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Hidden in the rapids: a new species of *Leporinus* (Characiformes: Anostomidae) endemic to the Xingu River basin, Brazil

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A new species of anostomid endemic to the Xingu River basin, Brazil, is described. Originally discovered during ecological surveys in the Volta Grande do Xingu, the species is formally recognized based on an integrated analysis of external morphology, osteology, and molecular data. Sixty specimens were examined, including cleared and stained material. Diagnostic features include eight elongated horizontal midlateral blotches, 14 transverse dorsal bars, three premaxillary teeth and four dentary teeth, 16 scale rows around the caudal peduncle. Osteological examination revealed fused fourth and fifth infraorbitals and a small ventral expansion of the antorbital, latter not previously documented in other anostomids. Species delimitation methods (ASAP and PTP) using DNA barcoding consistently supported the new species as a distinct lineage, with genetic distances ranging from 2 to 3% relative to the closest congeners (*L. nigrotaeniatus*, *L. vanzoi*, *L. unitaeniatus*, *L. sidlauskasi*). The species inhabits shallow rapids with rocky and sandy substrates, feeding predominantly on aquatic insect larvae, supplemented by benthic invertebrates, and plant material. Despite environmental pressures from hydropower development and mining, the new species is widely distributed in the basin and is suggested as Least Concern (LC) under IUCN criteria.

Keywords: Amazon, DNA Barcode, Osteology, Taxonomy.

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Uma nova espécie de anostomídeo endêmica da bacia do rio Xingu, Brasil, é descrita. Originalmente descoberta durante levantamentos ecológicos na Volta Grande do Xingu, a espécie é formalmente reconhecida com base em uma análise integrativa de morfologia externa, osteologia e dados moleculares. Foram examinados 60 exemplares, incluindo material diafanizado. Entre as características diagnósticas destacam-se: oito manchas horizontais alongadas na linha média lateral, 14 barras dorsais transversais, três dentes pré-maxilares e quatro dentes no dentário, 16 séries de escamas ao redor do pedúnculo caudal. O estudo osteológico relevou a fusão do quarto e quinto infraorbitais, e uma pequena expansão ventral do antorbital, esta última ainda não descrita em outros anostomídeos. As delimitações de espécies (ASAP e PTP) usando o DNA Barcode confirmaram a espécie nova como uma linhagem distinta, com distâncias genéticas variando entre 2 e 3% em relação às congêneres mais próximas (*L. nigrotaeniatus*, *L. vanzoi*, *L. unitaeniatus*, *L. sidlauskasi*). A espécie habita corredeiras rasas com substratos rochosos e arenosos, alimentando-se predominantemente de larvas de insetos aquáticos, complementadas por invertebrados bentônicos e material vegetal. Apesar das pressões ambientais relacionadas a hidrelétricas e mineração, a espécie nova apresenta ampla distribuição na bacia é sugerida como Pouco Preocupante (LC), segundo os critérios da IUCN.

Palavras-chave: Amazônia, DNA Barcode, Osteologia, Taxonomia.

INTRODUCTION

The Anostomidae is one of the most diverse families within the order Characiformes, comprising approximately 152 valid species allocated into 17 genera (Fricke *et al*., 2026). Members in this family play an important role in both commercial and subsistence fisheries across most South American countries, occurring in a wide range of freshwater environments, including lentic (lakes and ponds) and lotic systems, including large rivers and small streams (Santos, Jegu, 1996; Zuanon, 1999). The phylogenetic relationships within Anostomidae have been extensively investigated based on morphological evidence (Winterbottom, 1980; Sidlauskas, Vari, 2008; Panzeri *et al*., 2026), and molecular data or both combined (Ramirez *et al*., 2016, 2017a,b; Sidlauskas *et al*., 2022, 2025). Despite recent advances in the classification of the group, the genus *Leporinus* Agassiz, 1829 remains a paraphyletic and heterogenous assemblage (Sidlauskas *et al*., 2025) with species exhibiting considerable diversity in body size, mouth position, and coloration pattern (Sidlauskas, Vari, 2008; Birindelli, Sidlauskas, 2017).

The Xingu River is remarkable for its intricate network of interlaced channels, which range in width from a few meters to several kilometers. This geomorphological complexity provides a high degree of habitat heterogeneity, encompassing environments from calm backwaters to fast-flowing rapids. One of the most prominent features is the Volta Grande do Xingu, located in the middle section of the river (Fitzgerald *et al*., 2018; Montag *et al*., 2025). This region is part of an extensive system of rapids and islands, with channels flowing through fractures in the rocks of the Brazilian Shield, culminating in rapids and waterfalls (Sawakuchi *et al*., 2015).

The ichthyofauna of the Xingu river basin comprises approximately 821 species (Jézéquel *et al*., 2020), of which 26 belong to the family Anostomidae, distributed across 13 genera. At least three of these are apparently endemic to the rapids of the Xingu River, including *Hypomasticus torrenticola* (Birindelli, Teixeira & Britski, 2016), *Sartor respectus* Myers & Carvalho, 1959, and *Leporinus julii* Santos, Jégu & Lima, 1996. The genus *Leporinus* is the most species-rich in the basin, with 12 species recorded. In 1999, Zuanon investigated the ecology of the anostomid assemblage in the Volta Grande with extensive sampling of the fish fauna associated with the rapids. During this study, Zuanon (1999) identified a putative undescribed species of *Leporinus* of small size (Fig. 1). However, the description of this species was postponed due to the limited availability of specimens.

The Belo Monte dam was constructed in the Volta Grande area of the Xingu River between 2011 and 2016. During this period, intensified sampling efforts across the Xingu River basin yielded a substantial amount of material, including new specimens of the undescribed species of *Leporinus* first identified by Zuanon (1999). The aim of the present study is to describe this new species, based on evidence from external morphology, osteology, and DNA data, provide a diagnosis that distinguishes it from congeners, and investigate its geographical distribution.

MATERIAL AND METHODS

Morphological analyses. A total of 60 individuals deposited in scientific collections were examined. Institutional abbreviations for scientific collection follow Sabaj (2026). Counts and measurements were taken according to Britski, Garavello (1978) and Winterbottom (1980). Standard length (SL) is expressed in millimeters (mm) whereas all other measurements are expressed as percentages of SL, except for head measurements, which are expressed as percentages of head length (HL). Meristic data are provided in the species description, with the frequency of each count given in parentheses after the respective value. An asterisk indicates counts of the holotype. Measurements are summarized as minimum, maximum, mean, and standard deviation. Three specimens (73.8 mm, 97.0 mm, 110.5 mm SL) were cleared and stained (c&s) following the protocol of Taylor, Van Dyke (1985), dissected, and photographed using a DFC295 digital camera mounted on a Leica M205A stereomicroscope. Images were edited and assembled into plates using image editing software. Osteological characters descriptions follow Sidlauskas *et al*. (2022).

Molecular analyses. Genomic DNA was extracted from muscle tissue using the Wizard Genomic DNA Purification kit (Promega). The region of interest was amplified with the GoTaq Master Mix Kit (Promega) following the manufacturer's protocol. Using the polymerase chain reaction (PCR), a fragment of approximately 640 bp of the mitochondrial cytochrome c oxidase gene subunit 1 (COI) (Herbert *et al*., 2003), was amplified with primers FishF1 and FishR1 (Ward *et al*., 2005). Each PCR product was verified by agarose gel electrophoresis, purified with ExoSAP (GE Healthcare®), and sequenced in both directions using the BigDye Terminator v. 3.1 (Applied Biosystems®). Sequencing was performed on an ABI Prism 3500 XL Genetic Analyzer (Applied Biosystems®).

In this study, we generated four sequences of the new species and four sequences of *Leporinus geminis* Garavello & Santos, 2009. Additionally, we included one sequence each of *L. affinis* Günther, 1864, *L. jatuncochi* Ovchynnyk, 1971, *L. pearsoni* Fowler, 1940, and *L. sidlauskasi* Britski & Birindelli, 2019; two sequences of *L. britskii* Feitosa, Santos & Birindelli, 2011, *L. fasciatus* (Bloch, 1794), *L. nigrotaeniatus* Jardine, 1841and *L. vanzoi* Britski & Garavello, 2005; three sequences of *L. cylindriformis* Borodin, 1929 and *L. oliveirai* Ito, Souza-Shibatta, Venturieri & Birindelli, 2023; five sequences of *L. geminis* and *L. unitaeniatus* Garavello & Santos, 2009; and one sequence of *L. friderici* as the outgroup, all retrieved from GenBank. Accession numbers are provided in Tab. 1.

TABLE 1 | Access information for the COI sequences from GenBank used in this study, for the species delimitation analysis of *Leporinus*, and additional information for each voucher specimen.

