









## Ichthyofauna of the Nascentes do Rio Parnaíba National Park: watershed divide in the main agricultural encroachment area in the Brazilian Cerrado

Salu Coêlho da Silva<sup>1,2\*</sup> , Lucas Silva de Medeiros<sup>1,2</sup> , Miguel Fernandes Bezerra Neto<sup>1,2</sup>,  
Márcio Joaquim da Silva<sup>3,1</sup> , Telton Pedro Anselmo Ramos<sup>4,6</sup> , Flávio César Thadeo de Lima<sup>5</sup>  &  
Sergio Maia Queiroz Lima<sup>1</sup> 

<sup>1</sup>Universidade Federal do Rio Grande do Norte, Departamento de Botânica e Zoologia, Laboratório de Ictiologia Sistemática e Evolutiva, Natal, RN, Brasil.

<sup>2</sup>Universidade Federal do Rio Grande do Norte, Centro de Biociências, Programa de Pós-graduação em Sistemática e Evolução, Campus Universitário, 59084-100, Natal, RN, Brasil.

<sup>3</sup>Universidade Federal do Pará, Laboratório de Conservação, Ecologia e Sistemática de Peixes, Campus Universitário do Marajó-Soure, Soure, PA, Brasil.

<sup>4</sup>Universidade Federal da Paraíba, Departamento de Sistemática e Ecologia, João Pessoa, PB, Brasil.

<sup>5</sup>Universidade Estadual de Campinas, Museu de Diversidade Biológica, Campinas, SP, Brasil.

<sup>6</sup>Instituto Peixes da Caatinga, João Pessoa, PB, Brasil.

\*Corresponding author: salu.coelho@gmail.com

SILVA, S.C., MEDEIROS, L.S., NETO, M.F.B., SILVA, M.J., RAMOS, T.P.A., LIMA, F.C.T., LIMA, S.M.Q. **Ichthyofauna of the Nascentes do Rio Parnaíba National Park: watershed divide in the main agricultural encroachment area in the Brazilian Cerrado.** *Biota Neotropica* 23(1): e20221414. <https://doi.org/10.1590/1676-0611-BN-2022-1414>

**Abstract:** The Nascentes do Rio Parnaíba National Park (NPNP), located in Brazilian Cerrado, protects portions of three river basins: headwaters of Parnaíba, a small portion in upper Tocantins-Araguaia, and tributaries of the middle section of the São Francisco. This protected area is in the boundaries of the states of Maranhão, Tocantins, Piauí, and Bahia, also known as MATOPIBA, a region that has established rapid agricultural expansion associated to land conflicts between corporate agriculture, family agriculture, protected areas, indigenous territories, and quilombola communities. The knowledge of the ichthyofauna in this region is scarce while the impacts on the aquatic environments are increasing. We made a survey of fishes in the NPNP and its surroundings areas, estimating richness, endemics, introduced and shared species between river basins. During 2014, 54 sampling sites were visited, 19 in the NPNP and 35 in the surrounding area. Ninety-five species, 51 genera, 22 families, and six orders were recorded, of which 38 (40%) are in the NPNP. One introduced species were recorded in the Parnaíba River basin and no endangered species were registered. Our data corroborate the importance of the network of protected areas for the preservation of Cerrado fishes, including some possibly undescribed and restricted-range species that may be threatened due to intense agricultural encroachment in the MATOPIBA region.

**Keywords:** MATOPIBA; Tocantins-Araguaia River; headwaters, Cerrado fishes; conservation unit.

## Ictiofauna do Parque Nacional Nascentes do Rio Parnaíba: um divisor de bacias hidrográficas na principal área de expansão agrícola do Cerrado Brasileiro

**Resumo:** O Parque Nacional Nascentes do Rio Parnaíba (PNNP), localizado no Cerrado brasileiro, protege diferentes porções de três bacias hidrográficas, as cabeceiras do Parnaíba, uma pequena porção do alto rio Tocantins e tributários do trecho médio do São Francisco. Esta área protegida está localizada nos limites dos estados do Maranhão, Tocantins, Piauí e Bahia, também conhecida como MATOPIBA, região que tem apresentado rápida expansão agrícola associada a conflitos fundiários do agronegócio com agricultura familiar, áreas protegidas, territórios indígenas e comunidades quilombolas. O conhecimento da ictiofauna nessas regiões é escasso, embora os impactos sobre os ecossistemas aquáticos sejam crescentes. Assim, elaboramos um levantamento de peixes do PNNP e em seu entorno, identificando a riqueza, espécies endêmicas, introduzidas e compartilhadas entre bacias hidrográficas. Durante o ano de 2014 foram visitados 54 locais de amostragem, 19 no PNNP e 35 no entorno. Foram coletadas 95 espécies, 51 gêneros, 22 famílias e seis ordens, das quais 38 espécies (40%) estão no PNNP. Uma espécie introduzida foi registrada na bacia do rio Parnaíba e nenhuma espécie ameaçada de extinção foi registrada. Os dados aqui apresentados corroboram a importância da rede de áreas protegidas para a preservação dos peixes do Cerrado, com espécies potencialmente novas e de distribuição restrita, que podem estar ameaçadas devido à intensa expansão agrícola na região do MATOPIBA.

**Palavras-chave:** MATOPIBA; rio Tocantins-Araguaia; cabeceiras; peixes do Cerrado; unidade de conservação.

## Introduction

The Cerrado is a tropical woodland-savannah in central Brazil under intense anthropogenic pressure, with land conflicts and high deforestation rates, which have been increasing since the 1990s. It possesses a high level of endemism and is considered a global hotspot for biodiversity conservation (Myers et al. 2000, Strassburg et al. 2017). Thenceforth, approximately 50% of its area was transformed into agricultural areas or pastures (Beuchle et al. 2015), with the loss of natural landscapes approximately 47% larger than in the Amazon rainforest in the same period (Carvalho et al. 2019). Among the most intensely impacted areas is the MATOPIBA, an acronym formed by the initials of the Brazilian states of Maranhão, Tocantins, Piauí and Bahia, one of the main areas of agricultural expansion in Brazil, based on high technology productivity of vast soybean and corn plantations (Miranda et al. 2014, Lopes et al. 2020).

Despite the biological importance and the historical deforestation, when compared with other Brazilian biomes, few conservation units are in the Cerrado, protecting less than 10% of its original area. Among the federal protected areas, are the Ecological Station Serra Geral do Tocantins (7,163 km<sup>2</sup>), Araguaia National Park (5,577 km<sup>2</sup>), Chapada dos Veadeiros National Park (2,406 km<sup>2</sup>), Serra das Confusões National Park (8,234 km<sup>2</sup>), and Nascentes do Rio Parnaíba National Park (NPNP) (7,498 km<sup>2</sup>). This latter is located on the boundaries of the MATOPIBA states, encompassing three hydrographic basins and freshwater ecoregions, the Parnaíba, Tocantins-Araguaia, and São Francisco rivers (sensu Abell et al. 2008, Brasil 2019) (Figure 1). The NPNP and surrounding areas are considered of great importance for the conservation of Cerrado's biodiversity, given the advance of deforestation due to cash crops and cattle raising (Carvalho et al. 2019).

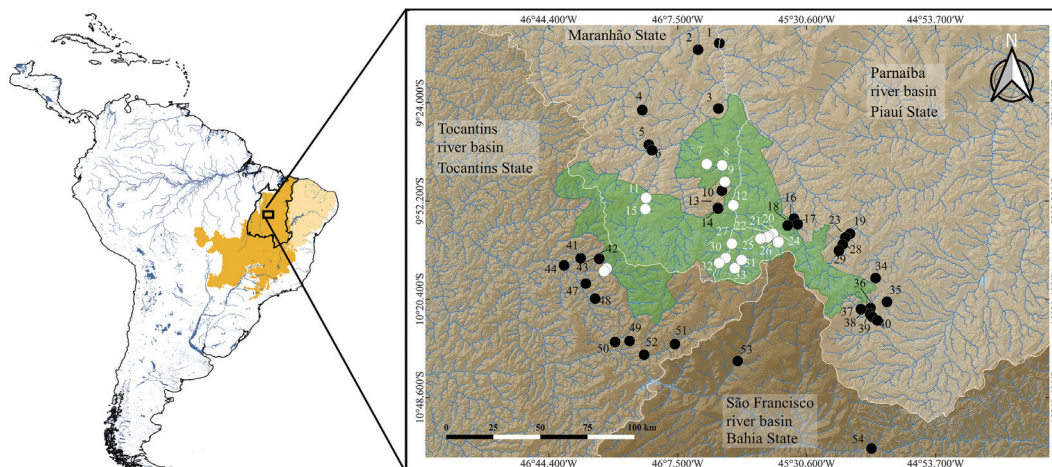
The Cerrado contributes to 43% of Brazil's surface water, outside the Amazon region (Strassburg et al. 2017), comprising headwaters from at least five hydrographic basins: Amazon, Tocantins-Araguaia, São Francisco, Paraná-Paraguay, and Parnaíba rivers (Lima & Silva 2005, Abell et al. 2008). The knowledge of fish diversity in these drainages is heterogeneous, varying among them and along different stretches of the same basin, usually reflecting the distance from research institutions

(Langeani et al. 2009, Dagosta & de Pinna 2019). The richness of fish species in the Cerrado drainages is estimated in approximately 1,200 species (Klink & Machado 2005).

Recent fish surveys in the Parnaíba, São Francisco, and Tocantins-Araguaia river basins were carried out by Lima & Caires (2011), Ramos et al. (2014), Lima et al. (2017), Bartolette et al. (2017), Silva et al. (2020a, b), and Chamon et al. (2022). However, the ichthyofauna of the headwaters of the upper Parnaíba and middle São Francisco basins were not fully explored (Ramos et al. 2014, Melo et al. 2016, Lima et al. 2017, Barbosa et al. 2017, Silva et al. 2020a, b). Among the studies encompassing the upper Parnaíba, Silva et al. (2015) recorded 90 species in the Gurgueia River (about 60% of the drainages' richness), with 34 endemic and six new records in the basin, including localities in the vicinity of the NPNP.

Few ichthyological studies focused on the Tocantins and São Francisco River basins in the MATOPIBA region. The most important was conducted by Lima & Caires (2011) at the Serra Geral do Tocantins Ecological Station and surrounding areas, encompassing headwaters of both drainages, including a shared one (known in Portuguese as 'águas emendadas'). As evidence of the exchange of fish species through this natural connection, Lima & Caires (2011) reported the presence of two species that have unequivocally traversed this common headwater, the characin *Astyanax novae* Eigenmann 1911 and the cichlid *Cichlasoma sanctifranciscense* Kullander 1983.

