

Gymnotus interruptus, a new species of electric fish from the Rio de Contas basin, Bahia, Brazil (Teleostei: Gymnotiformes: Gymnotidae)

FILIFE DA SILVA RANGEL-PEREIRA

Laboratório de Sistemática e Evolução de Peixes Teleósteos, Departamento de Zoologia, Universidade Federal do Rio de Janeiro, Caixa Postal 68049, CEP 21944-970, Rio de Janeiro, Brazil. [filipespereira\(at\)gmail.com](mailto:filipespereira(at)gmail.com)

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> Abstract

A new species of *Gymnotus* LINNAEUS is described from Riacho Cambiriba a clear water stream, tributary of the Rio de Contas basin, Bahia, northeastern Brazil. The new species is a member of the *G. carapo* species-group, which is characterized by the presence of a transparent patch near the posterior end of the anal fin and two (vs. one) laterosensory pores in the dorso-posterior region of the preopercle bone. *Gymnotus interruptus* may be diagnosed by a unique combination of morphometric and meristic characters: wider interorbital distance (44.6–45.9% of STO); 9 scales above lateral line at midbody; 23–28 ventrally oriented lateral line rami; 37–40 pored lateral line scales to first ventral ramus of lateral line; shorter snout (29.6–30.5% of STO). *Gymnotus interruptus*, the first record of a gymnotiform fish from the rio de Contas basin, may be easily distinguished from *G. carapo* or *G. bahianus*, two congeners also occurring in northeastern Brazil, by its colour pattern, in which the pale interbands, anterior to vertical through first ventral lateral line ramus, are ventrally and/or dorsally fragmented, allowing union of adjacent dark bands.

> Resumo

Uma nova espécie de *Gymnotus* LINNAEUS é descrita para o Riacho Cambiriba, um corpo de água clara, tributário da bacia do Rio de Contas, Bahia, nordeste do Brasil. A nova espécie é um membro do grupo de espécies *G. carapo*, caracterizado pela presença de uma mancha clara próxima a ponta posterior da nadadeira anal e dois (vs. um) poros latero-sensoriais na porção dorso-posterior do preopérculo. *Gymnotus interruptus* é diagnosticada através de dados morfométricos e merísticos, de onde é obtida a seguinte exclusiva combinação de caracteres: maior distância inter-orbital (44.6–45.9% do comprimento Focinho-opérculo); nove escamas acima da linha lateral na região mediana do corpo; nadadeira peitoral com 17 raios; 23–28 ramos da linha lateral ventralmente orientados; 37–40 escamas perfuradas na linha lateral anterior ao primeiro ramo ventralmente orientado. *Gymnotus interruptus* é mais suscetível a ser erroneamente identificado como *G. carapo* ou *G. bahianus*, porém esta espécie pode ser diferenciada de seus semelhantes através de seu único padrão de colorido onde as interbandas claras, anteriores ao primeiro ramo ventralmente orientado da linha lateral, são fragmentadas dorsalmente e/ou ventralmente, permitindo a união das bandas escuras adjacentes.

> Key words

Banded Knife-fish; Description; Biodiversity; Neotropical.

Introduction

The Gymnotiformes comprises a diversified assemblage of slender electric fishes, with about 170 living species, all endemic to the Neotropical region. They are classified into five families: Gymnotidae,

Hypopomidae, Rhamphichthyidae, Sternopygidae and Aptereronotidae (ALBERT & CRAMPTON, 2003b), among which the Gymnotidae comprises 38 species, including the one herein described. Except *Electrophorus*

electricus (LINNAEUS, 1758), all species of the latter family are placed in *Gymnotus* LINNAEUS, the most geographically widespread genus of the order, occurring from southern Mexico (15°N) to northern Argentina (36°S), in all major river systems. The main apomorphic character states diagnostic for the genus are the absence of displaced haemal spines at the posterior end of the body cavity, two processes separated by a notch in the anterior portion of mesethmoid bone and the absence of cranial fontanels on the dorsal surface of the head in adults (CAMPOS-DA-PAZ & COSTA, 1996; ALBERT & CRAMPTON, 2003b). On the basis of derived colour patterns, morphometrics and osteology, three main monophyletic groups have been recognized within *Gymnotus* (sensu ALBERT *et al.* 2005): the *G. cylindricus*, *G. pantherinus* and *G. carapo* species-groups. The latter group contains 21 living species (including the one described here) and is distributed along the whole South America north of the latitude 36°S, including the Island of Trinidad. It is mainly characterized by the presence of a transparent patch on the posterior end of the anal fin and two pores on the dorso-posterior corner of the preopercle bone (ALBERT *et al.*, 2005). The present paper has as purpose to describe a new species of *Gymnotus*, belonging to the *G. carapo* species-group, collected in the Riacho Cambiriba, a tributary of the Rio de Contas basin, northeastern Brazil.