Species	Locality	Voucher number	Tissues	GeBank accesion	References
Leporinus affinis	Araguaia River	LBP 12699	43693	KY524537	Sidlauskas *et al.* (2025)
Leporinus britskii	Tapajós River	LBP 14158	59221	PQ650300	Sidlauskas *et al.* (2025)
Leporinus britskii	Tapajós River	LBP 14214	59375	PQ650301	Sidlauskas *et al.* (2025)
Leporinus cylindriformis	Upper Xingu	LBP 15940	65660	PQ650303	Sidlauskas *et al.* (2025)
Leporinus cylindriformis	Uatumã River	MZUEL 10210	56	OR497014	Ito *et al.* (2023)
Leporinus cylindriformis	Uatumã River	MZUEL 10210	57	OR497015	Ito *et al.* (2023)
Leporinus fasciatus	Guiana	MHNG	GF15-106	MZ050948	Papa *et al.* (2021)
Leporinus fasciatus	Suriname	MHNG 2717	SU08-342	PQ650309	Sidlauskas *et al.* (2025)
Leporinus friderici	Suriname	MHNG 2718	SU08-655	MZ051034	Papa *et al.* (2021)
Leporinus geminis	Araguaia River	GEPEMA	5530	KF568984	Ramirez *et al.* (2016)
Leporinus geminis	Tocantins River	MZUEL 20675	79	PZ713665	Present study
Leporinus geminis	Tocantins River	MZUEL 20675	82	PZ713664	Present study
Leporinus geminis	Tocantins River	MZUEL 20675	153	PZ713663	Present study
Leporinus geminis	Tocantins River	MZUEL 20675	162	PZ713662	Present study
Leporinus jatuncochi	Upper Amazon	OS	18325	MF285873	Burns *et al.* (2017)
Leporinus nigrotaeniatus	Guyana	USNM 403524	GY11-1-14	PQ650329	Sidlauskas *et al.* (2025)
Leporinus nigrotaeniatus	Guyana	USNM 403536	GY11-2-49	PQ650330	Sidlauskas *et al.* (2025)
Leporinus octomaculatus	Tapajós River	LBP 13249	69386	PQ650332	Sidlauskas *et al.* (2025)
Leporinus octomaculatus	Upper Tapajós	MZUEL 7918	5	OR497018	Ito *et al.* (2023)
Leporinus oliveirai	Upper Tapajós	MZUEL 20844	2	OR497010	Ito *et al.* (2023)
Leporinus oliveirai	Upper Tapajós	MZUEL 20844	3	OR497011	Ito *et al.* (2023)
Leporinus oliveirai	Upper Tapajós	MZUEL 20844	1	OR497012	Ito *et al.* (2023)
Leporinus pearsoni	Upper Amazon	ANSP	180841	MF285874	Burns *et al.* (2017)
Leporinus sidlauskasi	Tapajós River	MZUEL 21738	4186	OR497013	Ito *et al.* (2023)
Leporinus tigrinus	Xingu River	INPA-LIA	4639	PP506336	Boaretto *et al.* (2024)
Leporinus tuirae	Xingu River	LIA 8171	8408	PZ709662	Present study
Leporinus tuirae	Xingu River	LIA 8171	8409	PZ709661	Present study
Leporinus tuirae	Xingu River	LIA 8171	8410	PZ709660	Present study
Leporinus tuirae	Xingu River	LIA 8171	8411	PZ709659	Present study
Leporinus unitaeniatus	Araguaia	GEPEMA	5549	KF569000	Ramirez *et al.* (2016)
Leporinus unitaeniatus	Tocantins River	MZUEL 20674	81	OR497030	Ito *et al.* (2023)
Leporinus unitaeniatus	Tocantins River	MZUEL 20674	83	OR497031	Ito *et al.* (2023)
Leporinus unitaeniatus	Tocantins River	MZUEL 20937	118	OR497032	Ito *et al.* (2023)
Leporinus unitaeniatus	Tocantins River	MZUEL 20674	80	OR497029	Ito *et al.* (2023)
Leporinus vanzoi	Tapajós River	MZUEL 8009	8009	OR497028	Ito *et al.* (2023)
Leporinus vanzoi	Tapajós River	LBP 16476	67482	PQ650345	Sidlauskas *et al.* (2025)

Sequences were edited using Geneious v. 7.1.4 (Kearse *et al*., 2012) and aligned with MUSCLE (Edgar, 2004) under default parameters. Substitution saturation was evaluated by the method (Xia *et al*., 2003), in the software DAMBE v. 7.1.4 (Xia, 2017). The best-fitting nucleotide substitution model was selected with ModelFinder (Kalyaanamoorthy *et al*., 2017) according to the Bayesian Information Criterion (BIC). Phylogenetic inference was conducted under Maximum Likelihood (ML) with 1,000 ultrafast bootstrap replicates (Nguyen *et al*., 2015), implemented in IQ-TREE v. 1.5.5 (Nguyen *et al*., 2015). Genetic distances (overall mean, interspecific, and intraspecific) were estimated with 1,000 pseudoreplicates in Mega v. 12 (Kumar *et al*., 2024), using the TN+G4 (Tamura-Nei 1993 + Gamma, 4 categories), best-fit model available in ModelFinder. Species delimitation analyses included two approaches: ASAP (Assemble Species by Automatic Partitioning) (Puillandre *et al*., 2021), performed through the graphical interface of iTaxoTools (https://itaxotools.org/index.html) (Vences *et al*., 2021) under the K2P model, and the Bayesian implementation of the Poisson Tree Processes (bPTP) (Zhang *et al*., 2013), using the best ML tree as input with default parameters. All delimitation analyses (ASAP, PTP, and genetic distances) were conducted excluding the outgroup *L. friderici*.

RESULTS

Leporinus tuirae, new species

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(Figs. 1–7; Tab. 2)

Leporinus "sp2". —Zuanon, 1999:87–90 (brief description of the species, species illustration, and ecological notes). —Buckup *et al*., 2011:173, figs. 7–8E (species citation and illustration in live).

Holotype. MZUSP 94466, 1 alc, 81.8 mm SL, Mato Grosso, Canarana, rio Coronel Vanick, tributary of rio Sete de Setembro, c.58 km from Canarana, on road MT-120, 13°33'32"S 52°33'51"W, 18 Oct 2004, O. T. Oyakawa, C. R. Moreira, J. L. Birindelli, M. I. Landim, J. C. Nolasco, A. Oliveira & A. Datovo.

Paratypes. All from Brazil, Xingu River basin. LBP 31058, 2 alc, 100.0–106.9 mm SL; LIA 8151, 18 alc, 79.0–112.3 mm SL + 1 c&s, 73.8 mm SL; MZUEL 21721, 1 alc, 121.5 mm SL + 2 c&s, 93.2–110.5 mm SL; MZUEL 21722, 1 alc, 108.2 mm SL; MZUSP 126735, 2 alc, 90.7–111.1 mm SL; ZUEC-PIS 17447, 1 alc, 107.6 mm SL, Pará, Vitória do Xingu, Xingu River at Canal of the Fish Transposition System at the Pimental Dam, 03°43'92.9"S 51°93'92.2"W, 8 Oct 2021, J. B. Santos. LIA 1165, 1 alc, 64.2 mm SL, Pará, São Felix do Xingu, Xandai above São Felix do Xingu, 06°89'32"S 52°03'73"W, 19 Feb 2015, L. M. Sousa, A. Gonçalves & C. Martins. LIA 1196, 3 alc, 54.5–64.6 mm SL, Pará, São Felix do Xingu, 07°13'21"S 52°50'00"W, 19 Feb 2015, L. M. Sousa, A. Gonçalves & C. Martins. LIA 1264, 3 alc, 77.8–89.6 mm SL, Pará, São Felix do Xingu, Xandai above São Felix do Xingu, 08°09'00"S 52°03'03"W, 19 Feb 2015, L. M. Sousa, A. Gonçalves & C. Martins. LIA 1309, 1 alc,

FIGURE 1 | Holotype of *Leporinus tuirae*, MZUSP 94466, 81.8 mm SL.

67.1 mm SL, Pará, São Felix do Xingu, 00°89'00"S 52°03'03"W, 19 Feb 2015, L. M. Sousa, A. Gonçalves & C. Martins. LIA 1328, 1 alc, 76.1 mm SL, Pará, São Felix do Xingu, Xingu onça, 07°12'42"S 52°50'44"W, 19 Feb 2015, L. M. Sousa, A. Gonçalves & C. Martins. LIA 1483, 2 alc, 62.4–62.8 mm SL, Pará, São Felix do Xingu, Xingu River at Araraquara, 06°55'44"S 52°11'19"W, 4 Mar 2015, L. M. Sousa, A. Gonçalves & C. Martins. LIA 6579, 1 alc, 102.7 mm SL, Pará, Vitória do Xingu, Xingu River, 03°10'52"S 51°71'37"W, 28 Apr 2013, UFPA/Belém monitoring team. LIA 6800, 1 alc, 48.7 mm SL, Pará, Altamira, Xingu River at Bom Jardim community, 03°21'02"S 52°21'25"W, 12 Feb 2016, A. Gonçalves & M. Dayane. LIA 7013, 1 alc, 83.3 mm SL, Pará, Vitória do Xingu, Xingu River at Fish Transposition System at the Pimental dam, 03°43'94"S 51°93'91"W, 26 Sep 2018, BIOS Team. INPA-ICT 30862, 2 alc, 39.90–61.3 mm SL, Pará, Altamira, mouth of the Iriri River, 03°81'50"S 52°61'91"W, 15 Aug 2008, H. López-Fernandez. MZUSP 88041, 1 alc, 85.0 mm SL, Mato Grosso, Canarana, Culuene River, 13°33'32"S 52°33'51"W, 19 Oct 2004, O. T. Oyakawa, J. L. Birindelli, C. R. Moreira, A. Akama, L. M. Sousa & H. Varella. MZUSP 94468, 1 alc, 72.8 mm SL, Mato Grosso, Gaúcha do Norte, 13°02'05"S 53°25'19"W, 19 Oct 2004, C. R. Moreira, M. I. Lamdin, A Datovo & C. Oliveira. MZUSP 108794, 1 alc, 87.4 mm SL, Mato Grosso, Campinápolis, Culuene River at Paranatinga 2, 13°49'00"S 53°15'00"W, 21 Aug 2006, J. L. Birindelli, L. M. Souza & H. Varella. MZUSP 111611, 1 alc, 48.1 mm SL, Pará, Iriri River, at the Cachoeira Grande, 03°52'08"S 52°41'52"W, 16 Nov 2011, O. T. Oyakawa, J. L. Birindelli, C. R. Moreira, A. Akama, L. M. Sousa & H. Varella.

