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New small-sized species of *Astyanax* (Characiformes: Characidae) from the upper rio Paraguai basin, Brazil, with discussion on its generic allocation

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A new species of *Astyanax* is described from the rio Salobra, tributary of rio Cuiabá, rio Paraguai basin. The new taxon can be distinguished from its congeners by having a well-defined dark midlateral stripe on body extending from the posterior margin of the opercle to the base of middle caudal-fin rays and a single vertical elongate humeral blotch. Although the new species is described in *Astyanax*, some specimens present an incomplete or a discontinuous series of perforated scales in the lateral line. Therefore, a discussion on its generic allocation is presented. Comments on different patterns of coloration among dark-striped species of *Astyanax* are also provided. The discovery of a new species in an underwater tourist point relatively near a large urban center underscores that even fish species daily observed by hundreds of people in limpid waters may lack a formal taxonomic identity. Such finding also highlights how the megadiverse Brazilian freshwater ichthyofauna still needs efforts and investments to identify and describe new taxa.

Keywords: Lateral line, Nobres, Longitudinal stripe, Taxonomy, Tourist destination.

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Uma nova espécie de *Astyanax* é descrita do rio Salobra, afluente do rio Cuiabá, bacia do rio Paraguai. O táxon novo pode ser diferenciado de seus congêneres por apresentar uma faixa médio-lateral escura bem definida no corpo, se estendendo da margem posterior do opérculo até a base dos raios medianos da nadadeira caudal e por possuir uma mancha umeral verticalmente alongada. Apesar da espécie nova ser descrita em *Astyanax*, alguns exemplares apresentam uma série incompleta ou descontínua de escamas perfuradas na linha lateral. Assim, uma discussão sobre sua alocação genérica é apresentada. Comentários sobre os diferentes padrões de coloração de espécies de *Astyanax* com faixa escura também são fornecidos. A descoberta de uma espécie nova em um ponto turístico subaquático relativamente próximo a um grande centro urbano ressalta que mesmo as espécies de peixes observadas diariamente por centenas de pessoas em águas límpidas podem não ter uma identidade taxonômica formal. Tal achado também evidencia o quanto a megadiversa ictiofauna de água doce brasileira ainda precisa de esforços de coleta adicionais e investimentos para identificar e descrever os táxons novos.

Palavras-chave: Linha lateral, Nobres, Faixa longitudinal, Taxonomia, Ponto turístico.

INTRODUCTION

Astyanax Baird & Girard, 1854, as defined by Eigenmann (1917, 1921), is one the most species-rich genera of characids, currently comprising 125 valid species, widely distributed on the Neotropical region from southern United States to central Argentina (Fricke *et al*., 2022). Unlike other highly diverse groups of characids (*e.g*., *Hemigrammus* Gill, 1858, *Hyphessobrycon* Durbin, 1908, and *Moenkhausia* Eigenmann, 1903) which have their greatest diversity occurring in the Amazon basin, only 20% of the *Astyanax* diversity occurs in that region (see Dagosta, de Pinna, 2019). In turn, most species are found in rio Paraná-Paraguai basin, Laguna dos Patos system, and Atlantic coastal rivers of southeastern Brazil. Also differing from other species-rich genera of Characidae, species of *Astyanax* typically have relatively low variety of body shapes and colors, unexpected patterns for a megadiverse and widely distributed group of Neotropical fishes.

A new species of Characidae was collected in a recent expedition to the headwaters of rio Paraguai after being recognized during underwater observations in the crystal clear waters of an ecotourism destination in the central Brazil. The generic allocation of the new species is problematic due to two factors: the variable morphology regarding trunk lateral-line canals that challenges the traditional classification of Eigenmann (1917, 1921); and the inconsistency of the current diagnosis of *Astyanax* and related genera provided by a recent phylogeny. Therefore, the generic assignment of the new species is discussed.

MATERIAL AND METHODS

Counts and measurements follow Fink, Weitzman (1974) and Menezes, Weitzman (1990), except for the number of horizontal scale rows below the lateral line counted to the pelvic-fin insertion, but not including the axillary scale, and with the addition of the pelvic-fin origin to anal-fin origin distance. Measurements were taken with a digital caliper to the nearest 0.1 mm. Standard length (SL) is expressed in millimeters (mm) and all other measurements are expressed as percentage of SL, except for subunits of head, which are expressed as percentage of head length (HL). In the description, counts are followed by their frequency of occurrence in parentheses. Asterisk indicates the counts of the holotype. Counts of supraneurals, tooth cusps, small dentary teeth, unbranched anal-fin rays, procurrent caudal-fin rays, and the position of the pterygiophores were taken from cleared and stained (c&s) specimens prepared according to Taylor, Van Dyke (1985). Vertebrae of the Weberian apparatus were counted as four elements and the compound caudal centra (PU1+U1) as a single element. Abdominal vertebrae include the Weberian apparatus and the vertebrae associated with ribs or hemal arches without hemal spine. Caudal vertebrae are vertebra associated with hemal spine. *Circuli* and *radii* counts were taken from scale row immediately above the lateral line. The sex of specimens was confirmed by dissection of four specimens (MZUSP 118302). Catalog numbers are followed by the number of specimens in alcohol, number of specimens measured and counted in parentheses, SL range of all specimens of the lot, and if any, the number of c&s specimens and their respective SL range. Institutional abbreviations follow Sabaj (2019).

