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An ode to beauty: the discovery of one of the most spectacular tetras (Characiformes: Acestrorhamphidae) – a new species of *Inpaichthys* from the rio Juruena, Brazil

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Inpaichthys luizae is described from tributaries of the rio dos Peixes basin, a tributary of the rio Juruena basin in central Brazil. The species is distinguished from all its congeners by the presence of well-defined, relatively broad oblique dark ventrolateral stripe on body, extending approximately from end of pectoral fin rays to base of middle caudal-fin rays, and continuing straight onto the tip of the middle caudal-fin rays. It shares seven of the eight synapomorphies attributed to the genus and exhibits all the defining characteristics of the clade *I. kerri* + *I. parauapiranga*, suggesting a close relationship with these species. Several morphological characters found in *I. luizae*, other species of *Inpaichthys*, and closely related groups are discussed. The biogeography of *Inpaichthys* is briefly addressed.

Keywords: Amazon, Biogeography, Rio Tapajós basin, Taxonomy.

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Inpaichthys luizae é descrita de tributários da bacia do rio dos Peixes, afluente da bacia do rio Juruena, região central do Brasil. A espécie se difere de todas as congêneres pela presença de uma faixa ventro-lateral bem definida, relativamente larga, que se estende aproximadamente do fim dos raios da nadadeira peitoral até a base dos raios medianos da nadadeira caudal, e retilíneaa até o final dos raios desta nadadeira. A espécie compartilha sete das oito sinapomorfias atribuídas ao gênero e possui todas as características que definem o clado *I. kerri* + *I. parauapiranga*, portanto provavelmente é relacionada a estas. Alguns caracteres presentes na espécie, nas outras espécies de *Inpaichthys* e em grupos proximamente relacionados são discutidos. A biogeografia de *Inpaichthys* é brevemente comentada.

Palavras-chave: Amazônia, Bacia do rio Tapajós, Biogeografia, Taxonomia.

INTRODUCTION

Characidae (*sensu* Mirande, 2019; Toledo-Piza *et al*., 2024), a megadiverse family of freshwater fishes native to the Americas and commonly referred to as tetras, displays especially high levels of species richness in the Neotropical region. With over 1,200 valid species, of which 400 have been described in the last two decades (Toledo-Piza *et al*., 2024), and a plethora of yet-to-be-described taxa, Characidae emerges as one of the most species-rich family among Neotropical freshwater fishes. Not only abundant in numbers, but also in the diversity of colors, body shapes and sizes, and evolutionary adaptations. In a recent study by Melo *et al*. (2024), the family Characidae was divided into three additional families: Spintherobolidae, Stevardiidae, and Acestrorhamphidae, based on ultraconserved elements. Despite the nomenclatural redefinition of Characidae in a more restricted sense, the clade formed by Characidae + Spintherobolidae + Stevardiidae + Acestrorhamphidae remains monophyletic and aligns with the circumscription of Characidae already present in Mirande (2019) and Toledo-Piza *et al.* (2024).

One of the most renowned genera among tetras is the Amazonian genus *Inpaichthys* Géry & Junk, 1977 which was described by Géry, Junk (1977) based on *Inpaichthys kerri* Géry & Junk, 1977. At present, the genus is assigned to the family Acestrorhamphidae *sensu* Melo *et al*. (2024). The species exhibits a distinctive life coloration, with a prominent longitudinal dark stripe traversing from the jaws to the caudal fin, complemented by a vivid blue dorsal region. Until recently, the genus was monotypic until Ferreira *et al.* (2024) described *I. parauapiranga* Ferreira, Ribeiro, Lima, Silva, Ferreira & Mirande, 2024 and also transferred *Hasemania nambiquara* Bertaco & Malabarba, 2007 to *Inpaichthys*. Thus, the genus had its diagnosis completely reformulated, and its richness was tripled (Ferreira *et al*., 2024; Fricke *et al*., 2025).

Recently, another remarkable species of *Inpaichthys* was discovered in the rio Juruena basin in Mato Grosso State. Specimens were first discovered by an ornamental fisherman who suspected the presence of a new species. He contacted me to check the identification and provided material for its scientific description. The aim of the present study is to describe the new species, including a brief discussion regarding its generic allocation and biogeographical insights.

MATERIAL AND METHODS

Counts and measurements follow Fink, Weitzman (1974), except for number of horizontal scale rows below lateral line, which are counted to the pelvic-fin insertion, not including the small scale at pelvic-fin insertion, and with the addition of head depth, measured at vertical through the base of supraoccipital process. Standard length (SL) is given in millimeters (mm) and all other measurements are expressed as percentage of SL or of head length (HL) for subunits of head. In the description, counts are followed by their frequency of occurrence in parentheses, and an asterisk indicates the counts of the holotype. Number of maxillary tooth cusps, small dentary teeth, supraneurals, branchiostegal rays, gill rakers, vertebrae, unbranched anal-fin rays, and procurrent caudal-fin rays were obtained only from cleared and stained (c&s) specimens prepared according to Taylor, Van Dyke (1985). Vertebrae of the Weberian apparatus are counted as four elements and the compound caudal centra (PU1+U1) as a single element. *Circuli* and *radii* counts were taken from scale row immediately above the lateral line and anterior to the dorsal fin. The sex of three specimens was confirmed by dissection and direct examination of the gonads. In the list of types and comparative material, catalog numbers are followed by the number of specimens in alcohol, their SL range, and if any, the number of c&s specimens and their respective SL range. In the type material, whenever DNA is mentioned, the specimens were fixed and preserved in absolute ethanol for genetic sampling. Institutional abbreviations follow Fricke, Eschmeyer (2025). Specimens of lot MUBIO 691 were neither measured nor counted due to their early juvenile developmental stage. Distribution data compiled for the biogeographic discussion were obtained directly from GBIF (2024), supplemented by an uncatalogued underscribed species of *Astyanacinus* Eigenmann, 1907 in the rio Jamanxim. Records falling outside the known distribution range of the taxa were suppressed. *Astyanacinus* was recently resurrected by Melo *et al.* (2024), and its definition here follows Dagosta (2011), encompassing *Astyanax orthodus* Eigenmann, 1907 and *A. superbus* Myers, 1942.

RESULTS

Inpaichthys luizae, new species

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(Figs. 1–4; 8; Tab. 1)

Holotype. MZUSP 130243, 32.1 mm SL, Brazil, Mato Grosso State, Juara municipality, tributary of the rio dos Peixes, near the confluence of the rio dos Peixes and rio Arinos, rio Tapajós basin, approx. 10°44’S 57°50’W, 11 Mar 2024, A. Bulgarelli.

