Area of occurrence extension of *Astyanax courensis* Bertaco, Carvalho & Jerep, 2010, and *Psalidodon goyanensis* (Miranda-Ribeiro, 1944) (Characiformes: Acestrorhamphidae) with new records from tributaries in the States of Goiás and the Federal District, Brazil

Ampliação da área de ocorrência de *Astyanax courensis* Bertaco, Carvalho & Jerep, 2010, e *Psalidodon goyanensis* (Miranda-Ribeiro, 1944) (Characiformes: Acestrorhamphidae), com novos registros provenientes de tributários nos estados de Goiás e do Distrito Federal, Brasil

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Abstract: In this study, we report new records of two freshwater fish species: *Astyanax courensis* and *Psalidodon goyanensis*. Both species are considered endemic to the Upper Tocantins river basin, with their known distribution originally restricted to the Chapada dos Veadeiros region in the State of Goiás, Brazil. The results of this study expand the known range of these species by documenting their presence in sub-basins located in both the Federal District and the State of Goiás, within the limits of the Upper Tocantins basin.

Keywords: *Cerrado*. Chapada dos Veadeiros. Endemism. Freshwater fishes. Upper Tocantins River.

Resumo: Neste estudo, relatamos novos registros de duas espécies de peixes de água doce: *Astyanax courensis* e *Psalidodon goyanensis*. Ambas são consideradas endêmicas da bacia do alto rio Tocantins, com ocorrência originalmente restrita à região da Chapada dos Veadeiros, no estado de Goiás, Brasil. Os resultados obtidos neste trabalho ampliam o conhecimento sobre a área de ocorrência dessas espécies, revelando sua presença em sub-bacias localizadas no Distrito Federal e em Goiás, ainda dentro dos limites da bacia do alto Tocantins.

Palavras-chave: Cerrado. Chapada dos Veadeiros. Endemismo. Peixes de água doce. Alto rio Tocantins.

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INTRODUCTION

The *Cerrado* is a Brazilian biome that holds significant importance as a water resource, often referred to as the "cradle of waters" (Oliveira et al., 2020). The elevated regions of this biome play a crucial role in bearing the headwaters of several river systems (Codeplan, 2020). Within the Federal District, the headwaters of three major South American basins originate: Tocantins (of the Tocantins-Araguaia rivers basin, part of the Amazon drainage), Upper Paraná, and São Francisco rivers. From those, 13% of the Federal District's territory is permeated by the Tocantins basin (Sawyer et al., 2017; Codeplan, 2020). Recent studies highlight the remarkable fish diversity in the Tocantins-Araguaia basin, which harbors around 750 valid fish species (Chamon et al., 2022; Araújo et al., 2025). However, along stretches of the Upper Tocantins basin, there is a noticeable expansion of land use, including agricultural activities and human occupation, resulting in significant loss of *Cerrado* landscapes (Araújo et al., 2025). These environmental changes negatively affect water bodies and detrimentally impact fish populations (McFadden et al., 2022).

Among the Tocantins-Araguaia basin, Characiformes represent the most diverse fish order, comprising 40.3% of the known fish diversity (Chamon et al., 2022). Recently, the formerly recognized Characidae (previously the most diverse characiform family) was divided into four families: Spintherobolidae, Stevardiidae, Characidae (redefined), and Acestrorhamphidae (Melo et al., 2024). Among those, Acestrorhamphidae, with 15 subfamilies, is now the most diverse family, including part of what is currently recognized as *Astyanax* (Baird et al., 1854; Melo et al., 2024).

The genus *Astyanax* was originally described to include small freshwater characids from Central and South America and eventually became an extremely broad genus (Baird et al., 1854; Ornelas-García et al., 2008), reaching a total of 272 species, with currently 125 valid species being recognized (Fricke et al., 2025). Through time, the absence of exclusive characters to delimit *Astyanax* led to the formation of artificial groupings within the genus, thereby bringing together unrelated lineages that shared some external resemblance (e.g., Lima et al., 2003; Mirande, 2010; Terán et al., 2020). In this context, some genera were synonymized under *Astyanax*, such as *Psalidodon* Eigenmann (1907), since the characters originally used to distinguish *Psalidodon* were later interpreted as variations of *Astyanax*, insufficient to delimit clades (Lima et al., 2003). Consequently, *Psalidodon* species came to be included within *Astyanax* (Lima et al., 2003; Mirande, 2010). However, more recently, based on morphological and molecular evidence, Terán et al. (2020) resurrected the genus *Psalidodon*, reallocating to it several species previously assigned to *Astyanax*. This taxonomic revision was later corroborated by the phylogenomic analyses conducted by Melo et al. (2024).

