

## Research article

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## Two new remarkable and endangered catfish species of the genus *Cambeva* (Siluriformes, Trichomycteridae) from southern Brazil

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**Abstract.** During a field inventory directed at trichomycterine habitats, two new species of the genus *Cambeva*, *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov., were found in the Rio Chapecó drainage, an area under high environmental decline due to intensive soya monoculture. These species share a peculiar head morphology and some unique osteological features, besides having a size that is smaller than in any other congener, being herein considered to be more closely related to each other than to other taxa. They differ from each other by several characters, including head shape, fin morphology, number of jaw teeth and opercular odontodes, and mesethmoid and metapterygoid shape. Furthermore, they were found in the same area, but in distinct biotopes, with one species found buried in the remnants of tree ferns and other plants on the stream bottom, restricted to a small residual fragment of the original forest, and the other species inhabiting a stream with gravel and small stones on the bottom. Field studies indicate that these species are threatened with extinction. Robust phylogenetic studies are still necessary to test relationship hypotheses involving the new taxa here described.

**Keywords.** Comparative morphology, mountain biodiversity, osteology, Rio Uruguai basin.

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## Introduction

The freshwater ichthyofaunas of tropical and subtropical regions of the world have been known for their huge species diversity and the unique specializations of their members (Lowe-McConnell 1987). However, several fish groups, mostly those living in specialised habitats, were poorly studied until recent years, containing numerous still undescribed taxa. This is the case of the Trichomycterinae

Bleeker, 1858, a Neotropical trichomycterid catfish subfamily with over 250 species occurring between southern Central America and Patagonia, in southern South America (Costa 2021; Costa *et al.* 2021b). Trichomycterines are found in a large array of freshwater habitats, but most species inhabit swift streams, mainly in mountain areas (Costa *et al.* 2021b). In the subtropical mountain areas of southern Brazil, trichomycterines are represented by *Cambeva* Katz, Barbosa, Mattos & Costa, 2018, only recently recognised as a distinct trichomycterine genus (Katz *et al.* 2018), with 39 valid species, of which 34 were described in the last 20 years (Costa *et al.* 2021a, 2021b), and many others still waiting to be formally described. *Cambeva* is distinguished from all other trichomycterine genera by a combination of a branched parapophysis of the first free vertebra (vs. unbranched in all genera except *Scleronema* Eigenmann, 1917), a parapophysis of the third free vertebra posteriorly directed (vs. laterally or posteriorly directed in all genera except *Scleronema*), and a small maxilla, slightly smaller to slightly larger than the premaxilla (vs. hypertrophied in *Scleronema*).

*Cambeva* is a relatively homogeneous group in terms of general morphology when compared to the closely related genus *Trichomycterus* Valenciennes, 1832 (Katz *et al.* 2018; Costa 2021). For example, phylogenetically distant species of *Cambeva* inhabiting the northern range border of the genus in the Rio São Francisco basin in central Brazil (Costa 1992) and the southern range border in the Lagoa do Patos system in southern Brazil (Ferrer & Malabarba 2013) have a similar overall morphology. An exception is a species pair restricted to a small area of the lower Rio Iguaçu basin, with a distinctive deep body (Wosiacki & de Pinna 2008a, 2008b). Another exception comprises the two species herein first described. They were found during a field inventory in an area without previous records of trichomycterines but suffering increasing environmental impact by deforestation for soya monoculture, in the middle Rio Chapecó drainage, southern Brazil. These undescribed species share a peculiar head morphology, consisting of an anteriorly positioned eye, with the posterior nostril nearly equidistant between the orbit and anterior nostril. These species also share some unique osteological features, besides having a smaller size. They reach only about 45 mm of standard length (SL), a condition confirmed in an additional field study conducted on 5 August 2021, therefore after the type series collection. These specimens are fully ossified, showing that are adults. In contrast, all other congeners, except *Cambeva grisea* Costa, Feltrin & Katz, 2001, reach about 60–130 mm SL. Although here considered as close relatives, these species differ from each other by numerous morphological features, as well as inhabiting different biotopes. The objectives of this study include providing formal descriptions for these two species, reporting ecological characteristics, and discussing morphological characters supporting them as sister taxa.

## Material and methods

Morphometric and meristic data were taken following Costa (1992), with modifications proposed by Costa *et al.* (2020b); measurements are presented as percent of standard length (SL), except for those related to head morphology, which are expressed as percent of head length. Measurements were made only in specimens above 30 mm SL. Fin-ray counts include all elements; in descriptions, lower case Roman numerals indicate unsegmented unbranched rays, upper case numerals indicate segmented unbranched rays, and Arabic numerals indicated segmented branched rays (Bockmann *et al.* 2004).

Vertebra counts include all vertebrae except those participating in the Weberian apparatus; the compound caudal centrum was counted as a single element. Specimens were cleared and stained for bone and cartilage (C&S in lists of specimens) following Taylor & Van Dyke (1985); osteological characters included in the descriptions are those belonging to structures that have informative variability among congeners (Costa *et al.* 2020a, 2021a), including the mesethmoidal region, suspensorium, opercular apparatus, and parurohyal. The terminology for bones is according to Costa (2021). Osteological illustrations were made using a Zeiss Stemi SV 6 stereo microscope with camera lucida. Bone measurements follow Costa & Katz (2021). The cephalic latero-sensory system terminology follows Arratia & Huaquin

(1995), with modifications proposed by Bockmann *et al.* (2004). Comparative material is listed in Costa (2021). Geographical names follow Portuguese terms used in the region, thus avoiding common errors or generalizations when tentatively translating them to English, besides making their identification easier in the field.

