



Redescription of ‘*Chasmocranus*’ *brachynema* (Heptapteridae: Heptapterini)

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The endangered species ‘*Chasmocranus*’ *brachynema* is redescribed and diagnosed among other Heptapterini by having the adipose fin extensively fused with the caudal fin, caudal fin shallowly bifurcate, and anal-fin insertion posterior to a vertical through the adipose-fin insertion, in addition to peculiarities of the head and mouth morphology. The species seems to be very rare, known only from five preserved specimens from the main channels of the Paraná and Mogi-Guaçu rivers, and from a tributary of the rio Ivaí, all in the Upper Paraná ecoregion.

Keywords: Endangered species, *Heptapterus longicauda*, Rio Ivaí, Rio Mogi-Guaçu, Taxonomic review.

A espécie ameaçada ‘*Chasmocranus*’ *brachynema* é redescrita e diagnosticada entre outros Heptapterini por ter a nadadeira adiposa extensamente fundida com a nadadeira caudal, nadadeira caudal com bifurcação rasa e inserção da nadadeira anal posterior a uma linha vertical que atravessa a inserção da nadadeira adiposa, além de peculiaridades da morfologia da cabeça e da boca. A espécie parece ser muito rara, conhecida apenas de cinco exemplares preservados dos canais principais dos rios Paraná e Mogi-Guaçu e de um tributário do rio Ivaí, todos na ecorregião Alto Paraná.

Palavras-chave: Espécie ameaçada, *Heptapterus longicauda*, Revisão taxonômica, Rio Ivaí, Rio Mogi-Guaçu.

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INTRODUCTION

Chasmocranus Eigenmann, 1912 is a catfish genus of Heptapteridae, erected to include the type-species *C. longior* Eigenmann 1912, altogether with *C. brevior* Eigenmann 1912, both from Guyana (Eigenmann, 1912). In the most recent complete classification of Heptapteridae, *Chasmocranus* was identified as comprising ten putatively valid species distributed in streams throughout tropical South America (Bockmann, Guazzelli, 2003). However, the genus itself has not yet been revised under a phylogenetic paradigm and is maintained as valid a priori, including some species with highly divergent morphologies (Bockmann, Slobodian, 2018).

Bockmann (1998) also investigated the relationship of *Chasmocranus* to other Heptapteridae in his morphological phylogenetic study of the family. Based on his findings, Bockmann, Slobodian (2018) suggested that the current delimitation of *Chasmocranus* is artificial, and some of the species assigned to it would belong to at least two new genera. Among these, '*Chasmocranus brachynema* Gomes & Schubart, 1958 would be part of "Heptapteridae genus D" (Bockmann, Slobodian, 2018), awaiting description (throughout the text, the use of inverted commas in a genus name indicates that the designation is inadequate, according to Bockmann, Slobodian, 2018).

Among the species currently assigned to the "Heptapteridae genus D", '*Chasmocranus brachynema* was described from the Emas rapids, rio Mogi-Guaçu, Brazil, based exclusively on the holotype (EEBP 617; Gomes, Schubart, 1958). Some years later, Schubart (1964:12) found a second specimen (EEBP 629) from the same locality. Concurrently, Akama *et al.* (2018) admitted that the species was known only "from a few individuals from the rio Mogi-Guaçu basin", thus considering it endangered (EN) according to the IUCN criteria B2ab(iii).

The rarity of '*Chasmocranus brachynema* in scientific collections (and probably in nature) is evident, with specimens listed in just a few works, such as in Pereira *et al.* (2013, additional file 1), who listed a '*C. brachynema* from the rio Ivaí basin (LBP 6414), and Thereza, Langeani (2019), who mentioned a record from the headwaters of the rio Corumbataí, rio Tietê basin. However, Pereira *et al.* (2013) did not provide phenotypic characteristics supporting their identification. In turn, Thereza, Langeani (2019) did offer one picture and a very brief description of the specimens, but not a thorough comparison with the original description. Despite all sampling efforts in the Upper Paraná ecoregion, no published records have been made from further localities.

In the meantime, the unexpected discovery in the fish collection of the Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura (NUP) of a specimen assignable to '*Chasmocranus brachynema*, collected in the rio Ivaí basin, led us on a quest to clarify the identity and geographic distribution of this rare species. Thus, we proceeded with reexamining the material previously identified as '*C. brachynema*, including specimens not mentioned in the literature before. Our study, facilitated by rediscovering the holotype and Schubart's (1964) topotype (see Azevedo-Santos *et al.*, 2023), revealed that the species' distribution is slightly wider than we thought. However, most of the specimens previously identified as '*C. brachynema* belong to an unidentified species of *Heptapterus* Bleeker, 1858. Acknowledging the obvious difficulties taxonomists face in recognizing '*C. brachynema*, we deemed it necessary to present a redescription of the species, including a proper comparative diagnosis with other heptapterids.

MATERIAL AND METHODS

Measurements were taken as point-to-point distances, with a digital caliper under a dissecting stereoscope, following Slobodian, Pastana (2018), with the inclusion of lateral head length to opercle, distance between posterior nostril and eye; pectoral-pelvic distance, pelvic-anal distance, body depth at adipose-fin origin, caudal-fin depth, last branched dorsal- and pectoral-fin rays' length. For clarification, the measurements are presented in Fig. S1. Measurements of head parts are presented as proportions of head length (HL), except for measurements of barbels, which are converted to proportions of standard length (SL). Some measurements are shown in scatter plot charts as evidence of putative allometric changes; however, no regression analysis was made due to the small sample size. Counts were made under a stereomicroscope in ethanol-preserved material; therefore fin-ray counts are according to visible fin-rays without dissection or clearing and staining preparation. Caudal-fin rays are given in the following order: unbranched (procurrent) dorsal caudal-fin rays, branched rays in the dorsal lobe, branched rays in the ventral lobe, unbranched (procurrent) ventral caudal-fin rays (question marks in these counts indicate that the rays are hidden in the surrounding tissues and counting them was not possible). Based on a radiograph of EEBP 629, vertebral counts include only the free vertebrae, not counting the five vertebrae of Weberian apparatus, and the caudal compound counted as one. Count values marked with an asterisk are those observed in the holotype. Terms such as 'sub-labial groove', 'labial slit', and 'cleithral skin fold' are as in Deprá *et al.* (2022). Osteological and cephalic laterosensory canals' terminology follows Bockmann, Miquelarena (2008). Institutional codes follow Fricke, Eschmeyer (2023). Maps were produced using Google Earth 9.140 and QGIS 3.16. Area of Occupation and Extension of Occurrence were calculated following ICMBio (2013). This work was based exclusively on museum specimens; thus, no permissions from Animal Ethics Committees apply.

RESULTS

'*Chasmocranus*' *brachynema* Gomes & Schubart, 1958

(Figs. 1–3; Tab. 1)

Chasmocranus brachynema Gomes, Schubart, 1958:413–16, figs. 1–3 (original description; type-locality: rio Mogi-Guaçu, cachoeira de Emas, Piraçununga, São Paulo, Brazil; holotype: EEBP 617). —Schubart, 1964:12, 18 (rio Mogi-Guaçu basin, collection of a new specimen EEBP 629, list of species). —Bockmann, Guazzelli, 2003:411 (catalog, type information, distribution). —MMA, 2004: anexo 1 (list of endangered species). —Langeani *et al.*, 2007:187 (upper rio Paraná basin, list of species). —Meschiatti, Arcifa, 2009:136, 140 (Mogi-Guaçu basin, list of species). —Oyakawa *et al.*, 2009:353, 381, 642 (list of endangered species of State of São Paulo, distribution). —Oyakawa, Menezes, 2011:25 (upper rio Paraná basin, list of species). —Azevedo-Santos *et al.*, 2023:541, 549, 551, fig. 8, 11 (list of species, whereabouts of holotype, photography of holotype EEBP 617, photography of topotype EEBP 629).