The delimitation proposed by Eigenmann (1917, 1921) for *Astyanax* was, for a long time, widely accepted, and used to assign species to this genus. This definition was based on the presence of two series of teeth on the premaxilla, with the second series generally composed of five teeth; denticulated crowns on the premaxillary and dentary teeth; maxilla bearing 0 to 9 teeth; a complete lateral line; the absence of a predorsal spine; and the absence of scales on the caudal fin (Eigenmann, 1921, 1971). However, most of these characters are broadly distributed among various tetra fish and piaba, and are not exclusive to *Astyanax*, highlighting the need for a redefinition of the genus through phylogenetic studies (Mirande, 2010; Terán et al., 2020).

The redefinition of the genus *Psalidodon* proposed by Terán et al. (2020) was based on an exclusive combination of derived morphological characters that distinguish it from other genera. The genus is diagnosed by the lateroventral orientation of the anterior laterosensory pore to the dilatator fossa; absence of a dorsal projection of the rhinosphenoid between the olfactory nerves; absence of circuli on the posterior portion of the scales; presence of an anterior branch in the maxillary tubules; presence of 0–3 maxillary teeth (generally one); origin of

the anal fin located posterior to the vertical line passing through the last dorsal-fin ray; and absence of scales on the caudal fin (Terán et al., 2020). This exclusive combination of characters, altogether with molecular evidence, support *Psalidodon* and confirm its distinction from the genus *Astyanax*, which was later corroborated by phylogenomic analyses (Melo et al., 2024).

In this study, we address the extension of occurrence of two species of Acestrorhamphidae currently assigned to the genera *Astyanax* and *Psalidodon*. *Astyanax courensis* (Bertaco et al., 2010) is currently considered endemic to the Upper Tocantins river basin. Its occurrence was originally recorded in tributaries of the Rio dos Couros, particularly in the Chapada dos Veadeiros region, Goiás State. The type-locality designated for *Astyanax courensis* corresponds to the Rio dos Couros, located in the Parque Portal da Chapada, a tributary of the Tocantinzinho river, which belongs to the Tocantins river basin (Bertaco et al., 2010). This species is distinguished from other congeners by presenting an exclusive combination of characters, being two humeral spots, a caudal peduncle spot; 35–36 lateral-line scales; three tricuspid to pentacuspid teeth in the outer premaxillary series and five pentacuspid teeth in the inner series; eight branched dorsal-fin rays; 11–13 branched anal-fin rays; and seven pelvic-fin rays (Bertaco et al., 2010).

Psalidodon goyanensis (Miranda-Ribeiro, 1944), originally described as *Astyanax goyanensis*, was transferred to *Psalidodon* by Terán et al. (2020) based on morphological and molecular data. Its occurrence was originally recorded in the Rio dos Couros, in the Chapada dos Veadeiros region, as well as in the Tocantinzinho and Paranã rivers (Bertaco et al., 2010). *Psalidodon goyanensis* is distinguished from other congeners by the exclusive combination of characters: presence of a single rounded humeral spot located just posterior to the opercle; horizontally elongated caudal peduncle spot, reaching the tip of the middle caudal-fin rays; complete lateral line, with 35–37 perforated scales; dorsal fin with two unbranched and eight branched rays; anal fin with three unbranched and 13–15 branched rays; and pelvic fins with one unbranched and 7 branched rays (Bertaco et al., 2010). To differentiate *P. goyanensis* from *A. courensis*, two similar species occurring in the same streams, the most notable characters are the number of pelvic-fin rays (seven in *P. goyanensis* and eight in *A. courensis*), as well as differences in the number of lateral-line scales and the pattern of humeral spots (two humeral spots in *A. courensis*, and one in *P. goyanensis*) (Bertaco et al., 2010).