### Institutional abbreviations

CICCAA = ichthyological collection of the Centre of Agrarian and Environmental Sciences,  
Federal University of Maranhão, Chapadinha, Brazil  
UFRJ = ichthyological collection of the Institute of Biology of the Federal University of  
Rio de Janeiro, Rio de Janeiro, Brazil

### Abbreviations for measurements

SL = standard length

### Results

Phylum Chordata Haeckel, 1874  
Class Actinopterygii Klein, 1885  
Order Siluriformes Cuvier, 1817  
Family Trichomycteridae Bleeker, 1858  
Genus *Cambeva* Katz, Barbosa, Mattos & Costa, 2018

#### *Cambeva alphabelardense* sp. nov.

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Figs 1, 2A–C, 3–4

### Diagnosis

A small species, maximum recorded adult size 46.4 mm SL, diagnosed by the presence of four pelvic-fin rays and the combination of the following features: posterior nostril about equidistant from anterior nostril and from orbit; a compact broad autopalatine, its width about equal to its length excluding anterior cartilage and postero-lateral process; presence of an anterior broad and rounded projection on the interopercle; five pectoral-fin rays; six or seven opercular odontodes; 20–23 premaxillary teeth; 24–25 dentary teeth; jaw teeth always pointed; largest rays of the dorsal and anal fins longer than the respective fin bases; dorsal and anal fins rounded; head width 83.5–91.3% of the head length; interorbital length 27.0–31.2%; mesethmoid robust, its width at the base of cornua about four fifths of autopalatine width (Fig. 2A); metapterygoid deeper than long (Fig. 2B).

### Differential diagnosis

*Cambeva alphabelardense* sp. nov. is distinguished from all other congeners by having four pelvic-fin rays (vs. five rays whenever the pelvic fin is present). *Cambeva alphabelardense* sp. nov. differs from all other congeners, except *C. betabelardense* sp. nov., by the relatively more anterior position of the orbit, making the posterior nostril nearly equidistant from anterior nostril and orbit, a compact broad autopalatine, its width about equal to its length excluding anterior cartilage (Fig. 2A; vs. width conspicuously smaller than that length), and the presence of an anterior broad and rounded projection on the interopercle (Fig. 2B; vs. never a similar projection). *Cambeva alphabelardense* sp. nov. is distinguished from *C. betabelardense* sp. nov. by having fewer pectoral-fin rays (five vs. six), fewer opercular odontodes (6–7 vs. 12), fewer teeth on the premaxilla (20–23 vs. 30–34) and dentary (24–25 vs. 30–34), jaw teeth always pointed (vs. anterior-most teeth incisiform), largest rays of the dorsal and anal fins longer than the respective fin bases (vs. shorter), a wider head (head width 83.5–91.3% of the head length, vs. 73.7–78.5%), a wider interorbital distance (27.0–31.2% of the head length, vs. 21.6–

**Table 1.** Morphometric data for *Cambeva alphabelardense* sp. nov.

	holotype	paratypes (n = 10)
Standard length (mm)	43.4	34.3–46.3
<b>Percent of standard length</b>		
Body depth	18.3	15.0–18.7
Caudal peduncle depth	12.3	11.5–13.8
Body width	11.1	9.9–12.2
Caudal peduncle width	3.3	3.4–4.5
Pre-dorsal length	69.0	66.3–69.1
Pre-pelvic length	65.1	63.7–66.9
Dorsal-fin base length	11.7	10.9–13.4
Anal-fin base length	9.6	9.2–12.0
Caudal-fin length	20.2	18.2–20.1
Pectoral-fin length	12.3	10.8–12.8
Pelvic-fin length	9.0	7.0–8.9
Head length	21.9	19.9–21.6
<b>Percent of head length</b>		
Head depth	58.7	53.3–60.3
Head width	88.1	83.5–91.3
Snout length	41.4	36.2–43.2
Interorbital length	30.2	27.0–31.2
Preorbital length	8.5	5.9–8.1
Eye diameter	9.5	8.6–11.0

26.2%), a very robust mesethmoid, its width at the base of the cornua about one third of the distance between tips of cornua (Fig. 2A; vs. about one fifth, Fig. 2D), and a deeper metapterygoid that is subrectangular and deeper than long (Fig. 2B; vs. subtriangular and longer than deep, Fig. 2E).

### Etymology

The species epithet ‘*alphabelardense*’ (‘alpha’, the first letter of the Greek alphabet, and ‘abelardense’, Portuguese word referring to people born in Abelardo Luz municipality) is an allusion to the first new species described for this area.