Diagnosis. The new species of *Leporinus* is distinguished from congeners by the combination of eight dark blotches on the body (including one blotch on the opercle extending to the preopercle and six to seven horizontally elongated midlateral blotches), 14 dark transverse bars on the dorsum counted from the supraoccipital (*vs.* dark transversal bars, dark longitudinal stripes, three large midlateral dark blotches, or seven to nine rounded midlateral blotches), and the dental formula of trhree premaxillary and four dentary teeth (*vs.* 4/4). *Leporinus tuirae* differs from *L. gutattus* Birindelli & Britski, 2009, *L. microphysus* Birindelli & Britski, 2013, *L. octomaculatus* Britski & Garavello, 1993, *L. oliveirai*, and *L. unitaeniatus* by 16 scale rows around the caudal peduncle (*vs.* 12), and from *L. guttatus*, *L. microphysus*, *L. sidlauskasi*, and *L. vanzoi* by having 37 to 39 lateral-line scales (*vs.* fewer than 37 or more than 39).

Description. Morphometric data of the holotype and paratypes in Tab. 2. Small size, largest specimen examined 121.5 mm SL. Body fusiform, with depth greatly at origin of dorsal fin. Dorsal profile gently convex from tip of snout to dorsal-fin origin, gradually convex along base of dorsal fin, straight or slightly convex from end of dorsal fin to origin of adipose fin and distinctly concave on caudal peduncle. Ventral profile convex from tip of lower jaw to vertical through origin of pectoral fin, distinctly convex from this point to origin of pelvic fin, straight or slightly convex from latter point to origin of anal fin, more or less straight along anal-fin base, and distinctly concave on caudal peduncle. Mouth subterminal, with opening aligned with ventral border of orbit. Three premaxillary teeth gradually diminishing in size laterally, and all with blunt cutting edge. Four dentary teeth gradually smaller laterally, all with blunt cutting edge. Medialmost premaxillary and dentary teeth with medial and lateral ridge.

Dorsal fin ii,10*(60), to fourth scale posterior to base when depressed. Pectoral fin i,14*(4), i,15(26) or 16(23), tip four - five scales. Pelvic fin i,8*(56), to third - fourth scale anterior to anus when adpressed to body. Anal fin ii,7(21) or 8*(35), last rays to fourth - fifth scale posterior to base; posterior margin straight. Caudal fin i,8,8,i(13), i,9,8, i*(43), forked, lobes rounded, dorsal lobe slightly longer than ventral lobe. Vertebrae 36(3).

Cycloid scales, lateral line complete with 37(19), 38*(28), 39(4). Transversal series with 5(56) scale rows from dorsal-fin origin to lateral line, and 4(56) scale rows from lateral line to pelvic-fin origin. Predorsal scale series 10*(28), 11(22) or 12(6). 16*(60) horizontal scale rows around caudal peduncle.

TABLE 2 | Morphometric data of *Leporinus tuirae*. N = Number of specimens; SD = Standard deviation.

	Holotype	N	Range	Mean	SD
Standard length (mm)	81.8	60	39.9–121.5	83.6	–
Percents of standard length					
Predorsal distance	47.8	59	44.4–52.9	46.9	1.5
Dorsal-fin origin to adipose-fin origin	40.4	57	35.3–43.0	39.1	2.0
Prepelvic distance	52.4	59	47.2–57.0	51.0	1.5
Body depth	23.5	57	19.8–24.6	21.7	1.1
Caudal peduncle depth	8.7	59	7.4–9.9	8.6	0.5
Caudal peduncle length	9.6	59	7.7–16.2	11.3	2.0
Head length	25.5	59	22.4–28.9	24.5	1.4
Percents of head length					
Preopercle length	78.2	59	74.7–84.0	78.9	2.3
Snout length	43.2	59	37.1–45.8	41.9	2.1
Head depth	67.2	58	62.1–71.0	66.8	2.4
Eye diameter	25.2	58	21.2–29.5	25.4	2.2
Bony interorbital	35.6	56	30.2–37.9	35.0	1.9

Osteology. Orbital series composed of six infraorbitals, antorbital, nasal, supraorbital (Fig. 2). First infraorbital broad, rounded, plate-like ventral margin, laterosensory canal follows what is described for caracter 82 (Sidlauskas, Vari, 2008). Second infraorbital triangular, anterodorsal portion overlapped by first. Third infraorbital large, encompassing most of orbit, dorsal lamina more developed than ventral. Fourth and fifth fused, tripartite sensory canal. Sixth infraorbital small compared to the third, straight canal. Supraorbital relatively small compared to the nasal and lacks sensory canal. Nasal large, narrow, ventral lamina larger than dorsal. Antorbital relatively large, comparable to first infraorbital, shape similar to *L. fasciatus* (Sidlauskas, Vari, 2008; fig. 9, infraorbital series), horizontally flange extending ventrally to nasal opening. Small ventral bony expansion in the antorbital, overlapping dorsally first infraorbital, resembling continuation of sensory canal.

Premaxillary bone trapezoidal, bearing three unicuspid incisiform teeth, size decreasing laterally (Fig. 3A). Maxillary bone on posterolateral edge of premaxillary, oriented vertically to body axis. Dentary with four single-cusped incisor teeth, size decreasing laterally. The fourth tooth of the dentary is considerably smaller than the previous ones. Retroarticular small cup-shaped bone, attachment point for interopercular- mandibular ligament, similar to (Sidlauskas, Vari, 2008, state 0, figs. 34–39). Anguloarticular narrow, no wide vertical ridge perpendicular to dentary.

Suspensorium L-shaped, horizontal portion longer than vertical. Autopalatine rounded, bearing distinct prominent process (Fig. 3B). Ectopterygoid transverse to body axis, shape similar to *L. fasciatus* (Sidlauskas, Vari, 2008, fig. 41), *L. oliveirai* (Ito *et al*., 2023, fig. 4), *L. lignator*, and *L. bleheri* Géry, 1999 (Boaretto *et al*., 2024, figs. 6G, H). Entopterygoid with well-developed ventral triangular process, overlapping ossified medial surface of quadrate, metapterygoid, ectopterygoid, and autopalatine. Quadrate elongated and triangular. Metapterygoid dorsal to symplectic, horizontally

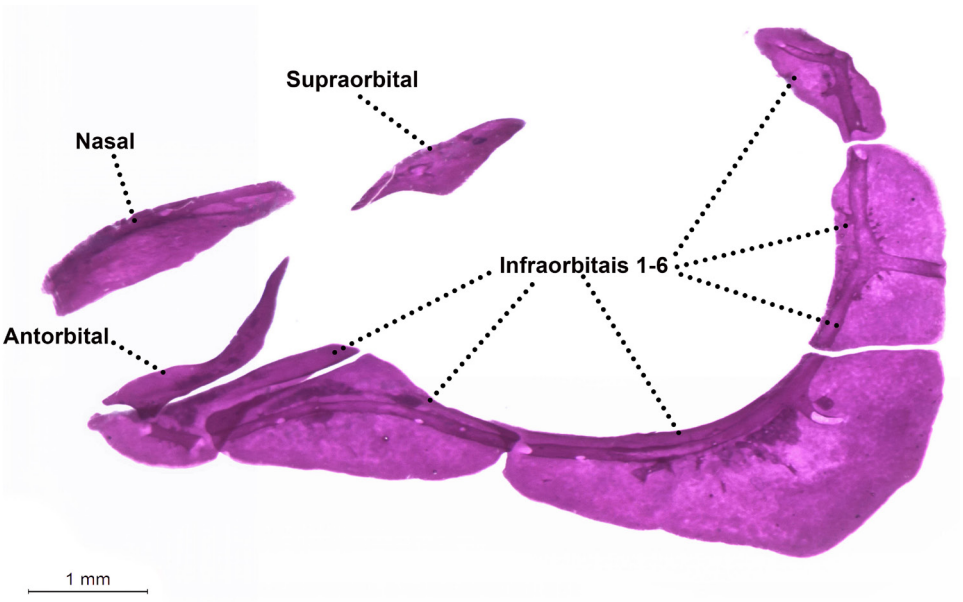

FIGURE 2 | *Leporinus tuirae*, MZUEL 21721, c&s paratype, 110.4 mm SL, detail of the infraorbital series showing the sensory canal in the antorbital.

