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Inventory

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 Piaui), 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 caracídeos, 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.

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 km^2 (Van Der Sleen & Albert 2018), with more than five million km^2 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 (Coleção de Peixes da Universidade Federal do Maranhão) and compiled data from published works (e.g., Reis et al. 2003, Soares 2005, Buckup et al. 2007, Lucinda et al. 2007, Soares et al. 2009, Mérona et al. 2010, Barros et al. 2011, Lima & Caires 2011, Claro-García & 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.

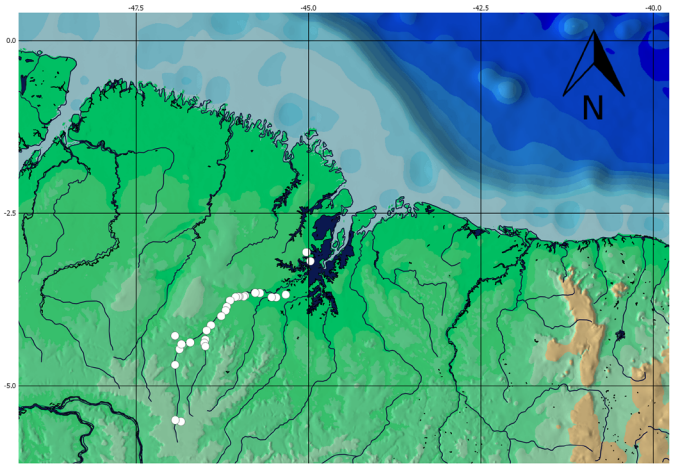

Figure 1. Collecting sites at Pindaré river drainage, Mearim river basin.

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, 35, 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).

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

Site	Locality	Municipality	Coordinates
1	Igarapé Açaizal	Matinha - MA	3° 3'50.59"S 45° 1'46.93"W
2	Lago de Viana	Viana-MA	3°11'37.58"S 44°58'16.92"W
3	Bacia 814/815	Santa Inês-MA	3°40'49.99"S 45°19'50.85"W
4	Olho d'água dos Carneiros	Pindaré-Mirim-MA	3°43'11.20"S 45°28'5.64"W
5	Rio Zutiua	Pindaré-Mirim-MA	3°43'1.79"S 45°32'2.98"W
6	Igarapé Jundiá	Pindaré-Mirim-MA	3°39'21.37"S 45°42'22.75"W
7	Lago do Lírio	Alto Alegre do Pindaré-MA	3°39'12.22"S 45°46'25.06"W
8	Igarapé Timbira	Alto Alegre do Pindaré-MA	3°41'43.77"S 45°55'13.80"W
9	Igarapé Mineirão	Alto Alegre do Pindaré-MA	3°42'30.23"S 45°56'20.33"W
10	Igarapé Arapapá	Alto Alegre do Pindaré-MA	3°42'26.91"S 46° 0'25.18"W
11	Igarapé Caititu	Alto Alegre do Pindaré-MA	3°42'30.69"S 46° 1'19.53"W
12	Igarapé do Fausto	Alto Alegre do Pindaré-MA	3°42'50.26"S 46° 3'29.61"W
13	Igarapé Igarapá	Alto Alegre do Pindaré-MA	3°45'51.31"S 46° 8'15.45"W
14	Igarapé Jenipapo	Alto Alegre do Pindaré-MA	3°51'20.24"S 46°11'9.56"W
15	Igarapé Araparizal	Alto Alegre do Pindaré-MA	3°54'33.34"S 46°12'6.24"W
16	Igarapé Presa de Porco	Buriticupu-MA	3°59'27.50"S 46°15'53.94"W
17	Pontilhão Km 353+900	Buriticupu-MA	4° 7'22.57"S 46°24'49.93"W
18	Rio Buritizinho	Buriticupu-MA	4°11'53.71"S 46°28'41.00"W
19	Rio Buritizinho	Buriticupu-MA	4°19'46.02"S 46°29'46.00"W
20	Rio Buritizinho	Buriticupu-MA	4°22'52.02"S 46°30'35.00"W
21	Rio Buritizinho	Buriticupu-MA	4°25'44.99"S 46°29'41.00"W
22	Rio dos Sonhos	Bom Jesus das Selvas-MA	4°22'19.74"S 46°42'53.33"W
23	Rio Pindaré	Bom Jesus das Selvas - MA	4°16'32.81"S 46°56'6.99"W
24	Rio Pindaré	Bom Jesus das Selvas-MA	4°23'51.99"S 46°50'33.48"W
25	Rio Pindaré	Bom Jesus das Selvas-MA	4°28'10.05"S 46°52'16.00"W
26	Rio Pindaré	Novo Bacabal - MA	4°41'49.35"S 46°56'2.02"W
27	Rio Pindaré	Pindarezinho - MA	5°29'50.86"S 46°55'52.01"W
28	Igarapé S/N	Buritirana - MA	5°31'4.47"S 46°50'58.04"W

