

A new species of the catfish genus *Cambeva* from the Paranapanema river drainage, southeastern Brazil (Siluriformes: Trichomycteridae)

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Abstract: The recently described catfish trichomycterid genus *Cambeva* comprises about 25 valid species, occurring mostly in river basins of south-eastern and southern Brazil. Fifteen species are endemic to the Paraná river basin, of which three are endemic to the Paranapanema river drainage. Herein we describe a fourth new species, *Cambeva guareiensis* n. sp., known only from the Guareí river. *Cambeva guareiensis* is similar to *C. brachykechenos*, *C. cubataonis*, *C. diabola*, *C. davisii*, *C. diatropoporos*, *C. pascuali*, *C. poikilos* and *C. stawiarski* by having a colour pattern consisting of dark brown spots scattered on the flank and can be differentiated by an exclusive combination of characters, including: the shape of the autopalatine; number of branchiostegal, anal-fin, dorsal-fin, dorsal and ventral caudal procurrent, and pectoral-fin rays; number of interopercular and opercular odontodes; number of vertebrae; and, insertion of anal fin, pelvic fin and urogenital papillae. This study indicates the potential for discovering a greater still unknown trichomycterid species diversity in the Paraná river basin.

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Key words: Taxonomy; Paraná River basin; biodiversity; Trichomycterinae; Neotropic.

Introduction

Popularly known as catfishes, the Siluriformes are among the most diverse vertebrate orders, with about 3700 species (Nelson et al. 2016; Fricke et al. 2019). Among Siluriformes, the Trichomycteridae is the second most diverse family, with over 300 valid species (Fricke et al. 2019). Trichomycterid catfishes are unique among other fish groups by all presenting a highly modified opercular bones and associated muscles, often used to climb waterfalls (Eigenmann 1918; Arratia 1983).

The Trichomycterinae is the most diverse subfamily of Trichomycteridae, occurring between Costa Rica in Central America and Patagonia in southern South America (Datovo

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and Bockmann 2010; Ochoa et al. 2017; Katz et al. 2018). Until recently Trichomycterinae and its genus *Trichomycterus* Valenciennes, 1832 were among the most controversial Neotropical fish groups, often considered paraphyletic (Baskin 1973, Arratia et al. 1978; de Pinna 1989; Arratia 1990; Costa and Bockmann 1993). However, recent morphological and molecular studies have consistently supported monophyly of the Trichomycterinae (Datovo and Bockmann 2010; Ochoa et al. 2017; Katz et al. 2018), as well as a more recent generic delimitation based on a multigene analysis proposed a new classification for part of the Trichomycterinae, where, *Trichomycterus* was restricted to a clade containing the type species, *T. nigricans* Valenciennes, 1832 and several other species from eastern Brazil (Katz et al. 2018). In the last cited study, *Trichomycterus* was strongly supported as sister group to a clade containing *Scleronema* Eigenmann, 1917 and a clade then named as a new genus *Cambeva* Katz, Barbosa, Mattos & Costa, 2018.

Species of *Cambeva* can be distinguished from all other trichomycterines by the presence of a bony flap on the maxillo-dentary ligament of the dentary channel and by having the interopercle shorter than the opercle, a deep constriction on the basal portion of the anterodorsal arm of the quadrate, absence of teeth in the coronoid process of the dentary, the maxilla shorter than the premaxilla, the cranial fontanel extending from the medial posterior portion of frontal to the medial region of the supraoccipital, and by the absence of the postorbital process of the sphenotic, prootic and pterosphenoid (Katz et al. 2018). *Cambeva* comprises about 25 valid species, occurring in river basins of south-eastern and southern Brazil (Katz et al. 2018), with each species usually found in isolated river headsprings with highly oxygenated waters, often exhibiting the habit of hiding in the bottom substrate (Bockmann et al. 2004; Katz and Barbosa 2014; Katz et al. 2018). Most species (15) of *Cambeva* are endemic to the Paran river basin, of which three are endemic to the Paranapanema river drainage (Nascimento et al. 2017; Bockmann et al. 2004; Ochoa et al. 2017). In the present study, we describe a new species from the upper section of the Paranapanema river drainage.

The material is deposited in the collections of the Departamento de Zoologia of the Universidade Federal do Rio de Janeiro (UFRJ) and the Museu Nacional do Rio de Janeiro (MNRJ).