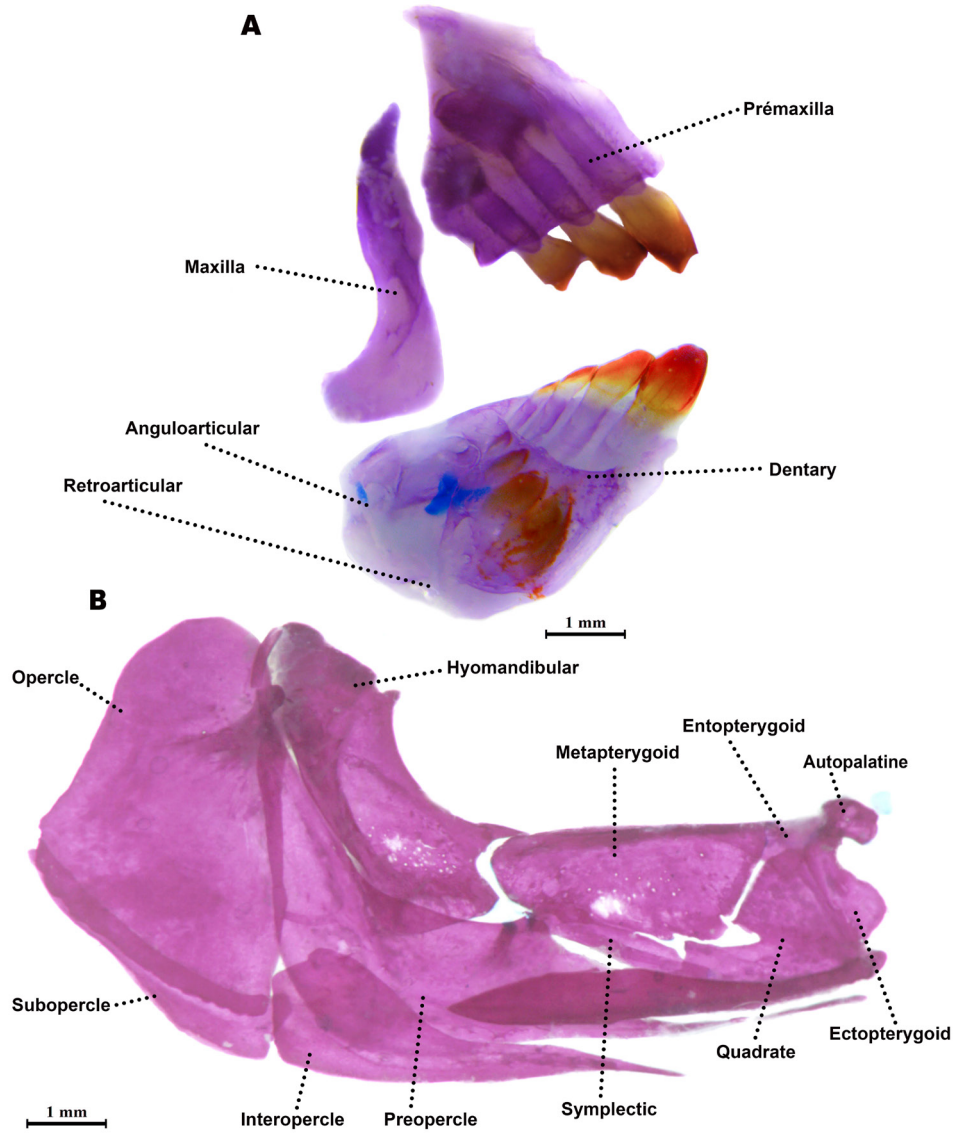

FIGURE 3 | A. Jaws of *Leporinus turiae*, including premaxillary and maxillary in lateral view, and lower jaw in medial view, and **B.** Suspensorium, MZUEL 21721, c&s paratype, 110.4 mm SL.

aligned, vertically positioned relative to dorsal quadrate; medially curved portion contacting entopterygoid. Metapterygoid-quadrate fenestra short, parallel to quadrate-metapterygoid articulation, depressions along quadrate margin resembling other *Leporinus* (Sidlauskas, Vari, 2008, fig. 41; Boaretto *et al*., 2024, figs. 6G, H), but smaller than those found in these species. Symplectic rod-shaped, located on medial face of suspensorium. Hyomandibular articulating with neurocranium via sphenotic and pterotic. Preopercle morphology similar to character 86, state 0 (Sidlauskas, Vari, 2008) anterior margin of ascending arm lacking distinct triangular process; overlapping articulation between interhyal, hyomandibula, metapterygoid, and symplectic in lateral view. Opercle slightly triangular, dorsally rounded, overlapping subopercle.

Mesethmoid triangular, with anterior portion narrow and posterior portion wide and forming anterior margin of cranial fontanel (Fig. 4). Anterior portion of mesethmoid slightly curved downward. Lateral ethmoid long, with lateral process directed posterolaterally. Frontal large, longer than wider, rectangular in shape, and joined to contralateral bone by an epiphyseal bar. Parietals broad. Supraoccipital small

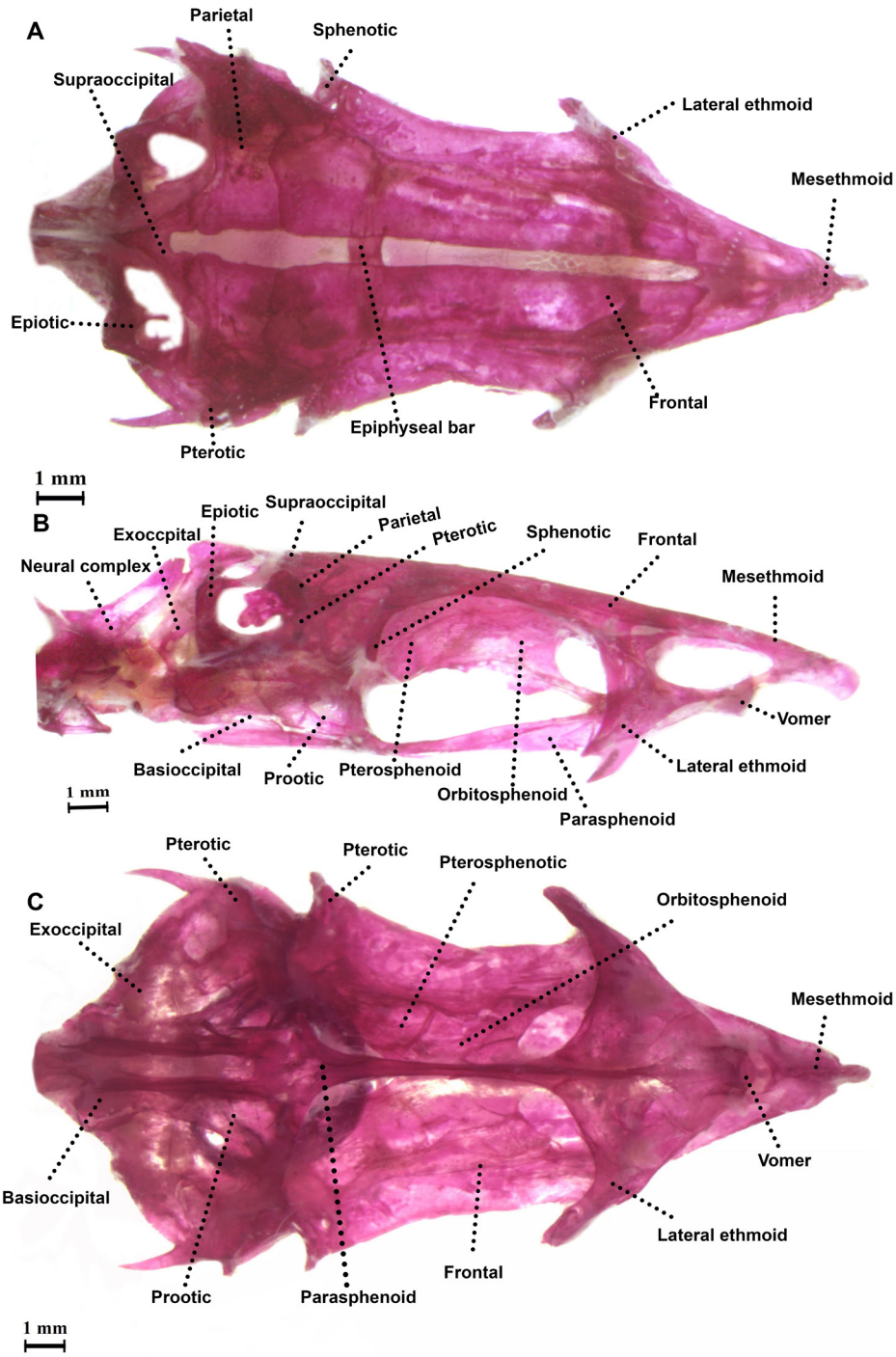

FIGURE 4 | Neurocranium bones of *Leporinus tuirae*, MZUEL 21721, c&s paratype, 93.1 mm SL. **A.** Dorsal, **B.** Lateral, and **C.** Ventral view.

and triangular. Cranial fontanel large, extended from mesethmoid to supraoccipital, and separated into two by epiphyseal bar. Sphenotic triangular, with distinct lateral process directed posterolaterally. Pterotic is located at posterolateral edge of neurocranium, with a distinct posterolateral process. Vomer triangular in ventral view, with rounded dorsal margin. Epiotic with three distinct bony bridges on posterior face of neurocranium. Exoccipital liying posterior to epiotic. Parasphenoid long and thin, extending from vomer to basioccipital. Orbitosphenoid, pterosphenoid, and prootic located dorsal to parasphenoid and ventral to frontal and parietal, forming most of medial wall of orbital cavity. Basioccipital thin and rounded, posterior to prootic and ventral to exoccipital.