As many Cerrado drainages from the region, the MATOPIBA rivers are threatened by the deforestation of riparian vegetation, the input of fertilizers and pesticides from nearby agriculture areas, and the construction of dams (ICMBio 2018, Latrubesse et al. 2019, Chamon et al. 2022). A mosaic of federal and private Protected Areas (PAs) in MATOPIBA encompass several tributaries of one of the largest and least known PAs of the Cerrado (Nogueira et al. 2011, ISA 2015). Thus, this study aimed to inventory the ichthyofauna in the drainages that are protected by the NPNP and its surroundings areas. With this, we intend to expand the knowledge of the fish diversity of the headwaters of the upper Parnaíba and Tocantins drainages and middle São Francisco River basins in the MATOPIBA region that is a knowledge gap presenting high vulnerability due to the intense agricultural expansion.



**Figure 1.** Sampling sites in the Nascentes do Rio Parnaíba National Park (NPNP) and surroundings in MATOPIBA (black line) in the Brazilian Cerrado (orange). White dots, sampling sites in the NPNP; black dots, sampling sites outside of the NPNP. The sites in Maranhão (MA) e Piauí (PI) states flow to Parnaíba River basin, those in Tocantins (TO) to Tocantins River basin and, those in Bahia (BA) to São Francisco River basin.

## Material and Methods

### 1. Study area

The studied area encompasses the headwaters of the upper Parnaíba River, and tributaries of the upper Tocantins (sensu Dagosta & de Pinna 2019) and middle of the São Francisco river basins located in the NPNP and vicinities (Figure 1). The park has an extension of 7,497.74 km<sup>2</sup>, and is situated in the boundaries of Maranhão (MA), Piauí (PI), Tocantins (TO), and Bahia (BA) states and nine municipalities, Alto Parnaíba (MA), Lizarda (TO), Mateiros (TO), São Félix do Tocantins (TO), Barreiras do Piauí (PI), Corrente (PI), Gilbués (PI), São Gonçalo do Gurgueia (PI) and Formosa do Rio Preto (BA).

Entirely inserted in the Cerrado biome, temperatures in the NPNP region vary between 20 °C and 32 °C, with rainfall concentrated from October to March (MMA 2019, Macena et al. 2008). The relief presents the Chapada das Mangabeiras as its main geological formation, which interconnects with the Urucuaia Formation, known for its sandstone composition and high soil permeability. These characteristics enable the formation of headwaters in the foothills, in addition to waterfalls and rapids which make up watercourses that later consolidate the drainages in the region (Brasil 2019).

The Parnaíba River headwaters are situated at the foothills of the Chapada das Mangabeiras, which is formed from numerous springs of the Água Quente (between PI and MA), Curriola, and Lontra rivers (PI). To the south of the Chapada das Mangabeiras, at the northern limit of NPNP, are the headwaters of the Sono River, a tributary of the upper Tocantins river basin. The southeast portion of the NPNP (BA) drains the São Francisco river basin, forming the Sapão River, one of the headwaters of the Preto River. However, the headwaters of the Sapão River (São Francisco) and the Galheiros River (Novo River, tributary of the Tocantins River), the region of 'águas emendadas', is situated outside the NPNP according to the shapefiles of the Agência Nacional de Águas e Saneamento Básico (ANA 2021) and federal conservation units by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio 2018).

### 2. Collection and identification

The collections were carried out in June 2014 at 54 sampling sites distributed in the São Francisco (2), Parnaíba (40), and Tocantins (12) river basins (Table 1, Figure 2), under permits n° 20088/2014 and 30532/2011 issued by the ICMBio/SISBIO. The effort for the collection followed the AquaRAP approach (Rapid Assessment

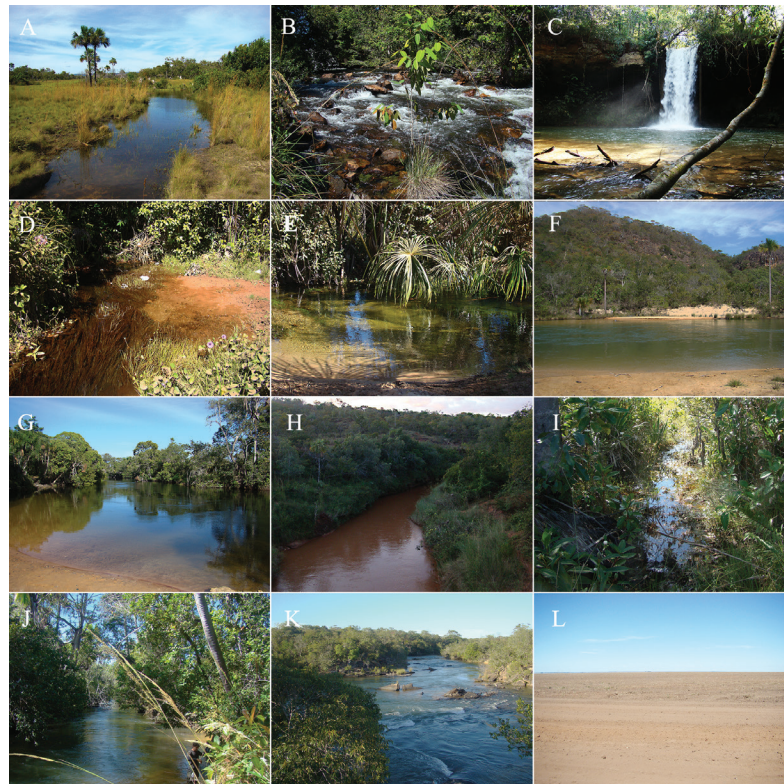
**Table 1.** Sampling sites in Nascentes do Rio Parnaíba National Park (NPNP) and surroundings. (P) sampling in the Park. BA, Bahia; MA, Maranhão; PI, Piauí; TO, Tocantins.

| ID | River basin  | Sampling sites  | Geographic coordinates    |
|----|--------------|---|---------------------------|
| 1  | Parnaíba     | Parnaíba River, Alto Parnaíba, MA   | 09°06'54.3"S 45°55'37.8"W |
| 2  | Parnaíba     | Brejinho Stream, road between Alto Parnaíba and Morrinhos, Alto Parnaíba, MA                    | 09°08'46.4"S 46°01'41.8"W |
| 3  | Parnaíba     | Unnamed stream between Taboca and Alto Parnaíba, Alto Parnaíba, MA                              | 09°25'40.1"S 45°55'53.4"W |
| 4  | Parnaíba     | Unnamed stream near Morrinhos, Alto Parnaíba, MA  | 09°26'05.8"S 46°17'39.7"W |
| 5  | Parnaíba     | Unnamed stream between Morrinhos and Bonfim, Alto Parnaíba, MA                                  | 09°36'04.5"S 46°15'47.6"W |
| 6  | Parnaíba     | Parnaibinha River, road between Morrinhos and Bonfim, Alto Parnaíba, MA                         | 09°37'37.0"S 46°14'54.3"W |
| 7  | Parnaíba (P) | Parnaíba River, Taboca rapids, Alto Parnaíba, MA  | 09°41'34.2"S 45°59'12.5"W |
| 8  | Parnaíba (P) | Unnamed stream between Castelo and Taboca, Alto Parnaíba, MA                                    | 09°41'57.2"S 45°54'48.3"W |
| 9  | Parnaíba     | Unnamed stream, Castelo village, Alto Parnaíba, MA  | 09°46'41.3"S 45°54'01.7"W |
| 10 | Parnaíba     | Unnamed stream between Curupá and Castelo, Alto Parnaíba, MA                                    | 09°49'16.2"S 45°54'53.7"W |
| 11 | Parnaíba (P) | Unnamed stream tributary of Riozinho river, Alto Parnaíba, MA                                   | 09°51'18.2"S 46°16'32.8"W |
| 12 | Parnaíba (P) | Parnaíba River, near bridge in NPNP, Alto Parnaíba, MA  | 09°53'24.3"S 45°51'37.6"W |
| 13 | Parnaíba     | Angico Stream (Curupá marsh), Alto Parnaíba, MA   | 09°54'08.4"S 45°56'03.5"W |
| 14 | Parnaíba     | Stream in Curupá (Sumidor marsh), Alto Parnaíba, MA   | 09°54'21.6"S 45°55'57.9"W |
| 15 | Parnaíba (P) | Unnamed stream tributary of Riozinho river, Alto Parnaíba, MA                                   | 09°54'31.5"S 46°16'47.4"W |
| 16 | Parnaíba     | Uruçuí-vermelho River, Prata village, Barreiras do Piauí, PI                                    | 09°57'14.7"S 45°34'15.2"W |
| 17 | Parnaíba     | Uruçuí Vermelho River, near Alto Alegre (Quebra-Bunda), Barreiras do Piauí, PI                  | 09°58'53.0"S 45°33'11.7"W |
| 18 | Parnaíba (P) | Temporary pond in Curicaca, near Prata village, Barreiras do Piauí, PI                          | 09°59'13.5"S 45°36'04.6"W |
| 19 | Parnaíba     | Gurgueia River, under bridge on highway BR-135, São Gonçalo do Gurgueia, PI                     | 10°01'37.1"S 45°18'12.4"W |
| 20 | Parnaíba (P) | Atoleiro marsh, Barreiras do Piauí, PI  | 10°01'37.4"S 45°40'16.0"W |
| 21 | Parnaíba (P) | Porto marsh, Barreiras do Piauí, PI   | 10°02'17.1"S 45°41'30.6"W |
| 22 | Parnaíba (P) | Lontras River in NPNP, Barreiras do Piauí, PI   | 10°02'36.2"S 45°41'56.1"W |
| 23 | Parnaíba     | Gurgueia River, Corrente, PI  | 10°02'41.6"S 45°19'33.6"W |
| 24 | Parnaíba (P) | Fortaleza marsh, Barreiras do Piauí, PI   | 10°03'52.2"S 45°38'35.1"W |
| 25 | Parnaíba (P) | Madeiro marsh, Barreiras do Piauí, PI   | 10°03'00.3"S 45°43'51.2"W |
| 26 | Parnaíba (P) | Fortaleza lagoon, Barreiras do Piauí, PI  | 10°04'04.4"S 45°38'47.4"W |
| 27 | Parnaíba (P) | Marsh, upstream confluence of Corriola and Água Quente rivers, Barreiras do Piauí, PI           | 10°04'27.0"S 45°52'01.7"W |
| 28 | Parnaíba     | Headwaters of Gurgueia River, São Gonçalo do Gurgueia, PI                                       | 10°04'38.8"S 45°20'18.2"W |
| 29 | Parnaíba     | Gurgueia River, Araras Park, Corrente, PI   | 10°06'27.0"S 45°21'24.0"W |
| 30 | Parnaíba (P) | Parnaíba River, downstream confluence of Pintado and Água Quente rivers, Barreiras do Piauí, PI | 10°08'35.4"S 45°53'50.7"W |

Continue...