Materials and Methods

All measurements were taken as point-to-point linear distances and recorded to the nearest 0.1 mm with the use of digital calipers. Specimens were fixed in 10% formalin during 14 days and then preserved in 70% ethanol. Drawings were made with a camera lucida connected to a stereoscopic microscope. Morphometric measurements follow MAGO-LECCIA (1978) and CAMPOS-DA-PAZ (2002). The term “postorbital” is used instead of “postocular”. To make possible the construction of the diagnosis through the comparison of obtained data with the data available in literature (e.g. original descriptions of valid species and reference papers as ALBERT & CRAMPTON, 2003a) the measurements reported as head length (HL) percentage were also reported as snout-to-opercle length percentage (equivalent to head length of some authors, e.g., ALBERT & CRAMPTON, 2003a; MAXIME *et al.*, 2011), making the data comparable to most data present in the literature. Meristic data were taken following the procedures given by ALBERT & CRAMPTON (2003a), except for the number of precaudal vertebrae, which follows CAMPOS-DA-PAZ (2002). Bands are counted from

posterior to anterior tips of trunk. Osteological data were obtained from the single specimen cleared and counterstained through a modification of the method of TAYLOR & VAN DYKE (1985). Bone nomenclature follows ALBERT *et al.* (2005) and MAGO-LECCIA (1978). The selection of osteological features, relevant at generic and specific levels, follows CAMPOS-DA-PAZ & COSTA (1996) & MAXIME *et al.* (2011). Measurements and counts were taken from the left side of specimens. None of the exemplars had significant damage at the caudal appendage. All material examined is deposited in the collection of the Laboratory of Systematics and Evolution of Teleost Fishes, Department of Zoology, Institute of Biology, Federal University of Rio de Janeiro (UFRJ).

Abbreviations used in the text

TL	total length;
HL	head length;
STO	snout-to-opercle length;
P1	paratype one;
P2	paratype two;
H	Holotype;
SD	standard deviation;
F	frontal;
Pa	parietal;
C	canal;
Ep	epioccipital;
Met	mesethmoid;
Io	infraorbital series;
So	supraorbital series;
Pm	preopercular-mandibular series;
Pl	posterior lateral line;
St	supratemporal series;
Bh	basihyal;
Eh	epihyal;
Hh	hypohyal;
Ch	ceratohyal;
Cb	ceratobranchials;
Eb	epibranchials;
Hb	hypobranchials;
Ib	infrapharyngobranchials;
Pfi	infra-pharyngeal dentigerous plate;
Pfs	supra-pharyngeal dentigerous plate;
Prm	pre-maxilla;
D	dentary;
An	anguloarticular;
Sim	symplectic;
Qua	quadrate;
Pre	preopercular-mandibular;
Mpt	mesopterygoid;
Mtp	metapterygoid;
Hio	hyomandibula;
Op	opercle;

Iop	infraopercular;
Cle	cleithrum;
Cor	coracoid;
Sca	scapula;
Rad	radials;
Scl	supracleithrum;
V	vomer;
Orb	orbitosphenoid;
Pas	parasphenoid;
Pts	pterosphenoid;
Esf	sphenotic;
Pro	prootic;
Exo	exoccipital;
Boc	basioccipital;
Pto	pteric;
Uh	urohyal;
Rb	branchiostegal rays;

Results

Gymnotus interruptus – new species

Figs. 1–10

Holotype. UFRJ 8218, 91.0 mm TL; Brazil: Bahia: Riacho Cambiriba, Rio Gongogi drainage, Rio de Contas basin, Guaira balnear, Iguai, 14°36'16.7"S 40°06'08.7"W, elevation: 347 m; coll.: P. BRAGANÇA, O. SIMÕES, G. JOAQUIM, J.L. MATTOS, W. COSTA and M.A. BARBOSA, 18 Jun. 2011.