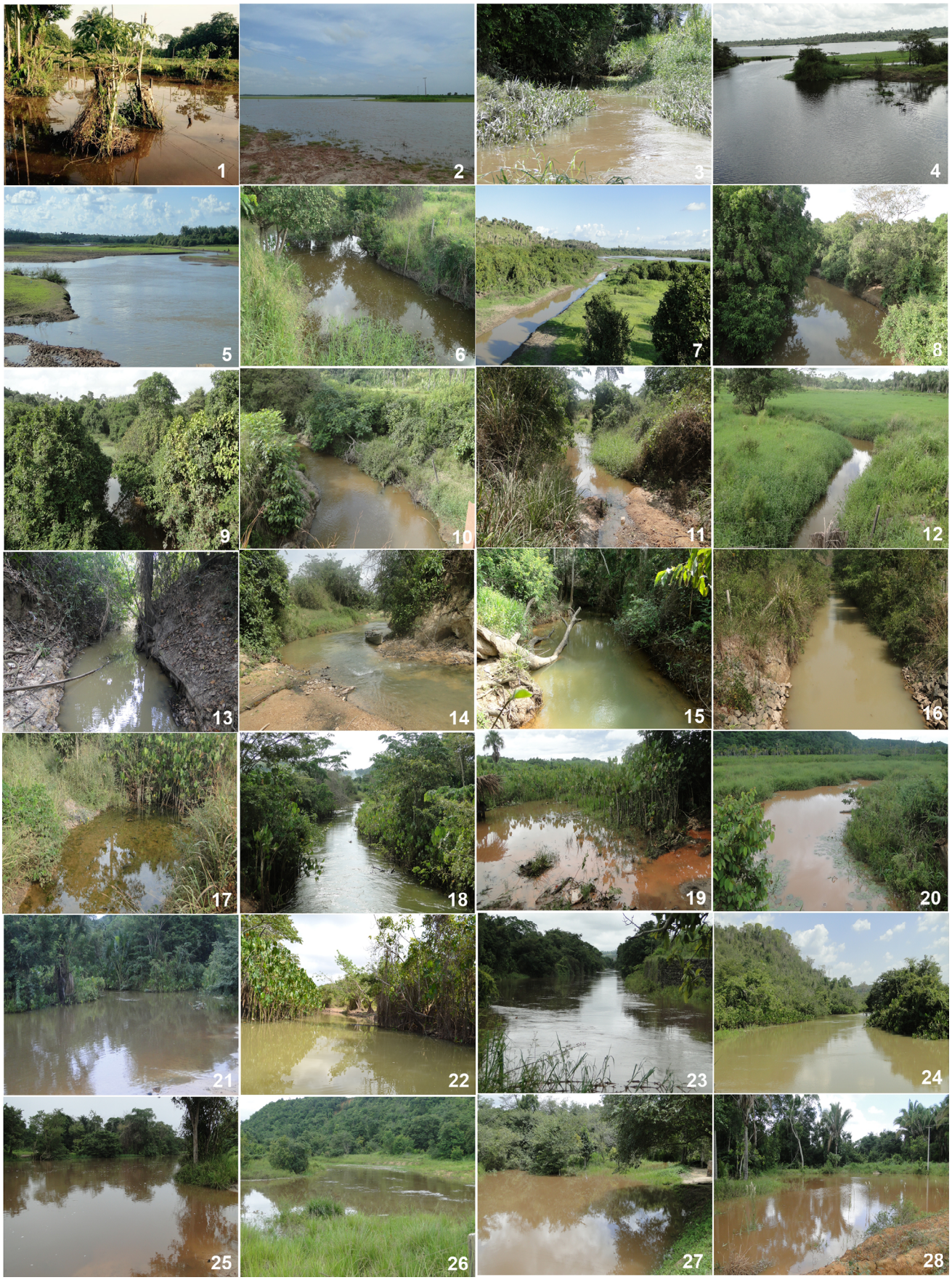

Figure 2. Sampled localities in the Pindaré river drainage. Numbers follow Table 1. Photographs by E.C. Guimarães and P.S. Brito.

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).

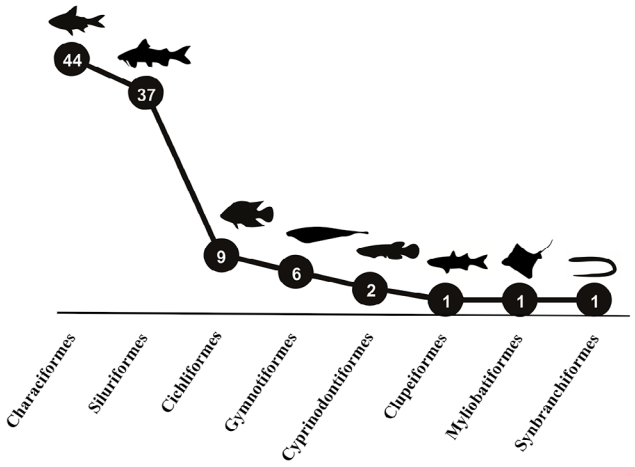

Figure 3. Ranking of richness by orders in the Pindaré river drainage, Mearim river basin.