### Material examined

#### Holotype

BRAZIL • 1 ex., 43.4 mm SL; Santa Catarina State, Abelardo Luz Municipality, stream tributary to middle Rio Chapecó, Rio Uruguai basin; 26°32'19" S, 52°25'17" W; 805 m a.s.l.; 20 Mar. 2021; C.R.M. Feltrin leg.; UFRJ 6990.

#### Paratypes (n = 21)

BRAZIL • 11 ex., 23.6–46.3 mm SL; same collection data as for holotype; UFRJ 6991 • 1 ex. (C&S), 41.8 mm SL; same collection data as for holotype; UFRJ 6992 • 3 ex., 34.1–39.7 mm SL; same collection data as for holotype; CICCAA 12706 • 4 ex., 29.8–46.4 mm SL; same locality as for holotype; 15 Jul.

2020; A. Bianco, F.H. Llanos and C.R.M. Feltrin leg.; UFRJ 6993 • 2 ex. (C&S), 34.3–39.5 mm SL; same collection data as for preceding; UFRJ 6994.

### Description

**GENERAL MORPHOLOGY.** Morphometric data appear in Table 1. Body relatively slender, subcylindrical and slightly depressed anteriorly, compressed posteriorly. Greatest body depth in area just anterior to pelvic-fin base. Dorsal and ventral profile of head and trunk slightly convex, approximately straight on caudal peduncle. Skin papillae minute. Anus and urogenital papilla in vertical through anterior portion of dorsal-fin base. Head sub-rectangular in dorsal view, almost rectangular. Anterior profile of snout slightly convex in dorsal view. Eye small, dorsally positioned in head, in its anterior half. Posterior nostril located approximately mid-way between anterior nostril and orbital rim. Tip of maxillary and rictal barbels posteriorly reaching interopercular patch of odontodes; tip of nasal barbel usually posteriorly reaching area just anterior to opercular patch of odontodes, sometimes shorter, reaching midway between orbit and opercular patch of odontodes. Mouth subterminal. Jaw teeth 20–23 on premaxilla, 24 or 25 on dentary, pointed and slightly curved, arranged in two irregular rows. Branchial

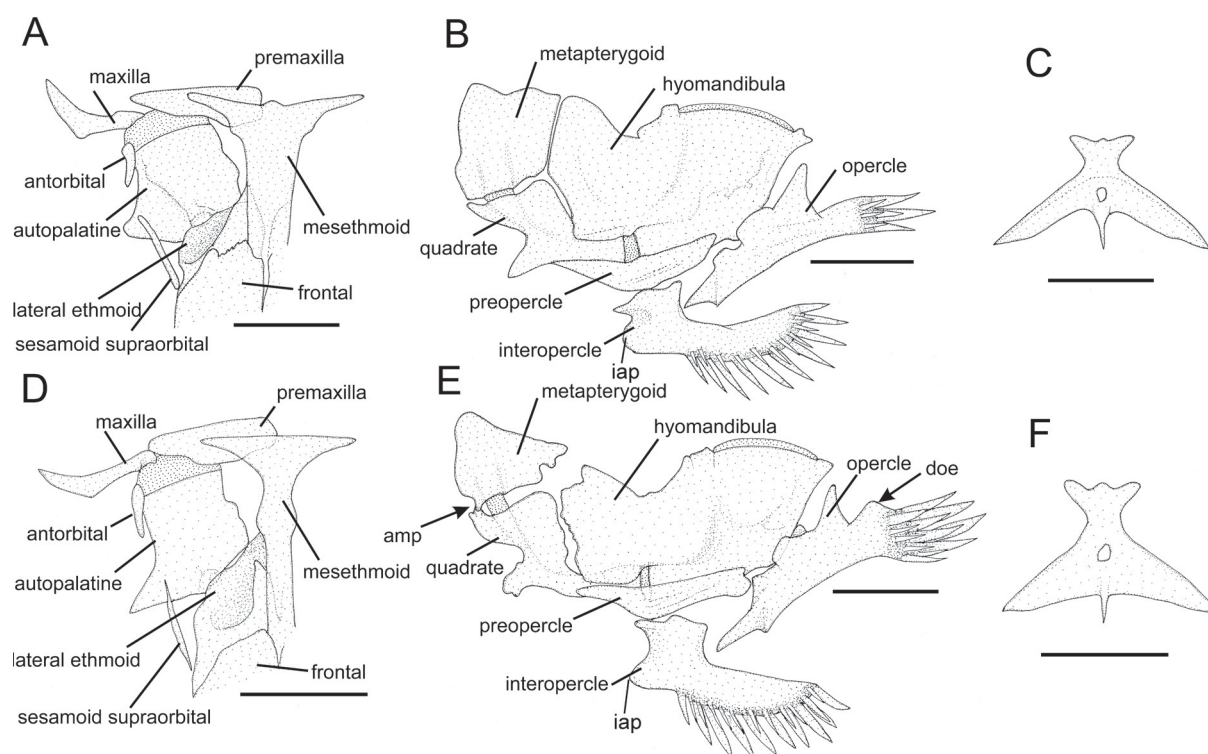


**Fig. 1.** *Cambeva alphabelardense* sp. nov., holotype (UFRJ 6990), 43.4 mm SL. A. Left lateral view. B. Dorsal view. C. Ventral view.



