

Redescription of *Hyphessobrycon cachimbensis* (Characiformes: Characidae) with the description of a new congener from the Serra do Cachimbo, Brazil



Correspondence:
Manoela Maria Ferreira Marinho
manoela.marinho@gmail.com

Manoela Maria Ferreira Marinho¹ and Fernando Cesar Paiva Dagosta^{2,3}

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The Serra do Cachimbo is a highland area at the southeastern portion of the Amazon Forest drained by the headwaters of tributaries of rios Xingu and Tapajós. It is known as an area of high level of endemism of fish, low species diversity, and very few taxa with broad distribution in the other parts of the Amazon. Despite its biogeographical importance, there are still many poorly sampled areas. Four expeditions to the region yielded in the rediscovery of a poorly known, endemic species, *Hyphessobrycon cachimbensis*, and the discovery of a similar, allopatric undescribed congener, frequently misidentified as *H. cachimbensis*. We provided the redescription of *H. cachimbensis* and the description of the new species. Both can be differentiated from most congeners by having a conspicuous longitudinal dark stripe on body and anal-fin base convex in males, due to thicker musculature insertion in the region. Other diagnostic features are mostly related to counts of scales and fin rays.

Keywords: Endemism, Ostariophysi, Rio Tapajós, Rio Xingu, Tetra.

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¹ Departamento de Sistemática e Ecologia, Universidade Federal da Paraíba, Cidade Universitária, s/n, Castelo Branco, 58033-455 João Pessoa, PB, Brazil. (MMFM) manoela.marinho@gmail.com (corresponding author).

² Laboratório de Biogeografia e Sistemática de Peixes, Universidade Federal da Grande Dourados, Rodovia Dourados/Itahum, km 12, 79804-970, Dourados, MS, Brazil. (FCPD) ferdagosta@gmail.com.

³ Museu da Biodiversidade, Universidade Federal da Grande Dourados, Rodovia Dourados/Itahum, km 12, 79804-970 Dourados, MS, Brazil.

A Serra do Cachimbo é uma área elevada da borda sudeste da Floresta Amazônica, drenada pelas cabeceiras dos tributários dos rios Xingu e Tapajós. É conhecida como uma área de alto endemismo de peixes, baixa diversidade de espécies e poucos táxons com ampla distribuição em outras partes da Amazônia. Apesar de sua importância biogeográfica, ainda há várias áreas pouco amostradas. Quatro expedições para a região resultaram na redescoberta de uma espécie pouco conhecida e endêmica, *Hyphessobrycon cachimbensis*, e a descoberta de uma congênera similar não descrita, alopátrica, frequentemente identificada erroneamente como *H. cachimbensis*. Nós fornecemos a redescrição de *H. cachimbensis* e a descrição da nova espécie. Ambas podem ser diferenciadas da maioria das congêneras por ter uma faixa longitudinal conspícua escura no corpo e base da nadadeira anal de machos convexa, por conta da inserção de musculatura mais robusta na região. Outros caracteres diagnósticos são, em sua maioria, relacionados à contagem de escamas e raios de nadadeiras.

Palavras-chave: Endemismo, Ostariophysi, Rio Tapajós, Rio Xingu, Tetra.

INTRODUCTION

Hyphessobrycon Durbin is the largest genus in Characidae, with more than 160 valid species (Fricke *et al.*, 2023). The species range from southern Mexico to the Rio de La Plata in Argentina, but the majority are found in the Cis-Andean region, particularly in the Amazon basin, where *Hyphessobrycon* ranks as the second most diverse genus (Dagosta, de Pinna, 2019). In the last decade, the taxonomic knowledge of *Hyphessobrycon* has advanced with the discovery of 45 new species (about 28% of its richness) (Fricke *et al.*, 2023) and with the redescription of some others (*e.g.*, Carvalho *et al.*, 2014, 2015; Dagosta *et al.*, 2016; Zanata *et al.*, 2018). However, there still remain old, poorly known available names that require further elucidation and numerous species to be described. The present manuscript advances the understanding of the genus in both regards, with the redescription of a little-known species and unveils a new, similar congeneric taxon from the same region.

During the 2010 decade, ichthyologists from the Museu de Zoologia da Universidade de São Paulo performed four expeditions to the Serra do Cachimbo, an elevated area located at the southeast border of the Amazon Forest, at the limit between Pará and Mato Grosso States, Brazil. These expeditions resulted in the description of many new species to science (*e.g.*, *Apistogramma kullanderi* Varella & Sabaj Pérez, 2014, *Corydoras thanatos* Tencatt, Ohara, Sousa & Britto, 2022, *Erythrocharax altipinnis* Netto-Ferreira, Birindelli, Sousa, Mariguela & Oliveira, 2013, *Harttia panara* Oyakawa, Fichberg & Rapp Py-Daniel, 2018, *H. rondoni* Oyakawa, Fichberg & Rapp Py-Daniel, 2018, *Jupiaba kurua* Birindelli, Zanata, Sousa & Netto-Ferreira, 2009, *Lebiasina minuta* Netto-Ferreira, 2012, *L. melanoguttata* Netto-Ferreira, 2012, *Leporinus oliveirai* Ito, Souza-Shibatta, Venturieri & Birindelli, 2023, *Moenkhausia chlorophthalma* Sousa, Netto-Ferreira & Birindelli, 2010, *M. plumbea* Sousa, Netto-Ferreira & Birindelli, 2010). Among the samples, specimens of two morphologically similar species of *Hyphessobrycon* were captured. Both species

share an overall body shape and the presence of a midlateral dark stripe with a humeral mark, a coloration found in few other congeners.

According to our investigation, one of the morphotypes corresponds to *Hyphessobrycon cachimbensis* Travassos, 1964, originally described from the Serra do Cachimbo based on three juvenile specimens, one of which poorly preserved. The other morphotype corresponds to a similar undescribed species that has been frequently misidentified as *H. cachimbensis* in scientific collections as well as in the aquarium trade. Considering that the original description of *H. cachimbensis* is very poor in detail, we feel that a new description is necessary in face of the high number of new discoveries. Thus, in this paper, we describe *H. cachimbensis*, significantly expanding the known ranges of its morphometric and meristic characters, recording its known distribution and providing a first-time description of its color pattern in life and sexual dimorphism. Furthermore, a new colorful congener is described.

