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Gymnotus capitimaculatus, a new species of electric fish from rio Jucuruçu basin, northeastern Brazil (Ostariophysi: Gymnotiformes: Gymnotidae)

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Abstract

A new species of *Gymnotus*, from the *G. pantherinus* species-group, is herein described from the rio Jucuruçu basin, a coastal river drainage located in the southern part of Bahia state, northeastern Brazil. *Gymnotus capitimaculatus* sp. n. differs from all congeners by having an pair of round blotches anteriorly positioned or under vertical passing through eye, on ventral portion of the head. Furthermore, *Gymnotus capitimaculatus* also differs from all members of the *G. pantherinus* species-group by having the following unique combination of characters states: tail with an unique series of bands or round spots; precaudal portion of trunk without bands but either with rounded and/or vermiculated spots; forty-five precaudal vertebrae; nine scales above lateral line at mid-body; anal-fin base length 75.2–78.6 % of TL; anus-anal fin length 101.4–122.8 % of HL; and branchial opening 38.5–45.0 % of HL.

Resumo

Uma nova espécie de *Gymnotus*, pertencente ao grupo de espécies *G. pantherinus*, é aqui descrita para a bacia do rio Jucuruçu, uma drenagem fluvial costeira localizada no sul do estado da Bahia, nordeste do Brasil. *Gymnotus capitimaculatus* sp. n. difere de todos seus congêneres por possuir a porção ventral da cabeça com um par de máculas posicionadas anteriormente ou sob vertical que passa pelo olho. Ademais, *Gymnotus capitimaculatus* também difere de todos os membros do grupo *G. pantherinus* pela seguinte combinação exclusiva de caracteres: cauda com uma única série de barras os manchas arredondadas; porção pré-caudal do tronco sem barras ou com manchas arredondadas ou vermiculadas; quarenta e cinco vértebras pré-caudais; nove escamas acima da linha lateral no meio do corpo; comprimento da base da nadadeira anal 75,2–78,6 % do TL; comprimento ânus-nadadeira anal 101,4–122,8 % do HL; e abertura branquial 38,5–45,0 % do HL.

Key words

Atlantic Forest, Biodiversity, electric eels, *Gymnotus pantherinus* complex, Knife-fish, taxonomy.

Introduction

The Gymnotidae is a family of slender electric fishes endemic from the freshwaters of the Neotropical region. Like other members of the order Gymnotiformes, gymnotids use a self-generated electric field, and the perception of its distortions, for intra-specific interactions and environmental recognizing (Caputi *et al*., 2005; Hopkins, 2005; Albert & Crampton, 2005). Except for *Electrophorus electricus* (Linnaeus, 1766), the only representative of its genus and famous for the strength of its electric discharge, all the remaining 38 species of this family

belong to the genus *Gymnotus* Linnaeus, 1758. The later genus comprises a group of weak electric fishes diagnosed by the presence of three main apomorphic character states: anterior portion of the mesethmoid bone with two processes separated by a notch; absence of cranial fontanels in adults; and posterior end of the body cavity without displaced haemal spines (Campos-da-Paz & Costa, 1996; Albert & Crampton, 2003). Species of *Gymnotus* can be found in all the major freshwater systems from southern Mexico (15°N) to northern Argentina (36°S), inhabiting streams, flood plains and river margins. The great majority of species presents nocturnal and predatory habits, staying in hidden shelters during the day, like riparian vegetation, roots clusters, leaf litter and rocks. Albert *et al*. (2005), searching for morphological diagnostic characters, recognised three main monophyletic species-groups within *Gymnotus*: the *G. cylindricus* group, formed by two species from Central America and southern extremity of North America; the *G. carapo* group, with 22 species occurring throughout South America north to 36° S, including Trinidad island; and the *G. pantherinus* group, containing 15 species (including the one herein described) found in cis-Andean basins from Panamá to Uruguay. The *Gymnotus pantherinus* species group is mainly characterized by the presence of three morphological traits: slender body (body depth 6.1–9.0 % of TL); proximal portion of fifth rib with broad triangular ridge, more than three times width of sixth rib; one laterosensory pore in the dorso-posterior portion of preopercle, in the preopercular-mandibular canal.

