



Diversity of potamodromous fishes in the Tocantins–Araguaia basin

Correspondence:
Thiago Nascimento da Silva Campos
thiago_tnsc@hotmail.com

Thiago Nascimento da Silva Campos¹, Hasley Rodrigo Pereira²,
 Phâmela Bernardes Perônico³, Carine Cavalcante Chamon⁴,
 Philip Teles Soares⁵ and Fernando Mayer Pelicice⁴

Migratory fishes are deeply connected with human societies. In the Tocantins–Araguaia basin, a region marked by high biodiversity, endemism and environmental degradation, there is little information about these fishes. In this scenario, the present study investigated taxonomic and functional diversity of potamodromous fishes, with the objective to compile the first species list, and examine patterns in species richness, composition, and functional diversity. The migratory status of each species was assigned based on the most recent literature on fish diversity in the Tocantins–Araguaia and Amazon basins. The study consolidated a list of 77 potamodromous fish species (three orders, 12 families and 41 genera), including eight endemic, three threatened and two non-native species. Pimelodidae summed most species, followed by Serrasalminidae and Curimatidae. Most species were classified as medium (42) and long-distance (32) migrants, with few carrying out continental migrations (3). Most species were widely distributed in the basin, resulting in little spatial variation in species richness, composition and functional diversity. However, trait composition varied among species, families and migratory scale. This is the first broad assessment focused on migratory fishes in this basin, with potential to generate basic information to support fisheries management, environmental planning, and conservation initiatives.

Keywords: Brazil, Conservation, Functional diversity, Migratory, Pimelodidae.

Submitted September 26, 2024

Accepted December 12, 2024

by Paulo Pompeu

Epub February 10, 2025

Online version ISSN 1982-0224

Print version ISSN 1679-6225

Neotrop. Ichthyol.
vol. 23, no. 1, Maringá 2025

1 Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação (PPGBec), Universidade Federal do Tocantins (UFT), 77500-000 Porto Nacional, TO, Brazil. (TNSC) thiago_tnsc@hotmail.com (corresponding author).

2 Secretaria de Estado da Educação de Goiás, 5ª Av., Quadra 71, 212, 74643-030 Goiânia, GO, Brazil. (HRP) hasleybio08@gmail.com.

3 Universidade Estadual de Goiás (UEG), Laboratório de Biogeografia e Ecologia Aquática, 75132-903 Anápolis, GO, Brazil. (PBP) phamelabernardes@gmail.com.

4 Núcleo de Estudos Ambientais (Neamb), Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação (PPGBec), Universidade Federal do Tocantins (UFT), Rua 3, Quadra 17, Jardim dos Ipês, 77500-000 Porto Nacional, TO, Brazil. (CCC) carinechamon@mail.uft.edu.br. (FMP) fmpelicice@mail.uft.edu.br.

5 Instituto Nacional de Ciência e Tecnologia em Ecologia, Evolução e Conservação da Biodiversidade (INCT EECBio), Universidade Federal de Goiás (UFG), Avenida Esperança, s/n, Campus Samambaia, 74690-900 Goiânia, GO, Brazil. (PTS) philip13ph@gmail.com.

Os peixes migradores têm profunda ligação com as sociedades humanas. Na bacia Tocantins-Araguaia, marcada por elevada diversidade e endemismo, mas também por acelerada degradação ambiental, existe pouca informação sobre estes peixes. Neste cenário, o presente estudo investigou a diversidade taxonômica e funcional de peixes potamódromos, com o objetivo de compilar a primeira lista de espécies, e examinar padrões de riqueza, composição e diversidade funcional. O status migratório de cada espécie foi determinado considerando a bibliografia mais recente sobre a diversidade de peixes nas bacias Tocantins-Araguaia e Amazônica. O estudo consolidou uma lista de 77 espécies de peixes potamódromos (três ordens, 12 famílias e 41 gêneros), incluindo oito espécies endêmicas, três ameaçadas de extinção e duas não-nativas. Pimelodidae foi a mais especiosa, seguida de Serrasalminidae e Curimatidae. A maior parte das espécies foi classificada como migrador de média (42) e longa distância (32), sendo poucas aquelas que desempenham migrações continentais (3). A maior parte das espécies apresentou ampla distribuição na bacia, resultando em pouca variação espacial na riqueza de espécies, composição e diversidade funcional. No entanto, a composição de traços variou entre as espécies, famílias e status migratório. Esta é a primeira avaliação sobre os peixes potamódromos da bacia, com potencial de gerar informações básicas para amparar o manejo da pesca, planejamento ambiental e ações de conservação.

Palavras-chave: Brasil, Conservação, Ecologia funcional, Migrador, Pimelodidae.

INTRODUCTION

Freshwater fishes developed an array of strategies to cope with environmental variation and explore resources to survive and recruit populations (Winemiller, 1989; Brown-Peterson *et al.*, 2011). Potamodromous fishes, in particular, are iteroparous organisms that carry out migratory movements across the river network to complete their life cycle, using different habitats to maximize survival, growth and reproduction (Lucas, Baras, 2001; Brönmark *et al.*, 2013). Movements vary among species, from small migrations (tens of kilometers) to long-distance movements (hundreds to thousands of kilometers), including different patterns, behaviors, environments, timing and direction (Barthem *et al.*, 2017; Lucas, Baras, 2001; Carolsfeld *et al.*, 2003; Makrakis *et al.*, 2012; Dean *et al.*, 2022; Herrera-R *et al.*, 2024). Potamodromous fishes are found in all continents (excepting Antarctica), where they colonized river systems and associate environments.

Potamodromous fishes are deeply connected with human societies, as they generate a number of ecosystem services (Olden *et al.*, 2020; Pelicice *et al.*, 2023), especially those associated with fishing (Petrere *et al.*, 2002; Duponchelle *et al.*, 2021; Scarabotti *et al.*, 2021). However, knowledge about basic aspects of their life cycle remains scarce or absent. In tropical ecosystems, where fish diversity is extraordinary (Winemiller *et al.*, 2016), information on potamodromous fishes is commonly fragmented, incomplete or uncertain, sometimes lacking species lists, not to mention data on migratory routes, spawning sites and nursery areas; important biodiversity shortfalls persist, *e.g.*, Linnean,

Wallacean, Prestonian, Raunkieran. Furthermore, specific ecological needs and complex life cycles make these fishes highly vulnerable to environmental degradation. Main stressors include river regulation, habitat loss, changes in land use, the introduction of non-native species, overfishing, in addition to the adoption of inappropriate management practices (Pelicice *et al.*, 2017; Bailly *et al.*, 2021; Duponchelle *et al.*, 2021; Santana *et al.*, 2021; Lee *et al.*, 2023). Currently, migratory fishes are threatened on a global scale, as their populations have consistently reduced worldwide over the last five decades (*e.g.*, Brown *et al.*, 2013; Agostinho *et al.*, 2016; Deinet *et al.*, 2020; Ohms *et al.*, 2022; Huang, Li, 2024).

The diversity of potamodromous fishes is especially high in the Neotropics. The group is composed of hundreds of species with different sizes, behaviors, life cycles and geographic distribution (Carolsfeld *et al.*, 2003; Herrera-R *et al.*, 2024), including iconic species with giant body sizes and continental migratory patterns (Barthem *et al.*, 2017). Despite the social and economic importance of these fishes, knowledge about the group remains very incomplete. Studies have been conducted in the La Plata and São Francisco basins (*e.g.*, Agostinho *et al.*, 2003; Sato, Godinho, 2003), and only recently more complete surveys and syntheses have focused on Amazon fishes (Barthem *et al.*, 2017; Dagosta, de Pinna, 2019; Duponchelle *et al.*, 2021; Herrera-R *et al.*, 2024). Yet, some regions remain poorly investigated, such as the Tocantins–Araguaia basin, marked by high fish diversity, endemism and relative geographic isolation (Ribeiro *et al.*, 1995; Dagosta, de Pinna, 2017; Chamon *et al.*, 2022). Located in Brazil, this basin (*ca.* 770,000 km²) is formed by two large rivers that flow across savannahs and rainforests, *i.e.*, the Tocantins River, marked by fish endemism, and the Araguaia River, which holds a large floodplain system (Bananal Island; Latrubesse *et al.*, 2019). Recent studies compiled a species list for the basin (*ca.* 751 species; Dagosta, de Pinna, 2019; Chamon *et al.*, 2022), but the migratory status of these fishes remains uncertain.

The lack of information about potamodromous fishes in the Tocantins–Araguaia basin raises concerns, because this basin has been subjected to large-scale environmental degradation (Latrubesse *et al.*, 2019; Pelicice *et al.*, 2021; Ferreira *et al.*, 2022); currently, 53 fish species are listed as threatened with extinction, the highest number in the Amazon region (Santana *et al.*, 2021). This scenario is particularly unfavorable to migratory fishes, stressing the need for more information about this group. In this context, the present study investigated taxonomic and functional diversity of potamodromous fishes in the Tocantins–Araguaia basin, with the aim to (i) compile a species list, (ii) examine species richness, composition and functional diversity, and (iii) investigate fish diversity patterns considering spatial, taxonomic, and migration aspects. This is the first broad assessment focused on migratory fishes in this basin, with potential to generate basic information to support fisheries management, environmental planning, and conservation initiatives.

MATERIAL AND METHODS

Study area. The Tocantins–Araguaia basin drains approximately 770,000 km² of central/northern Brazil (Fig. 1), with an average discharge of *ca.* 11,000 m³/s (Ribeiro *et al.*, 1995). The Tocantins River (*ca.* 343,000 km²) is a main channel of the basin; originally, its upper and middle stretches were channelized and characterized by the