MATERIAL AND METHODS

Counts and measurements follow Fink, Weitzman (1974), except for the number of longitudinal scale rows below the lateral line, which were 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. 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. In the description, counts are followed by their frequency of occurrence in parentheses, an asterisk indicates the counts of the holotype. Counts of supraneurals, branchiostegal rays, gill-rakers of first branchial arch, 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 centrum (PU1+U1) as a single element. Sexually dimorphic features were confirmed by direct examination of gonads of two males and two females of *H. cachimbensis* (MZUSP 101377) and four males and five females of the new species (MZUSP 101429 and 96823). In the material examined, catalog numbers are followed by the number of specimens in alcohol, SL range, and the number of c&s specimens or the number of specimens available for molecular studies at MZUSP (MZICT) (mol), if any. Institutional abbreviations follow Fricke, Eschmeyer (2023). Comparative material is that listed by Dagosta *et al.* (2016).

RESULTS

Hyphessobrycon cachimbensis Travassos, 1964

(Figs. 1–4; Tab. 1)

Hyphessobrycon cachimbensis Travassos, 1964:542 (holotype: MNRJ 9196; type-locality: “Rio Cachimbo, Cachimbo, Aeroporto da FAB. Abaixo do Salto, Estado do Pará. Lat. 9°22’S e Long. 54°55’W [= rio Cachimbo at Serra do Cachimbo, airport of the Brazilian Airforce below waterfall, State of Pará, Brazil]). —Géry, 1977:478 (identification key). —Lima *et al.*, 2003:135 (listed). —Lima, Zuanon, 2004:120 (literature compilation). —Zarske, Géry, 2004:36 (literature compilation). —Bertaco, Carvalho, 2005:442 (literature compilation). —Carvalho, Bertaco, 2006:307 (literature compilation). —Lima *et al.*, 2007:53 (listed). —Sousa *et al.*, 2010:262 (literature compilation). —Buckup *et al.*, 2011:173 (photograph). —Dagosta, de Pinna, 2019:35 (shared occurrence between rio Tapajós and rio Xingu basins); 80 (wrongly assigned as endemic to rio Teles Pires). —Marinho *et al.*, 2021:14 (information on lateral-line scale morphology). —Dagosta *et al.*, 2022:3 (diagnosis with *Hyphessobrycon comodoro*); 11 (putative relationships).

Hyphessobrycon cf. *cachimbensis*. —Lima, Birindelli, 2006:57 (listed under comparative material).

Hyphessobrycon cf. *melanostichos*. —Hoffman, Hoffmann, 2012:38 (male and female photographs).

Diagnosis. *Hyphessobrycon cachimbensis* can be distinguished from all congeners, except *H. chiribiquete* García-Alzate, Lima, Taphorn, Mojica, Urbano-Bonilla & Teixeira, 2020, *Hyphessobrycon* n. sp. (described below), *H. comodoro* Dagosta, Seren, Ferreira & Marinho, 2022, *H. cyanotaenia* Zarske & Géry, 2006, *H. fernandesi* 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, 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 the posterior margin of the eye to the middle caudal-fin rays (*vs.* longitudinal stripe absent, stripe starting approximately at vertical through the dorsal-fin origin, or midlateral dark stripe becoming blurred towards the caudal peduncle). It distinguishes from the aforementioned species, except *H. chiribiquete*, *Hyphessobrycon* n. sp., *H. comodoro*, *H. cyanotaenia*, *H. melanostichos*, *H. nigricinctus*, and *H. petricolus*, by presenting humeral spot (*vs.* humeral spot absent). The new species can be diagnosed from *Hyphessobrycon* n. sp., *H. comodoro*, *H. cyanotaenia*, *H. melanostichos*, and *H. nigricinctus* by having 18–22 branched anal-fin rays (*vs.* 14–17 in *Hyphessobrycon* n. sp., 13–16 in *H. comodoro* and in *H. cyanotaenia*, 16–18 in *H. melanostichos*, and 22–26 in *H. nigricinctus*). Differs from *H. chiribiquete* by the midlateral stripe with an even width, covering more than one scale along its entire length (*vs.* midlateral stripe clearly decreasing in width towards the caudal peduncle) and from *H. petricolus* by having 14 horizontal scale rows around caudal peduncle (*vs.* 12) and 34–36 total scales in the longitudinal lateral series (*vs.* 30–32). It can be further distinguished from *H. nigricinctus* by having five or six longitudinal scale rows between lateral line and dorsal-fin origin (*vs.* seven or eight) and one to three maxillary teeth (*vs.* five to eight), and from *H. chiribiquete*, *Hyphessobrycon* n.

sp., *H. comodoro*, *H. cyanotaenia*, *H. melanostichos*, and *H. petricolus* by having lepidotrichia of pelvic-, dorsal-, anal- and caudal-fin rays more branched in males than in females (*vs.* lepidotrichia of those fins as branched in males as in females) and presence of bony spinules in pelvic and anal fins (*vs.* spinules absent).



FIGURE 1 | Holotype of *Hyphessobrycon cachimbensis*, MNRJ 9196, 30.6 mm SL, rio Cachimbo, Cachimbo, airport of Brazilian airforce, below waterfall, State of Pará, Brazil. Credits: South American Characiformes Inventory project (SACI).



FIGURE 2 | *Hyphessobrycon cachimbensis*, MZUSP 101377, Brazil, Pará, rio Xingu basin, rio Iriri drainage, tributary of rio Curuá at bridge of BR-163 road. **A.** 51.6 mm SL, male; **B.** 48.3 mm SL, female.

Description. Morphometric data in Tab. 1. Small characid species, largest examined specimen with 56.5 mm SL. Body compressed, moderately elongate. Greatest body at dorsal-fin origin. Dorsal profile of head convex from upper lip to vertical through anterior nostril; straight to slightly concave from that point to tip of supraoccipital spine. Dorsal profile of body slightly convex along predorsal region, straight along dorsal-fin base, straight to slightly convex from terminus of dorsal-fin base to adipose-fin origin, and concave along caudal peduncle. Ventral profile of head and body slightly convex from tip of lower jaw to pectoral-fin origin, convex from that point to pelvic-fin origin, straight from that point to anal-fin origin, markedly convex along anal-fin base in males and straight to slightly convex in females (see Sexual dimorphism), and concave along caudal peduncle.

Anterior tip of upper and lower jaws aligned, mouth terminal. Premaxillary teeth in two rows (Fig. 3). Outer row with 2(7), 3*(22), or 4(2) teeth bearing five cusps. Inner row with 5*(31) or 6 (1) teeth with seven to nine cusps except symphyseal teeth, bearing six cusps. Posterior tip of maxilla extending to vertical through posterior half of second infraorbital. Maxilla with 1(2), 2*(27), or 3(3), with three to seven cusps. Dentary with 5*(30) larger teeth with seven to nine cusps, decreasing in size laterally, followed by one smaller tricuspid tooth in most specimens, and by one to three diminutives, conical to tricuspid teeth. Central median cusp more developed than lateral cusps in all cuspidate teeth. Four branchiostegal rays (6). First gill arch with 2(6) gill rakers on hypobranchial, 8(4) or 9(2) rakers on ceratobranchial, 1(6) rakers on intermediate cartilage, and 5(5) or 6(1) rakers on epibranchial.