RESULTS

Astyanax nobre, new species

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(Figs. 1–4; Tab. 1)

Astyanax sp. —Marinho *et al*., 2021: tab. 2 (listed as having intraspecific variation in the lateral line trunk morphology).

Holotype. MZUSP 125905, 25.6 mm SL, Brazil, Mato Groso State, Municipality of Nobres, rio Salobra at Recanto Ecológico Lagoa Azul, Bom Jardim district, tributary of rio Cuiabá, rio Paraguai basin, 14°35'43.2"S 55°58'09.6"W, F. C. P. Dagosta & W. M. Ohara, 18 Nov 2014.

Paratypes. All from Brazil, Mato Grosso State, Municipality of Nobres, Lagoa Azul, rio Paraguai basin: MZUSP 110406, 11, 23.8–30.0 mm SL, I. K. Ribeiro, 23 July 2011; MZUSP 118302, 154, 11.9–27.0 mm SL, 3 c&s; UFPB 12087, 10, 15.4–23.8 mm SL, same data as holotype.

Diagnosis. *Astyanax nobre* can be distinguished from its congeners, except *A. joaovitori* Oliveira, Pavanelli & Bertaco, 2017 and *A. scintillans* Myers, 1928, by the presence of a well-defined, dark midlateral stripe on body extending from opercle to middle caudal-fin rays (*vs.* longitudinal stripe absent; stripe starting posterior the anterior humeral and never connected to it; stripe starting immediately posterior to the humeral blotch; narrower stripe starting at posterior margin of the opercle, becoming blurred posteriorly and not reaching the caudal fin). The new species can be clearly distinguished from *A. scintillans* by the presence of a vertical humeral blotch (*vs.* absence). *Astyanax nobre* can be distinguished from *A. joaovitori* by having the dark midlateral stripe ending at the base of the middle caudal-fin rays (*vs.* reaching the distal tip of the middle caudal-fin rays) and three scale series below the lateral line (*vs.* five or six). Another remarkable difference between these species is the body size. *Astyanax nobre* has mature individuals at about 25 mm SL and reaching up to 30 mm SL whereas *A. joaovitori* reaches a much larger body size, with up to 77 mm SL (see Oliveira *et al*., 2017). *Astyanax nobre* fits within the *A. scabripinnis* species complex *sensu* Bertaco, Lucena (2006). According to the authors, the group is characterized by species with body deepest and heaviest in area close to middle of pectoral fins, head heavy, snout short and abrupt by tapering, body depth smaller than 41% of SL (mean 30–33% of SL), reduced number of branched anal-fin rays (13–21, usually 17–18, rarely 22 or 23), presence of one or two humeral spots, and a dark, midlateral, body stripe extending to the tip of the middle caudal-fin rays. Except for the midlateral dark stripe that does not reach the tip of the middle caudal-fin rays, all characteristics are found in *Astyanax nobre*. According to Oliveira *et al*. (2017), it is impossible to infer about the dark midlateral stripe of *A. scabripinnis* (Jenyns, 1842) due to the loss of coloration in the holotype. *Astyanax nobre* differs from the holotype of *A. scabripinnis* by having 32–36 lateral line scales (*vs.* 38).

Description. Morphometric data presented in Tab. 1. Body compressed, moderately elongate. Greatest body depth at dorsal-fin origin. Dorsal profile of head convex from upper lip to vertical through posterior nostril; slightly convex from that point to tip of supraoccipital spine. Dorsal profile of body slightly convex along predorsal region, straight to slightly convex along dorsal-fin base, slightly convex from terminus of dorsal-fin base to adipose-fin origin, and slightly concave from that point to origin of anteriormost dorsal procurrent caudal-fin ray. Ventral profile of head and body convex from tip of lower lip to pelvic-fin origin, straight to slightly concave between latter point to anal-fin origin, straight to slightly convex along anal-fin base, and slightly concave from that point to origin of anteriormost ventral procurrent caudal-fin ray.

Upper and lower jaws equal lenght, mouth terminal. Upper lip slightly anteriorly positioned than lower lip in some specimens. Premaxillary teeth in two distinct rows. Outer row with 2(1), 3*(27), or 4(2) tricuspid teeth. Inner row with 5*(30) teeth with 7–9 cusps (Fig. 2). Posterior tip of maxilla at vertical through posterior half of second infraorbital. Maxilla with 1(4) or 2*(26) tri- to pentacuspid teeth. Dentary with 4*(30) larger penta- to heptacuspid teeth, followed by one small tricuspid tooth and a series of five to eight diminute conical teeth. Central median cusp in all teeth longer than lateral cusps. Branchiostegal rays four (3). First gill arch with two (3) gill rakers on hypobranchial, seven (1) or eight (2) rakers on ceratobranchial, one (3) raker on intermediate cartilage, and four (1) or five (2) rakers on epibranchial.

TABLE 1 | Morphometric data of *Astyanax nobre*. Range includes the holotype and 30 paratypes. SD = Standard deviation.

