824) | 10, 11 | 58801 |
| **Loricariidae**        |          |              |
| **Hypostominae**        |          |              |
| *Ancistrus dolichopterus* Kner, 1854 | 1, 2, 4 | 58851 |
| *Dekeyseria amazonica* Rapp Py-Daniel, 1985 | 3 | 58861 |
| **Loricariinae**        |          |              |
| *Loricariichthys acutus* (Valenciennes, 1840) | 2, 3 | 58871 |
| *Loricariichthys* sp.   | 2, 4 | 58872 |
| **Pimelodidae**         |          |              |
| *Calophysus macropterus* (Lichtenstein, 1819) | 4 | 58925 |
| *Hemisorubim platyrhynchos* (Valenciennes, 1840) | 4 | 58924 |
| *Hypophthalmus edentatus* Spix & Agassiz, 1829 | 2, 3, 4, 11 | 58789 |
| *Pimelodus blochii* Valenciennes, 1840 | 4 | 58869 |
| *Pinirampus pirinampu* (Spix & Agassiz, 1829) | 4 | 58926 |
| *Pseudoplatystoma tigrinum* (Valenciennes, 1840) | 2 | 58923 |
| *Sorubim elongatus* Littmann, Burr, Schmidt & Isern, 2001 | 2, 4 | 58884 |
| **GOBIIFORMES**         |          |              |
| **Eleotridae**          |          |              |
| *Microphilypnus ternetzi* Myers, 1927 | 5, 8, 13 | 57928 |
### Classification

| Order            | Family                      | Species                                | Locality       | Voucher INPA |
|------------------|-----------------------------|----------------------------------------|----------------|--------------|
| SYNBRANCHIFORMES | Synbranchidae               | Synbranchus sp.                        | 5, 6, 9, 10    | 57903        |
|                  | CICHLIFORMES                |                                        |                |              |
|                  | Cichlidae                   | Acarichthys heckelii (Müller & Troschel, 1849) | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 57914        |
|                  |                              | Acaronia nassa (Heckel, 1840)          | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 57887        |
|                  |                              | Aequidens pallidus (Heckel, 1840)      | 5              | 58806        |
|                  |                              | Aequidens tetramerus (Heckel, 1840)    | 10, 11, 12, 13 | 58798        |
|                  |                              | Apistogramma agassizii (Steindachner, 1875) | 7, 10, 12 13   | 57904        |
|                  |                              | Apistogramma gephyra Kullander, 1980   | 8              | 58839        |
|                  |                              | Apistogramma pertensis (Haseman, 1911) | 8, 10, 11, 12  | 57908        |
|                  |                              | Biotocclus opercularis (Steindachner, 1875) | 8, 10, 11, 12, 13 | 57905        |
|                  |                              | Cichla monoculus Spix & Agassiz, 1831  | 2, 5, 7, 8, 9, 10, 11, 12, 13 | 58796        |
|                  |                              | Cichla temensis Humboldt, 1821         | 2, 3, 4, 5, 9, 10, 12, 13 | 58794        |
|                  |                              | Crenicichla lenticulata Heckel, 1840   | 1, 5, 10, 13   | 58797        |
|                  |                              | Crenicichla lugubris Heckel, 1840      | 4              | 58858        |
|                  |                              | Crenicichla regani Ploeg, 1989         | 7              | 58823        |
|                  |                              | Crenicichla sp.                        | 4              | 58859        |
|                  |                              | Geophagus altifrons Heckel, 1840       | 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 57886        |
|                  |                              | Heros spurtus Heckel, 1840             | 4, 10, 11, 12, 13 | 57890        |
|                  |                              | Hypelecura coryphaenoides (Heckel, 1840) | 8              | 58838        |
|                  |                              | Hypelecura temporalis (Günther, 1862)  | 5, 8, 9, 10, 11, 12 | 58799        |
|                  |                              | Laetacara thayeri (Steindachner, 1875) | 6, 7, 8, 5, 9, 10, 11, 12, 13 | 57888        |
|                  |                              | Mesonauta festivus (Heckel, 1840)      | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 57916        |
|                  |                              | Pterophyllum scalare (Schultz, 1823)   | 4, 8           | 58809        |
|                  |                              | Satanoperca acuticeps (Heckel, 1840)   | 1, 3, 4, 8, 9, 10, 11, 13 | 57888        |
|                  |                              | Satanoperca jurupari (Heckel, 1840)    | 2, 4, 5, 9, 12, 13 | 57931        |
|                  |                              | Satanoperca lilith Kullander & Ferreira, 1988 | 1, 2, 3, 4, 5, 6, 7, 9, 10,11, 12 | 57898        |
|                  |                              | Symphysodon discus Heckel, 1840        | 1              | 57897        |
|                  |                              | Taeniacara candidi Myers, 1935         | 7, 8, 13       | 57926        |
|                  |                              | Uaru amphiacanthoides Heckel, 1840     | 11, 12         | 58788        |
|                  | CYPRINODONTIFORMES          |                                        |                |              |
|                  | Fluviphylacidae             |                                        |                |              |
|                  |                            | Fluviphylax pygmaeus (Myers & Carvalho, 1955) | 5, 6, 8        | 58819        |
|                  | Rivulidae                   |                                        |                |              |
|                  | Anablepsoides ornatus (Garman, 1895) | 8                                      | 58837         |
|                  | BELONIFORMES                |                                        |                |              |
|                  | Belonidae                   |                                        |                |              |
|                  |                            | Belonion dibranchodon Collette, 1966   | 6              | 58828        |
|                  |                            | Potamorrhaphis guianensis (Jardine, 1843) | 8              | 58832        |
|                  | PERCIFORMES                 |                                        |                |              |
|                  | Polycentridae               |                                        |                |              |
|                  |                            | Monocirrhus polyacanthus Heckel, 1840  | 8              | 58822        |
|                  |                            | Sciaenidae                             |                |              |
|                  |                            | Plagioscion squamosissimus (Castelnau, 1855) | 4              | 5887         |
The most representative families were Cichlidae (28 species), Serrasalmidae (19 species), and Characidae (16 species). In terms of genera, the families that were most representative were Cichlidae (17 genera), Serrasalmidae and Auchenipteridae (both with eight genera).