Scales cycloid, with 3 to 7 *radii*, from focus to posterior border of scales; *circuli* weakly developed proximally and absent distally. Total scales in the longitudinal lateral series 34*(6), 35(10), or 36(7). Scales on the lateral series variably perforated. Twenty specimens with 8(1), 9(1), 11(2), 10(2)12*(3), 13(2), 14(3), 15(3), 16(4), 17(2), 20(1), or 23(1) pored scales, followed by non-pored ones (incomplete lateral line) and three specimens with pored scales interspersed with non-pored ones (discontinuous lateral line), as follows: 17 pored + 2 non-pored + 2 pored + 14 non-pored; 12 pored + 1 non-pored + 2 pored + 20 non-pored; and 10 pored + 2 non-pored + 2 pored + 21 non-pored. Longitudinal scale rows between dorsal-fin origin and lateral line 5*(14) or 6(15). Longitudinal scale rows between lateral line and pelvic-fin origin 4*(26) or 5(3). Predorsal scales 9(2), 10(11), 11*(13), or 12(5), in single series. Horizontal scale rows around caudal peduncle 14*(23). Base of anteriormost anal-fin rays covered by series of 3 to 5 scales. Caudal fin not scaled.

Supraneurals 5(5) or 6(1), with dorsal bony lamellae. Dorsal-fin rays ii,9*(32). Proximal tip of first dorsal-fin pterygiophore inserted posterior to neural spine of 9th(3) or 10th (3) vertebra. Pectoral-fin rays i*(23), 10(11), 11*(15), or 12(6). Pelvic-fin rays i*(23), 6(1) or 7*(30) or 8(1). Adipose-fin origin at vertical through base of 11th to 13th branched anal-fin rays. Anal fin with iv(4) or v(2), 18(3), 19(8), 20*(8), 21(11), or 22(3) rays. See Sexual Dimorphism section for description of anal-fin profile. Proximal tip of first anal-fin pterygiophore inserted posterior to haemal arch of 16th(3) or 17th(1) or haemal spine of 16th(1) or 18th(1) vertebra. Dorsal procurrent caudal-fin rays 7(1), 9(1), 10(2), 11(1), or 12(1). Ventral procurrent caudal-fin rays 9(2), 10(3), or 11(1). Caudal-fin with i,8,9,i (32) rays. Caudal fin forked with similar sized lobes. Total vertebrae 33(3), 34(2), or 36(1): precaudal vertebrae 15(1), 16(4), or 17(1) and caudal vertebrae 17(2), 18(3), or 19(1).

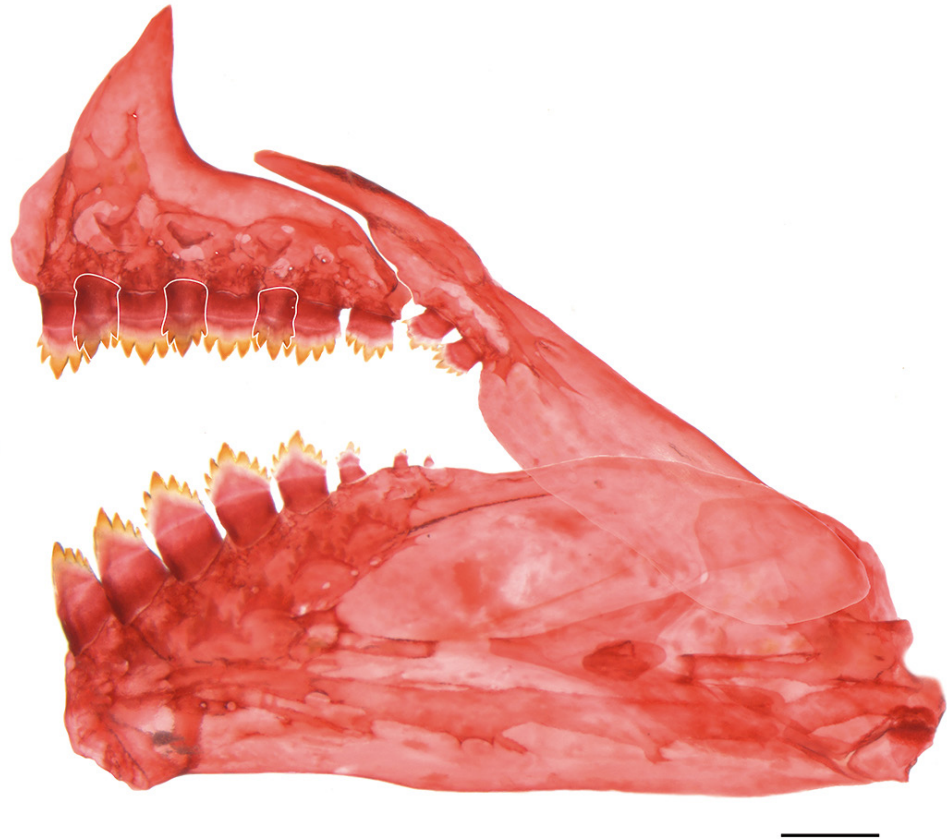


FIGURE 3 | Lateral view of upper and lower jaws of *Hyphessobrycon cachimbensis*, MZUSP 101416. Scale bar = 0.5 mm.

Coloration in alcohol. Overall ground coloration of head and body pale yellow to ocher (Figs. 1, 2). Dorsal portion of head and body darker. Snout, jaws and maxilla with concentration of dark chromatophores, infraorbital series with scattered dark pigmentation, except for the 5th and 6th infraorbitals, which are densely pigmented with dark chromatophores, continuing with the dark longitudinal stripe. Upper half of opercle densely pigmented with dark chromatophores, lower half only with sparse dark pigmentation. Middorsal portion of body with slight reticulated pattern. Humeral blotch large and conspicuous, with diffuse borders, encompassing approximately three scales horizontally and four vertically. Dark midlateral stripe on body two to three scales wide, extending from posterior margin of the eye to tip of middle caudal-fin rays. Abdominal region with only sparse chromatophores, mainly at margin of the scales; scattered dark chromatophores above anal fin. Dorsal, pectoral, pelvic, anal and caudal fins with dark chromatophores scattered along edge of lepidotrichia and concentration of dark chromatophores in interradial membranes, mainly at distal half. Anal fin frequently with distal margin intensely pigmented. Adipose fin with concentration of brown chromatophores. Caudal-peduncle blotch absent. Pigmentation at middle caudal-fin rays frequently darker than the chromatophores of midlateral stripe, especially on juveniles.