Paratypes. UFRJ 8219, 121.1 mm TL; UFRJ 8243, 79.7 mm TL (c&s); collected with holotype. Same locality and collectors, 18 Jun. 2011.

Diagnosis. *Gymnotus interruptus* is a member of the *G. carapo* species-group, which is characterized by the presence of a transparent patch near the posterior end of the anal fin, most visible in juveniles and subadults, and two (vs. one in *G. pantherinus* and *G. cylindricus* species groups) laterosensory pores in the dorso-posterior region of the preopercle bone. *Gymnotus interruptus* can be distinguished from all others members of *G. carapo* species-group by the following unique combination of meristic and morphometric characters: wider interorbital distance (44.6–45.9% of STO vs. 28.6–43.7% of STO in *G. arapaima* ALBERT & CRAMPTON (2001), *G. bahianus* CAMPOS-DA-PAZ & COSTA (1996), *G. chimarrao* COGNATO *et al.* (2008), *G. choco* ALBERT *et al.* (2003), *G. esmeraldas* ALBERT & CRAMPTON (2003), *G. mamiraua* ALBERT & CRAMPTON (2001), *G. obscurus* CRAMPTON *et al.* (2005), *G. paraguensis* ALBERT & CRAMPTON (2003), *G. sylvius* ALBERT & FERNANDES-MATIOLI (1999) and *G. ucumara* CRAMPTON *et al.* (2003)); 9 scales above lateral line at midbody (vs. 5–7 or 11–13 in *G. bahianus*,

G. chimarrao, *G. choco*, *G. mamiraua*, *G. obscurus*, *G. omarorum* RICHER-DE-FORGES (2009), *G. paraguensis* and *G. ucumara*); 23–28 ventrally oriented lateral line rami (vs. 0–19 or 49–55 in *G. chaviro* MAXIME & ALBERT (2009), *G. choco*, *G. curupira* CRAMPTON *et al.* (2005), *G. esmeraldas*, *G. mamiraua*, *G. paraguensis*, *G. ucumara* and *G. inaequilabiatus* (VALENCIENNES, 1839)); 37–40 pored lateral line scales to first ventral ramus of lateral line (vs. 27–35 or 45–78 in *G. arapaima*, *G. ardilai* MALDONADO-OCAMPO & ALBERT (2004), *G. chaviro*, *G. choco*, *G. curupira*, *G. esmeraldas*, *G. henni* ALBERT *et al.* (2003), *G. obscurus*, *G. tigre* ALBERT & CRAMPTON (2003) and *G. varzea* CRAMPTON *et al.* (2005)); shorter snout (29.6–30.5% of STO vs. 31.4–41.4% of STO in *G. arapaima*, *G. bahianus*, *G. carapo* LINNAEUS (1758), *G. chaviro*, *G. choco*, *G. curupira*, *G. diamantinensis* CAMPOS-DA-PAZ (2002), *G. esmeraldas*, *G. henni*, *G. inaequilabiatus*, *G. obscurus*, *G. omarorum*, *G. paraguensis*, *G. sylvius*, *G. tigre* and *G. ucumara*).

Description. Morphometric and meristic data listed in Tables 1–4. Overall body shape cylindrical or slightly subcylindrical, more compressed between end of abdominal cavity and vertical through transparent patch of anal fin. Greatest body depth close to anal fin origin, at abdominal region. Dorsal profile of body slightly convex. Pectoral fin with rounded extremity. Anal fin extending to posterior tip of body. Anus located in the ventral vertex of two branchial openings. Cycloid scales covering whole trunk, scale above lateral line larger than below it, smaller over anal-fin base. Lateral line extending to posterior tip of body. First perforated scale on vertical adjacent to posterior margin of pectoral-fin base. Lateral sensory system of the head (figs. 1–2) with four channels; supratemporal series with one median pore on occipital region; supraorbital series with six pores; infraorbital series with six pores; preopercular-mandibular series with 11 lateral pores and one median pore on tip of chin. Greatest head width and depth at opercular level. Snout short, semi-truncated in dorsal view, dorsal profile weakly convex on anterior half and straight on posterior half. Mouth prognathous and superior, rictus straight or slightly decurved. Anterior nares conical, situated within gape. Posterior nares pore-shaped, located in shallow depression of skin. Gape slightly surpassing vertical through posterior nares. Eye dorso-laterally positioned in head. Two rows of conical teeth on premaxilla, inner row with 5 teeth without ossified base, outer row with 10 teeth with ossified base. Two rows of dentary teeth, inner row with 7 teeth without ossified base, outer row with 14 teeth with ossified base. Edentulous maxilla and mesopterygoid. Pharyngeal tooth plate of fourth epibranchial with 22–24 teeth. Pharyngeal tooth plate of fifth ceratobranchial with 12 teeth.