membrane attached to isthmus only at its anterior-most point, in ventral midline. Dorsal and anal fins rounded, long, their length larger than respective fin base; total dorsal-fin rays 10–11 (i–ii + II + 7), total anal-fin rays 9 (ii + II + 5); anal-fin origin at vertical through posterior half of dorsal-fin base. Dorsal-fin origin at vertical through centrum of 20<sup>th</sup> or 21<sup>st</sup> vertebra; anal-fin origin at vertical through centrum of 23<sup>rd</sup> or 24<sup>th</sup> vertebra. Pectoral fin subtriangular in dorsal view, narrow, posterior margin slightly convex, first pectoral-fin ray terminating in short filament, about 10–20% of pectoral-fin length; total pectoral-fin rays 5 (I + 4). Pelvic fin subtruncate, its posterior extremity in vertical just anterior or just posterior to dorsal-fin origin; pelvic-fin bases medially separated by small interspace, about half pelvic-fin base width; total pelvic-fin rays 4 (I + 3). Caudal fin subtruncate, often asymmetrical with dorsal portion slightly longer than ventral one; total principal caudal-fin rays 13 (I + 11 + I), total dorsal procurent rays 21 (xx + I), total ventral procurent rays 15 (xiv + I).

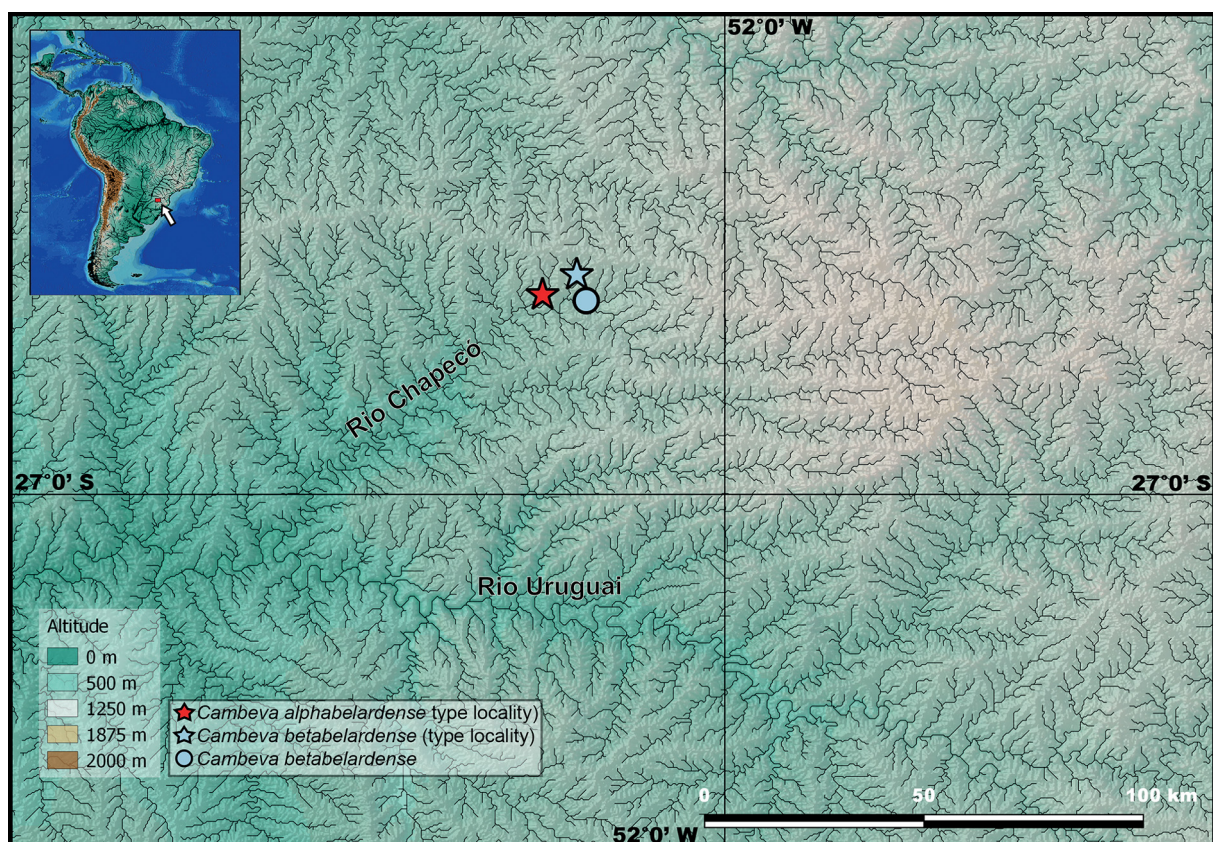
**LATEROSENSORY SYSTEM.** Supraorbital sensory canal continuous, connected to posterior section of infraorbital canal posteriorly. Supraorbital sensory canal with 3 pores: s1, adjacent to medial margin of anterior nostril; s3, adjacent and just posterior to medial margin of posterior nostril; and s6, in transverse line through posterior half of orbit; pore s6 nearer orbit than its paired homologous pore. Single infraorbital sensory canal segment, with two pores, corresponding to pore i10, adjacent to ventral margin of orbit, and pore i11, posterior to orbit; anterior segment of infraorbital canal absent. Postorbital canal with 2 pores: po1, in vertical line above posterior portion of interopercular patch of odontodes, and