Heptapterus brachynema. —Mees, 1974:180 (comparison with *Heptapterus lopezi* [= '*Chasmocranus*' *lopezae*]). —Mees, 1987:455 (list of *Heptapterus* species, anal-fin rays number, adipose-fin morphology).

Chasmocranus brachynemus. —Ferraris Jr., 2007:182 (catalog, type information, distribution). —MMA, 2014: anexo 1 (list of endangered species). —Akama *et al.*, 2018:228–230 (endangered species, distribution, threats).

“*Chasmocranus*” *brachynema*. —Bockmann, Slobodian, 2018:250 (Heptapteridae genus D composition).

‘*Chasmocranus*’ *brachynema*. —Deprá *et al.*, 2022:330 (Mogi-Guaçu basin, comparison with *Heptapterus* genus, comparison with *Chasmocranus*, *sensu stricto*, examined material EEBP 629).

Diagnosis. ‘*Chasmocranus*’ *brachynema* is placed in Heptapterini by having the dorsal- and pectoral-fin spines stiffened only basally and without serrations and by having a minute supraoccipital process, far apart from the dorsal-fin insertion. ‘*Chasmocranus*’ *brachynema* is distinguished from all other Heptapterini, except *Acentronichthys* Eigenmann & Eigenmann, 1889, *Chasmocranus bleekeri* (Boeseman, 1953) (*sensu* Deprá *et al.*, 2022), *Heptapterus*, ‘*H.*’ *multiradiatus* Ihering, 1907, ‘*H.*’ *stewarti* Haseman, 1911, ‘*H.*’ *sympterygium* Buckup, 1988, and *Nemuroglanis* Eigenmann & Eigenmann, 1889, by the presence of an adipose fin extensively fused with the caudal fin. The very shallowly bifurcate caudal fin distinguishes ‘*Chasmocranus*’ *brachynema* from *Acentronichthys* (deeply bifurcate), *Heptapterus* (ellipsoid, obliquely truncate, falcate or lanceolate, but never bifurcate), ‘*H.*’ *multiradiatus* (ellipsoid), ‘*H.*’ *stewarti* (ellipsoid), ‘*H.*’ *sympterygium* (ellipsoid), and *Nemuroglanis* (deeply bifurcate or lanceolate). The anal-fin insertion

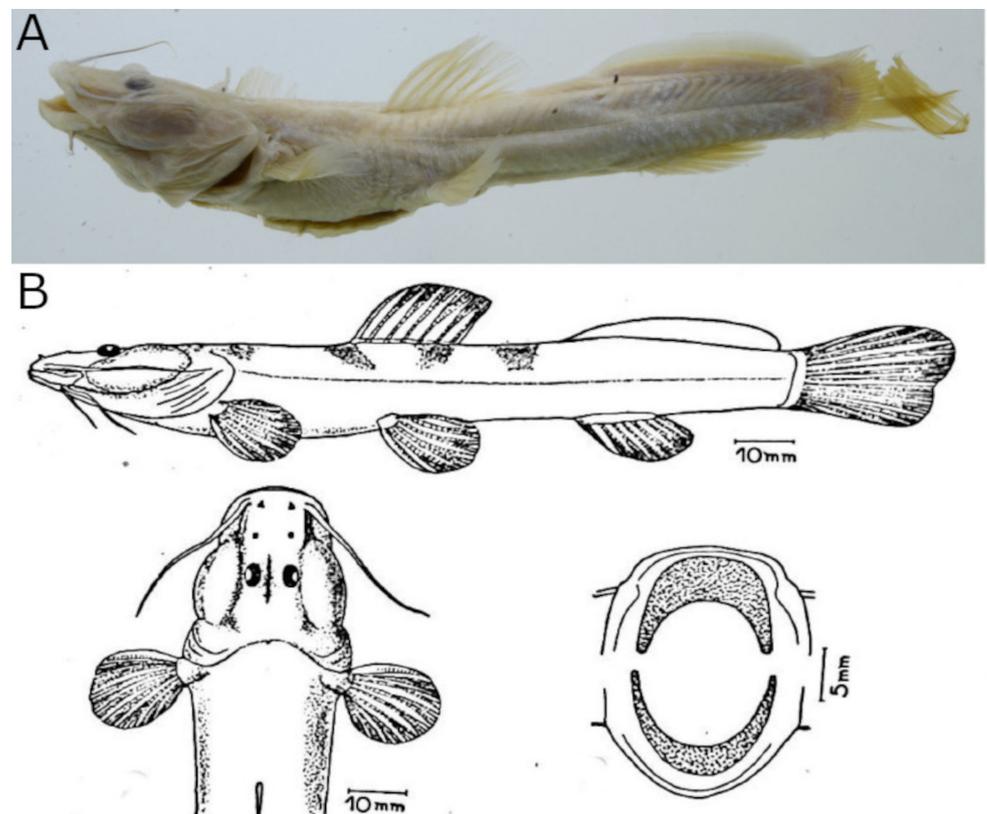


FIGURE 1 | ‘*Chasmocranus*’ *brachynema*, EEBP 617, holotype, 128.3 mm SL, rio Mogi-Guaçu at Cachoeira de Emas, upper rio Paraná basin at Pirassununga, State of São Paulo. **A.** Recent photograph showing the current state of preservation of the specimen. **B.** Drawings from the original description, evidencing the original coloration of the specimen and the shape of the premaxillary (top) and dentary tooth plates.

posterior to a vertical through the adipose-fin insertion distinguishes '*C.* *brachynema* from all *Chasmocranus* species, including *C. bleekeri* (*sensu* Deprá *et al.*, 2022). In addition, '*C.* *brachynema* is distinguished from all *Heptapterus* species by having a longer posterior extension of the mouth rim, with the rictus reaching a vertical line between the posterior nostril and the eye *vs.* shorter, with the rictus barely reaching a vertical line through the posterior nostril; and the premaxillary tooth plate with a very long posterolateral extension (Fig. 4A) *vs.* no posterolateral extension or a small one (Fig. 4B).

Description. Morphometric data in Tab. 1. Dorsal profile convex from premaxillary symphysis to posterior nostril, straight to eye. Dorsally positioned eye with strongly convex profile. Dorsal profile straight from eye to end of supraoccipital, slightly convex to dorsal-fin insertion, slightly concave to adipose-fin insertion, straight along adipose-fin base. Caudal-fin base slightly convex. Ventral head profile and ventral abdominal profile slightly convex. Ventral profile from pelvic-fin to anal-fin insertion approximately straight. Anal-fin base straight, slightly ascending. Caudal peduncle profile straight. In



FIGURE 2 | '*Chasmocranus* *brachynema*, NUP 22699, 93.0 mm SL, 23°40'42"S 53°15'47"W, córrego Piava, tributary to the rio das Antas, tributary to the rio Ivaí, upper rio Paraná basin at the municipality of Umuarama, State of Paraná, Brazil.



FIGURE 3 | '*Chasmocranus' brachynema*, EEBP 629, 74.9 mm SL, rio Mogi-Guaçu about 1 km downstream from Cachoeira de Emas. Schubart (1964) reported this specimen after the original description.

dorsal view, mouth rim convex. Lateral profile of head convex due to well-developed *adductor mandibulae* muscle. Lateral profile of body straight to slightly convex along abdomen, then tapering to caudal-fin base. Abdominal region depressed, distinctly broader than deep; in cross-section, something between elliptic and rectangular. Cross section at dorsal-fin base approximately as broad as deep, between round and square. Body compressed from adipose-fin base to caudal fin, cross-section distinctly deeper than broad.

Head much depressed, flat dorsally and ventrally, rounded laterally. Mouth slightly prognathous. Mouth rictus fleshy, folding ventrally, with large sub-labial groove ventral to it. Lips double, divided by deep labial slit. Lips with numerous small papillae. Tubular anterior nostril far apart from mouth rim. Deep skin fold surrounding entire posterior nostril, but with deep posterior notch. Maxillary barbel groove extending from base of barbel to vertical through pupil; in dorsal view, rims of contralateral groove diverging posteriorly. Very subtle depression between posterior nostril and eye. Elongate depression marking anterior cranial fontanel. Bulging eyes, covered with thick skin, with no free rim, almost completely dorsal. Base of inner mental barbel anterior to outer mental barbel, and posterior to vertical through base of maxillary barbel. Maxillary barbel reaching anterior margin of first pectoral-fin ray. Shallow cleithral skin fold immediately posterior to branchial aperture, posterior terminus medial to base of first pectoral-fin ray.

