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Phallobrycon synarmacanthus, a new species of Stevardiinae from the Xingu basin, Brazil (Teleostei: Characidae)

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Phallobrycon synarmacanthus, new species, is described from the rio Bacajaí (right bank tributary of the rio Xingu). It is recognized based on the presence of bilaterally arranged bony hooks on the last unbranched and anterior 11 or 12 branched anal-fin rays of sexually mature males, the presence of a set of 3 to 5 hypertrophied spines on the unbranched portion of the fifth branched anal-fin ray partially connected to each other by a lamellar crest-like bony projection, the presence of 35–38 perforated lateral line scales and 35–36 vertebrae. The putative phylogenetic position of the genus among the Diapomini (Stevardiinae) is proposed.

Phallobrycon synarmacanthus, espécie nova, é descrita do rio Bacajaí (afluente da margem direita do rio Xingu). O táxon é reconhecido pela presença de ganchos ósseos distribuídos lateralmente no último raio não-ramificado e nos 11 ou 12 raios ramificados anteriores da nadadeira anal de machos maduros, pela presença de um conjunto de 3 a 5 espinhos hipertrofiados na porção não-ramificada do quinto raio da nadadeira anal parcialmente conectados entre si por uma projeção lamelar óssea, pela presença de 35–38 escamas perfuradas na linha lateral e 35–36 centros vertebrais. Adicionalmente, o posicionamento filogenético putativo do gênero entre os Diapomini (Stevardiinae) é proposto.

Introduction

The genus *Phallobrycon* was diagnosed on the basis of the presence of two developed spines on unbranched portions of fifth to seventh anal-fin rays associated with intumescent glandular tissue on the anterior portion of the anal fin of sexually mature males not organized into an organ (as observed in *Bryconadenos* or in other members of the Stevardiinae), as well as the presence of an urogenital papilla, and the absence of pelvic-fin hooks (Menezes et al., 2009a). The sole species of the genus so far, *P. adenacanthus*, originates from the headwaters of the rio Culuene and Iriri in the

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rio Xingu basin. Given the distance between the only known localities of that species, Menezes et al. (2009a) predicted that the genus could be more widespread in the Xingu basin, also occurring in areas with similar ecological conditions. Herein a new *Phallobrycon* species is described from the rio Bacajaí, near the highly threatened Volta Grande area, in the Rio Xingu. The diagnosis of the genus is revised to fit the new taxon, and the putative phylogenetic position of the genus among the Diapomini (Stevardiinae) is discussed. Additionally, morphometric data for the type series of *P. adenacanthus*, which is missing in the original description (Menezes et al., 2009a), are presented (Table 1).

Material and methods

Counts and measurements follow Fink & Weitzman (1974) and Menezes & Weitzman (1990). All measurements are taken point-to-point with digital calipers. Standard length (SL) is presented in millimeters and all other measurements as percentages of SL, except for subunits of the head that are presented as percentages of head length (HL). In the species description, meristic data are followed by the frequency of each count in parentheses with an asterisk indicating the value of the holotype. Numbers of vertebrae, supraneurals, gill rakers, procurrent caudal-fin rays, branchiostegal rays and tooth cusps were obtained from cleared and stained (c&s) paratypes prepared according to Taylor & Van Dyke (1985). Vertebrae of the Weberian apparatus were included in vertebral counts, and the compound centrum formed by the first preural and first ural (PU1+U1) of the caudal region was counted as a single element. Sex of mature specimens was determined by direct examination of their gonads or by examination of their urogenital papilla and anal-fin hooks. All examined specimens are alcohol preserved, except when indicated by c&s. Institutional abbreviations follow Ferraris (2007), with the addition of LIA, Laboratório de Ictiologia de Altamira, Altamira campus, Universidade Federal do Pará. Examined comparative material follows Menezes et al. (2009a–b) and Netto-Ferreira et al. (2014).