Coloration in life. Dark chromatophores pattern described in Color in alcohol section, except by the concentration of dark pigmentation in the posterior third of the eye, just after the pupil. Overall coloration of body yellow to olive. Red pigmentation around pupil. Caudal peduncle and base of caudal-fin rays yellow. Dorsal, pectoral, pelvic, anal fins and distal portions of caudal-fin lobe red to orange. Distal tip of first three to four dorsal-fin rays white. Adipose fin yellow to orange (Fig. 4).

Sexual dimorphism. *Hyphessobrycon cachimbensis* presents a series of sexual dimorphic traits, mostly related to fin morphology (Figs. 2, 4), namely: (1) distal portion of all branched anal-fin rays and in the four lateralmost pelvic-fin rays of males with bony spinules, amount and distribution of spinules along rays varies intraspecifically; (2) dorsal-fin profile of males slightly rounded whereas in females it is falcate; (3) when adpressed, pectoral and pelvic fins reaches the pelvic and anal fins, respectively, in males not in females; (4) pelvic fin of males with most rays of similar size whereas in females, the lateralmost rays are longer, remaining rays decreasing in size medially; (5) anal-fin base convex in males and straight in females, due to thicker musculature in the area; (6) anal-fin distal profile straight to convex in males, not forming an anterior lobe vs. slightly falcate in females, forming an anterior lobe; and (7) males larger than females.

Geographical distribution. Known from the Serra do Cachimbo, in the headwaters of the rio Curuá, tributary of the rio Iriri, rio Xingu basin and the headwaters of the Igarapé Santa Úrsula and rio Braço Norte, both tributaries of the rio Teles Pires, rio Tapajós basin, Pará State, Brazil (Fig. 5). Coordinates of MZUSP 30358 and 31819 do not correspond to given localities (*i.e.*, rio Curuá, rio Xingu basin, and rio Teles Pires, rio Tapajós basin, respectively), therefore these holdings were not mapped in Fig. 5.



FIGURE 4 | Living specimens of *Hyphessobrycon cachimbensis*, not catalogued, Brazil, rio Teles Pires, Novo Progresso, tributary of the rio Braço Norte at the Favaretto farm. **A.** Male; **B.** Female.

Conservation status. *Hyphessobrycon cachimbensis* is endemic from the Serra do Cachimbo, in the headwaters of the rio Curuá, tributary of the rio Iriri, rio Xingu basin and the headwaters of the igarapé Santa Úrsula and rio Braço Norte, both tributaries of the rio Teles Pires, rio Tapajós basin. Despite forest degradation in some of the areas where the species occurs, the surrounding regions are well-preserved, with a significant portion of the drainage systems located within protected areas such as the Reserva Biológica Nascentes da Serra do Cachimbo and the FAB Military Zone. It is noteworthy that the region is poorly sampled, field expeditions being concentrated in the vicinity of road BR-163. Therefore, *H. cachimbensis* should be classified as Least Concern (LC) following the International Union for Conservation of Nature (IUCN) categories and criteria (IUCN Standards and Petitions Subcommittee, 2022).

TABLE 1 | Morphometric data of *Hyphessobrycon cachimbensis*, taken from MNRJ 9196, holotype, MZUSP 101377, 101416, and 116642, non-types. Range includes the holotype. N = number of specimens; SD = Standard deviation.

	Holotype	N	Range	Mean	SD
Standard length (mm)	30.6	21	28.5–56.5	47.2	–
Percentages of standard length					
Depth at dorsal-fin origin	32.4	21	32.3–39.7	35.5	2.1
Snout to dorsal-fin origin	52.0	21	49.0–53.1	50.9	1.1
Snout to pectoral-fin origin	26.5	21	23.9–28.1	25.4	1.0
Snout to pelvic-fin origin	45.8	21	42.5–47.3	45.1	1.2
Snout to anal-fin origin	61.1	21	57.2–63.5	60.8	1.7
Caudal-peduncle depth	10.1	21	8.5–12.2	10.7	1.0
Caudal-peduncle length	13.1	21	10.5–14.7	12.4	1.1
Pectoral-fin length	22.9	21	20.2–26.3	23.2	1.5
Pelvic-fin length	18.3	21	16.3–20.6	18.4	1.1
Pelvic-fin origin to anal-fin origin	17.0	21	15.0–19.4	17.0	1.2
Dorsal-fin length	33.3	21	27.3–33.3	30.1	1.6
Dorsal-fin base length	15.4	21	13.0–17.3	15.4	1.1
Anal-fin length	19.3	21	16.6–23.2	19.5	1.6
Anal-fin base length	29.1	21	28.1–36.7	31.5	2.4
Eye to dorsal-fin origin	37.9	21	36.8–40.6	38.6	0.9
Dorsal-fin origin to caudal-fin base	53.6	21	47.8–54.5	52.1	1.8
Head length	25.5	21	21.9–26.3	23.4	1.1
Percentages of head length					
Horizontal eye diameter	43.6	21	36.8–43.6	40.2	1.8
Snout length	23.1	21	21.6–27.6	24.2	1.5
Interorbital width	32.1	21	29.9–37.0	34.2	1.9
Upper jaw length	47.4	21	38.3–47.4	42.3	2.1

Remarks. The records of *Hyphessobrycon cachimbensis* by Zarske, Géry (2006: fig. 17) from the rio Tocantins drainage and *Hyphessobrycon* cf. *cachimbensis* by Géry, Junk (1977) and Lima *et al.* (2014) from the rio Aripuanã in fact refer respectively to *H. stegemanni* and *H. vilmae*.

Material examined. *Hyphessobrycon cachimbensis*: All from Brazil. Rio Amazonas basin. **Rio Tapajós basin:** MNRJ 9196, holotype, 30.6 mm SL. MNRJ 34466, 157, 18.4–40.9 mm SL, 7 mol. MNRJ 34467, 398, 17.2–41.2 mm SL, 5 mol. MPEG 7774, 18, 16.9–31.6 mm SL. MPEG 7801, 53, 15.5–40.9 mm SL. MZUSP 116642, 5, 27.3–30.8 mm SL (2, 28.5–31.3 mm SL). MZUSP 119918, 90, 25.3–42.7 mm SL. **Rio Xingu basin:** MZUSP 30358, 68, 21.1–31.6 mm SL, 2 c&s. MZUSP 31819, 2, 28.9–31.55 mm SL. MZUSP 96879, 8, 37.6–44.8 mm SL. MZUSP 97586, 64, 19.9–45.0 mm SL. MZUSP 97599, 16, 25.0–45.4 mm SL. MZUSP 101377, 17, 33.1–56.5 mm SL (13, 48.4–56.5 mm SL), 1 c&s, 54.4 mm SL. MZUSP 101386, 4, 14.7–28.1 mm SL. MZUSP 101416, 31, 19.4–46.9 mm SL (5, 37.4–46.9 mm SL), 5 c&s, 34.6–43.9 mm SL. MZUSP 124623, 10, 41.0–52.2 mm SL. MZUSP 124633, 33, 30.3–56.4 mm SL. MZUSP 128238, 139, not measured.