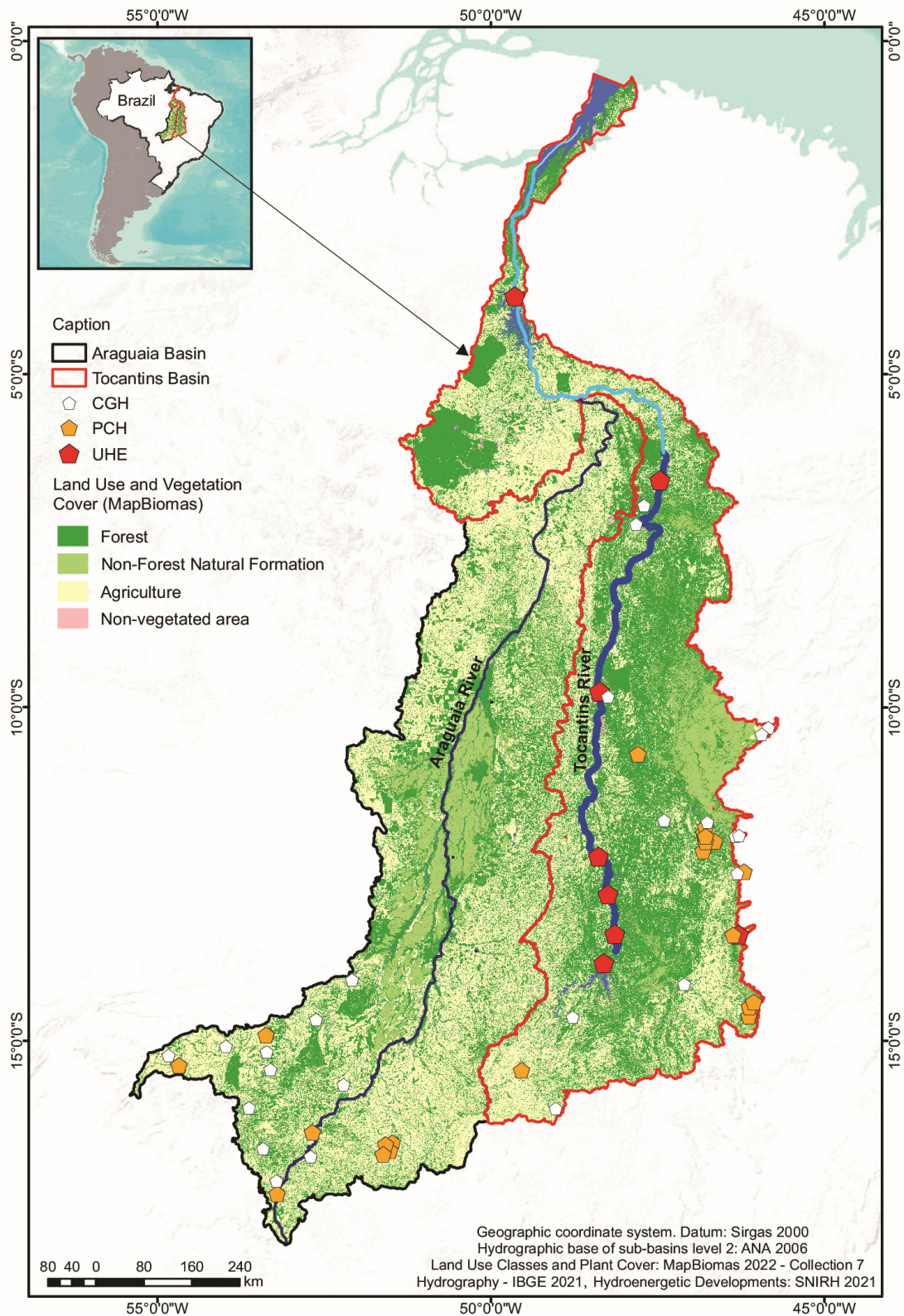


FIGURE 1 | The Tocantins-Araguaia Basin. The map indicates drainage limits (Tocantins and Araguaia), the studied sections (dark blue = upper/middle Tocantins; soft blue = lower Tocantins; black = Araguaia Basin), land cover categories, and operational small (CGH and PCH) and large dams (UHE).

presence of rapids and waterfalls, while the lower stretch was marked by lowlands and some floodplain development. This river runs in the south–north direction (ca. 2,500 km) towards the Marajó Island, near the confluence of the Amazon River with the Atlantic Ocean. The Araguaia River (ca. 382,000 km²) is another main channel of the basin. This river is free-flowing (ca. 2,100 km) and characterized by the presence of a large floodplain system, the Bananal Island (Latrubesse, Stevaux, 2002). Both rivers run across a landscape dominated by savannah vegetation, with Amazon rainforests in the lower stretch.

The Tocantins River is divided in three main sections: upper, middle and lower (Ribeiro *et al.*, 1995). The upper Tocantins (ca. 1,060 km) extends from Central Brazil to the confluence with the Paranã River, characterized by steep slopes with elevations varying from 1,400 to 300 m a.s.l. The middle Tocantins (ca. 980 km) extends to the confluence with the Araguaia River, flowing through gentle slopes (300 to 100 m a.s.l.). The lower Tocantins is a lowland area (ca. 360 km) with gentle slopes (100 to 0 m a.s.l.), where the river flows towards the estuary of the Amazon River. Several tributary rivers flow into the Tocantins River, such as the Almas, Paranã, Manoel Alves, Sono and Itacaunas.

The Araguaia River is also divided in three main sections: upper, middle and lower (Ribeiro *et al.*, 1995; Latrubesse, Stevaux, 2002). The upper Araguaia River (ca. 450 km) has its sources in Central Brazil, where the river flows inside the valley and goes through a marked difference in elevation, from 800 to 350 m a.s.l. The middle Araguaia is a long river stretch (ca. 1,160 km) with low declivity (300 to 150 m a.s.l.), which favors the formation of floodable areas. This section holds the largest fluvial island on the planet, the Bananal Island (ca. 20,000 km²), surrounded by the Araguaia and Javaés rivers. The lower Araguaia, with ca. 500 km, is a lowland river (150 to 90 m a.s.l.) with a meandering channel, rapids, and islands, which flows towards the Tocantins River. Along its course, the main tributary rivers are: Peixe, Garças, Caiapó, Vermelho, Cristalino, das Mortes, and Javaés.

The expansion of human activities has impacted both rivers (Fig. 1), notably agriculture (Trigueiro *et al.*, 2020), aquaculture (Lima *et al.*, 2018), hydropower (Winemiller *et al.*, 2016), and the use of water resources (Daga *et al.*, 2020), associated with changes in land cover, river fragmentation, and the expansion of irrigated agriculture (Castello *et al.*, 2013; Latrubesse *et al.*, 2019; Pelicice *et al.*, 2021). Currently, about 42% of the original vegetation has been removed or altered (Pelicice *et al.*, 2021), a process that has accelerated in the last decade. The construction of hydropower dams has impacted the Tocantins River and its tributaries (Winemiller *et al.*, 2016; Akama, 2017); the main channel is regulated by seven large dams (Fig. 1), which created large impoundments and changed the natural flow regime, causing multiple and persistent impacts on the fish fauna (Araújo *et al.*, 2013; Perônico *et al.*, 2020; Pereira *et al.*, 2021). In the Araguaia River, the fast expansion of agriculture has changed the landscape, increasing water deficits, siltation, and contamination by hazardous pesticides (Scaramuzza *et al.*, 2017; Latrubesse *et al.*, 2019; Lima-Junior *et al.*, 2024; Teixeira *et al.*, 2024).

The fish fauna. The Tocantins–Araguaia basin flows into the Amazon estuary near Belém (Pará State). Although the basin has a particular geological origin and flow/sediment dynamics, it shares some fish species with other Amazonian tributaries (Ferreira *et al.*, 2011; Dagosta, de Pinna, 2017; Orsi *et al.*, 2018). Recent studies compiled

about 751 species until 2020 (Dagosta, de Pinna, 2019; Chamon *et al.*, 2022), and many others described more species recently (*e.g.*, Deprá *et al.*, 2021; Ota *et al.*, 2021; Chamon, Fichberg, 2022; Soares *et al.*, 2023); several taxa remain undescribed (*e.g.*, Aloísio *et al.*, 2005; Lucinda *et al.*, 2007; Lima *et al.*, 2021). The basin has high levels of fish endemism (Hubert, Renno, 2006; Abell *et al.*, 2008; Dagosta, de Pinna, 2019), with approximately 30% of its fauna being endemic (Chamon *et al.*, 2022).

Fish with migratory behavior have been reported to the basin (Neuberger *et al.*, 2008; Barthem *et al.*, 2017; Orsi *et al.*, 2018). The ecology and behavior of migratory fishes, however, remain poorly known, with information limited to some fish with commercial value (Carvalho, Mérona, 1986; Mérona *et al.*, 2010), or derived from other Amazonian systems (Duponchelle *et al.*, 2021; Herrera-R *et al.*, 2024). In the absence of long-term monitoring and large-scale studies, current knowledge remains deficient and tentative, lacking specific data, broad synthesis, or even species lists. Few studies have focused on reproductive dynamics. In the Araguaia River, a recent study showed that fish (including migratory species) reproduce mainly during the flood period, using tributaries and the main channel as spawning sites and nursery grounds (Carnicer *et al.*, 2023). In the Tocantins River, migratory fish also reproduce during the wet season (Medeiros *et al.*, 2008), but eggs and larvae have been observed mainly in the main channel of free-flowing sections (Pinto *et al.*, 2008).

Data collection. To characterize the taxonomic and functional diversity of migratory fishes in the Tocantins-Araguaia basin, the present study followed a methodology articulated in four sequential steps (Fig. 2).

- Step 1: General species list. This step compiled a broad species list for the Tocantins-Araguaia basin, based on Dagosta, de Pinna (2019), and Chamon *et al.* (2022). All records found in these papers were consolidated into a general list, with the addition of species described after 2020. Furthermore, Eschmeyer's Catalog of Fishes (Fricke *et al.*, 2024) was consulted to confirm the validity of the species. The procedure cataloged 761 species, 16 orders, and 51 families, with 229 species considered endemic (Tab. S1).
- Step 2: Potential potamodromous species. From the general species list (Step 1), potential potamodromous species were identified based on specialized literature devoted to migratory fishes in the Amazon region: Carolsfeld *et al.* (2003), Agostinho *et al.* (2008), Van Damme *et al.* (2011), Barthem *et al.* (2017), Doria *et al.* (2018), and Duponchelle *et al.* (2021). All species or genera reported as migratory were assigned as such. Some supposedly migratory species not mentioned by these references were also assigned as such. The procedure resulted in a list of 124 potentially potamodromous species for the Tocantins-Araguaia basin (Tab. S1).
- Step 3: List of potamodromous species. Based on the list of potential potamodromous species (Step 2), the migratory status of each species was checked. Each species was categorized according to a migration scale: (i) Sedentary, that is, non-migratory; (ii) short-distance migration (< 50 km), which implies longitudinal movements between river reaches and tributaries, or lateral movements toward floodplain areas; (iii) medium-distance migration (50 to 99 km), which involves longitudinal movements between river stretches and tributaries; (iv) long-distance migration (100 to 1000 km), which implies longitudinal movements between basin sections (upper, middle and lower); and (v) continental migrations (>1000 km), which implies longitudinal

movements from estuaries to headwaters, including the movement across drainages. This classification was based on the same literature used in Step 2 (the most comprehensive to date), in addition to papers about the biology and ecology of Neotropical migratory fish, and the expertise of researchers involved in this research. After this classification, sedentary species and short-distance migrants (scale i and ii) were excluded from the list. We decided to exclude short-distance migrants because their displacements may be facultative or involve different motivations (e.g., dispersal, drifting), not necessarily associated with life cycles. Therefore, the final list intended to include only species that migrate over long distances (> 50 km) with the purpose to complete their life cycles, which resulted in a list of 77 species (Tab. S1).

- Step 4: Functional traits. A series of functional traits (Tab. S2) were assigned to the 77 selected fish species (Tab. S3), in order to characterize the functional diversity of potamodromous fishes. Trait assignment followed previous studies conducted in the basin (e.g., Agostinho *et al.*, 2008; Vitorino Jr. *et al.*, 2016; Perônico *et al.*, 2020, Pereira *et al.*, 2021), in addition to FishBase (Froese, Pauly, 2022). The chosen traits (Tab. S2) are directly related to habitat use, reproduction, trophic ecology, behavior and defense, representing niche dimensions that affect organism's ecological performance (Winemiller *et al.*, 2015). In total, we considered 16 functional traits divided in 50 trait-states (Tab. S2). The assignment of trait-states for each species is shown in Tab. S3.