TABLE 1 | Morfometric data of '*Chasmocranus*' *brachynema*. *Approximate value. SD = Standard deviation.

	Holotype (EEBP 617)	EEBP 629	NUP 22699	MZUSP 22511	Mean	SD
Total length	152*	90*	115.3	–	–	–
Standard length	128.3	74.9	93.0	42.2–50.1		
Percentages of standard length						
Body depth at dorsal-fin origin	12.2	14.0	11.3	9.4–10.9	11.6	1.7
Body depth at adipose-fin origin	12.5	12.4	13.0	11.4–11.4	12.1	0.7
Caudal-fin depth	–	11.2	16.2	–	13.7	3.6
Body width at dorsal-fin origin	14.0	12.7	13.9	11.8–12.6	13.0	0.9
Cleithral width	18.1	17.8	17.1	17.0–18.0	17.6	0.5
Head length to base of supra-occipital process	22.0	22.4	23.1	22.2–24.4	22.8	1.0
Lateral head length (to posteriormost point of opercle)	25.1	25.2	25.5	25.3–27.0	25.6	0.8
Maxillary-barbel length	23.7	23.2	23.5	22.0–26.3	23.7	1.6
Outer mental-barbel length	10.0	12.0	13.0	10.6–12.3	11.6	1.3
Inner mental-barbel length	7.0	7.9	9.0	8.6–9.5	8.4	1.0
Predorsal length	42.5	43.4	41.3	42.5	42.4	0.9
Distance between snout tip and terminus of dorsal-fin base	54.2	55.9	53.1	54.5–56.4	54.8	1.3
Distance between snout tip and dorsal-fin distal end, adpressed	63.0	65.3	64.5	64.7–65.3	64.5	0.9
Dorsal fin to adipose fin	14.3	13.5	14.4	14.7–15.4	14.5	0.7
Dorsal-fin base	12.5	13.0	12.0	11.8–12.6	12.4	0.4
Length of first dorsal-fin ray (unbranched)	12.9	15.0	14.7	11.6–15.8	14.0	1.7
Length of stiffened part of first dorsal-fin ray	7.3	6.8	7.4	8.1–9.0	7.7	0.8
Length of second dorsal-fin ray (first branched)	14.1	16.3	16.8	15.6	15.7	1.2
Length of third dorsal-fin ray (second branched)	13.3	17.4	16.6	15.8	15.8	1.7
Length of last dorsal-fin ray	9.0	9.7	10.8	10.6	10.0	0.8
Prepectoral length	26.6	24.6	23.9	25.3–28.0	25.7	1.6
Distance between snout tip and terminus of pectoral-fin base	30.2	28.0	28.0	28.9–31.3	29.3	1.4
Distance between snout tip and pectoral-fin distal end, adpressed	40.2	–	–	–	–	–
Length of first pectoral-fin ray (unbranched)	10.2	13.4	12.7	13.4–15.6	13.1	1.9
Length of stiffened part of first pectoral-fin ray	5.0	7.1	6.7	6.6–7.3	6.5	0.9
Length of second pectoral-fin ray (first branched)	12.1	13.6	13.5	14.2–15.4	13.8	1.2
Length of third pectoral-fin ray (second branched)	11.7	13.8	14.9	14.8	13.8	1.5
Pectoral to pelvic-fin distance	18.1	21.8	22.8	17.5–21.0	20.2	2.3
Prepelvic length	47.8	45.4	44.7	45.3–47.2	46.1	1.3
Distance between snout tip and terminus of pelvic-fin base	51.0	48.6	–	48.1–52.1	50.0	1.9
Distance between snout tip and pelvic-fin distal end, adpressed	63.1	60.7	62.2	62.3–65.9	62.8	1.9
Distance between pelvic fins	7.8	7.7	7.3	6.2–6.2	7.0	0.8
Length of first pelvic-fin ray (unbranched)	9.8	10.1	12.3	12.6–13.3	11.6	1.5
Length of second pelvic-fin ray (first branched)	11.7	13.4	14.9	14.5–15.0	13.9	1.4
Length of third pelvic-fin ray (second branched)	12.2	14.6	14.8	15.8–15.9	14.6	1.5
Pelvic to anal-fin distance	27.8	26.7	28.0	24.9–28.9	27.3	1.5
Anal-fin base	9.7	10.8	12.6	9.8–10.9	10.7	1.2
Preanal length	74.5	71.4	70.3	72.5–75.4	72.8	2.1



TABLE 1 | (Continued)

	Holotype (EEBP 617)	EEBP 629	NUP 22699	MZUSP 22511	Mean	SD
Distance between snout tip and terminus of anal-fin base	84.6	82.5	83.1	83.4–86.0	83.9	1.4
First branched anal-fin ray length	9.2	11.3	11.8	12.4	11.2	1.4
Distance between snout tip and anal-fin distal end, adpressed	91.3	88.8	92.2	91.0–93.8	91.4	1.8
Adipose-fin length	28.2	29.1	27.5	26.7–28.4	28.0	0.9
Preadipose length	68.3	69.7	67.5	69.7–70.3	69.1	1.1
Distance between snout tip and adipose-fin base end	97.0	97.5	96.7	97.2–97.6	97.2	0.4
Adipose-fin depth	4.6	3.7	3.1	4.2–5.0	4.1	0.7
Caudal-peduncle length	16.3	16.8	18.7	17.2–18.2	17.4	1.0
Caudal-peduncle depth at adipose-fin terminus	8.8	9.2	9.4	8.6–9.2	9.0	0.3
Snout-anus distance	–	51.9	52.7	53.5–54.5	53.2	1.1
Snout-urogenital papilla distance	–	56.2	55.6	56.5–59.7	57.0	1.8
Anus-urogenital papilla distance	–	3.2	3.5	3.1–3.2	3.3	0.2
Dorsal lobe of caudal fin length	–	20.6	24.2	–	22.4	2.6
Ventral lobe of caudal fin length	15.1	18.0	–	–	16.6	2.1
Percentages of head length						
Head depth	49.1	42.3	42.2	39.4–40.4	42.7	3.8
Head width	76.1	69.3	70.5	65.8–69.3	70.2	3.7
Eye diameter	15.2	18.0	14.3	18.1–18.4	16.8	1.9
Fleshy interorbital	12.7	10.6	9.3	10.5–11.8	11.0	1.3
Bony interorbital	9.9	7.9	8.0	9.6–11.0	9.3	1.3
Mouth gape	50.9	37.0	38.8	40.9–43.9	42.3	5.4
Snout length	33.9	31.7	33.8	30.7–33.1	32.6	1.4
Distance between snout tip and posterior nare	23.0	23.8	23.6	21.9–24.4	23.4	0.9
Distance between posterior nostril and eye	11.5	10.1	11.4	7.9–7.9	9.7	1.8
Anterior internarial width	21.4	19.6	20.3	16.5–16.7	18.9	2.2
Posterior internarial width	17.7	18.5	17.7	17.3–17.5	17.8	0.5
Intranarial length	14.6	16.9	17.3	15.8–16.5	16.2	1.1

Dorsal fin triangular, distal margin convex, not reaching adipose fin when adpressed. Dorsal fin with $i,6^*(5)$ rays (first ray rigid only at basal half). Distance between dorsal-fin terminus and adipose-fin origin larger than dorsal-fin base. Anteriormost dorsal-fin pterygiophore inserted posterior to neural spine of vertebra 6 (1), posteriormost dorsal-fin pterygiophore inserted anterior to neural (or pseudoneural) spine of vertebra 14 (1).