Prior to European colonization, the South American Atlantic Forest originally occupied an area of 1,481,946 km², comprising the second largest rainforest of the American continent (SOS MATA & INPE, 2009). Unfortunately, due to the suppression imposed by urban and agricultural expansion, this biome presents itself with no more than 8 % of its original extent (Tabarelli *et al*., 2005). Regardless to its decline, the Atlantic Forest is still one of the five main "hotspots" of the world (Myers *et al*., 2000; Laurance, 2009), constituting a matter of concern to the organizations engaged in biodiversity conservation and a challenge for taxonomists who intend to reveal its biodiversity.

In the present paper, a new species belonging to the *Gymnotus pantherinus* species-group is described from the middle course of the rio Jucuruçu basin (sensu Sarmento-Soares *et al*., 2009), a coastal river from southern state of Bahia, eastern Brazil.

Material and Methods

Specimens were collected with hand nets and euthanized in a solution of tricain mesylate (MS 222). Individuals used in morphological analysis were fixed in 10 % formalin during 14 days and then preserved in 70 % ethanol. All examined material is deposited in the collection of the Laboratory of Systematics and Evolution of Teleost Fishes, Institute of Biology, Universidade Federal do Rio de Janeiro (UFRJ).

All measurements were taken as point-to-point linear distances, from the left side of specimens, and recorded to the nearest 0.1 mm with the use of digital calipers. Morphometrics and meristics follow Albert & Crampton (2003); measurements and counts not found in Albert & Crampton (2003) follow Mago-Leccia (1978) and Campos-Da-Paz (2002). Morphometrics are given as percentages of total length (TL) or head length (HL). Measurements and counts based on total length, excluded exemplars with significantly damaged or regenerated caudal appendage. Osteological data were obtained from specimens cleared and counterstained through the method proposed by Taylor & Van Dyke (1985). Bone nomenclature follows Albert *et al*. (2005) and Mago-Leccia (1978). The osteological description focuses on features relevant at generic and specific levels, (sensu Campos-Da-Paz & Costa, 1996 and Maxime *et al.*, 2011). Characters derived from position and distribution of chromatophores were used in the diagnosis of species. The colour patterns of live and preserved specimens were described to represent the intrinsic variation in each species.

For species delimitation, it was adopted the Population Aggregation Analysis (Davis & Nixon, 1992), a character-based method in which species are delimited by a unique combination of stable morphological character states occurring in one or more populations.

Comparative Material

Morphological data for *G. coropinae* Hoedeman, 1962 and *G. tiquie* Maxime *et al*., 2011 were taken from Crampton & Albert (2003) and Maxime *et al*. (2011), respectively. The data for the remaining species of the *G. pantherinus* species-group (except for *G. pantherinus* (Steindachner, 1908)) were taken from Albert & Crampton (2003).

Gymnotus pantherinus: Brazil: Santa Catarina state: UFRJ 9500, 8, 114.8–205.5 mm TL, Florianópolis municipality, road Bento Manoel Ferreira, Ratones. Paraná state: MZUSP 25055, 5, 1 (C&S), 116.5–151.2 mm TL, Guaratuba municipality, stream near the beach. São Paulo state: MZUSP 93121, 5, 2 (C&S), 99–235.8 mm TL, rio Ribeira do Iguape basin, stream afl. rio Momuna, c. 1,5 km from Momuna ville. MZUSP 113632, 5, 2 (C&S), 148.8–216.3 mm TL, São Bernardo do Campo municipality , rio Cubatão. MCP 20665, 3, 150.6–179.2 mm TL, Salesópolis municipality, riacho Paraitinguinha by Salesópolis-Jacareí road. Rio de Janeiro state: UFRJ 0536, 11, 115.3–229.3 mm TL, Paraty municipality, stream afluent of rio Taquari. UFRJ 7852, 7, 107.8–167.6 mm TL, Petrópolis municipality, stream by cachoeira road. UFRJ 9646, 19, 109.1–171.7 mm TL, Silva Jardim municipality, stream crossing RJ-126 road.