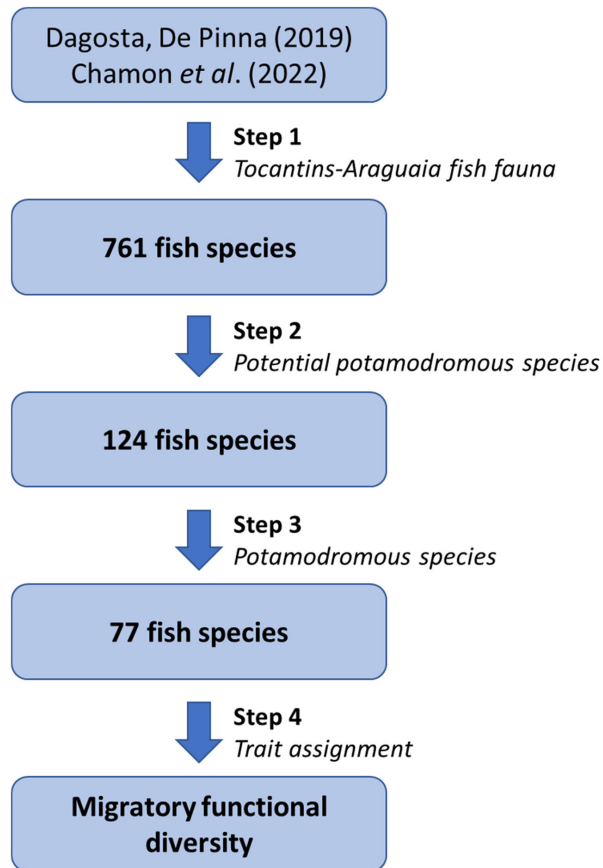


FIGURE 2 | Methodology used (four steps) to identify potamodromous fishes in the Tocantins-Araguaia Basin, generating data to assess taxonomic and functional diversity.

Data analyses. To characterize the diversity of migratory fishes in the Tocantins-Araguaia basin, two matrices were generated: one with all migratory species (taxonomic, Tab. S1), and another with functional traits (functional, Tab. S3). Then, following objective (i), we built the list of potamodromous fishes in the basin. Following objectives (ii) and (iii), we calculated species richness for the basin, regions (upper Tocantins, lower Tocantins, and Araguaia), taxonomic families, and migration scale (medium, long and continental). Regions were restricted to the upper Tocantins (which included the middle section), lower Tocantins and Araguaia because we followed occurrence data as provided by Dagosta, de Pinna (2019), and Chamon *et al.* (2022). To evaluate changes in species composition between regions, we calculated beta diversity using the “beta” function of the BAT package (Cardoso *et al.*, 2015), based on incidence data and Sorensen similarity.

Functional diversity was measured considering the functional traits assigned to each species. Following objectives (ii) and (iii), the functional diversity of migratory fishes was assessed by calculating functional richness (FRic). FRic represents the functional volume occupied by all species in a multidimensional space, obtained by extracting the first two axes of a Principal Coordinate Analysis (PCoA), generated from the dbFD function (Laliberté *et al.*, 2014). The functional volume occupied by a set of species was measured using the “convex hull” approach (Villéger *et al.*, 2008), which is based on the formation of polygons in a multidimensional space. Differences in the functional space (axis scores) occupied by the species were tested through Multivariate Analysis of Variance (MANOVA), considering regions, families and migratory scale as factors. Pairwise comparisons were conducted with the `pairwise.perm.manova` function, with 999 repetitions, using the `RVAideMemoire` package (Hervé, Hervé, 2020). Finally, variations in trait composition between regions were measured using the “beta” function of the BAT package (Cardoso *et al.*, 2015), based on a trait incidence matrix and Sorensen similarity. Traits with no variation were excluded from all analyses (*i.e.*, swimming, embryo development, and parental care).

All figures were drawn using the `ggplot2` package (Wickham, 2011). All analyzes were conducted in R v. 4.3.2 (R Development Core Team, 2023). Statistical differences were considered at a level of significance of 5%.

RESULTS

We consolidated a list of 77 potamodromous species in the Tocantins-Araguaia basin (Tab. 1), which include fish of different sizes, shapes, behavior, and lineages (Fig. 3). These fishes belonged to three orders, Clupeiformes ($S = 02$ species), Characiformes ($S = 42$) and Siluriformes ($S = 33$), 12 families, and 41 genera. Pimelodidae was the most species-rich family ($S = 25$), followed by Serrasalminidae ($S = 15$), and Curimatidae ($S = 10$); other families had less than three species (Tab. 1). Most species ($S = 69$) were widely distributed across the basin; eight were endemic, three threatened with extinction, and two non-natives (the tambaqui *Colossoma macropomum* and the pacu *Piaractus mesopotamicus*). Most species were classified as medium ($S = 42$) and long-distance ($S = 32$) migrants, and few as continental migrants ($S = 03$); this proportion was similar between regions (Fig. 4), excepting for continental migrants, recorded only in the lower

Tocantins. We recorded 64 species in the upper and lower Tocantins, and 56 in the Araguaia; taxonomic composition was very similar between the three regions (Tab. 2).

TABLE 1 | List of potamodromous fishes in the Tocantins-Araguaia basin (S = 77), indicating their occurrence (1 = upper Tocantins; 2 = lower Tocantins; 3 = Araguaia), status (endemism, threat, origin), and migration scale.

Taxa	Regions			Status	Migration
	1	2	3		
CLUPEIFORMES					
PRISTIGASTERIDAE					
<i>Pellona castelnaeana</i> Valenciennes, 1847	X	X	X		Long
<i>Pellona flavipinnis</i> (Valenciennes, 1837)	X	X			Long
CHARACIFORMES					
ANOSTOMIDAE					
<i>Leporinus fasciatus</i> (Bloch, 1794)	X		X		Medium
<i>Leporinus friderici</i> (Bloch, 1794)	X	X	X		Medium
<i>Megaleporinus trifasciatus</i> (Steindachner, 1876)	X	X	X		Long
BRYCONIDAE					
<i>Brycon falcatus</i> Müller & Troschel, 1844	X	X	X		Long
<i>Brycon gouldingi</i> Lima, 2004	X	X	X	Endemic, Threatened	Long
<i>Brycon nattereri</i> Günther, 1864	X		X		Medium
<i>Salminus hilarii</i> Valenciennes, 1850	X	X	X		Long
CURIMATIDAE					
<i>Curimata acutirostris</i> Vari & Reis, 1995	X	X	X		Medium
<i>Curimata cyprinoides</i> (Linnaeus, 1766)	X	X	X		Medium
<i>Curimata inornata</i> Vari, 1989	X	X	X		Medium
<i>Curimata ocellata</i> Eigenmann & Eigenmann, 1889	X	X			Medium
<i>Curimata vittata</i> (Kner, 1858)		X			Medium
<i>Curimatella alburnus</i> (Müller & Troschel, 1844)		X			Medium
<i>Curimatella dorsalis</i> (Eigenmann & Eigenmann, 1889)	X	X	X		Medium
<i>Curimatella immaculata</i> (Fernández-Yépez, 1948)	X	X	X		Medium
<i>Curimatopsis macrolepis</i> (Steindachner, 1876)	X		X		Medium
<i>Psectrogaster amazonica</i> Eigenmann & Eigenmann, 1889	X	X	X		Medium
CYNODONTIDAE					
<i>Hydrolycus armatus</i> (Jardine, 1841)	X	X	X		Long
<i>Hydrolycus tatauaia</i> Toledo-Piza, Menezes & Santos, 1999	X	X			Long
<i>Rhaphiodon vulpinus</i> Spix & Agassiz, 1829	X	X	X		Medium
HEMIODONTIDAE					
<i>Anodus orinocensis</i> (Steindachner, 1887)	X	X	X		Medium
<i>Argonectes robertsi</i> Langeani, 1999	X	X	X		Medium
PROCHILODONTIDAE					
<i>Prochilodus nigricans</i> Spix & Agassiz, 1829	X	X	X		Long
<i>Semaprochilodus brama</i> (Valenciennes, 1850)	X	X	X		Long
SERRASALMIDAE					
<i>Colossoma macropomum</i> (Cuvier, 1816)	X	X		Non-native	Long
<i>Mylesinus paucisquamatus</i> Jégu & Santos, 1988	X	X	X	Endemic, Threatened	Medium
<i>Myleus setiger</i> Müller & Troschel, 1844	X	X	X		Medium
<i>Myloplus arnoldi</i> Ahl, 1936	X		X		Medium
<i>Myloplus asteria</i> (Müller & Troschel, 1844)	X	X	X		Medium
<i>Myloplus nigrolineatus</i> Ota, Machado, Andrade, Collins, Farias & Hrbek, 2020		X			Medium
<i>Myloplus rubripinnis</i> (Müller & Troschel, 1844)		X	X		Medium
<i>Myloplus schomburgkii</i> (Jardine, 1841)	X	X	X		Medium



TABLE 1 | (Continued)

Taxa	Regions			Status	Migration
	1	2	3		
<i>Myloplus torquatus</i> (Kner, 1858)	X	X	X		Medium
<i>Mylossoma duriventre</i> (Cuvier, 1818)	X				Medium
<i>Mylossoma unimaculatum</i> (Steindachner, 1908)	X	X	X	Endemic	Medium
<i>Piaractus brachypomus</i> (Cuvier, 1818)	X	X	X		Long
<i>Piaractus mesopotamicus</i> (Holmberg, 1887)	X			Non-native	Long
<i>Tometes ancylorhynchus</i> Andrade, Jégu & Giarrizzo, 2016	X	X	X		Long
<i>Tometes siderocarajensis</i> Andrade, Machado, Jégu, Farias & Giarrizzo, 2017		X			Long
TRIPORTHEIDAE					
<i>Triportheus albus</i> Cope, 1872	X	X	X		Medium
<i>Triportheus auritus</i> (Valenciennes, 1850)	X	X	X		Medium
<i>Triportheus trifurcatus</i> (Castelnau, 1855)	X	X	X	Endemic	Medium
SILURIFORMES					
AUCHENIPTERIDAE					
<i>Ageineiosus inermis</i> (Linnaeus, 1766)	X	X	X		Medium
<i>Ageineiosus lineatus</i> Ribeiro, Rapp Py-Daniel & Walsh, 2017		X			Medium
<i>Ageineiosus ucayalensis</i> Castelnau, 1855	X	X	X		Medium
<i>Ageineiosus vittatus</i> Steindachner, 1908		X			Medium
DORADIDAE					
<i>Lithodoras dorsalis</i> (Valenciennes, 1840)	X				Medium
<i>Megalodoras uranoscopus</i> (Eigenmann & Eigenmann, 1888)	X	X	X		Long
<i>Oxydoras niger</i> (Valenciennes, 1821)	X	X	X		Long
<i>Pterodoras granulatus</i> (Valenciennes, 1821)	X	X	X		Long
PIMELODIDAE					
<i>Aguarunichthys tocantinsensis</i> Zuanon, Rapp Py-Daniel & Jégu, 1993	X	X	X	Endemic, Threatened	Long
<i>Brachyplatystoma filamentosum</i> (Lichtenstein, 1819)	X	X	X		Long
<i>Brachyplatystoma platynemum</i> Boulenger, 1898		X			Continental
<i>Brachyplatystoma rousseauxii</i> (Castelnau, 1855)		X			Continental
<i>Brachyplatystoma vaillantii</i> (Valenciennes, 1840)		X			Continental
<i>Hemisorubim platyrhynchos</i> (Valenciennes, 1840)	X	X	X		Long
<i>Hypophthalmus marginatus</i> Valenciennes, 1840	X	X	X		Long
<i>Phractocephalus hemioliopterus</i> (Bloch & Schneider, 1801)	X	X	X		Long
<i>Pimelodina flavipinnis</i> Steindachner, 1876	X	X	X		Medium
<i>Pimelodus albofasciatus</i> Mees, 1974	X		X		Medium
<i>Pimelodus blochii</i> Valenciennes, 1840	X	X	X		Medium
<i>Pimelodus luciae</i> Rocha & Ribeiro, 2010		X		Endemic	Medium
<i>Pimelodus ornatus</i> Kner, 1858	X	X	X		Medium
<i>Pimelodus quadratus</i> Lucinda, Ribeiro & Lucena, 2016	X		X	Endemic	Medium
<i>Pimelodus speciosus</i> Costa e Silva, Ribeiro, Lucena & Lucinda, 2018	X		X	Endemic	Medium
<i>Pimelodus tetramerus</i> Ribeiro & Lucena, 2006	X	X	X		Medium
<i>Pinirampus pirinampu</i> (Spix & Agassiz, 1829)	X	X	X		Long
<i>Platynematichthys notatus</i> (Jardine, 1841)		X			Long
<i>Platystomatichthys sturio</i> (Kner, 1858)		X			Medium
<i>Pseudoplatystoma fasciatum</i> (Linnaeus, 1766)	X				Long
<i>Pseudoplatystoma punctifer</i> (Castelnau, 1855)	X		X		Long
<i>Pseudoplatystoma reticulatum</i> Eigenmann & Eigenmann, 1889	X				Long
<i>Sorubim lima</i> (Bloch & Schneider, 1801)	X	X	X		Long
<i>Sorubimichthys planiceps</i> (Spix & Agassiz, 1829)	X	X	X		Long
<i>Zungaro zungaro</i> (Humboldt, 1821)	X	X	X		Long