Material and methods

Measurements and counts follow Barbosa and Costa (2003). Measurements are presented as percentages of standard length (SL), except for subunits of head, which are presented as percentage of head length (HL). Counts of procurrent caudal-fin rays, vertebrae, branchiostegal rays, teeth and odontodes were made only in cleared and stained specimens (C&S) prepared according to Taylor and Van Dyke (1985). Terminology for osteological nomenclature follows Datovo and Bockmann (2010). Nomenclature and homologies for supraorbital and infraorbital sensory canal systems follow Arratia and Huaquin (1995). Comparative material appears in supplementary material, available on line.

Taxonomy

Cambeva guareiensis n. sp.

(Figures 1-4)

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Material examined

Holotype. UFRJ 12173, 59.5 mm SL, Brazil: So Paulo State: Angatuba Municipality:

Correntes waterfall, in Guareí river of the Paranapanema river drainage, Paraná river basin, 23°26'05"S, 48°23'19"W, altitude about 650 m a.s.l., leg. P. Hamilton & V.M. Azevedo-Santos, 6.XI.2017.

Paratypes. 19 ex., UFRJ 12170, 14.3–52.1 mm SL; 6 ex. (C&S), UFRJ 12171, 34.6–54.1 mm SL; 10 ex., MNRJ 51423, 25.1–37.3 mm SL, same locality as holotype, leg. H. Rodrigues & V.M. Azevedo-Santos, 26.VII.2017; 3 ex., UFRJ 12172, 40.5–52.1 mm SL, collected with holotype.

Diagnosis

Cambeva guareiensis is distinguished from all other congeners except *Cambeva brachykechenos* (Ferrer & Malabarba, 2013), *C. cubataonis* (Bizerril, 1994), *C. diabola* (Bockmann, Casatti & de Pinna, 2004), *C. davisii* (Haseman, 1911), *C. diatropoporos* (Ferrer & Malabarba, 2013), *C. pascuali* (Ochoa, Silva, Silva, Oliveira & Datovo, 2017),

