An inventory of Ichthyofauna of the Pindaré River drainage, Mearim River basin, Northeastern Brazil

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Abstract: In the present work, we conducted an extensive long-lasting inventory of the fishes, using different collection methodologies, covering almost the entire Pindaré River drainage, one of the principal tributaries of the Mearim River basin, an area included in the Amazônia Legal region, northeastern Brazil. We reported 101 species, just three of them being non-native, demonstrating that the composition of this studied fish community is majority composed of native species. We found a predominance of species of the orders Characiformes and Siluriformes, corroborating the pattern usually found for the Neotropical fish fauna. Similar to other studies, this inventory was mainly dominated by small characids, representing 21% of the species herein recorded. When comparing the present survey with other species lists published for this region (including the States of Maranhão and Piauí), we can conclude that the freshwater fish fauna of the State of Maranhão is probably still underestimated. We reported 41 more species, and one more species than Soares (2005, 2013) and Abreu et al. (2019) recorded for the entire Mearim River basin, respectively. We believe, however, that the number of species presented by Abreu et al. (2019) is overestimated. We compared our results with all other freshwater fish species inventories performed for the hydrological units Maranhão and Parnaíba sensu Hubbert & Renno (2006). With these comparisons, we concluded that our results evidenced that a high effort was put in the inventory here presented. The two works including more species recorded from coastal river basins of the hydrological units Maranhão and Parnaíba were the works published by Ramos et al. (2014) for the Parnaíba River basin, one of the main and larger river basin of Brazil, and the compiled data published by Castro & Dourado (2011) for the Mearim, Pindaré, Pericumã, and upper Turiaçu River drainages, including 146 and 109 species, respectively. Our survey recorded only 45 less species than Ramos et al. (2014), and eight less species than Castro & Dourado (2011). However, it is essential to emphasize that the number of species presented by Castro & Dourado (2011) is probably overestimated since they did not update and check the taxonomic status of the species of their compiled data. In several cases, they considered more than one name for the same species.

Keywords: Amazônia Legal; Endemic species; Ichthyology; Maranhão; Neotropical Region; Species list.

Inventário da ictiofauna da drenagem do rio Pindaré, bacia do rio Mearim, nordeste do Brasil

Resumo: No presente trabalho nós conduzimos um inventário de peixes extensivo e de longa duração, utilizando diferentes métodos de coletas, e cobrindo a vasta maioria da drenagem do Rio Pindaré, um dos principais afluentes da bacia do Rio Mearim, uma área incluída na região da Amazônia Legal, nordeste do Brasil. Nós registramos 101 espécies, apenas três delas sendo exóticas, demonstrando que a composição dessa comunidade de peixes estudada é majoritariamente composta por espécies nativas. Nós encontramos uma predominância de espécies das ordens Characiformes e Siluriformes, corroborando com o padrão geralmente encontrado na fauna de peixes Neotropicais. De maneira similar a outros estudos, o presente inventário foi principalmente dominado por espécies de pequenos caracídios, representando 21% das espécies aqui registradas. Quando comparamos o presente inventário com outros inventários realizados para a região (incluindo os Estados do Maranhão e Piauí), nós podemos concluir que a fauna de peixes de água doce do estado está provavelmente subestimada. Nós registramos 41 mais espécies, e uma espécie a mais do que Soares (2005, 2013) e Abreu et al. (2019) registraram para a bacia inteira do Rio Mearim, respectivamente.

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Entretanto, nós acreditamos que o número de espécies apresentados por Abreu et al. (2019) está superestimado. Nós comparamos nossos resultados com todos os outros inventários de peixes de água doce realizados nas unidades hidrológicas Maranhão e Parnaíba sensu Hubbert & Renno (2006). Com essas comparações pudemos concluir que nosso resultado evidencia o grande esforço colocado no inventário aqui apresentado. Os dois trabalhos incluindo mais espécies registradas para bacias costeiras nas unidades hidrológicas Maranhão e Parnaíba foram os trabalhos publicados por Ramos et al. (2014) para a bacia do Rio Parnaíba, uma das principais e maiores bacias hidrográficas do Brasil, e a compilação de dados publicada por Castro & Dourado (2011) para as drenagens dos Rios Mearim, Pindaré, Pericumã e alto Turiaçu, incluindo 146 e 109 espécies, respectivamente. Nosso inventário registrou 45 espécies a menos do que o trabalho de Ramos et al. (2014), e oito espécies a menos do que Castro & Dourado (2011). Entretanto, é importante enfatizar que o número de espécies apresentadas por Castro & Dourado (2011) está provavelmente superestimado, pois eles não atualizaram nem checaram o status taxonômico das espécies de seus dados compilados, e em vários casos eles consideraram mais de um nome para a mesma espécie.

Palavras-chave: Amazônia Legal; Espécies endêmicas; Ictiologia; Lista de espécies; Maranhão; Região Neotropical.