	Holotype	Range	Mean	SD
Standard length (mm)	25.6	21.6–30.2	23.8	–
Percentages of standard length				
Depth at dorsal-fin origin	31.3	25–32	29.3	2.0
Snout to dorsal-fin origin	52.0	51.6–56.8	53.3	1.1
Snout to pectoral-fin origin	27.3	26.8–31	27.9	0.9
Snout to pelvic-fin origin	48.8	46.3–52.6	49.3	1.4
Snout to anal-fin origin	62.9	61.3–68	63.6	1.4
Caudal-peduncle depth	10.9	8.6–11	9.8	0.6
Caudal-peduncle length	10.9	9.6–13.4	11.4	1.0
Pectoral-fin length	21.5	19.7–23.3	21.8	0.9
Pelvic-fin length	16.0	14.7–18.7	16.4	0.9
Dorsal-fin length	27.0	25.2–31.1	27.4	1.3
Dorsal-fin base length	15.6	12.2–15.6	14.3	0.8
Anal-fin length	18.4	17.5–21	18.9	0.8
Anal-fin base length	27.3	23.6–28.2	26.3	1.2
Eye to dorsal-fin origin	38.3	36.6–41.4	38.5	1.1
Dorsal-fin origin to caudal-fin base	52.0	45.4–52.2	48.9	1.6
Head length	27.7	25.1–29.5	27.5	0.9
Percentages of standard length				
Horizontal eye diameter	42.3	40–45.2	42.9	1.3
Snout length	23.9	22.7–30.6	25.3	1.7
Interorbital width	36.6	31.5–38.7	34.5	1.6
Upper jaw length	53.5	45.3–53.5	49.5	2.1

FIGURE 1 | Holotype of *Astyanax nobre*, MZUSP 125905, 25.6 mm SL, Brazil, Mato Grosso State, Municipality of Nobres, rio Paraguai basin, upper rio Salobra drainage.

Lateral line straight to slightly curved ventrally, with total of 32(1), 33*(11), 34(12), 35(5), or 36(1) scales. Scales on lateral line series variably perforated. Five specimens with completely perforated lateral line, with 33*(4) or 34(1) perforated scales; 20 specimens with incomplete lateral line, with 31(4), 32(11), or 33(5) perforated scales followed by 1(5), 2(12), or 3(3) non-perforated ones, and five specimens with discontinuous lateral line, with perforated scales interspersed with non-perforated ones of variable pattern. Longitudinal scale rows between dorsal-fin origin and lateral line 5*(30). Longitudinal scale rows between lateral line and pelvic-fin origin 3*(30). Scales along middorsal line between posterior tip of supraoccipital process and dorsal-fin origin 9*(3), 10(21), or 11(6). Horizontal scale rows around caudal peduncle 14*(30). Base of anteriormost anal-fin rays covered by a series of 3 or 4 scales. Caudal fin not scaled.

Supraneurals five (3). Dorsal-fin rays ii*(30), 9*(29) or 8+i(1). First dorsal-fin pterygiophore inserted posterior to neural spine of nineth (3) vertebra. Base of last dorsal-fin ray at vertical through base of first branched anal-fin ray. Pectoral-fin rays i*(30), 9(2), 10*(20), or 11(8). Pelvic-fin rays i*(30), 7*(30). Adipose fin present. Analfin, with iv(2) or v(1) 18(4), 19*(16), 20(9), or 21(1) rays. First anal-fin pterygiophore inserted posterior to haemal spine of 16th(3) vertebra. Principal caudal-fin rays i,9,8,i*(30); caudal fin forked, lobes somewhat rounded and small, of similar size. Dorsal procurrent caudal-fin rays 11(1) or 12(2); ventral procurrent caudal-fin rays 9(1) or 10(2). Total vertebrae 34(3): precaudal vertebrae 15(2) or 16(1) and caudal vertebrae 18(1) or 19(2).

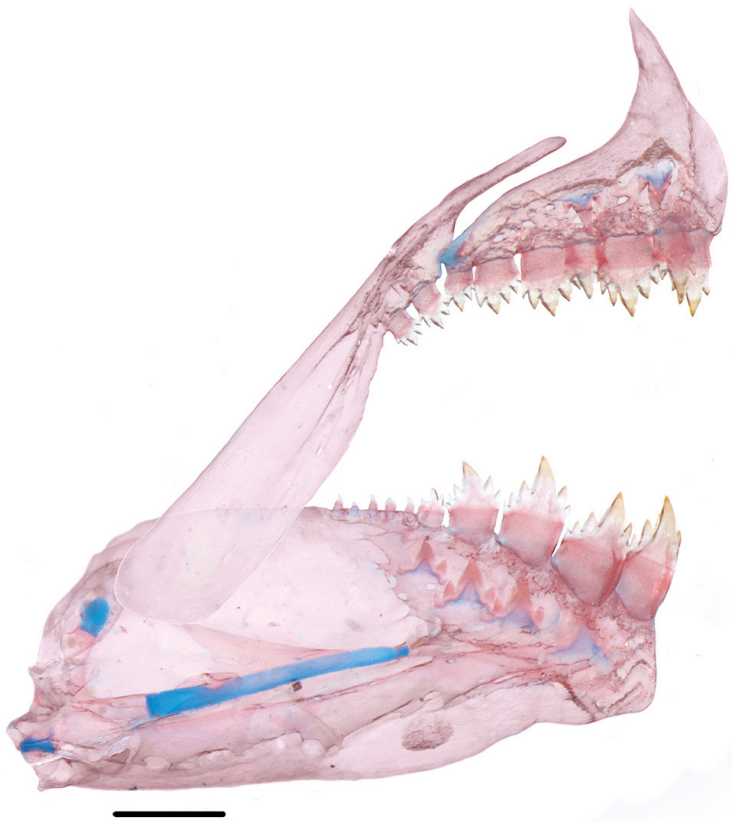

FIGURE 2 | Lateral view of right side, premaxillary, maxillary, and dentary of *Astyanax nobre*, MZUSP 118302, paratype. Scale bar = 0.5 mm.