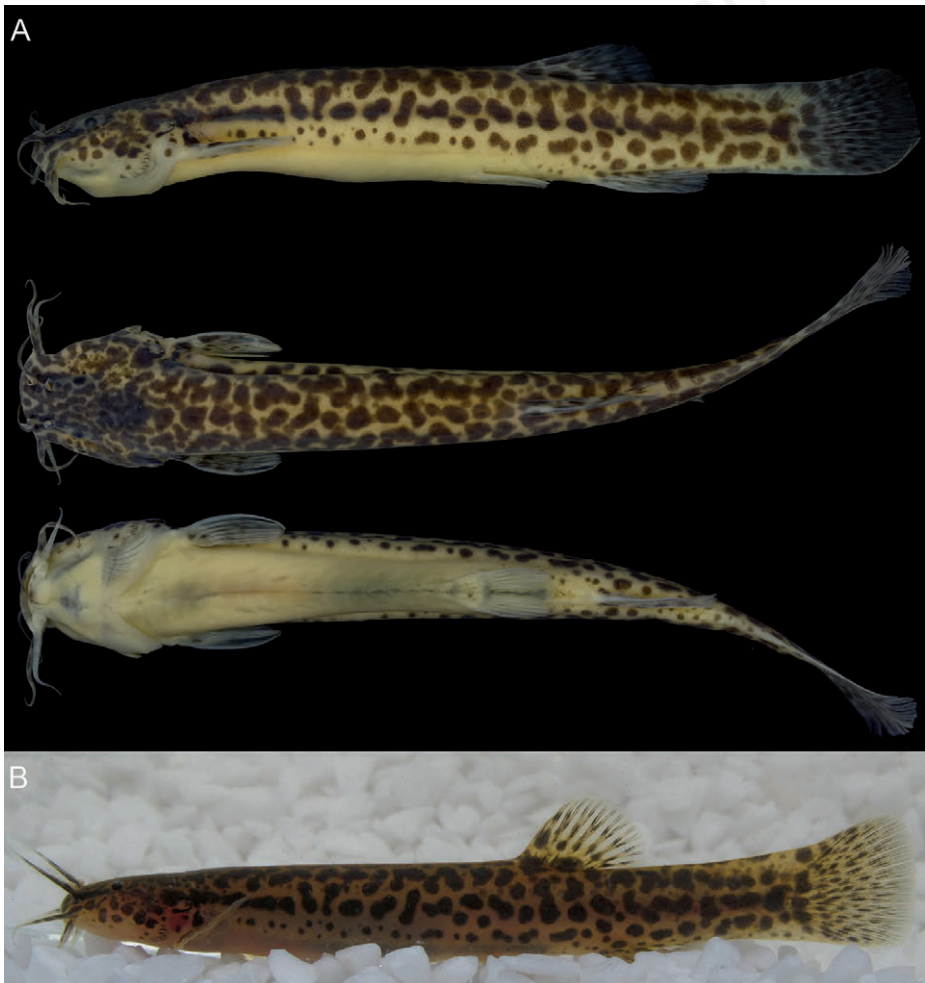


Figure 1. *Cambeva guareiensis* n. sp. A, UFRJ 12173 holotype, 51.2 mm SL; Brazil: São Paulo State State: Angatuba: Paranapanema river basin; B, live holotype.

C. poikilos (Ferrer & Malabarba, 2013), and *C. stawiarski* (Miranda Ribeiro, 1968) by having a colour pattern consisting of dark brown spots scattered on the flank (Figures 1, 3) (vs. plain brown, often with minute brown dots, sometimes with stripes). Distinguished from *C. brachykechenos*, *C. diabola*, *C. poikilos* and *C. stawiarski* by having the mesial margin of autopalatine with deep concavity (vs. straight in *C. poikilos* and *C. stawiarski* or just slightly concave in *C. brachykechenos* and *C. diabola*); from *C. brachykechenos*, *C. diabola*, *C. diatropoporos* and *C. stawiarski* by the presence of 8–9 anal-fin rays (vs. 6–7 in *C. brachykechenos* and *C. diatropoporos*; and 10 in *C. diabola* and *C. stawiarski*); from *C. brachykechenos*, *C. diabola*, *C. pascuali* and *C. poikilos* by having 7 pectoral-fin rays (vs. 5 in *C. pascuali*; 6 in *C. brachykechenos* and *C. poikilos*; and 8 in *C. diabola*); from *C. brachykechenos*, *C. diatropoporos*, *C. pascuali* and *C. stawiarski* by having 35–36 vertebrae (vs. 37–41); from *C. brachykechenos*, *C. diabola*, and *C. stawiarski* by having the anal-fin insertion in the vertical through centrum of the 23th–24th vertebrae (vs. 21st–22th in *C. brachykechenos* and *C. stawiarski*; and 25th–26th in *C. diabola*); from *C. davisi*, *C. pascuali* and *C. stawiarski* by having 8 branchiostegal rays (vs. 7 in *C. pascuali* and 9–11 in *C. davisi* and *C. stawiarski*); from *C. cubataonis*, *C. diabola* and *C. poikilos* by the presence of 11 dorsal-fin rays (vs. 7–9 in *C. poikilos* and 12 in *C. cubataonis* and *C. diabola*); from *C. cubataonis*, *C. diabola* and *C. stawiarski* by having the pelvic-fin origin in the vertical through centrum of the 17th vertebrae (vs. 16th in *C. cubataonis*, 21st in *C. diabola* and 16th in *C. stawiarski*), the dorsal-fin origin in the vertical through centrum of 19th–20th vertebrae (vs. 17th–18th in *C. cubataonis* and *C. stawiarski* and 21st–22th in *C. diabola*), and the anal-fin origin in the vertical through the 9th or 10th dorsal-fin ray base (vs. anterior to the dorsal-fin base in *C. diabola* and *C. stawiarski*); from *C. davisi* and *C. stawiarski* by possessing the urogenital papillae in the vertical through centrum of the 21st–22th vertebrae (vs. 23th–24th in *C. davisi* and 20th in *C. stawiarski*); from *C. cubataonis* and *C. stawiarski* by the presence of 10–13 opercular odontodes (vs. 14–19); from *C. stawiarski* by the presence of 14–20 dorsal procurrent rays on the caudal fin (vs. 27), and 25–32 interopercular odontodes (vs. 40); and from *C. pascuali* by the presence of pelvic fin (vs. absence), 12–13 pleural ribs (vs. 14), 25–32 interopercular teeth (vs. 11–12), and 9–12 procurrent ventral rays on the caudal fin (vs. 15–16).