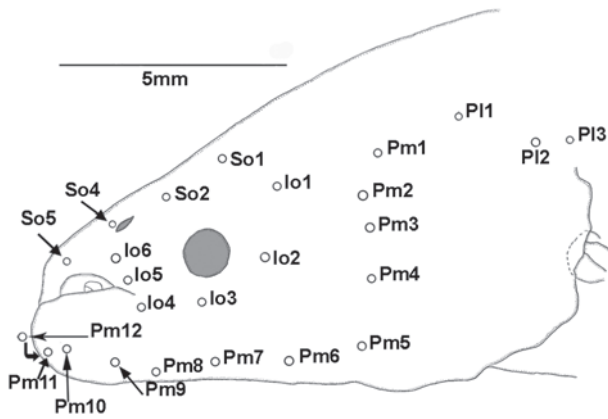


Fig. 1. Scheme presenting the arrangement of cephalic latero-sensorial system's pores of *Gymnotus interruptus* (UFRJ 8218) in lateral view. Eye and poster-nare shaded in gray.

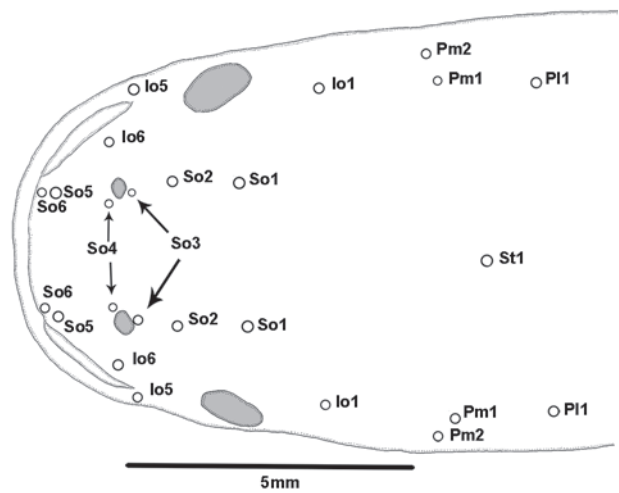


Fig. 2. Scheme presenting the arrangement of cephalic latero-sensorial system's pores of *Gymnotus interruptus* (UFRJ 8218) in dorsal view. Eyes and poster-nares shaded in gray.

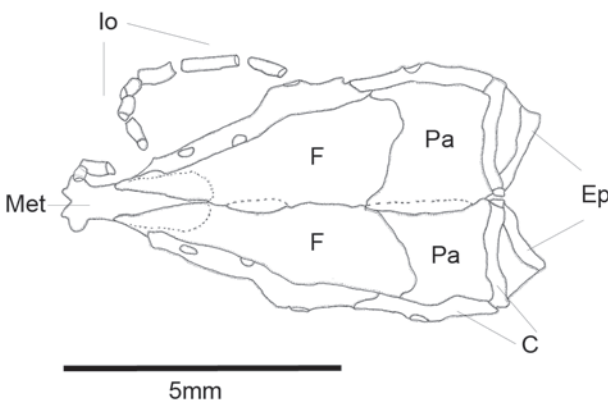


Fig. 3. Neurocranium of *Gymnotus interruptus* (UFRJ 8243) in dorsal view. Infraorbital series illustrated only on the right side.

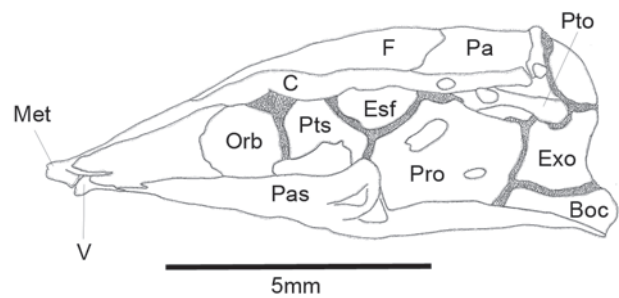


Fig. 4. Neurocranium of *Gymnotus interruptus* (UFRJ 8243) in lateral view. Cartilage presented in dense dotting.