Understanding the geographic distribution of these species is essential for elucidating their patterns of diversity (Albert & Reis, 2011). Although studies have been conducted on tributaries of the Paraná basin in the Federal District (e.g., Aquino et al., 2009), research on the ichthyofauna of tributaries of the Tocantins river basin remains scarce, possibly because this basin occupies a smaller portion of the region. However, recent collections, carried out mainly between 2021 and 2023, captured specimens of *A. courensis* and *P. goyanensis* outside their previously known distribution ranges. In this context, the present study expands the area of occurrence of *A. courensis* and *P. goyanensis* in the Upper Tocantins river basin.

MATERIAL AND METHODS

The data analyzed were obtained from specimens harbored in the Ichthyological Collection of the University of Brasília (CIUnB), collected between 2006 and 2023. At CIUnB, 12 lots comprising 269 specimens of *A. courensis* and 8 lots with 148 specimens of *P. goyanensis* were analyzed. Specimens of *A. courensis* and *P. goyanensis* were recorded in several localities of the Upper Tocantins River basin (Table 1). Both species were identified according to their original descriptions (Bertaco et al., 2010; Miranda-Ribeiro, 1944) and subsequent updates (Terán et al., 2020; Melo et al., 2024). The morphometric data used for the proper delimitation of the species were organized and are presented in the Table 2, following the procedures proposed by Bertaco et al. (2010).

Table 1. Localities of lots of *A. courensis* and *P. goyanensis* deposited at CIUnB.

Region	Catalog number	Watercourse	Geographic coordinate
Astyanax courensis			
Distrito Federal, Brasília	CIUnB 533	Dois Irmãos Stream	15.55050° S, 48.10580° W
Distrito Federal, Brasília	CIUnB 513	Palma River	15.51487° S, 48.06089° W
Distrito Federal, Fercal	CIUnB 541	Buraco Stream	15.59683° S, 47.90883° W
Distrito Federal, Fercal	CIUnB 139	Maranhão River	15.59430° S, 47.91675° W
Distrito Federal, Fercal	CIUnB 868	Taquari Stream	15.57313° S, 47.93952° W
Distrito Federal, Fercal	CIUnB 555	Cafuringa Stream	15.54164° S, 47.96622° W
Distrito Federal, Planaltina	CIUnB 837	Vereda Grande Stream	15.54216° S, 47.57801° W
Distrito Federal, Planaltina	CIUnB 2267	Brejo Stream	15.54018° S, 47.68743° W
Distrito Federal, Planaltina	CIUnB 2312	Maranhão River	15.51613° S, 47.69635° W
Distrito Federal, Brazlândia	CIUnB 1941	Poço Azul	15.55800° S, 48.04400° W
Distrito Federal, Sobradinho	CIUnB 1450	Salinas Morro da Pedreira Stream	15.51441° S, 47.95142° W
Goiás, Planaltina	CIUnB 1051	Contendas Stream	15.46805° S, 47.64161° W
Psalidodon goyanensis			
Distrito Federal, Brasília	CIUnB 128	Buraco Stream	15.59885° S, 47.89685° W
Distrito Federal, Planaltina	CIUnB 840	Vereda Grande Stream	15.52037° S, 47.56781° W
Distrito Federal, Sobradinho	CIUnB 1768	Ouro Stream	15.51200° S, 47.93000° W
Goiás, Cavalcante	CIUnB 1375	Conceição River	13.63500° S, 47.83826° W
Goiás, Cavalcante	CIUnB 1355	Mirante Stream	13.63241° S, 47.81905° W
Goiás, Cavalcante	CIUnB 1362	Santa Rita Stream	13.61496° S, 47.84793° W
Goiás, Cavalcante	CIUnB 1358	Santa Rita River	13.60140° S, 47.84300° W
Goiás, Cavalcante	CIUnB 1503	São Félix River	13.56268° S, 47.71522° W

Table 2. Morphometric data of analyzed specimens of *Astyanax courensis* and *Psalidodon goyanensis*. Legends: Min = minimum; Max = maximum; SD = standard deviation; *n* = number of analyzed specimens; SL = standard length.