Table 1. Morphometric data of holotype and 65 male and female paratypes of *Phallobrycon adenacanthus*. Values of holotype included in data of male specimens. SD, standard deviation. H, holotype.

	males					females			
	H	n	range	mean	SD	n	range	mean	SD
Standard length (mm)	37.0	41	17.5–41.0			25	13.0–40.0		
Percentages of standard length									
Body depth	33.5	38	25.0–33.5	28.7	2.2	25	23.2–30.0	27.4	1.7
Snout to dorsal-fin origin	54.0	41	50.0–55.0	52.6	1.1	25	50.0–55.0	52.6	1.2
Snout to pectoral-fin origin	24.8	41	23.0–28.2	25.1	1.5	25	23.1–27.2	25.1	1.2
Snout to pelvic-fin origin	51.3	41	47.4–52.6	49.5	1.0	25	47.6–53.3	49.8	1.7
Snout to anal-fin origin	64.8	41	60.0–64.8	62.2	1.3	25	60.0–63.7	62.1	1.1
Caudal peduncle depth	12.1	41	9.4–12.1	10.8	0.7	25	9.3–11.7	10.3	0.6
Caudal peduncle length	17.8	41	17.0–20.2	17.8	1.3	25	16.1–19.0	17.7	0.8
Pectoral-fin length	23.8	41	20.0–26.6	22.7	1.8	25	20.5–24.6	22.4	1.6
Pelvic-fin length	17.3	41	13.1–18.7	15.8	1.4	25	13.7–17.0	14.8	1.0
Dorsal-fin base length	12.4	41	11.7–13.5	12.7	0.4	25	11.6–13.8	12.6	0.6
Dorsal-fin height	27.0	41	20.5–27.3	24.5	1.5	25	21.6–25.3	24.0	1.0
Anal-fin base length	23.0	41	21.0–25.1	22.8	1.0	25	21.0–24.7	23.0	1.0
Anal-fin lobe length	19.7	41	16.7–20.4	18.7	1.0	25	17.2–21.0	19.1	1.0
Eye to dorsal-fin origin	39.2	41	36.5–40.5	38.3	1.0	25	36.0–40.6	38.1	1.2
Dorsal-fin origin to caudal-fin base	50.8	41	47.2–53.8	50.3	1.5	25	48.0–52.6	50.5	1.3
Head length	26.0	41	24.4–29.4	26.1	1.2	25	24.5–27.8	26.0	1.0
Percentages of head length									
Horizontal eye diameter	42	41	37–45	40.5	1.5	25	40–43	41.1	1.0
Snout length	27	41	24–29	26.4	1.2	25	24–29	26.0	1.8
Least interorbital width	33	41	28–34	31.3	1.3	25	29–33	31.4	1.1
Upper jaw length	40	41	34–40	37.0	1.7	25	36–39	36.8	1.1

Fig. 1. *Phallobrycon synarmacanthus*; Brazil: Pará: Senador José Porfírio, rio Bacajaí; **a,** MZUSP 118815, holotype, 31.3 mm SL, adult male; **b,** MZUSP 118816, paratype, 30.1 mm SL, adult female.

***Phallobrycon synarmacanthus*, new species**
(Fig. 1)

Holotype. MZUSP 118815 (ex-LIA 318), 31.3 mm SL; Brazil: Pará: Senador José Porfírio, rio Bacajaí, 3°53'40"S 51°43'28"W; A. Gonçalves & D. Bastos, 11 Jul 2014.

Paratypes. All from Brazil: Pará: Senador José Porfírio: LIA 245, 9, 24.6–30.0 mm SL; rio Bacajaí, 3°48'47"S 51°41'7"W; A. Gonçalves & D. Bastos, 9 Jul 2014. – LIA 283, 4, 27.5–33.8 mm SL; rio Bacajaí, Cachoeira do Pintado, 3°54'36"S 51°44'34"W; A. Gonçalves & D. Bastos, 10 Jul 2014. – MZUSP 118816, 10, 28.0–31.0 mm SL; LIA 318, 39, 17.9–31.8 mm SL; same data as holotype. – LIA 354, 7, 25.3–34.0 mm SL; rio Bacajaí, 3°53'31"S 51°43'14"W; A. Gonçalves & D. Bastos, 11 Jul 2014. – LIA 571, 3, 26.1–31.3 mm SL; rio Bacajaí, 3°41'56"S 51°44'23"W; A. Gonçalves & D. Bastos, 11 Jul 2014. – LIA 572, 4, c&s 26.0–28.5 mm SL; 3°54'36"S 51°44'34"W; D. Bastos & A. Gonçalves, 10 Jul 2014. – LIA 661, 1, 29.5 mm, rio Bacajaí, 3°38'54"S 51°45'35"W; A. Gonçalves & D. Bastos, 12 Jul 2014. – LIA 697, 4, 22.5–34 mm SL; rio Bacajaí, 3°38'42"S 51°45'14"W, A. Gonçalves & D. Bastos, 12 Jul 2014. – LIA 2918, 2, 31.8–34.4 mm SL Cachoeira do Igarapé Bacajaí, 3°54'36"S 51°44'34"W; A. Gonçalves & M. D. S. Lima, 8 Jun 2015.