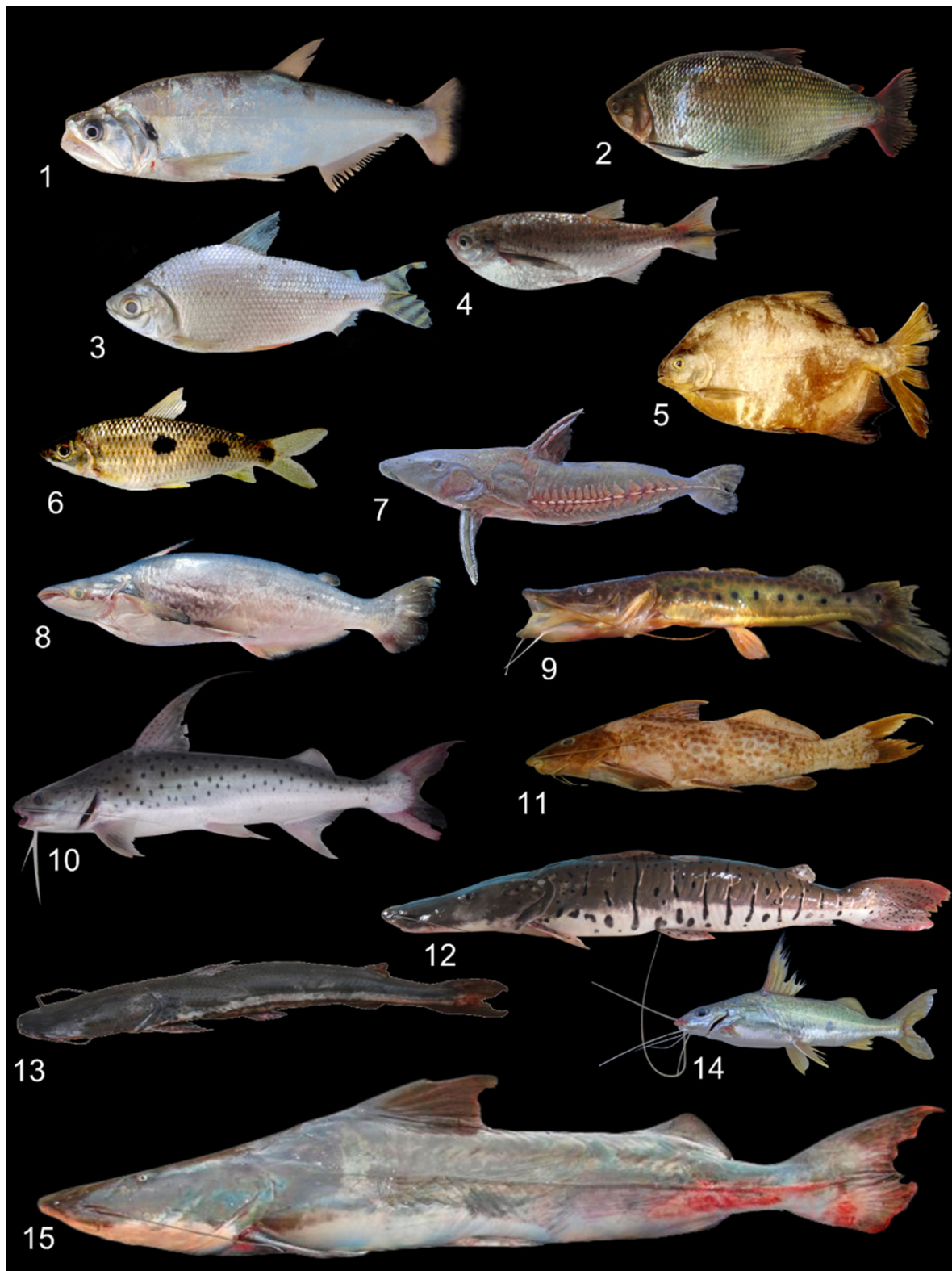


FIGURE 3 | Potamodromous fishes from the Tocantins-Araguaia Basin. Characiformes: 1 = *Hydrolycus armatus*; 2 = *Brycon falcatus*; 3 = *Semaprochilodus brama*; 4 = *Triportheus trifurcatus*; 5 = *Tometes siderocarajensis*; 6 = *Leporinus friderici*. Siluriformes: 7 = *Oxydoras niger*; 8 = *Ageneiosus inermis*; 9 = *Hemisorubim platyrhynchos*; 10 = *Platynematachthys notatus*; 11 = *Aguarunichthys tocantinsensis*; 12 = *Pseudoplatystoma punctifer*; 13 = *Sorubimichthys planiceps*; 14 = *Pimelodus albofasciatus*; 15 = *Brachyplatystoma filamentosum*. Fish size is not to scale. Credits: Thiago N. S. Campos (1, 2, 4, 6-9, 12, 14), Lucas G. M. Frota (3), and Anderson B. Soares (5, 10, 11, 13, 15).

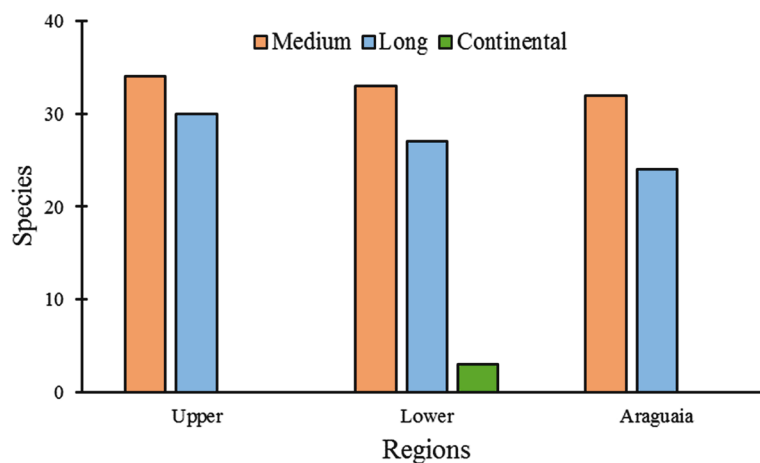


FIGURE 4 | Number of potamodromous species in the three studied regions (upper and lower Tocantins, and Araguaia), considering the migration scale.

TABLE 2 | Taxonomic (species, lower triangle) and functional (traits, upper triangle) similarity in the composition of migratory fishes between the studied regions: upper and lower Tocantins, and Araguaia.

Region	Upper Tocantins	Lower Tocantins	Araguaia
Upper Tocantins	1	0.992	1
Lower Tocantins	0.796	1	0.8
Araguaia	0.916	0.992	1

The functional volume occupied by potamodromous fishes was similar between regions (Fig. 5A), indicating high similarity in trait composition; this pattern was confirmed by Sorensen similarity (Tab. 2) and MANOVA ($F = 0.34$, $df = 2$, $p = 0.9$). FRic values were higher in the lower Tocantins (197.73), followed by the upper Tocantins (183.35) and Araguaia (182.99). Taxonomic families occupied a different functional space (Fig. 5B), indicating functional complementarity (MANOVA: $F = 264.62$, $df = 11$, $p < 0.0001$); pairwise comparisons showed that only Pimelodidae and Doradidae occupied similar functional spaces (Tab. S4). Pimelodidae occupied the largest functional space, but all families showed some intra-group variation. The functional space also differed between migratory scales (MANOVA: $F = 110.30$, $df = 2$, $p < 0.0001$; Fig. 5C).

All species presented carangiform swimming, external embryo development, and absence of parental care (Tab. 3). Furthermore, most species had maximum length greater than 20 cm, laterally or dorsally compressed bodies, no dermal plates, furcate caudal fin, and external fecundation. However, some traits were variable, such as the presence of barbels and spikes (present in some Siluriformes), mouth position and biting mechanics, feeding ecology, trophic position, and habitat use (Tab. 3).