Fig. 1. *Gymnotus capitimaculatus,* UFRJ 9964, paratype, 156.0 mm TL; Brazil: Bahia: Itamaraju. Photo: José L. O. Mattos.

Results

Gymnotus capitimaculatus nov. spec.

Figs. 1–4, Table 1

Holotype. Brazil: Bahia State: Itamaraju municipality: UFRJ 9785, 131.4 mm TL, rio do Ouro, crossing road perpendicular to BR-101, about 7 km north of Itamaraju, 16°57'04"S, 39°33'21"W, *coll.* Rangel-Pereira FS, Ottoni FP, 22 June 2013.

Paratypes. Brazil: Bahia State: Itamaraju municipality: UFRJ 9625, 7, 120.7–158.4 mm; UFRJ 9728, 2, 101.0–106.5 mm TL (c&s), collected with holotype. UFRJ 9964, 2, 116.0–156.0 mm TL, rio do Ouro, crossing road perpendicular to BR-101, about 7 km north of Itamaraju, 16°57'04"S, 39°33'21"W, *coll*. Costa WJEM, Simões OC, Rangel-Pereira FS, Mattos JLO, Rizzieri RC, 18 February 2014.

Diagnosis. *Gymnotus capitimaculatus* is a member of the *Gymnotus pantherinus* species-group, possessing a slender body (body depth 7.2–8.9 % of TL), proximal portion of the fifth rib with broad triangular ridge, more than three times width of the sixth rib (vs. narrow ridge, less than three times width of the sixth rib) and one laterosensory pore in the dorso-posterior portion of the preopercle, in the preopercular-mandibular canal (vs. two pores). The new species can be distinguished from all congeners by having a pair of round blotches anteriorly positioned or under vertical passing through eye, on ventral portion of the head (Fig. 2). Furthermore, *Gymnotus capitimaculatus* also differs from all members of the *G. pantherinus* species-group (sensu Albert *et al*., 2005) by the following unique combination of characters: tail with a unique series of bands or round spots (Fig. 3) [vs. tail with randomly disposed spots, never forming a unique series]; precaudal portion of the trunk without bands or with rounded and/or vermiculated spots scattered all over it (Figs. 1 and 4) [vs. with well defined bands]; forty-five precaudal vertebrae (vs. 31–43 or 46–51); nine scales above lateral line at mid-body (vs. 6–8 or 10); anal fin base length 75.2–78.6 % of TL (vs. 62.9–74.7 or 79–83.8 %); anus-anal fin length 101.4–122.8 % of HL (vs. 50–96.3 %); and branchial opening 38.5–45.0 % of HL (vs. 24–35).

Description. Morphometric and meristic data of holotype and type series of *Gymnotus capitimaculatus* appear in Table 1. No sexual dimorphism observed. Overall body shape (Fig. 1) cylindrical or subcylindrical, progressively more compressed from first 1/6 of anal fin to tail tip. Greatest body depth immediately posterior to anal fin origin, at abdominal region. Body dorsal profile straight or slightly convex. Pectoral fin with rounded extremity. Anal fin ending very close to posterior body tip. Anus located anterior to pectoral fin, vertical tangent to its posterior margin tangent to anterior margin of pectoral-fin base. Cycloid scales covering all trunk, smaller over pterygiophores and tail, larger at lateral line ramification zone and middle at remaining parts of trunk. First pored scale between fifth and sixth postcephalic lateral line pores. Postcephalic lateral line posterior portion with mostly ventral ramifications. Cephalic lateral sensory system with four chanels. Supratemporal series with two or three pores, one median and one or two laterals. Supraorbital series with six pores. Infraorbital series with six pores. Preopercular-mandibular series with ten ventro-lateral pores plus median pore at chin. Greatest head width and depth at opercular level. Snout semi-truncated in dorsal view, its dorsal profile convex. Mouth prognathous and superior, rictus decurved not reaching vertical through posterior nare. Anterior nares rounded and included within gape, its anterior margin projecting over posterior margin forming lobe. Posterior nares with rounded or elliptical pore shape. Eyes dorso-laterally positioned. Premaxilla with two rows of conical teeth, inner row with six teeth, outer row with eight teeth. Dentary with 14 to 16 teeth. Edentulous maxilla and mesopterygoid. Upper pharyngeal tooth plate with 16 to 21 teeth. Lower pharyngeal tooth plate with 9 to 11 teeth.