Diagnosis. *Phallobrycon synarmacanthus* can be readily distinguished from *P. adenacanthus* by having the anal fin of sexually mature males with bilateral bony hooks (Fig. 2) on the largest unbranched ray and first 11 or 12 branched rays (vs. anal fin of sexually mature males with bilateral bony hooks restricted to largest unbranched ray and first two branched rays), and a set of three to five bilaterally developed spines on the unbranched portion of the fifth branched anal-fin partially connected by a lamellar bony portion (vs. two developed spines on unbranched portions of fifth, sixth, and seventh branched rays never connected to each other by a lamellar projection). Additionally, *P. synarmacanthus* differs from *P. adenacanthus* in having 35–38 perforated lateral line scales and 35–36 vertebrae (vs. 38–40, and 37–38 respectively).

Description. Morphometric information of holotype and 29 paratypes presented in Table 2. Body

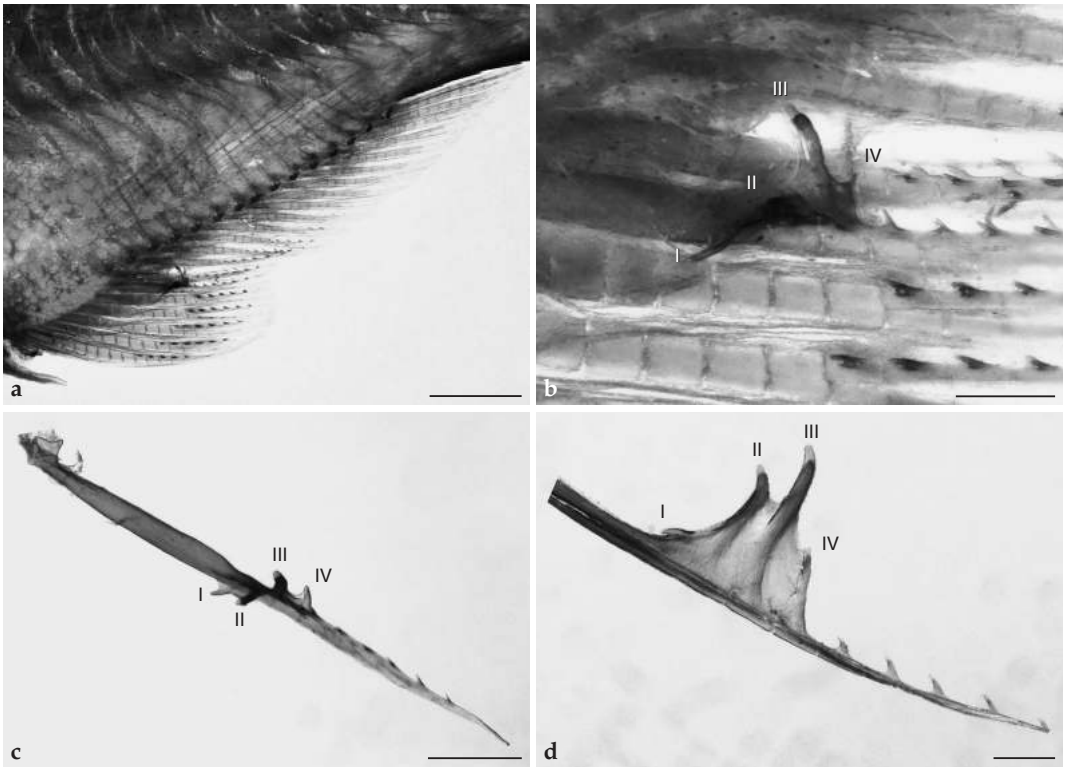

Fig. 2. *Phallobrycon synarmacanthus*, LIA 572, c&s paratype, 28.5 mm SL, adult male: **a,** lateral view of anal-fin illustrating hooks and spines distribution along last unbranched and 11 branched rays; **b,** close up on set of spines (I–IV) on fifth anal-fin ray, associated with anal-fin gland and adjacent spines, oblique lateral view; **c,** dissected left hemitrichium of fifth anal-fin ray in lateral view showing the position and orientation of the four spines (I–IV) associated with the anal-fin gland; **d,** dissected left hemitrichium of fifth anal-fin ray in anterior view showing the position and orientation of four spines (I–IV) associated with anal-fin gland. Scale bars: a, 500 µm; b, 100 µm; c, 200 µm; d, 200 µm).

small (under 32 mm SL), elongate and laterally compressed; greatest body depth at vertical through dorsal-fin origin. Dorsal body profile only slightly inclined at anterior part of snout, gently convex from upper part of snout to dorsal-fin origin, slightly depressed at occipital region, straight and posteroventrally inclined through dorsal-fin base, slightly concave from end of dorsal-fin base to about vertical through middle of anal-fin base, slightly concave at caudal peduncle. Ventral body profile gently convex from tip of lower jaw to anal-fin origin, nearly straight and dorsally inclined along anal-fin base and slightly concave along ventral margin of caudal peduncle. Lower jaw covered laterally by upper jaw when mouth closed. Posterior tip of maxilla extending slightly beyond vertical at anterior border of orbit.