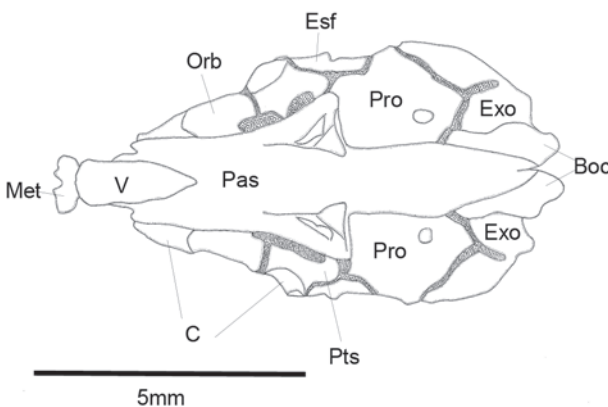


Fig. 5. Neurocranium of *Gymnotus interruptus* (UFRJ 8243) in ventral view. Cartilage presented in dense dotting.

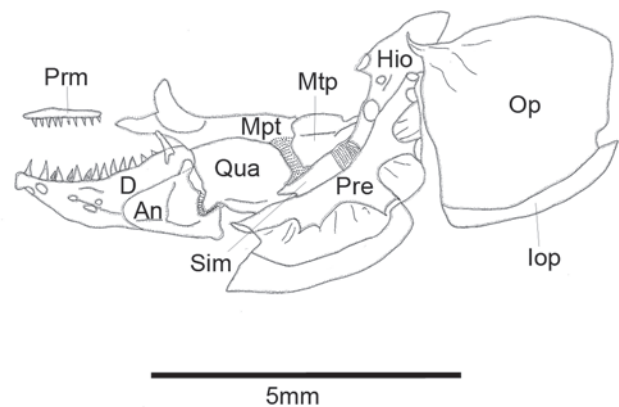


Fig. 6. Suspensorium of *Gymnotus interruptus* (UFRJ 8243) in lateral view. Cartilage presented in dense dotting.

General osteology presented in figs. 3–9. Neurocranium (figs. 3–5) depressed, with short preorbital region; mesethmoid expanded and rounded antero-

laterally, with two anterior processes separated by notch; mesethmoid neck broad; anterior margin of frontal sub-triangular; parasphenoid two times longer

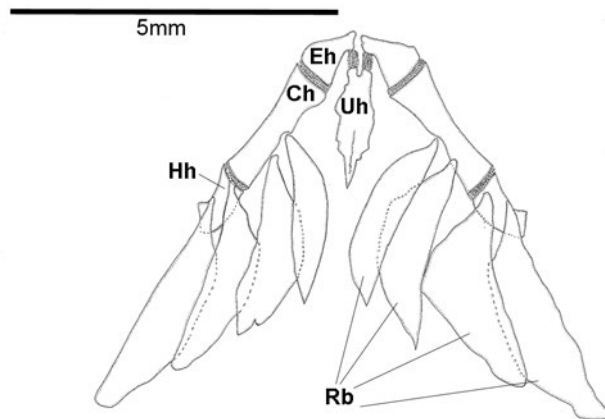


Fig. 7. Branchiostegal rays of *Gymnotus interruptus* (UFRJ 8243) in ventral view. Cartilage presented in dense dotting.

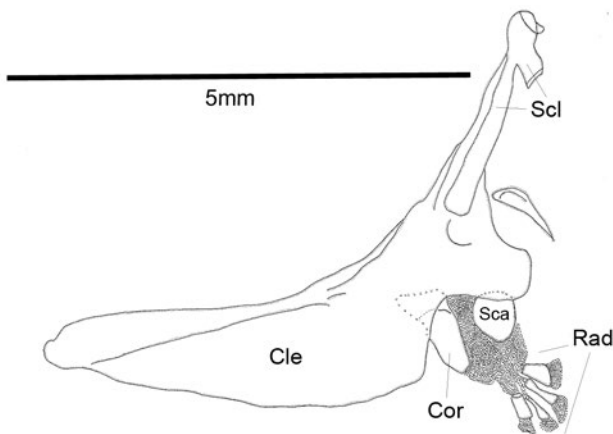


Fig. 9. Scapular girdle of *Gymnotus interruptus* (UFRJ 8243) in lateral view. Cartilage presented in dense dotting.