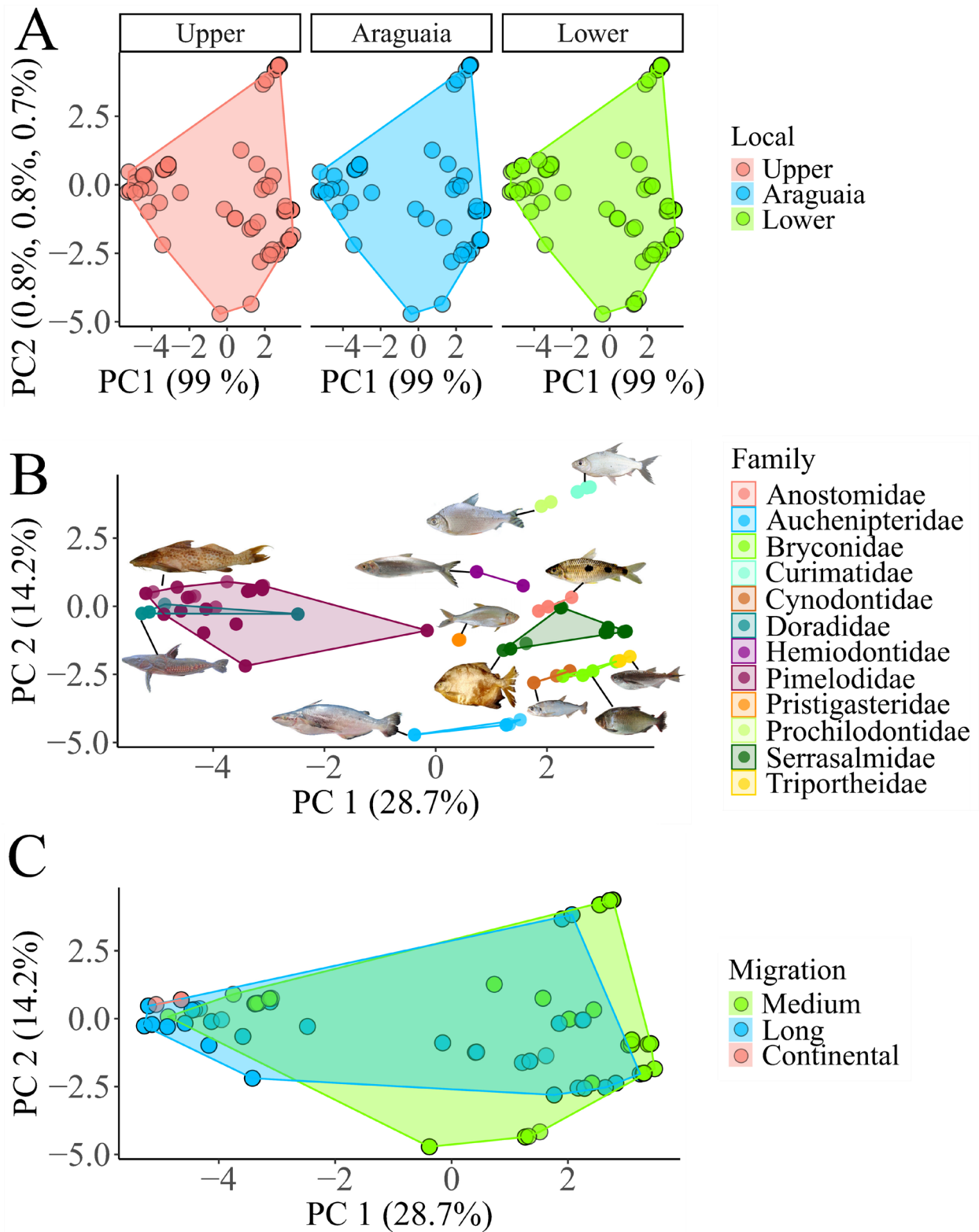


FIGURE 5 | Functional space (FRic) occupied by potamodromous fishes, considering the three regions investigated (A), taxonomic families (B) and migration scale (C).

TABLE 3 | Percentage of species classified in each trait-state.

Traits	%	Traits	%
1. Length (cm)		9. Mouth position	
> 20	16.9	Terminal	48.1
20.1 - 40	41.6	Supraterminal	3.9
40.1 - 60	11.7	Subterminal	27.3
< 60.1	29.9	Inferior	20.8
2. Body shape		10. Feeding	
Anguilliform	0.0	Detritivore	15.6
Elongated	0.0	Herbivore	10.4
Fusiform/cylindrical	7.8	Planktivore	2.6
Dorsoventral compression	35.1	Carnivore	7.8
Lateral compression	37.7	Piscivore	26.0
Dorsoventral compression (rounded)	0.0	Omnivore	37.7
Lateral compression (rounded)	19.5	11. Trophic level	
3. Swimming		2 a 2.9	39.0
Anguilliform	0.0	3 a 3.9	22.1
Carangiform	100	4 a 4.9	27.3
Labriform	0.0	Na	11.7
Rajiform	0.0	12. Fertilization	
Gymnotiform	0.0	Internal	5.2
4. Caudal fin		External	94.8
Emarginate	32.5	13. Embryo development	
Furcate	67.5	Internal	0.0
5. Spikes		External	100
Present	58.4	14. Parental care	
Absent	41.6	Present	0.0
6. Plates		Absent	100.0
Present	5.2	15. Migration	
Absent	94.8	Medium	54.5
7. Barbels		Long	41.6
Present	39.0	Continental	3.9
Absent	61.0	16. Habitat	
8. Mouth mechanics		Benthonic	33.8
Bite	36.4	Pelagic	26.0
Suction	48.1	Benthopelagic	40.3
Scraper	15.6		

DISCUSSION

This is the first broad assessment about potamodromous fishes from the Tocantins-Araguaia basin. Of the 761 fish species recorded in this basin (Dagosta, de Pinna, 2019; Chamon *et al.*, 2022), we identified 77 as potamodromous (*ca.* 10%, including two non-natives). Potamodromous fishes are widely distributed across the globe, characterized by performing mid to long-distance movements across the river networks to complete their life cycles (Lucas, Baras, 2001; Carolsfeld *et al.*, 2003; Dean *et al.*, 2022; Herrera-R *et al.*, 2024). Our results showed that this group is especially diverse in the Tocantins-Araguaia basin, in taxonomic and functional terms. It is worth noting that this is the first synthesis conducted in the basin, based on information available in the literature, still incomplete, and fragmented. More studies are needed to further address biodiversity shortfalls (*i.e.*, Linnean, Wallacean, and Raunkieran), especially to uncover basic biological aspects, migratory patterns, and population dynamics. The acquisition of more data is necessary to validate the species list, updating distribution patterns and the migratory status of species.

The high diversity of potamodromous fishes mirrors the high diversity found in the Tocantins-Araguaia basin, a common pattern to large Amazonian rivers (Jézéquel *et al.*, 2020). The Tocantins-Araguaia basin is home to *ca.* 30% of all species recorded in the Amazon region (2,716 species; Dagosta, de Pinna, 2019), and its migratory fauna represents *ca.* 35% of all migratory species recorded in the region (223 species; Herrera-R *et al.*, 2024). The vast drainage network of the Tocantins-Araguaia basin (*ca.* 770,000 km²), and the presence of different habitats (*e.g.*, river channels, floodplains, large tributaries, streams), must also favor the maintenance of migratory fishes, which include species with different behaviors and ecological needs (Herrera-R *et al.*, 2024). One important finding was the wide spatial distribution of species, with a few restricted to the upper or lower Tocantins. Furthermore, few migratory species were classified as endemic (eight, *ca.* 10%), contrasting with the high levels of endemism of the Tocantins-Araguaia basin (*ca.* 30%). These results indicate low beta diversity at regional scales, *i.e.*, intra-basin and between Amazonian drainages. It is expected considering the dispersal potential of potamodromous fishes, as well as their life cycle, which involves the use of different habitats in the riverscape.

The 77 potamodromous species belonged to three orders (Clupeiformes, Characiformes, and Siluriformes) and 12 families, with most species classified as medium (54.5%) and long-distance (41.6%) migrants. Pimelodidae, Serrasalminidae, and Curimatidae summed most species – a common pattern observed in other Neotropical rivers (Carolsfeld *et al.*, 2003; Herrera-R *et al.*, 2024). Pimelodidae includes catfishes of different sizes and migratory behaviors, which perform mid-distance (*e.g.*, *Pimelodus*), long-distance (*e.g.*, *Pseudoplatystoma*), and continental migrations (*e.g.*, *Brachyplatystoma*). Some large catfishes perform the longest known migration within freshwaters, involving thousands of kilometers between spawning and nursery sites in the Amazon system. Yet, they were restricted to the lower Tocantins, probably because Tucuruí Dam, in the lower Tocantins, blocked access to upstream sections of the basin. In fact, old fishers have reported the presence of *B. rousseuxii* in the upper Tocantins in periods that preceded hydropower development (Santos, Pelicice, *in press*), constituting evidence that goliath catfishes dispersed across the Tocantins-Araguaia basin in pristine

conditions. The basin was not a spawning ground according to previous research (Barthem *et al.*, 2017), and probably worked as a feeding site. Serrasalminae is a group of rounded fish characterized by high taxonomic and functional diversity in the Amazon (Andrade *et al.*, 2019); in the Tocantins-Araguaia basin, these fish probably perform mid and long-distance migrations, but this family also includes sedentary and short-distance migrants (*e.g.*, *Serrasalmus*). Curimatidae is another diverse family, composed of mid-sized detritivorous fish that form large aggregations during migrations, usually inhabiting river channels and floodplains (Herrera-R *et al.*, 2024), where they serve as prey for large predatory fish (Montaña *et al.*, 2011).

Ecological information about potamodromous fishes from the Tocantins-Araguaia Bains remains lacking, particularly data on migration routes, timing, spawning sites, and nursery areas. Based on data from other South American basins, we offer some speculation. Mid-distance (*e.g.*, Curimatidae, Hemiodontidae, Serrasalminae and Pimelodidae) and some long-distance migrants (*e.g.*, *Prochilodus nigricans*) probably complete their life cycle within river stretches, forming regional sub-populations, with periodic migrations between river segments, tributaries, and floodplain areas (*e.g.*, Lopes *et al.*, 2019; Perini *et al.*, 2021; Herrera-R *et al.*, 2024). Long-distance migrants (*e.g.*, *Semaprochilodus brama*, *Piaractus brachyomus*, *Pseudoplatystoma fasciatum*, *Zungaro zungaro*) probably perform up-downstream movements between lower, middle and upper sections, using tributaries as spawning sites (*e.g.*, Agostinho *et al.*, 2003; Sato, Godinho, 2003; Makrakis *et al.*, 2012). Different recruitment dynamics are expected between the Tocantins and Araguaia rivers, because these systems have contrasting environmental conditions. The Tocantins River flows substantially channelized with little floodplain development (Ribeiro *et al.*, 1995), which poses constraints to fish recruitment, probably involving the use of alternative habitats, such as river confluences and backwaters (*e.g.*, Silva *et al.*, 2020; Pachla *et al.*, 2022). In fact, in free-flowing conditions, eggs and larvae have been recorded mainly in the main channel (Pinto *et al.*, 2008). The Araguaia River, on the other hand, is home to a large floodplain system (*i.e.*, Bananal Island; Latrubesse, Stevaux, 2002), a type of environment that provides nursery habitats for migratory fishes (*e.g.*, Agostinho *et al.*, 2004). In the upper and middle Araguaia, eggs and larvae have been recorded both in tributaries and in the main channel (Carnicer *et al.*, 2023), probably drifting towards the floodplain area located downstream. In pristine conditions, some migratory fishes probably migrated between the Araguaia and Tocantins rivers (Carvalho, Mérona, 1986), involving also movements towards the Amazon estuary and other sub-basins. The former record of goliath catfishes in the upper Tocantins (*i.e.*, *B. rousseauxii*; Santos, Pelicice, *in press*) supports the idea that some migratory fish migrated between different parts of the system. All these patterns, however, are difficult to assess, given the current fragmentation imposed by hydroelectric dams constructed along the Tocantins River, and the consequent isolation of the Araguaia River (which remains free from dams along its main channel). Future studies must consider the existence of isolated sub-populations and regional recruitment dynamics.