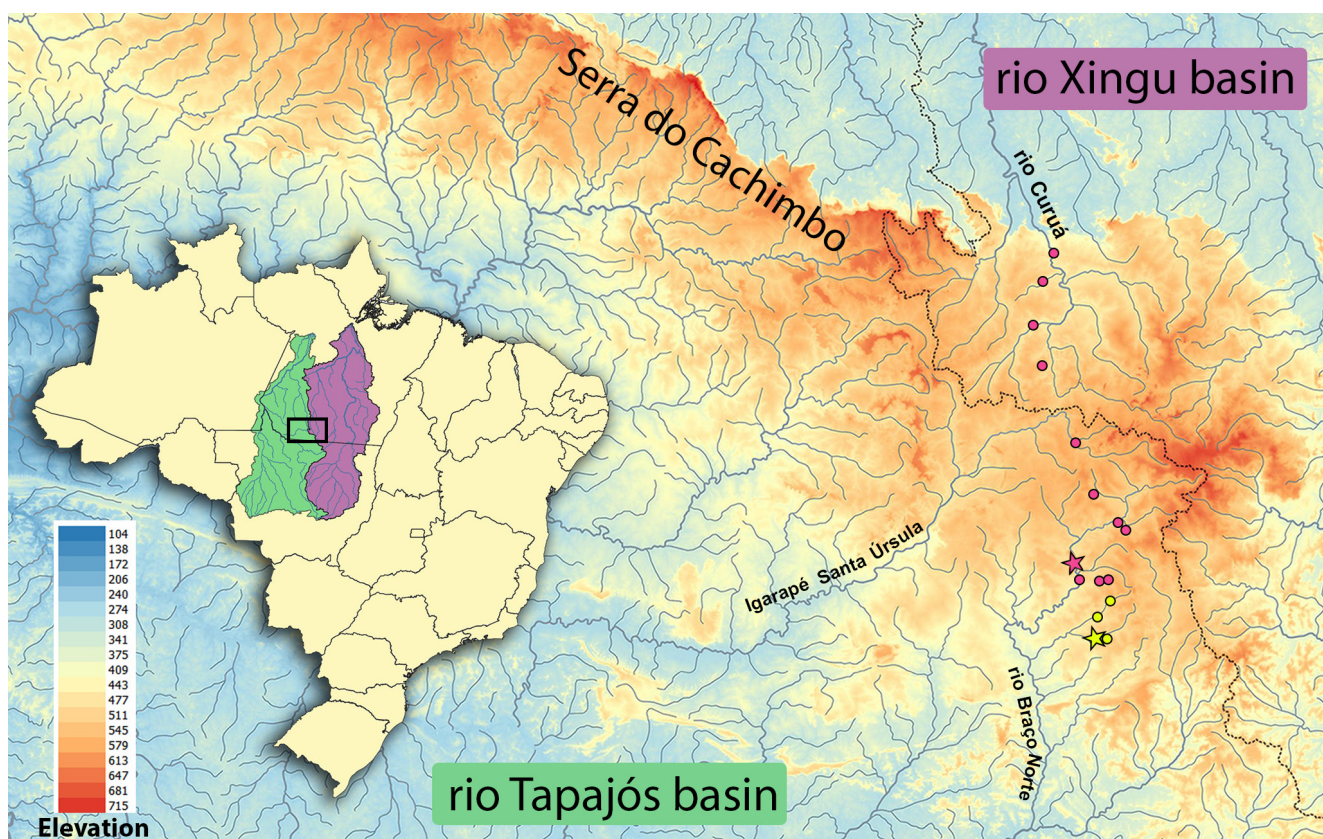


FIGURE 5 | Distribution map of *Hyphessobrycon cachimbensis* (pink); *Hyphessobrycon* n. sp. (yellow). Stars represent type-localities. The type-locality of *Hyphessobrycon cachimbensis* is the same as the FAB Airport - Campo de Provas Brigadeiro Velloso. Dashed line delineates the watershed boundary between the rio Tapajós and rio Xingu basins.

Hyphessobrycon citrus, new species

urn:lsid:zoobank.org:act:740F2376-F8F3-4F82-A511-04B5DF262D35

(Figs. 6–8; Tab. 2)

Hyphessobrycon cachimbensis non Travassos, 1964. —Birindelli *et al.*, 2009: fig. 5 (rio Tapajós basin). —Marinho *et al.*, 2014:263 (rio Tapajós basin, listed as comparative material). —Pastana, Dagosta, 2014:394 [rio Tapajós basin, listed as comparative material (MZUSP 101429 not 101249)]. —Dagosta *et al.*, 2016:258 (rio Tapajós basin, listed as comparative material). —Pastana, Ohara, 2016:396 (rio Tapajós basin, listed as comparative material).

Hyphessobrycon cf. *cachimbensis*. —Ohara *et al.*, 2017:249 (listed under comparative material).

Hyphessobrycon sp. —Hoffman, Hoffmann, 2012:39 (image indicated as “*Hyphessobrycon* sp. “Schwarzstreifen-Rotauge”. —Marinho *et al.*, 2021:15 (information on lateral-line scale morphology).

Holotype. MZUSP 128236, 38.0 mm SL, Brazil, Pará State, Novo Progresso, rio Tapajós basin, rio Teles Pires basin, tributary of rio Braço Norte at bridge on BR-163 road, near FAB military base, 09°28'20"S 54°52'11"W, 22 Jan 2009, A. L. Netto-Ferreira, J. L. O. Birindelli, L. M. Sousa & P. Hollanda-Carvalho.



FIGURE 6 | *Hyphessobrycon citrus*, Brazil, Pará State, rio Tapajós basin, rio Teles Pires drainage, tributary of rio Braço Norte. **A.** MZUSP 128236, holotype, 38.0 mm SL, male; **B.** MZUSP 101429, paratype, 39.4 mm SL, female.