than wide; posterior processes of parasphenoid robust, width similar to length; antero-ventral and postero-lateral portions of pterosphenoid reaching parasphenoid; cranial fontanels closed; maxilla (fig. 6) shaped as inverted “Y”, its length approximately one third of half premaxillary length, slightly anteriorly tilted; premaxilla with convex anterior margin; most of sensory canal of mandibular portion autogenous; mesopterygoid with well-developed ascending process reaching horizontal line with median orbitosphenoid; mesopterygoid ascending process simple, robust and longer than maxilla; preopercle with two laterosensory pores on its dorso-posterior portion; opercle sub-triangular; four laminar branchiostegal rays (fig. 7), progressively wider from inner pair to outer pair; urohyal similar in size to inner branchiostegal ray, composed of arrowhead shaped ventral plate, anteriorly bifurcated, with dorsal laminar crest as wide as the plate and with similar shape; basihyal (fig. 8) equal in length to first ceratobranchial, narrower in its medial portion, both

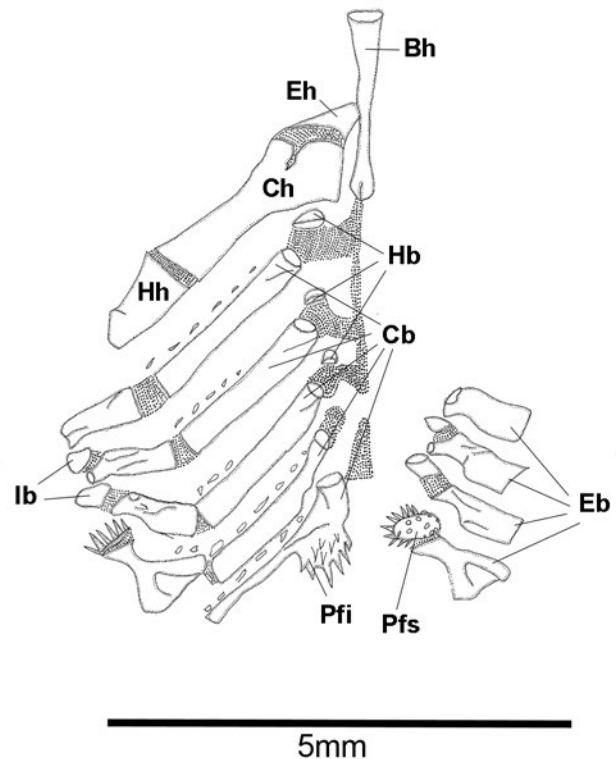


Fig. 8. Branchial arches of *Gymnotus interruptus* (UFRJ 8243) in dorsal view. Inferior right side suppressed to allow better visualization on superior right side. Cartilage presented in dense dotting.

extremities with similar width, anterior portion tube like and posterior portion with globoid expansion; no ossified basibranchials; first pharyngobranchial absent as independently ossified element; second and third ossified, fourth cartilaginous; epibranchials 1–4 ossified, fifth cartilaginous; upper pharyngeal tooth plate without ossified connection to fourth epibranchial; mesocoracoid present; scapular foramen absent; coracoid (fig. 9) without postero-ventral process and with dorsal process; posttemporal in contact but not co-ossified with supracleithrum; extrascapular absent; knife shaped postcleithrum almost as long as coracoid and with half width of coracoid; four pectoral radials; 33 precaudal vertebrae (including those of Weberian apparatus); neural and haemal spines present; well-developed inter-muscular bones, clustered posteriorly to nape and sparse on dorsal and dorso-lateral back, most of them branched at extremities.

Colouration in life. Overall colour pattern appears in Fig. 10. Head dark to light brown on region above ventral-most pore of infraorbital series. Ventro-lateral and ventral portions of snout light brown. Ventro-lateral and ventral postorbital regions of head with white ground colour with tiny brown chromatophores. Pupils black, sclerotic region white. Highly vascularized regions, like opercle, with pink to red colour

Table 1. Morphometric data of *Gymnotus interruptus* showed as percentage of Total length.