Introduction

The South America is the continent with the richest ichthyofauna of the world, with currently estimates of more than 9,100 species, about 27% of all the fishes around the world (including freshwater fishes and nearshore marine waters) (Reis et al. 2016). The freshwater ichthyofauna is richer than the marine ichthyofauna in South America: about 5,160 are freshwater fishes, representing about 1/3 of all the freshwater fish species of the world, occurring in about 12% of the total continental surface area of the planet. New estimates, however, suggest that the diversity of freshwater ichthyofauna in the Neotropical region is still underestimated, and may be much greater, on the order of eight to nine thousand species (Albert & Reis 2011, Reis et al. 2016), a similar estimate already proposed by Schaefer (1998).

The Amazonia biome, which occurs in the Neotropical region, extends across all countries in northern South America (Martins & Oliveira 2011, Van Der Sleen & Albert 2018, Val 2019), comprising an area of more than eight million km² (Van Der Sleen & Albert 2018), with more than five million km² belonging to Brazil (Val 2019). The biome is covered with dense tropical rainforests, being a large and important center for freshwater fish diversity, having more than 3,000 species (Van Der Sleen & Albert 2018). This high diversity is distributed in several aquatic ecosystems, such as large rivers, lakes, streams, floating vegetation, and beaches (Santos & Ferreira 1999). In addition to the Amazon River basin, the Amazonia biome comprises other river basins and drainages (Van Der Sleen & Albert 2018, fig., 1), such as Orinoco River basin and Guiana shield basins, both located to the north of the biome region; and a series of coastal river basins and drainages in its eastern portion, after the mouth of the Amazon River, in the State of Pará, and in the west and center of the State of Maranhão; forming the Amazônia Legal area (Martins & Oliveira 2011, Van Der Sleen & Albert 2018).

The State of Maranhão stands out for presenting few studies related to its freshwater ichthyofauna, especially in the area of taxonomy; causing gaps and lack of information related to the taxonomy and systematics of the species and groups, species composition, geographical distribution and biogeography of the ichthyofauna from the State (Guimarães et al. 2018). Biodiversity estimates and inventories of freshwater fishes have been continually published in the last decades for water bodies occurring in the State of Maranhão (e.g. Garavello et al. 1998, Piorski 1998, Castro 2001, Castro et al. 2002, Piorski et al. 2003, Soares 2005, Piorski et al. 2007, Castro et al. 2010, Barros et al. 2011, Martins & Oliveira 2011, Sousa et al. 2011, Fraga et al. 2012, Almeida et al. 2013, Viana et al. 2014, Ribeiro et al. 201, Lima et al. 2015, Matavelli et al. 2015, Ramos et al. 201, Melo et al. 2016, Piorski et al. 2017, Brito et al. 2019, Lima et al. 2019, Teixeira et al. 2019). However, the published information regarding the diversity and composition of fishes from the Mearim River basin is limited to only one book published by Soares (2005) and reprinted by Soares (2013), focusing mainly in commercial importance and large size species, and a book chapter by Martins & Oliveira (2011). This book chapter compiled data based on Soares (2005), on a study about the fishing practice among indigenous groups performed by Piorski et al. (2003), and on non-published data, such as a project report and a graduate course completion work. In addition to these two works, Abreu et al. (2019) published a paper on the Historical biogeography of fishes from coastal basins of Maranhão State. Aiming to conduct their biogeographic analysis, they make a matrix of fish species occurring in coastal drainages of the State based on examination of material deposited in CPUFMA (Colecção de Peixes da Universidade Federal do Maranhão) and compiled data from published works (e.g., Reis et al. 2003, Soares 2005, Bueckup et al. 2007, Lucinda et al. 2007, Soares et al. 2009, Mérone et al. 2010, Barros et al. 2011, Lima & Caires 2011, Claro-Garcia & Shibatta 2013, Ramos et al. 201, Melo et al. 2016, Bartolette et al. 2017, Dagosta & de Pinna 2017, Piorski et al. 2017), listing 160 fish species for all the coastal river drainages of the State of Maranhão, and 100 species for the Mearim River basin. This recent paper, however, was not a taxonomic revision, neither a species inventory, thus many species had not their taxonomic status revised and updated (see Abreu et al. 2019: S2). A common fact among these three works is that none of them presented voucher numbers for their reported species (not designating testimony material for their identifications). Therefore, the present study aims to present an extensive long-lasting inventory, using different collection methodologies, of the fishes from the Pindaré River drainage, one of the main drainages of the Mearim River basin, a river basin included at the Amazonia Legal area in the State of Maranhão, northeastern Brazil. This inventory focused on the entire ichthyofauna occurring in Pindaré River drainage.
Material and Methods

1. Study area

This study was carried out in the rivers, streams, and lagoons of the Pindaré River drainage, Mearim River basin, located in the State of Maranhão, Northeastern Brazil (Figure 1). The Pindaré River rises in the Serra do Gurupi (5º 9’ S 46º 54’ W), in elevations of approximately 300 meters (Silva et al. 2017). It travels about 575.59 km until it flows into the Mearim River in the vicinity of its mouth in São Marcos Bay (Silva et al. 2017). Its main tributaries are the rivers Buriticupu, Negro, Paragominas, Zutiua, Timbira, Água Preta, and Santa Rita (Silva et al. 2017). The Pindaré River and its tributaries have a simple hydrological regime, with two well-defined seasons: the maximum - full - water that runs from February to May and the minimum - drought or ebb - that last from August to November (IBGE 1997).