**Fig. 2.** Osteological structures. **A–C.** *Cambeva alphabelardense* sp. nov., paratype (UFRJ 6993). **D–F.** *Cambeva betabelardense* sp. nov., paratype (UFRJ 6996). **A, D.** Mesethmoidal region and adjacent structures, left and middle portions, dorsal view. **B, E.** Left jaw suspensorium and opercular series, lateral view. **C, F.** Parurohyal, ventral view. Abbreviations of structures indicated by arrows are: amp = anteroventral metapterygoid process; doe = dorsal opercular expansion; iap = anterior projection of interopercle. Heavier stippling represents cartilaginous areas. Scale bar: 1 mm.

po2, in vertical line above posterior portion of opercular patch of odontodes. Lateral line of body short, with 2 pores, posterior-most pore in vertical just posterior to pectoral-fin base.

**OSTEOLOGY** (Fig. 2A–C). Mesethmoid robust, its width at cornua bases about four fifths of autopalatine width; anterior margin slightly concave, often with slight middle projection; mesethmoid cornu narrow, with rounded extremity. Lateral ethmoid articulated with autopalatine by broad articular facet. Antorbital thin, narrow, and short; sesamoid supraorbital slender, without processes, short, its length about twice antorbital length. Premaxilla sub-trapezoidal in dorsal view, laterally narrowing, moderate in length, longer than maxilla. Maxilla boomerang-shaped, slightly curved. Autopalatine sub-rectangular in dorsal view, broad, its width about equal to its length excluding anterior cartilage; medial margin almost straight and with small projection, lateral margin slightly concave; autopalatine posterolateral process minute, almost indistinct. Metapterygoid large and thin, sub-rectangular, deeper than longer. Quadrate slender, dorsal process with constricted base, dorsoposterior margin separated from hyomandibula outgrowth by small interspace. Hyomandibula long, with well-developed anterior outgrowth; middle portion of dorsal margin of hyomandibula slightly concave. Opercle long, longer than interopercle, opercular odontode patch slender, its depth slightly shorter than half length of dorsal hyomandibula articular facet; opercular odontodes 6 or 7; odontodes pointed, nearly straight, transversely arranged; dorsal process of opercle short, extremity rounded; opercular articular facet for hyomandibula with prominent sub-rectangular flap, articular facet for preopercle well developed, rounded. Interopercle moderate, about two thirds hyomandibula length, with pronounced anterior rounded projection; interopercular odontodes 20–22; odontodes pointed, arranged in irregular longitudinal rows. Preopercle compact, with short ventral projection. Parurohyal robust, lateral process narrow, sub-triangular, latero-posteriorly directed, tip



**Fig. 3.** Map of geographical distribution of *Cambeva alphabelardense* sp. nov. and *C. betabelardense* sp. nov.



pointed; parurohyal head well-developed, with prominent anterolateral paired process; middle foramen oval; posterior process moderate in length, about half distance between anterior margin of parurohyal and anterior insertion of posterior process. Branchiostegal rays 7. Vertebrae 37. Ribs 12 or 13. Two dorsal hypural plates, partially or completely fused, corresponding to hypurals 3 + 4 + 5; single ventral hypural plate corresponding to hypurals 1 + 2 and parhypural.

**COLOURATION IN ALCOHOL** (Fig. 1). Flank, dorsum and head side with dense concentration of small dark brown spots over pale yellow background; spots irregularly shaped, arranged in irregular longitudinal rows, slightly larger and often coalesced on dorsal portion, slightly darker along flank midline. Nasal and maxillary barbels dark brown, rictal barbel pale yellowish brown. Venter and ventral surface of head white. Unpaired fins hyaline with minute dark grey dots. Paired fins hyaline.

**COLOURATION IN LIFE.** Similar to colouration in alcohol, but light yellowish brown pigmentation slightly more intense on trunk.

### **Distribution and habitat**

*Cambeva alphabelardense* sp. nov. is known only from the type locality area in the middle Rio Chapecó drainage, Rio Uruguai basin, southern Brazil (Fig. 3). The type locality is situated in the headwaters of a narrow stream, altitude about 800 m a.s.l., with clearwater, clay bottom and dense marginal vegetation mainly composed of ferns (Fig. 4). This short area, about 600 m long, corresponds to a small residual fragment of the original vegetation consisting of a mixed rainforest. This area is now surrounded by a



**Fig. 4.** Type locality of *Cambeva alphabelardense* sp. nov.



vast area occupied by soya plantations. However, there is no evidence of siltation in the stream. *Cambeva alphabelardense* sp. nov. was only found in the well-preserved residual fragment, where the stream was about three or four meters wide and about one meter deep. All specimens, collected with small dip nets (40 × 30 cm) during daylight, were found buried in vegetal debris (mostly tree ferns, and other plant remnants) on the bottom of stream banks. The well-developed marginal vegetation partially shades. Considering the small area occupied by the species, the high level of environmental decline around that area, and the unsuccessful attempts to find other similar biotopes in the region, *C. alphabelardense* sp. nov. should be regarded as highly threatened with extinction.