FIGURE 1 | *Inpaichthys luizae*, holotype, MZUSP 130243, 30.2 mm SL, male, Brazil, Mato Grosso State, Juara municipality, tributary of the rio dos Peixes, affluent of the rio Juruena, rio Tapajós basin, approx. 10°44'S 57°50'W.

Paratypes. Same data from holotype. MUBIO 500, 2, 25.5–26.3 mm SL c&s, 6, 25.5–38.2 mm SL, 1, 25.8 mm SL DNA; LBP 36835, 1, 26.9 mm SL DNA; ICTL 1570, 2, 24.2–26.4 mm SL. MUBIO 691, 8, 11.8–23.3 mm SL, 5 Feb 2025, A. Bulgarelli.

Diagnosis. *Inpaichthys luizae* can be easily distinguished from all congeners by the autapomorphic presence of a well-defined, relatively broad oblique dark ventrolateral stripe on body, extending approximately from end of pectoral fin rays to base of middle caudal-fin rays, and continuing straight onto the tip of the middle caudal-fin rays (*vs*. well-defined longitudinal stripe absent, or dark lateral stripe never oblique). Additionally, *I. luizae* can also be distinguished from *I. nambiquara* and *I. parauapiranga* by the absence of humeral blotch (*vs*. two in *I. parauapiranga* and one in *I. nambiquara*). It is further distinguished from *I. kerri* by 19–21 branched anal-fin rays (*vs*. 22–26 branched anal-fin rays).

Description. Morphometric data in Tab. 1. Greatest body depth at dorsal-fin origin. Dorsal profile slightly convex from tip of snout to dorsal-fin origin. Straight along dorsal-fin base and straight from that point to adipose-fin origin. Concave from terminus of adipose fin origin to origin of anteriormost dorsal procurrent caudal-fin ray. Ventral profile of head and body convex from tip of lower lip to anal-fin origin, slightly convex along anal-fin base (see Sexual dimorphism section), and concave from anal-fin end to origin of anteriormost ventral procurrent caudal-fin ray.

Lower jaw slightly anterior to upper jaw, mouth slightly sub-superior. Second or third and fourth or fifth premaxillary teeth positioned slightly anteriorly, forming two roughly rows. Outer row with 2(10) or 3*(2) tricuspid teeth. Inner row with 5*(10) or 6(2) tricuspid teeth. Posterior tip of maxilla at vertical through posterior half of second infraorbital. Maxilla with 6(3), 7(8), or 8*(2) tricuspid teeth, anterior tooth larger and with more developed cusps than others. Dentary with 4(1) or 5*(12) larger tricuspid teeth followed by series of 9-10 diminute conical teeth. Central cusp in all teeth longer than

TABLE 1 | Morphometric data of the holotype and 12 paratypes of *Inpaichthys luizae*. Range includes the holotype. The high standard deviation observed in dorsal fin length is primarily attributed to damage sustained by many specimens, likely resulting from fin mutilation during live transport. SD = Standard deviation.

	Holotype	Range	Mean	SD
Standard length (mm)	30.2	23.3–38.2	28.7	–
Percentages of standard length				
Depth at dorsal-fin origin	34.0	29.5–34.0	31.7	1.5
Snout to dorsal-fin origin	56.6	52.8–59.2	56.3	1.9
Snout to pectoral-fin origin	24.4	24.3–28.6	26.6	1.4
Snout to pelvic-fin origin	45.4	45.1–48.7	46.7	1.2
Snout to anal-fin origin	62.1	59.7–65.2	62.3	1.7
Caudal-peduncle depth	12.3	11.3–13.6	12.5	0.8
Caudal-peduncle length	12.2	8.8–12.2	10.2	1.2
Pectoral-fin length	20.8	17.8–22.4	20.4	1.3
Pelvic-fin length	14.2	12.2–15.6	14.0	1.0
Pelvic-fin origin to anal-fin origin	14.6	14.3–16.6	15.5	0.8
Dorsal-fin length	30.8	20.5–31.5	27.5	3.5
Dorsal-fin base length	13.9	12.6–14.3	13.7	0.5
Anal-fin length	14.6	12.9–18.8	16.4	1.8
Anal-fin base length	31.8	28.0–34.4	30.6	1.7
Eye to dorsal-fin origin	42.5	40.3–45.6	42.7	1.5
Dorsal-fin origin to caudal-fin base	54.2	47.5–54.2	50.7	2.1
Head depth	23.3	22.4–25.8	23.7	1.0
Head length	27.5	24.0–28.2	26.3	1.2
Percentages of head length				
Horizontal eye diameter	36.5	34.4–39.3	36.8	1.6
Snout length	23.3	19.8–24.4	22.1	1.4
Interorbital width	35.5	32.7–36.0	33.7	1.1
Upper jaw length	39.0	39.0–44.2	41.6	1.5

lateral cusps. Four (2) branchiostegal rays; 3 on anterior ceratohyal, and 1 on posterior ceratohyal. Gill-rakers 9(2) in the lower (hypobranchial and ceratobranchial) and 5(2) in the upper branch (epibranchial) and one (2) on cartilage between ceratobranchial and epibranchial. Fourth infraorbital absent (2), sixth present but extremely reduced (2).

Cycloid scales, with 4–6 *radii* from focus to posterior border, and conspicuous *circuli* anteriorly. Lateral line incomplete and canals poorly developed, with 4*(2), 5(7), 6(2), or 7(2) perforated scales, and 29(4), 30(5), 31(2), 32*(1) or 33(1) total scales on longitudinal series. Longitudinal scale rows between dorsal-fin origin and lateral line 6*(5) or 7(8). Longitudinal scale rows between lateral line and pelvic-fin origin 4*(13). Scales along middorsal line between posterior tip of supraoccipital process and dorsal-fin origin 11(2) or 12*(11) and anteriorly irregular. Horizontal scale rows around caudal peduncle 14*(8) or 15(5). Base of anteriormost anal-fin rays covered by series of 4 to 6 scales. Caudal lobes scaled only at base, by scales roughly same size as rest of body. Supraneurals 6(1) or 7(1).

Dorsal-fin rays iii(2), 9*(13), first unbranched dorsal-fin ray reduced, visible only in c&s specimens. Base of last dorsal-fin ray posterior to anal fin origin. First dorsal-fin pterygiophore located after neural spine of 11th vertebra (2). Pectoral-fin rays i*(13), 9*(8), 10(4) or 11(1). Pelvic-fin rays i*(13), 5(1) or 6*(12). Adipose fin with variable development: present (13)*, or absent (8). Anal fin without an anterior lobe, with iv(2), 19(3), 20*(5), or 21(5) branched rays. First anal-fin pterygiophore inserted behind haemal spine of 16th vertebra (2). Males with bony hooks on anal-fin rays. Principal caudal-fin rays i,9,8,i(12) or i,8,8,i*(1); caudal fin forked, lobes somewhat pointed, of similar size. Dorsal procurrent caudal-fin rays 8(1) or 9(1); ventral procurrent caudal-fin rays 8(2). Total vertebrae 34(2): precaudal vertebrae 14(2) and caudal vertebrae 20(2).