...Continuation

| ID | River basin              | Sampling sites   | Geographic coordinates    |
|----|--------------------------|--|---------------------------|
| 31 | Parnaíba <sup>(P)</sup>  | Curriola River, under bridge, Barreiras do Piauí, PI   | 10°09'06.4"S 45°49'15.0"W |
| 32 | Parnaíba <sup>(P)</sup>  | Sussuapara Waterfall, Sussuapara River, tributary of Água Quente River, Barreiras do Piauí, PI | 10°09'56.7"S 45°55'39.1"W |
| 33 | Parnaíba <sup>(P)</sup>  | Pintado Waterfall, tributary of Água Quente River, Barreiras do Piauí, PI                      | 10°11'28.9"S 45°51'12.9"W |
| 34 | Parnaíba                 | Pond at the margins of highway BR-135, Corrente, PI  | 10°14'19.4"S 45°10'53.9"W |
| 35 | Parnaíba                 | Corrente River, Corrente, PI   | 10°21'09.4"S 45°07'38.2"W |
| 36 | Parnaíba                 | Taji River, Corrente, PI   | 10°22'54.9"S 45°12'21.4"W |
| 37 | Parnaíba                 | Corrente River, Corrente, PI   | 10°23'14.9"S 45°15'05.9"W |
| 38 | Parnaíba                 | Unnamed stream, tributary of Corrente River, Corrente, PI                                      | 10°24'39.4"S 45°12'25.0"W |
| 39 | Parnaíba                 | Corrente River under bridge at highway BR-135, Corrente, PI                                    | 10°25'30.6"S 45°11'47.4"W |
| 40 | Parnaíba                 | Corrente River under bridge at highway BR-135, Corrente, PI                                    | 10°26'29.4"S 45°10'24.3"W |
| 41 | Tocantins                | Unnamed stream tributary of Prata River, São Felix do Tocantins, TO                            | 10°08'39.6"S 46°35'19.6"W |
| 42 | Tocantins                | Prata Stream, Prata Village, São Felix do Tocantins, TO  | 10°08'45.0"S 46°29'55.4"W |
| 43 | Tocantins                | Porcos Stream, Prata Village, São Felix do Tocantins, TO                                       | 10°08'48.1"S 46°30'00.4"W |
| 44 | Tocantins                | Soninho River, São Felix do Tocantins, TO  | 10°10'40.8"S 46°40'04.4"W |
| 45 | Tocantins <sup>(P)</sup> | Vereda in Prata River, between Cachoeira and Mateiros, São Felix do Tocantins, TO              | 10°11'33.5"S 46°27'52.0"W |
| 46 | Tocantins <sup>(P)</sup> | Prata Waterfall, São Felix do Tocantins, TO  | 10°12'21.6"S 46°28'35.4"W |
| 47 | Tocantins                | Unnamed stream under bridge between Prata and Mateiros Village, Mateiros, TO                   | 10°15'55.1"S 46°33'49.9"W |
| 48 | Tocantins                | Formiga River under bridge between Prata and Mateiros, Mateiros, TO                            | 10°20'13.3"S 46°31'10.1"W |
| 49 | Tocantins                | Unnamed stream under bridge between Mateiros and Coaceral, Mateiros, TO                        | 10°32'23.4"S 46°21'18.9"W |
| 50 | Tocantins                | Unnamed stream under bridge, Mateiros, TO  | 10°32'42.4"S 46°25'27.7"W |
| 51 | Tocantins                | Raízes Stream, under bridge between Mateiros and Coaceral, Mateiros, TO                        | 10°33'16.3"S 46°08'20.5"W |
| 52 | Tocantins                | Come Assado Stream, Mateiros, TO   | 10°36'20.9"S 46°17'08.2"W |
| 53 | São Francisco            | Sassafrás River, tributary of Sapão River, Formosa do Rio Preto, BA                            | 10°38'08.5"S 45°50'21.2"W |
| 54 | São Francisco            | Preto River, Formosa do Rio Preto, BA  | 11°03'14.3"S 45°12'04.8"W |



**Figure 2.** Subset of sampling sites visited in Nascentes do Rio Parnaíba National Park and surroundings. A. Temporary pond Curicaca, Barreiras do Piauí – PI; B. Prata waterfall, São Felix do Tocantins – TO; C. Sussuapara waterfall, Barreiras do Piauí – PI; D. Porcos stream, São Felix do Tocantins – TO; E. Unnamed stream, Mateiros – TO; F. Parnaíba River, Alto Parnaíba – MA; G. Soninho River, São Felix do Tocantins – TO; H. Atoleiro marsh, Barreiras do Piauí, PI; I. Vereda tributary of Prata River, São Felix do Tocantins – TO; J. Parnaibinha River, road between Morrinhos and Bonfim, Alto Parnaíba – MA; K. Parnaíba River, Taboca rapids, Alto Parnaíba – MA; L. Area deforested by business agriculture in São Francisco River basin in Bahia. MA, Maranhão; PI, Piauí; TO, Tocantins.

**Table 2.** Systematic list of fish species collected in Nascentes do Rio Parnaíba National Park (NPNP) and surroundings. PAR, Parnaíba River basin; TOC, Tocantins River basin; SFR, São Francisco River basin. END = Endemic species.

| ORDER/Family/Species   | NPNP | PAR | TOC | SFR | END | VOUCHER   |
|--|------|-----|-----|-----|-----|---|
| <b>CHARACIFORMES</b>   |      |     |     |     |     |   |
| <b>Acestrorhynchidae</b>                                       |      |     |     |     |     |   |
| <i>Acestrorhynchus lacustris</i> (Lütken, 1875)                |      |     |     | X   |     | UFRN 3746   |
| <b>Anostomidae</b>   |      |     |     |     |     |   |
| <i>Leporinus friderici</i> (Bloch, 1794)                       | X    | X   |     |     |     | UFRN 2725   |
| <i>Leporinus piau</i> Fowler, 1941                             |      | X   |     | X   |     | UFRN 2724 (PAR)<br>UFRN 3651 (SFR)                    |
| <i>Megaleporinus obtusidens</i> (Valenciennes, 1837)           |      | X   |     |     |     | UFRN 3094   |
| <b>Characidae</b>  |      |     |     |     |     |   |
| <i>Astyanax lacustris</i> (Lütken, 1875)                       |      |     |     | X   |     | UFRN 3739   |
| <i>Astyanax novae</i> Eigenmann, 1911                          |      |     | X   |     |     | UFRN 2816   |
| <i>Brachyhalcinus parnaíbae</i> Reis, 1989                     | X    | X   |     |     | X   | UFRN 3143   |
| <i>Bryconamericus</i> sp.                                      | X    | X   |     |     | X   | UFRN 3034   |
| <i>Caiapobrycon tucuruí</i> Malabarba & Vari, 2000             |      |     | X   |     | X   | UFRN 2814   |
| <i>Compsura heterura</i> (Eigenmann, 1915)                     |      | X   |     |     |     | UFRN 2715   |
| <i>Creagrutus</i> sp.  |      |     | X   |     | X   | UFRN 3597   |
| <i>Hasemania</i> sp.   |      | X   |     |     | X   | UFRN 2874   |
| <i>Hemigrammus brevis</i> Ellis, 1911                          | X    | X   |     |     | X   | UFRN 3039   |
| <i>Hemigrammus marginatus</i> Ellis, 1911                      |      | X   | X   |     |     | UFRN 2840 (PAR)<br>UFRN 3696 (TOC)                    |
| <i>Hemigrammus rodwayi</i> Durbin, 1909                        |      | X   |     |     |     | UFRN 2854   |
| <i>Hemigrammus</i> sp. 1                                       | X    | X   |     |     | X   | UFRN 2829   |
| <i>Hemigrammus</i> sp. 2                                       | X    |     | X   |     | X   | UFRN 3594   |
| <i>Hemigrammus</i> sp. 3                                       |      |     | X   |     | X   | UFRN 3738   |
| <i>Hyphessobrycon stegemanni</i> Géry, 1961                    |      |     | X   |     | X   | UFRN 3596   |
| <i>Hyphessobrycon</i> sp. 1                                    |      | X   |     |     | X   | UFRN 2876   |
| <i>Hyphessobrycon</i> sp. 2                                    | X    |     | X   |     | X   | UFRN 2788   |
| <i>Jupiaba polylepis</i> (Günther, 1864)                       |      | X   | X   |     |     | UFRN 3084 (PAR)<br>UFRN 3691 (TOC)                    |
| <i>Knodus chapadae</i> (Fowler, 1906)                          |      |     | X   |     |     | UFRN 3665   |
| <i>Knodus victoriae</i> (Steindachner, 1907)                   | X    | X   |     |     | X   | UFRN 3095   |
| <i>Knodus</i> sp. 1  |      |     | X   |     | X   | UFRN 2810   |
| <i>Knodus</i> sp. 2  |      |     |     | X   | X   | UFRN 3742   |
| <i>Moenkhausia collettii</i> (Steindachner, 1882)              |      |     | X   |     |     | UFRN 3593   |
| <i>Moenkhausia costae</i> (Steindachner, 1907)                 |      |     |     | X   | X   | UFRN 3722   |
| <i>Moenkhausia sanctaefilomenae</i> (Steindachner, 1907)       | X    | X   | X   | X   |     | UFRN 2706 (PAR)<br>UFRN 2790 (TOC)<br>UFRN 3374 (SFR) |
| <i>Orthospinus franciscensis</i> (Eigenmann, 1914)             |      |     |     | X   | X   | UFRN 339  |
| <i>Phenacogaster calverti</i> (Fowler, 1941)                   |      | X   |     |     |     | UFRN 2740   |
| <i>Psalidodon fasciatus</i> (Cuvier, 1819)                     | X    | X   |     |     |     | UFRN 2707   |
| <i>Serrapinnus heterodon</i> (Eigenmann, 1915)                 |      | X   |     |     |     | UFRN 2714   |
| <i>Serrapinnus</i> sp.   |      | X   |     |     | X   | UFRN 2754   |
| <b>Chilodontidae</b>   |      |     |     |     |     |   |
| <i>Caenotropus labyrinthicus</i> (Kner, 1858)                  | X    | X   |     |     |     | UFRN 3134   |
| <b>Crenuchidae</b>   |      |     |     |     |     |   |
| <i>Characidium</i> aff. <i>bahiensis</i> Almeida, 1971         |      |     | X   |     | X   | UFRN 3702   |
| <i>Characidium</i> gr. <i>zebra</i> Eigenmann, 1915            | X    | X   |     |     |     | UFRN 3044   |
| <i>Characidium tapuia</i> Zanata, Ramos & Oliveira-Silva, 2018 | X    | X   |     |     | X   | UFRN 2784   |
| <i>Characidium</i> sp.   | X    | X   |     |     | X   | UFRN 2871   |

Continue...