	Astyanax courensis				*Psalidodon goyanensis*			
	Min	Max	SD	*n*	Min	Max	SD	n
Standard length (mm)	12.22	79.96	0	83	19.4	60.93		51
	As percentage of SL							
Predorsal distance	49.2	59.7	2.1	81	45.5	59.5	2.7	51
Prepelvic distance	32.1	57.6	3.4	81	42.4	55.6	2.4	51
Prepectoral distance	17.9	34.1	2.4	81	24.3	33.4	2.0	51
Preanal distance	60.5	72.0	2.1	81	61.7	77.5	2.9	51
Depth at dorsal-fin origin	22.5	43.6	4.0	81	26.6	36.6	2.3	51
Caudal-peduncle depth	7.7	25.3	1.9	81	9.5	20.9	2.6	51
Caudal-peduncle length	12.6	25.2	1.8	81	9.7	19.7	2.4	51
Anal-fin base	15.4	24.4	1.9	81	16.3	22.6	1.4	51
Dorsal-fin length	19.3	31.3	2.1	81	19.2	25.8	1.4	51
Pelvic-fin length	11.4	27.3	2.2	81	11.6	16.8	1.2	51
Pectoral-fin length	16.5	26.6	1.8	81	13.4	23.6	2.4	51
Head length	20.7	33.0	2.1	81	17.4	33.0	2.4	51

The QGIS software (QGIS Development Team, 2025) was used to prepare distribution maps (Figure 1), illustrating the new records of *Astyanax courensis* and *Psalidodon goyanensis*. These specimens originate from several locations, including Brasília National Park (PARNA Brasília), the Águas Emendadas Ecological Station (ESECAE), both in the Federal District, and Serra do Tombador, in the municipality of Cavalcante (State of Goiás). Notably, both Brasília National Park (PARNA) and the Águas Emendadas Ecological Station (ESECAE) are officially designated conservation units. The PARNA, located only 10 km from downtown Brasília, is drained by streams belonging to both the Upper Paraná and Upper Tocantins basins. The ESECAE, in turn, contains the headwaters of the Maranhão River, an important tributary of the Upper Tocantins basin. Finally, the Serra do Tombador is a Private Natural Heritage Reserve located approximately 330 km from Brasília and is drained by streams of the Upper Tocantins basin.

RESULTS

New occurrence records were obtained for *Astyanax courensis* and *Psalidodon goyanensis*, all within the Upper Tocantins basin (Figure 1). For *A. courensis*, the new records include Brasília National Park; in the Federal District, the administrative regions of Fercal, Planaltina, Brazlândia, and Sobradinho; and, in the State of Goiás, the municipality of Planaltina. For *P. goyanensis*, the new records include Brasília National Park; in the Federal District, the administrative regions of Planaltina and Sobradinho; and, in the State of Goiás, the municipality of Cavalcante (Table 1).

To distinguish the species, we used the diagnosis of *Astyanax courensis* (Figure 2), which differs from *Psalidodon goyanensis* by having a more elongated and less deep body (body depth 28-34% of standard length); vertically elongated humeral blotch extending across 3-4 scale rows; rounded and diffuse caudal blotch that slightly overlaps the median caudal-fin rays; 35-36 lateral-line scales; 6-7 scale

rows dorsal to and 5-6 ventral to the lateral line, and 20-23 anal-fin rays (Bertaco et al., 2010).