Paratypes. All from Brazil, Pará, Novo Progresso, rio Tapajós basin, rio Teles Pires drainage. INPA 52183, 10, 27.2–43.4 mm SL, MCP 49451, 10, 27.0–43.5 mm SL, MUBIO 182, 15, 20.1–35.2 mm SL, MZUEL 14350, 10, 24.4–40.8 mm SL, MZUSP 96823, 561, 16.2–48.5 mm SL (18, 37.5–48.5 mm SL), MZICT 3630, rio Braço Norte drainage, tributary of rio Peixoto de Azevedo at bridge on BR-163 road, near FAB, 09°25'55"S 54°52'11"W, 19 Oct 2007, J. L. O. Birindelli, A. L. Netto-Ferreira, M. H. Sabaj & N. Lujan. MZUSP 96847, 10, 34.9–39.9 mm SL (2, 34.7–38.9 mm SL), 3 c&s, 33.9–35.7 mm SL, rio Braço Norte drainage, tributary of rio Peixoto de Azevedo at bridge on BR-163 road, near FAB, 09°28'20"S 54°52'11"W, 19 Oct 2007, J. L. O. Birindelli, A. L. Netto-Ferreira, M. H. Sabaj & N. Lujan. MZUSP 101429, 13, 23.1–41.0 mm SL (10, 27.9–41 mm SL), 1 c&s, 34.8 mm SL, same data as holotype. MZUSP 116590, 42, 17.3–42.4 mm SL, rio Braço Norte at BR-163 road, near divide between Pará and Mato Grosso State, 09°28'19.9"S 54°51'21.7"W, 5 Nov 2014, W. M. Ohara. MZUSP 128237, 20, 14.2–34.9 mm SL, tributary of rio Braço Norte near BR-163 road, 09°24'5.3"S 54°50'52.9"W, 4 Aug 2015, F. C. P. Dagosta, M. M. F. Marinho, P. Camelier & V. Giovanetti.

Diagnosis. *Hyphessobrycon citrus* can be distinguished from its congeners, except *H. cachimbensis*, *H. chiribiquete*, *H. comodoro*, *H. cyanotaenia*, *H. fernandezi*, *H. melanostichos*, *H. nigricinctus*, *H. paucilepis*, *H. petricolus*, *H. piranga*, *H. psittacus*, *H. scholzei*, *H. sovichthys*, *H. stegemanni*, *H. taphorni*, *H. tuyensis*, and *H. vilmae*, by the presence of a well-defined, relatively narrow dark midlateral stripe on body, from immediately behind the opercular opening to the tip of middle caudal-fin rays (*vs.* longitudinal stripe absent, stripe starting approximately at vertical through the dorsal-fin origin, or midlateral dark stripe becoming blurred towards the caudal peduncle). It can be distinguished from the aforementioned species, except *H. cachimbensis*, *H. chiribiquete*, *H. comodoro*, *H. cyanotaenia*, *H. melanostichos*, *H. nigricinctus*, and *H. petricolus*, by the presence of a humeral spot (*vs.* absence). *Hyphessobrycon citrus* can be distinguished from *H. cachimbensis*, *H. comodoro*, *H. cyanotaenia*, and *H. melanostichos* by having the longitudinal black stripe starting immediately behind the opercle (*vs.* starting at the posterior margin of orbit), from *H. chiribiquete*, *H. nigricinctus* and from *H. cachimbensis* by having 14–17 anal-fin rays (*vs.* 18 or more), and from *H. petricolus* by having 14 horizontal scale rows around caudal peduncle (*vs.* 12) and non-symphyseal teeth of the premaxillary inner row with 7 to 9 cusps (*vs.* 3 to 5). The yellow citrus coloration and a vivid colored red eye in life also help distinguishing *H. citrus* from congeners.

Description. Morphometric data in Tab. 2. Small characid species, largest recorded specimen with 48.5 mm SL. Body compressed, moderately elongate. Greatest body depth slightly anterior to dorsal-fin origin. Dorsal profile of head convex from upper lip to vertical through anterior nostril; straight to slightly convex from that point to tip of supraoccipital spine. Dorsal profile of body slightly convex along predorsal region, straight along dorsal-fin base, convex from terminus of dorsal-fin base to adipose-fin origin, and concave along caudal peduncle. Ventral profile of head and body slightly convex from tip of lower jaw to pectoral-fin origin, convex from that point to pelvic-fin origin, straight from that point to anal-fin origin, convex along anal-fin base in males and roughly straight in females (see Sexual dimorphism), and concave along caudal peduncle.

TABLE 2 | Morphometric data of *Hyphessobrycon citrus*, taken from MZUSP 128236 (holotype), 96823, 96847, and 101429, paratypes. Range includes the holotype. N = number of specimens; SD = Standard deviation.

	Holotype	N	Range	Mean	SD
Standard length (mm)	38.0	30	27.9–48.5	40.9	–
Percentages of standard length					
Depth at dorsal-fin origin	36.3	30	32.9–38.5	36.3	1.4
Snout to dorsal-fin origin	53.4	30	50.4–56.0	53.9	1.2
Snout to pectoral-fin origin	27.1	30	23.2–29.1	27.1	1.1
Snout to pelvic-fin origin	50.3	30	45.9–52.2	49.2	1.4
Snout to anal-fin origin	66.1	30	65.2–71.1	67.3	1.6
Caudal-peduncle depth	11.3	30	9.5–13.1	11.9	0.9
Caudal-peduncle length	12.6	30	10.2–14.1	12.1	0.9
Pectoral-fin length	23.7	30	21.6–26.5	23.8	1.1
Pelvic-fin length	18.2	30	16.6–19.7	18.3	0.8
Pelvic-fin origin to anal-fin origin	17.4	30	17.4–24.6	19.7	1.5
Dorsal-fin length	28.9	30	27.7–31.2	29.5	0.9
Dorsal-fin base length	15.5	30	14.1–17.3	15.3	0.8
Anal-fin length	21.1	30	19.4–24.5	21.3	1.2
Anal-fin base length	24.2	30	22.9–28.0	24.7	1.1
Eye to dorsal-fin origin	39.7	30	39.0–43.3	40.7	1.0
Dorsal-fin origin to caudal-fin base	48.7	30	46.8–53.8	49.6	1.6
Head length	26.6	30	23.7–27.6	25.7	0.8
Percentages of head length					
Horizontal eye diameter	36.6	30	34.2–42.2	38.3	1.9
Snout length	23.8	30	22.8–27.3	24.8	1.1
Interorbital width	33.7	30	30.9–36.4	33.7	1.4
Upper jaw length	42.6	30	41.1–49.5	43.7	1.9

Upper and lower jaws anteriorly aligned, mouth terminal. Premaxillary teeth in two rows (Fig. 8). Outer row with 2(1), 3*(26), 4(2), or 5(1) teeth, bearing five cusps. Inner row with 5*(28) or 6(2) teeth, with seven to nine cusps except symphyseal teeth, bearing six cusps. Posterior tip of maxilla extending to vertical through posterior half of second infraorbital. Maxilla with 2*(24), or 3(6) teeth, with five to seven cusps. Dentary with 5*(30) larger teeth with seven cusps, followed by one smaller tooth with five cusps (one specimen with a smaller tricuspid tooth), and by four to five diminutives, conical to tricuspid teeth. Central median cusp more developed than lateral cusps in all cuspidate teeth. Four branchiostegal rays (4). First gill arch with 3(4) gill rakers on hypobranchial, 9(4) rakers on ceratobranchial, 1(4) rakers on intermediate cartilage, and 6(4) rakers on epibranchial.