2. Sampling design

The collection of samples was conducted at 28 collecting sites distributed within the boundaries of Pindaré River drainage, Mearim River Basin, comprising rivers, streams, lagoons, and lakes (Table 1, Figures 1, 2). The sampling design of this study based on the establishment of (1) fixed sites for seasonal collection (18 collection sites with 50 meters in size, dry and wet seasons, from 2011 to 2017), (2) five random expeditions performed between 2017 and 2020, during both wet and dry seasons, which covered almost the entire drainage.

3. Collection and identification of specimens

Fishes were collected with manual trail-net (2 m long × 1.8m high; mesh size, 2mm), cast nets (2 m height, mesh size 15 mm), gillnets of various mesh sizes (15, 20, 25, 30, 40, 45, 50, 60, 70, 80, 100 mm), and dip nets (mesh size 5 and 10 mm). The collected ichthyological material was euthanized in a buffered solution of ethyl-3-amino-benzoate-methanesulfonate (MS-222) at a concentration of 250 mg/l until completely ceasing opercular movements, according to animal welfare laws and guidelines (Close et al. 1996, 1997; Leary et al. 2013).

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Table 1. Collecting sites within the Pindaré River drainage, Mearim River basin, Maranhão, Brazil.

| Site | Locality | Municipality | Coordinates |
|------|----------|--------------|-------------|
| 1    | Igarapé Açaizal | Matinha - MA | 3º 3'50.59’S 45º 1’46.93”W |
| 2    | Lago de Viana | Viana-MA | 3º11’37.58’S 44º58’16.92”W |
| 3    | Bacia 814/815 | Santa Inês-MA | 3º40’49.99’S 45º19’50.85”W |
| 4    | Olho d’água dos Carneiros | Pindaré-Mirim-MA | 3º43’11.20’S 45º28’5.64”W |
| 5    | Rio Zutuia | Pindaré-Mirim-MA | 3º43’1.79’S 45º32’22.98”W |
| 6    | Igarapé Jundiaí | Pindaré-Mirim-MA | 3º39’21.37’S 45º42’22.75”W |
| 7    | Lago do Lírio | Alto Alegre do Pindaré-MA | 3º39’12.22’S 45º46’25.06”W |
| 8    | Igarapé Timbira | Alto Alegre do Pindaré-MA | 3º41’43.77’S 45º55’13.80”W |
| 9    | Igarapé Mineirão | Alto Alegre do Pindaré-MA | 3º42’30.23’S 45º56’20.33”W |
| 10   | Igarapé Arapapá | Alto Alegre do Pindaré-MA | 3º42’26.91’S 46º02’18.18”W |
| 11   | Igarapé Caítiti | Alto Alegre do Pindaré-MA | 3º42’30.69’S 46º11’53”W |
| 12   | Igarapé do Fausto | Alto Alegre do Pindaré-MA | 3º42’50.26’S 46º32’61”W |
| 13   | Igarapé Igapará | Alto Alegre do Pindaré-MA | 3º45’51.31’S 46º8’15.45”W |
| 14   | Igarapé Jenipapo | Alto Alegre do Pindaré-MA | 3º51’20.24’S 46º11’9.56”W |
| 15   | Igarapé Araparizal | Alto Alegre do Pindaré-MA | 3º54’33.34’S 46º12’6.24”W |
| 16   | Igarapé Presa de Porco | Buriticupu-MA | 3º59’27.50’S 46º15’3.94”W |
| 17   | Pontilhão Km 353+900 | Buriticupu-MA | 4º7’22.57’S 46º24’49.93”W |
| 18   | Rio Buritizinho | Buriticupu-MA | 4º11’53.71’S 46º28’41.00”W |
| 19   | Rio Buritizinho | Buriticupu-MA | 4º19’46.02’S 46º29’46.00”W |
| 20   | Rio Buritizinho | Buriticupu-MA | 4º22’52.02’S 46º30’35.00”W |
| 21   | Rio Buritizinho | Buriticupu-MA | 4º25’44.99’S 46º29’41.00”W |
| 22   | Rio dos Sonhos | Bom Jesus das Selvas-MA | 4º22’19.74’S 46º42’53.33”W |
| 23   | Rio Pindaré | Bom Jesus das Selvas - MA | 4º16’32.81’S 46º56’6.99”W |
| 24   | Rio Pindaré | Bom Jesus das Selvas-MA | 4º23’51.99’S 46º50’33.48”W |
| 25   | Rio Pindaré | Bom Jesus das Selvas-MA | 4º28’10.05’S 46º52’16.00”W |
| 26   | Rio Pindaré | Novo Bacabal - MA | 4º41’49.35’S 46º56’2.02”W |
| 27   | Rio Pindaré | Pindarezinho - MA | 5º29’50.86’S 46º55’2.01”W |
| 28   | Igarapé S/N | Buritirana - MA | 5º31’4.47’S 46º50’58.04”W |
Figure 2. Sampled localities in the Pindarê river drainage. Numbers follow Table 1. Photographs by E.C. Guimarães and P.S. Brito.
Specimens selected for morphological analysis were fixed in formalin and left for ten days, after which they were preserved in 70% ethanol. Specimens selected for future molecular analysis were fixed and preserved in absolute ethanol. Sorting and identification of specimens were carried out at the Laboratório de Sistemática e Ecologia de Organismos Aquáticos of the Universidade Federal do Maranhão using specialized bibliography for each taxonomic group and consulting experts. The ichthyological material was deposited in the Coleção de Peixes da Universidade Federal do Maranhão (CPUFMA) and Coleção Ictiológica do Centro de Ciências Agrárias e Ambientais of the Universidade Federal do Maranhão (CICCAA). The taxonomic classification, the names of species considered as valid, authors and years of species descriptions, and geographic distribution, were based on the compilations made by Fricke et al. (2020a, b), where the authors gather all the most recent classifications for each group of fish. The name of the collections and the acronyms can be consulted in Fricke & Eschmeyer (2020).