Hyoid arch composed of dorsal and ventral hypohyals, anterior and posterior ceratohyals, urohyal, interhyal and four brachiostegals (Fig. 5A). Four brachiostegal rays spatula-shaped, first three articulated anterior ceratohyal, and the last with the posterior ceratohyal. Branchial apparatus includes three basibranchials, basihyal, basihyal plate, five ceratobranchials, four epibranchials, three hypobranchial and four pharyngobranchials (Fig. 5B). Basihyal elongated and connected to the first basibranchial. Basibranchials 1–3 are rod-shaped and joined by cartilage. The fourth pharyngobranchial bears a pharyngeal tooth plate with small conical teeth, associated with the fourth epibranchial. Fifth ceratobranchial possesses two complete rows of approximately 20 teeth on the pharyngeal tooth plate. The morphology of pharyngeal teeth is like that described for species of *Leporinus* (Sidlauskas, Vari, 2008).

Pectoral girdle (Fig. 5D) connected to neurocranium extrascapular, posttemporal, and pterotic. Supracleithrum large and vertically elongated. Cleithrum is robust, bearing a short posterior triangular process. Coracoid with a short, pointed posterior process. Mesocoracoid form support on posterior face of girdle, between scapula and cleithrum. Scapula exhibits a three-armed bridge morphology. Three postcleithra present and well developed. Pelvic fin bears one unbranched ray, nine branched rays, and supporting elements (radials). Ischiatic process prominent, projecting posterolaterally forming a bifurcated morphology with the opposite process (Fig. 5C). Pelvic bone (basipterygium) elongated, parallel to its homologue, triangular in shape.

Dorsal fin (Fig. 6A) with first pterygiophore largest with anterior bony expansion and supporting two unbranched rays, remaining pterygiophores connected each to a single ray. Anal fin (Fig. 6B) with nine pterygiophores, the first associated with two unbranched rays and remaning eight associated with nine branched rays. Caudal skeleton (Fig. 6C) composed of a compound centrum, pleurostyle, three epurals, two uroneurals, opistural cartilage, parhypural, and six hypurals.

Coloration in alcohol. Head and body light brown. The head bears two to three dark transverse bars. Trunk with 14 dark transverse bars on the dorsum, counted after the supraoccipital, together with eight dark blotches along the midlateral line. A dark blotch is present on the opercle, extending to the preopercle, and six to seven horizontally elongated dark blotches are distributed along the midlateral line. In some specimens, additional small dark blotches are present above and below the lateral line (Fig. 7A). Ventral surfaces of head and body pale to cream. Dorsal fin hyaline, except for last two or three rays and adjacent membranes, which are slightly darkened. Pectoral fin hyaline, except for first ray slightly darker. Adipose fin with dark distal margin. Anal and caudal fins hyaline.

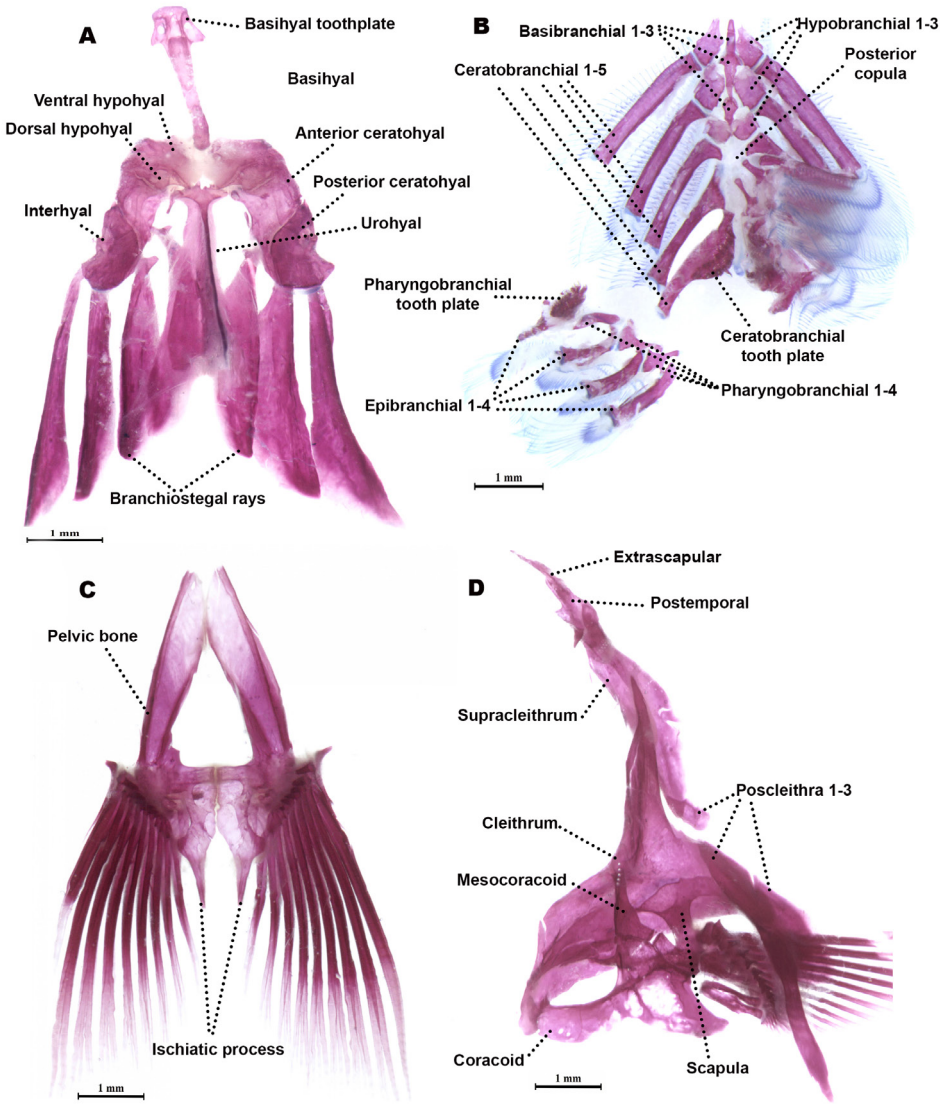

FIGURE 5 | *Leporinus tuirae*, MZUEL 21721, c&s paratype, 93.1 mm SL. **A.** Detailed view of the hyoid arch, **B.** Branchial apparatus, **C.** Pelvic fin and **D.** Pectoral fin.

Coloration in life. Coloration in life (Figs. 7B, C) is generally similar to preserved specimens, but with head and body lighter brown, operculum slightly silver with a bright yellow hue, and ventral surfaces paler. The bases of the dorsal, pectoral, pelvic and caudal fins are tinged with orange to yellow, with distal portions ranging from light yellow to completely transparent. Adipose fin exhibits an orange spot at its center.

Geographical distribution. The new species is endemic to the Xingu River, occurring in both its middle section in Pará State, and the upper portion in Mato Grosso State (Fig. 8). Recently, individuals of *L. tuirae* were also collected in the artificial lake formed by the Belo Monte hydroelectric power plant, between Pimental and Belo Monte.