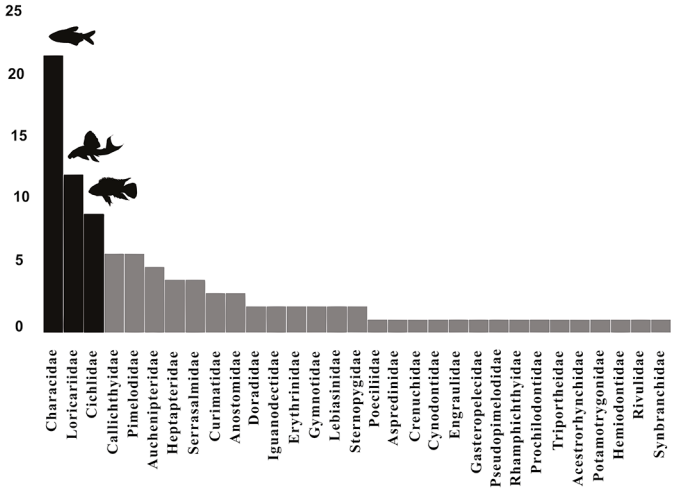

Figure 4. Ranking of richness by families in the Pindaré river drainage, Mearim river basin.

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 (Cyprinodontiformes) 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.

Table 2. List of species collected at the Pindaré river dranaige, Mearim River basin.

CLASS/ORDER/FAMILY/SPECIES	Popular Names
ELASMOBRANCHII	
MYLIOBATIFORMES	
Potamotrygonidae	
Potamotrygon motoro (Müller & Henle 1841)	Raia
ACTINOPTERYGII	
CLUPEIFORMES	
Engraulidae	
Anchovia sp.	Sardinha
CHARACIFORMES	
Crenuchidae	
Characidium cf. *zebra*	Canivete
Erythrinidae	
Hoplias malabaricus (Bloch 1794)	Traíra
Hoplerythrinus unitaeniatus (Spix & Agassiz 1829)	Jejú

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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. *parnaguae*	Flecheira
Anostomidae	
Leporinus aff. *friderici*	Piau
Megaleporinus macrocephalus (Garavello & Britski, 1988) *	Piavuçu
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 parnaibae 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
Microschemobrycon sp.	-
Moenkhausia cf. *intermedia*	Piaba
Moenkhausia oligolepis (Günther 1864)	Lambari-olho-de-fogo
Phenacogaster cf. *pectinata*	Piaba

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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 argenteus Cuvier 1816	Matupiri
GYMNOTIFORMES	
Gymnotidae	
Gymnotus carapo Linnaeus 1758	Tuvira, sarapó
Electrophorus varii de Santana, Wosiacki, Crampton, Sabaj, Dillman, Mendes-Júnior & Castro 2019.	Poraquê
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 ucayalensis Castelnau 1855	Mandubé
Auchenipterus menezesi Ferraris & Vari, 1999**	-
Tatia intermedia (Steindachner 1877)	Tatia
Trachelyopterus galeatus (Linnaeus 1766)	Mole, Cumbá
Doradidae	
Hassar affinis (Steindachner 1881) **	Botinho
Platydoras brachylecis Piorski, Garavello, Arce H. & Sabaj Pérez 2008**	Platydoras
Heptapteridae	
Imparfinis sp.	-
Mastiglanis asopos Bockmann 1994	Bagrinho
Pimelodella parnahybae Fowler 1941 **	Mandi Chorão
Rhamdia quelen (Quoy & Gaimard 1824)	Bagre
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*	Coridora
Corydoras cf. *julii*	Coridora
Corydoras vittatus Nijssen 1971**	Coridora
Hoplosternum littorale (Hancock, 1828)	Tamboatá
Megalechis thoracata (Valenciennes 1840)	Tamboatá
Loricariidae	
Ancistrus sp.	Acari
Farlowella cf. *amazonum*	Acari-viola
Hemiodontichthys acipenserinus (Kner 1853)	-
Hypoptopoma incognitum Aquino & Schaefer 2010	-
Hypostomus cf. *plecostomus*	Acari
Loricaria aff. *cataphracta*	rapa-canoa
Loricariichthys sp.	rapa-canoa
Otocinclus sp.	-
Pterygoplichthys sp.	Acari
Pterygoplichthys parnaibae (Weber, 1991) **	Acari
Rineloricaria sp.	-
Sturisoma aff. *lyra*	Cascudo-Chicote
SYNBRANCHIFORMES	
Synbranchidae	
Synbranchus marmoratus Bloch 1795	Muçum
CICHLIFORMES	
Cichlidae	
Aequidens tetramerus (Heckel 1840)	Acará
Apistogramma cf. *piauiensis*	Apistograma
Cichla sp.*	Tucunaré
Cichlasoma zarskei Ottoni 2011**	Acará
Crenicichla brasiliensis (Bloch 1792)	Jacundá
Crenicichla sp.	Jacundá
Geophagus cf. *parnaibae*	Acará
Satanoperca jurupari (Heckel 1840)	Acará
Oreochromis sp.*	Tilapia
CYPRINODONTIFORMES	
Rivulidae	
Anablepsoides cf. *vieirai*	killifishes
Poeciliidae	
Poecilia sarrafae Bragança & Costa 2011**	Guppy, barrigudinho