Coloration in alcohol. Overall ground coloration of head and body beige (Fig. 1). Dorsal portion of head and dorsal midline of body darker. Snout, jaws and fifth and sixth infraorbitals with concentration of dark chromatophores, remaining infraorbitals and opercle region with scattered dark pigmentation. Central region of the opercle bone lacking pigmentation. Humeral blotch absent. Narrow subjacent longitudinal dark line extending along horizontal septum, from vertical through anal-fin origin to end of caudal peduncle. Broad oblique dark ventro-lateral stripe on body, extending approximately from end of pectoral fin rays to base of middle caudal-fin rays, and continuing straight onto the tip of the middle caudal-fin rays. Black chromatophores more densely concentrated in middle caudal-fin rays than in rest of ventrolateral stripe. Abdominal region below ventrolateral dark stripe with few scattered chromatophores. Sparse dark chromatophores above anal fin. Absence of delimited caudal-peduncle blotch. Adipose fin, when present, with dark chromatophores on anterior portion. Dorsal and anal fins with dark chromatophores on interadial membrane, not on lepidotrichia. Chromatophores darker at distal portion of anal fin, forming thin dark stripe at fin edge less intense in anteriormost anal-fin rays. Caudal fin with dark chromatophores on interadial membrane and lepidotrichia. Base of outer caudal fin rays, on both lobes, with lower pigment concentration, resulting in clearer areas above and below dark stripe. Pectorals and pelvics with dark chromatophores scattered along edge of lepidotrichia.

Coloration in life. Similar to color in alcohol except in the following details. Dorsal region olive green with blue iridescence (Figs. 2–3), abdominal region silvery. Midlateral surface with purplish coloration, mainly in males (see details in Sexual dimorphism section). Upper portion of eye orange to red, posterior region light blue. Opercular region with few guanine, exposing red branchial filaments inside branchial chamber, resulting in the cheek area with a rosy aspect. Gular region with orange pigmentation in some specimens. Bright orange stripe immediately above and contrasting oblique dark lateral stripe on body. All fins yellow to orange, less intense in pectoral fin. Distal portion of anal-fin rays darker. Base of outer caudal fin rays, on both lobes, usually distinctly orange.

FIGURE 2 | Life coloration of the holotype, MZUSP 130243 (male, 30.2 mm SL).

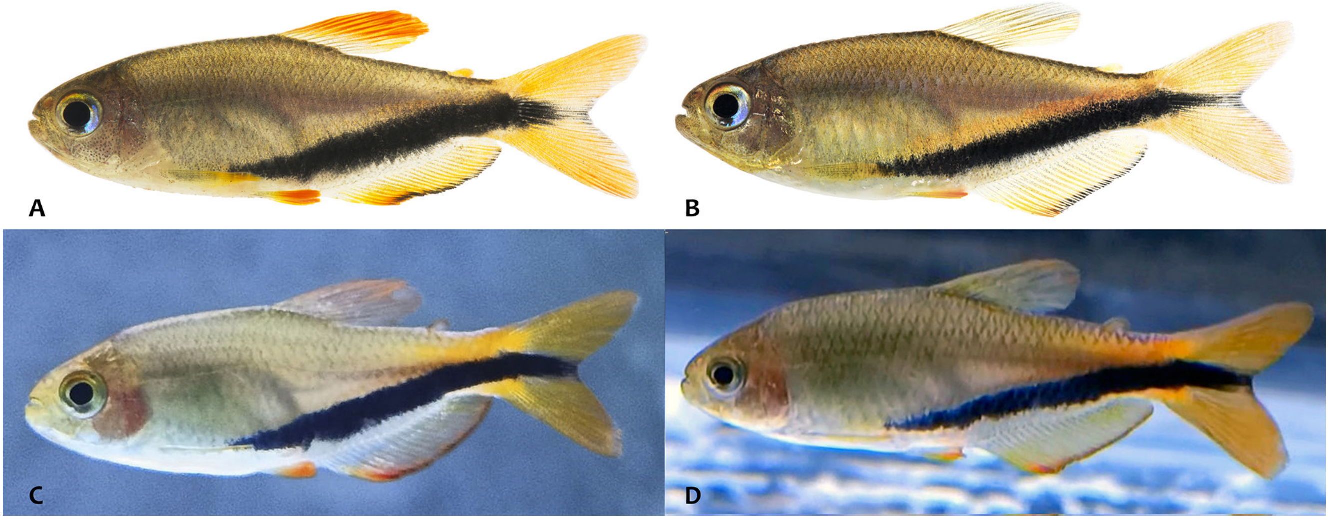

FIGURE 3 | Sexual dimorphism of *Inpaichthys luizae*: **A.** MUBIO 691 (male, 31.5 mm SL); **B.** MUBIO 691 (female, 38.2 mm SL); **C.** Unvouchered specimen (male); **D.** Unvouchered specimen (female). Photos C–D by André Bulgarelli.

Sexual dimorphism. Anal-fin rays of males more posteriorly inclined, appearing shorter than of females and resulting in a relatively convex distal margin (Figs. 3–4). Female anal-fin rays slightly more elongated than in males, resulting in distal margin straighter than in males. Male body slightly deeper and smaller. Males with more marked coloration, particularly in unpaired fins and in oblique dark lateral stripe. Hooks present on first to fifth branched anal-fin rays in males (Fig. 4). One pair of hooks per lepidotrichia segment, maximum four segments with hooks. Segment preceding the branching of the lepidotrichia is the most proximal with hooks.