***Cambeva betabelardense* sp. nov.**

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Figs 2D–F, 5–6

**Diagnosis**

A small species, maximum recorded adult size 42.7 mm SL, diagnosed by the presence of a dorsal projection adjacent to the opercular odontode patch (Fig. 2E) and the combination of the following features: posterior nostril about equidistant from anterior nostril and from orbit; a compact broad autopalatine, its width about equal to its length excluding anterior cartilage and postero-lateral process (Fig. 2D); presence of an anterior broad and rounded projection on the interopercle (Fig. 2E); six pectoral-fin rays; 12 opercular odontodes; 30–34 premaxillary teeth; 32–34 dentary teeth; anterior jaw teeth incisiform, posterior teeth pointed; largest rays of the dorsal and anal fins shorter than respective fin bases; dorsal and anal fins subtrapezoidal; head width 73.7–78.5% of the head length; interorbital length 21.6–26.2%; mesethmoid thin, its width at the base of cornua about half autopalatine width (Fig. 2D); metapterygoid longer than deep, approximately triangular (Fig. 2E).

**Differential diagnosis**

*Cambeva betabelardense* sp. nov. is distinguished from all other congeners, except *C. alphabelardense* sp. nov., by the relatively more anterior position of the orbit, making the posterior nostril nearly equidistant from anterior nostril and orbit, a compact broad autopalatine, its width about equal to its length excluding anterior cartilage (Fig. 2D; vs. width conspicuously smaller than that length), and the presence of an anterior broad and rounded projection on the interopercle (Fig. 2E; vs. never a similar projection). *Cambeva betabelardense* sp. nov. is distinguished from *C. alphabelardense* sp. nov. by having more pectoral-fin rays (six vs. five), more opercular odontodes (12 vs. 6 or 7), more teeth on the premaxilla (30–34 vs. 20–23) and dentary (32–34 vs. 24–25), anterior jaw teeth incisiform, posterior teeth pointed (vs. all teeth pointed), largest rays of the dorsal and anal fins shorter than respective fin bases (vs. longer), a narrower head (head width 73.7–78.5% of the head length, vs. 83.5–91.3%), a narrower interorbital distance (21.6–26.2% of the head length, vs. 27.0–31.2%), a thinner mesethmoid, its width at the base of the cornua about one fifth of the distance between tips of cornua (Fig. 2D; vs. about one third, Fig. 2A), and a more slender metapterygoid that is sub-triangular and longer than deep (Fig. 2E; vs. sub-rectangular and deeper than long, Fig. 2B). *Cambeva betabelardense* sp. nov. also differs from all other congeners by the presence of a dorsal projection on the opercle adjacent to the odontode patch (Fig. 2E; vs. absence).

**Etymology**

The species epithet ‘*betabelardense*’ (‘beta’, the second letter of the Greek alphabet, and ‘abelardense’, Portuguese word referring to people born in Abelardo Luz municipality) is an allusion to the second new species described for this area.

**Table 2.** Morphometric data for *Cambeva betabelardense* sp. nov.

	<b>holotype</b>	<b>paratypes (n = 10)</b>
Standard length (mm)	42.7	32.4–42.1
<b>Percent of standard length</b>		
Body depth	16.3	16.3–17.7
Caudal peduncle depth	12.6	11.9–13.6
Body width	11.3	10.6–12.3
Caudal peduncle width	3.8	3.0–3.9
Pre-dorsal length	65.5	64.8–66.7
Pre-pelvic length	62.7	61.7–65.9
Dorsal-fin base length	12.2	10.6–12.4
Anal-fin base length	8.6	7.6–10.1
Caudal-fin length	16.8	17.4–19.1
Pectoral-fin length	11.3	11.2–12.7
Pelvic-fin length	8.4	7.4–9.9
Head length	19.4	19.3–21.2
<b>Percent of head length</b>		
Head depth	56.3	52.3–55.8
Head width	77.8	73.7–78.5
Snout length	37.8	36.0–41.5
Interorbital length	23.1	21.6–26.2
Preorbital length	6.9	6.4–7.8
Eye diameter	11.2	9.9–12.1

**Material examined****Holotype**

BRAZIL • 1 ex., 42.7 mm SL; Santa Catarina State, Abelardo Luz Municipality, stream tributary to middle Rio Chapecó, Rio Uruguai basin; 26°29'32" S, 52°20'32" W; 820 m a.s.l.; 20 Mar. 2021; C.R.M. Feltrin leg.; UFRJ 6995.

**Paratypes (n = 17)**

BRAZIL • 10 ex., 19.7–38.6 mm SL; same collection data as for holotype; UFRJ 6996 • 3 ex. (C&S), 32.4–37.4 mm SL; same collection data as for holotype; UFRJ 6997 • 2 ex., 33.2–34.8 mm SL; same collection data as for holotype; CICCAA 12707 • 4 ex., 36.8–41.3 mm SL; Santa Catarina State, Abelardo Luz Municipality, stream tributary to middle Rio Chapecó, in front of Parque Quedas de Chapecó; 26°33'08" S, 52°19'13" W; 760 m a.s.l.; 20 Mar. 2021; C.R.M. Feltrin leg.; UFRJ 6998.