Results

This fish survey resulted in 101 species representing eight orders and 32 fish families occurring in the Pindaré river drainage (Table 2, Table S1). Orders comprising the highest percentage of species richness were Characiformes 44 (43%), Siluriformes 37 (37%), Cichliformes 9 (9%), and Gymnotiformes 6 (6%), representing 96% of the total species richness. Cyprinodontiformes (Anablepsoides Huber 1992 and Poecilia Bloch & Schneider 1801), Clupeiformes (Anchovia Jordan & Evermann 1895), Myliobatiformes (Potamotrygon Garman, 1877) and Synbranchiformes (Synbranchus Bloch 1795) complete the list of Orders, with two species (Characiformes) and one species (other orders). The most species diverse family was Characidae 21 (21% of total species), followed by Loricariidae 12 (12%) and Cichlidae 9 (9%) (Table 2). From these 101 species herein recorded, just three are non-native, while the other 98 are native species.
Cynodontidae
*Cynodon gibbus* (Spix & Agassiz 1829) Cachorrinha

Serrasalmidae
*Metynnis lippincottianus* (Cope 1870) Dolár
*Myloplus rubripinnis* (Müller & Troschel 1844) Pacu
*Pygocentrus nattereri* Kner 1858 Piranha-vermelha
*Serrasalmus rhombeus* (Linnaeus 1766) Piranha-preta

Hemiodontidae
*Hemiodus cf. parnaguai* Flecheira

Anostomidae
*Leporinus aff. friderici* Piau
*Megaleporinus macrocephalus* (Garavello & Britski, 1988) * Piavuçú
*Schizodon dissimilis* (Garman 1890) ** Piau-cabeça-gorda

Curimatidae
*Curimata macrops* Eigenmann & Eigenmann, 1889** Branquinha
*Psectrogaster rhomboides* Eigenmann & Eigenmann 1889 Sagüiru
*Steindachnerina notonota* (Miranda Ribeiro 1937) Biruba

Prochilodontidae
*Prochilodus lacustris* Steindachner 1907** Curimbatá

Lebiasinidae
*Copella arnoldi* (Regan 1912) Copella
*Nannostomus beckfordi* Günther 1872 Peixe-lápis

Triportheidae
*Triportheus signatus* (Garman 1890) Voadeiras

Gasteropelecidae
*Gasteropelecus sternicla* (Linnaeus 1758) Peixe-Borboleta

Iguanodectidae
*Bryconops aff. caudomaculatus* João-duro
*Piabucus dentatus* (Koelreuter 1763) -

Acestrorhynchidae
*Acestrorhynchus falcatus* (Bloch 1794) Peixe-cachorro

Characidae
*Aphyocharax sp.* Enfermerinha
*Astyanax cf. bimaculatus* Piaba
*Brachychalcinus parnaibaie* Reis 1989**Piaba
*Charax awa Guimarães, Brito, Ferreira & Ottoni 2018** Cacunda
*Ctenobrycon cf. spilurus* Piaba
*Hemigrammus aff. ocellifer* Piaba
*Hemigrammus cf. rodwayi* Piaba
*Hemigrammus sp.* Piaba
*Hyphessobrycon caru* Guimarães, Brito, Feitosa, Carvalho-Costa & Ottoni** Tetra, piaba
*Knodus victoriae* (Steindachner 1907) ** Piaba
*Microschocorycon sp.* -
*Moenkhausia cf. intermedia* Piaba
*Moenkhausia oligolepis* (Günther 1864) Lambari-olho-de-fogo
*Phenacogaster cf. pectinata* Piaba
### Inventory of Ichthyofauna of the Pindaré River

- **Poptella compressa** (Günther 1864) Piaba
- **Pristella maxillaris** (Ulrey 1894) Tetra Pristella
- **Psellogrammus kennedyi** (Eigenmann, 1903) Piaba
- **Roeboides margareteae** Lucena 2003** Saicanga
- **Roeboides sazimai** Lucena 2007** Saicanga
- **Serrapinnus sp.** Piaba
- **Tetragonopterus argentaeus** Cuvier 1816 Matupiri