Morphometrics	H	P1	P2	MEAN	SD
TL	91.01	121.09	79.73	97.28	21.38
Ratios based in TL:					
HL	13.37	12.77	14.32	13.49	0.78
Length to end of anal fin	100	100	100	100	0
Anal-fin base length	82.08	80.81	80.77	81.22	0.74
Greatest body depth	10.03	8.94	10.31	9.76	0.72
Body depth at anal-fin origin	9.94	8.88	10.31	9.71	0.74
Snout to opercle	12.43	11.91	12.87	12.40	0.48
Pre-anal fin distance	20.22	20.22	21.96	20.80	1.01
Pre-pectoral fin distance	13.16	12.81	14.34	13.44	0.80

Table 2. Morphometric data of *Gymnotus interruptus* showed as percentage of Head length.

Morphometrics	H	P1	P2	MEAN	SD
HL	12.17	15.47	11.42	13.02	2.15
Ratios based in HL:					
Snout to opercle	92.93	93.21	89.84	92.00	1.87
Snout length	27.53	27.73	27.41	27.56	0.16
Mouth	22.10	17.00	22.33	20.48	3.01
Eye diameter	10.27	9.05	9.46	9.59	0.62
Interorbital width	41.41	42.73	41.24	41.79	0.81
Snout to occiput	77.81	83.39	80.12	80.44	2.80
Postorbital distance	63.27	63.35	62.08	62.90	0.71
Pectoral-fin length	44.45	43.96	35.73	41.38	4.90
Snout to anus	77.07	83.13	77.93	79.38	3.28
Anus-anal fin	73.05	77.57	71.89	74.17	3.00
Anter-poster nare	9.86	11.05	10.51	10.47	0.60
Poster nare-eye	14.54	14.41	13.84	14.26	0.38
Head depth at eye	44.37	42.53	46.76	44.56	2.12
Head depth at nape	59.57	60.76	61.56	60.63	1.00
Branchial opening	44.54	39.95	42.21	42.23	2.29

**Fig. 10.** *Gymnotus interruptus* sp. n., holotype, UFRJ 8218, 91.00 mm TL; Brazil: Bahia: riacho Cambiriba, rio Gongogi's drainage, rio de Contas' basin, Guaira balnearny, Iguaí. The specimen was alive in the moment in which the photo was taken.

seen by transparency. Body ground colour ranging from pale yellow to light brown. Body, anterior to first ventral lateral line ramus, dark brown above lateral line and banded under lateral line. Bands above lateral line clearly visible posterior to first ventral lateral line ramus. Pectoral fin membrane transparent with sparse brown chromatophores. Anal fin membrane transparent with brown chromatophores whose number increases from anterior to posterior portion until saturation on vertical through first ventral lateral line ramus, saturation persisting until vertical through seventh band, where it suddenly returns transparency that persists until body end.

Colouration in alcohol. Specimens fixed in 10% formalin and preserved for three months in 70% ethanol

maintain similar colors as in life, except for the disappearing pink colour in areas once highly vascularized, as well as darkening of head chromatophores.

Band pattern. Overall band pattern appears in fig. 10. Band pattern is clearly visible in holotype, smaller paratype and in posterior region of greater paratype. Dark bands obliquely oriented, its dorsal portions more posterior than ventral portions. Dark bands progressively wider from anterior to posterior portions of trunk. Pale interbands almost the same width along trunk. Dark bands, anterior to transparent portion of anal fin posterior portion can assume an inverted "Y" shape. Pale interbands, anterior to vertical through first ventral lateral line ramus, ventrally and/or dorsally fragmented, allowing union of adjacent dark bands.

Table 3. Morphometric data of *Gymnotus interruptus* showed as percentage of snout-to-opercle length.

Morphometrics	H	P1	P2	MEAN	SD
STO	11.31	14.42	10.26	12.00	2.16
Ratios based in STO:					
Snout length	29.62	29.75	30.51	29.96	0.48
Mouth	23.78	18.24	24.85	22.29	3.55
Eye diameter	11.05	9.71	10.53	10.43	0.68
Interorbital width	44.56	45.84	45.91	45.44	0.76
Snout to occiput	83.73	89.46	89.18	87.46	3.23
Postorbital distance	68.08	67.96	69.10	68.38	0.63
Pectoral-fin length	47.83	47.16	39.77	44.92	4.48
Snout to anus	82.94	89.18	86.74	86.29	3.15
Anus-anal fin	78.60	83.22	80.02	80.61	2.36
Anter-poster nare	10.61	11.86	11.70	11.39	0.68
Poster nare-eye	15.65	15.46	15.40	15.50	0.13
Head depth at eye	47.75	45.63	52.05	48.47	3.27
Head depth at nape	64.10	65.19	68.52	65.94	2.30
Branchial opening	47.92	42.86	46.98	45.92	2.69

Band margins irregularly shaped. In biggest paratype (121 mm TL) ground color gets darker, making bands visualization more difficult.