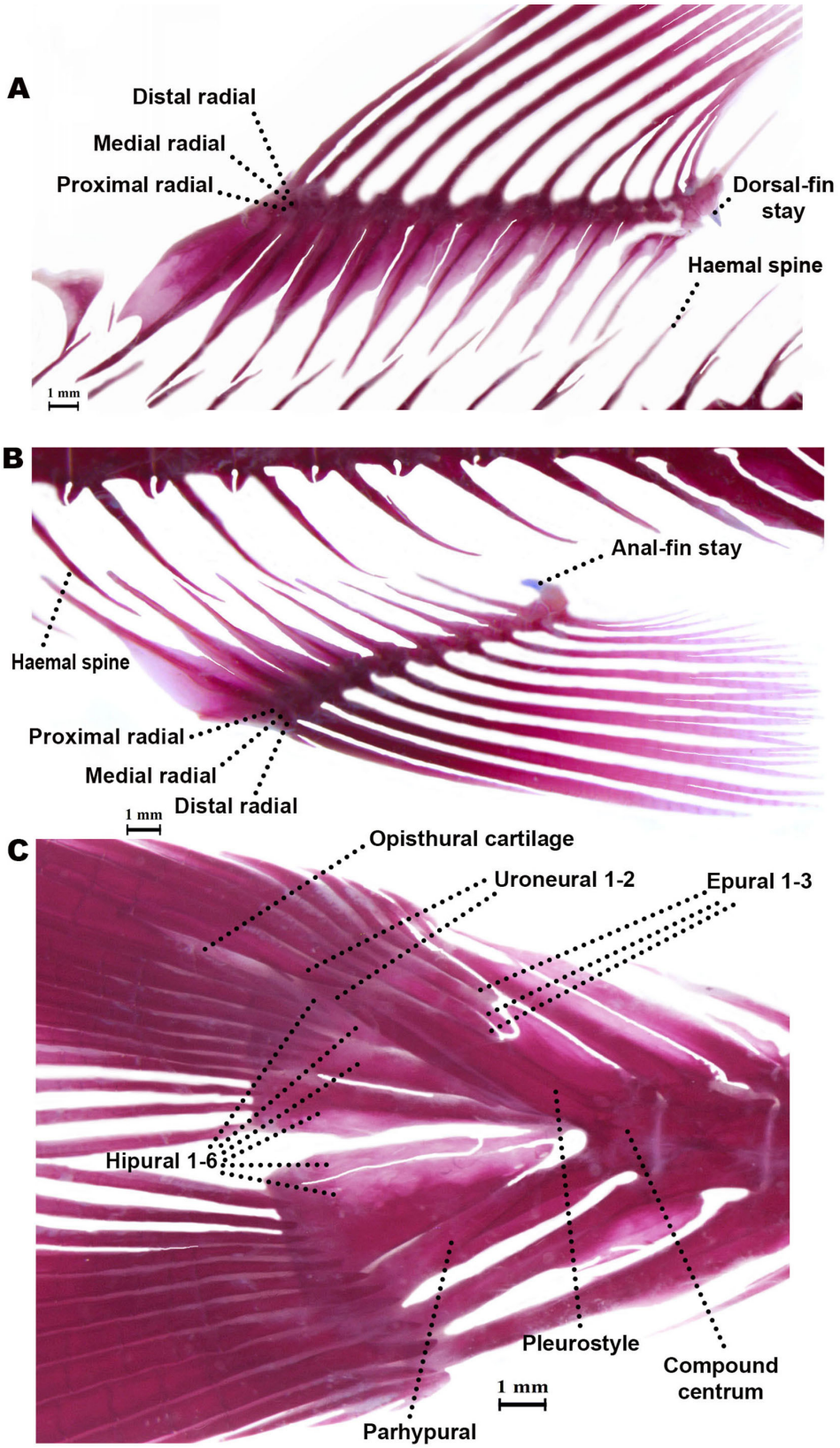

FIGURE 6 | A. Dorsal fin, **B.** Anal fin, and **C.** Caudal fin of *Leporinus tuirae*, MZUEL 21721, c&s paratype, 93.1 mm SL.

FIGURE 7 | **A.** Paratype of *Leporinus tuirae*, LIA 8151, 78.9 mm SL. Photo: Claudia Chaves. **B.** Living coloration of *L. tuirae* from the upper Xingu River. Photo: José Cezar Nolasco. **C.** Living coloration of *L. tuirae*. (uncatalogued specimen) from the middle Xingu River. Photo: Leandro M. Sousa.

Ecological notes. *Leporinus tuirae* inhabits rapids of the Xingu River (Fig. 9), where substrates are typically composed of rocky boulders, gravel and sand, and where moderate to strong currents form turbulent flows. *Leporinus tuirae* is often found at depths of 50 cm during the low-water season. It exhibits a scavenging feeding strategy (Zuanon, 1999), with a diet primarily consistent of aquatic insect larvae (Diptera). Oligochaeta and Gastropoda are also consumed, though less frequently. Additionally, grains of sand, fish scales and plant material were reported in stomach contents (Fig. 10).

Conservation status. The new species is widely distributed throughout much of the Xingu River basin. Despite recent habitat degradation, particularly from dams (UHE Belo Monte, PCH Culuene, and others) and mining projects, the species occurs within the Rio Xingu extractive reserve and indigenous territories that encompass extensive areas of its distribution. The conservation status of the species was assessed based on the criteria of the International Union for Conservation of Nature (IUCN Standards and Petitions Committee, 2024). We estimated the Extent of Occurrence (EOO) 1714,9 km^2 (B1, bi, iv) using QGIS v. 3.30.2 (QGIS, 2025) and the HydroBASINS database (Lehner, Grill, 2013), defining the minimum convex polygon as the total area of the microbasins encompassing the known distribution of the species. Therefore, at this time, we suggest that the conservation status of *Leporinus tuirae* is likely Least Concern (LC).

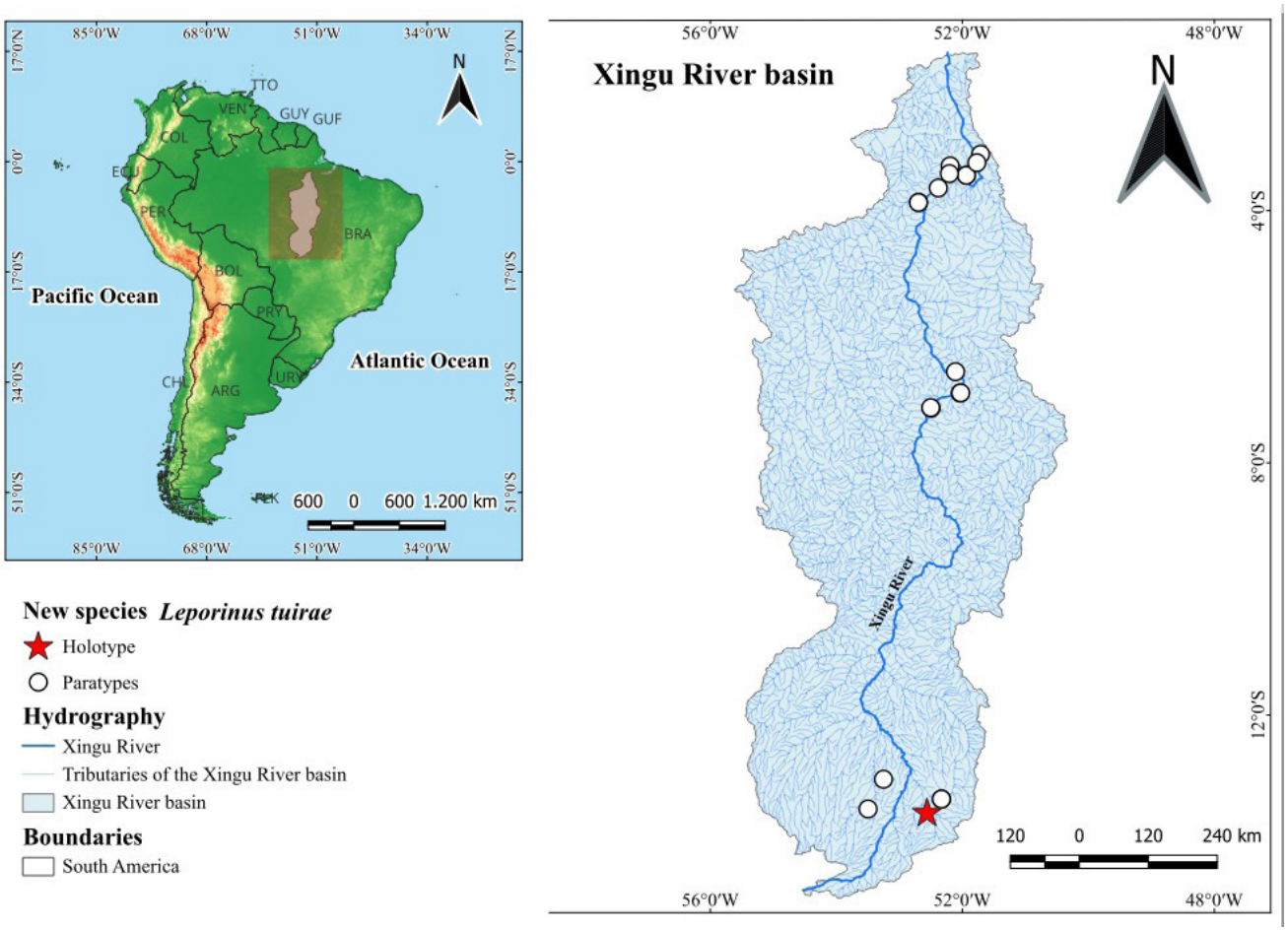

FIGURE 8 | Geographic distribution map of the new *Leporinus* species in the Xingu River basin, Brazil.