Description

Morphometric data for holotype and paratypes given in Table 1. Body subcylindrical on anterior portion, compressed on caudal peduncle. Dorsal profile slightly convex between snout and end of dorsal-fin base, straight on caudal peduncle. Ventral profile straight to slightly convex between lower jaw and end of anal-fin base, slightly concave on caudal peduncle. Greatest body depth in vertical immediately in front of pelvic-fin origin. Skin papillae minute. Urogenital papilla conical, in vertical through centrum of 21st–22th vertebrae.

Head trapezoidal in dorsal view. Mouth subventral. Tip of nasal, maxillary and rictal barbels reaching anterior edge of interopercular patch of odontodes. Tip of maxillary barbel not reaching pectoral-fin base. Interopercular odontodes 25–32; opercular patch of odontodes broad, with 10–13 odontodes; odontodes conical (Figure 2A).

Anterior cornua of mesentmoid straight. Anterior fontanel straight immediately anterior to epiphyseal bar. Posterior cranial fontanel long and broad between frontals and extending into parieto-supraoccipital. Sphenotic, prootic and pterosphenoid entirely fused to each other (Figure 2B). Vomer arrow-shaped with long posterior process. Antorbital about 1/3 of supraorbital length. Sesamoid supraorbital rod-like. Autopalatine square-like,

with anterior margin convex, mesial margin deeply concave, distal margin slightly concave and small posterior process extending slightly over metapterygoid (Figure 2C).

Premaxilla with 3 rows of conical teeth; anteriormost row with 12–14 teeth. Maxilla large, boomerang-shaped and more slender than premaxilla. Lower jaw with bone flap over maxilla-dentary channel, 3 rows of conical and spatulate teeth, most external row with 14–19 teeth (Figure 2D).

Metapterygoid sub-triangular, wider than deep, without distinct processes. Dorsal surface of hyomandibula with deep concavity. Articulation between metapterygoid and quadrate restricted to cartilage block. Preopercle slender, sub-triangular, covering ventral margins of quadrate and hyomandibula (Figure 2A).

Hypohyal subtriangular in ventro-lateral view, with elliptical hollow; anterior ceratohyal long, posterior ceratohyal short, about one third anterior ceratohyal; branchiostegal rays 8; lateral process of parurohyal short and robust, extremity truncate, posterior process short and narrow, anterior process settled in elliptical hollow of hypohyal (Figure 2E).

Anterior tip of basibranchial axis extending to level of hypobranchials 1, not reaching dorsal surface of urohyal keel, with posterior tip situated immediately in front of anteromedial region of contralateral hypobranchials 3. Ossification of basibranchial 2 nearly as long as bony portions of basibranchial 3 and hypobranchial 1. Basibranchial 4 completely cartilaginous, represented by sub-rectangular plate. Basibranchial 4 bordered anteriorly by hypobranchials 3, laterally by cartilaginous heads of ceratobranchials 4, and posteriorly by cartilaginous heads of ceratobranchials 5. Hypobranchial 1 rod-like, with

Table 1. Morphometric data for holotype and paratypes of *Cambeva guareiensis* (n=16 including the holotype).

	Holotype	n=16	MEAN	SD
Standard length (mm)	51.2	34.48–59.5		
Percentage of Standard length				
Body depth	13.7	11.3–16.0	13.6	1.3
Caudal peduncle depth	11.3	7.9–12.6	11.0	1.1
Body width	7.5	7.2–12.4	8.8	1.7
Caudal peduncle width	3.5	3.3–5.4	4.1	0.7
Dorsal-fin base length	10.4	8.7–11.5	10.3	0.8
Anal-fin base length	8.0	6.9–10.4	8.4	0.9
Pelvic-fin base length	8.8	7.1–11.0	8.6	1.0
Pectoral-fin length	13.9	10.8–14.5	13.0	1.0
Pre-dorsal length	62.3	56.0–65.6	61.2	2.7
Pre-pelvic length	54.1	50.4–56.8	54.0	1.7
Head length	15.2	15.2–20.8	17.6	1.8
Percentage of Head length				
Head depth	65.9	48.0–65.9	57.6	5.5
Head width	103.8	82.9–106.2	95.2	6.9
Interorbital distance	37.8	29.6–37.9	33.5	2.7
Snout length	50.0	34.4–50.8	44.7	4.4
Eye diameter	12.8	7.5–13.0	10.1	1.9

SD, Standard deviation.