Coloration in alcohol. Overall ground coloration pale (Fig. 1). Some specimens retaining guanine on opercular and gular areas. Dorsal portion of head and body dark. Dark chromatophores concentrated at jaws and opercle. Dark chromatophores scattered at infraorbital series. Humeral blotch present. Humeral blotch roughly rectangular, vertically oriented, extending vertically five scale rows and encompassing two scales horizontally. Conspicuous dark midlateral stripe on body, extending from upper half of opercule to base of middle caudal-fin rays. Dark midlateral stripe expanded at caudal-peduncle region forming a roughly oval caudal-peduncle blotch ending onto base of middle caudal-fin rays. Scattered dark chromatophores above anal fin, especially along margins of myosepta. Abdominal region with sparse chromatophores. Dorsal-fin rays and anteriormost anal-fin rays with dark chromatophores along edge of lepidotrichias. Pectoral and pelvic fins and distal portion of dorsal and anal fins with sparse pigmentation on interadial membranes. Adipose fin with concentration of dark chromatophores in its proximal and middle portions, distal margin hyaline.

Coloration in life. Dorsal portion of body light tan, ventral portion with silvery hue (Figs. 3–4). Dorsal and middorsal area with dark pigmentation. Infraorbitals, preopercle, and opercle silvery. Jaws and gular area light yellow to silver. Dorsal portion of eye orange to red; ventral portion silvery. Greenish iridescent pigmentation bordering above and below the longitudinal dark stripe, less evident in region posterior to adipose fin. Paired fins hyaline. Adipose, base of dorsal and of caudal fin orange. Anal fin slightly orange anteriorly, posterior portion nearly hyaline.

Sexual dimorphism. Males with distal margin of anal fin nearly straight (Figs. 1, 3A, 4A) (*vs.* anal fin falcate in females, distal margin anteriorly concave, Figs. 3B, 4B). Dorsal and caudal fins shorter and rounder in males (Figs. 1, 3A, 4A) than females (Figs. 3B, 4B). Unpaired fins coloration more intense in males (Figs. 3A, 4A). No bony hooks were found.

Geographical distribution. *Astyanax nobre* is so far known only from the rio Salobra, tributary of rio Cuiabá, rio Paraguai basin (Fig. 5).

Ecological notes. *Astyanax nobre* was collected in clear water river, with moderate water flow, over bottoms typically composed of rock and sand (Fig. 6). Vegetation includes areas with dense aquatic macrophytes and well preserved riparian forest. The species is one of the most abundant fish species in the locality. Individuals are very used to the human presence; frequently approaching the swimmers to nibble skin from the legs and arms.

Etymology. The specific name *nobre* refers to the municipality of Nobres (Mato Grosso State, Brazil) where the species occurs. Additionally, "nobre" means noble in Portuguese, in allusion to the beauty of the type locality and of being a noteworthy species of *Astyanax*. A noun in apposition.

Conservation status. *Astyanax nobre* is endemic to Brazil and is a restricted-range species. The new species is known by only the type locality, but its EOO (Extent of

FIGURE 3 | Live coloration of *Astyanax nobre*, paratypes, MZUSP 118302: **A.** Male; **B.** Female. Specimens not measured. Photo by W. Ohara.

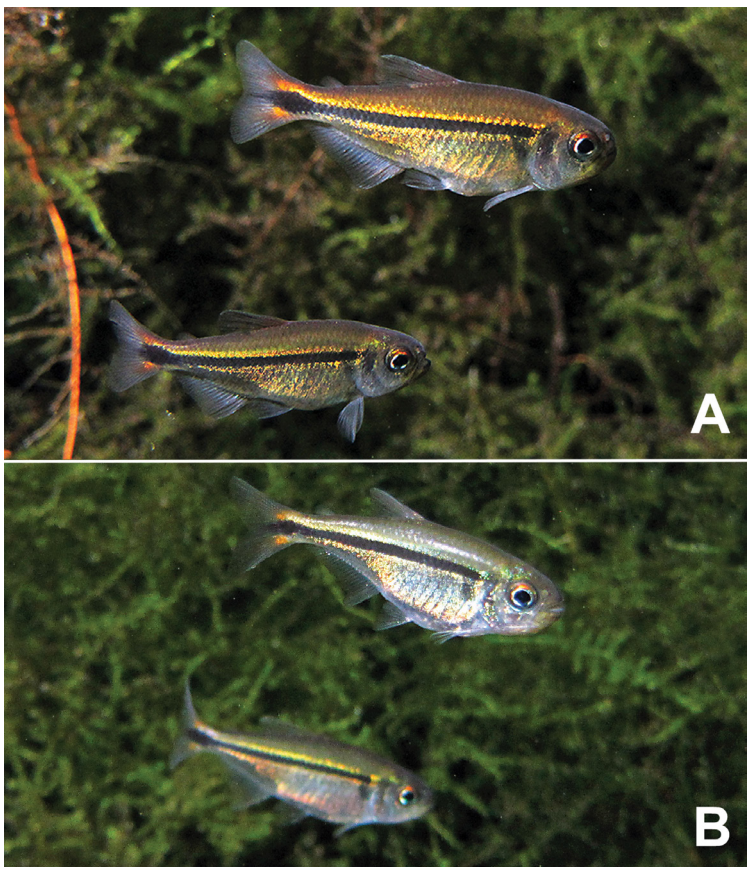

FIGURE 4 | Underwater photographs of wild specimens of *Astyanax nobre* at its type locality Recanto Ecológico Lagoa Azul, Bom Jardim district, Municipality of Nobres, Mato Grosso State, rio Salobra drainage, rio Paraguai basin: **A.** Pair of males; **B.** Pair of females. Details about differences between sexes can be found in Sexual dimorphism section. Photo by M. Melo.

occurrence) is likely underestimated since the region is poorly sampled. The species is so far only known from a tourist site, but with apparently low environmental impact since only snorkeling is allowed. The headwaters of the rio Cuiabá are relatively well protected, with part of it inside of the Parque Estadual Águas do Cuiabá. Therefore, given that no significant threats were identified for this species, it is assessed as Least Concern (LC) according to the International Union for Conservation of Nature (IUCN) categories and criteria (IUCN Standards and Petitions Subcommittee, 2019).