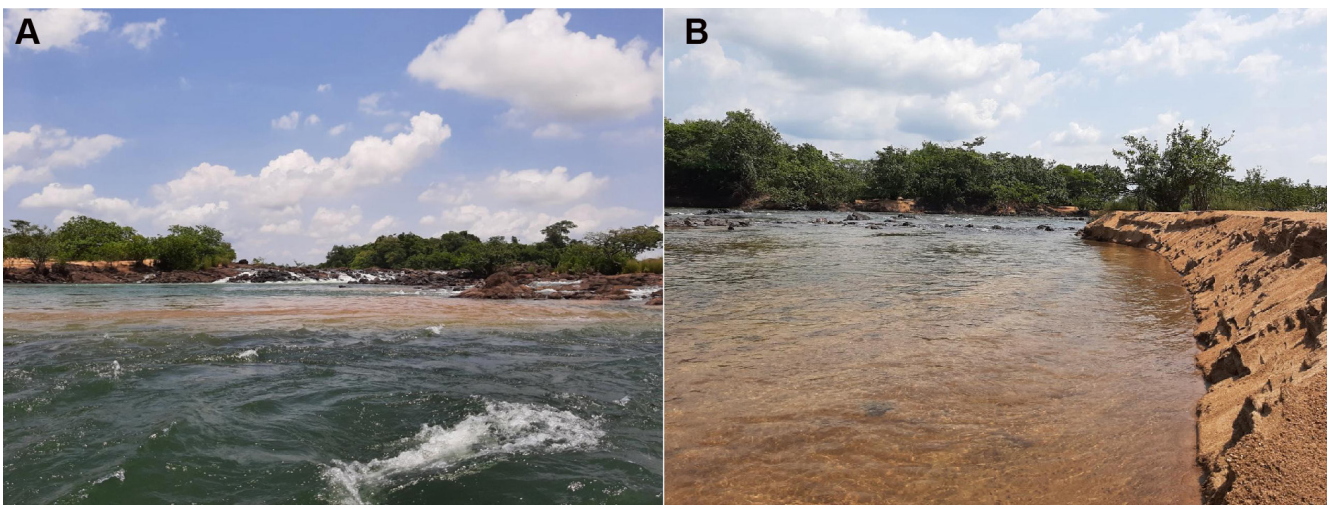

FIGURE 9 | **A.** Xingu River in Brazil, at the type locality of *Leporinus tuirae*. **B.** Collection site of the new species. The stretch of the river illustrated here is located upstream from the Belo Monte hydroelectric dam.

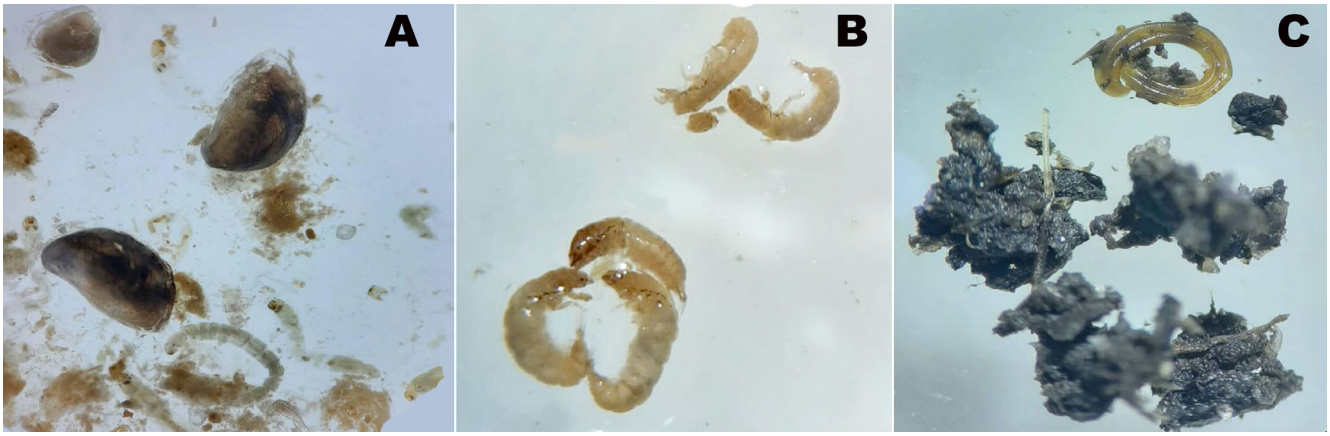

FIGURE 10 | Food items found in the stomachs of *Leporinus tuirae* analyzed. **A.** Insect larvae and gastropod, **B.** Aquatic insect larvae, **C.** Sand grains, plant remains, and nematode.

Etymology. The specific epithet honors Tuíre Kayapó Mẽbêngôkre of the Kayapó people. Tuíre Kayapó was a pioneer of female leadership in the defense of Indigenous people and their territory, and the environment. She achieved international recognition in the late 1980s when she held a machete to the face of an Eletronorte engineer in protest during a meeting in Altamira to discuss the construction of a hydroelectric complex on the Xingu River, then named Kararaô. Tuíre remains am emblematic figure of indigenous resistance. A genitive noun.

Species delimitation analyses. The final matrix comprised 584 bp with 184 variable sites. The nucleotide frequency composition obtained was A = 24.5%, C = 27.3%, G = 16.5%, and T = 31.5%. The Iss values were lower than Iss.c, indicating the absence of saturation in our dataset. The genetic distance analysis was performed using the best model, TN+G4 (Tamura-Nei 1993 + Gamma, 4 categories), with a BIC value of 5366.9296. Genetic distance analysis (Tab. 3) revealed that the smallest divergence among species was 1.8%, observed between *L. sidlauskasi* and *L. vanzoi*. All other interspecific distances among *Leporinus* examined in this study ranged from 1.8 to 15.1%. Intraspecific genetic variation ranged from 0.0 to 4.4%. The overall mean genetic distance was 9%. Between the new species and its congeners, values ranged from 2.5 to 11.9%, with the lowest divergences observed with *L. nigrotaeniatus* (2.5%), *L. vanzoi* (2.7%), *L. unitaeniatus* (2.8%), and *L. sidlauskasi* (3%). Both species delimitation analyses (ASAP and PTP, Fig. 11) recovered *L. friderici*, *L. geminis*, *L. pearsoni*, *L. britskii*, *L. tigrinus* Borodin, 1929, *L. octomaculatus*, and *L. oliveirai* as distinct and unique MOTUs (Molecular Operational Taxonomic Units). Conversely, *L. affinis* and *L. fasciatus* were grouped into the same MOTU in the PTP analysis. *Leporinus* cylindriformis was recovered as distinct MOTUs in PTP and ASAP, but clustered within the same MOTU as *L. nigrotaeniatus*, *L. vanzoi*, *L. sidlauskasi*, *L. unitaeniatus*, and the new species in PTP. In contrast, ASAP recovered these taxa in separate MOTUs. Finally, *L. unitaeniatus* and the new species were recognized as distinct MOTUs and as sister groups in the ASAP analysis.

TABLE 3 | Genetic distance based on COI gene sequences and the TN+G4 model. The values on the diagonal represent intraspecific variation (%); the values in black represent interspecific variation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. L. affinis	**n/c**														
2. L. fasciatus	4.1	**n/c**													
3. L. britskii	10.9	10.3	**0.9**												
4. L. octomaculatus	10.9	10.3	7.7	**0.6**											
5. L. cylindriformis	12.7	12.5	9.8	7.5	**4.4**										
6. L. nigrotaeniatus	11.6	11.1	9.2	6.4	3.4	**0.2**									
7. L. sidlauskasi	12.5	12.4	11.0	7.4	4.6	2.4	**0.6**								
8. L. unitaeniatus	12.8	13.5	12.0	8.0	5.5	3.2	3.5	**0.2**							
9. L. vanzoi	11.9	12.6	10.7	7.2	4.4	1.9	1.8	3.0	**n/c**						
10. L. tuirae	10.9	11.9	10.7	7.1	4.8	2.5	3.0	2.8	2.7	**0.1**					
11. L. oliveirai	9.6	9.8	8.4	2.9	8.3	7.3	8.2	8.7	8.0	7.5	**0.0**				
12. L. tigrinus	8.3	8.5	8.1	7.1	9.2	8.0	9.4	9.5	9.1	9.1	7.1	**n/c**			
13. L. jatuncochi	13.1	15.0	10.6	11.4	10.6	10.7	10.9	11.2	11.1	11.0	10.7	11.0	**n/c**		
14. L. pearsoni	13.0	12.4	9.5	10.2	12.2	11.0	12.3	13.6	12.1	12.2	10.9	10.7	10.6	**n/c**	
15. L. geminis	13.7	13.2	13.8	13.7	14.8	15.0	14.7	14.8	15.1	14.6	12.9	12.9	13.8	13.2	**0**