Scales cycloid, with 5 to 9 *radii*, from focus to posterior border of scales; *circuli* weakly developed proximally and absent distally. Total scales in the longitudinal lateral series 31(3), 32(10), or 33*(9). Scales on the lateral series variably perforated. Twenty specimens with 10(1), 11(1), 12(1), 13*(6), 14(4), 15(2), 16(1), 17(2), or 19(2) pored scales, followed by non-pored ones (incomplete lateral line) and two specimens with pored scales interspersed with non-pored ones (discontinuous lateral line), as follows: 11 pored + 2 non-pored + 2 pored + 17 non-pored and 19 pored + 3 non-pored + 2 pored

+ non-pored. Longitudinal scale rows between dorsal-fin origin and lateral line 5(15) or 6*(11). Longitudinal scale rows between lateral line and pelvic-fin origin 4*(21) or 5(9). Predorsal scales 10(9), 11(17), or 12(1), in single series. Horizontal scale rows around caudal peduncle 14*(28). Base of anteriormost anal-fin rays covered by a series of 3 to 5 scales. Caudal fin not scaled.

Supraneurals 5(3), with dorsal bony lamellae. Dorsal-fin rays ii,9*(23). Dorsal-fin rays ii*(30), 8(2) or 9(28). Proximal tip of first dorsal-fin pterygiophore inserted posterior to neural spine of 10th(4) vertebra. Pectoral-fin rays i*(29), 10(6), 11(22), or 12(1). Pelvic-fin rays i*(30), 7*(29) or 8(1). Adipose-fin origin at vertical through base of 11th to 13th branched anal-fin rays. Anal fin falcate, with iv(3), 14(11), 15(7), 16*(15), or 17(1) rays. Proximal tip of first anal-fin pterygiophore inserted posterior to haemal arch of 17th(2) or haemal spine of 17th(2) vertebra. Dorsal procurrent caudal-fin rays 9(1), 11(2), or 12(1). Ventral procurrent caudal-fin rays 8(1), 9(2), or 10(1). Caudal-fin with i*(29), 8(1) or 9*(28) rays on upper and i*(29), 8*(29), rays on lower lobe. Caudal fin forked with similar sized lobes. Total vertebrae 33(4): precaudal vertebrae 17(4) and caudal vertebrae 16(4).

Coloration in alcohol. Overall ground coloration of head and body beige (Fig. 7). Dorsal portion of head and body darker. Specimens usually with slight reticulated pattern on uppermost three horizontal scale rows, formed by concentration of chromatophores on the posterior portion of scales. Dark chromatophores concentrated at upper and lower jaws. Infraorbital series with only sparse chromatophores, except for the 5th and 6th infraorbitals, which are scattered dark pigmentated. Upper half of opercle with scattered pigmentation. Humeral blotch faint, with diffuse borders, encompassing approximately two scales horizontally and three vertically. Dark midlateral stripe on body one scale wide, extending from immediately behind the opercular opening to tip of middle caudal-fin rays. Abdominal region with only sparse chromatophores; scattered dark chromatophores above anal fin. Dorsal and anal fins with scattered dark chromatophores in interradiation membranes. Pectoral and pelvic fins with hyaline, except for dark chromatophores scattered along edge of lepidotrichia. Adipose fin with sparse dark chromatophores. Outermost upper and lower caudal-fin rays with dark chromatophores along its entire length, remaining rays with scattered dark pigmentation. Caudal-peduncle blotch absent.

Coloration in life. Dark chromatophores pattern described in Color in alcohol section. Overall body coloration yellow citrus, darker at middorsal (Fig. 6). Upper portion of eye intensely red. Infraorbital and opercular areas silvery. Some specimens with light orange coloration at the distal portions of dorsal and anal fins.

Sexual dimorphism. Sexually dimorphic characters of *Hyphessobrycon citrus* are related to fin length and shape. Pectoral and pelvic fins of males are slightly larger than in females. When adpressed, tip of pectoral fin reaches pelvic-fin origin in males, however, not in females. When adpressed, tip of pelvic fin of males may reach the base of anal fin or falls shortly, whereas not in females. Anal-fin base convex in males and roughly straight in females. Anal fin lobe with pointed profile in males due to elongated anteriormost branched anal-fin rays; smooth in females (Figs. 6-7).



FIGURE 7 | Living specimens of *Hyphessobrycon citrus*, not measured, from Brazil, Pará, rio Tapajós basin, rio Teles Pires drainage. **A.** MZUSP 128237, male paratype, tributary of rio Braço Norte near BR-163 road; **B.** MZUSP 96823, female paratype, tributary of rio Peixoto de Azevedo at bridge on BR-163 road.

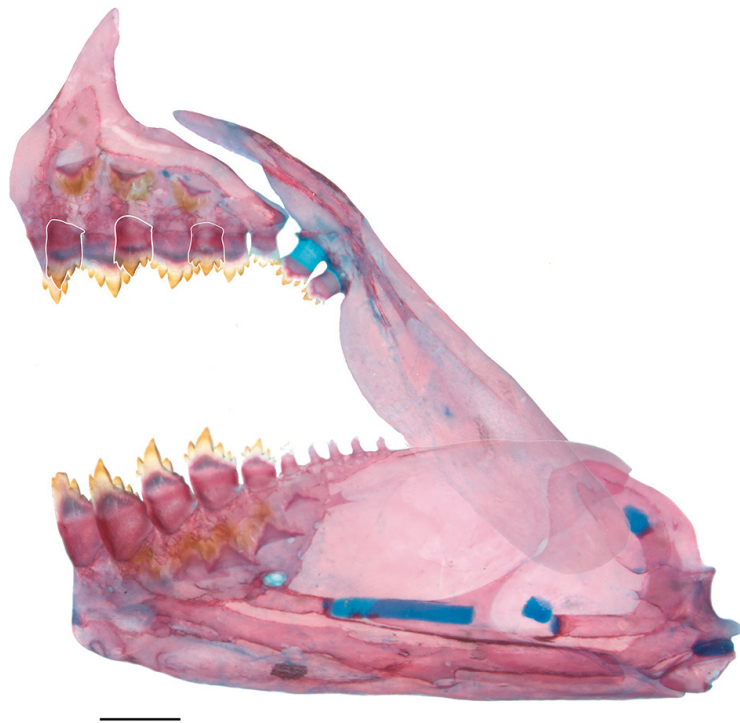


FIGURE 8 | Lateral view of upper and lower jaws of *Hyphessobrycon citrus*, MZUSP 96847, paratype, 35.6 mm SL, coronomeckelian removed. Scale bar = 0.5 mm.