Functional diversity was similar between regions, reflecting the high similarity in taxonomic composition. Moreover, some traits were widely shared among species, such as medium to large size, compressed body (laterally or dorsally), no dermal plates, carangiform swimming, furcated fins, external fertilization and development, and

absence of parental care. These traits are common among Neotropical potamodromous fishes (e.g., Agostinho *et al.*, 2003; Sato, Godinho, 2003; Zaniboni-Filho, Schulz, 2003), and seem to represent a broad functional characterization of this group. However, we observed significant variation in the functional space occupied by each species, with a clear segregation among families, indicating functional variation and complementarity. Almost all trait-states showed some variation, particularly the presence of barbels and spikes (i.e., some Siluriformes), mouth position, biting mechanics, feeding ecology, trophic position, and habitat use; functional variation was also observed within families (e.g., Pimelodidae). In addition, functional richness was higher for mid and long-distance migrants, possibly associated with a diversity of needs, behaviors, and strategies, as these groups may use different migratory routes, perform longitudinal and lateral migration, and use different spawning and nursery sites (Godinho, Kynard, 2009; Makrakis *et al.*, 2012; Herrera-R *et al.*, 2024). These results therefore revealed that potamodromous fishes share several common traits, but trait composition is variable, indicating they have developed different solutions to survive and reproduce. Although the functional diversity of Neotropical fishes is well recognized (Toussaint *et al.*, 2016; Vitule *et al.*, 2017), functional approaches have not focused on migratory fishes, with a strong bias toward stream fishes (e.g., Carvalho, Tejerina-Garro, 2015; Teresa *et al.*, 2015; Borba *et al.*, 2021). Future studies must investigate the relationship between functional traits and aspects of the life cycle, for example, whether traits are related to migratory behavior (distance, routes, timing) and critical habitats. Such understanding would allow the prediction of behavioral aspects, habitat needs and human impacts.

The criteria used to classify migratory fish deserves some consideration, as there are different views in the literature. Traditionally, migratory fish have been those that perform long longitudinal movements along the river (e.g., Agostinho *et al.*, 2003; Makrakis *et al.*, 2012; Soares *et al.*, 2022), but recent studies have adopted a broader view by including short-distance and lateral movements (Duponchelle *et al.*, 2021; Herrera-R *et al.*, 2024). In the present work, we adopted an intermediate approach, considering only species that perform migrations along the river (> 50 km), which includes mid-distance migrants, but excludes short-distance migrants (e.g., some Anostomidae, Serrassalmidae, Gymnotiformes), whose migratory status may be controversial. In the case of the Tocantins-Araguaia basin, a broader criterion (e.g., Herrera-R *et al.*, 2024) would change substantially the species list, considering that our initial compilation gathered 124 species. Moreover, primary data are absent or incomplete for many species, so future studies must reassess and validate our classification, which was based on the best available information, but significantly limited. Multiple approaches are necessary, including telemetry techniques, otolith chemistry, eggs and larvae distribution, and fishery catches (e.g., Barthem *et al.*, 2017). It must be considered that migration is a complex phenomenon, as Neotropical fishes evolved in lotic environments (Albert *et al.*, 2020), where dispersion and migratory movements are common features, even among typically sedentary (e.g., cichlids or *Arapaima gigas*; Hoeinghaus *et al.*, 2003; Castello, 2008) or small-sized fish (e.g., *Astyanax* or *Trichomycterus*; Miranda-Chumacero *et al.*, 2015; Vidotto-Magnoni *et al.*, 2021). This situation highlights the high diversity of migratory behaviors among Neotropical potamodromous fish, an aspect that remains poorly known, which contrasts with well-known migratory fish from other regions (Dean *et al.*, 2022).

The conservation of migratory fishes is a matter of preoccupation, as these fishes have declined on a global scale (Deinet *et al.*, 2020; Huang, Li, 2024). The conservation status of migratory fishes in the Tocantins-Araguaia basin raises concerns, considering the current scenario of environmental degradation induced by river regulation, deforestation, water diversion and other stressors (Latrubesse *et al.*, 2019; Pelicice *et al.*, 2021; Swanson, Bohlman, 2021; Chamon *et al.*, 2022). Currently three endemic migratory species are threatened with extinction (*i.e.*, *Aguarunichthys tocantinsensis*, *Brycon gouldingi*, and *Mylesinus paucisquamatus*), but the situation is probably worse, considering the lack of monitoring and assessments. In fact, populations have declined or even disappeared from some reaches (Perônico *et al.*, 2020; Pereira *et al.*, 2021), with effects on small-scale artisanal fisheries (Santos, Pelicice, *in press*). In the current scenario, fish movements are substantially blocked by hydroelectric dams that isolated the Araguaia River and fragmented the upper, middle and lower stretches of the Tocantins River (Winemiller *et al.*, 2016; Akama, 2017). Moreover, both rivers have been progressively impacted by changes in land use, the expansion of irrigated agriculture, and contamination (Scaramuzza *et al.*, 2017; Sano *et al.*, 2019; Trigueiro *et al.*, 2020; Lima-Junior *et al.*, 2024). Management actions have been controversial, as installed fishways (ladders) have proven to be ineffective or prejudicial (Agostinho *et al.*, 2011; Pelicice, Agostinho, 2012). In this scenario, the maintenance of river networks, flow regimes and habitats must be priority; in particular, the preservation of fluvial remnants in the Tocantins River and the floodplain area on the Bananal Island.

ACKNOWLEDGMENTS

The authors thank the Universidade Federal do Tocantins (UFT), the Núcleo de Estudos Ambientais (Neamb) and the Programa de Pós-Graduação em Biodiversidade, Ecologia e Conservação (PPGBec) for providing infrastructure and support. Financial support was received from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), by providing scholarship for TNSC (master thesis) and research grants for FMP (process number 312256/2020-5).

REFERENCES

- **Abell R, Thieme ML, Revenga C, Bryer M, Kottelat M, Bogutskaya N *et al.*** Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *Bioscience*. 2008; 58(5):403–14. <https://doi.org/10.1641/B580507>
- **Agostinho AA, Gomes LC, Santos NCL, Ortega JCG, Pelicice FM.** Fish assemblages in Neotropical reservoirs: colonization patterns, impacts and management. *Fish Res*. 2016; 173:26–36. <https://doi.org/10.1016/j.fishres.2015.04.006>
- **Agostinho AA, Gomes LC, Suzuki HI, Júlio Jr. HF.** Migratory fish from the upper Paraná river basin, Brazil. In: Carosfeld J, Harvey B, Ross C, Baer A, editors. *Migratory fishes of the South America: biology, social importance and conservation status*. Victoria: World Fisheries Trust; 2003. p.19–99.
- **Agostinho AA, Gomes LC, Veríssimo S, Okada EK.** Flood regime, dam regulation and fish in the Upper Paraná River: effects on assemblage attributes, reproduction and recruitment. *Rev Fish Biol Fish*. 2004; 14(1):11–19. <https://doi.org/10.1007/s11160-004-3551-y>

- **Agostinho CS, Pelicice FM, Marques EE.** Reservatório de Peixe Angical: bases ecológicas para o manejo da ictiofauna. São Carlos: RiMa; 2008.
- **Agostinho CS, Pelicice FM, Marques EE, Soares AB, Almeida DAA.** All that goes up must come down? Absence of downstream passage through a fish ladder in a large Amazonian river. *Hydrobiologia*. 2011; 675(1):1–12. <https://doi.org/10.1007/s10750-011-0787-0>
- **Akama A.** Impacts of the hydroelectric power generation over the fish fauna of the Tocantins River, Brazil: Marabá dam, the final blow. *Oecol Aust*. 2017; 21(3):222–31. <https://doi.org/10.4257/oeco.2017.2103.01>
- **Albert JS, Tagliacollo VA, Dagosta F.** Diversification of Neotropical freshwater fishes. *Annu Rev Ecol Evol Syst*. 2020; 51:27–53. <https://doi.org/10.1146/annurev-ecolsys-011620-031032>
- **Aloísio GR, Oliveira FG, Angelini R.** Fish, State Park of Jalapão, State of Tocantins, Brazil. *Checklist*. 2005; 1(1):10–13.
- **Araújo ES, Marques EE, Freitas IS, Neuberger AL, Fernandes R, Pelicice FM.** Changes in distance decay relationships after river regulation: Similarity among fish assemblages in a large Amazonian river. *Ecol Freshw Fish*. 2013; 22(4):543–52. <https://doi.org/10.1111/eff.12054>
- **Bailly D, Batista-Silva VF, Silva Cassemiro FA, Lemes P, Graça WJ, Oliveira AG et al.** The conservation of migratory fishes in the second largest river basin of South America depends on the creation of new protected areas. *Aquat Conserv Mar Freshw Ecosyst*. 2021; 31(9):2515–32. <https://doi.org/10.1002/aqc.3594>
- **Barthem RB, Goulding M, Leite RG, Cañas C, Forsberg B, Venticinque E et al.** Goliath catfish spawning in the far western Amazon confirmed by the distribution of mature adults, drifting larvae and migrating juveniles. *Sci Rep*. 2017; 7(41784):1–13. <https://doi.org/10.1038/srep41784>
- **Borba GC, Costa FRC, Espírito-Santo HMV, Leitão RP, Dias MS, Zuanon J.** Temporal changes in rainfall affect taxonomic and functional composition of stream fish assemblages in central Amazonia. *Freshw Biol*. 2021; 66(4):753–64. <https://doi.org/10.1111/fwb.13675>
- **Brönmark C, Hulthén K, Nilsson PA, Skov C, Hansson LA, Brodersen J et al.** There and back again: migration in freshwater fishes. *Can J Zool*. 2013; 92(6):467–79. <https://doi.org/10.1139/cjz-2012-0277>
- **Brown-Peterson NJ, Wyanski DM, Saborido-Rey F, Macewicz BJ, Lowerre-Barbieri SK.** A standardized terminology for describing reproductive development in fishes. *Mar Coast Fish*. 2011; 3(1):52–70. <https://doi.org/10.1080/19425120.2011.555724>
- **Brown JJ, Limburg KE, Waldman JR, Stephenson K, Glenn EP, Juanes F et al.** Fish and hydropower on the U.S. Atlantic coast: failed fisheries policies from half-way technologies. *Conserv Lett*. 2013; 6(4):280–86. <https://doi.org/10.1111/conl.12000>
- **Cardoso P, Rigal F, Carvalho JC.** BAT - Biodiversity Assessment Tools, an R package for the measurement and estimation of alpha and beta taxon, phylogenetic and functional diversity. *Methods Ecol Evol*. 2015; 6(2):232–36. <https://doi.org/10.1111/2041-210X.12310>
- **Carnicer C, Lima LB, Taguti TL, Oliveira FJ, Lima-Junior DP.** Spatial and seasonal distribution of fish eggs and larvae in one free-flowing river in the Neotropical savana. *J Fish Biol*. 2023; 103(3):481–95. <https://doi.org/10.1111/jfb.15455>
- **Carolsfeld J, Harvey B, Ross C, Baer A.** Migratory fishes of South America: biology, fisheries and conservation status. British Columbia, Canada: World Fisheries Trust; 2003.
- **Carvalho JL, Merona B.** Estudos sobre dois peixes migratorios do baixo Tocantins, antes do fechamento da barragem de Tucuruí. *Amazoniana*. 1986; IX(4):595–607.
- **Carvalho RA, Tejerina-Garro FL.** The influence of environmental variables on the functional structure of headwater stream fish assemblages: a study of two tropical basins in Central Brazil. *Neotrop Ichthyol*. 2015; 13(2):349–60. <https://doi.org/10.1590/1982-0224-20130148>
- **Castello L.** Lateral migration of *Arapaima gigas* in floodplains of the Amazon. *Ecol Freshw Fish*. 2008; 17(1):38–46. <https://doi.org/10.1111/j.1600-0633.2007.00255.x>
- **Castello L, Mcgrath DG, Hess LL, Coe MT, Lefebvre PA, Petry P et al.** The vulnerability of Amazon freshwater ecosystems. *Conserv Lett*. 2013; 6(4):217–29. <https://doi.org/10.1111/conl.12008>