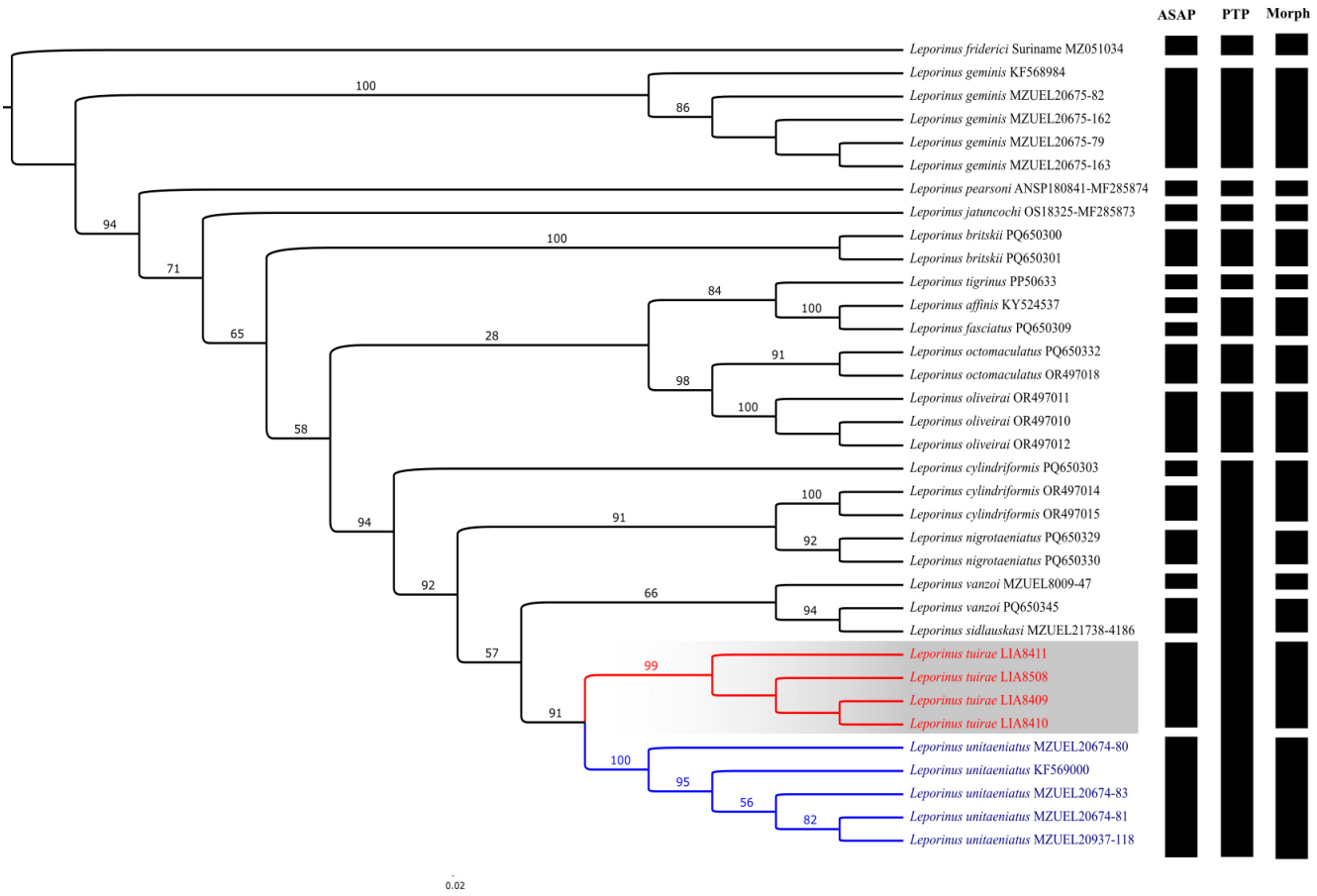

FIGURE 11 | Phylogenetic tree of *Leporinus tuirae* and related species generated by maximum-likelihood based on the COI gene sequence. Vertical bars on the left show the results of delimitation species analyses. ASAP = Assemble Species by Automatic Partitioning, PTP = Poisson Tree-Processes, Morph = morphology.

DISCUSSION

Leporinus tuirae shows morphological similarities with several congeners, such as *L. britskii* (Feitosa *et al*., 2011, figs. 1–2), *L. guttatus* (Birindelli, Britski, 2009, figs. 1–2), *L. marcgravii* (Birindelli, Britski, 2009, fig. 7C), *L. microphthalmus* (Birindelli, Britski, 2009, fig. 7D), *L. microphysus* (Birindelli, Britski, 2013), *L. octomaculatus* (Birindelli, Britski, 2009, fig. 7A), *L. oliveirai* (Ito *et al*., 2023, fig. 1), *L. sidlauskasi* (Britski, Birindelli, 2019, figs. 1–2), *L. unitaeniatus* (Fig. 12), and *L. vanzoi* (Britski, Birindelli, 2019, fig. 4), particularly in body size and coloration pattern. However, it is distinguished by the unique arrangement of dark oval and irregular blotches extending from the opercle to the end of the caudal peduncle, by the presence of three premaxillary teeth (*vs*. four in *L. vanzoi* and *L. unitaeniatus*), and by possessing 16 rows of scales around the caudal peduncle (*vs*. 12 in *L. sidlauskasi*, *L. marcgravii*, *L. microphthalmus*, *L. microphysus*, *L. octomaculatus*, *L. guttatus*, and *L. britskii*). Athough coloration is often used as an indicator of phylogenetic proximity, in *Leporinus*, it is considered a homoplastic trait (Sidlauskas, Vari, 2008; Birindelli, Britski, 2013). Interestingly, specimens from the upper Xingu River (Mato Grosso, lots MZUSP 88041, 94468, 94466, and 108794; Fig. 9) differ from type material from Altamira and São Félix do Xingu (middle course of the river) in coloration pattern, yet they agree entirely in all other diagnostic characters, reinforcing the consistency of the species.

From a genetic perspective, *L. tuirae* belongs to the "*fasciatus* clade" characterized by species with vertical bars, longitudinal stripes, or body blotches (Sidlauskas *et al*., 2025). Within this clade, the new species integrates the third unbarred subclade, which includes *L. cylindriformis*, *L. geminis*, *L. nigrotaeniatus*, *L. sidlauskasi*, *L. vanzoi*, and *L. unitaeniatus*. All these species have relatively low bodies (height ≤ 25% of standard

FIGURE 12 | A. Specimen of *Leporinus unitaeniatus* (uncatalogued specimen) in life. **B.** Specimen of *L. unitaeniatus*, ANSP 211143, 78.2 mm SL (in alcohol). Photo: Mark Sabaj.

length) and are small-sized; in *L. tuirae*, the mean body height is 21.7%. Our genetic results indicated the smallest distance between *L. nigrotaeniatus* and *L. tuirae* (2.5%), suggesting a close relationship despite their distinctiveness. Notably, *L. nigrotaeniatus* does not occur in the Xingu River basin, but rather in Negro and Branco river systems of the Amazon, and in the Essequibo, Demerara, and Berbice rivers in Guyana (Taphorn *et al*., 2022). In contrast, *L. unitaeniatus* is the sister group of *L. tuirae*, with a genetic distance of 3%, both belonging to the *L. cylindriformis* clade together with *L. nigrotaeniatus*, *L. sidlauskasi*, and *L. vanzoi* (Fig. 7). Conversely, *L. geminis* was found to be genetically more distant from *L. tuirae*, a surprising result given that both species co-occur in the Xingu basin, and that they are externally similar. However, differences in tooth morphology, body size, and body shape clearly distinguish the two species, with *L. geminis* being more similar to *L. friderici*.

The osteology of *L. tuirae* is generally similar to that observed in other Anostomidae, particularly within *Leporinus* (see *L. fasciatus* in Sidlauskas, Vari, 2008). As in most anostomids, the fourth and fifth infraorbitals are not fused, a condition considered derived to date (Sidlauskas, Vari, 2008). The species also exhibits a relatively small metapterygoid-quadrate fenestra compared to that found in other Anostomidae (Sidlauskas, Vari, 2008; Sidlauskas *et al*., 2021; Boaretto *et al*., 2024). Another noteworthy osteological feature is the presence of a small ventral bony expansion in the antorbital, possibly associated with the dorsal portion of the laterosensory canal of the first infraorbital. This condition has not been reported in other anostomids (see Winterbottom, 1980; Sidlauskas, Vari, 2008). However, its occurrence varies among the examined specimens, which may indicate polymorphic condition or an anomalous feature. Among Characiformes, this trait is uncommon and has been observed only in rare cases, such as in *Bryconops* Kner, 1858, where a tubular canal is present in the antorbital region (Chernoff, Machado-Allison, 1999), as well as in some species of *Brycon* Müller & Troschel, 1844 (Malabarba, 1998) and in members of the subfamily Iguanodectinae, such as *Iguanodectes* Cope, 1872 (Moreira, 2002; Mirande, 2010). However, in Iguanodectinae species, according to Silva-Oliveira (2020), what is observed is a groove in the posterior portion of the antorbital region. Therefore, the combination of morphological, genetic, and osteological evidence confirms the distinctiveness of *L. tuirae* within the *fasciatus* clade.

Although *Leporinus tuirae* is not listed as a threatened species, biodiversity loss in the Amazon region is directly linked to anthropogenic impacts, with dam construction in rivers being one of the main causes of decreased fish diversity due to the blockage of gene flow between populations (Winemiller *et al*., 2016). The Belo Monte Hydroelectric Plant on the Xingu River has already altered the known distribution of some species (Sabaj Perez, 2015; Winemiller *et al*., 2016; Chaves *et al*., 2023), and the greatest concern for preserving aquatic life is the conversion of lotic environments into lentic ones, which poses a considerable threat to various fish species (Lopes *et al*., 2024). Another major concern is the Belo Sun mining project, planned for the Volta Grande region of the Xingu River, since developments of this nature can influence the river's hydrological dynamics and be extremely harmful to the conservation of rheophilic species that require intact areas of rapids for survival.

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Claudia Sousa Chaves: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing-original draft, Writing-review and editing.

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ETHICAL STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

We confirm that the data supporting the conclusions of this study are available in the article. All sequences generated and analyzed in this study are deposited in GenBank.

AI STATEMENT

The authors declare that AI tools were used exclusively to perform minor English language corrections, without any influence on the scientific content, data, analysis or interpretation of the results.

COMPETING INTERESTS

The authors declare no competing interests.

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