* 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* Hubbert & 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 Parnaíba 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 Turiaçu 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 Turiaçu, 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 *Acestrorhynchus* [*Acestrorhynchus falcatus* (Bloch, 1794), *Acestrorhynchus lacustris* (Lütken, 1875), *Acestrorhynchus heterolepis* (Cope, 1878), *Acestrorhynchus 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 *Elachocharax 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* Bragança, 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 - *Triportheus angulatus* (Spix, Agassiz, 1829) is *Triportheus 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 parnaibae* 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 parnaguae* 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 *Crenicihla* 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. *parnaibae*) 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. *parnaguae*) 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 Parnaíba 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 Itapecuru 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. *bimaculatus*, *Characidium* cf. *zebra*, *Geophagus* cf. *parnaibae*, *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 Piaui. Although it is very similar to *Apistogramma caetei* 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 is still necessary to let we know which of these two species occurs in the Pindaré River system, or if it is an undescribed species. A third example is *Geophagus parnaibae* Staeck & Schindler 2006, which was described from tributaries of the Parnaiba River basin, in the State of Maranhão (Staeck & Schindler 2006). Although our few collected specimens from the Pindaré River drainage morphologically resemble this species, there are aquarium publications that argue that the population of the Pindaré River drainage is, in fact, an undescribed species, known by aquarists as *Geophagus* sp. "Pindare" (e.g., Grad, 2004). 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 bimaculatus* (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., *Aphyocharax* sp., *Bryconops* aff. *caudomaculatus*, *Hemigrammus* sp., *Microschemobrycon* sp., *Loricariichthys* sp., *Serrapinnus* sp., and *Sturisoma* 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. *Microschemobrycon* 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 Mearim River basin 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, Piorski 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 parnaibae* Reis 1989, *Charax awa* Guimarães, Brito, Ferreira & Ottoni 2018, *Cichlasoma zarskei* Ottoni 2011, *Crenicichla brasiliensis* (Bloch 1792), *Corydoras vittatus* Nijssen 1971, *Curimata macrops* Eigenmann & Eigenmann, 1889, *Hassar affinis* (Steindachner 1881), *Hyphessobrycon caru* Guimarães, Brito, Feitosa, Carvalho-Costa & Ottoni 2019, *Knodus victoriae* (Steindachner 1907), *Myloplus rubripinnis* (Müller & Troschel 1844), *Pimelodella parnahybae* Fowler 1941, *Platydoras brachylecis* Piorski, Garavello, Arce H. & Sabaj Pérez 2008, *Psectrogaster rhomboides* Eigenmann & Eigenmann 1889, *Poecilia sarrafae* Bragança & Costa 2011, *Prochilodus lacustris* Steindachner 1907, *Pterygoplichthys parnaibae* (Weber, 1991), *Schizodon dissimilis* (Garman 1890), *Steindachnerina notonota* (Miranda Ribeiro 1937), *Triportheus signatus* (Garman 1890), *Rhamphichthys atlanticus* Triques 1999, *Roeboides margareteae* Lucena 2003, and *Roeboides sazimai* Lucena 2007]; 18 of them (*Auchenipterus menezesi*, *Brachychalcinus parnaibae*, *Charax awa*, *Cichlasoma zarskei*, *Corydoras vittatus*, *Curimata macrops*, *Hassar affinis*, *Hyphessobrycon caru*, *Knodus victoriae*, *Pimelodella parnahybae*, *Platydoras brachylecis*, *Poecilia sarrafae*, *Prochilodus lacustris*, *Pterygoplichthys parnaibae*, *Schizodon dissimilis*, *Rhamphichthys atlanticus*, *Roeboides margareteae*, *Roeboides 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.

According to Rosa et al. (2003), the fish fauna of the Maranhão-Piaui ecoregion, which includes the Prn and part of Mrn, was historically pointed out as poorly endemic. Otherwise, the low level of endemism recorded during the past decades would be related to few sampling effort on the whole region (Piorski 2010, Ramos et al. 2014, Guimarães et al. 2018). Several species in the Maranhão-Piaui 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 Itapecuru 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 endemism. 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 endemism, 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 Storck 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.

References

ABREU, J.M.S., CRAIG, J.M., ALBERT, J.S. & PIORSKI, N.M. 2019. Historical biogeography of fishes from coastal basins of Maranhão State, northeastern Brazil. Neotropical Ichthyology. 17 (2): e180156. https://doi.org/10.1590/1982-0224-20180156

ALBERT, J.S. & REIS, R. 2011. Historical Biogeography of Neotropical Freshwater Fishes. University of California Press.

ALMEIDA, Z.S., SANTOS, L.S., NUNES, J.L.S., SANTOS, N.B., FIGUEIREDO, M.B. & PIORSKI, N.M. 2013. Diversidade e Cadeia Produtiva de Peixes nos Grandes Lagos da área de Proteção Ambiental da Baixada Maranhense. In Diversidade e Cadeia Produtiva de Peixes nos Grandes Lagos da área de Proteção Ambiental da Baixada Maranhense (Z.S. Almeida, Org.). São Luis, v. 1, 100-119.

ABELHA, M.C.F., AGOSTINHO, A.A. & GOULART, E. 2001. Plasticidade trófica em peixes de água doce. Acta Scientiarum. 23 (2): 425-434.

BARROS, M.C., FRAGA, E.C. & BIRINDELLI, J.L.O. 2011. Fishes from Itapecuru River basin, State of Maranhão, northeast Brazil. Brazilian Journal of Biology. 71 (2): 375-380.

BARTOLETTE, R., VIEIRA, C.S., SANTOS, J.F.L., SANTOS, C.D.C., LUDUVICE, J.S.V., PASSOS, T.S., D'AVILLA, T., NASCIMENTO, B.O., ERNESTO, D., ARGOLO, F.H., AGUIAR, A.J.M., ARGOLO, F., PEREIRA, M.S.A., SANTOS, T.F. & BRITO, M.F.G. 2017. The ichthyofauna in the influence area of the Lajeado reservoir, Tocantins state, Brazil. Check List. 13 (3): 2156. Available from: http://dx.doi.org/10.15560/13.3.2156

BUCKUP, P.A., MENEZES, N.A. & GHAZZI, M.S. 2007. Catálogo das espécies de peixes de água doce do Brasil. Museu Nacional, Rio de Janeiro.