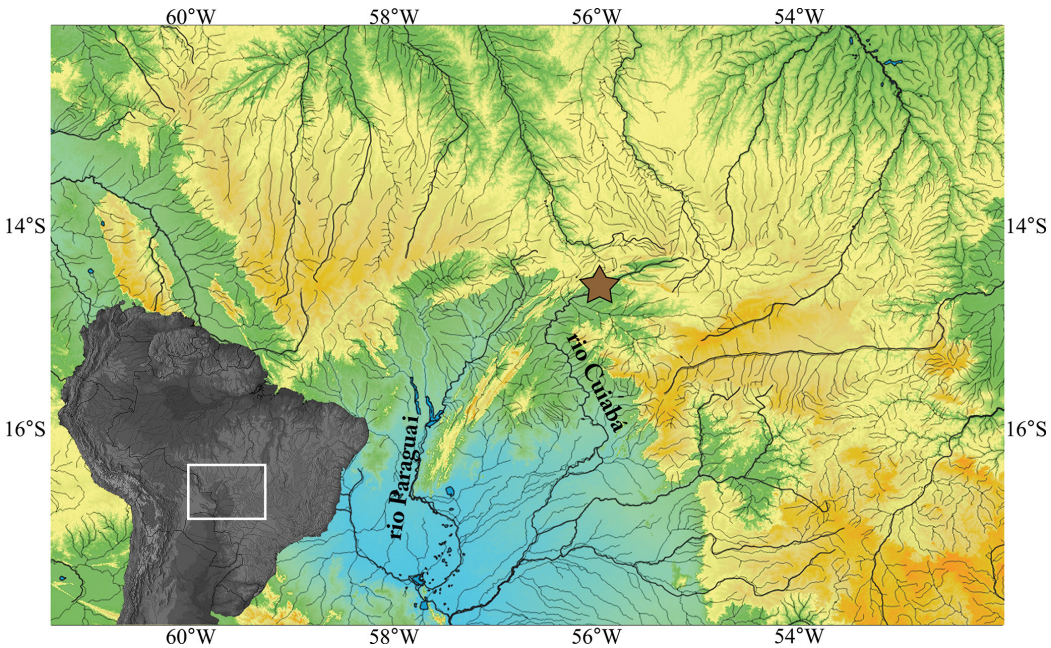

FIGURE 5 | Distribution map of *Astyanax nobre* in the rio Salobra, upper rio Paraguai basin, Brazil. Brown star (type locality).

FIGURE 6 | Type locality of *Astyanax nobre*, rio Salobra at Lago Azul, tributary of rio Cuiabá, rio Paraguai basin, 14º35'43.2"S 55º58'09.6"W, Nobres, Mato Grosso State, Brazil. Photo by M. A. Junghans.

DISCUSSION

Variation of lateral-line perforation and generic assignment of the new species. A recent cladistic study focused on the genus *Astyanax* was performed by Téran *et al.* (2020) using integrative phylogeny of molecular and morphological characters combined. The study efficiently corroborated the non-monophyletic nature of the genus, but failed in providing a reliable and consistent diagnosis for the proposed clades, making the taxonomic practice even more problematical.

In that paper, *Astyanax*, as traditionally defined, was recovered as a polyphyletic group, with some species more closely related to other genera (*e.g.*, *Deuterodon* Eigenmann, 1907, *Tetragonopterus* Cuvier, 1816, *Eretmobrycon* Fink, 1976). Most species, although closely related, were divided into three large clades supported solely by molecular synapomorphies (*e.g.*, *Andromakhe* Terán, Benitez & Mirande, 2020), or on highly homoplastic characters such as the presence of five or more cusps on teeth in the outer premaxillary row and in the maxilla (*e.g.*, *Psalidodon* Eigenmann, 1911). The authors additionally presented a non-phylogenetic diagnosis for these genera, based on a combination of non-exclusive characters. However, the characters presented are, in practice, not useful for the distinction between *Andromakhe*, *Astyanax*, and *Psalidodon* since all have the same condition (*e.g.*, rhinosphenoid lacking a dorsal expansion between olfactory nerves; presence of an anterior branch of the tubule for passage of blood vessels on lamellar portion of maxilla; naked caudal fin; presence of a complete lateral line; two series of teeth in the premaxilla, etc.). The only exception is the presence of *circuli* on posterior field of scales in *Astyanax* (*vs.* absent in *Andromakhe* and *Psalidodon*). Yet, it is a highly homoplastic character as authors themselves report its presence in species of *Psalidodon*. In view of that, and in the absence of molecular data for the new species, the new species is herein assigned in *Astyanax*.