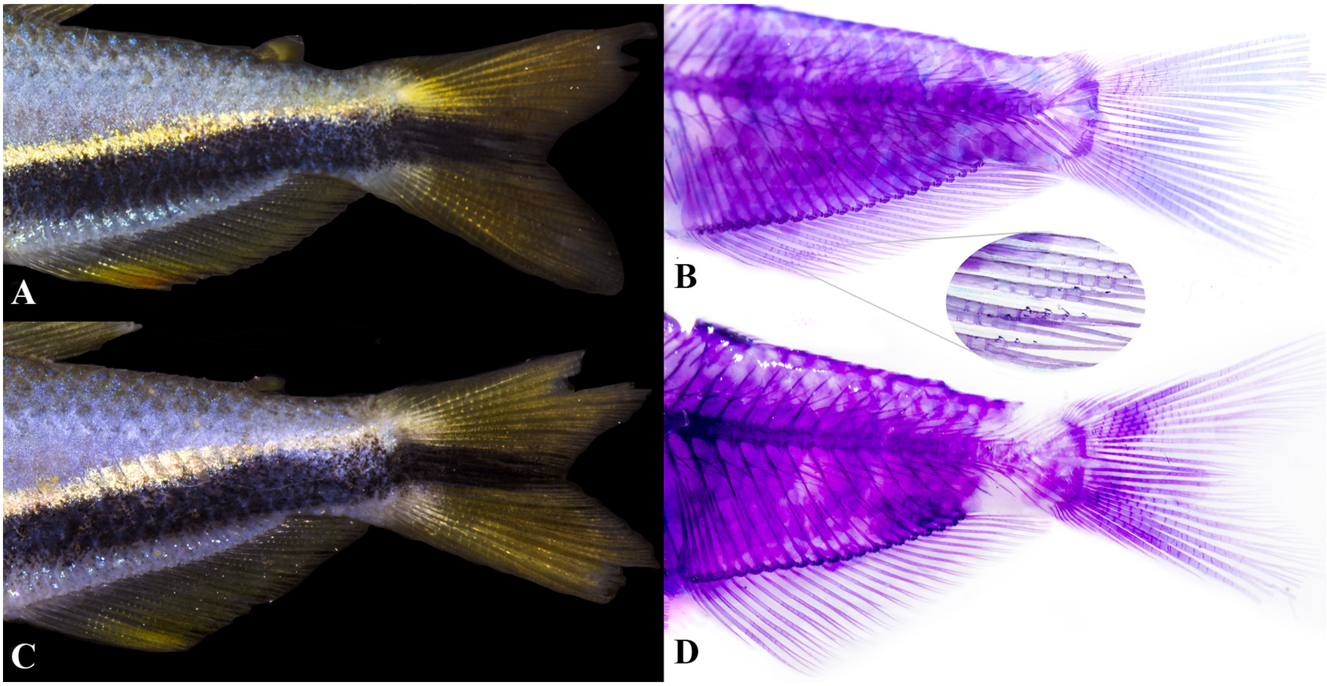

FIGURE 4 | Posterior half of the body of *Inpaichthys luizae*, highlighting the sexual dimorphism in the morphology of the anal fin: **A.** MUBIO 500 (male, 26.2 mm SL); **B.** MUBIO 500 (male, 25.5 mm SL, c&s), male, detail of hooks on rays; **C.** MUBIO 500 (female, 28.7 mm SL); **D.** MUBIO 500 (female, 26.3 mm SL, c&s).

Geographical distribution. Although the exact geographic coordinates remain unknown, the species occurs in tributaries of the rio dos Peixes basin, in the municipality of Juara, Mato Grosso State, Brazil (A. Bulgarelli, 2024, pers. comm.).

Etymology. The specific epithet *luizae* (n. f. gen. sg.) comes from Luíza. *Inpaichthys luizae* is named after my daughter Luíza Krauss Dagosta. A noun in a genitive case.

Conservation status. According to local fishermen who collected specimens, *Inpaichthys luizae* occurs in certain tributaries of the rio dos Peixes. These habitats are well-preserved and situated within privately owned lands, currently facing no immediate environmental threats (A. Bulgarelli, pers. comm.). The only potential concern for the species lies in its ornamental appeal, which is likely to be significantly heightened in the aquarium trade following the publication of its description. This could result in increased collection pressure in its natural habitat, potentially necessitating a future reassessment of its conservation status. At present, however, there is no substantial evidence of threats that would warrant a classification other than Least Concern. Therefore, *Inpaichthys luizae* should be listed as Least Concern (LC) under the categories and criteria of the International Union for Conservation of Nature (IUCN Standards and Petitions Subcommittee, 2024), pending the availability of additional data that may support a more comprehensive evaluation.

DISCUSSION

New species lacking exact geographic coordinates: describe or not? A formal taxonomic description is essential for granting a species legal recognition, preventing unsustainable exploitation, and enabling effective conservation actions. Recognizing a species through valid scientific nomenclature is fundamental not only for its taxonomic legitimacy but also for allowing other biological research and management concerns. This is particularly crucial for species of commercial interest, such as *Inpaichthys luizae*, whose striking appearance and rarity make it valuable in the aquarium trade. Without a formal name, the species remains invisible to science, hindering ecological studies and precluding any assessment of its conservation status. A valid description not only enhances scientific recognition but also fosters public awareness and deepens understanding of the species' natural populations.

Nevertheless, the process of describing species based on specimens lacking precise locality data raises significant taxonomic and conservation challenges. As highlighted by Marinho *et al*. (2016), several neotropical fish species have been described from individuals sourced via the aquarium trade. While this practice contributes to addressing the Linnean shortfall in neotropical ichthyology (Brown, Lomolino, 1998; Whittaker *et al*., 2005), it carries inherent risks related to the accuracy of distribution data and subsequent conservation assessments. For instance, some tetras described in the 2000s without precise locality data still lack published distribution records, such as *Dectobrycon armeniacus* Zarske & Géry, 2006, *Hyphessobrycon clavatus* Zarske, 2015, *H. jackrobertsi* Zarske, 2014, and *H. paepkei* Zarske, 2014 whose distributions remain entirely unknown since their original descriptions. Even more problematic is the case of *Hyphessobrycon cyanotaenia* Zarske & Géry, 2006 also described from aquarium material, whose type-locality was later proven to be completely incorrect, a mistake only rectified a decade later by Dagosta *et al*. (2016). A very similar situation occurred with *Hyphessobrycon scholzei* Ahl, 1937 also described from aquarium material, with its type-locality corrected only in Lima *et al*. (2025). Nevertheless, when used appropriately, aquarium specimens can be valuable for taxonomic purposes. For instance, Lima *et al*. (2025, fig. 1a) used individuals obtained through the aquarium trade to illustrate the coloration of the species, a practice also adopted by Marinho *et al*. (2016, fig. 2) and Marinho, Dagosta (2023, figs. 2C–D). These cases demonstrate that, even without precise provenance, such material can still contribute meaningfully to taxonomic research.

Marinho *et al*. (2016) emphasize that aquarium-derived material should only be used after comprehensive searches in ichthyological collections have failed to yield reliably localized specimens: "Therefore, an extensive examination of fish collections should be encouraged before naming a fish species from the aquarium trade in order to search for specimens from a reliable locality to be used in the description". This is precisely the case with *I. luizae*, which, although lacking precise geographic coordinates, is not entirely of uncertain origin. Extensive surveys in the rio Juruena and neighboring basins have failed to locate specimens of *I. luizae* and no specimens of *I. luizae* have been found in Brazilian scientific collections, strongly suggesting that the species is narrowly distributed. Under these circumstances, relying on aquarium specimens obtained directly from local fishermen is currently a feasible approach for its formal description. Considering the species' potential vulnerability, formally recognizing

I. luizae is clearly preferable to leaving it in taxonomic obscurity. Doing so enables further biological research, informs conservation actions, and ultimately contributes to the sustainable management of its natural populations.