Pectoral fin with $i,7,i(1)$, $i,7,ii^*(1)$, $i,8(2)$, $i,8,ii(1)$ rays on left side and $i,7,i(2)$, $i,8(2)$, $i,8,i^*(1)$ on right side (total pectoral-fin rays 9–11). Pectoral-fin triangular, distal margin convex. Large axillary pore dorsally to pectoral-fin base. First pectoral-fin unbranched, rigid only at its basal half, without ornamentations.

Pelvic fin with $i,5^*(4)$, $i,6(1)$ rays on left side and $i,5^*(5)$ on right side. Expanded pelvic fin with distal margin convex, slightly pointed at middle. Pelvic-fin insertion between verticals through second (first branched) (1), third (second branched) (1) to fourth (third branched) (1^*) dorsal-fin ray.

Anal fin with iii,7(1), iv,6(2), iv,6,i(1), iv,7*(1) rays (total rays 10–11). Distal margin of expanded anal fin round. Anal-fin origin slightly posterior to adipose-fin origin; anal-fin terminus distinctly anterior to adipose-fin posterior limit. Anteriormost anal-fin pterygiophore inserted posterior to haemal spine of vertebra 23(1), posteriormost anal-fin pterygiophore inserted anterior to haemal spine of vertebrae 30(1).

Adipose fin originating slightly anteriorly to vertical through anal-fin insertion. Adipose fin long, forming a pronounced ascending curve in lateral profile, emerging gradually, with deepest point between its half and last third, descending gradually towards posterior region. Posterior limit continuous (*i.e.*, connected) with anteriormost procurrent ray of caudal fin dorsal lobe.

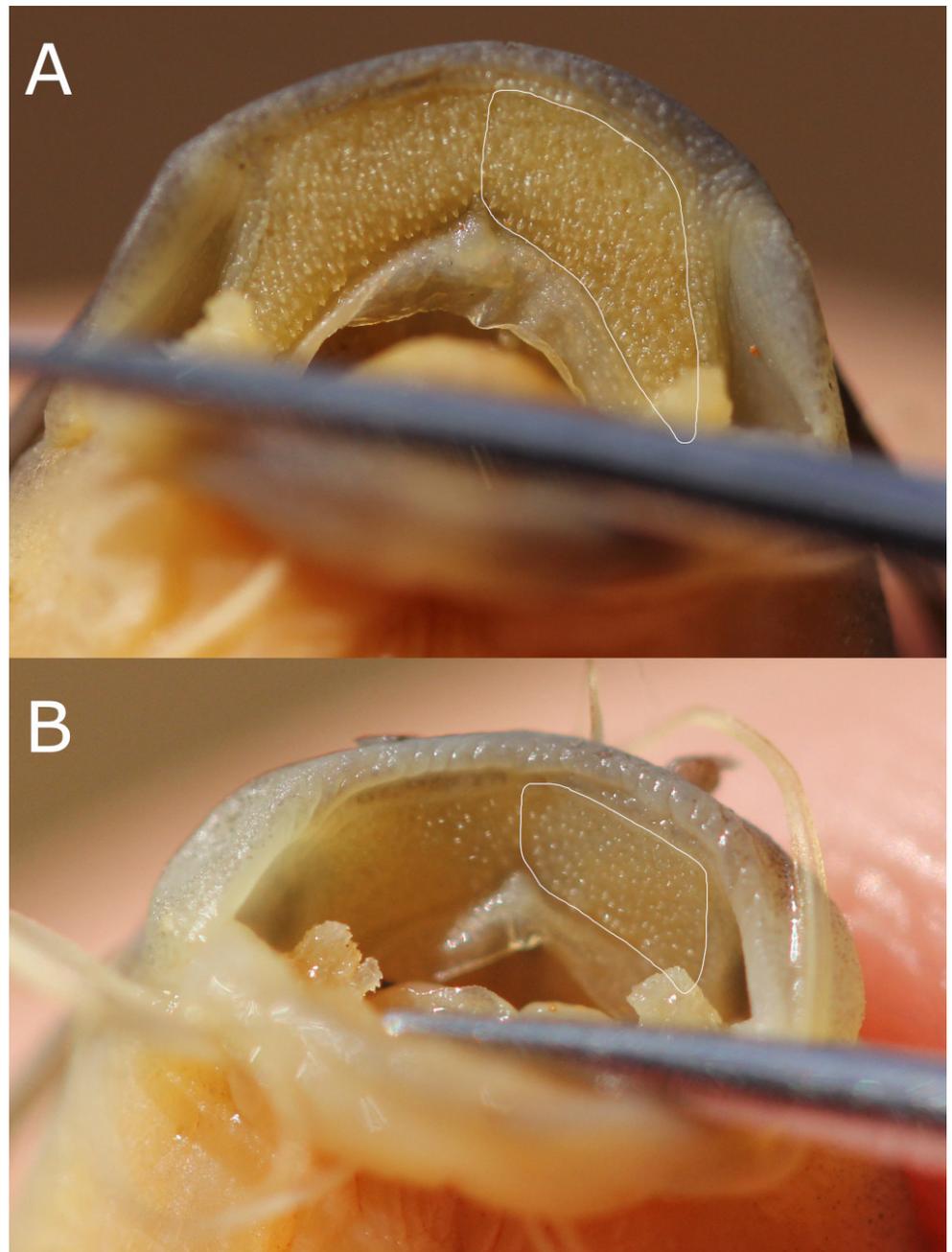


FIGURE 4 | Shape of the premaxillary tooth plates. **A.** *Chasmocranus brachynema*, NUP 22699, 93.0 mm SL. **B.** *Heptapterus longicauda*, NUP 18882, 85.9 mm SL.

Caudal fin with two rounded lobes, not forked, dorsal lobe slightly longer. Longest dorsal-lobe ray fourth (counting from the diastema between dorsal and ventral hypural plates). Longest ventral-lobe ray third (counting from diastema). Caudal-fin rays xii,6,6,ix*(1), xii,6,6,xii(1), ?,6,6,?(1). Eight (1) rays articulated with dorsal caudal-fin plate, six (1) rays articulated with ventral caudal-fin plate.

Premaxillary tooth plate with very long posterolateral extension; length of lateral margin at least twice as long as symphyseal margin; about nine rows of conical teeth. External gill rakers on first arch 0+4(1), 1+3(2), 1+4*(1), 1+5(1) on right side, 0+3(1), 1+3(1), 1+4*(2) on left side. Branchiostegal rays 8*(5) on both sides. Vertebrae 42(1). Ribs 11(1).

Cephalic laterosensory system. Based on three specimens (EEBP 617, holotype; EEBP 629; and NUP 22699; Fig. 5). Cephalic laterosensory pores as in *Rhamdella cainguae* Bockmann, Miquelarena (2008), except by (Fig. 5): s2+i2 closer to anterior nostril (*vs.* at about the middle of the distance between anterior and posterior nostrils); s4 absent from both sides (*vs.* present); s6+s6 situated at transversal line across posterior limit of eye (*vs.* across middle of eye); pm5 anteromedial to rictus (*vs.* posterior to it). Pore s3 absent from left side of one specimen (NUP 22699); po3 protruding from skin as short tube in holotype; ll1 and ll2 close together or not, protruding or not from skin as short tube; pm6–9 variably developed; pm7 absent from right side of one specimen (NUP 22699); i4 in one specimen (EEBP 629) displaced anteriorly, close to posterior nostril.