The pre-cladistic concepts proposed by Eigenmann (1917, 1921), based on a combination of characters, are still used to define many characids (*i.e.*, *Bryconamericus* Eigenmann, 1907, *Hemigrammus*, *Hyphessobrycon*, *Knodus* Eigenmann, 1911, *Moenkhausia*). According to such classification, the only feature to distinguish *Astyanax* from *Hyphessobrycon* is the extension of the lateral-line perforation, which is completely pored in *Astyanax vs.* incompletely pored in *Hyphessobrycon*. The new species present a variable condition regarding lateral-line perforation. Of 30 examined specimens, only five have fully developed tubes in all scales of the lateral-line series. Most specimens analyzed (n = 20) has most lateral line scales perforated but not all (31 to 33 perforated scales plus 1 to 3 non-perforated scales at the end of the lateral-line series), and five specimens have discontinuous lateral line, *i.e.*, perforated scales interspersed with non-perforated ones.

Intraspecific variation of lateral-line perforation was documented for several characids (see Dagosta *et al.*, 2014; Marinho *et al.*, 2014, 2021), and its evolutionary significance in the family was discussed in Marinho *et al.* (2021). For more than a century after Eigenmann's legacy, the generic allocation of new species in Characidae was indisputably based on his proposal. This scenario only began to change in the last decade with the implementation of cladistic analyses revaluating the traditional morphological characters in a phylogenetic framework.

Many characters once used to delimit genera are now hypothesized to have been independently acquired within the family. Interruption of lateral-line perforation is one

of them (Mirande, 2010, 2019) and is probably related to the loss of terminal stages in the development, a common trend in the evolution of miniaturization process (Weitzman, Vari, 1988; Hanken, Wake, 1993; Marinho, 2017). Compared to other characids, *A. nobre* is a very small-sized species, of maximum known length of 30 mm SL. Dissection of four specimens confirmed maturation at 25 mm SL (MZUSP 118302), indicating that *A. nobre* may not grow much longer. Therefore, it is possible that such variation in the length perforation of lateral line may be related to the evolutionary reduction of body size in the species (see discussion in Marinho *et al*., 2021).

The lateral line of *A. nobre* is mostly perforated along its extension (see Description), differing from the "typical" interrupted lateral line found in most species of *Hemigrammus* or *Hyphessobrycon*, in which only few scales are perforated. Therefore, the new species is provisionally assigned to *Astyanax*, aware that further phylogenetic studies need to be conducted for its proper allocation, along with studies on the evolution of miniaturization to evaluate questions related to the homology of lateral-line interruption.

Given the unsolved systematic situation of several genera of Characidae discussed above and the similarity of *A. nobre* with species of *Hyphessobrycon*, a brief diagnosis from all species of *Hyphessobrycon* is necessary. The new species can be distinguished from most species of *Hyphessobrycon*, except *H. cachimbensis* Travassos, 1964, *H. fernandezi* Fernández-Yépez, 1972, *H. melanostichos* Carvalho & Bertaco, 2006, *H. nigricinctus* Zarske & Géry, 2004, *H. paucilepis* García-Alzate, Román-Valencia & Taphorn, 2008, *H. petricolus* Ohara, Lima & Barros, 2017, *H. piranga* Camelier, Dagosta, Marinho & Oyakawa, 2018, *H. psittacus* Dagosta, Marinho, Camelier & Lima, 2016, *H. scholzei* Ahl, 1937, *H. sovichthys* Schultz, 1944, *H. stegemanni* Géry, 1961, *H. taphorni* García-Alzate, Román-Valencia & Ortega, 2013, *H. tuyensis* García-Alzate, Román-Valencia & Taphorn, 2008, and *H. vilmae* Géry, 1966, by the presence of a well-defined, relatively narrow dark midlateral stripe on body extending from opercle to base of middle caudal-fin rays (*vs.* absence of a well-defined longitudinal stripe, stripe starting approximately at vertical through the dorsal-fin origin, or midlateral dark stripe that becomes blurred towards the caudal peduncle). It differs from *H. fernandezi*, *H. paucilepis*, *H. piranga*, *H. psittacus*, *H. sovichthys*, *H. scholzei*, *H. stegemanni*, *H. taphorni*, *H. tuyensis*, and *H. vilmae* by the presence of a humeral blotch (*vs.* absence), from *H. cachimbensis*, *H. cyanotaenia*, and *H. petricolus* by having 14 horizontal scale rows around caudal peduncle (*vs.* 12) and by *H. melanostichos* and *H. nigricinctus* by the presence of 3 longitudinal scale rows between lateral line and pelvic-fin origin (*vs.* 4–5).

Patterns of dark midlateral stripe in *Astyanax*. The most remarkable morphological character of *A. nobre* is the presence of a conspicuous, straight, and relatively narrow dark midlateral stripe on body. Despite being a highly homoplastic feature found in phylogenetic distant groups of characids such as *Astyanax* (Oliveira *et al*., 2017), *Caiapobrycon* Malabarba & Vari, 2000 (Malabarba, Vari, 2000), *Creagrutus* Günther, 1864 (Dagosta, Pastana, 2014), *Erythrocharax* Netto-Ferreira, Birindelli, Sousa, Mariguela & Oliveira, 2013 (Netto-Ferreira *et al*., 2013), *Hemigrammus* (Marinho *et al*., 2014), *Hyphessobrycon* (Camelier *et al*., 2018), *Moenkhausia* (Petrolli *et al*., 2016), *Serrapinnus* Malabarba, 1998 (Jerep *et al*., 2018), *Thayeria* Eigenmann, 1908 (Moreira, Lima, 2017), *Varicharax* Vanegas-Ríos, Faustino-Fuster, Meza-Vargas & Ortega, 2020 (Vanegas-Ríos *et al*., 2020), it is taxonomically informative when details of the pigmentation pattern are considered. Species of *Astyanax* with a dark-stripe differ from the condition found in *A.*

nobre mainly concerning the starting and the ending point of the stripe.