The most common species were Acarichthys heckelii, Geophagus altifrons, Mesonauta festivus, Satanoperca lilith, and Pygopristis denticulata (Figure 3). Important species for commercial aquarium trade like Monocirrhus polyacanthus (site 8), Symphysodon discus (site 1), Pterophyllum scalare (sites 4 and 8) (Figure 4) and species of genera Apistogramma (sites 7, 8, 10, 11, and 13), and Nannostomus (sites 5, 6, 8, 9, 10, 12 and 13) were registered. Additionally, important species for fisheries were captured, like Brycon amazonicus, Cichla monoculus, C. temensis, Colossoma macropomum, Osteoglossum bicirrhosum, Semaprochilodus insignis, and S. taeniurus. One species that remains unknown for science, but is in process of formal description, identified as Moenkhausia aff. colletii was registered in site 12 (Figure 4).

The most abundant species in this study were Hemigrammus levis (62.1%), Hemigrammus stictus (8.7%), and Acarichthys heckelii (3.3%), the last one was very abundant in the barred watercourses (sites 5, 7, 9, 11, 12, and 13). The sites with the lowest relative abundance were located in Serpa Lake. The site 12 presented the highest relative abundance (Figure 5). In number of species, the sites with the highest and lowest number were site 4 and 1, respectively (Figure 6).

**Discussion**

The predominance of Characiformes, Siluriformes and Cichliformes corroborates the pattern observed for freshwater environments in South America (Lowe-Mcconnell 1999, Siqueira-Souza & Freitas 2004, Fernandes et al. 2012, Freitas et al. 2013, Queiroz et al. 2013,
Hemigrammus ocellifer, popularly known as tetras or piabas, were captured in the present study, as rivers (Anjos et al. 2009). Besides the ciclids, many species of Characidae, such as Semaprochilodus fish markets, as the popularly known as jaraquis (registered by us in this study, some of them very common in Itacoatiara Pimelodus of only 6 to 12 species, such as Hyphessobrycon eques, Hyphessobrycon rosaceus, and Apistogramma and market like filamentous algae and terrestrial invertebrates (Bayley 1988). 

Approximately 100 million ornamental fish were exported from the beautiful color patterns, small size and are commonly found in aquariums. Many species having opportunistic diet resistant to environmental disturbances standing out over other species sensitive to disorders (Santos & Ferreira 1999, Oliveira & Bennemann 2005). A representative species of this pattern is Acarichthys heckelii that was registered in all sampling sites, with makeable abundance in the barred watercourses (sites 4, 5, 7, 9, 11, 12, and 13). Thus, the habitat changing due to damming and flow modification in sites along AM-010 and the connection between Serpa Lake and Amazonas River may provide favorable conditions to ciclids survival. Nevertheless, sampling using seine nets in the shallow littoral habitats in these sites should increased the number of ciclids, due to its feeding habitats that includes aquatic invertebrates, detrital macrophytes, filamentous algae and terrestrial invertebrates (Bayley 1988).