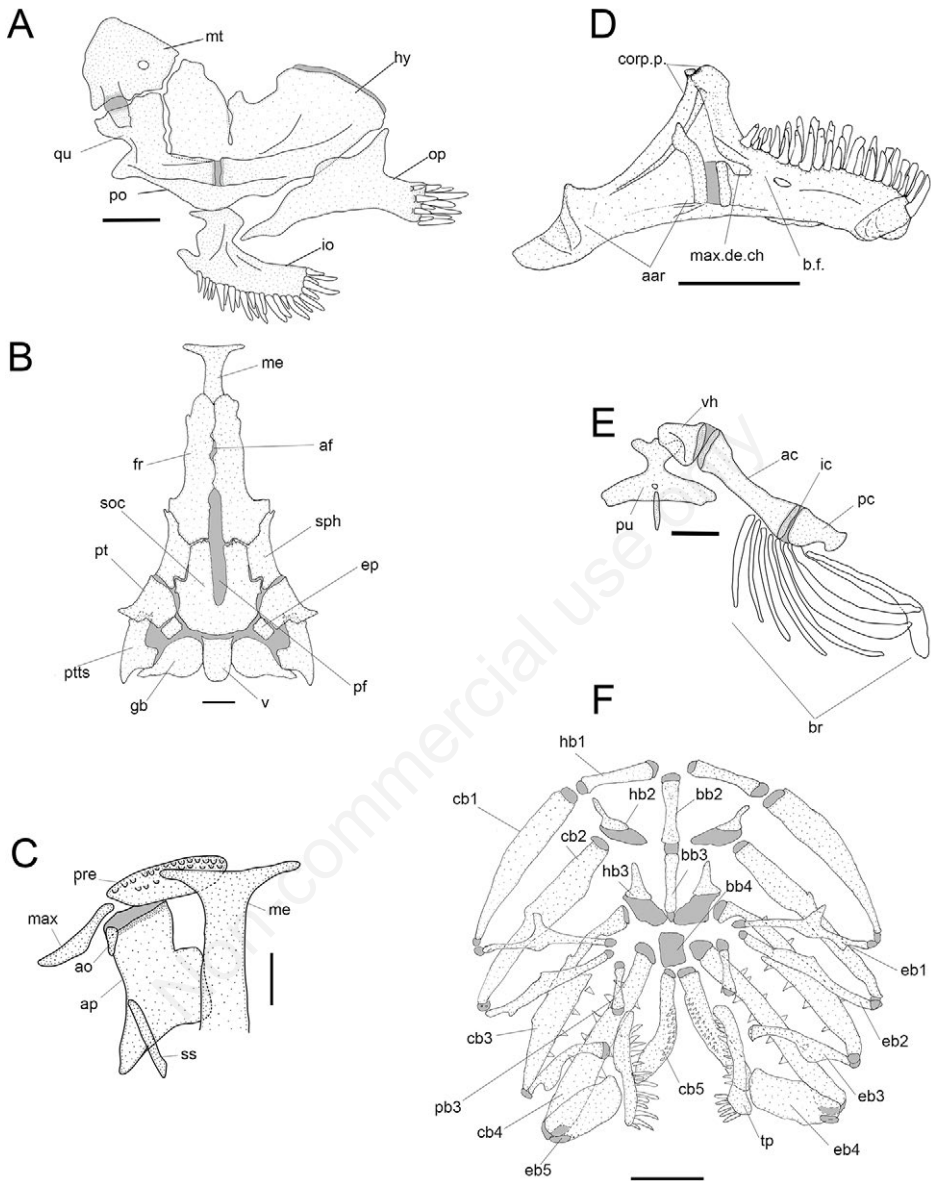


Figure 2. *Cambeva guareiensis* n. sp., UFRJ 12171, 49.2 mm SL. A, left suspensory in dorsal view; B, cranium in dorsal view; C, left autopalatine in dorsal view; D, Left lower jaw in medial view; E, left hyoid arch in dorsal view; F, branchial skeleton in dorsal view. Abbreviations: ac, anterior ceratohyal; af, anterior fontanel; ao, antorbital; ap, autopalatine; bb2-4, basibranchials 2 to 4; b.f. bone flap; br, branchiostegal rays; cb1-5, ceratobranchials 1 to 5; corp.p, coronoid process; de, dentary; eb1-5, epibranchials 1 to 5; ep, epioccipital; fr, frontal; gb, gasbladder capsule; hb1-3, hypobranchials 1 to 3; hy, hyomandibula; ic, inter-ceratohyal cartilage; io, interopercle; max.de.ch., maxillo-dentary channel; me, mesethmoid; mt, metapterygoid; mx, maxilla; op, opercle pb3-4; pharyngobranchials 3 and 4; pc, posterior ceratohyal; pf, posterior fontanel; pm, premaxilla; po, preopercle; pfts, post-temporo-supracleithrum; pt, pterotic; qu, quadrate; sph, sphenotic; ss, sesamoid supraorbital; soc, parieto-supraoccipital; tp, tooth plate; vh, ventral hypohyal. Scale bar = 1 mm.

cartilage only in its proximal and distal tips, and without uncinat process on its anterodistal portion. Hypobranchial 2 elongate, approximately triangular, mostly cartilaginous except for pointed, anterolaterally-oriented, process on its anterodistal region. Hypobranchial 3 approximately triangular, closely positioned relative to its counterpart, mostly cartilaginous except for pointed, antero-laterally-oriented, process on its anterodistal region. Ceratobranchials well-ossified, with small cartilage at their extremities. Proximal portion of ceratobranchial 3 with concavity at its posterior margin. Ceratobranchial 5 supporting patch of fine 12-16 conical teeth arranged in 2 rows, teeth of most mesial row distinctly larger. Epibranchials 1–3 rod-like and well-ossified, except at tips. Anterior margin of epibranchial 1 with prominent elongate uncinat process. Anterior border of epibranchial 2 with small blunt process. Posterior margin of epibranchial 3 with robust uncinat process. Epibranchial 4 broad, rectangular. Epibranchial 5 minute, oval, cartilaginous, situated close to distal cartilaginous head of ceratobranchial 4. Pharyngobranchials 1 and 2 absent. Pharyngobranchial 3 elongate, rod-like. Pharyngobranchial 4 well-ossified and elongate, ventrally attached to well-developed upper pharyngeal tooth plate, bearing 14-18 fine conical teeth arranged in 2 rows, with 4-5 most posterior teeth larger and curved at their tips (Figure 2E).