Mouth terminal; lower jaw shorter than upper jaw. Premaxillary teeth in two rows (Fig. 3). Outer row with 3 (3), 4* (21) or 5 (5) tricuspid teeth, somewhat cylindrical and elongate, distally compressed, with central cusp largest; teeth in outer row slightly shorter than inner row teeth. Inner row with 4 teeth in all specimens, compressed, slightly convex on labial surface; teeth pentacuspid in larger specimens, one or two teeth occasionally with 3 or 4 cusps in smaller specimens; central cusp largest with lateral ones gradually decreasing in size. Maxillary teeth 2 (25) or 3* (4), compressed, with 5 or 6 cusps, middle cusp usually largest (Fig. 3). Dentary with 4 anterior teeth largest, pentacuspid in all specimens, followed by 4 (3), 5* (23), or 6 (4) smaller tetra- or tricuspid teeth, gradually decreasing in size posteriorly. Largest anterior teeth with lingual surface concave and labial surface convex (Fig. 3). Total number

of gill rakers on first branchial arch 13*(1), 14(4), 15(12), 16(8) or 17(5). Branchiostegal rays 4(4), 3 rays originating on anterior and 1 on posterior ceratohyal.

Scales cycloid. Lateral line complete, slightly curved ventrally, with 35(3), 36(8), 37*(15) or 38(4) perforated scales. Predorsal scales 10(1), 11(13), 12(14) or 13*(2). Longitudinal scale rows between dorsal-fin origin and lateral line 5*(30); longitudinal scale rows between lateral line and pelvic-fin origin 3*(30). Circumpeduncular scales 14*(30).

Pectoral-fin rays i,11(16), i,12(13) or i,13*(1). Distal tip of longest pectoral-fin ray falling short of pelvic-fin origin. Pectoral-fin rays without hooks. Pelvic-fin rays i,6,i*(30). Distal tip of longest pelvic-fin rays extending slightly beyond anal-fin origin. Supraneurals 5(2) or 6(2) located anterior to neural spines of 5th to 9th (3) or 10th (1) vertebrae. Dorsal-fin rays ii,8 in all specimens, with posteriormost ray branched. First dorsal-fin pterygiophore inserted immediately behind neural spine of 10th (1) or 11th (3) vertebra. Anal-fin rays iii*(26) or iv(4), 17(2), 18*(9), 19(11),