On the other hand, *Psalidodon goyanensis* (Figure 3) has a deeper, more laterally compressed body (body depth 36-42% SL); complete lateral line; oval and well-defined humeral blotch, that does not extend beyond the fourth scale row; conspicuous and sharply defined caudal blotch, that clearly extends over the median caudal-fin rays; 35-37 lateral-line scales; 6-7 scale rows dorsal to and 5-6 ventral the lateral line; and 24-28 anal-fin rays (Bertaco et al., 2010; Terán et al., 2020). Additionally, *P. goyanensis* differs by having 2-3 pentacuspid teeth on the inner premaxillary row and

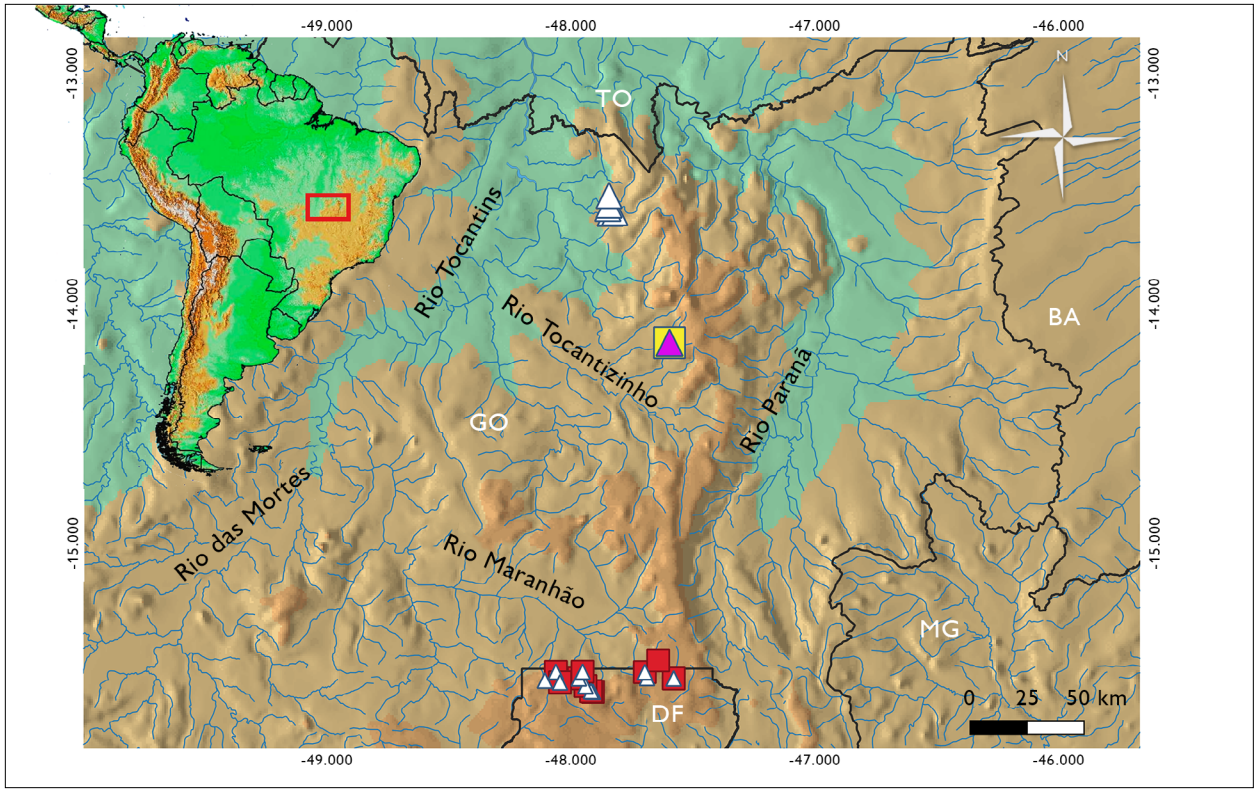

Figure 1. Map of new records of *Astyanax courensis* and *Psalidodon goyanensis* in tributaries of the Federal District and the State of Goiás. Sources: purple triangle = holotype of *Psalidodon goyanensis*; white triangle = new records of *P. goyanensis*; yellow square = holotype of *Astyanax courensis*; red square = new records of *A. courensis*. Map: Firmino (2025).

Figure 2. Left lateral view of *Astyanax courensis*, CIUnB 533, 20.3 mm SL. Image: Firmino (2025).

Figure 3. Left ateral view of *Psalidodon goyanensis*, CIUnB 1358, 21.5 mm SL. Image: Firmino (2025).