A particularly illustrative example of an even more challenging situation is *Trichogenes beagle*, described by de Pinna, Reis, and Britski (2020) without any assigned collection locality. At the time of its description, the complete absence of geographic information precluded any assessment of its conservation status. Only later in Santos *et al*. (2025) its distribution finally was identified, enabling a proper evaluation of its conservation needs. This case clearly demonstrates that formal taxonomic recognition, even under suboptimal circumstances, is a first step toward effective conservation.

While the practice of describing species without precise locality data should generally be avoided, given the taxonomic uncertainties and conservation challenges it entails, the case of *I. luizae* represents a justified exception. Unlike scenarios where no geographic information is available, in this case, the species' occurrence is reliably associated with the rio dos Peixes, a tributary of the rio Juruena basin, and even the municipality of origin is known. This level of geographic certainty significantly mitigates the risks typically associated with descriptions based on aquarium-sourced material. Furthermore, it is expected that, in the near future, geo-referenced specimens will be collected, further refining the species' distributional knowledge and strengthening its conservation framework.

Generic allocation. The generic allocation of the new species is based on the presence of synapomorphies for the genus proposed by Mirande (2019) and modified by Ferreira *et al.* (2024) (Fig. 5). Out of the eight synapomorphies listed by the authors, *I. luizae* presents seven, which are: nasal septum of mesethmoid formed by two parallel lamellae (9:1), absence of a dorsal expansion of rhinosphenoid projected medial to olfactory nerves (35:0), short supraoccipital spine covering dorsally only anterior axis of neural complex of Weberian apparatus (62:1), articulation between second and third infraorbitals anteroventrally angled (86:1), frontal and pterotic laterosensory canals forming an angle on pore receiving infraorbital canal (118:1), maxillary teeth extended approximately to half maxillary length (191:0), and presence of 24 or fewer branched anal-fin rays (420:0). The only synapomorphy of *Inpaichthys* absent in the species is the absence of the anguloarticular portion of the mandibular laterosensory canal (105:1).

Additionally, from nine of the characters listed by Ferreira *et al.* (2024) as useful for the diagnosis of the genus *Inpaichthys*, eight are present in *I. luizae*: two or more maxillary teeth with larger one, tri or pentacuspidate, ten or fewer gill rakers on first hypobranchial and ceratobranchial, interrupted lateral line, lack of parietal branch of supraorbital cephalic laterosensory canal, pore of the supraorbital cephalic laterosensory canal situated just anterior to dilatator fossa oriented dorsomedially, circuli absent on posterior field of scales, iii+9 dorsal-fin rays with the anterior one visible only in c&s specimens, and lack of pseudotympanum. Only the character-state 'lack of secondary-sexual hooks on males' differs in *I. luizae*, as the males of the species do have hooks (Fig. 4), being the first record of these structures in males of the genus.

The unequivocal phylogenetic placement of the species demands its inclusion in the character matrix of Ferreira *et al.* (2024). However, the species likely belongs to the clade *I. kerri* + *I. parauapiranga*, as it possesses all the three synapomorphies listed for that

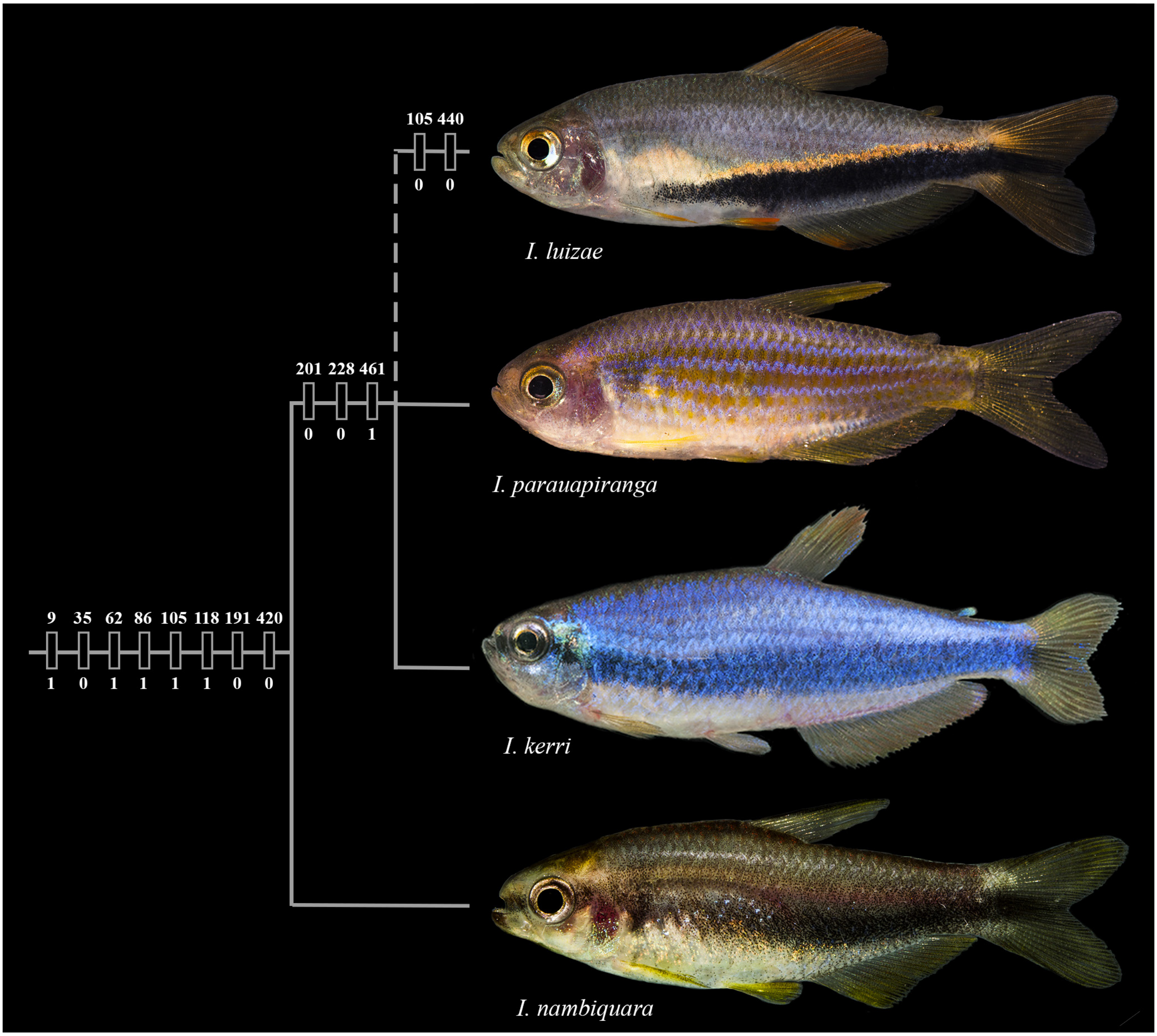

FIGURE 5 | Life coloration and hypotheses on the phylogenetic relationships among *Inpaichthys* species following Ferreira *et al.* (2024) with the addition of *I. luizae*. Characters and corresponding states follow Mirande (2019). The dashed line represents the hypothesized placement of *I. luizae*, inferred from the examination of genus-level synapomorphies as outlined by Ferreira *et al.* (2024), without the execution of a formal phylogenetic analysis.