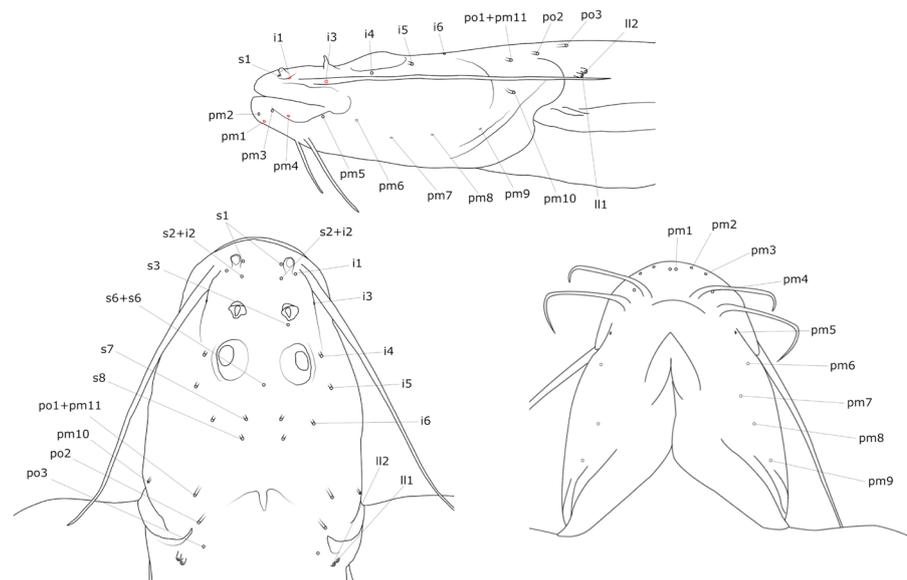


FIGURE 5 | Cephalic laterosensory pores in '*Chasmocranus brachynema*, NUP 22699, 93.0 mm SL. Well-developed pores are outlined in black, except when hidden by other structures (in which case they are outlined in red). Poorly developed pores are outlined in grey. Abbreviations: i1–6, infraorbital sensory pores 1 to 6; ll1–2, lateral-line sensory pores 1 and 2; pm1–11, preoperculo-mandibular sensory pores 1 to 11; po1–3, postotic sensory pores 1–3; s1–8, supra-orbital sensory pores 1–8.

Color in alcohol. Based mainly on NUP 22699 (other specimens faded) (Fig. 2). Ground color light yellowish-brown, grading to beige on ventral side of head and abdominal region. Transition slightly more abrupt on head. Pre-orbital stripe, interorbital bar, and dorsal bar (DB)1 diffuse, grey. DB2–DB5 brown. Laterodorsal stripe between DB2 and DB3. DB2 immediately posterior to transverse bar through base of last pectoral-fin ray. DB3 immediately anterior to dorsal-fin origin. DB4 at posterior half of dorsal-fin base. DB5 closer to adipose fin than to dorsal fin. DB6–DB8, caudal spot, humeral mark and midlateral stripe absent. Fin rays greyish brown. Fin membranes mostly hyaline, except for slight yellowish-brown tint at the base. Dorsal surface of maxillary barbel light brown; remaining barbels light beige.

Geographical distribution. '*Chasmocranus*' *brachynema* is known from the main stream of the rio Mogi-Guaçu at Pirassununga, State of São Paulo; from the main stream of the rio Paraná at Jupuí, between states of São Paulo and Mato Grosso do Sul; and from the córrego Piava, a tributary of the rio Ivaí, State of Paraná (Fig. 6).

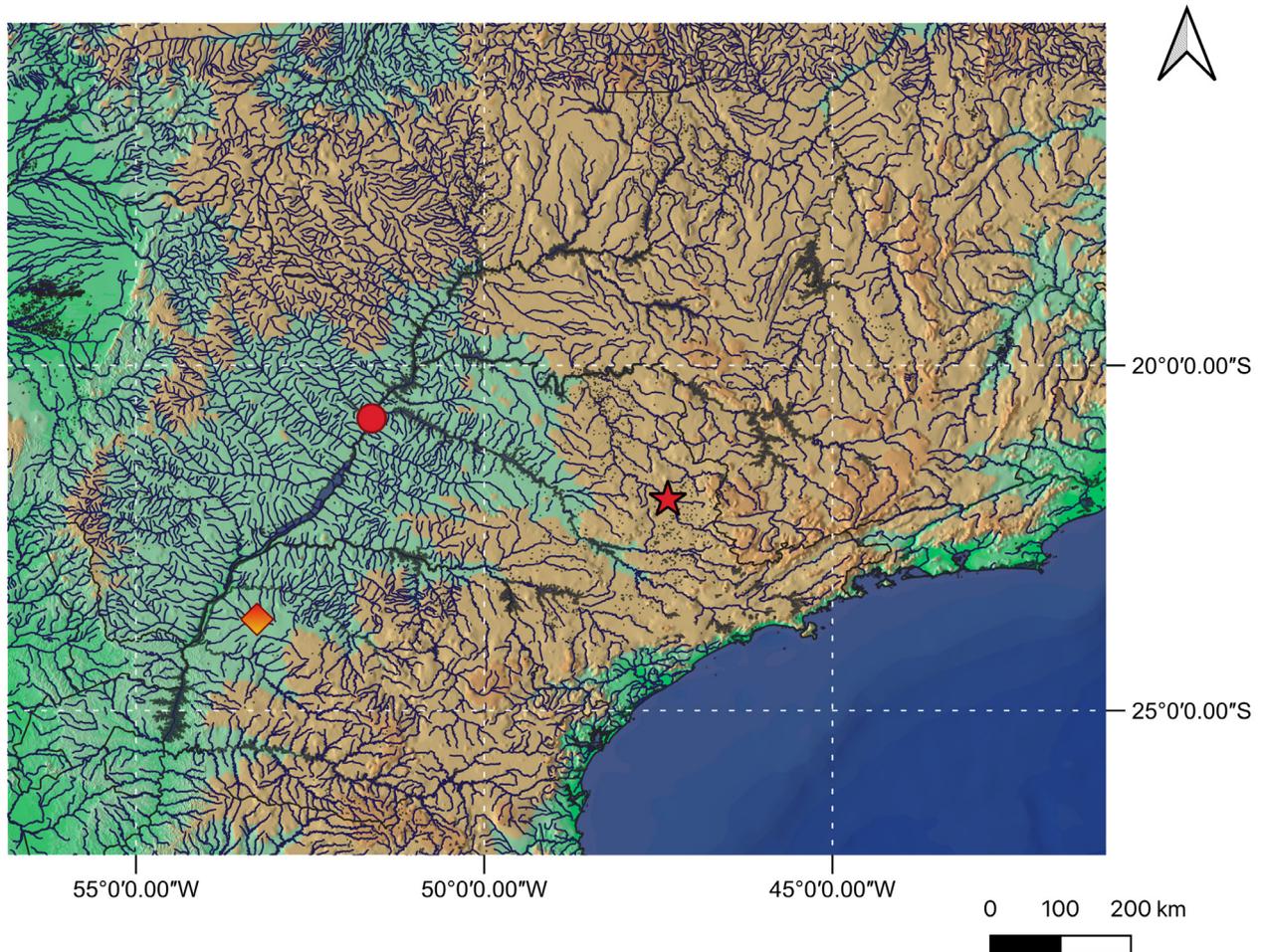


FIGURE 6 | Partial map of South America, showing the distribution of '*Chasmocranus*' *brachynema* in the upper rio Paraná basin. Star, type-locality; losangle, NUP 22699; circle, MZUSP 22511 (rocky river channel submerged in 1974).

Ecological notes. At the localities in the Mogi-Guaçu where '*C.* *brachynema* was collected (EEBP 617 and 629), the river is 100 m wide and comprises a series of rapids with a rocky bottom (Figs. 7A, B). Jupιά is the name given to a stretch of the rio Paraná, next to the town of Três Lagoas, State of Mato Grosso do Sul, in which the rocky river channel was narrow, and the flow strong, forming a whirlpool that was famous among ancient navigators for being capable of swallowing whole canoes. This place was submerged in 1974 during the filling of the reservoir of the Engenheiro Souza Dias hydroelectric power plant, thus after the collection of MZUSP 22511. The córrego Piava (Fig. 7C) is about 2 m wide, circa 0.8–1.0 m deep, with sandy bottom including small pebbles and grassy margins in the collection site of NUP 22699. The waterbody has been subject to a high degree of siltation due to the anthropized landscape in which it is inserted, mostly pasturelands.