...Continuation

| ORDER/Family/Species                                      | NPNP | PAR | TOC | SFR | END | VOUCHER   |
|---|------|-----|-----|-----|-----|---|
| <b>Curimatidae</b>  |      |     |     |     |     |   |
| <i>Curimatella immaculata</i> (Fernández-Yépez, 1948)     | X    | X   |     |     |     | UFRN 3140   |
| <i>Cyphocharax</i> cf. <i>spilurus</i> (Günther, 1864)    |      |     | X   |     |     | UFRN 3676   |
| <i>Steindachnerina notonota</i> (Miranda Ribeiro, 1937)   | X    | X   |     |     |     | UFRN 2759   |
| <b>Erythrinidae</b>                                       |      |     |     |     |     |   |
| <i>Hoplerythrinus unitaeniatus</i> (Spix & Agassiz, 1829) | X    | X   | X   | X   |     | UFRN 2830 (PAR)<br>UFRN 3185 (TOC)<br>UFRN 3375 (SFR) |
| <i>Hoplias malabaricus</i> (Bloch, 1794)                  | X    | X   | X   | X   |     | UFRN 2739 (PAR)<br>UFRN 3338 (TOC)<br>UFRN 3373 (SFR) |
| <b>Hemiodontidae</b>                                      |      |     |     |     |     |   |
| <i>Hemiodus parnaguae</i> Eigenmann & Henn, 1916          |      | X   |     |     | X   | UFRN 3079   |
| <b>Iguanodectidae</b>                                     |      |     |     |     |     |   |
| <i>Bryconops affinis</i> (Günther, 1864)                  |      |     |     | X   |     | UFRN 3719   |
| <i>Bryconops</i> gr. <i>melanurus</i> (Bloch, 1794)       | X    | X   | X   |     |     | UFRN 2713 (PAR)<br>UFRN 3674 (TOC)                    |
| <i>Bryconops</i> sp. 1                                    |      |     |     | X   | X   | UFRN 3750   |
| <i>Bryconops</i> sp. 2                                    |      |     | X   |     | X   | UFRN 2787   |
| <i>Bryconops</i> sp. 3                                    |      |     | X   |     | X   | UFRN 3704   |
| <b>Paradontidae</b>                                       |      |     |     |     |     |   |
| <i>Apareiodon</i> sp. 1                                   |      | X   |     |     | X   | UFRN 2774   |
| <i>Apareiodon</i> sp. 2                                   |      | X   |     |     | X   | UFRN 2746   |
| <b>Serrasalminidae</b>                                    |      |     |     |     |     |   |
| <i>Colossoma macropomum</i> (Cuvier, 1816)                |      | X   |     |     |     | UFRN 3011   |
| <i>Metynnis lippincottianus</i> (Cope, 1870)              |      |     | X   |     |     | UFRN 3692   |
| <b>Triporthidae</b>                                       |      |     |     |     |     |   |
| <i>Triporthus signatus</i> (Garman, 1890)                 |      | X   |     |     |     | UFRN 3081   |
| <b>CICHLIFORMES</b>                                       |      |     |     |     |     |   |
| <b>Cichlidae</b>  |      |     |     |     |     |   |
| <i>Aequidens tetramerus</i> (Heckel, 1840)                | X    | X   | X   |     |     | UFRN 2827 (PAR)<br>UFRN 2818 (TOC)                    |
| <i>Cichlasoma orientale</i> Kullander, 1983               | X    | X   |     |     |     | UFRN 3009   |
| <i>Cichlasoma sanctifranciscense</i> Kullander, 1983      | X    | X   | X   |     |     | UFRN 3016 (PAR)<br>UFRN 3255 (TOC)                    |
| <i>Crenicichla brasiliensis</i> (Bloch, 1792)             | X    | X   |     |     |     | UFRN 2712 (PAR)<br>UFRN 3255 (TOC)                    |
| <i>Crenicichla</i> sp. 1                                  | X    |     | X   |     | X   | UFRN 3763   |
| <i>Crenicichla</i> sp. 2                                  | X    | X   |     |     | X   | UFRN 2859   |
| <i>Geophagus parnaibaiae</i> Staeck & Schindler, 2006     | X    | X   |     |     | X   | UFRN 2796   |
| <b>CYPRINODONTIFORMES</b>                                 |      |     |     |     |     |   |
| <b>Rivulidae</b>  |      |     |     |     |     |   |
| <i>Melanorivulus jalapensis</i> (Costa, 2010)             | X    |     | X   |     | X   | UFRN 3065   |
| <i>Melanorivulus parnaibensis</i> (Costa, 2003)           | X    | X   |     |     | X   | UFRN 3061   |
| <i>Melanorivulus</i> sp.                                  | X    |     | X   | X   |     | UFRN 3187 (TOC)<br>UFRN 3376 (SFR)                    |
| <b>GYMNOTIFORMES</b>                                      |      |     |     |     |     |   |
| <b>Gymnotidae</b>   |      |     |     |     |     |   |
| <i>Gymnotus</i> aff. <i>carapo</i> Linnaeus, 1758         | X    | X   | X   |     |     | UFRN 3058 (PAR)<br>UFRN 3673 (TOC)                    |
| <b>Sternopygidae</b>                                      |      |     |     |     |     |   |
| <i>Eigenmannia besouro</i> Peixoto & Wosiacki, 2016       |      |     | X   | X   |     | UFRN 3705 (TOC)<br>UFRN 3740 (SFR)                    |

Continue...

...Continuation

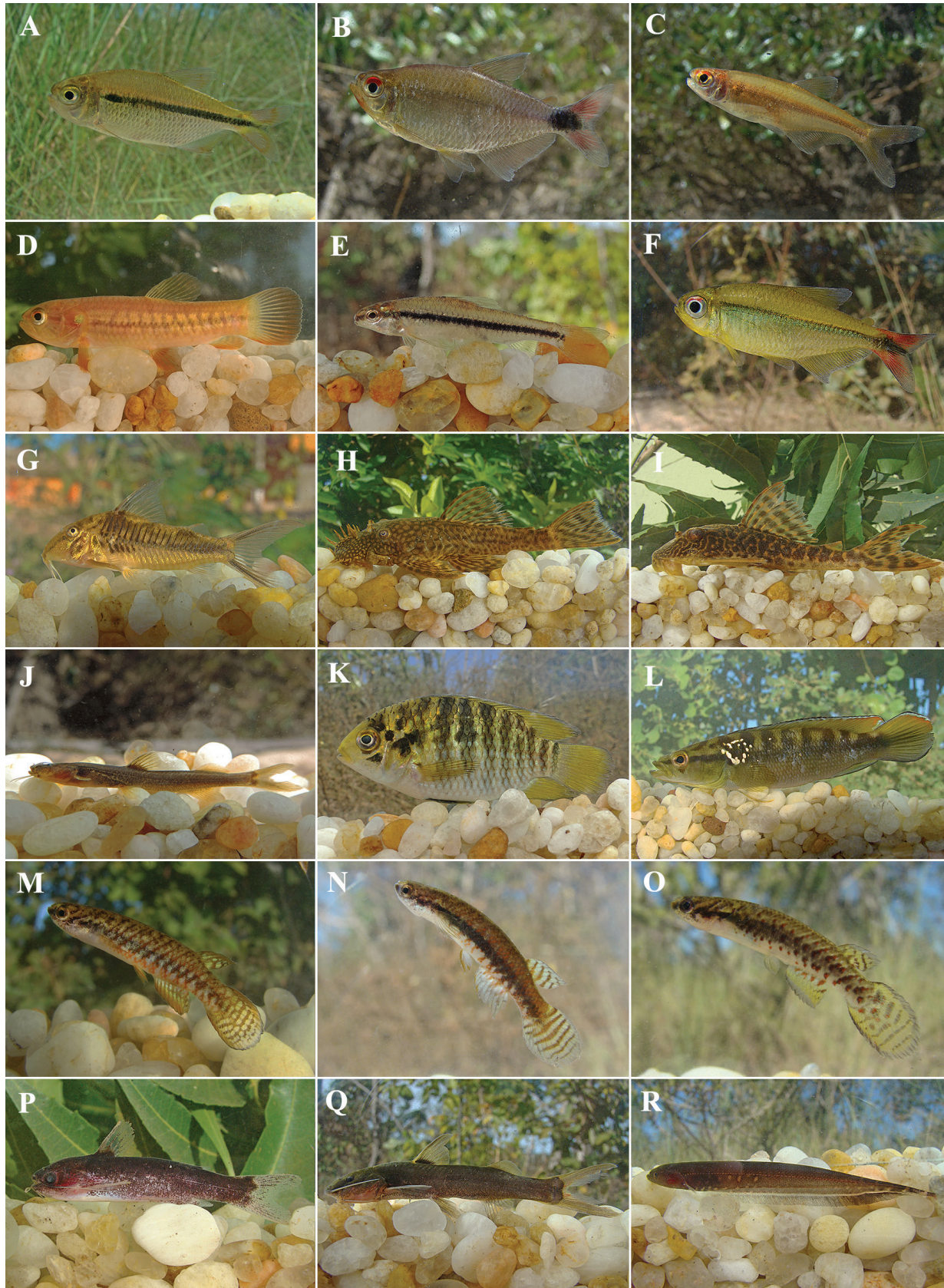
| ORDER/Family/Species  | NPNP | PAR | TOC | SFR | END | VOUCHER   |
|---|------|-----|-----|-----|-----|-----------|
| <i>Sternopygus macrurus</i> (Bloch & Schneider, 1801)                   |      |     | X   |     |     | UFRN 3652 |
| <i>Sternopygus</i> sp.  |      |     |     | X   | X   | UFRN 3743 |
| <b>SILURIFORMES</b>   |      |     |     |     |     |           |
| <b>Auchenipteridae</b>  |      |     |     |     |     |           |
| <i>Tatia bockmanni</i> (Sarmiento-Soares & Buckup, 2005)                |      |     |     | X   | X   | UFRN 3730 |
| <i>Centromochlus</i> sp.  |      |     |     | X   | X   | UFRN 3413 |
| <b>Callichthyidae</b>   |      |     |     |     |     |           |
| <i>Aspidoras raimundi</i> (Steindachner, 1907)                          | X    | X   |     |     | X   | UFRN 2795 |
| <i>Aspidoras</i> sp.  | X    | X   |     |     | X   | UFRN 3069 |
| <i>Callichthys callichthys</i> (Linnaeus, 1758)                         |      | X   |     |     |     | UFRN 3377 |
| <i>Corydoras</i> sp.  | X    | X   |     |     | X   | UFRN 3028 |
| <b>Heptapteridae</b>  |      |     |     |     |     |           |
| <i>Cetopsorhamdia</i> sp.   |      | X   |     |     | X   | UFRN 3356 |
| <i>Imparfinis</i> sp.   |      | X   |     |     | X   | UFRN 2716 |
| <i>Phenacorhamdia cabocla</i> Rocha, Ramos & Ramos, 2018                |      | X   |     |     | X   | UFRN 2768 |
| <i>Phenacorhamdia</i> sp.   |      |     | X   |     | X   | UFRN 2815 |
| <i>Pimelodella parnahybae</i> Fowler, 1941                              | X    | X   |     |     | X   | UFRN 2733 |
| <i>Pimelodella</i> sp.  |      |     |     | X   | X   | UFRN 3598 |
| <i>Rhamdia quelen</i> (Quoy & Gaimard, 1824)                            | X    | X   |     |     |     | UFRN 3057 |
| <b>Loricariidae</b>   |      |     |     |     |     |           |
| <i>Ancistrus damasceni</i> (Steindachner, 1907)                         |      | X   |     |     | X   | UFRN 2719 |
| <i>Hypostomus</i> gr. <i>plecostomus</i> (Linnaeus, 1758)               |      |     | X   |     | X   | UFRN 3590 |
| <i>Hypostomus johnii</i> (Steindachner, 1877)                           |      |     | X   |     |     | UFRN 2705 |
| <i>Hypostomus velhomonge</i> Lustosa-Costa, Ramos, Zawadzki & Lima 2022 |      | X   |     |     | X   | UFRN 2720 |
| <i>Hypostomus</i> sp. 1   |      | X   |     |     | X   | UFRN 2718 |
| <i>Hypostomus</i> sp. 3   |      |     | X   |     | X   | UFRN 2811 |
| <i>Hypostomus</i> sp. 4   |      |     | X   |     | X   | UFRN 2812 |
| <i>Hypostomus</i> sp. 5   | X    | X   |     |     | X   | UFRN 3043 |
| <i>Loricaria parnahybae</i> Steindachner, 1907                          | X    | X   |     |     | X   | UFRN 3112 |
| <i>Parotocinclus cabessadecuia</i> Ramos, Lima & Ramos, 2017            |      | X   |     |     | X   | UFRN 2846 |
| <b>Pimelodidae</b>  |      |     |     |     |     |           |
| <i>Pimelodus maculatus</i> Lacepède, 1803                               |      | X   |     |     |     | UFRN 3023 |
| <i>Pimelodus</i> sp.  |      | X   |     |     | X   | UFRN 3025 |
| <b>SYNBRANCHIFORMES</b>   |      |     |     |     |     |           |
| <b>Synbranchidae</b>  |      |     |     |     |     |           |
| <i>Synbranchus</i> gr. <i>madeirae</i> Rosen & Rumney, 1972             | X    | X   |     |     |     | UFRN 2837 |