Geographical distribution. Endemic Known from the Serra do Cachimbo, in the headwaters of the rio Braço Norte, tributary of the rio Teles Pires, rio Tapajós basin, Pará State, Brazil (Fig. 5).

Etymology. The specific epithet comes from the Latin “*citrus*”, referring to its bright yellow coloration similar to several citrus fruits. A noun in apposition.

Conservation status. *Hyphessobrycon citrus* is exclusive to the Serra do Cachimbo, in the headwaters of the rio Braço Norte, tributary of the rio Teles Pires, rio Tapajós basin. Despite a highly restricted distribution, the species inhabits a relatively well-preserved basin with no identifiable threats. Most of the basin where it occurs is located within protected areas (Reserva Biológica Nascentes da Serra do Cachimbo and FAB Military Zone). Therefore, *Hyphessobrycon citrus* should be classified as Least Concern (LC) following the International Union for Conservation of Nature (IUCN) categories and criteria (IUCN Standards and Petitions Subcommittee, 2022).

DISCUSSION

Remarks on relationships. The interrelationships of the species currently classified as *Hyphessobrycon* are poorly known. The phylogenetic studies of Mirande (2010, 2019) and Elías *et al.* (2023) confirmed the long assumed polyphyly of the genus. *Hyphessobrycon compressus*, the type-species, was suggested to be close to the species of the “rosy tetra clade” (Weitzman, Palmer, 1997; Mirande, 2019), a group of tetras with dark blotch on dorsal fin and red coloration on body. On the other hand, Téran *et al.* (2020), in an augmented analysis of Mirande (2019), recovered it as close to *Hyphessobrycon boulengeri* (Eigenmann, 1907) and *Hemibrycon columbianus* Eigenmann, 1914. Further, Elías *et al.* (2023) recovered it as close to the trans-Andean species of the genus. The remaining species of *Hyphessobrycon*, which now reaches over 160 species, have been hypothesized as more closely related to species belonging to several other genera of Characidae, including the highly speciose and non-monophyletic *Astyanax* Baird & Girard, 1854 and *Moenkhausia* Eigenmann, 1903 (Mirande, 2019; Téran *et al.*, 2020). This situation illustrates the still incipient knowledge on the interrelationships of *Hyphessobrycon* and other characids.

The relationships of *Hyphessobrycon cachimbensis* and *H. citrus* are unknown. Morphologically, they are similar to *H. comodoro*, *H. cyanotaenia*, *H. melanostichos*, *H. nigricinctus*, and *H. petricolus* but none of them have ever been included in a phylogenetic study. These species share a distinct coloration pattern among characids and distinct sexual dimorphism. Such species share the presence of a conspicuous midlateral stripe crossed by a humeral blotch. *Hyphessobrycon chiribiquete* could also be included in this group, but its dark longitudinal stripe seems not to be homologous, as it decreases in width towards the caudal peduncle (García-Alzate *et al.*, 2020), unlike the condition present in the remaining aforementioned species. Furthermore, some of these species share a distinct sexual dimorphism regarding the shape of anal-fin base and shape of anal-fin profile. Except *H. nigricinctus* and *H. petricolus* in which information is unavailable, all such species share a modified shape of the anal-fin base in males, which is convex

due to thicker musculature insertion in the area (*vs.* straight in females). Additionally, males of *H. cachimbensis*, *H. comodo*, *H. cyanotaenia*, and *H. melanostichos* share the anal-fin distal profile straight to convex (*vs.* concave in female). *Hyphessobrycon nigricinctus* presents an opposite pattern, in which the anal-fin distal profile of females is straight (*vs.* concave in males) (Zarske, Géry, 2004). The anal-fin distal profile of *H. citrus* is not dimorphic and there is no information for *H. petricolus*. Similar sexual dimorphism regarding the anal fin shape is also found in few other species of *Hyphessobrycon*, but with distinct coloration and overall morphology, such as *H. heliacus* Moreira, Landim & Costa, 2002, *H. kayabi* Teixeira, Lima & Zuanon, 2014, *H. loweae* Costa & Géry, 1994, and *H. peugeoti* Ingenito, Lima & Buckup, 2013 (see Teixeira *et al.*, 2013). All these morphological similarities should be tested in a phylogenetic analysis.

The Serra do Cachimbo region. The Serra do Cachimbo region was considered by Dagosta, de Pinna (2019) as an example of the Extreme Shield biogeographic pattern of Amazonian lands. According to the authors, such biogeographic pattern encompasses an extremely high level of endemism, low species diversity, and very few taxa with broad distribution in the other parts of the Amazon. The present study recognizes the distribution of two endemic taxa in the region reinforcing the distinctiveness of the region. It is also noteworthy that the Serra do Cachimbo region is one of the Endemic Amazonian Fish Areas (EAFAs) delimited by Dagosta *et al.* (2020) as priority areas for conservation in South America, due to the combination of an exclusive ichthyofaunal assemblage, few protected areas, and the presence of threats. Although there are no recognized imminent threats specifically for *H. cachimbensis* and *H. citrus*, the Serra do Cachimbo region as a whole is experiencing massive deforestation pressure from illegal mining and logging.

The Serra do Cachimbo has a particular biogeographic history with unique faunal elements occurring in each portion of its territory. Its northwest portion is drained by the Jamanxim basin (rio Tapajós basin), northeast and east by the rio Iriri basin (rio Xingu basin) and south by the rio Teles Pires basin (rio Tapajós basin), and endemic species can be found in each of these regions. None of the endemic species occur throughout the entire region and almost all species occur in only one basin. The only so far known exception is *H. cachimbensis*, which is endemic to the Serra do Cachimbo and occurring on both the rios Teles Pires and Xingu basin slopes (Fig. 5). Therefore, considering its unique ichthyofauna, it is crucial that conservation efforts in the region considers the plurality of its territory.

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AUTHORS' CONTRIBUTION

Manoela Maria Ferreira Marinho: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing–original draft, Writing–review and editing.

Fernando Cesar Paiva Dagosta: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing–original draft, Writing–review and editing.

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Not applicable.

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The author declares no competing interests.

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