Conservation status. With our additional locality from córrego Piava, '*Chasmocranus' brachynema* Extension of Occurrence (EEO) and Area of Occupation (AOO) are 45,143 km² and 4,868 km², respectively. We opted not to include the Jupιά rapids in our calculations, since they have been completely altered after collecting of the '*C.* *brachynema* specimens. Therefore, even with this new site, the species would still be considered under threat of extinction following the IUCN criterion B, as previously assessed by Akama *et al.* (2018). Furthermore, the imminent reactivation of a hydropower plant in Cachoeira de Emas, and the continuous decline in the habitat quality due to anthropization in the Upper Paraná region (Akama *et al.*, 2018), also contribute to maintaining '*C.* *brachynema* as an Endangered (EN) species.



FIGURE 7 | Localities where '*Chasmocranus' brachynema* has been collected. **A.** Type-locality in the rio Mogi-Guaçu at Cachoeira de Emas. In the dry season, the water level lowers considerably, exposing the rocky bottoms. **B.** In the puddles thus formed, occasional fish specimens get trapped, such as this putative '*C.* *brachynema* (the identification is tentative since the specimen was not preserved). Photographs by Wellington A. M. Peres. **C.** Córrego Piava. Photograph by Weferson J. Graça.

Remarks. The specimens identified by Pereira *et al.* (2013) and Thereza, Langeani (2019) as ‘*Chasmocranus*’ *brachynema* belong to *Heptapterus* sp. 1, a putatively new species similar to *Heptapterus longicauda* (Borodin, 1927). Thereza, Langeani (2019) examined specimens from two different river basins, *viz.* Mogi-Guaçu (LIRP 10970) and Tietê (DZSJRP 7973). While the photographed specimen is from LIRP 10970, we assume the morphological data was taken from both lots. However, their data does not match the original description of ‘*C.*’ *brachynema*, as the adipose-fin base length was contained about three times in SL (*vs.* 3.5 times in SL in the original description). As shown in Fig. 8, that proportion matches smaller specimens of *Heptapterus* sp. 1 instead. So does the shape of the caudal fin, which is obliquely truncate in the young and lanceolate in adults (Fig. 9; *vs.* with two rounded lobes in ‘*C.*’ *brachynema*); the shape of the mouth, in which the rictus reaches the vertical through posterior nostril’s anterior rim (*vs.* between posterior nostril and eye); and anterior nostril reaching or almost reaching the snout rim (*vs.* far from reaching it). Thereza, Langeani (2019) also recorded specimens they identified as ‘*Imparfinis*’ *borodini* (a name that currently is a synonym of *Heptapterus longicauda*; see Deprá *et al.*, 2023) from several drainages in the Upper Paraná ecoregion. We analyzed two of these lots, *viz.* DZSJRP 20527 and 20532, which also belong to *Heptapterus* sp. 1 (Fig. 9).

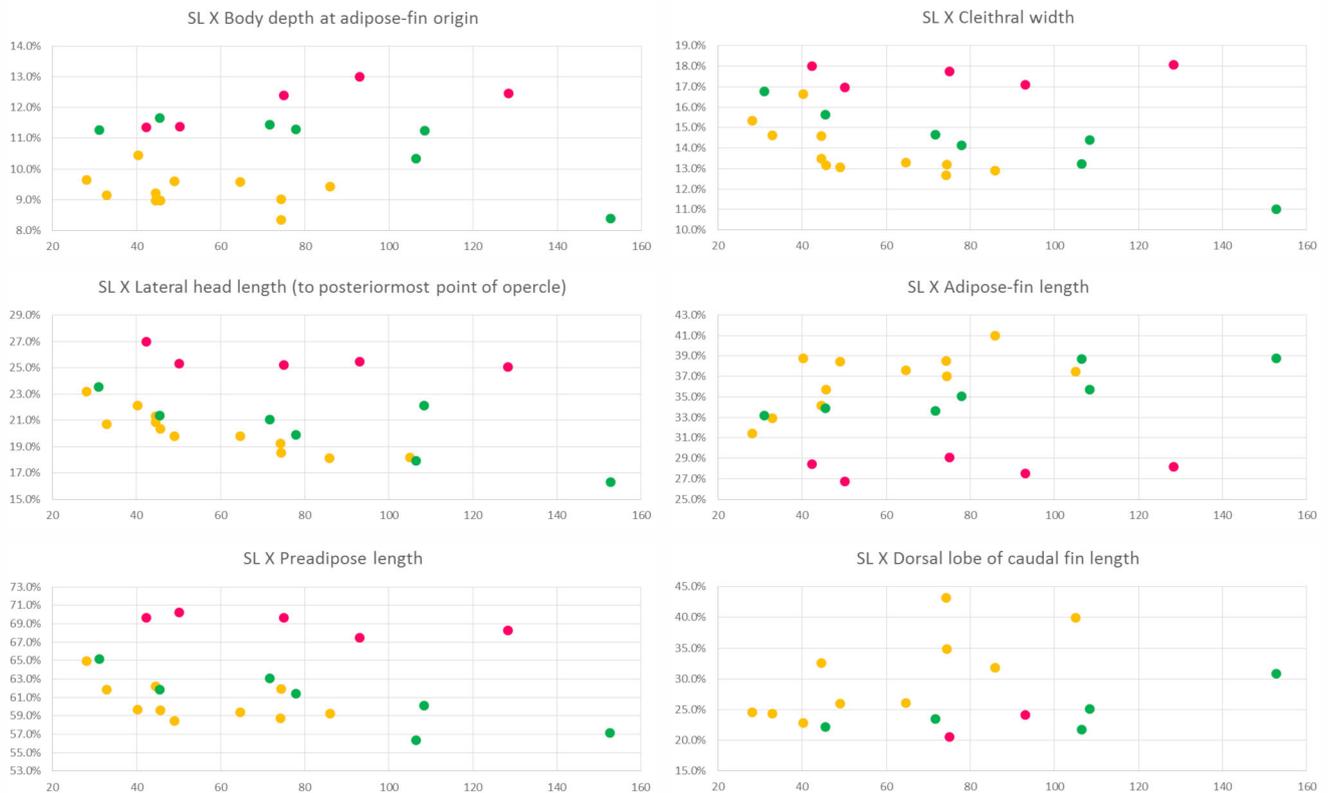


FIGURE 8 | Scatter plot charts of several morphometric characters as percentages of the standard length in ‘*Chasmocranus*’ *brachynema* (pink), *Heptapterus longicauda* (yellow), and *Heptapterus* sp. 1 (green). Depth at adipose-fin origin, cleithral width, lateral head length to opercle, adipose-fin base length, and pre-adipose length proportions are useful to distinguish between the three species, and dorsal caudal-fin lobe length to distinguish ‘*C.*’ *brachynema* and *Heptapterus* sp. 1 from *H. longicauda*. Data from the holotype of *H. longicauda* taken from Borodin (1927).