**Description**

GENERAL MORPHOLOGY. Morphometric data appear in Table 2. Body slender, subcylindrical and slightly depressed anteriorly, compressed posteriorly. Greatest body depth in area just anterior to pelvic-fin base. Dorsal and ventral profile of head and trunk slightly convex, approximately straight on caudal peduncle. Skin papillae minute. Anus and urogenital papilla in vertical through anterior portion of dorsal-fin base. Head trapezoidal in dorsal view. Anterior profile of snout slightly convex in dorsal view. Eye small, dorsally positioned in head, in its anterior half. Posterior nostril located approximately mid-way

between anterior nostril and orbital rim. Tip of maxillary and rictal barbels posteriorly reaching anterior margin of interopercular patch of odontodes; tip of nasal barbel posteriorly reaching area between one and two thirds of distance between orbit and opercular patch of odontodes. Mouth subterminal. Jaw teeth 30–34 on premaxilla, 32–34 on dentary, pointed internally to incisiform in external rows, slightly curved, arranged in three irregular rows. Branchial membrane attached to isthmus only at its anterior-most point, in ventral midline. Dorsal and anal fins subtrapezoidal, short, their length smaller than respective fin base; total dorsal-fin rays 11 (ii + II + 7), total anal-fin rays 9 (ii + II + 5); anal-fin origin at vertical through posterior half of dorsal-fin base. Dorsal-fin origin at vertical through centrum of 21<sup>st</sup> vertebra; anal-fin origin at vertical through centrum of 24<sup>th</sup> vertebra. Pectoral fin subtriangular in dorsal view, posterior margin slightly convex, first pectoral-fin ray slightly projected beyond fin membrane but not forming filament; total pectoral-fin rays 5 (I + 4). Pelvic fin subtruncate, its posterior extremity in vertical just anterior to or through dorsal-fin origin; pelvic-fin bases medially separated by small interspace, about half pelvic-fin base width; total pelvic-fin rays 5 (I + 4). Caudal fin rounded, dorso-ventrally symmetrical; total principal caudal-fin rays 13 (I + 11 + I), total dorsal procurent rays 16–19 (xv–xviii + I), total ventral procurent rays 12–14 (xi–xiii + I).



**Fig. 5.** *Cambeva betabelardense* sp. nov., holotype (UFRJ 6995), 42.7 mm SL. **A.** Left lateral view. **B.** Dorsal view. **C.** Ventral view.





**Fig. 6.** Type locality of *Cambeva betabelardense* sp. nov.

**LATEROSENSORY SYSTEM.** Supraorbital sensory canal continuous, connected to posterior section of infraorbital canal posteriorly. Supraorbital sensory canal with 3 pores: s1, adjacent to medial margin of anterior nostril; s3, adjacent and just posterior to medial margin of posterior nostril; and s6, in transverse line through posterior half of orbit; pore s6 nearer orbit than its paired homologous pore. Single infraorbital sensory canal segment, with two pores, corresponding to pore i10, adjacent to ventral margin of orbit, and pore i11, posterior to orbit; anterior segment of infraorbital canal absent. Postorbital canal with 2 pores: po1, in vertical line above posterior portion of interopercular patch of odontodes, and po2, in vertical line above posterior portion of opercular patch of odontodes. Lateral line of body short, with 2 pores, posterior-most pore in vertical just posterior to pectoral-fin base.

**OSTEOLOGY** (Fig. 2D–F). Mesethmoid thin, its width at cornua bases about half autopalatine width; anterior margin about straight, mesethmoid cornu narrow, with rounded extremity. Lateral ethmoid articulated with autopalatine by broad articular facet. Antorbital thin, narrow and short; sesamoid supraorbital slender, without processes, short, its length about twice antorbital length. Premaxilla sub-trapezoidal in dorsal view, laterally narrowing, moderate in length, longer than maxilla. Maxilla boomerang-shaped, slightly curved. Autopalatine sub-rectangular in dorsal view, broad, its width about equal to its length excluding anterior cartilage; medial margin sinuous, with small projection, lateral margin slightly concave, almost straight; autopalatine posterolateral process triangular in dorsal view, small, about one third autopalatine length. Metapterygoid moderate in length, thin, subtriangular, longer than deep; anteroventral process articulating with adjacent expansion in quadrate. Quadrate slender, dorsal process with constricted base, dorsoposterior margin separated from hyomandibula outgrowth by small interspace. Hyomandibula long, with well-developed anterior outgrowth; middle portion of dorsal margin of hyomandibula slightly concave. Opercle long, longer than interopercle, opercular odontode patch moderate, its depth slightly shorter than dorsal hyomandibula articular facet, with 11 or 12 odontodes; odontodes pointed, nearly straight, transversely arranged; dorsal projection adjacent to odontode patch; dorsal process of opercle short, extremity rounded; opercular articular facet for hyomandibula with prominent sub-rectangular projection, articular facet for preopercle well developed, rounded. Interopercle moderate, about two thirds hyomandibula length, with pronounced anterior rounded projection; interopercular odontodes; odontodes pointed, arranged in irregular longitudinal rows. Preopercle compact, with short ventral projection. Parurohyal robust, lateral process broad, sub-triangular, laterally directed, tip pointed; parurohyal head well-developed, with prominent anterolateral paired process; middle foramen rounded; posterior process short, about one third of distance between anterior margin of parurohyal and anterior insertion of posterior process. Branchiostegal rays 8. Vertebrae 37. Ribs 12. Two dorsal hypural plates corresponding to hypurals 3 + 4 + 5; single ventral hypural plate corresponding to hypurals 1 + 2 and parhypural.