Dorsal and anal fins sub-triangular, with slightly convex distal margin. Origin of dorsal fin posterior to middle of total length, in vertical through centrum of 19th–20th vertebrae; anal-fin origin in vertical of 9th–10th dorsal-fin base rays, through centrum of 23th–24th vertebrae. Caudal fin truncate. Pectoral fin well-developed, sub-triangular, lateral and posterior edges slightly convex, fin insertion posterior to opercular membrane; tip of first pectoral-fin ray not prolonged as filament. Pelvic fin shorter than anal fin, covering urogenital opening, but tip not reaching anal fin, in vertical just anterior to dorsal-fin origin; pelvic-fin insertion through centrum of 17th vertebra; pelvic girdle short with mesial process; pelvic-fin bases medially in close proximity. Dorsal-fin rays III+6–7; anal-fin rays II–III+6; caudal-fin principal rays I+6+5+I, dorsal procurent rays 14–20, ventral procurent rays 9–12; pectoral-fin rays I+6; pelvic-fin rays I+4.

Upper hypural plates separated, ventral plate slightly wider than dorsal plate. Total vertebrae 35–36. Pleural ribs 12–13. First pleural rib straight and much thicker than second rib. First complete hemal spine on 18th–19th vertebrae.

Head sensory canals with simple (non-dendritic) tubes ending in single pores. Supraorbital sensory canal continuous and connected to optic and infraorbital sensory canals posteriorly. Supraorbital sensory canal bearing 3 branches and pores s1, s3, and s6 (epiphyseal branch and pore); s2, s4, s5, s7, and s8 (parietal) branches and pores absent. Otic sensory canal short, without pores, and continuous with posterior limits of supra- and infraorbital sensory canals, anteriorly, and with anterior limit of postotic sensory canal, posteriorly. Postotic (or temporal) sensory canal extends from posterior limit of otic sensory canals to anterior limit of lateral line, bearing 2 branches and pores (po1 and po2). Infraorbital sensory canal with one segment with 2 branches and pores (i10 and i11), i1 and i3 branches and pores absent. Preoperculomandibular sensory canal absent. Lateral-line canal very short, with 2 pores, extending from posteriormost region of opercle to above middle of pectoral fin. Conspicuous rostral line of neuromasts surrounding anterior limit of anterior nostril.