Without implying homologies, four different types of dark midlateral stripes can be recognized in *Astyanax*: 1) stripe of variously shapes and pigmentation, starting posterior to the anterior humeral blotch and never connected to it (Fig. 7A; *e.g.*, *A. bagual* Bertaco & Vigo, 2015, *A. eremus* Ingenito & Duboc, 2014); 2) stripe starting immediately posterior to the humeral blotch and usually ending at the tip of middle caudal-fin rays (Fig. 7B; *e.g.*, species typically assigned to the *Astyanax bimaculatus*-group such as *A. argyrimarginatus* Garutti, 1999, *A. clavitaeniatus* Garutti, 2003, *A. novae* Eigenmann, 1911, *A. saltor* Travassos, 1960, *A. unitaeniatus* Garutti, 1998, and *A. utiariti* Bertaco & Garutti, 2007); 3) narrower stripe starting at posterior margin of the opercle, becoming blurred posteriorly and not reaching the caudal fin (Fig. 7C; *e.g.*, *Astyanax myersi* (Fernández-Yépez, 1950), *Jupiaba anterior* (Eigenmann, 1908), and *J. ajuricaba* (Marinho & Lima, 2009)); 4) stripe starting immediately posterior to the opercle (Fig. 7D; *e.g.*, *A. joaovitori* and *A. scintillans*).

Among all species of *Astyanax*, the stripe of *A. nobre* is more similar to that of *A. joaovitori* and *A. scintillans*. The former is discussed in details in the diagnose section. The latter was described by Myers (1928), without illustrations – a usual practice of the author – and, up to date, it is a poorly known species, only known by the type-material, in which the dark pigmentation is today completely faded. Therefore, similarities between the stripe of *A. scintillans* and that of *A. nobre* are only based on the textual description of the original description: "there is a darker, wide, plumbeous lateral bland, from upper end of gill-slit to caudal base…" (Myers, 1928:29). Nonetheless, following words in the same sentence leaves no doubt that it is distinct from *A. nobre*: "…but no humeral or caudal spots are discernible" (Myers, 1928:29).

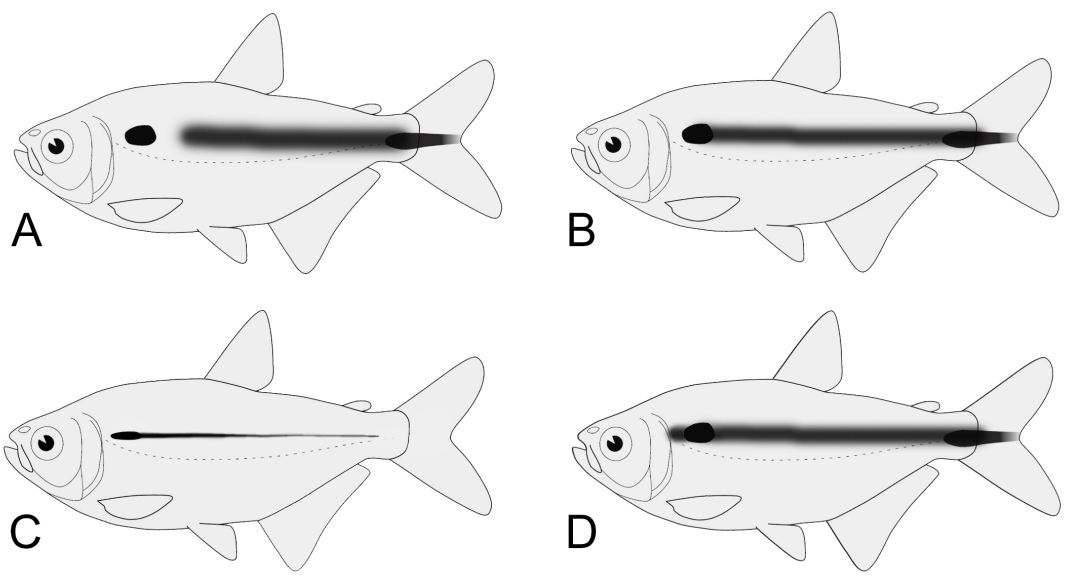

FIGURE 7 | Different types of dark midlateral stripes in *Astyanax*: **A.** Stripe of variously shapes and pigmentation starting posterior to the humeral blotch and never connected to it (*e.g.*, *A. bagual* and *A. eremus*); **B.** Stripe starting immediately posterior to the humeral blotch and usually ending at the tip of middle caudal-fin rays (*e.g.*, species typically assigned to the *Astyanax bimaculatus*-group); **C.** Narrower stripe starting at posterior margin of the opercle, becoming blurred posteriorly and not reaching the caudal fin (*e.g.*, *Jupiaba anterior* and *J. ajuricaba*); **D.** Stripe starting immediately posterior to the opercle (*e.g.*, *A. joaovitori* and *A. scintillans*). See discussion for further details. Fish layout modified from Van der Sleen, Albert (2018).