Habitat and Ecology notes. The specimens were collected with hand nets in a clear water stream which topical width was about 4 m, depth about 1.5 m, with bottom composed of sand, gravel and rocks of variable size (fig. 11). Individuals were found hidden among marginal vegetation and roots. The stomach content of smaller paratype showed traces of Nematocera larvae, adult Coleoptera and insect eggs.

Distribution. Known only from Riacho Cambiriba, an affluent of the rio Gongogi, Guáira Balneary, Iguai, Bahia, Brazil.

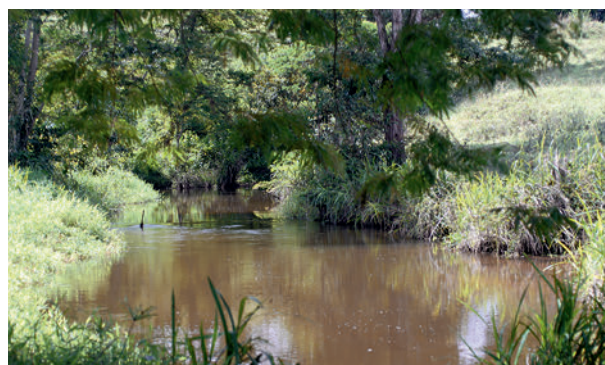
Etymology. Named *interruptus* from the Latin adjective interrupted due to its pale interbands, anterior to vertical through first ventral lateral line ramus, ventrally and/or dorsally fragmented (same as interrupted), allowing union of adjacent dark bands.

Discussion

The rio de Contas basin, located in the Brazilian state of Bahia, has as main components the rivers de Contas, Gongogi, Brumado, do Antônio, Jacaré, Sincorá, Gavião e Jequezinho. Occupying an area of 55.534 km²,

Table 4. Meristic data of *Gymnotus interruptus*.

Meristics	H	P2	P1
Anal Fin Rays (AFR)	s/d	219	s/d
Pigment bands (BND)	23	22	26
Precaudal vertebrae (PCV)	s/d	33	s/d
Pectoral rays (PIR)	s/d	17	s/d
Pored lateral line scales (PLL)	82	83	97
Pored scales 1° ventral ramus (PLR)	40	37	40
Scales above Later. Line (SAL)	9	9	9
Ventrally oriented L. line rami (VLR)	26	28	23

**Fig. 11.** Riacho Cambiriba, One of the points of view from the environment where the type series of *Gymnotus interruptus* was collected.

this basin is the fourth largest on north-eastern Brazil. However, despite the great area occupied by this important basin, no species of *Gymnotus* has been recorded to it until this moment (REIS *et al.*, 2003).

All specimens of the type series of *G. interruptus* were collected in the Riacho Cambiriba, a small tributary of rio Gongogi which in turn is a tributary of rio de Contas, consisting of the first gymnotiform fish recorded to the rio de Contas basin.

Other congeners occurring in areas near to the rio de Contas basin are *G. bahianus*, endemic to rio Almada basin, an isolated small coastal basin of Bahia, and *G. carapo* which has been recorded from a huge area, including the Amazon and Orinoco basins below c. 500 m elevation, the Island of Trinidad, isolated drainages of Guyanas, and northeastern Brazil

(ALBERT & CRAMPTON, 2003a). Distinction of *G. interruptus* among the latter congeners is possible, even during field works, by the observation of its colour pattern, in which the pale interbands, anterior to vertical through first ventral lateral line ramus, are ventrally and/or dorsally fragmented, allowing union of adjacent dark bands. Moreover *G. interruptus* may be distinguished from *G. bahianus* and *G. carapo* by having shorter snout (27.4–27.7% vs. 32.4–35.7% of HL in *G. bahianus* and 29.6–30.5% vs. 32–39.4% of STO in *G. carapo*).

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