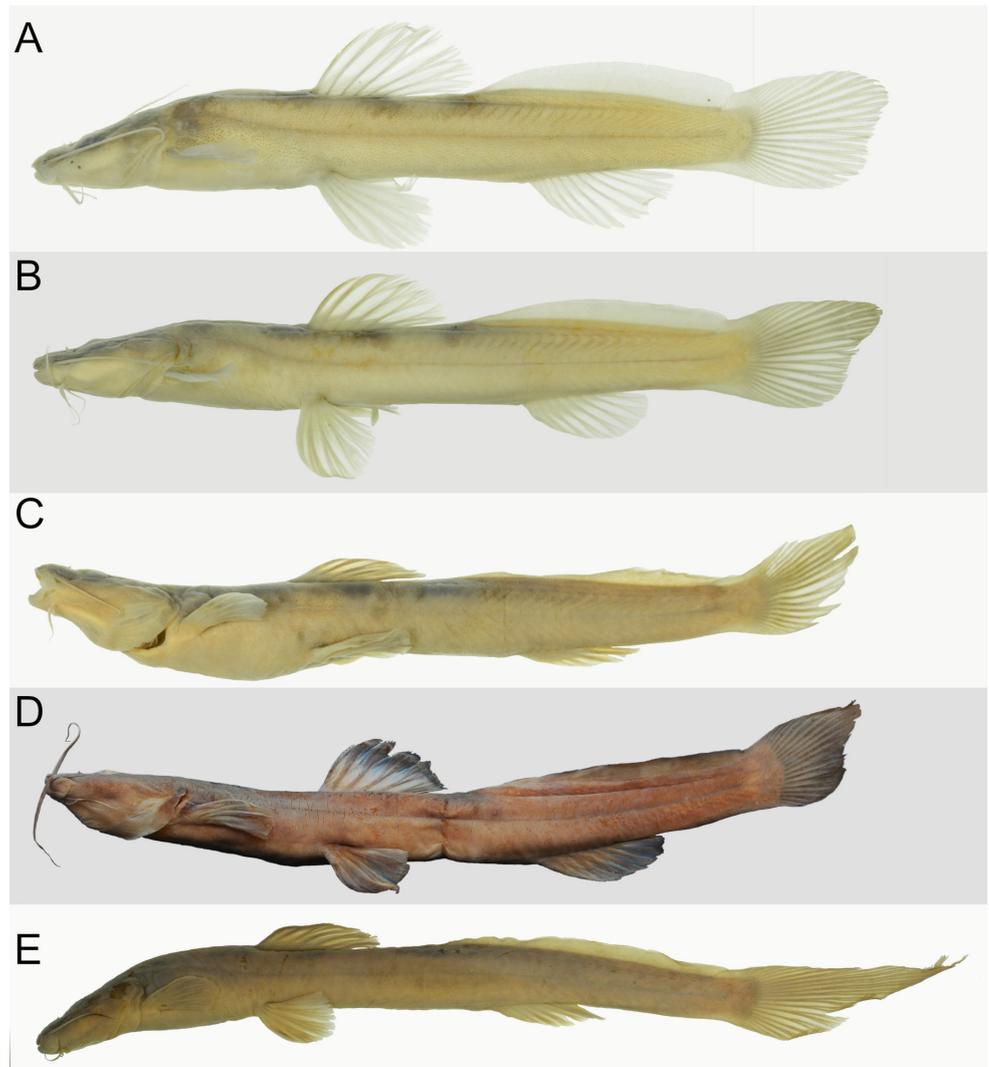


FIGURE 9 | *Heptapterus* sp. 1. **A.** DZSJRP 7973, 45.4 mm SL. **B.** DZSJRP 7973, 108.4 mm SL. **C.** DZSJRP 20527, 109.2 mm SL. **D.** LBP 6414, 133.1 mm SL (photograph by Gabriel Silva). **E.** DZSJRP 20532, 152.6 mm SL. Notice the allometry in body depth, adipose-fin length, and caudal-fin length – smaller specimens present higher body depth and shorter adipose- and caudal-fin length. **A** and **B** were identified as '*Chasmocranus*' *brachynema* by Thereza, Langeani (2019); **C** and **E** were identified as '*I.*' *borodini* by Thereza, Langeani (2019); and **D** was identified as '*C.*' *brachynema* by Pereira *et al.* (2013).

Thereza, Langeani (2019), in their identification key, distinguished their '*Chasmocranus*' *brachynema* from their '*Imparfinis*' *borodini* based on the degree of body elongation, adipose-fin base length and caudal peduncle depth. Despite that, our data show that those supposed differences are satisfactorily explained by allometry rather than by interspecific variation (Fig. 8). On the other hand, allometric morphometric characters help distinguish between *Heptapterus* sp. 1 and *H. longicauda*, especially dorsal caudal-fin lobe length, which is extremely high in the latter (Figs. 8–10). In sum, the only reliable previously published records of '*C.*' *brachynema* are the holotype and the topotype examined herein. With the addition of MZUSP 22511 and NUP 22699, only five preserved specimens of '*C.*' *brachynema* are known to us.



FIGURE 10 | *Heptapterus longicauda*, NUP 18882, 74.3 mm SL, 23°40'42"S 53°15'47"W, córrego Piava, tributary to the rio das Antas, tributary to the rio Ivaí, upper rio Paraná basin, municipality of Umuarama, State of Paraná, Brazil.

Material examined. All from Brazil. *Chasmocranus* *brachynema*: All from the upper rio Paraná basin. EEBP 617, holotype, 128.3 mm SL, State of São Paulo, municipality of Pirassununga, rio Mogi-Guaçu at Cachoeira de Emas, tributary to the rio Grande, 21°56'40"S 47°21'52"W, 24 Dec 1956. EEBP 629, 1, 74.9 mm SL, 1 km downstream of Cachoeira de Emas, 28 Sep 1952. MZUSP 22511, 2, State of Mato Grosso do Sul, municipality of Três Lagoas, rio Paraná, ca. 20°46'S 51°37'W, Zoology Department Expedition, 15 Sep 1962. NUP 22699, 1, 93.0 mm SL, State of Paraná, municipality of Umuarama, córrego Piava, tributary to the lower rio Ivaí basin, 23°40'42"S 53°15'47"W, W. J. da Graça, 31 Dec 2011. *Heptapterus longicauda*: All from upper rio Paraná basin. AMNH 8639, holotype (photograph), 105 mm SL, State of São Paulo, municipality of Franca, rio Grande, 20°35'38"S 47°25'27"W, E. Garbe, 1910. NUP 5221, 6 (5, 32.8–64.6 mm SL), State of Goiás, municipality of Caldas Novas, rio Corumbá, tributary to the rio Paranaíba, 17°43'37"S 48°32'54"W. NUP 6088, 1, 74.2 mm SL, State of Goiás, municipality of Corumbá, Gameleira Stream, tributary to the rio Corumbá, 17°59'49"S 48°29'46"W. NUP 14882, 3, 44.5–85.9 mm SL, collected with NUP 22699. NUP 17591, 1, 28.0 mm SL, State of Mato Grosso do Sul, municipality of Carapó, Araponga Stream, tributary to the rio Amambá, 22°50'39"S 54°49'28"W, Y. Suárez. *Heptapterus* sp. 1: All from the upper rio Paraná basin. DZSJRP 7973, 15 (5, 31.0–108.4 mm SL), State of São Paulo, municipality of Analândia, unnamed tributary to rio Corumbatá (rio Piracicaba, rio Tietê basin), 22°09'59"S 47°37'38"W, P. Gerhard, 15 Sep 2006. DZSJRP 20527 (10, none measured), State of São Paulo, municipality of Itirapina, Cachoeira Stream, tributary to rio Passa Cinco, 22°21'42"S 47°53'04"W, G. Brejão, 7 Sep 2006. DZSJRP 20532, 9 (2, 106.4–152.6 mm SL), State of São Paulo, municipality of Itirapina, Anzol Stream, tributary to rio Passa Cinco (rio Piracicaba, rio Tietê basin), 22°21'48"S 47°53'30"W, G. Brejão, 7 Sep 2006. LBP 6414, 4 (1, photograph), State of Paraná, municipality of Campo Mourão, rio Mourão (rio Ivaí River), 22°04'22"S 52°17'29"W, R. Devidé. LIRP 10970, 1 (photograph), 65.7 mm SL, State of São Paulo, municipality of São Simão, rio Mogi Mirim, tributary to the rio Mogi-Guaçu, 21°35'25"S 47°57'13"W.

DISCUSSION

'*Chasmocranus*' *brachynema* was described with a single specimen that was illustrated by the authors (Gomes, Schubart, 1958: fig. 1) as having the adipose and caudal fins not fused. Although there is no mention of that character state in the text of the original description, the beforementioned drawing illustrates it clearly. Also, those authors placed the species in *Chasmocranus*, which should not have such fusion according to Eigenmann (1912). However, upon examination of the holotype (EEBP 617) of '*C.*' *brachynema*, we could observe that the posterior portion of the adipose fin is confluent with the anteriormost procurrent rays of the dorsal caudal-fin lobe, as in the other specimens analyzed herein. This character state defines some heptapterid genera but is variable in *Chasmocranus* (see Deprá *et al.*, 2022).