node: three cusps on anterior dentary teeth (201:0), metapterygoid foramen as a simple rounded opening (228:0), and first anal-fin pterygiophore located ventral to last dorsal-fin pterygiophores (416:1). Furthermore, *I. luizae* lacks any of the autapomorphies reported for *I. nambiquara*: third infraorbital not reaching the horizontal arm of preopercle in its anterior margin (88:1), presence of (a reduced, in this species) fourth infraorbital (90:0), three or fewer maxillary teeth (190:0), five or more cusps on anterior maxillary teeth (193:1), and the possession of four or fewer supraneurals (392:0).

Phylogenetic insights. The phylogenetic placement of the genus *Inpaichthys* remains somewhat controversial in the literature. Géry, Junk (1977:418) were the first to highlight the difficulty in establishing its evolutionary relationships, describing the genus as "difficult to position". Four recent phylogenetic analyses of characids have proposed hypotheses regarding the placement of *Inpaichthys* (Fig. 6). Although the topologies proposed by Mirande (2019), Cucalón, Tan (2022), and Ferreira *et al*. (2024) are generally more congruent with one another and differ from that of Melo *et al*. (2024), a detailed comparison shows that the differences are not as substantial as they first appear.

Melo *et al*. (2024) present the most comprehensive and up-to-date phylogenetic analysis of Characidae, incorporating an extensive dataset of newly generated molecular data based on ultraconserved elements (UCEs). In their study, *Inpaichthys* is recovered as sister to *Bryconamericus orinocoensis* Román-Valencia plus *Hyphessobrycon* sp. Jari, with this clade positioned at the base of Thayeriinae (*sensu* Melo *et al*., 2024). Thayeriinae, in turn, is the sister group to a clade composed of Rhoadsiinae and (Grundulinae + Acestrorhamphinae). While the relationship between *Inpaichthys*, *B. orinocoensis*, and *Hyphessobrycon* sp. Jari is strongly supported (100% bootstrap), at present, no morphological synapomorphies have been identified to support this arrangement, nor are there any morphological features considered relevant for discussion within this evolutionary scenario. Notably, *B. orinocoensis* exhibits a complete lateral line, a short anal fin, and pale body coloration marked by a broad silvery lateral stripe, whereas *Hyphessobrycon* sp. Jari represents an undescribed species.

In contrast, the other three studies consistently recover *Inpaichthys* as closely related to *Nematobrycon* Eigenmann, 1911, or to a clade including *Nematobrycon* along with the Rhoadsiini genera (*Pseudochalceus* Kner, 1863, *Carlana* Strand, 1928, and *Rhoadsia* Fowler, 1911) (Mirande, 2019; Cucalón, Tan, 2022; Ferreira *et al*., 2024). Although the precise phylogenetic affinities of *Inpaichthys* and its potential close relatives remain subject to debate (Fig. 6), several morphological features observed in *I. luizae*, in other *Inpaichthys* species, and in some of the aforementioned related taxa (*e.g*., fin coloration, bluish-purple iridescence on the lateral body, elongation of the posterior anal-fin rays, and absence of the adipose fin) are noteworthy and should not be overlooked at this point. Although the evolutionary significance of these traits requires further phylogenetic investigation, they would be interpreted as homoplasies if the hypothesis proposed by Melo *et al*. (2024) is ultimately supported over time. Accordingly, this brief discussion of these characters is intended to encourage further exploration of these questions in future studies, using as a framework the convergent hypotheses of Mirande (2019), Cucalón, Tan (2022), and Ferreira *et al*. (2024).

i. Yellowish to orangish fins

All species of *Inpaichthys* exhibit yellowish or orangish fins, particularly in males. This characteristic is less pronounced in *I. kerri*, particularly noticeable in its lightly pigmented pelvic fin (Fig. 5). Among *Nematobrycon* species, this condition varies; while present in *N. palmeri* Eigenmann, 1911, *N. lacortei* Weitzman & Fink, 1971 displays pinkish or reddish fins. In Rhoadsiini (*sensu* Mirande, 2019), a similar pattern of fin coloration is observed.

ii. Bluish-purple iridescence on lateral body

All species of *Inpaichthys* and *Nematobrycon* exhibit a bluish-purple iridescence along the lateral of their bodies. In *I. nambiquara*, this pattern is notably less intense, yet some specimens may exhibit such iridescence above the base of the anal fin (Fig. 7). Although bluish iridescence has independently evolved in various lineages of Characidae (*sensu* Mirande, 2019), such as in Stevardiinae (*Boehlkea* Géry, 1966, *Cyanogaster* Mattox Britz, Toledo-Piza & Marinho, 2013, *Diapoma* Cope, 1894, *Glandulocauda* Eigenmann, 1911, and *Mimagoniates* Regan, 1907), Heterocharacinae (*Heterocharax* Eigenmann, 1912), and Stethaprioninae (*Paracheirodon* Géry, 1960) and in some species of *Hyphessobrycon* (*e.g.*, *H. columbianus* Zarske & Géry, 2002, *H. margitae* Zarske & Géry, 2016, and *H. wadai* Marinho, Dagosta, Camelier & Oyakawa, 2016), none of them have been proposed to be related to the *Inpaichthys* + *Nematobrycon* clade (cf. Mirande, 2019; Ferreira *et al.*, 2024). Therefore, this coloration pattern could be interpreted as an additional morphological character supporting a close relationship between *Inpaichthys* and *Nematobrycon*.

iii. Length of the posterior rays of the anal fin

Some species within the *Inpaichthys* + *Nematobrycon* + Rhoadsiini clade exhibit relatively elongated posterior anal-fin rays compared to other tetras, extending to the ventral procurrent rays and, in some cases, even reaching the principal caudal-fin rays of the ventral lobe. This pattern is not observed in *I. kerri* but is evident in well-developed individuals of *I. nambiquara* (see Fig. 7) present, albeit more subtly, in *I. luizae*,