Colouration

Flank yellow with dark rounded brown spots, larger and more concentrated on dorsal half of flank and whole peduncle caudal side, their diameter twice or more eye diameter,

sometimes coalesced on lateral midline; spots on anteroventral portion of flank smaller, equal or slightly larger than eye diameter. Dorsal surface between head and dorsal fin yellow with dark brown blotches. Venter pale yellow. Head side light yellow with small dark brown spots. Interopercular and opercular patches of odontodes yellow, sometimes with minute dark brown dots. Distal part of barbels yellow, proximal part brown. Fins hyaline, with transverse rows of dark brown spots (Figures 1A,B; 3A,B).

Distribution

Cambeva guareiensis is only known from a small stream tributary to the Guareí River, tributary of upper section of the Paranapanema river drainage, Paraná river basin (Figure 4).

Etymology

The name *guareiensis* refers to the occurrence of the new species in the Guareí river drainage, a noun in apposition.

Discussion

Currently five species of *Cambeva* have been reported to occur in the Paranapanema river drainage: *C. davisii*, *C. diabolus*, *C. guareiensis*, *C. pascuali* and *C. perkosi* (Datovo, Carvalho & Ferrer, 2012). Although phylogenetic relationships among species of *Cambeva* are still unknown and osteological data for most taxa are not available, *C. guareiensis* n. sp. seems to be more closely related to *C. davisii* and *C. cubataonis* by these three species sharing a unique morphology of autopalatine consisting of a deep constriction on the mesial margin of the autopalatine, with the anterior part of the margin nearly straight and the posterior prominent and rounded (Figure 2C). In other taxa that constriction is absent. *Cambeva guareiensis* is readily distinguished from *C. davisii* by the relative position of the urogenital papillae that is situated in the vertical through the centrum of 21st–22th vertebrae (vs. 23th–24th in *C. davisii*), and by the presence of eight branchiostegal rays (vs. nine to



Figure 3. *Cambeva guareiensis* n. sp., Brazil, São Paulo State, Angatuba, Paranapanema river basin. A, UFRJ 12172 paratype, 59.5 mm SL; B, UFRJ 12170 live paratype, 33.5 mm SL.

eleven). In addition, these two species may be easily distinguished by their adult colour pattern, with *C. guareiensis* having round dark brown spots over flank highly contrasting with the yellow colour ground (Figures 1A,B; 3A,B), whereas in *C. davisii* there are minute brown spots highly overlapped over flank, weakly contrasting with the yellowish-brown colour ground (Figure 5A). The distribution of *C. davisii* is much wider than that of *C.*