BRAGANÇA, P.H.N. & COSTA, W.J.E.M. 2011. *Poecilia sarrafae*, a new poeciliid from the Paraíba and Mearim river basins, northeastern Brazil (Cyprinodontiformes: Cyprinodontoidei). Ichthyological Exploration of Freshwaters. 21 (4): 369-376.

BRITO, P.S., GUIMARÃES, E.C., FERREIRA, B.R.A., OTTONI, F.P. & PIORSKI, N.M. 2019. Freshwater fishes of the Parque Nacional dos Lençóis Maranhenses and adjacent areas. Biota Neotropica. 19 (3): e20180660. https://doi.org/10.1590/1676-0611-bn-2018-0660

BRITO, P.S., GUIMARÃES, E.C., FERREIRA, B.R.A., SANTOS, J.P., AMARAL, Y.T. & OTTONI, F.P. 2020. Updated and supplementary data on Brito et al. (2019): Freshwater fishes of the PN dos Lençóis Maranhenses and adjacent areas. Ichthyological Contributions of PecesCriollos. 73: 1-17

CASTRO, A.C.L. 2001. Diversidade da assembléia de peixes em igarapés do estuário do Rio Paciência (MA - Brasil). Atlántida (Madrid), Rio Grande, v. 23, p. 39-46.

CASTRO, A.C.L., PIORSKI, N.M. & PINHEIRO JUNIOR, J.R. 2002. Avaliação qualitativa da ictiofauna da Lagoa da Jansen, São Luís-MA. Boletim do Laboratório de Hidrobiologia. 15: 39-50.

CASTRO, A.C.L., CASTRO, K.D.D. & PORTO, H.L.R. 2010. Distribuição da assembléia de peixes na área de influência de uma indústria de alumínio na ilha de São Luís-MA. Arquivos de Ciências do Mar. 43: 71-78.

CASTRO, A.C.L. & DOURADO, E.C.S. 2011. Ictiofauna da Amazônia Oriental Brasileira – um panorama das regiões maranhenses. In Amazônia Maranhense: diversidade e conservação (M.B. Martins & T.G. Oliveira, eds). MPEG, Belém, p.195-202.

CLARO-GARCÍA, A. & SHIBATTA, O.A. 2013. The fish fauna of streams from the upper rio Tocantins basin, Goiás State, Brazil. Check List. 9 (1): 28-33.

CLOSE, B., BANISTER, K., BAUMANS, V., BERNOTH, E.M., BROMAGE, N., BUNYAN, J., ERHARDT, W., FLECKNELL, P., GREGORY, N., HACKBARTH, H., MORTON, D. & WARWICK, C. 1996. Recommendations for euthanasia of experimental animals: Part 1. Laboratory Animals. 30: 293–316. https://doi.org/10.1258/002367796780739871

CLOSE, B., BANISTER, K., BAUMANS, V., BERNOTH, E.M., BROMAGE, N., BUNYAN, J., ERHARDT, W., FLECKNELL, P., GREGORY, N., HACKBARTH, H., MORTON, D. & WARWICK, C. 1997. Recommendations for euthanasia of experimental animals: part 2. Laboratory Animals. 31: 1–32. https://doi.org/10.1258/002367797780600297

DAGOSTA, F.C.P. & DE PINNA, M. 2017. Biogeography of Amazonian fishes: deconstructing river basins as biogeographic units. Neotropical Ichthyology. 15 (3): e170034. https://doi.org/10.1590/1982-0224-20170034

DAGOSTA, F.C. & DE PINNA, M. 2019. The fishes of the Amazon: Distribution and biogeographical patterns, with a comprehensive list of species. Bulletin of the American Museum of Natural History. 2019(431):1-163

FERRARIS, C.J. JR. & VARI, R.P. 1999. The South American catfish genus *Auchenipterus* Valenciennes, 1840 (Ostariophysi: Siluriformes: Auchenipteridae): monophyly and relationships, with a revisionary study. Zoological Journal of the Linnean Society. 126 (4): 387–450. https://doi.org/10.1111/j.1096-3642.1999.tb00156.x

FISHBASE. http://www.fishbase.org/home.htm (last access in 10/04/2020)

FRAGA, E., BIRINDELLI, J.L.O., AZEVEDO, C.A.S. & BARROS, M.C.A. 2012. Ictiofauna da Área de Proteção Ambiental Municipal do Inhamum, Caxias/MA. In Biodiversidade na Área de Proteção Ambiental Municipal do Inhamum (M.C. Barros, Org.). UEMA, São Luís, v. 1, p. 107-115.