Among the ciclids collected, some species are important in aquarium market like Symphysodon discus, Pterophyllum scalare, Mesonauta festivus, and Apistogramma spp. Species of this family are exported from the middle Solimões (Reserva Mamirauá and Anamã), Madeira and Uatumã rivers (Anjos et al. 2009). Besides the ciclids, many species of Characidae, popularly known as tetras or piabas, were captured in the present study, as Hemigrammus ocellifer, Hemigrammus stictus, Hyphessobrycon bentosi, Hyphessobrycon eques, and Hyphessobrycon roscaceus, which possess beautiful color patterns, small size and are commonly found in aquariums. Approximately 100 million ornamental fish were exported from the Amazonas State between 2002 and 2005 (Anjos et al. 2009).

Despite the high number of fish species in the Amazon region, the fisheries are concentrated in few species, in which about 80% is composed of only 6 to 12 species, such as Brycon, Hypophthalmus, Pellona, Pinemus, Pseudoplatsyton, Semaprochilodus, and Tripotheus (Barthem & Fabrè 2004). Representatives of all these genera were registered by us in this study, some of them very common in Itacoatiara fish markets, as the popularly known as jaraquis (Semaprochilodus insignis and S. taeniurus), matrixxã (Brycon amazonicus and B. melanopterus), sorubim (Pseudoplatsyton tigrinum), and sardinhas (Tripotheus albus, T. auritus, and T. rotundatus), with the addition of aruã (Osteoglossum bicirrhosum), pacu (Mylossoma albiscopum), and tucunãres (Cichla monoculus and C. temensis), also appreciated by local population. This indicates that besides environmental disturbances caused mainly by human activities in this region, the sampling areas are important resources of commercial fish species, and more attention to conservation and management efforts should be addressed to this region.

The lowest values of relative abundance were registered in the four Serpa lake sampling sites, possibly due to the use of a unique sampling method (gill net). Moreover, in Serpa lake were registered the highest richness (almost 70 species in site 4 - nearest to Amazonas river) and lowest richness (a little more than 10 species in site 1- nearest to Urubu river). However, Symphysodon discus, popularly known as disco, was exclusively caught in the site with the lowest abundance and lowest richness (site 1). Disco is an endemic ciclild from the Amazon basin, and is one of the most popular ornamental fish species, extensively used in aquarium (Ferraz 1999). Sequentially, the second (approximately 70 species in site 8) and the third (approximately 70 species in site 6) sites with the highest richness comprise small streams, located downstream the barrier from sites 5 and 7, respectively, suggesting less habitat changing and flow modification downstream the damming. Moreover, all barred water courses registered no more than 40 species. Changes in connectivity (Hurd et al. 2016, Benoni et al. 2018) and damming (Anderson et al. 2018) are well-reported causes of modification in structure and composition of fish fauna.

About 28% of South America’s known fauna has been described in the last 11 years, due to the unique environmental aspects of the Amazon basin, which contribute to new species discoveries (Reis et al. 2016). We recorded six species described for the Amazonas river basin in the last decade, Moenkhausia nikia, Hemigrammus diagnosicus, Eigenmannia muirapinima, Metynnis melanogrammus, Curimatopsis pallida, and Ageneiosus lineatus (Marinho & Langeani, 2016, Mendonça & Wosiacki 2011, Peixoto et al. 2015, Ota et al. 2016, Melo & Oliveira 2017, Ribeiro et al. 2017), along with a common species that was recently redescribed as Mylossoma albiscopum (Mateussi et al. 2017). Still, a new species for science, identified here as Moenkhausia aff. colletti is being formally described by one of the authors of this investigation (RPO) and I. M. Soares.

The sampled region is composed by a complex fluvial system river system with channels, holes, paranas and lakes that integrate both black and clearwater environments such as igapós and campinaranas, as well as a vast floodplain area enriched by alluvial deposits of whitewater rivers such as the Amazonas and Madeira rivers (Cavallini 2014). The Madeira river drains one-third of the Amazonian lowlands and is the richest tributary of Amazonas river (Dagosta & Pinna 2019). Therefore, the confluence of Madeira and Amazonas rivers just upstream the studied area and the proximity to Urubu and Uatumã rivers may explain the high number of fish species recorded in this study, due the hydrological connectivity and biological exchanges among these lowland aquatic environments, mainly in high waters. Additionally, attention to the different anthropogenic impacts that occur in the sampling sites, evolving human occupancy, emission of effluents without sanitary treatment, barrage for construction of artificial beaches for recreational use, and disruption of water body flow for AM-010 road construction should be reinforced. In this way, cataloging fish fauna in modified environments in order to access the fish diversity is a fundamental step to support investigation on the potential impacts of fish fauna composition, maintenance, and survival in these environments directly affected by human activities.
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Author Contributions

Rafaela Prsicila Ota: Substantial contribution in the concept and design of the study; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Rayane da Silva Pereira: Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Rayanna Grazziiela Amaral da Silva: Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

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Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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