4-5 tricuspid teeth on the anterior dentary (Bertaco et al., 2010), whereas *A. courensis* has predominantly tricuspid teeth in both tooth rows (Bertaco et al., 2010).

The type locality of *Astyanax courensis* is the Rio dos Couros basin, Tocantinzinho River, Alto Paraíso de Goiás, Chapada dos Veadeiros, Goiás State (Bertaco et al., 2010). The new records are: Distrito Federal: Brasília National Park, Dois Irmãos Stream; 15,5505° S; 48,1058° W; 29/IX/2010; collector and identifier PPU Aquino; 3, sex indet., CIUnB 533; Brasília National Park, Palma River; 15,51487° S; 48,06089° W; 29/IX/2010; collector and identifier PPU Aquino; 3, sex indet., CIUnB 513; Fercal, Buraco Stream; 15,59683° S; 47,90883° W; 28/IX/2010; collector and identifier PPU Aquino; 5, sex indet., CIUnB 541; Fercal, Maranhão River, Pindaíba Stream; 15,594303° S; 47,91675° W; 28/I/2006; collector and identifier PPU Aquino; 17, sex indet., CIUnB 139; Fercal, Taquari Stream; 15,57313° S; 47,93952° W; 11/V/2011; collector and identifier PPU Aquino; 61, sex indet., CIUnB 868; Fercal, Cafuringa Stream; 15,54164° S; 47,96622° W; 28/IX/2010; collector and identifier PPU Aquino; 5, sex indet., CIUnB 555; Planaltina, Águas Emendadas Ecological Station, Vereda Grande Stream; 15,54216° S; 47,57801° W; 8/IV/2017; collector and identifier PPU Aquino; 80, sex indet., CIUnB 837; Planaltina, Brejo Stream; 15,540183° S; 47687433° W; 24/VII/2023; collector A. Firmino, R. Nayara; identifier R. Nayara; 39, sex indet., CIUnB 2267; Planaltina, Maranhão River, downstream dam; 15,516128° S, 47,696348° W; 23/VII/2023; collector A. Firmino, R. Nayara; identifier R. Nayara; 41, sex indet., CIUnB 2312; Brazlândia, Poço Azul; 15,558° S; 48,044° W; 4/VI/2023; collector A. Firmino, R. Nayara; identifier R. Nayara; 12, sex indet., CIUnB 1941; Sobradinho, Salinas Morro da Pedreira Stream; 15,514408° S; 47,951416° W; 9/VI/2015; collector and identifier PPU Aquino; 1, sex indet., CIUnB 1450. Goiás: Planaltina, Contendas Stream; 15,46805° S; 47,64161° W; 19/IX/2014; collector and identifier PPU Aquino; 2, sex indet., CIUnB 1051.

The type locality of *Psalidodon goyanensis* is the Rio dos Couros basin, Tocantinzinho River, Alto Paraíso de Goiás, Chapada dos Veadeiros, Goiás State (Bertaco et al., 2010). The new records are: Distrito Federal: Brasília National Park, Buraco Stream; 15,59885° S; 47,896853° W; 28/I/2006; collector and identifier PPU Aquino; 16, sex indet., CIUnB 128; Planaltina, Águas Emendadas Ecological Station, Vereda Grande Stream; 15,52037° S; 47,56781° W; 8/IV/2011; collector and identifier PPU Aquino; 74, sex indet., CIUnB 840; Sobradinho, Ouro Stream; 15,512° S; 47,930° W; 8/VI/2023; collector and identifier A. Firmino; 6, sex indet.; CIUnB 1768. Goiás: Cavalcante, Serra do Tombador, Conceição River; 13,63500° S; 47,83826° W; 19/XI/2016; collector and identifier PPU Aquino; 5, sex indet., CIUnB 1375; Cavalcante, Serra do Tombador, Mirante Stream; 13,63241° S; 47,81905° W; 18/XI/2016; collector and identifier PPU Aquino; 14, sex indet., CIUnB 1355; Cavalcante, Serra do Tombador, Santa Rita River; 13,61496° S; 47,84793° W; 18/XI/2016; collector and identifier PPU Aquino; 19, sex indet., CIUnB 1362; Cavalcante, Serra do Tombador, Santa Rita River; 13,60140° S; 47,84300° W; 18/XI/2016; collector and identifier PPU Aquino; 10, sex indet., CIUnB 1358; Cavalcante, São Félix River; 13,562679° S; 47,715224° W; 13/X/2019; collector and identifier PPU Aquino; 4, sex indet., CIUnB 1503.