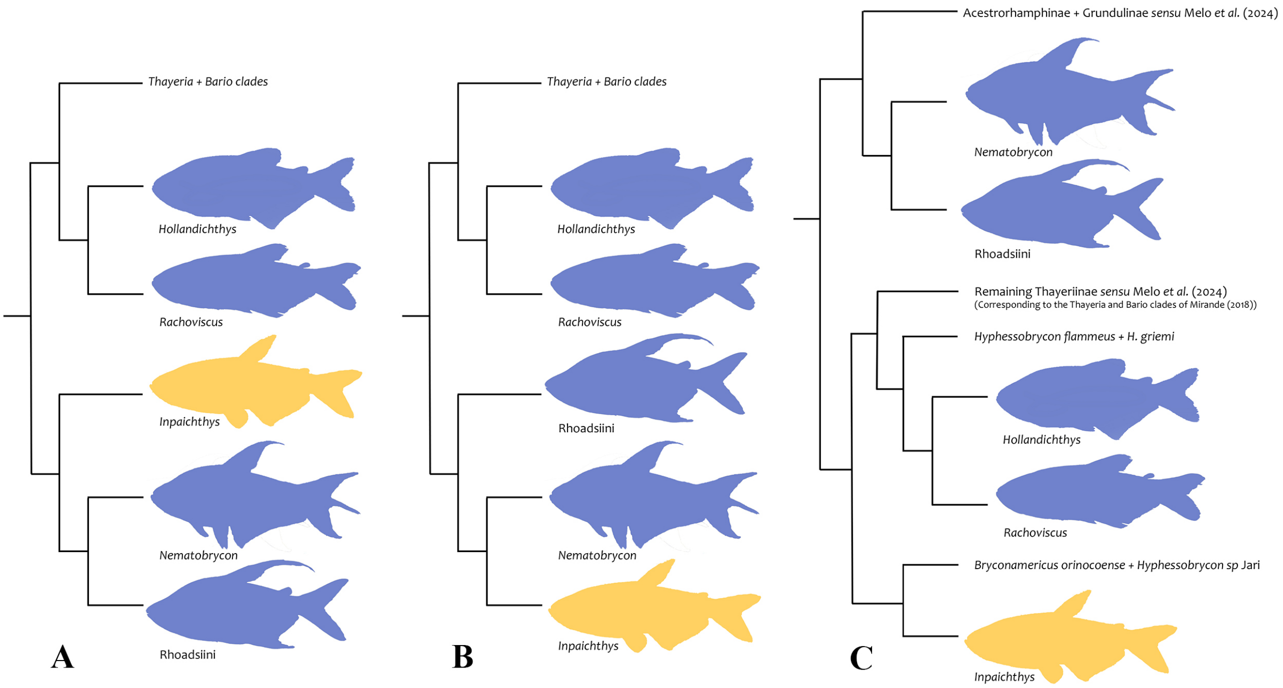

FIGURE 6 | Hypotheses on the phylogenetic relationships of *Inpaichthys* in the most recent publications: **A.** Mirande (2019), Cucalón, Tan (2022); **B.** Ferreira *et al.* (2024); **C.** Melo *et al.* (2024).

FIGURE 7 | Live specimen of *Inpaichthys nambiquara*, MZUSP uncatalogued, male. White arrows indicate bluish iridescence on lateral body and black arrow shows elongated posterior anal-fin rays reaching procurrent rays.

I. parauapiranga, and in other three undescribed species of the genus (FCPD, 2014, pers. obs.). Both species of *Nematobrycon* prominently display this trait. Among Rhoadsiini, the condition is either subtle or absent in *Rhoadsia* and *Parastremma* Eigenmann, 1912, whereas *Carlana eigenmanni* (Meek, 1912) and all four species of *Pseudochalceus* clearly exhibit it. Other lineages consistently recovered as closely related to this group, such as *Hollandichthys* Eigenmann, 1909 + *Rachoviscus* Myers, 1926 (cf. Mirande, 2019; Ferreira *et al*., 2024), also present this condition, rendering the evolutionary interpretation of this trait more complicated. Bertaco, Malabarba (2013) described the elongation of the posterior anal-fin rays in *Hollandichthys* as a synapomorphic modification for the genus. While *Hollandichthys* indeed exhibits an anterior constriction of the anal-fin rays, its homology with similar traits in other species remains uncertain, as relatively closely related groups exhibit conditions that, while morphologically similar, are not necessarily identical.

iv. Absence of adipose fin

Inpaichthys luizae is one of the few species of Characidae (*sensu* Mirande, 2019) exhibiting polymorphism in the presence of the adipose fin (Fig. 8). Dagosta *et al.* (2022) list eight tetra species that show variation in the presence or absence of this fin. *Inpaichthys luizae* falls into the "most specimens with an adipose fin" category, alongside four species of *Hyphessobrycon*. The compilation of Dagosta *et al.* (2022) highlights the rarity of this polymorphism, suggesting it may hold phylogenetic significance. Notably, while the absence of an adipose fin is generally uncommon among tetras, within the *Inpaichthys* + *Nematobrycon* + Rhoadsiini clade (cf. Mirande, 2019; Ferreira *et al*., 2024), it occurs in *I. nambiquara*, both *Nematobrycon* species, and as a polymorphic trait in *I. luizae*. Whether this pattern is merely coincidental or holds deeper significance remains uncertain and requires further investigation.

FIGURE 8 | Juvenile specimen of *Inpaichthys luizae* (MUBIO 691, 23.3 mm SL) lacking adipose fin.

Biogeographic comments. Under the hypothesis proposed by Melo *et al.* (2024), little biogeographic information can be inferred, as *Inpaichthys* would be associated with other species from the crystalline shield (*Bryconamericus orinocoensis* and *Hyphessobrycon* sp. Jari). In contrast, the hypotheses of Mirande (2019), Cucalón, Tan (2022), and Ferreira *et al.* (2024), which suggest a close evolutionary relationship between *Inpaichthys*, *Nematobrycon*, and Rhoadsiini, may carry significant biogeographic implications. Both *Nematobrycon* and the Rhoadsiini lineages occur only in Andean region, whereas *Inpaichthys* is endemic to the uplands of the northwestern edge of the Brazilian shield, draining into the Amazon by the Aripuanã and Tapajós drainages. At least two other monophyletic lineages exhibit a similar allopatric pattern: *Lebiasina* and *Astyanacinus*. The genus *Lebiasina* Valenciennes, 1847 is predominantly diversified in the Andean slopes, with only a few exceptions such as *Lebiasina yepezi* Netto-Ferreira, Oyakawa, Zuanon & Nolasco, 2011, found in the upper rio Negro, rio Branco, and rio Orinoco in the Guiana Shield (Netto-Ferreira *et al.*, 2011), and three *Lebiasina* species endemic to the rio Curuá basin in the Serra do Cachimbo, also on the northwestern edge of the Brazilian shield (Netto-Ferreira, 2012). Other case is *Astyanacinus* (*sensu* Dagosta, 2011), whose diversity is predominantly Andean but with records of *Astyanacinus moori* on the western edge of the Brazilian shield, drained by the headwaters of the rio Paraguay and a record in the northwestern edge of the Brazilian shield (a new species from the rio Jamanxim basin, FCPD, pers. obs.).