Protocol in Aquatic Systems) (Alonso & Willink 2011), and in order to avoid selectivity in captures, active collection gear, such as a short seine net (4 m × 1.5 m high and 5 mm mesh), sieves (0.8 m × 0.5 mm) and trawl nets (10 m × 4 m and 5.0 mm), and passive, as gill nets (25 mm × 35 m and 45 mm) and traps, were used (Sabino 1999).

To record the natural live coloration, some specimens were photographed in aquarium during collections. The specimens were anesthetized in eugenol alcoholic solution (9:1 dilution of ethanol 92° GL and eugenol) (Lucena et al. 2013) and fixed in formalin aqueous solution (9:1 dilution of water and a solution of formalin containing a minimum of 37% formaldehyde). Tissue samples or entire specimens were fixed in ethanol P.A. (99.9%) for molecular studies.

In laboratory, they were transferred to an ethanol 70% solution, and separated into lots.

The specimens were sorted and identified using the ichthyological literature available for the Parnaíba, São Francisco, and Tocantins river basins (Fowler 1941, Menezes 1969, Nijssen & Isbrücker 1976, Kullander 1983, Britski et al. 1984, Ploeg 1991, Lima & Gerhard 2001, Staack & Schindler 2006, Costa 2016, Melo & Espindola 2016, Ramos et al. 2017a, b, Ramirez et al. 2017, Rocha et al. 2018, Varella et al. 2018, Zanata et al. 2018, Lustosa-Costa et al. 2022). Whenever necessary, the taxonomic term 'aff.' was used for a taxon that has an affinity with another species but that can be recognized as distinct, 'cf.' when additional studies are necessary to confirm the identification, 'gr.'



**Figure 3.** Subset of species collected in Nascentes do Rio Parnaíba National Park and surroundings. A. *Astyanax novae*; B. *Hyphessobrycon* sp.; C. *Knodus victoriae*; D. *Hopleythrinus unitaeniatus*; E. *Characidium tapuia*; F. *Hemigrammus* sp. 1; G. *Aspidoras* sp.; H. *Ancistrus damasceni*; I. *Hypostomus* sp. 3; J. *Phenacorhamdia cabocla*; K. *Aequidens tetramerus*; L. *Crenicichla brasiliensis*; M. *Melanorivulus jalapensis*; N. *Melanorivulus* sp.; O. *Melanorivulus parnaibensis*; P. *Tatia bockmanni*; Q. *Cetopsorhamdia* sp.; R. *Gymnotus* aff. *carapo*.



for taxa with affinities to, but which must be distinct from the nominal taxon to which it was assigned, and ‘sp.’ indicating possibly undescribed species or simply specimens that could not be identified at the specific level (Winston 1999). The collected material was deposited in the ichthyological collection of the Universidade Federal do Rio Grande do Norte (UFRN) (Table 2).

The systematic classification and nomenclature of the species followed Fricke et al. (2023). Endemism was attributed to species restricted to a single hydrographic ecoregion as proposed by Albert et al. (2011). The geographic distribution of species was verified in Reis et al. (2003), Buckup et al. (2007), Ramos et al. (2014), and Lima et al. (2017). To ascertain the conservation status, the official national lists of endangered fish species from Brazil were used (MMA 2014, 2022).

### Results

In total, 411 specimens were sampled among the 54 locations, representing 95 species in 56 genera, 22 families, and six orders (Table 2, Figure 3, Figure 4a–b). The order Characiformes had the highest richness, with 55 species (58%), 32 genera, and 12 families, followed by Siluriformes with 25 species (26%), 15 genera and five families, and Cichliformes with seven species (8%), four genera and a single family. Some orders were represented by a few species, such as Gymnotiformes with two families and four species (4%), Cyprinodontiformes with one family and three species (3%), and Synbranchiformes with one family and species (1.5%). The family Characidae was the most representative, with 30 species (32%), followed by Loricariidae with ten (11%), and Heptapteridae and Cichlidae

with seven (7%), each. The families Gymnotidae (Gymnotiformes), Triportheidae, Hemiodontidae, Chilodontidae, and Acestrorhynchidae (Characiformes) were represented by a single species.

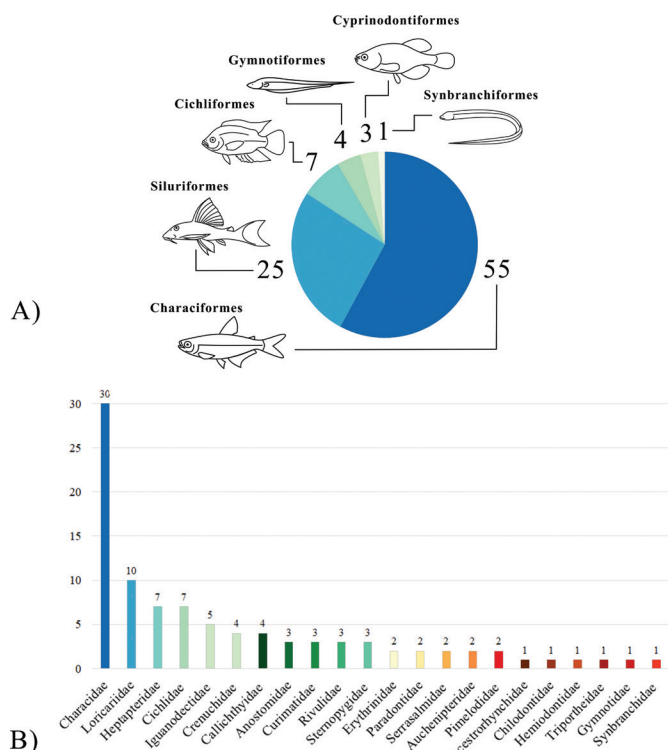
Of the 95 species recorded, 58 (61%) occurred in only one of the three hydrographic ecoregions that compose the NPNP and its surroundings area. Thirty-three species (34.7%) were identified at the generic level and may represent species belonging to a complex or represent potential undescribed species. *Colossoma macropomum* (Cuvier 1816) was recorded near the NPNP in the Parnaíba river basin and was the only introduced species recorded in the survey. No recorded species is currently classified in any threatened IUCN category.

In the Parnaíba River basin, 59 species (62%) were recorded in 40 sampling sites, while in the Tocantins River basin 34 species (36%) in 12 localities, and in the São Francisco River basin, 17 species (18%) in two sampling sites (Tables 1–2, Figure 3c). Nineteen localities were sampled in the NPNP, 17 in the Parnaíba, and two in the Tocantins river basins, with 38 species (40%) belonging to 28 genera, 14 families, and six orders (Tables 1–2). In the NPNP, the order Characiformes was the most representative, with 19 species representing 50% of those recorded in the PA, followed by Siluriformes and Cichliformes, with seven species (18%), each. The Characidae family was the richest in the NPNP, with nine species (24%), followed by Cichlidae, with seven (18%) (Table 2).

The comparison of fish fauna between river basins tends to be superficial because sampling effort and access to water bodies were quite heterogeneous between each one. However, four species (4%) were recorded in Parnaíba and São Francisco drainages (*Hoplerythrinus unitaeniatus* (Spix & Agassiz, 1829), *Hoplias* aff. *malabaricus* (Bloch 1794), *Moenkhausia sanctaefilomenae* (Steindachner, 1907), and *Leporinus piau* Fowler, 1941) (Figure 3d). Nine species (9%) are shared between the Parnaíba and Tocantins rivers basins (*Aequidens tetramerus* (Heckel 1840), *Bryconops* gr. *melanurus* (Bloch, 1794), *Cichlasoma sanctifranciscense*, *H. unitaeniatus*, *H. aff. malabaricus*, *Jupiaba polylepis* (Günther 1864), *Gymnotus* aff. *carapo* Linnaeus 1758, *Hemigrammus marginatus* Ellis 1911, and *M. sanctaefilomenae*) (Figure 3d). And five species (5%) shared between the Tocantins and São Francisco basins (*Eigenmannia besouro* Peixoto & Wosiacki 2016, *Melanorivulus* sp., *H. unitaeniatus*, *H. aff. malabaricus* and *M. sanctaefilomenae*) (Figure 3d). The species *H. aff. malabaricus*, *H. unitaeniatus*, and *M. sanctaefilomenae* were recorded in the three drainages. In the region of the shared headwaters between Tocantins and São Francisco river basins, *Eigenmannia besouro* was recorded, and may indicate a potential use of the natural connection as a passage.