#### GYMNOTIFORMES

**Gymnotidae**

- **Gymnotus carapo** Linnaeus 1758 Tuvira, sarapó

**Electrophorus varius** de Santana, Wosiacki, Crampton, Sabaj, Dillman, Mendes-Júnior & Castro 2019.

**Rhamphichthyidae**

- **Rhamphichthys atlanticus** Triques 1999** Tuvira, Ituí

**Hypopomidae**

- **Brachyhypopomus pinnicaudatus** (Hopkins, Comfort, Bastian & Bass 1990) Tuvira, Ituí

**Sternopygidae**

- **Eigenmannia virescens** (Valenciennes 1836) -
  - **Sternopygus macrurus** (Bloch & Schneider 1801) Tuvira, Ituí

#### SILURIFORMES

**Aspredinidae**

- **Pseudobunocephalus timbira** Leão, Carvalho, Reis & Wosiacki, 2019 -

**Auchenipteridae**

- **Auchenipterichthys sp.** -
  - **Ageneiosus ucalensis** Castelnau 1855 Mandubé
  - **Auchenipterus menezesi** Ferraris & Vari, 1999** -
  - **Tatia intermedia** (Steindachner 1877) Tatia
  - **Trachelyopterus galeatus** (Linnaeus 1766) Mole, Cumbá

**Doradidae**

- **Hassar affinis** (Steindachner 1881) ** -

**Platydoras brachylecis** Piorski, Garavello, Arce H. & Sabaj Pérez 2008** -

**Heptapteridae**

- **Imparfinis sp.** -
  - **Mastiglanis aspos** Bockmann 1994 Bagrinho
  - **Pimelodella parnabiae** Fowler 1941 ** -
  - **Rhamdia quelen** (Quoy & Gaimard 1824) Mandi Chorão

**Pimelodidae**

- **Cheirocerus goeldii** (Steindachner, 1908) -
  - **Hemisorubim platyrhynchos** (Valenciennes 1840) Lírio
  - **Pimelodus blochii** Valenciennes 1840 Mandi
  - **Pimelodus ornatus** Kner 1858 Mandi
  - **Pseudoplatystoma punctifer** (Castelnau 1855) Surubim
  - **Sorubim lima** (Bloch & Schneider 1801) Surubi bico-de-pato

**Pseudopimelodidae**

- **Batrochoglanis villosus** (Eigenmann 1912) -

**Callichthyidae**

- **Callichthys callichthys** (Linnaeus 1758) Tamboatá

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Corydoras aff. splendens
Corydoras cf. julii
Corydoras vittatus Nijssen 1971**
Hoplosternum littorale (Hancock, 1828)
Megalechis thoracata (Valenciennes 1840)

Loricariidae
Ancistrus sp.
Farlowella cf. amazonum
Hemiodontichthys acipenserinus (Kner 1853)
Hypoptopoma incognitum Aquino & Schaefer 2010
Hypostomus cf. plecostomus
Loricaria aff. cataphracta
Loricariichthys sp.
Otocinclus sp.
Pterygoplichthys sp.
Pterygoplichthys parnaibaes (Weber, 1991)**
Rineloricaria sp.
Sturisoma aff. lyra

SYNBRANCHIFORMES
Synbranchidae
Synbranchus marmoratus Bloch 1795

CICHLIFORMES
Cichlidae
Aequidens tetramerus (Heckel 1840)
Apistogramma cf. piuaiensis
Cichla sp.*
Cichlasoma zarskei Ottoni 2011**
Crenicichla brasiliensis (Bloch 1792)
Crenicichla sp.
Geophagus cf. paranaeb
Satanoperca jurupari (Heckel 1840)
Oreochromis sp.*

CYPRINODONTIFORMES
Rivulidae
Anablepsoides cf. vieirai

Poeciliidae
Poecilia sarrafa Bragança & Costa 2011**

* indicates exotic species. ** indicates endemic species to the hydrological units Maranhão and Parnaíba sensu Hubbert & Renno (2006)

Discussion

In the present work, we conducted an extensive long-lasting inventory of fishes, using different collection methodologies, covering almost the entire studied drainage (Fig. 1 and Table 1). We found a predominance of species of the Orders Characiformes and Siluriformes, corroborating the pattern usually found for the Neotropical fish fauna (Lowe-McConnell 1999, Pelicice et al. 2005, Langeani et al. 2007; Vari et al. 2009, Polaz et al. 2014, Reis et al. 2016, Brito et al., 2019, Dagosta & de Pinna 2019). Similar to other studies, this inventory was mainly dominated by small characids (e.g. Ramos et al. 2014, Brito et al. 2019), probably due to their ability to obtain oxygen from upper layers of the water column, high trophic plasticity (Abelha et al. 2001), and exceptional species diversity in the Neotropical region (Dagosta & de Pinna 2019).