FRICKE, R. & ESCHMEYER, W.N. 2020. Guide to fish collections. http://researcharchive. calacademy.org/research/ichthyology/catalog/collections.asp (last access in 10/04/2020)

FRICKE, R., ESCHMEYER, W.N., & VAN DER LAAN, R. 2020a. Eschmeyer's Catalog of fishes: genera, species, references. http://researcharchive.calacademy.org (last access in 10/04/2020)

FRICKE, R., ESCHMEYER, W.N., & FONG, J.D. 2020b Species by Family/Subfamily. http:// researcharchive.calacademy.org (last access in 10/04/2020)

GUIMARÃES, E. C., OTTONI, F.P., KATZ, A.M. & BRITO, P.S. 2016. Range extension of *Moenkhausia oligolepis* (Günther,1864) to the Pindaré river drainage, of Mearim river basin, and Itapecuru river basin of northeastern Brazil (Characiformes: Characidae). International Journal of Aquatic Biology. 4 (3): 202-207. https://doi.org/10.22034/ijab.v4i3.202

GUIMARÃES, E.C., OTTONI, F.P., BRITO, P.S., PIORSKI, N.M. & NUNES, J.L.S. (2017a) Range extension of *Gasteropelecus sternicla* (Characiformes) for three coastal river basins of the Eastern Amazon region as well as for the Itacaiunas River drainage of the Tocantins River basin. Cybium. 41 (1): 72-74.

GUIMARÃES, E.C., OTTONI, F.P. & KATZ, A.M. (2017b) Range extension of *Piabucus dentatus* (Koelreuter, 1763) for the Pindaré River drainage, Mearim River basin, Brazil (Characiformes: Iguanodectinae). Cybium. 41 (3): 287-289.

GUIMARÃES, E.C., BRITO, P.S., FERREIRA, B.R. & OTTONI, F.P. 2018. A new species of *Charax* (Ostariophysi, Characiformes, Characidae) from northeastern Brazil. Zoosystematics and Evolution 94 (1): 83–93. https://doi.org/10.3897/zse.94.22106

GUIMARÃES, E.C., DE BRITO, P.S., FEITOSA, L.M., CARVALHO-COSTA, L.F. & OTTONI, F.P. 2019. A new cryptic species of *Hyphessobrycon* Durbin, 1908 (Characiformes, Characidae) from the Eastern Amazon, revealed by integrative taxonomy. Zoosystematics and Evolution. 95 (2): 345-360. https://doi. org/10.3897/zse.95.34069

GRAD, J. 2004. *Geophaugus* sp. "Pindare". DCG-Informationen. 35 (11): 248-251.

HUBERT, N. & RENNO, J.F. 2006. Historical biogeography of South American freshwater fishes. Jounal of Biogeography. 33: 1414-1436. https://doi.org/10.1111/j.1365-2699.2006.01518.x

KULLANDER, S.O. 1980. A taxonomical study of the genus *Apistogramma* Regan, with a revision of Brazilian and Peruvian species (Teleostei: Percoidei: Cichlidae). Bonner Zoologische Monographien. 14: 1-152.

LANGEANI, F., CASTRO, R.M.C., OYAKAWA, O.T., SHIBATTA, O.A., PAVANELLI, C.S. & CASATTI, L. 2007. Diversidade da ictiofauna do Alto Rio Paraná: composição atual e perspectivas futuras. Biota Neotropica. 7 (3): bn03407032007. https://doi.org/10.1590/S1676-06032007000300020

LEARY, S., UNDERWOOD, W., ANTHONY, R., CARTNER, S., COREY, D. & GRANDIN, T. 2013. AVMA guidelines for the euthanasia of animals: 2013 edition.

LEÃO, M.DV., CARVALHO, T.P., REIS, R.E. & WOSIACKI, W.B. 2019. A new species of *Pseudobunocephalus* Friel, 2008 (Siluriformes: Aspredinidae) from the lower Tocantins and Mearim river drainages, North and Northeast of Brazil. Zootaxa. 4586 (1): 109. https://doi.org/10.11646/zootaxa.4586.1.5

LIMA, F.C.T. & CAIRES, R.A. 2011. Peixes da Estação Ecológica Serra Geral do Tocantins, bacias dos rios Tocantins e São Francisco, com observações sobre as implicações biogeográficas das "águas emendadas" dos rios Sapão e Galheiros. Biota Neotropica. 11(1):231-50.

LIMA, R.C., NASCIMENTO, M.H.S., BARROS, M.C. & FRAGA, E. 2015. Identificação Molecular via DNA Barcoding dos peixes da APA Municipal do Inhamum, Caxias/MA. In Áreas de Proteção Ambiental no Maranhão: situação atual e estratégias de manejo (R.N.F. Carvalho Neta, Org.). UEMA, São Luís, v. 1, p. 303-315.

LIMA, R.C., ALMEIDA, M.S., BARROS, M.C. & FRAGA, E. 2019. Identificação e caracterização molecular de peixes da APA do Inhamum, Leste Maranhense, Brasil. In Conceitos Básicos da Genética (B.R. Silva Neto, Org.), Atena Editora, Ponta Grossa, p. 151-168.

LINKE, H. & STAECK, W. 1995. Dwarf Cichlids (American Cichlids): Dwarf cichlids: a handbook for their identification, care and breeding. Voyageur Press, 232 p.

LOWE-MCCONNELL, R. 1999. Estudos ecológicos em comunidades de peixes tropicais. EDUSP, São Paulo.