- **Chamon CC, Fichberg I.** *Rineloricaria quilombola*: a new species of whiptail catfish (Siluriformes, Loricariidae, Loricariinae) from upper and middle Tocantins River basin, Brazil. *Zootaxa*. 2022; 5194(1):58–70. <https://doi.org/10.11646/zootaxa.5194.1.3>
- **Chamon CC, Serra JP, Camelier P, Zanata AM, Fichberg I, Marinho MMF.** Building knowledge to save species: 20 years of ichthyological studies in the Tocantins-Araguaia River basin. *Biota Neotrop*. 2022; 22(2):e20211296. <https://doi.org/10.1590/1676-0611-BN-2021-1296>
- **Daga VS, Azevedo-Santos VM, Pelicice FM, Fearnside PM, Perbiche-Neves G, Paschoal LRP et al.** Water diversion in Brazil threatens biodiversity. *Ambio*. 2020; 49(1):165–72. <https://doi.org/10.1007/s13280-019-01189-8>
- **Dagosta FCP, de Pinna M.** Biogeography of Amazonian fishes: deconstructing river basins as biogeographic units. *Neotrop Ichthyol*. 2017; 15(3):e170034. <https://doi.org/10.1590/1982-0224-20170034>
- **Dagosta FCP, de Pinna M.** The fishes of the Amazon: distribution and biogeographical patterns, with a comprehensive list of species. *Bull Am Museum Nat Hist*. 2019; 2019(431):1–163. <https://doi.org/10.1206/0003-0090.431.1.1>
- **Dean EM, Cooper AR, Wang L, Daniel W, David S, Ernzen C et al.** The North American Freshwater Migratory Fish Database (NAFMFD): Characterizing the migratory life histories of freshwater fishes of Canada, the United States and Mexico. *J Biogeogr*. 2022; 49(6):1193–203. <https://doi.org/10.1111/jbi.14367>
- **Deinet S, Scott-Gatty K, Rotton H, Twardek WM, Marconi V, McRae L et al.** The Living Planet Index (LPI) for migratory fish - technical report. The Netherlands: 2020.
- **Deprá GC, Ota RR, Vitorino Júnior OB, Ferreira KM.** Two new species of *Knodus* (Characidae: Stevardiinae) from the upper rio tocantins basin, with evidence of ontogenetic meristic changes. *Neotrop Ichthyol*. 2021; 19(1):e200106. <https://doi.org/10.1590/1982-0224-2020-0106>
- **Doria CR, Duponchelle F, Lima MAL, Garcia A, Carvajal-Vallejos FM, Méndez CC et al.** Review of fisheries resource use and status in the Madeira River basin (Brazil, Bolivia, and Peru) before hydroelectric dam completion. *Rev Fish Sci Aquac*. 2018; 26(4):494–514. <https://doi.org/10.1080/23308249.2018.1463511>
- **Duponchelle F, Isaac VJ, Doria C, Van Damme PA, Herrera-R GA, Anderson EP et al.** Conservation of migratory fishes in the Amazon basin. *Aquat Conserv Mar Freshw Ecosyst*. 2021; 31(5):1087–105. <https://doi.org/10.1002/aqc.3550>
- **Ferreira E, Zuanon J, dos Santos G, Amadio S.** A ictiofauna do Parque Estadual do Cantão, Estado do Tocantins, Brasil. *Biota Neotrop*. 2011; 11(2):277–84. <https://doi.org/10.1590/S1676-06032011000200028>
- **Ferreira ME, Nogueira SHM, Latrubesse EM, Macedo MN, Callisto M, Bezerra Neto JF et al.** Dams pose a critical threat to rivers in Brazil's Cerrado Hotspot. *Water*. 2022; 14(22):3762. <https://doi.org/10.3390/w14223762>
- **Fricke R, Eschmeyer WN, Fong JD.** Eschmeyer's catalog of fishes: genera/species by Family/Subfamily. [Internet]. San Francisco: California Academy of Science; 2024. Available from: <http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp>
- **Froese R, Pauly D.** FishBase. World Wide Web electronic publication. 2022. Available from: <http://www.fishbase.org>
- **Godinho AL, Kynard B.** Migratory fishes of Brazil: life history and passage needs. *River Res Appl*. 2009; 25(6):702–12. <https://doi.org/10.1002/rra.1180>
- **Herrera-R GA, Heilpern SA, Couto TBA, Victoria-Lacy L, Duponchelle F, Correa SB et al.** A synthesis of the diversity of freshwater fish migrations in the Amazon basin. *Fish Fish*. 2024; 25(1):114–33. <https://doi.org/10.1111/faf.12795>
- **Hervé M, Hervé MM.** Package 'RVAideMemoire.' 2020. Available from: <https://cran.r-project.org/web/packages/RVAideMemoire/index.html>
- **Hoeinghaus DJ, Layman CA, Arrington DA, Winemiller KO.** Movement of *Cichla* species (Cichlidae) in a Venezuelan floodplain river. *Neotrop Ichthyol*. 2003; 1(2):121–26. <https://doi.org/10.1590/S1679-62252003000200006>

- **Huang Z, Li H.** Dams trigger exponential population declines of migratory fish. *Sci Adv.* 2024; 10(19):eadi6580. <https://doi.org/10.1126/sciadv.adi6580>
- **Hubert N, Renno J-F.** Historical biogeography of South American freshwater fishes. *J Biogeogr.* 2006; 33(8):1414–36. <https://doi.org/10.1111/j.1365-2699.2006.01518.x>
- **Jézéquel C, Tedesco PA, Bigorne R, Maldonado-Ocampo JA, Ortega H, Hidalgo M et al.** A database of freshwater fish species of the Amazon Basin. *Sci Data.* 2020; 7(96):1–9. <https://doi.org/10.1038/s41597-020-0436-4>
- **Laliberté E, Legendre P, Shipley B.** FD: measuring functional diversity from multiple traits, and other tools for functional ecology. R package version 1., 0–12; 2014.
- **Latrubesse EM, Arima E, Ferreira ME, Nogueira SH, Wittmann F, Dias MS et al.** Fostering water resource governance and conservation in the Brazilian Cerrado biome. *Conserv Sci Pract.* 2019; 1(9):e77. <https://doi.org/10.1111/csp2.77>
- **Latrubesse EM, Stevaux JC.** Geomorphology and environmental aspects of the Araguaia fluvial basin, Brazil. *Zeitschrift Fur Geomorphol Suppl.* 2002; 129:109–27.
- **Lee D, Eschenroeder JC, Baumgartner LJ, Chan B, Chandra S, Chea S et al.** World heritage, hydropower, and earth's largest freshwater fish. *Water.* 2023; 15(10):1936. <https://doi.org/10.3390/w15101936>
- **Lima LB, Oliveira FJM, Borges FV, Corrêa F, Lima-Junior DP.** Streams fish from Upper Araguaia and Middle Rio da Mortes basin, Brazil: generating subsidies for preservation and conservation of this critical natural resource. *Biota Neotrop.* 2021; 21(4):e20211205. <https://doi.org/10.1590/1676-0611-bn-2021-1205>
- **Lima LB, Oliveira FJM, Giacomini HC, Lima-Junior DP.** Expansion of aquaculture parks and the increasing risk of non-native species invasions in Brazil. *Rev Aquac.* 2018; 10(1):111–22. <https://doi.org/10.1111/raq.12150>
- **Lima-Junior DP, Lima LB, Carnicer C, Zanella R, Prestes OM, Floriano L, Marco Jr. P.** Exploring the relationship between land-use and pesticides in freshwater ecosystem: A case study of the Araguaia River Basin, Brazil. *Environ Adv.* 2024; 15:100497. <https://doi.org/10.1016/j.envadv.2024.100497>
- **Lopes JM, Pompeu PS, Alves CBM, Peressin A, Prado IG, Suzuki FM et al.** The critical importance of an undammed river segment to the reproductive cycle of a migratory Neotropical fish. *Ecol Freshw Fish.* 2019; 28(2):302–16. <https://doi.org/10.1111/eff.12454>
- **Lucas MC, Baras E.** Migration of freshwater fishes. London: John Wiley & Sons Ltd.; 2001. <http://doi.org/10.1002/9780470999653>
- **Lucinda PHF, Freitas IS, Soares AB, Marques EE, Agostinho CS, Oliveira RJ.** Fish, Lajeado Reservoir, rio Tocantins drainage, State of Tocantins, Brazil. *Check List.* 2007; 3(2):70–83. <https://doi.org/10.15560/3.2.70>
- **Makrakis MC, Miranda LE, Makrakis S, Fontes Júnior HM, Morlis WG, Dias JHP et al.** Diversity in migratory patterns among Neotropical fishes in a highly regulated river basin. *J Fish Biol.* 2012; 81(2):866–81. <https://doi.org/10.1111/j.1095-8649.2012.03346.x>
- **Medeiros ER, Neuberger AL, Agostinho CS.** Variações sazonais na atividade reprodutiva de peixes na área de influência do reservatório de Peixe Angical. In: Agostinho CS, Pelicice FM, Marques EE, editors. Reservatório de Peixe Angical: bases ecológicas para o manejo da ictiofauna. São Carlos: RiMa; 2008. p.69–76.
- **Mérona B, Juras AA, Santos GM, Cintra IHA.** Os peixes e a pesca no baixo Tocantins. vol. 1. Brasília DF: Ministério de Minas e Energia, Eletrobrás, Eletronorte; 2010.
- **Miranda-Chumacero G, Álvarez G, Luna V, Wallace RB, Painter L.** First observations on annual massive upstream migration of juvenile catfish *Trichomycterus* in an Amazonian River. *Environ Biol Fishes.* 2015; 98(8):1913–26. <https://doi.org/10.1007/s10641-015-0407-3>
- **Montaña CG, Layman CA, Winemiller KO.** Gape size influences seasonal patterns of piscivore diets in three Neotropical rivers. *Neotrop Ichthyol.* 2011; 9(3):647–55. <https://doi.org/10.1590/S1679-62252011005000028>
- **Neuberger AL, Marques EE, Agostinho CS, Pelicice FM.** Variações espaciais na atividade reprodutiva de peixes na área de influência do reservatório de Peixe Angical. In: Agostinho CS, Pelicice FM, Marques EE, editors. Reservatório de Peixe Angical: bases ecológicas para o manejo da ictiofauna. São Carlos: RiMa; 2008. p.59–68.