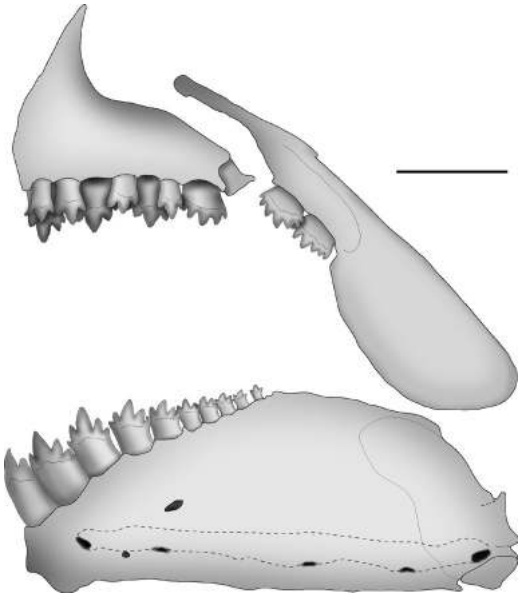

Fig. 3. *Phallobrycon synarmacanthus*, LIA 572, 28.5 mm SL, adult male; reversed lateral view of right side of upper and lower jaws and dentition. Anterior to left.

Table 2. Morphometric data of holotype and 29 male and female paratypes of *Phallobrycon synarmacanthus*. Values of holotype included in data of male specimens. SD, standard deviation. H, holotype.

	males					females			
	H	n	range	mean	SD	n	range	mean	SD
Standard length (mm)	31.3	18	26.3–31.8			12	26.0–31.3		
Percentages of standard length									
Body depth	32.9	18	28.2–32.9	30.7	1.3	12	28.5–32.8	30.1	1.3
Snout to dorsal-fin origin	51.9	18	50.0–52.9	51.6	0.8	12	51.3–53.0	52.1	0.6
Snout to pectoral-fin origin	24.3	18	23.5–25.0	24.1	0.4	12	22.7–24.9	24.3	0.6
Snout to pelvic-fin origin	49.8	18	47.7–50.4	48.9	0.8	12	48.1–52.4	49.4	1.2
Snout to anal-fin origin	65.2	18	62.4–65.3	64.0	1.0	12	62.7–65.4	63.8	0.9
Caudal peduncle depth	11.8	18	10.1–12.0	11.1	0.6	12	9.7–12.0	10.8	0.6
Caudal peduncle length	18.8	18	15.8–19.5	18.3	0.8	12	16.8–19.9	18.2	1.0
Pectoral-fin length	21.9	18	19.6–24.1	21.0	1.0	12	19.7–22.1	21.0	0.8
Pelvic-fin length	15.5	18	14.5–17.3	15.6	0.7	12	13.7–15.4	14.6	0.6
Dorsal-fin base length	13.8	18	11.6–13.8	12.6	0.5	12	11.6–12.8	12.2	0.4
Dorsal-fin height	25.5	18	23.4–25.8	24.7	0.8	12	23.4–26.0	24.3	0.8
Anal-fin base length	22.2	18	21.0–24.0	22.2	1.0	12	21.1–24.5	22.8	1.1
Anal-fin lobe length	12.9	18	12.8–15.2	13.8	0.7	12	15.9–17.7	17.0	0.6
Eye to dorsal-fin origin	37.3	18	35.3–38.7	37.2	1.0	12	36.7–38.4	37.7	0.6
Dorsal-fin origin to caudal-fin base	52.7	18	49.5–53.4	51.5	1.2	12	50.0–53.8	51.2	1.0
Head length	24.5	18	23.8–24.8	24.3	0.3	12	23.7–25.4	24.6	0.5
Percentages of head length									
Horizontal eye diameter	43	18	41–46	44.2	1.3	12	42–46	44.7	1.2
Snout length	27	18	23–27	25.3	1.1	12	23–27	25.2	1.2
Least interorbital width	34	18	31–35	32.5	1.0	12	30–34	32.5	1.1
Upper jaw length	37	18	33–37	35.4	1.2	12	34–38	35.9	1.4

20 (5) or 21 (3), with posteriormost ray branched adnate. Anterior anal-fin lobe formed by anterior unbranched rays and first 5–6 branched rays in both sexes. First anal-fin pterygiophore inserted immediately anterior of haemal arch of 17th (4) vertebra. Adipose fin present. Caudal fin forked; lobes approximately equal in size. Principal caudal-fin rays i,9/8,i in all specimens. Total vertebrae 35 (3) or 36 (1), precaudal vertebrae 15 (3) or 16 (1); caudal vertebrae 20 (4).