From these 101 species herein recorded, just three are non-native [Megaleporinus macrocephalus (Garavello & Britski, 1988), Oreochromis sp. and Cichla sp.] occurring in the middle-lower Pindaré River drainage region, while the other 98 are native species. This demonstrates that the composition of the studied fish community is majority composed of native species, with rare cases of introduced species.
When comparing the present survey with other inventories published for the hydrological units Maranhão and Parnaíba sensu Hubert & Renno (2006) (hereafter Mrn and Prn following the acronyms proposed by the same authors), we can conclude that the freshwater fish fauna of the State of Maranhão is probably still underestimated, as argued by Piorski (2010) and Guimarães et al. (2018). Were reported a total of 101 species to only one of the main drainages of the Mearim River basin, the Pindaré River drainage (Table 2), 41 more species, and one more species than Soares (2005, 2013) (60 species) and Abreu et al. (2019: S2) (100 species) recorded for the entire Mearim River basin, respectively. In addition, we reported only 59 less species than the number of species reported by Abreu et al. (2019: S2) (160 species) for all the coastal river systems of the State of Maranhão. We believe, however, that the number of species reported by Abreu et al. (2019) overestimated, and we will discuss it in detail below.

The two works including more species recorded from coastal river basins of the Mrn and Prn, were the works published by Ramos et al. (2014) for the Parnaiba River basin, the major coastal river basin of the Mrn and Prn, and the compiled data published by Castro & Dourado (2011) for the Mearim, Pindaré, Pericumã, and upper Turiça River drainages, including 146 and 109 species, respectively. The first one was an exhaustive inventory of one of the main and larger river basins of Brazil, and the largest of the hydrological units mentioned above (Mrn and Prn). The second one included compiled data from three distinguished river drainages: Mearim and Pindaré from the Mearim river system, the second major river system of the Mrn and Prn, and Turiça, one of the main river basins of the Mrn and Prn. Even so, our survey recorded only 45 less species than Ramos et al. (2014) and eight less species than Castro & Dourado (2011), which demonstrates the high effort put in the inventory here presented. It is important to emphasize that the number of species presented by Castro & Dourado (2011) is probably overestimated since they did not update and check the taxonomic status of the species of their compiled data. In several cases, they considered more than one name for the same species, for example, two names representing Charax awa Guimarães, Brito, Ferreira & Ottoni 2018 [Charax gibbosus (Linnaeus, 1758) and Charax sp.]; and four names representing Acestrorhynchos [Acestrorhynchos falcatus (Bloch, 1794), Acestrorhynchos laccusros (Lütken, 1875), Acestrorhynchos heterolepis (Cope, 1878), Acestrorhynchos microlepis (Schomburgk, 1841)]. This situation, however, was not restricted to only those two mentioned examples, but also to several other fish species.

Based on the examination of material deposited in CPUFMA, and based on the examination of material collected during our survey, an exhaustive study conducted over nine years of collections (2011 to 2020), we verified some inconsistencies in the 100 species listed for the Mearim River basin by Abreu et al. (2019: S2). Some species were misidentified, some genera had their diversity overestimated, and some species did not have their taxonomic status updated. Examining the material deposited in CPUFMA and CICCAA, we could notice that there were the following identification errors: 1- While conducting this inventory some specimens were provisionally identified as Elachocara ax pulcher Myers, 1927, but after a detailed morphological inspection it was verified that, in fact, these specimens were Hoplias malabaricus (Bloch 1794) in the initial juvenile stage. 2 - A similar case occurred with some specimens of Gymnotiformes. While conducting this inventory, some specimens of Gymnotiformes presenting a paler coloration were provisionally identified as Eigenmannia limbata (Schreiner & Miranda Ribeiro, 1903). However, after a detailed morphological inspection, it was verified that these specimens were Sternopygus macrurus (Bloch & Schneider 1801), and this paler coloration occurred due to the fixation process of those specimens. 3 - Poecilia branneri Eigenmann, 1894 is, in fact, Poecilia sarrafae Braga, Costa, 2011. 4- Rhamphichthys rostratus (Linnaeus, 1766) is Rhamphichthys atlanticus Triques, 1999. 5 - Leporacanthicus galaxias is Pterygoplichthys sp. 6 - Nannostomus unifasciatus Steindachner 1876 is Nannostomus beckfordi Günther 1872. 7- Prochilodus brevis Steindachner, 1875, is Prochilodus lacustris Steindachner, 1907. 8 - Triprotheus angulatus (Spix, Agassiz, 1829) is Triprotheus signatus (Garman, 1890). And 9 - And Auchenipterus nuchalis (Spix, Agassiz, 1829) is Auchenipterus menezesi Ferraris & Vari 1999 (Table 2).

Regarding the overestimation of the species diversity within some genera, we could notice that Abreu et al. (2019: S2) recorded the following species for the Mearim River basin: two species of Geophagus Heckel 1840, both species belonging to the G. surinamensis species group [Geophagus parnaiabe Staeck, Schindler, 2006 and Geophagus surinamensis (Bloch, 1791)]; three species of Crenicichla Heckel 1840 [(Crenicichla lepidota Heckel, 1840, Crenicichla marmorata Pellegrin, 1904, and Crenicichla brasiliensis (Bloch 1792)]; two species of Poecilia (Poecilia branneri and Poecilia sarrafae); and three species of Hemiodus Müller 1842 [Hemiodus microlepis Kner, 1858, Hemiodus parnagae Eigenmann, Henn, 1916, and Hemiodus unimaculatus (Bloch, 1794)]. However, based on the examination of the material collected during our exhaustive study (nine years of collections in the Pindaré River drainage) and examination of material from CPUFMA, it was reported the following number of species for those genera mentioned above: 1- Two species of the genus Crenicichla (Crenicichla brasiliensis and Crenicichla sp., this latter species only few specimens were collected from one single locality at the municipality of Pindaré-Mirim). 2- One species of Geophagus not identified at the species level (G. cf. parnaiabe) since the need of a taxonomic study for this group along the coastal river basins of the State of Maranhão. 3 - One species of Hemiodus also not identified at the species level (Hemiodus cf. parnagae) since the need of a taxonomic study for this group along the coastal river basins of the State of Maranhão. 4 - And one species of Poecilia (P. sarrafae), with its type locality in the Prn (Table 2). After this careful inspection and taxonomic update in the compiled data listed by Abreu et al. (2019: S2), we can conclude that the number of species for the Mearim River basin proposed by them was overestimated and included some taxonomically outdated data.