### Discussion

The knowledge of fish diversity in the Parnaíba, São Francisco and Tocantins river basins has advanced considerably in recent decades (e.g., Lima & Caires 2011, Ramos et al. 2014, Lima et al. 2017, Chamon et al. 2022), although the headwaters of these drainages, part of which are located in the NPNP, remain relatively unexplored. As other Brazilian protected areas, the NPNP does not have a management plan and this fish survey can support future environmental policies, in addition to taxonomic, systematics, ecological, biogeographic, and conservation studies of the aquatic biota in the Cerrado. Although Brazil is responsible for the majority of new PAs in the world (approximately



**Figure 4.** Taxonomic composition of the fishes from the Nascentes do Rio Parnaíba National Park and surroundings. A. Sampled orders; B. Sampled families.

75%) established since 2003 (Jenkins & Joppa 2009), the freshwater fauna has generally not been considered for demarcation strategies (Agostinho et al. 2005). For example, at the Tocantins River basin the number of threatened fish species is greater than of other vertebrates (ICMBio 2018).

No endangered species was recorded in the NPNP drainages and surroundings area. However, it is noteworthy that in the Tocantins basin there are at least 51 threatened species, 42 in the São Francisco, and one in the Parnaíba River basin (Chamon et al. 2022, Lima et al. 2017, MMA 2014, 2022). Additionally, the impacts resulting from agricultural expansion can adversely affect species that inhabit the ‘veredas’ (i.e., palm swamps dominated by the *Mauritia flexuosa* L.f) (Figure 2h). In these habitats, three species of non-annual rivulids were found. This family includes the largest number of threatened freshwater fish species in Brazil (MMA 2014, 2022), mainly due to the loss of their shallow and lentic habitats (Costa 2002). *Melanorivulus* sp. is possibly an undescribed species recorded in some ‘veredas’ of the NPNP in the Parnaíba and Tocantins drainages (Figure 3n, Table 2). *Melanorivulus jalapensis* has not been recorded since its original description and was only known from its type locality (Costa 2010). The new records expands its distribution by 55 km to the northeast (Figure 1). Anteriorly known only from two localities (Costa 2016), *Melanorivulus parnaibensis* were collected in several ‘veredas’ sampling sites, expanding the range of the species in about 240 km to the south. In the middle and lower Parnaíba, Tocantins and São Francisco River basins, previous studies recorded several introduced species (Ramos et al. 2014, Silva et al. 2015, Garavello et al. 2010, Bartolette et al. 2017, Barbosa et al. 2017). In the NPNP no exotic species was recorded, however, in the surrounding region, juveniles of ‘tambaqui’ (*Colossoma macropomum*) were collected. It is a well-known species that has a native range encompassing the western and central Amazon basins, and the Llanos portion of the Orinoco basin (Araújo-Lima & Goulding 1997, Jégu & Keith 1999). Its occurrence out of its native range, as in the rivers of northeastern Brazil, are the result of escapes from aquaculture facilities, since it is one of the most cultivated freshwater fishes in South America.

Thirty-three species were identified only at the generic level as they have diagnostic characters different from the known species in the sampled basins, requiring further taxonomic studies. Some of these were previously identified by Ramos et al. (2014), Silva et al. (2015), and Melo et al. (2016) in the Parnaíba River basin, and by Lima & Caires (2011) in the Tocantins River basin. Recent taxonomic revisions using material of the NPNP expedition from the Parnaíba River basin resulted in the description of four new species, the cascudinho *Parotocinclus cabessadecua* (Ramos et al. 2017), the characid *Characidium tapuia* (Zanata et al. 2018), the small heptapterid *Phenacorhamdia cabocla* (Rocha et al. 2018), and the armored catfish *Hypostomus velhomonge* (Lustosa-Costa et al. 2022).

It is estimated that the Parnaíba River harbor approximately 155 species (Ramos et al. 2014, Lima et al. 2017). In the portion of the NPNP that protects the headwaters of this drainage, 20% (32 species) of the basin were recorded. According to Chamon et al. (2022), in the Tocantins-Araguaia River basin there are 751 species. Although the number of species recorded in the Tocantins River basin in the NPNP is relatively low (13 species), this area protects the headwaters, small environments characterized by low diversity and high endemism

(Richardson 2019). Finally, the São Francisco River basin, with 304 fish species, and approximately 60% of these are endemic (Barbosa et al. 2017), does not have its headwaters protected by the NPNP. However, it presented a distinct and diverse ichthyofauna, with 17 species recorded in just two localities.

The headwaters and tributaries of the São Francisco River that cross Bahia State remain little studied (Langeani et al. 2009, Silva et al. 2020b). However, some stretches of the São Francisco River in northwestern Bahia harbor one of the largest and best-preserved areas of Cerrado, including streams and ‘veredas’ (Nogueira et al. 2011), which should be integrated in the mosaic of PAs, known as the Jalapão Region Ecological Corridor Project (ICMBio 2023), in the MATOPIBA region. During collections, the area apparently most impacted by agricultural expansion was in the São Francisco River basin, with vast landscape completely deforested for soybean and cotton plantations (Figure 2l), with some croplands close to the rivers.

While there is no standardization in our sampling effort to support more accurate comparisons across watersheds, the shared species may indicate some evidence. Four shared species were recorded between the Parnaíba and São Francisco River basins (Table 2), possibly evidencing a recent hydrological connection (about 400,000 years) as suggested by Costa et al. (2018) between these drainages (Coutinho-Abreu et al. 2008). Five species were shared between the São Francisco and Tocantins River basins (Table 2). Although some of these species are widely distributed and the taxonomy poorly understood (e.g. *Gymnotus* aff. *carapo*, *Hoplias* aff. *malabaricus*, and *Rhamdia* aff. *quelen*), the occurrence of some species may be due to the natural connection between these basins. Among the species that occur in the upper Tocantins and middle São Francisco River basins are *Astyanax novae*, *Cichlasoma sanctifranciscense*, *Eigenmannia besouro*, *Hyphessobrycon diastatos* Dagosta, Marinho & Camelier 2014 and *Pristella crinogi* Lima, Caires, Conde-Saldaña, Mirande & Carvalho 2021 (Garutti & Venere 2009, Lima & Caires 2011, Dagosta et al. 2014, Birindelli et al. 2015, Lima et al. 2021). Lima & Caires (2011) and Dagosta et al. (2014) discussed the connections between the headwaters of the three drainages and the possible routes for the exchange of freshwater organisms, including those between the Novo River (Tocantins basin) and the Sapão river (São Francisco River basin), and between the São Domingos River (Tocantins basin) and the Grande River (São Francisco River basin). Since this is a region with unique hydrographic aspects (preserved ‘veredas’, clear water rivers used for tourism, and shared headwaters between drainages) and inhabited by many possibly undescribed species, we suggest that additional studies be carried out in the region to assess the possibility of expanding the NPNP encompassing portions of the Sapão River, thereby also protecting part of the fish fauna from the headwaters of the middle São Francisco River drainage.

While some headwaters of the Parnaíba and Tocantins river basins are protected in the NPNP, the intense agricultural expansion, as well as the construction of hydroelectric dams and water diversion projects (Daga et al. 2020, Chamon et al. 2022) may compromise the downstream habitats in the tributaries that drain the MATOPIBA region. To ensure the conservation of the fish species of this watershed divide, the freshwater environments must be included in the creation or expansion of the protected areas (Azevedo-Santos et al. 2019).

## Acknowledgments

This study was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq (Process# 483878/2013-8). To Janeil Lustosa de Oliveira (manager of the NPNP) for logistic support during the fieldwork in the UC and for sharing the road shapesfiles in the park. To the fire brigade teamwork of the NPNP for helping to access some sampling sites. All authors are grateful to Luciano Barros-Neto, Mateus Germano, Roney Paiva and Yuri Ponce for the fieldwork assistance. SCS is grateful to CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for a Master's scholarship (#88887.688228/2022-00). LSM is grateful to CAPES for a PhD scholarship (#88887.483610/2020-00). FCTL was funded by FAPESP (grants nos. 2007/02978-7, 2011/51532-7, and 2013/20936-0). SMQL receives CNPq research productivity grant (Proc. 312066/2021-0).

## Associate Editor

Rosana Mazzoni

## Authors' Contribution

Salu Coêlho da Silva: contributed to data curation; analysis, writing – original draft; conceptualization and manuscript preparation.

Lucas Silva de Medeiros: contributed to data collection: data curation and writing – review: editing.

Miguel Fernandes Bezerra Neto: contributed to data analysis; writing – original draft.

Márcio Joaquim da Silva: contributed to data collection, validation, and writing – review, editing.

Telton Pedro Anselmo Ramos: contributed to data collection, writing, validation, and data analysis.

Flávio César Thadeo de Lima: contributed to data analysis, validation, and manuscript preparation.

Sergio Maia Queiroz Lima: contributed to data collection, supervision, conceptualization, validation, funding acquisition, writing – review, editing.

## Conflicts of Interest

The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript.

## Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

## Data Availability

The datasets generated during and/or analyzed during the current study are available at: [https://ipt.sibbr.gov.br/sibbr/resource?r=ufrn\\_ciufrn\\_pnnp01](https://ipt.sibbr.gov.br/sibbr/resource?r=ufrn_ciufrn_pnnp01)

## References

- ABELL, R., THIEME, M.L., REVENGA, C., BRYER, M., KOTTELAT, M., BOGUTSKAYA, N., COAD, B., MANDRAK, N., BALDERAS, S.L., BUSSING, W., STIASSNY, M.L.J., SKELTON, P., ALLEN, G.R., UNMACK, P., NASEKA, A., NG, R., SINDORF, N., ROBERTSON, J., ARMIJO, E., HIGGINS, J.Y., HEIBEL, T.J., WIKRAMANAYAKE, E., OLSON, D., LÓPEZ, H.L., REIS, R.E., LUNDBERG, J.G., PÉREZ, M.H.S. & PETRY, P. 2008 Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *Bioscience*, 58(5):403–414.
- AGOSTINHO, A.A., THOMAZ, S.M. & GOMES, L.C. 2005. Conservação da biodiversidade em águas continentais do Brasil. *Megadiversidade*, 1(1):70–78.
- ALBERT, J.S., PETRY, P. & REIS, R.E. 2011. Major Biogeographic and Phylogenetic Patterns. In: *Historical Biogeography of Neotropical Freshwater Fishes* (ALBERT J.S. & R.E. REIS, eds.). Los Angeles: University of California Press, p.21–57.
- ALONSO, L.E. & P. WILLINK. 2011. History and overview of AquaRAP; pp. 80–91, in: ALONSO, L.E., J.L. DEICHMANN, S.A. MCKENNA, P. NASKRECKI & S.J. RICHARDS (eds.). *Still counting...: Biodiversity exploration for conservation — the first 20 years of the Rapid Assessment Program*. Arlington: Conservation International. 316 pp.
- AGÊNCIA NACIONAL DE ÁGUAS E SANEAMENTO BÁSICO (ANA). 2021. <https://dadosabertos.ana.gov.br> (last access in 01/05/2021).
- ARAÚJO-LIMA, C.A.R.M. & GOULDING, M. 1997. So fruitful a fish. Ecology, conservation, and aquaculture of the Amazon's tambaqui. New York: Columbia University Press, 191 pp.
- AZEVEDO-SANTOS, V.M., FREDERICO, R.G., FAGUNDES, C.K., POMPEU, P.S., PELICICE, F.M., PADIAL, A.A., NOGUEIRA, M.G., FEARNSIDE, P.M., LIMA, L.B., DAGA, V.S., OLIVEIRA, F.J.M., VITULE, J.R.S., CALLISTO, M., AGOSTINHO, A.A., ESTEVES, F.A., LIMA-JUNIOR, D.P., ANDRÉ, L.B., MAGALHÃES, JOSÉ SABINO, MORMUL, R.P., GRASEL, M.D., ZUANON, J., VILELLA, F.S. & HENRY R. 2018. Protected areas: A focus on Brazilian freshwater biodiversity. *Divers Distrib*, 25(3):442–448.
- BARBOSA, J.M., SOARES, E.C., CINTRA, I.H.A., HERMANN, M. & ARAÚJO, A.R.R. 2017. Perfil da ictiofauna da bacia do rio São Francisco. *Acta Fish*, 5(1):70–90.
- 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., ARGOLLO, F.H., AGUIAR, A.J.M., ARGOLLO, 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. <http://dx.doi.org/10.15560/13.3.2156>
- BEUCHLE, R., GRECCI, R.C., SHIMABUKURO, Y.E., SELIGER, R., EVA, H.D., SANO, E. & ACHARD, F. 2015. Land cover changes in the Brazilian Cerrado and Caatinga biomes from 1990 to 2010 based on a systematic remote sensing sampling approach. *Appl Geogr*, 58:116–127.
- BIRINDELLI, J.L.O., SARMENTO-SOARES, L.M. & LIMA, F.C.T. 2015. A new species of *Centromochlus* (Siluriformes, Auchenipteridae, Centromochlinae) from the middle Rio Tocantins basin, Brazil. *Journal of Fish Biology*, 87(4):860–875.
- BRITSKI, H.A., SATO, Y. & ROSA, A.B.S. 1984. Manual de Identificação de Peixes da Região de Três Marias: Com Chave de Identificação Para os Peixes da Bacia do São Francisco. Brasília: Câmara dos Deputados, Coordenação de Publicações - CODEVASF, Divisão de Piscicultura e Pesca.
- BUCKUP, P.A., MENEZES, N.A. & GHAZZI, M.S. 2007. Catálogo das Espécies de Peixes de Água Doce do Brasil. Rio de Janeiro, Museu Nacional, p. 1–195.
- CARVALHO, W.D., MUSTIN, K., HILÁRIO, R.R., VASCONCELOS, I.M., EILERS, V. & FEARNSIDE, P.M. 2019. Deforestation control in the Brazilian Amazon: A conservation struggle being lost as agreements and regulations are subverted and bypassed. *Perspect Ecol Conserv*, 17(3):122–130.
- CHAMON, C.C., SERRA, J.P., CAMELIER, P., ZANATA, A.M., FICHBERG, I. & MARINHO, M.M.F. 2022. Building knowledge to save species: 20 years of ichthyological studies in the Tocantins-Araguaia River basin. *Biota Neotropica*, 22(2):e20211296. <https://doi.org/10.1590/1676-0611-BN-2021-1296>

- COUTINHO-ABREU, I.R., SONODA, I.V., FONSECA, J.A., MELO, M.A., BALBINO, V.Q. & RAMALHO-ORTIGÃO, M. 2008. *Lutzomyia longipalpis* s.l. in Brazil and the impact of the Sao Francisco River in the speciation of this sand fly vector. *Parasites Vectors*, 1(16):11. <https://doi.org/10.1186/1756-3305-1-16>
- COSTA, W.J.E.M. 2002. Peixes anuais brasileiros: diversidade e conservação. Editora UFPR, Curitiba, 240p.
- COSTA, W.J.E.M. 2010. *Rivulus jalapensis*, a new killifish from the Tocantins River basin, central Brazil (Cyprinodontiformes: Rivulidae). *Ichthyol Explor Freshw*, 21(3):193–198.
- COSTA, W.J.E.M. 2016. Comparative morphology, phylogenetic relationships, and taxonomic revision of South American killifishes of the *Melanorivulus zygometes* species group (Cyprinodontiformes: Rivulidae). *Ichthyol Explor Freshw*, 27(2):107–152.
- COSTA, W.J.E.M., AMORIM, P.F. & MATTOS, J.L. O. 2018. Synchronic historical patterns of species diversification in seasonal aplocheiloid killifishes of the semi-arid Brazilian Caatinga. *Plos One*, 13(2):e0193021.
- DAGA, V.S., AZEVEDO-SANTOS, V.M., PELICICE, F.M., FEARNESIDE, P.M., PERBICHE-NEVES, G., PASCHOAL, L.R.P., CAVALLARI, D.C., ERICKSON, J., RUOCCO, A.M.C., OLIVEIRA, I., PADIAL, A.A. & VITULE, J.R.S. 2020. Water diversion in Brazil threatens biodiversity. *Ambio*, 49:165–172.
- DAGOSTA, F.C.P., MARINHO, M.M.F. & CAMELIER, P. 2014. A new species of *Hypheobrycon* Durbin (Characiformes: Characidae) from the middle rio São Francisco and upper and middle rio Tocantins basins, Brazil, with comments on its biogeographic history. *Neotrop Ichthyol*, 12(2):365–375.
- DAGOSTA, F.C.P. & DE PINNA, M. 2019. The fishes of the Amazon: Distribution and biogeographical patterns, with a comprehensive list of species. *Bull Am Mus Nat Hist*, 431:1–22.
- FOWLER, H.W. 1941. A collection of fresh-water fishes obtained in eastern Brazil by Dr. Rodolpho von Ihering. *Proc Acad Nat Sci Phila*, 93:123–336.
- FRICKE, R., ESCHMEYER, W.N. & VAN DER LAAN, R. (eds.) 2023. Eschmeyer's catalog of fishes: genera, species, references. <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp> (last access in 028/03/2023).
- GARAVELLO, J.C., GARAVELLO, J.P. & OLIVEIRA, A.K. 2010. Ichthyofauna, fish supply and fisherman activities on the mid-Tocantins River, Maranhão State, Brazil. *Braz J Biol*, 70(3):575–585.
- GARUTTI, V. & VENERE, P.C. 2009. *Astyanax xavante*, a new species of characid from middle rio Araguaia in the Cerrado region, Central Brazil (Characiformes: Characidae). *Neotrop Ichthyol*, 7(3):377–383.
- ICMBIO. 2018. Instituto Chico Mendes de Conservação da Biodiversidade. Plano de Ação Nacional para Conservação das Espécies Ameaçadas de Extinção da Ictiofauna, Herpetofauna e Primatas do Cerrado e Pantanal (PAN). <https://www.gov.br/icmbio/pt-br/assuntos/biodiversidade/pan/pan-cerpan/1-ciclo/pan-cerpan-sumario.pdf> (last access in 17/09/2021).
- ICMBIO. <https://www.icmbio.gov.br/projetosalapao/pt/corredor-2/localizacao.html> (last access in 26/01/2023).
- ISA. 2015. Instituto Socioambiental. Governo altera limites do Parque Nacional das Nascentes do Rio Parnaíba. 2015. <https://www.socioambiental.org/pt-br/blog/blog-do-monitoramento/governo-altera-limites-do-parque-nacional-das-nascentes-do-rio-parnaiba> (last access in 10/05/2019).
- JÉGU, M. & KEITH, P. 1999. Le bas Oyapock limite septentrionale ou simple étape dans la progression de la faune des poissons d'Amazonie occidentale. *Comptes Rendus Academie de Sciences de Paris, Science de la vie*, 322: 1133–1143.
- JENKINS, C.N. & JOPPA, L. 2009. Expansion of the global terrestrial protected area system. *Biol Conserv*, 142(10):2166–2174.
- KLINK, C.A. & MACHADO, R.B. 2005. Conservation of the Brazilian Cerrado. *Conserv Biol*, 19(3):707–713.
- KULLANDER, S.O. 1983. A revision of the South American cichlid genus *Cichlasoma* (Teleostei, Cichlidae). Swedish Museum of Natural History, Research Department, California.
- LANGEANI, F.L., BUCKUP, P.A., MALABARBA, L.R., PY-DANIEL, L.H.R., LUCENA, C.A., ROSA, R.S., ZUANON, J.A.S., LUCENA, Z.M.S., BRITTO, M.R., OYAKAWA, O.T. & GOMES-FILHO, G. 2009. Peixes de água Doce. In: Estado da arte e perspectivas para a Zoologia no Brasil. (Rocha, R.M. & W.A.P. Boeger, orgs.). Universidade Federal do Paraná, Curitiba, Brasil, p.211–230.
- LATRUBESSE, E.M., ARIMA, E., FERREIRA, M.E., NOGUEIRA, S.H., WITTMANN, F., DIAS, M.S., DAGOSTA, F.C. & BAYER, M. 2019. Fostering water resource governance and conservation in the Brazilian Cerrado biome. *Conserv Sci Pract*, 1(9):e77.
- 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 Neotrop*, 11(1):231–250. <https://doi.org/10.1590/S1676-06032011000100024>
- LIMA, F.C.T., CAIRES, R.A., CONDE-SALDAÑA, C.C., MIRANDE, J.M. & CARVALHO, F.R. 2021. A new miniature *Pristella* (Actinopterygii: Characiformes: Characidae) with reversed sexual dimorphism from the rio Tocantins and rio São Francisco basins, Brazil. *Canadian Journal of Zoology*, 99(5):339–348.
- LIMA, F.C.T. & GERHARD, P. 2001. A new *Hypheobrycon* (Characiformes: Characidae) from Chapada Diamantina, Bahia, Brazil, with notes on its natural history. *Ichthyol Explor Freshw*, 12(2):105–114.
- LIMA, J.E.F.W. & SILVA, E.D. 2005. Estimativa da produção hídrica superficial do Cerrado brasileiro. In SCARIOT, A., SOUSA-SILVA, J.C. & FELFILI, J.M. Cerrado: ecologia, biodiversidade e conservação. Ministério do Meio Ambiente, Brasília. p.61–72.
- LIMA, S.M.Q., RAMOS, T.P.A., DA SILVA, M.J. & DE SOUZA ROSA, R. 2017. Diversity, distribution, and conservation of the Caatinga fishes: advances and challenges. In *Caatinga* (pp. 97–131). Springer, Cham.
- LOPES, G.R., LIMA, M.G.B.A. & REIS, T.N.P. 2020. Maldevelopment revisited: Inclusiveness and social impacts of soy expansion over Brazil's Cerrado in Matopiba, World Dev, 139. 105306.
- LUCENA, C.A.S., CALEGARI, B.B., PEREIRA, E.H.L. & DALLEGRAVE, E. 2013. O uso de óleo de cravo na eutanásia de peixes. *Bol Soc Bras Ictiologia*, 105:20–24.
- LUSTOSA-COSTA, S.Y., RAMOS, T.P.A., ZAWADZKI, C.H. & LIMA, S.M.Q. 2022. Review of the armoured catfish genus *Hypostomus* (Siluriformes: Loricariidae) from the Parnaíba River basin, Northeastern Brazil, with description of a new species. *Neotrop Ichthyol*, 20(1):e210126.
- MACENA, F., ASSAD, E.D., STEINKE, E.T., MÜLLER, A.G. 2008. Clima do bioma cerrado. In ALBUQUERQUE, A.C.S. & SILVA, A.G. Agricultura tropical: quatro décadas de inovações tecnológicas, institucionais e políticas. Embrapa Informação Tecnológica. Brasília. p.93–148.
- MIRANDA, R.A., LÍCIO, A.M.A., PURCINO, A.A.C., PAULINELLI, A., PARENTONI, S.N., DUARTE, J.O., GONTIJO-NETO, M.M., LANDAU, E.C., QUEIROZ, V.A.V. & OLIVEIRA, I.R. 2014. Diagnóstico dos problemas e potencialidades da cadeia produtiva do milho no Brasil. Embrapa Milho e Sorgo. Sete Lagoas.
- MYERS, N., MITTERMEIER, R.A., MITTERMEIER, C.G., FONSECA, G.A.B. & KENT, J. 2000. Biodiversity hotspots for conservation priorities. *Nature*, 403:853–845.
- MELO, F.A.G., BUCKUP, P.A., RAMOS, T.P.A., SOUZA, A.K.N., SILVA, C.M.A., COSTA, T.C. & RIBEIRO, A.T. 2016. Fish Fauna of the lower course of the Parnaíba river, northeastern Brazil. *Boletim do Museu de Biologia Melo Leitão*, 38(4):363–400.
- MELO, M.R. & ESPINDOLA, V.C. 2016. Description of a new species of *Characidium* Reinhardt, 1867 (Characiformes: Crenuchidae) from the Chapada Diamantina, Bahia, and redescription of *Characidium bimaculatum* Fowler, 1941. *Zootaxa*, 4196(4):552–568.
- MENEZES, N.A. 1969. Systematics and evolution of the tribe Acestrorhynchini (Pisces, Characidae). *Arquivos de Zoologia*, 18(1-2):1–150.