Color in alcohol. Body pale to light yellow. Dark spots on dorsum along median scale row, extending from occiput to dorsal part of caudal peduncle, separated by two and a half scale rows from lateral body stripe. Dark lateral body stripe extending from upper part of opercle to caudal base where becoming wider. Stripe diffuse anteriorly, more conspicuous and darker from vertical through dorsal-fin origin to caudal base, its posterior margin covering bases of 5–15 principal caudal-fin rays; caudal-fin stripe extending to distal tips of caudal-fin rays 5–12. Vertically elongate dark spot at humeral region. Scattered dark chromatophores on upper sides of head and above and below mid-lateral dark body stripe with ventral portion of body with diffuse dark patches of chromatophore between the pectoral- and pelvic-fin origins, gradually more conspicuous around anus base and base of anteriormost anal-fin rays. Dorsal part of head dark. Fins hyaline with scattered dark chromatophores.

Sexual dimorphism. As in *P. adenacanthus* mature males of *P. synarmacanthus* have a well-developed urogenital papilla anterior to the anal fin (Fig. 1a), already observed in specimens as small as 26.5 mm SL. Additionally, three to five highly developed spines are present on the fifth branched anal-fin ray and are associated with glandular tissue in mature males (Fig. 2a). Anal fin of sexually mature males have bilaterally arranged bony hooks on the largest unbranched ray and the first 11 or 12 branched rays. In one male specimen (30.0 mm SL), five hooks are present on the largest unbranched ray, six on the posterior branch of the first to the seventh branched rays, five on the posterior branch of the eighth ray, four on the ninth, two on the tenth and one on the eleventh branched rays and three to five developed spines on the unbranched portion of the fifth branched ray located slightly below the middle of the ray (Fig. 2b–d). Unlike *P. adenacanthus* (Table 1), males of *P. synarmacanthus* have significantly shorter anal-fin lobes and longer pelvic fins than those observed in female specimens ($p = 0.00803$ and $p = 0.00008$, respectively).

Distribution. *Phallobrycon synarmacanthus* is known from the rio Bacajaí, a right bank affluent of the rio Xingu near Volta Grande, near the Belo Monte Village (Fig. 4).

Ecological notes. Specimens of *P. synarmachanthus* were collected in three main habitats along the Bacajaí River: beaches, rapids and small streams. The rapids are located in the main channel of the Bacajaí River, being shallow (1 m deep), with turbid water, moderate current flow, with substrate composed of many rocks covered with Podestemaceae and thick sand. Small streams have clear water, moderate current and the bottom covered with sand, trunks and leaves. Specimens were also captured along beaches on the banks along the Bacajaí River. Collection sites of *P. synarmacanthus* indicate a high association of that species with sandy habitats. Specimens were collected with Characidae species typical of such environments: *Hemigrammus* aff. *geisleri*, *Knodus* spp., *Microschemobrycon* spp., and *Rhinopetitia* cf. *myersi*.

Etymology. The specific epithet derives from the Greek *syn* (together), *harma* (joint) and *akanthos* (spine) in allusion to the three to five hypertrophied spines of the fifth anal-fin branched ray, which are connected via a bony crest in sexually mature male specimens. A noun in apposition.

Discussion

Phallobrycon synarmacanthus shares with *P. adenacanthus* the presence of a well-developed urogenital papilla, the presence of entumescent glandular tissue associated with hypertrophied spines on the fifth anal-fin ray, the presence of a distinct anal-fin lobe in both males and females, and the lack of bony hooks on the pelvic-fin rays, thus justifying its inclusion in the genus *Phallobrycon*. Both species share the three morphological synapomorphies proposed by Mirande (2010) to redefine the Stevardiinae, and, therefore, should be considered members of that group. Although