The Preguiças and Periá River basins, two very small coastal river basins when compared to the major coastal river basins of the Mrn and Prn, possess a total of 56 recorded species (Piorski et al. 2017, Brito et al. 2019, 2020). This number is about half of the number that we have reported for the Pindaré River basin. This fact, however, was already expected due to the small size of the two basins mentioned above. In relation to the Munin River basin, a medium-size coastal river basin from eastern Maranhão, we reported at least five times more species than the surveys performed by Matavelli et al. (2015) (13 species), including in addition to water bodies of the lower Munin, water bodies the other rivers system, such as the lower Parnaiba and other and smaller coastal river basins; and Ribeiro et al. (2014) (20 species) for an area of the upper Munin River basin.
When comparing our study with the surveys published by Barros et al. (2011) (69 species) and Nascimento et al. (2016) (64 species), both for the Itapepecur River basin, one of the main coastal river basins of the Mrn and Prn, we can notice that we report about a third more species than these both studies. Moreover, finally, we recorded 46 more species than the survey published by Melo et al. (2016) (65 species) for the lower portion of the Parnaíba River basin. All these numbers and facts pointed out above only emphasize the great sampling force that we carried out in our inventory, as well as the importance of the present work.

From the 98 native species herein reported, it was not possible to identify 32 taxa accurately at the species level (about 31%). The reason that did not allow us to identify these 32 taxa accurately at the species level were: The lack of taxonomic knowledge and information on fish species and groups occurring in the State of Maranhão (Guimarães et al. 2018). Some of these species may be part of species complex or groups taxonomically still poorly resolved (e.g., *Anablepsoides cf. vieirai*, *Apistogramma cf. piauiensis*, *Astyanax cf. bicamatus*, *Characidium cf. zebra*, *Geophagus cf. parnaiba*, *Hemigrammus aff. ocellifer*, *Leporinus aff. friderici*, *Loricaria aff. cataphracta*, *Phenacogaster cf. pectinata*). In this case, we can take as example the species *Apistogramma piauiensis* Kullander 1980. This species was described based on three specimens, one subadult female (holotype) and two juveniles (paratypes), from the Parnaíba River basin, in the State of Piauí. Although it is very similar to *Apistogramma caerulei* Kullander 1980, described based on four species (three types and one additional male) from the Apeu and Caeté River basins, in the eastern State of Pará (Kullander 1980). As the Pindaré River is located between the type locality of these two species, these species are very similar and difficult to differentiate from each other, and they were described based on few material and were never redescribed; it is difficult to know exactly which of them occur in the Pindaré River basin, or if the population is an undescribed species. Although some aquarium publications recorded *A. piauiensis* as the species occurring in the Pindaré River drainage (e.g., Link & Staeck 1995, Schindler 1998), we believe that a comprehensive taxonomic study should be carried out in populations of this genus along the coastal river basins of Maranhão, as well as, these two species should be redescribed. Another example is *Anablepsoides vieirai* Nielsen 2016. This species was described from one single locality in the Parnaíba River basin (Nielsen 2016). Despite this is the closest geographically species of the *Anablepsoides urophthalmus* species group to the Pindaré River basin, the general color pattern of the specimens collected in the Pindaré River drainage is quite different from the color pattern of the specimens from the type locality of the species. In addition, the type locality of *Anablepsoides urophthalmus* ( Günther 1866) is from Belém, State of Pará (Fricke et al. 2020a), a location not so far from the studied drainage. Therefore, a taxonomic study among the populations occurring in the coastal river system from Belém (State of Pará) to the Parnaíba River basin.

In addition, several species of this genus are reported for the Tocantins River Basin, Lower Amazon, and coastal river basin of Guiana Shield (Fricke et al. 2020a). Therefore, this is another group that needs to be better taxonomically studied, mainly the populations of the coastal river systems from Belém (State of Pará) to the Parnaíba River basin.