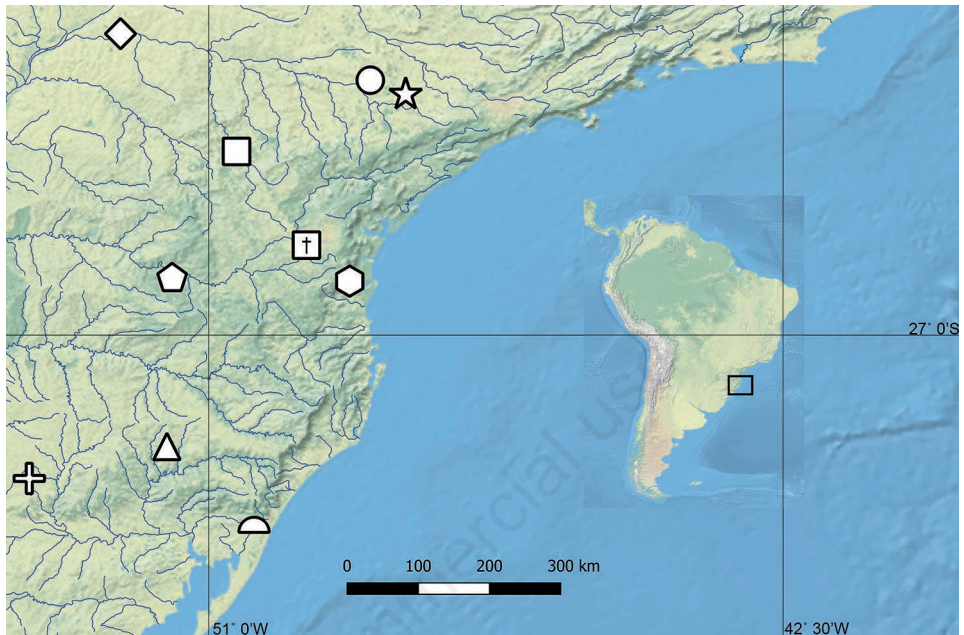


Figure 4. Distribution of *Cambeva brachykechenos* (half circle); *C. cubataonis* (hexagon); *C. diabolus* (diamond); *C. davisii* (square with cross, type locality in the Iguaçu river drainage; square non type locality in the Paranapanema river drainage); *C. diatropoporos* (triangle); *C. pascuali* (circle); *C. poikilos* (cross); *C. stawiarski* (pentagon); and *C. guareiensis* (star).

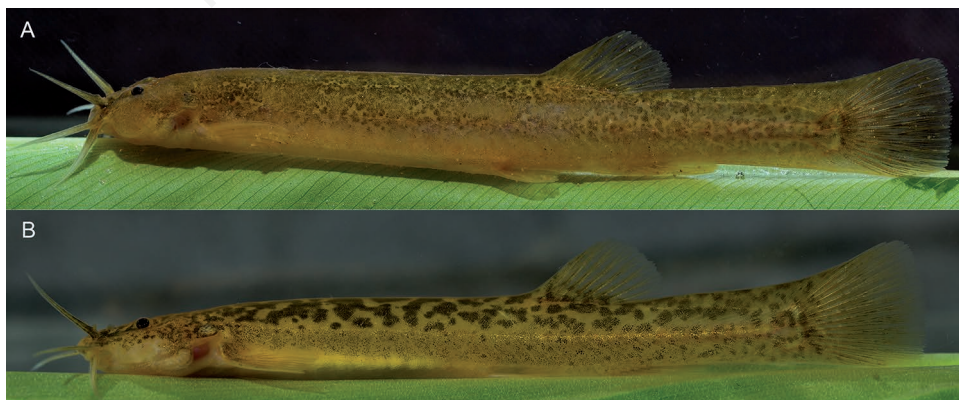


Figure 5. A, *Cambeva davisii*, topotype, UFRJ 9759, 67.6 mm SL, Brazil, Paraná, Balsa Nova; B, *Cambeva cubataonis*, UFRJ 10603, 51.6 mm SL, Brazil, Santa Catarina, Florianópolis. Photograph by A.M. Katz.

guareiensis, occurring both in the Iguaçú and Paranapanema river drainages (Nascimento et al. 2017) (Figure 4). However, even with this wider distribution recorded for *C. davisi*, there is a considerable distance between the localities where the two species occur in the Paranapanema river drainage (Figure 4).

Cambeva guareiensis differs from *C. cubataonis* by the relative position of the dorsal-fin origin that is situated in the vertical through the centrum of 19th–20th vertebrae (vs. 17th–18th), the relative position of the pelvic-fin origin that is situated in the vertical through the centrum 17th vertebrae (vs. 16th), the presence of 11 dorsal-fin rays (vs. 12) and the presence of 10–13 opercular odontodes (vs. 14–19). *Cambeva cubataonis* (Figure 5B) is endemic to the coastal basins of southern Brazil (Figure 4).

Over the last decades, many species have been described for the Paranapanema river drainage (Langeani et al. 2007, Cetra et al. 2016), especially for small size species of *Cambeva* and *Trichomycterus*. With several small drainages still not explored, possibly the number of species will continue to rise (Langeani et al. 2007, Cetra et al. 2016), indicating that this drainage that has the greatest known *Cambeva* diversity to date, may have an even greater diversity than expected.

Key to Paranapanema river drainage species of *Cambeva*

1. Presence of pelvic fin girdle.....2
 - Absence of pelvic fin girdle.....*C. pascuali*
2. Flank with scattered blots3
 - Flank with three wide dark stripes.....*C. perkos*
3. Caudal-fin hyaline or with blots scattered4
 - Caudal-fin with vertical stripe on the edge*C. diabola*
4. Relative position of the urogenital papillae that is situated in the vertical through the centrum of 23th–24th vertebrae and 9–11 branchiostegal rays*C. davisi*
 - Relative position of the urogenital papillae that is situated in the vertical through the centrum of 21st–22th vertebrae and 8 branchiostegal rays.....*C. guareiensis*

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