The megadiverse but still poorly known Brazilian freshwater ichthyofauna. The region where the new species was collected is relatively near to the municipality of Cuiabá, Mato Grosso State, a large urban area in Central Brazil. This discovery, in proximity of a large urban center that have been repeatedly explored for fish diversity, further underscores the fact that major elements of tropical biodiversity remain unknown. The region surrounding Cuiabá, mainly to the North, has attracted attention of ichthyologists in recent years where many species have been recently described. Most species are restricted to the headwaters of the Cuiabá and Sepotuba rivers, both tributaries of the Paraguai River, such as the following examples *Astyanax dolinae* da Graça, Oliveira, Lima, da Silva & Fernandes, 2017 (da Graça *et al*., 2017), *A. pirapuan* Tagliacollo, Britzke, Silva & Benine, 2011 (Tagliacollo *et al*., 2011), *Characidium nupelia* da Graça, Pavanelli & Buckup, 2008 (da Graça *et al*., 2008), *Crenicichla ploegi* Varella, Loeb, Lima & Kullander, 2018 (also in the rio Juruena basin) (Varella *et al*., 2018), *Curculionichthys coxipone* Roxo, Silva, Ochoa & Oliveira, 2015 (Roxo *et al*., 2015), *Curculionichthys paresi* (Roxo, Zawadzki & Troy, 2014) (Roxo *et al*., 2014), *Gephyrocharax machadoi* Ferreira, Faria, Ribeiro, Santana, Quagio-Grassioto & Menezes, 2018 (Ferreira *et al*., 2018), *Hyphessobrycon rutiliflavidus* Carvalho, Langeani, Miyazawa & Troy, 2008 (Carvalho *et al*., 2008), *Hypostomus renestoi* Zawadzki, da Silva & Troy, 2018 (Zawadzki *et al*., 2018), *Knodus geryi* Lima, Britski & Machado, 2004 (Lima *et al*., 2004), and *Moenkhausia flava* Britzke, Troy, Oliveira & Benine, 2018 (Britzke *et al*., 2018).

Even more remarkable is the fact that *Astyanax nobre* was discovery at an underwater tourist point, which means that even species daily observed by hundreds of people in limpid waters can lack a formal taxonomic identity. Interestingly, the case of *A. nobre* is not exclusive. Several freshwater fish species from popular underwater tourist points in Brazil were described in the last decades (*e.g*., *Astyanax brucutu* Zanata, Lima, Di Dario & Gerhard, 2017 (Zanata *et al*., 2017), *Characidium deludens* Zanata & Camelier, 2015 (Zanata, Camelier, 2015), *Hyphessobrycon negodagua* Lima & Gerhard, 2001 (Lima, Gerhard, 2001), *Hypostomus jaguar* Zanata, Sardeiro & Zawadzki, 2013 (Zanata *et al*., 2013), *Kolpotocheirodon figueiredoi* Malabarba, Lima & Weitzman, 2004 (Malabarba *et al*., 2004), *Lepidocharax diamantina* Ferreira, Menezes & Quagio-Grassiotto, 2011 in the rio Pratinha, Bahia State (Ferreira *et al*., 2011; Vita *et al*., 2020); *A. dolinae* in Dolina Água Milagrosa, Mato Grosso State (da Graça *et al*., 2017); *Ancistrus formoso* Sabino & Trajano, 1997 (Sabino, Trajano, 1997), *Hypostomus basilisko* Tencatt, Zawadzki & Froehlich, 2014 (Tencatt *et al*., 2014), *H. froehlichi* Zawadzki, Nardi & Tencatt, 2021 (Zawadzki *et al*., 2021), *Moenkhausia bonita* Benine, Castro & Sabino, 2004 (Benine *et al*., 2004) in Serra da Bodoquena, Mato Grosso do Sul State). If fish diversity that is daily observed is barely known, what can be predicted for the ichthyofauna that inhabits turbid water rivers, or even deep channel of rivers? Definitely, there are many more species waiting to be described.

These perceptions agree with the suspicious that the number of South American species is, in fact, much greater than we know today (Reis *et al*., 2016). Unfortunately, such incipient knowledge has disastrous consequences for the conservation of aquatic diversity. As highlighted by Heilpern (2015), freshwater biotas remain too poorly known to be integrated into conservation strategies based on terrestrial environments, despite their intrinsic importance and urgent need for protection (Amis *et al*., 2009; Strayer, Dudgeon, 2010; Dagosta *et al*., 2020). The global-scale extinction crisis, with

the current alarming rate of biodiversity loss, requires the selection of taxa to concentrate limited resources on regions of highest conservation value and with the most pressing need for conservation plans (Vane-Wright *et al*., 1991; Margules, Pressey, 2000; Myers, *et al*., 2000; Brooks *et al*., 2006; Kier *et al*., 2009). Therefore, the Brazilian freshwater ichthyofauna needs to be described as quickly as possible so that its elements may have a chance to have their conservation picture evaluated. For this, it is crucial that Brazil supports more taxonomy research and especially the training of new taxonomists to value its greatest wealth: its biodiversity.

Comparative material examined. *Astyanax ajuricaba*: MZUSP 18277, holotype, 65.5 mm SL, rio Negro basin, Brazil. *Astyanax scintillans*: CAS 39493, 2 syntypes, 27.3–29.2 mm SL, Playa Matepalma, rio Orinoco, Venezuela. *Jupiaba anterior*: MZUSP 18277 (53, 62.1–111.3 mm SL), rio Tapajós, Brazil. Species of *Hyphessobrycon* examined listed at Dagosta *et al.* (2016).

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AUTHORS' CONTRIBUTION

Fernando Cesar Paiva Dagosta: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review and editing.

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The authors declare no competing interests.

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