Other species such as, *Astyanax bicamatus* (Linnaeus 1758), *Characidium zebra* Eigenmann 1909, *Hemigrammus ocellifer* (Steindachner 1882), *Leporinus friderici* (Bloch 1794), *Loricaria cataphracta* Linnaeus 1758, *Phenacogaster pectinata* (Cope 1870) are already known to be species complexes based on several studies (e.g., Isbrucker, 1972, Lucena et al. 2010, Fricke et al. 2020a), needing comprehensive taxonomic studies to reveal the hidden diversity under these species names. Some taxa probably correspond to still undescribed species (e.g., *Ancistrus sp.*, *Aphyochuras sp.*, *Bryconops aff. caudomaculatus*, *Hemigrammus sp.*, *Microschsymbron sp.*, *Loricarichthys sp.*, *Serrapinnus sp.*, and *Sterisoma aff. lyra*) that still need a more detailed taxonomic study to make sure that they are new to the science. Besides, some of these species had very few specimens collected (e.g., *Microschymbron sp.* and *Sturisoma aff. lyra*), which makes taxonomic studies difficult. It is important to emphasize that in the last two decades several new species occurring in the Mrn and Prn basins have been described, what reinforces this possibility that these taxa could be still undescribed species (e.g., *Ferraris & Vari 1999, Triques 1999, Lucena 2003, 2007, Porski et al. 2008, Bragança & Costa 2011, Ottoni 2011; Guimarães et al. 2018, Guimarães et al. 2019, Leão et al. 2019, Santana et al. 2019). From the 98 native species herein recorded, 32 of them were not possible to be accurately identified at the species level. Thus, we will not address these species in our biogeographic comments.

From the remaining 66 species, 25 (almost half of the species) did not occur in the Amazon River basin (*Auchenipterus menezesi* Ferraris & Vari, 1999, *Brachychalcinus parnahybae* Reis 1989, *Charax awa* Guimarães, Brito, Ferreira & Ottoni 2018, *Cichlasoma brasiliensis* Eigenmann & Eigenmann, 1889, *Hassar affinis* (Steindachner 1881), *Hypessobrycon caru* Guimarães, Brito, Feitosa, Carvalho-Costa & Ottoni 2019, *Knodus victoriae* (Steindachner 1907), *Myloplus rubripinnis* (Müller & Troschel 1844), *Pimelodella parnayhbae* Fowler 1941, *Platydoras brachylepis* Porski, Garavello, Arce H. & Sabaj Pérez 2008, *Pse揣trogaster schomboides* Eigenmann & Eigenmann 1889, *Poecilia sarrafae* Bragança & Costa 2011, *Prochilodus lacustris* Steindachner 1907, *Pteroglyphichthys parnayhbae* (Weber, 1991), *Schizodon dissimilis* (Garman 1890), *Steindachnerina notonota* (Miranda Ribeiro 1937), *Triportheus signatus* (Garman 1890), *Rhamphichthys atlanticus* Triques 1999, *Roeboidei margaretae* Lucena 2003, and *Roeboidei sazimai* Lucena 2007); 18 of them (*Auchenipterus menezesi*, *Brachychalcinus parnahybae*, *Charax awa*, *Cichlasoma zarskei*, *Corydoras macroph* *Hassar affinis*, *Hypessobrycon caru*, *Knodus victoriae*, *Pimelodella parnayhbae*, *Platydoras brachylepis*, *Poecilia sarrafae*, *Prochilodus lacustris*, *Pteroglyphichthys parnayhbae*, *Schizodon dissimilis*, *Rhamphichthys atlanticus*, *Roeboidei margaretae*, *Roeboidei sazimai*) being endemic to the Mrn and Prn (see Fricke et al. 2020a). All the remaining species herein reported (41 species) have their distribution known to the Amazon River basin (see Fricke et al. 2020a), showing a considerable biogeographic influence of the Amazon basin in the Pindaré River drainage.

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According to Rosa et al. (2003), the fish fauna of the Maranhão-Piauí ecotone, which includes the Mrn and part of Mrn, was historically pointed out as poorly endemic. Otherwise, the low level of endemicity recorded during the past decades would be related to few sampling effort on the whole region (Pioriski 2010, Ramos et al. 2014, Guimarães et al. 2018). Several species in the Maranhão-Piauí rivers are known to occur along the Amazon basin (including coastal rivers in Suriname and the Guianas), a distribution pattern suggested by Barros et al. (2011), who observed a predominance of Amazonian species in the Itaperucu basin, as well as corroborated for some putative species by Guimarães et al. (2016, 2017a, b). Besides, this influence of the Amazon River basin in theses hydrological units (Mrn and Prn) was also advocated by Hubert & Renno (2006) and Dagosta & de Pinna (2017), in their biogeographic studies. However, these same authors also advocated the possibility of the coastal river basin of the State of Maranhão constituting one or more areas of endemicity. Both papers, however, suggest that data related to the freshwater ichthyofauna from this region are too scarce to have a more conclusive hypothesis. However, a list of several species endemic to the Mrn and Prn, or also occurring just on neighboring areas, was provided Guimarães et al. (2018), reinforcing the hypothesis that the coastal river basins of the State of Maranhão could constitute one or more areas of endemicism, as suggested as a possibility by Hubert & Renno (2006) and Dagosta & de Pinna (2017).

Supplementary Material

The following online material is available for this article:
Table S1 – Examined material

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Author Contributions

Erick C. Guimarães: 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.

Pâmella S. de Brito: 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.

Cléverson Storeck Gonçalves: Substantial contribution in the concept and design of the study.

Felipe Polivanov Ottoni: Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Conflicts of Interest

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

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