**COLOURATION IN ALCOHOL** (Fig. 5). Flank, dorsum and head side pale yellow, with rounded dark brown blotches, often longitudinally coalesced, larger and darker on middle and dorsal portions of flank. In some specimens, blotches darker, smaller and not coalesced. Nasal and maxillary barbels dark brown, rictal barbel pale yellowish brown. Venter and ventral surface of head white. Fins hyaline with dark grey spots.

**COLOURATION IN LIFE.** Similar to colouration in alcohol, but with paler colours.

### **Distribution and habitat**

*Cambeva betabelardense* sp. nov. is only known from two localities in the type locality area, in the middle Rio Chapecó drainage, Rio Uruguai basin, southern Brazil (Fig. 3), at altitudes between about 760 and 820 m a.s.l. At both localities, the stream was about 8 m wide, with bottom comprising small stones and gravel (Fig. 6). *Cambeva betabelardense* sp. nov. was collected in shallow places, about 30 cm deep, on the gravel bottom and associated vegetal remnants. Some vestiges of stream siltation



at the type locality, probably as a result of the intense process of deforestation associated with soya plantations in the region, may be indicative that *C. betabelardense* sp. nov. is an endangered species.

## Discussion

The anteriorly positioned eye occurring in *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov. highly suggests that these species are more closely related to each other than to any other congener. All other species of the genus have the eye more posteriorly placed, making the distance between the orbit and the posterior nostril conspicuously longer than the distance between the anterior and posterior nostrils, a condition also occurring in other trichomycterine genera (i.e., *Bullockia* Arratia, Chang, Menu-Marque & Rojas, 1978, *Eremophilus* Humboldt, 1805, *Trichomycterus* Velenciennes, 1832) and thus considered to possibly be plesiomorphic for trichomycterines. Similarly, the morphology of the anterior portion of the interopercle occurring in both *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov., consisting of a pronounced anterior rounded projection (Fig. 2B, E), is not present in other congeners and other trichomycterine taxa from eastern South America with available data on osteological features of the opercular series bones (Costa *et al.* 2020a: fig. 2b; 2021a: fig. 4b, e), corroborating that hypothesis. The presence of a robust autopalatine, with a small or rudimentary postero-lateral process occurring in *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov. (Fig. 2A, D), suggests that these species may be closely related to some congeners sharing a broad autopalatine, including *C. diatropoporos* (Ferrer & Malabarba, 2013), *C. flavopicta* Costa, Feltrin & Katz, 2020, and *C. poikilos* (Ferrer & Malabarba, 2013). However, only in *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov. is the autopalatine a compact bone, being shorter and proportionally wider (Fig. 2B, E) than the autopalatine in those species (Ferrer & Malabarba 2013: figs. 2b–c; Costa *et al.* 2020a: fig. 2a), possibly constituting a different condition and again supporting closer relationships between the two species herein described.

Some morphological similarity between *C. alphabelardense* sp. nov. and *Cambeva taroba* (Wosiack & Garavello, 2004) deserves mention. These two species have a similar colour pattern (Fig. 1; Wosiack & Garavello 2004: fig. 6) and few opercular odontodes (six or seven in *C. alphabelardense* sp. nov. and seven or eight in *C. taroba*), conditions not found in other congeners. Unfortunately, material of *C. taroba* was not available and its original description is brief, not including data on informative osteological structures such as the autopalatine, jaw suspensorium and opercular series bones. However, the eye position of *C. taroba* (Wosiack & Garavello 2004: fig. 6) differs from that described here for *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov., thus suggesting that *C. taroba* is more distantly related to those two species. In addition, *C. alphabelardense* sp. nov. is readily distinguished from *C. taroba* by the former species having four pelvic-fin rays (vs. five) and a shorter pectoral fin (pectoral-fin length 10.8–12.8% SL, vs. 15.0–22.4% SL), besides not having a prominent lateral process on the lateral ethmoid that is present in *C. taroba* (Wosiack & Garavello 2004: fig. 6).

The present study consists of the first record of *Cambeva* for the middle Rio Chapecó drainage, which is part of the middle Rio Uruguai drainage, filling an additional gap in the known distribution of the genus. The occurrence of two species, *C. alphabelardense* sp. nov. and *C. betabelardense* sp. nov., that apparently are more closely related among themselves than to other congeners (see discussion above), in the same area, but in biotopes with very different ecological characteristics highly suggests a recent local evolutionary diversification. However, further collections are needed to search for other possible closely related species in this still poorly sampled region, and phylogenetic studies involving a substantial sample of congeners are necessary to test this hypothesis.

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