As pointed out by Deprá *et al.* (2022, 2023), the classification of several Heptapteridae genera is in a chaotic state, of which the genus *Chasmocranus* is one of the uttermost instances. Since its original description, *Chasmocranus* encompassed two highly divergent species, *viz.* *C. longior* (type-species) and '*C.*' *brevior*. The first has a more elongated body; broad, strongly depressed head and abdominal region; dorsal eyes; adipose fin reaching (but not connected to) the keel formed by the anteriormost caudal-fin rays; and posterior nostril only slightly closer to the eye than to the anterior nostril. The second has a less elongated body; narrower, much less depressed head and abdominal region; laterodorsal eyes; adipose fin not reaching the keel formed by the anteriormost caudal-fin rays; and posterior nostril about twice as close to the eye than to the anterior nostril. Eigenmann (1912) could have used these and other character states that differ between *C. longior* and *C. brevior* to assign them to different genera. Instead, he set *Chasmocranus* to become a notorious catch-all genus within Heptapteridae.

Throughout the XX century, seven additional species were described in *Chasmocranus*: '*C.*' *rosae* Eigenmann, 1922, '*C.*' *truncatorostris* Borodin, 1927, '*C.*' *quadrizonatus* Pearson, 1937, '*C.*' *peruanus* Eigenmann & Pearson, 1942, *C. chimantanus* Inger, 1956, '*C.*' *brachynema* Gomes & Schubart, 1958, and '*C.*' *lopezae* Miranda Ribeiro, 1968. Of these, only *C. chimantanus* is morphologically and geographically close to *C. longior*; all other species are quite distant from the type-species and could have been assigned to other genera, already described or new, at some time. Not surprisingly, several *Chasmocranus* species were suggested as of other Heptapteridae genera, especially *Heptapterus*, another genus whose taxonomic problems are intertwined with *Chasmocranus* (*e.g.*, Mees, 1986; Burgess, 1989).

Three other species, which are morphologically and geographically close to *C. longior*, were originally described in *Heptapterus* and posteriorly removed to *Chasmocranus*: Inger (1956) proposed the new combination for *H. surinamensis* (Bleeker, 1862) in *Chasmocranus* because he noticed that the former does not have the adipose fin connected to the caudal. Bockmann, Slobodian (2018) proposed that *H. tapanahoniensis* (Mees, 1967) is, in fact, a *Chasmocranus*, in agreement with a new diagnosis of the genus proposed therein. Deprá *et al.* (2022) proposed *Chasmocranus bleekeri* based on the topology recovered by Faustino-Fuster *et al.* (2021, fig. 2), in which *C. bleekeri* is sister to *C. longior*, and on the general morphological similarity between those species. It must be noted that in *C. bleekeri*, the adipose and caudal fins are connected, in contrast with other species of *Chasmocranus*. Even so, Deprá *et al.* (2022) noticed that all these species

share the anal-fin insertion anterior to a vertical through the adipose-fin insertion, in contrast with *Heptapterus* and '*C.* *brachynema*', for instance.

To date, no published phylogenetic analyses have included members of *Chasmocranus* with the two divergent morphologies (more elongated body, strongly depressed head and abdominal region, and adipose fin reaching the keel formed by the anteriormost caudal-fin rays *vs.* less elongated body, much less depressed head and abdominal region, and adipose fin not reaching the keel formed by the anteriormost caudal-fin rays) presented by the described species in such a way that *Chasmocranus* was recovered as monophyletic and is maintained as valid (*e.g.*, Silva *et al.*, 2021; Faustino-Fuster *et al.*, 2021). However, in his doctoral thesis, Bockmann (1998) suggested that *Chasmocranus* is currently recognized as a polyphyletic genus, which demands the description of at least three new genera to encompass its diversity. There is no evidence of a close relationship between *Chasmocranus sensu stricto* and '*C.* *brachynema*', which prompted us to investigate a better classification for the species. However, the phylogenetic position of '*Chasmocranus*' *brachynema* has never been thoroughly investigated. The species is too rare in collections to allow the dissection of specimens for osteological analysis, not to mention that formaldehyde-free tissue samples are unavailable.

Moreover, osteological data would be of little help since there are few published morphological phylogenetic studies of Heptapteridae genera (and none published for the entire family) that we could use as a framework for the investigation of the relationships of '*C.* *brachynema*'. Thus, we cannot rely on phylogenetic evidence to propose a new classification for '*C.* *brachynema*'. The species does not fit the definition of any valid genus and redefining one with the sole purpose of including a species that already is valid would make heptapterid classification even more confuse. As Bockmann, Slobodian (2018) pointed out, '*C.* *brachynema*' appears to belong to an undescribed genus. However, to avoid taxonomic instability, we recommend that this *incertae sedis* Heptapterini be maintained temporarily in *Chasmocranus* until more robust data support the description of the new genus or an alternative generic allocation. Using inverted commas in the genus name indicates that the genus determination is inadequate.

Aside from Gomes, Schubart (1958) and Schubart (1964), only two published works seem to have recorded '*Chasmocranus*' *brachynema* (Pereira *et al.*, 2013; Thereza, Langeani, 2019). We concluded that the specimens analyzed by those authors had been misidentified, but five specimens available in fish collections can be assigned to '*C.* *brachynema*'. Of these, four were collected in the decades of 1950 and 1960. The most recent specimen was collected in the córrego Piava in 2011. Although the specimen in Fig. 7B may be a '*C.* *brachynema*', this identification is tentative since the specimen was not preserved.

Thus, our findings seem to present a dire prospect for the conservation of the species. The scarce number of specimens obtained from such a densely sampled area, especially in recent years, and the evident environmental degradation undergone by the regions from which '*Chasmocranus*' *brachynema* is known may be symptoms of an advanced process of extinction. Whereas the Cachoeira de Emas rapids are still free, Jupia's long submerged ones no longer provide a suitable habitat for the species. The fact that '*C.* *brachynema*' was also captured in a low-order stream with slow-flowing water must be considered, since the collection was made during summer when most species reproduce. Given that the collection site is little more than 10 km upstream from the mouth of the

córrego Piava in the fast-flowing rio das Antas, the fish may perform short migrations to find a suitable spawning site in calmer waters. If this is true, the siltation and pollution undergone by the córrego Piava lately is another reason for concern.

On the other hand, the rocky bottoms in which '*Chasmocranus brachynema* dwells pose difficulties in collecting this fish. According to Carla Polaz (personal communication), benthic species are hardly captured when the water level is high at Cachoeira de Emas. When the water level lowers, however (Fig. 7A), some specimens get trapped in puddles on the dried bedrock and can be gathered (Fig. 7B). Gomes (1956:412) observed the same phenomenon regarding the collection of *Imparfinis schubarti* (Gomes, 1956) type materials. Thus, the apparent rarity of '*C.* *brachynema* may be an artifact of the lack of directed sampling efforts. Still, until more specimens are collected at different localities, we must regard the species as rare and disjunctively distributed.

The rio Ivaí basin harbors an additional species with a similarly disjunctive distribution, viz. *Cyphocharax corumbae* (Pavanelli & Britski, 1996) (see Frota *et al.*, 2016), otherwise known from the rio Paranaíba basin. The absence of both '*Chasmocranus brachynema* and *Cyphocharax corumbae* from the Tietê, Paranapanema, and other minor tributaries of the upper rio Paraná basin, suggests that they may have been extinct from some of these waterbodies, perhaps due to the excessive anthropization of the region. While the Ivaí sub-ecoregion lacks many species common to other rivers in the Upper Paraná ecoregion (Reis *et al.*, 2020), it may represent one of the last refuges for certain fishes. If that hypothesis is true, the fact that a single '*Chasmocranus brachynema* and few *Cyphocharax corumbae* specimens are known from the rio Ivaí suggests that their habitats are already alarmingly degraded.

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AUTHORS' CONTRIBUTION

Gabriel de Carvalho Deprá: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing–original draft, Writing–review and editing.

Veronica Slobodian: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing–original draft, Writing–review and editing.

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The author declares no competing interests.

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