The three lineages are not closely related, but the biogeographic homology of their distribution pattern should be investigated using molecular approaches, whose dating may confirm whether they share a convergent spatial distribution driven by the same geomorphological events. These lineages conform to the pattern described by Lima, Ribeiro (2011) and Dagosta, de Pinna (2019), where species are restricted to the highlands surrounding the cis-Andean lowlands, predominantly around the Western Amazon. This pattern is intricately linked with the historical dynamics of the foreland basin and the uplift of the Andes and typically features rheophilic lineages adapted to swift-flowing, oxygen-rich waters.

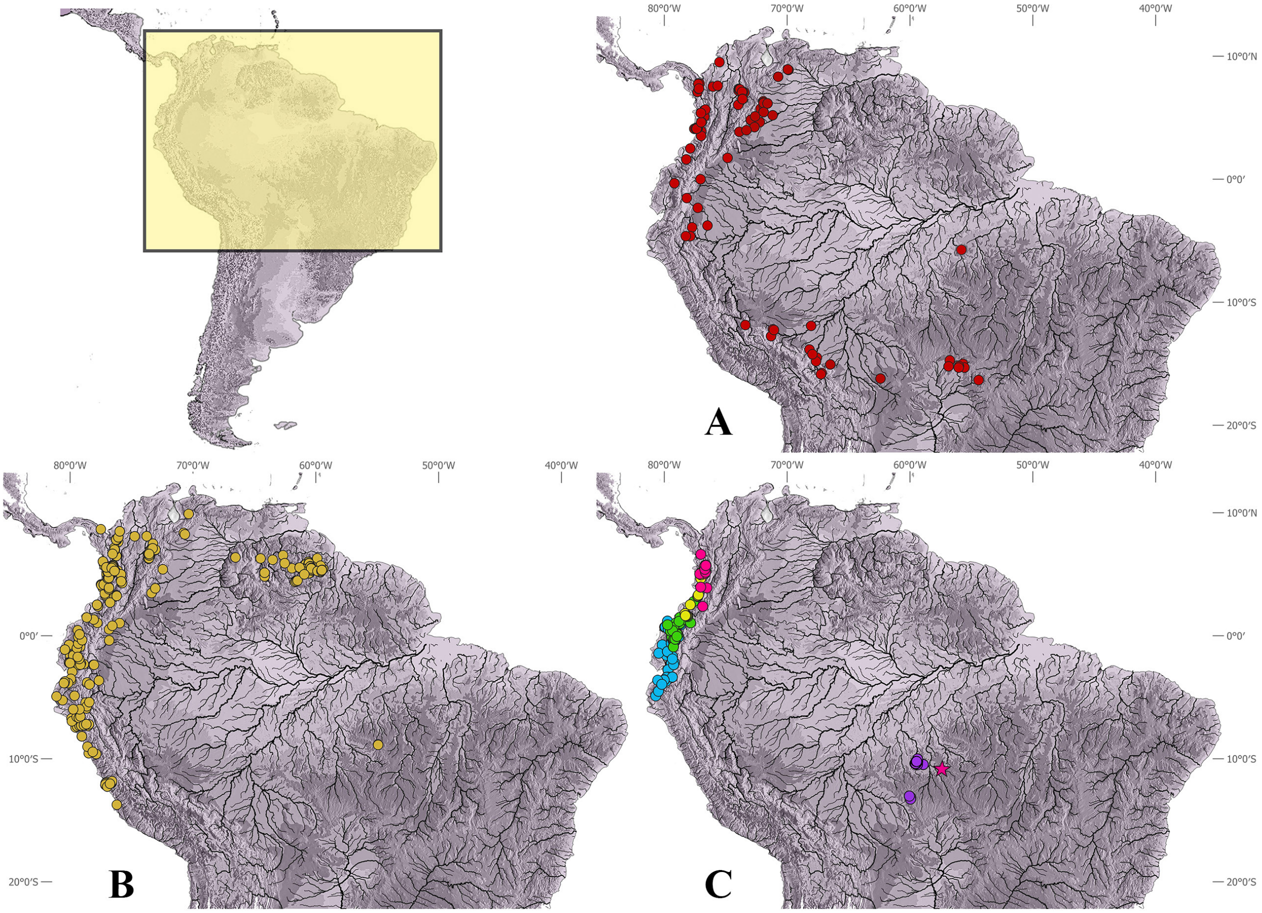

FIGURE 9 | Distributional maps of: **A.** *Astyanacinus* spp.; **B.** *Lebiasina* spp.; **C.** *Inpaichthys* spp. (purple), *Nematobrycon* spp. (pink), *Parastremma* spp. (yellow), *Rhoadsia* spp. (blue), type-locality of *Inpaichthys luizae* (pink star).

The isolation of these records in southern Amazonia from their congeners in other uplands is remarkable (Fig. 9). Such occurrences lack plausible explanations for their presence other than being relictual lineages, remnants of a broader distribution that once extended continuously to the Andean foothills but subsequently became extinct in the lowland Amazon. These examples highlight the importance of shields as repositories of biodiversity, where lineages persist over geological time (Albert *et al*., 2011, 2021). Clearly, the Brazilian shield region still requires more comprehensive sampling to thoroughly grasp distribution patterns. Consequently, isolated records may be attributed in part to the incomplete understanding of the region. Nevertheless, an extensive sampling of the ichthyofauna living in the Brazilian shield may reveal new lineages closely related to species associated with the highlands of western South America, particularly those from the Andean region.

Comparative material examined. Material listed in Dagosta *et al.* (2016); *Inpaichthys kerri*, holotype, INPA 10408, 28 mm; *Inpaichthys parauapiranga*, paratypes, MUBIO 113, 5, 19.0–26.3 mm SL; ZUEC 17920, 4, 20.9–22.4 mm SL.

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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.

ETHICAL STATEMENT

Specimens were collected under a professional license for the collection of ornamental fish issued by the Secretaria do Meio Ambiente do Estado de Mato Grosso (SEMA/MT), license nº 698/2024–2025 and registered in the RGP/MPA (MTPA92778046100, 52813.100046/2018–06). Specimens were sent to me alive and, following acclimation and in vivo color pattern documentation, were euthanized using eugenol (clove oil) at a concentration of 200 mg/L.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the author upon reasonable request.

COMPETING INTERESTS

The authors declare no competing interests.

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