- MMA. 2014. Ministério do Meio Ambiente. Portaria nº 445, de 17 de dezembro de 2014. Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção - Peixes e Invertebrados Aquáticos. Diário Oficial da União. Brasília. p. 126–130.
- MMA. Ministério do Meio Ambiente. Relatório parametrizado de Unidade de Conservação. 2019. <http://sistemas.mma.gov.br/cnuc/index.php?ido=relatorioparametrizado.exibeRelatorio&relatorioPadrao=true&i dUc=156> (last access in 02/05/2019).
- MMA. 2022. Ministério do Meio Ambiente. Portaria nº 148, de 7 de junho de 2022. atualização da Lista Nacional de Espécies Ameaçadas de Extinção. Diário Oficial da União. Brasília. p. 74.
- NIJSSEN, H. & ISBRÜCKER, I.J.H. 1976. The South American Plated Catfish Genus *Aspidoras* R. von Ihering, 1907: with descriptions of nine new species from Brazil (Pisces, Siluriformes, Callichthyidae). *Contrib Zool*, 46(1):107–131.
- NOGUEIRA, C.C., FERREIRA, M.N., RECODER, R.S., CARMIGNOTTO, A.P., VALDUJO, P.H., LIMA, F.C.T., GREGORIN, R., SILVEIRA, L.F. & RODRIGUES, M.T. 2011. Vertebrados da Estação Ecológica Serra Geral do Tocantins: faunística, biodiversidade e conservação no Cerrado brasileiro. *Biota Neotrop*, 11(1):329–338. <https://doi.org/10.1590/S1676-06032011000100030>
- PEIXOTO, L.A. & WOSIACKI, W.B. 2016. *Eigenmannia besouro*, a new species of the *Eigenmannia trilineata* species-group (Gymnotiformes: Sternopygidae) from the rio São Francisco basin, northeastern Brazil. *Zootaxa*, 4126(2):262–70. <https://doi.org/10.11646/zootaxa.4126.2.6>
- PLOEG, A. 1991. Revision of the South American cichlid genus *Crenicichla* Heckel, 1840, with descriptions of fifteen new species and considerations on species groups, phylogeny and biogeography (Pisces, Perciformes, Cichlidae). Universiteit van Amsterdam, Amsterdam.
- RAMIREZ, J.L., BIRINDELLI, J.L., CARVALHO, D.C., AFFONSO, P.R., VENERE, P.C., ORTEGA, H., CARRILLO-AVILA, M., RODRÍGUEZ-PULIDO, J.A. & GALETTI, P.M. 2017. Revealing hidden diversity of the underestimated neotropical ichthyofauna: DNA barcoding in the recently described genus *Megaleporinus* (Characiformes: Anostomidae). *Front Genet*, 8:149.
- RAMOS, T.P.A., LIMA, S.M. & RAMOS, R.T.C. 2017a. A new species of armored catfish *Parotocinclus* (Siluriformes: Loricariidae) from the rio Parnaíba basin, northeastern, Brazil. *Neotrop Ichthyol*, 15(2):e160153.
- RAMOS, T.P.A., RAMOS, R.T.C. & RAMOS, S.A.Q.A. 2014. Ichthyofauna of the Parnaíba river Basin, Northeastern Brazil. *Biota Neotrop*, 14(1):e20130039. <https://doi.org/10.1590/S1676-06020140039>
- RAMOS, T.P.A., ZAWADZKI, C.H., RAMOS, R.T.D.C. & BRITSKI, H.A. 2017b. Redescription of *Hypostomus johnii*, a senior synonym of *Hypostomus eptingi* (Siluriformes: Loricariidae), Northeastern Brazil. *Neotrop Ichthyol*, 15(2): E160064.
- REIS, R.E., KULLANDER, S.O., FERRARIS, J. & CARL, J. 2003. Check List of the freshwater fishes of South and Central America. EDIPUCRS, Porto Alegre.
- RICHARDSON, J.S. 2019. Biological Diversity in Headwater Streams. *Water*, 11(2):366.
- ROCHA, Y.G.P.D.C., RAMOS, T.P.A. & RAMOS, R.T.D.C. 2018. *Phenacorhamdia cabocla*, a new heptapterid from the Parnaíba River basin, Northeastern Brazil (Siluriformes: Heptapteridae). *Zootaxa*, 4402(2):353–362.
- SABINO, J. 1999. Comportamento de peixes em riachos: métodos de estudo para uma abordagem naturalística. In Caramaschi, E.P., Mazzoni, R., Bizerril, C.R.S.F. & Peres-Neto, P.R. *Oecologia Brasiliensis*, Rio de Janeiro. p.183–208.
- SILVA, M.J., COSTA, B.G., RAMOS, T.P.A., AURICCHIO, P. & LIMA, S.M.Q. 2015. Ichthyofauna of the Gurgueia River, Parnaíba River basin, northeastern Brazil. *Check List*. 2015; 11(5):1765.
- SILVA, A.T., JUCÁ-CHAGAS, R., CLISTENES, A., ZANATA, A., RODRIGUES, B., POLAZ, C.M.N., ALVES, C.B.M., VIEIRA, C.S., SOUZA, F.B., VIEIRA, F., SAMPAIO, F.A.C., FERREIRA, H., ALVES, H.S.R., SARMENTO-SOARES, L.M., PINHO, M., MARTINS-PINHEIRO, R.F., LIMA, S.M.Q., CAMPIOLO, S. & CAMELIER, P. 2020a. Freshwater fishes of the Bahia State, Northeastern Brazil. *Biota Neotrop*, 20(4):e20200969.
- SILVA, M.J., RAMOS, T.P.A., CARVALHO, F.R., BRITO, M.F.G., RAMOS, R.T.C., ROSA, R.S., SÁNCHEZ-BOTERO, J.I., NOVAES J.L.C., COSTA, R.S. & LIMA, S.M.Q. 2020b. Freshwater fish richness baseline from the São Francisco Interbasin Water Transfer Project in the Brazilian Semiarid. *Neotrop Ichthyol*, 2020b; 18(4):e200063.
- STAECK, W. & SCHINDLER, I. 2006. *Geophagus parnaibaes* sp. n. – a new species of cichlid fish (Teleostei: Perciformes: Cichlidae) from the rio Parnaíba basin, Brazil. *Zool Abh*, 55:69–75.
- STRASSBURG, B.B.N., BROOKS, T., FELTRAN-BARBIERI, R., IRIBARREM, A., CROUZEILLES, R., LOYOLA, R., LATAWIEC, E.A., FILHO, F.J.B.O., SCARAMUZZA, C.A.M., SCARANO, F.R., SOARES-FILHO, B. & BALMFORD, A. 2017. Moment of truth for the Cerrado. *Nature Ecology & Evolution*, 1(99), 1–3.
- VARELLA, H.R., LOEB, M.V., LIMA, F.C. & KULLANDER, S.O. 2018. *Crenicichla ploegi*, a new species of pike-cichlid of the *C. saxatilis* group from the Rio Juruena and upper Rio Paraguay basins in Brazil, with an updated diagnosis and biogeographical comments on the group (Teleostei: Cichlidae). *Zootaxa*, 4377(3):361–386.
- WINSTON, J.E. 1999. Describing species: practical taxonomic procedure for biologists. Columbia University Press, New York.
- ZANATA, A.M., RAMOS, T.P. & OLIVEIRA-SILVA, L. 2018. A new species of *Characidium* (Characiformes: Crenuchidae) from the rio Parnaíba basin, northeastern Brazil. *Zootaxa*, 4514(1):77–86.

Received: 16/08/2022

Accepted: 23/03/2023

Published online: 15/05/2023