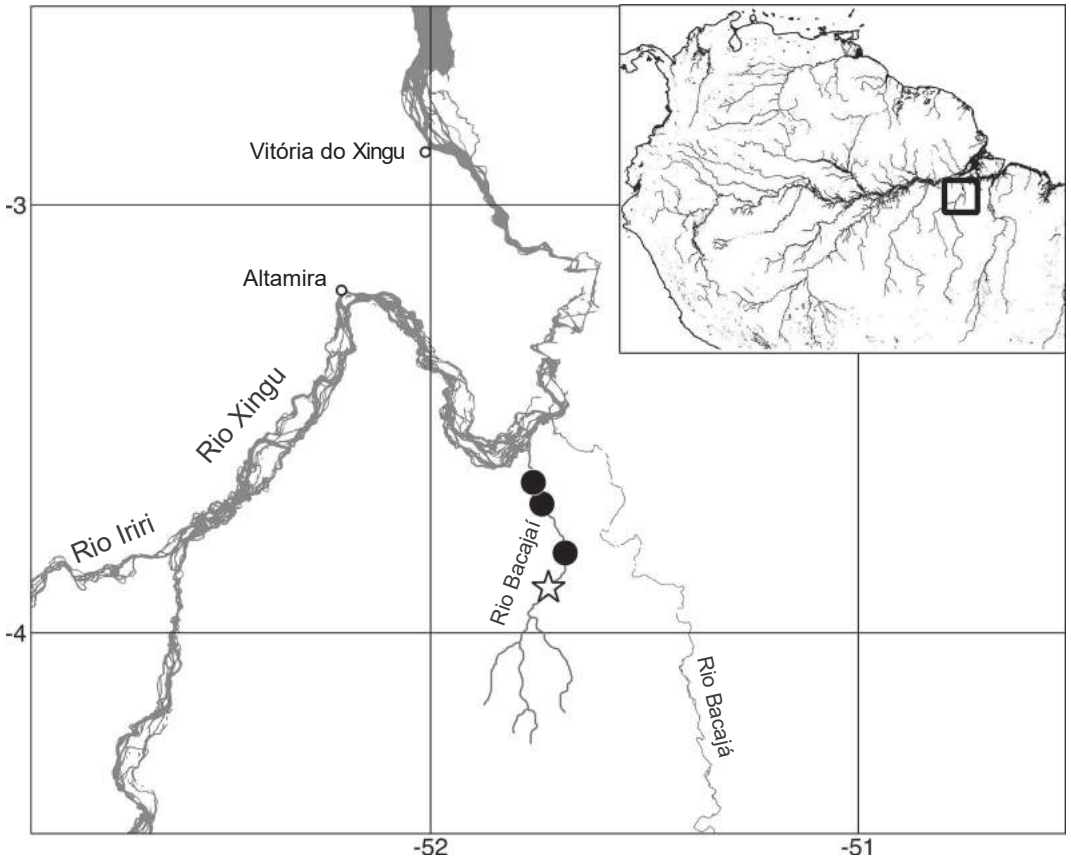

Fig. 4. Lower rio Xingu basin and adjoining areas showing collecting sites (●) and type-locality (☆) of *Phallobrycon synarmacanthus*. Symbols may represent more than one collecting locality.

Thomaz et al. (2015) did not comment on the relationships of *Phallobrycon* among other Stevardiinae, the overall morphology of *Phallobrycon* and the derived features shared between that genus and *Bryconadenos* (i.e. presence of entumescent glandular tissue on the anal-fin lobe, and lack of bony hooks on the pelvic-fin rays – Weitzman et al., 2005; Menezes et al., 2009b) are considered herein putative characters to place *Phallobrycon* among the Diapomini (sensu Thomaz et al., 2015). Such shared derived characters may as well be considered sufficient evidence for the genus to be nested within representatives of *Knodus* in a broad sense along with *Bryconadenos* in the topology presented by Thomaz et al. (2015). On the other hand, the limited sample of representatives of that genus as well as other taxonomically complex genera (i.e. *Bryconamericus*) and the accuracy of the identification (i.e. part of the specimens identified as *Knodus heteresthes* in that contribution are actually *Rhinopetitia* sp. – MNRJ 34410 and MNRJ 34678) in Thomaz et al. (2015) make it still premature to hypothesize nomenclatural changes involving both *Phallobrycon* or *Bryconadenos*, and therefore, the names are still considered valid herein.

Although no histological study on the sexual organs and spermatozoans was performed, the presence of a well-developed urogenital papilla in mature males of *P. synarmacanthus* is a strong indication that it functions as an intromitent organ as in *P. adenacanthus*. Hence, fertilization in representatives of *P. synarmacanthus* is apparently also achieved by means of insemination.

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