LUCENA, C.A.S. 2003. Revisão taxonômica e relações filogenéticas das espécies de *Roeboides* grupo-microlepis (Ostariophysi, Characiformes, Characidae). Iheringia Série Zoologia. 93(3): 283–308. http://dx.doi.org/10.1590/S0073-47212003000300008

LUCENA, C.A.S. 2007. Revisão taxonômica das espécies do gênero *Roeboides* grupo-affinis (Ostariophysi, Characiformes, Characidae). Iheringia Série Zoologia. 97(2): 117–136. http://dx.doi.org/10.1590/S0073-47212007000200001

LUCINDA, P.H.F., FREITAS, I.S., SOARES, A.B., MARQUES, E.E., AGOSTINHO, C.S. & OLIVEIRA, R.J. 2007. Fish, Lajeado Reservoir, rio Tocantins drainage, State of Tocantins, Brazil. Check List. 3 (2). https://doi.org/10.15560/3.2.70

MATAVELLI, R., CAMPOS, A.M., VALE, J., PIORSKI, N.M. & POMPEU, P.S. 2015. Ichthyofauna sampled with tadpoles in northeastern Maranhão state, Brazil. Check List. 11 (1): 1550. DOI: 10.15560/11.1.1550

MARTINS, M.B. & OLIVEIRA, T.G. 2011. Amazônia Maranhense: Diversidade e Conservação. MPEG, Belém, PA.

MELO, F.A.G., BUCKUP, P.A., RAMOS, T.P.A., SOUZA, A.K.N., SILVA, C.M.A., COSTA, T.C. & TORRES, A.R. 2016. Fish fauna of the lower course of the Parnaíba river, northeastern Brazil. Boletim do Museu de Biologia Mello Leitão. 38(4):363-400.

MÉRONA, B.J.L., JURAS, A.A., SANTOS, G.M. & CINTRA, I.H.A. 2010. Os peixes e a pesca no baixo rio Tocantins: vinte anos depois da UHE Tucuruí. Eletronorte, Belém.

NASCIMENTO, M.H.S., ALMEIDA, M.S., VEIRA, M.N.S., LIMEIRA FILHO, D., LIMA, R.C., BARROS, M.C. & FRAGA, E.C. 2016. DNA barcoding reveals high levels of genetic diversity in the fishes of the Itapecuru Basin in Maranhão, Brazil. Genetics and molecular research. 15 (3): gmr.15038476. https://doi.org/10.4238/gmr.15038476

NIELSEN, D.T. 2016. Description of two new species of *Anablepsoides* (Cyprinodontiformes: Cynolebiidae) from Rio Madeira, Amazon drainage, Rondônia state and from Rio Itapecurú basin, Maranhão state, Brazil. Aqua International Journal of Ichthyology. 22 (4): 165-176.

OTTONI, F.P. 2011. *Cichlasoma zarskei*, a new cichlid fish from northern Brazil (Teleostei: Labroidei: Cichlidae). Vertebrate Zoology. 61(3): 335–342.

PELICICE, F.M., AGOSTINHO, A.A. & THOMAZ, S.M. 2005. Fish assemblages associated with Egeria in a tropical reservoir: investigating the effects of plant biomass and diel period. Acta Oecologica. 27 (1): 9-16.

PIORSKI, N.M., CASTRO, A.C.L., PEREIRA, L.G. & MUNIZ, M.E.L. 1998. Ictiofauna do trecho inferior do Rio Itapecuru, nordeste do Brasil. Boletim do Laboratório de Hidrobiologia. 11: 15-24.

PIORSKI, N.M., CASTRO, A.C.L. & PINHEIRO, C.U.B. 2003. A prática da pesca entre os grupos indígenas das bacias dos rios Pindaré e Turiaçu, no Estado do Maranhão, Nordeste do Brasil. Boletim do Laboratório de Hidrobiologia. 16:67-74.

PIORSKI, N.M., CASTRO, A.C.L. & SOUSA NETO, A.M. 2007. Peixes do cerrado da região sul maranhense. In Cerrado Norte do Brasil (L.N. Barreto. Org.). São Luís: USEB; 2007. p.177-212

PIORSKI, N.M., GARAVELLO, J.C., ARCE, M.H. & SABAJ PÉREZ, M.H. 2008. *Platydoras brachylecis*, a new species of thorny catfish (Siluriformes: Doradidae) from northeastern Brazil. Neotropical Ichthyology. 6(3):481–494. http://dx.doi.org/10.1590/S1679-62252008000300021

PIORSKI, N.M. 2010. Diversidade genética das espécies de *Hoplias malabaricus* (Bloch, 1794) e *Prochilodus lacustris* Steindachner, 1907 no Nordeste do Brasil. Tese de doutorado, Universidade Federal de São Carlos, São Carlos.

PIORSKI, N.M., FERREIRA, B.R.A., GUIMARÃES, E.C., OTTONI, F.P., NUNES, J.L.S. & BRITO, P.S. 2017. Peixes do Parque Nacional dos Lençóis Maranhenses. EDUFMA, São Luís.

POLAZ, C.N.M., MELO, B.F., BRITZKE, R., RESENDE, E.K., MACHADO, F., LIMA, J.A.F. & PETRERE, JR. M. 2014. Fishes from the Parque Nacional do Pantanal Matogrossense, upper Paraguai River basin, Brazil. Check List. 10 (1): 122–130. https://doi.org/10.15560/10.1.122

RAMOS, T.P.A., RAMOS, R.T.C. & RAMOS, S.A.Q.A. 2014. Ichthyofauna of the Parnaíba River basin, northeastern Brazil. Biota Neotropica 14 (1): e20130039.