DISCUSSION

Acestrorhamphidae is currently considered one of the most diverse families within the order Characiformes (Melo et al., 2024), and it presents numerous challenges for the taxonomic delimitation and systematics of its taxa. The species *Astyanax courensis* and *Psalidodon goyanensis* are emblematic examples of these taxonomic challenges (e.g., Bertaco et al., 2010; Terán et al., 2020). Both were originally assigned to the genus *Astyanax* and included in the *Astyanax scabripinnis* complex due to their general morphological similarity, such as body shape and the presence of a characteristic humeral blotch (Bertaco et al., 2010).

However, recent studies have indicated that *Astyanax*, as delimited based on the works of Eigenmann (1917, 1921), does not correspond to a natural group. As a result, other genera have been resurrected (such as *Psalidodon*, following Terán et al., 2020) or newly described

(such as *Makunaima* Terán et al., 2020) to accommodate the diversity previously assigned to *Astyanax*.

The taxonomic advances reinforce the importance of updated and properly documented records in scientific collections, such as those presented in this study. Consequently, these findings expand our understanding of the spatial distribution of the species reported herein, contributing to the reconstruction of the history of Neotropical biodiversity, particularly in the Tocantins-Araguaia basin. Much of the knowledge about Neotropical fishes comes from ichthyological collections (Bogotá-Gregory et al., 2020), which serve as essential tools for studying biodiversity through time.

The Upper Tocantins river basin deserves attention due to its ecological importance and the number of associated endemic species (Campos et al., 2025). Unfortunately, portions of the Upper Tocantins basin have been affected by the expansion of agricultural activities directed toward grain production, such as corn and soy (Barbosa et al., 2017). In addition, cattle ranching is practiced on properties with large territorial extensions (Klink & Machado, 2005; Barbosa et al., 2017). This alteration of the natural environment leads to the replacement of *Cerrado* vegetation by monocultures, which in turn directly impacts negatively the existing water bodies (Sano et al., 2007).

Although some of the new records of *A. courensis* and *P. goyanensis* are located within strict-protection conservation units, such as Brasília National Park and the Águas Emendadas Ecological Station, others are not protected by any legal conservation designation. Notably, ecotourism, as observed in Brasília National Park, exerts negative impacts on the local fauna and flora (Berto & Luquez, 2016). These impacts arise from factors such as intense vehicle traffic, significant waste generation, and the improper use of water resources (Berto & Luquez, 2016). It is important that the impacts on the species studied here continue to be monitored; however, the expansion of their known distribution, including in the aforementioned conservation units, supports their classification as Least Concern (Melo et al., 2024).

CONCLUSION

Overall, the distribution of *Astyanax courensis* and *Psalidodon goyanensis* shows their notable presence in the Upper Tocantins river basin. Studying and mapping their distribution is essential for several purposes, including understanding population variation, conducting biogeographic studies, expanding knowledge on evolutionary processes, and identifying the threats faced by these species (e.g., Lomolino et al., 2010; Primack, 2010).

Additionally, these data may contribute to phylogenetic studies that significantly assist in more accurately delimiting species complexes of the genus *Astyanax* in the headwaters of the Central *Cerrado* (Castro et al., 2014). Such studies are essential to clarify if other records correspond to already described species, or whether regional variations indicate the presence of new species that have not yet been formally described (Lima et al., 2003; Lomolino et al., 2010).

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AUTHORS' CONTRIBUTION

R. N. S. Oliveira contributed to project administration, formal analysis, conceptualization, data curation, investigation, methodology, validation, visualization, and writing (original draft, review, and editing); A. Firmino contributed to formal analysis, data curation, investigation, and methodology; and V. B. Slobodian contributed to funding acquisition, conceptualization, resources, supervision, validation, and writing (review and editing).