- **Ohms HA, Chargualaf DN, Brooks G, Hamilton C, Palkovacs EP, Boughton DA.** Poor downstream passage at a dam creates an ecological trap for migratory fish. *Can J Fish Aquat Sci.* 2022; 79(12):2204–15. <https://doi.org/10.1139/cjfas-2022-0095>
- **Olden JD, Vitule JRS, Cucherousset J, Kennard MJ.** There's more to fish than just food: exploring the diverse ways that fish contribute to human society. *Fisheries.* 2020; 45(9):453–64. <https://doi.org/10.1002/fsh.10443>
- **Orsi CH, Message HJ, Debona T, Baumgartner D, Baumgartner G.** Hydrological seasonality dictates fish fauna of the lower Araguaia River, Tocantins-Araguaia basin. *Environ Biol Fishes.* 2018; 101(6):881–97. <https://doi.org/10.1007/s10641-018-0744-0>
- **Pachla LA, Hartmann PB, Massaro MV, Pelicice FM, Reynalte-Tataje DA.** Recruitment of migratory fish in free-flowing rivers with limited floodplain development. *Aquat Conserv Mar Freshw Ecosyst.* 2022; 32(12):1888–900. <https://doi.org/10.1002/aqc.3860>
- **Pelicice FM, Agostinho AA, Akama A, Andrade Filho JD, Azevedo-Santos VM, Barbosa MVM et al.** Large-scale degradation of the Tocantins-Araguaia River Basin. *Environ Manage.* 2021; 68:445–52. <https://doi.org/10.1007/s00267-021-01513-7>
- **Pelicice FM, Agostinho AA, Azevedo-Santos VM, Bessa E, Casatti L, Garrone-Neto D et al.** Ecosystem services generated by Neotropical freshwater fishes. *Hydrobiologia.* 2023; 850:2903–26. <https://doi.org/10.1007/s10750-022-04986-7>
- **Pelicice FM, Agostinho CS.** Deficient downstream passage through fish ladders: the case of Peixe Angical dam, Tocantins river, Brazil. *Neotrop Ichthyol.* 2012; 10(4):705–13. <https://doi.org/10.1590/S1679-62252012000400003>
- **Pelicice FM, Azevedo-Santos VM, Vitule JRS, Orsi ML, Lima-Junior DP, Magalhães ALB et al.** Neotropical freshwater fishes imperilled by unsustainable policies. *Fish Fish.* 2017; 18(6):1119–33. <https://doi.org/10.1111/faf.12228>
- **Pereira HR, Gomes LF, Soares PT, Martins PR, Pelicice FM, Teresa FB et al.** Long-term responses of fish diversity to river regulation: a multi-metric approach. *Environ Biol Fishes.* 2021; 104(1):71–84. <https://doi.org/10.1007/s10641-021-01056-0>
- **Perini VR, Paschoalini AL, Bazzoli N, Rizzo E, Carvalho DC.** Metapopulation dynamics of the migratory fish *Prochilodus lineatus* (Characiformes: Prochilodontidae) in a lotic remnant of the Grande River, Southeastern Brazil. *Neotrop Ichthyol.* 2021; 19(4):e20200046. <https://doi.org/10.1590/1982-0224-2020-0046>
- **Perônico PB, Agostinho CS, Fernandes R, Pelicice FM.** Community reassembly after river regulation: rapid loss of fish diversity and the emergence of a new state. *Hydrobiologia.* 2020; 847(2):519–33. <https://doi.org/10.1007/s10750-019-04117-9>
- **Petrere M, Agostinho AA, Okada EK, Júlio HF.** Review of the fisheries in the Brazilian portion of the Paraná/Pantanal Basin. In: Cowx IG, editor. *Management and ecology of lake and reservoir fisheries.* Osney Mead, Oxford: Fishing News Books, Blackwell Science; 2002. p.123–43.
- **Pinto MDS, Melo JRB, Freitas IS, Marques EE.** Distribuição longitudinal da abundância de ovos e larvas de peixes no reservatório da UHE Peixe Angical. In: Agostinho CS, Pelicice FM, Marques EE, editors. *Reservatório de Peixe Angical: bases ecológicas para o manejo da ictiofauna.* São Carlos: RiMa; 2008. p.113–19.
- **R Development Core Team.** R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2023. Available from: <https://www.r-project.org/>
- **Ribeiro MCLB, Petrere M, Juras AA.** Ecological integrity and fisheries ecology of the Araguaia—Tocantins River Basin, Brazil. *Regul Rivers Res Manag.* 1995; 11(3–4):325–50. <https://doi.org/10.1002/rrr.3450110308>
- **Sano EE, Rosa R, Scaramuzza CAM, Adami M, Bolfe EL, Coutinho AC et al.** Land use dynamics in the Brazilian Cerrado in the period from 2002 to 2013. *Pesq Agropec Bras.* 2019; 54:e00138. <https://doi.org/10.1590/S1678-3921.pab2019.v54.00138>
- **Santana MLC, Carvalho FR, Teresa FB.** Broad and fine-scale threats on threatened Brazilian freshwater fish: variability across hydrographic regions and taxonomic groups. *Biota Neotrop.* 2021; 21(2):e20200980. <https://doi.org/10.1590/1676-0611-bn-2020-0980>

- **Santos MAA, Pelicice FM.** Sentinels of environmental change: shifts in fish diversity through the lens of artisanal fishers. *Neotrop Ichthyol.* Forthcoming 2025.
- **Sato Y, Godinho HP.** Migratory fishes of the São Francisco River. In: Carosfeld J, Harvey B, Ross C, Baer A, editors. *Migratory fishes of the South America: biology, social importance and conservation status.* Victoria: World Fisheries Trust; 2003. p.195–232.
- **Scarabotti PA, Lucifora LO, Espínola LA, Rabuffetti AP, Liotta J, Mantinian JE et al.** Long-term trends of fishery landings and target fish populations in the lower La Plata basin. *Neotrop Ichthyol.* 2021; 19(3):e210013. <https://doi.org/10.1590/1982-0224-2021-0013>
- **Silva FO, Andrade Neto FR, Silva SH, Silva JO, Zaniboni Filho E, Prado IG et al.** Recruitment dynamics of a migratory fish in a semiarid river system. *Inl Waters.* 2020; 10(4):529–41. <https://doi.org/10.1080/20442041.2020.1805977>
- **Soares A, Andrade MC, Lucinda PHF.** A new species of *Myloplus* Gill 1896 (Teleostei: Serrasalminae) from the Rio Tocantins basin, Brazil. *Ichthyol Explor Freshw.* 2023; IEF-1191:1–10.
- **Soares ML, Massaro MV, Hartmann PB, Siveris SE, Pelicice FM, Reynalte-Tataje DA.** The main channel and river confluences as spawning sites for migratory fishes in the middle Uruguay River. *Neotrop Ichthyol.* 2022; 20(3):e20210094. <https://doi.org/10.1590/1982-0224-2021-0094>
- **Swanson AC, Bohlman S.** Cumulative impacts of land cover change and dams on the land–water interface of the Tocantins River. *Front Environ Sci.* 2021; 9:662904. <https://doi.org/10.3389/fenvs.2021.662904>
- **Teixeira AL, Vieira LCG, Souza CA, Bernardi JVE, Monteiro LC.** Evidence of water surface and flow reduction in the main hydrographic basin of the Brazilian savannah (Cerrado Biome): the Araguaia River. *Hydrobiologia.* 2024; 851:2503–18. <https://doi.org/10.1007/s10750-024-05471-z>
- **Teresa FB, Casatti L, Cianciaruso MV.** Functional differentiation between fish assemblages from forested and deforested streams. *Neotrop Ichthyol.* 2015; 13(2):361–70. <https://doi.org/10.1590/1982-0224-20130229>
- **Toussaint A, Charpin N, Brosse S, Villéger S.** Global functional diversity of freshwater fish is concentrated in the Neotropics while functional vulnerability is widespread. *Sci Rep.* 2016; 6:22125. <https://doi.org/10.1038/srep22125>.
- **Trigueiro WR, Nabout JC, Tessarolo G.** Uncovering the spatial variability of recent deforestation drivers in the Brazilian Cerrado. *J Environ Manage.* 2020; 275:111243. <https://doi.org/10.1016/j.jenvman.2020.111243>
- **Van Damme PA, Carvajal-Vallejos FM, Camacho J, Munoz H, Coronel J.** Peces migratorios de la Amazonía boliviana. In: Van Damme PA, Carvajal-Vallejos FM, Molina Carpio J, editors. *Los peces y delfines de la Amazonía boliviana: hábitats, potencialidades y amenazas.* Cochabamba, Bolívia: Edit. INI; 2011. p.149–200.
- **Vidotto-Magnoni AP, Kurchevski G, Lima FP, Nobile AB, Garcia DAZ, Casimiro ACR et al.** Population biology of *Astyanax lacustris* (Pisces, characiformes) in a neotropical reservoir and its tributaries. *An Acad Bras Ciênc.* 2021; 93(2):1–14. <https://doi.org/10.1590/0001-3765202120190565>
- **Villéger S, Mason NWH, Mouillot D.** New multidimensional functional diversity indices for a multifaceted framework in functional ecology. *Ecology.* 2008; 89(8):2290–301. <https://doi.org/10.1890/07-1206.1>
- **Vitorino Jr. OB, Fernandes R, Agostinho CS, Pelicice FM.** Riverine networks constrain β -diversity patterns among fish assemblages in a large Neotropical river. *Freshw Biol.* 2016; 61(10):1733–45. <https://doi.org/10.1111/fwb.12813>
- **Vitule JRS, Agostinho AA, Azevedo-Santos VM, Daga VS, Darwall WRT, Fitzgerald DB et al.** We need better understanding about functional diversity and vulnerability of tropical freshwater fishes. *Biodivers Conserv.* 2017; 26(3):757–62. <https://doi.org/10.1007/s10531-016-1258-8>
- **Wickham H.** Ggplot2. *Wiley Interdiscip Rev Comput Stat.* 2011; 3(2):180–85. <https://doi.org/10.1002/wics.147>
- **Winemiller KO.** Patterns of variation in life history among South American fishes in seasonal environments. *Oecologia.* 1989; 81(2):225–41. <https://doi.org/10.1007/BF00379810>

- **Winemiller KO, Fitzgerald DB, Bower LM, Pianka ER.** Functional traits, convergent evolution, and periodic tables of niches. *Ecol Lett.* 2015; 18(8):737–51. <https://doi.org/10.1111/ele.12462>
- **Winemiller KO, Nam S, Baird IG, Darwall W, Lujan NK, Harrison I *et al.*** Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. *Science.* 2016; 351(6269):128–29. <https://doi.org/10.1126/science.aac7082>
- **Zaniboni-Filho E, Schulz U.** Migratory fishes of the Uruguay River. In: Carosfeld J, Harvey B, Ross C, Baer A, editors. *Migratory fishes of the South America: Biology, social importance and conservation status.* Victoria: World Fisheries Trust; 2003. p.157–94.

AUTHORS' CONTRIBUTION

Thiago Nascimento da Silva Campos: Data curation, Formal analysis, Investigation, Methodology, Software, Writing–original draft, Writing–review and editing.

Hasley Rodrigo Pereira: Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing–review and editing.

Phâmela Bernardes Perônico: Investigation, Methodology, Supervision, Validation, Writing–review and editing.

Carine Cavalcante Chamon: Validation, Visualization, Writing–review and editing.

Philip Teles Soares: Formal analysis, Investigation, Methodology, Software, Writing–review and editing.

Fernando Mayer Pelicice: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing.

ETHICAL STATEMENT

Not applicable.

COMPETING INTERESTS

The authors declare no competing interests.

HOW TO CITE THIS ARTICLE

- **Campos TNS, Pereira HR, Perônico PB, Chamon CC, Soares PT, Pelicice FM.** Diversity of potamodromous fishes in the Tocantins-Araguaia basin. *Neotrop Ichthyol.* 2025; 23(1):e240098. <https://doi.org/10.1590/1982-0224-2024-0098>

Neotropical Ichthyology

OPEN ACCESS



This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

Distributed under
Creative Commons **CC-BY 4.0**

© 2025 The Authors.
Diversity and Distributions Published by SBI



Official Journal of the
Sociedade Brasileira de Ictiologia