REIS, R.E., KULLANDER, S.O. & FERRARIS, JR.C.J. 2003. Check list of the freshwater fishes of South and Central America. EDIPUCRS, Porto Alegre.

REIS, R.E., ALBERT, J.S., DI DARIO, F., MINCARONE, M.M., PETRY, P. & ROCHA, L.A. 2016. Fish biodiversity and conservation in South America. Journal of Fish Biology. 89 (1): 12-47. https://doi.org/10.1111/jfb.13016

RIBEIRO, M.F.R., PIORSKI, N.M., ALMEIDA, Z.S. & NUNES, J.L.S. 2014. Fish aggregating known as moita, an artisanal fishing technique performed in Munim river, State of Maranhão, Brasil. Boletim do Instituto de Pesca (Impresso). 40 (4): 677-682. http://www.pesca.sp.gov.br/40_4-677-682.pdf

ROSA, R.S., MENEZES, N.A., BRITSKI, H.A., COSTA, W.J.E. & GROTH, F. 2003. Diversidade, padrões de distribuição e conservação dos peixes da caatinga. In Ecologia e Conservação da Caatinga (I.R. Leal, M. Tabarelli, J.M.C. Da Silva, eds). Editora Universitária da Universidade Federal de Pernambuco, Recife, p.135-180.

SANTOS, G.M. & FERREIRA, E.J.G. 1999. Peixes da bacia Amazônica. In Estudos ecológicos de 297 comunidades de peixes tropicais (R.H. Lowe-McConnell, ed.). EDUSP, São Paulo. p.349-354.

SANTANA, D.C., CRAMPTON, W.G.R., DILLMAN, C.B., ET AL. 2019. Unexpected species diversity in electric eels with a description of the strongest living bioelectricity generator. Nature Communications. 10:4000. https://doi.org/10.1038/s41467-019-11690-z

SCHAEFER, S. A. 1998. Conflict and resolution: impact of new taxa on phylogenetic studies of the Neotropical cascudinhos (Silurioidei: Loricariidae). In Phylogeny and Classification of Neotropical Fishes (L.R. Malabarba et al., eds). EDIPUCRS, Porto Alegre.

SOARES, E.C. 2005. Peixes do Mearim. Instituto Geia, São Luís.

SOARES, E.C. 2013. Peixes do Mearim. Instituto Geia, São Luis.

SOARES, A.B., PELICICE, F.M., LUCINDA, P.H.F. & AKAMA, A. 2009. Diversidade de peixes na área de influência da barragem de Peixe Angical, antes e após a formação do reservatório. In Reservatório de Peixe Angical: bases ecológicas para o manejo da ictiofauna (C.S. Agostinho, F.M. Pelicice & E.E. Marques, eds). RIMa, São Carlos. p.15-27.

SOUSA, M.R.J., CASTRO, A.C.L. & SILVA, M.H.L. 2011. Comunidade de peixes como indicador de qualidade ambiental na área de influência da indústria ALUMAR, ilha de São Luís - MA. Boletim do Laboratório de Hidrobiologia. 24: 1-8.

SILVA, M.R., SILVA, L.V., BARRETO, L.N.C., RODRIGUES, E.H.C., MIRANDA, R.C.M., BEZERRA, D.S. & PEREIRA, D.C.A. 2017. Quality of the water from the Pindare river Basin, In the facts corresponding to the municipalities of Pindare Mirim, Tufilandia and Alto Alegre In the State of Maranhão. Águas Subterrâneas. 31(4): 347-354.

SCHINDLER, I. 1998. *Apistograma piauiensis* Kullander, 1980. DCG-Informationen. 29 (3): 1-4.

STAECK, W. & SCHINDLER, I. 2006. *Geophagus parnaibae* sp. n. - a new species of cichlid fish (Teleostei: Perciformes: Cichlidae) from the rio Parnaíba basin, Brazil. Zoologische Abhandlungen, Staatliche Naturhistorische Sammlungen Dresden, Museum für Tierkunde. 55: 69–75.

TEIXEIRA, B.R.S., BARROS, M.C. & FRAGA, E.C. 2019. DNA barcoding confirma a ocorrência de espécies amazônicas na ictiofauna do rio Turiaçu, Maranhão/Brasil. In Conceitos Básicos da Genética. (B.R. Silva Neto, Org.). Atena Editora, Ponta Grossa, p. 98-110.

TRIQUES, M.L. 1999. Three new species of *Rhamphichthys* Müller et Troschell [sic], 1846 (Ostariophysi: Gymnotiformes: Rhamphichthyidae). Revue française d'Aquariologie Herpétologie. 26(1–2): 1–6.

VARI, R.P., FERRARIS, C.J., RADOSAVLJEVIC, A. & FUNK, V.A. 2009. Checklist of the Freshwater Fishes of the Guiana Shield. Bullletin of the Biological Society of Washington. 17 (1): 1–94. https://doi.org/10.2988/0097-0298-17.1.i

VAN DER SLEEN, P. & ALBERT, J.S. 2018. Field Guide to the fishes of the Amazon, Orinoco & Guianas. Princeton University Press, Priceton.

VAL, A.L. 2019. Fishes of the Amazon: divversity and beyound. Anais da Academia Brasileira de Ciências. 91(3): e20190260.

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