Osteology. Neurocranium depressed; mesethmoid expanded and rounded antero-laterally, with two anterior processes separated by notch; mesethmoid neck broad; anterior margin of frontal triangular; parasphenoid three times longer than wide; posterior processes of parasphenoid thin, two times longer than wide; antero-ventral and

postero-lateral portions of pterosphenoid reaching parasphenoid; cranial fontanels closed; maxilla with similar length to premaxilla, dorsal portion thin and globoid in extremity, ventral portion rounded, expanded and compressed; premaxilla with straight or slightly convex anterior margin; sensory canal of mandibular portion mostly autogenous; mesopterygoid with well-developed ascending process surpassing horizontal line with median orbitosphenoid; mesopterygoid ascending process with variable shape, its length reaching two thirds of maxillary length; preopercle with one laterosensory pore on its dorso-posterior portion; opercle sub-triangular; four laminar branchiostegal rays, progressively wider from inner pair to outer pair; urohyal equal length four-fifths of inner branchiostegal ray; basihyal similar in length to first ceratobranchial; basibranchials cartilaginous or absent; first, second and third pharyngobranchial, fourth pharyngobranchial cartilaginous or absent; epibranchials 1–4 ossified; upper pharyngeal tooth plate without ossified connection to fourth epibranchial; mesocoracoid present; scapular foramen absent; coracoid with postero-ventral process and with dorsal process; posttemporal in contact but not co-ossified with supracleithrum; post-cleithrum knife-shaped, with size similar to coracoid; four pectoral radials; 45 precaudal vertebrae (including those of Weberian apparatus); neural and haemal spines present; inter-muscular bones well-developed, clustered posteriorly to nape and sparse on dorsal and dorso-lateral back, branched at extremities.

Colouration in life. Overall colouration of live specimens represented in Figure 1. Dorsal and dorso-lateral portions of head ranging from dark to light brown, ventral and ventro-lateral portions dark brown or light brown or beige; ventral portion with more sparse chromatophores, with pair of ventral blotches located anteriorly or under vertical through eye (Fig. 2); additional spots on head present or not. Pupil black, sclerotic region beige when visible. Highly vascularized areas on operculum and pterigyophores with pinkish or reddish colour seen by transparency. Trunk ground colour ranging from pale yellow to dark brown, trunk colour always darker above lateral line; ground colour area clearly wider than spots-covered area; spots conspicuous or inconspicuous, thick and vermiculated and/or big and rounded. Tail (Fig. 3) with single series of rounded spots or bands. Pectoral fin membrane transparent, with sparse brown chromatophores. Anal fin membrane transparent with brown chromatophores, more concentrated antero-posteriorly.

Colouration in alcohol. Overall colouration of preserved specimens (Fig. 4) similar to colouration in life.

Distribution. Known only from rio do Ouro, a tributary of the rio Jucuruçu, Itamaraju municipality, Bahia state, northeastern Brazil.

Etymology. Named *capitimaculatus* from the *Latin* subject *capitis* (head) and adjective *maculatus* (blotchy), due to the presence of a pair of blotches in the ventral portion of the head.

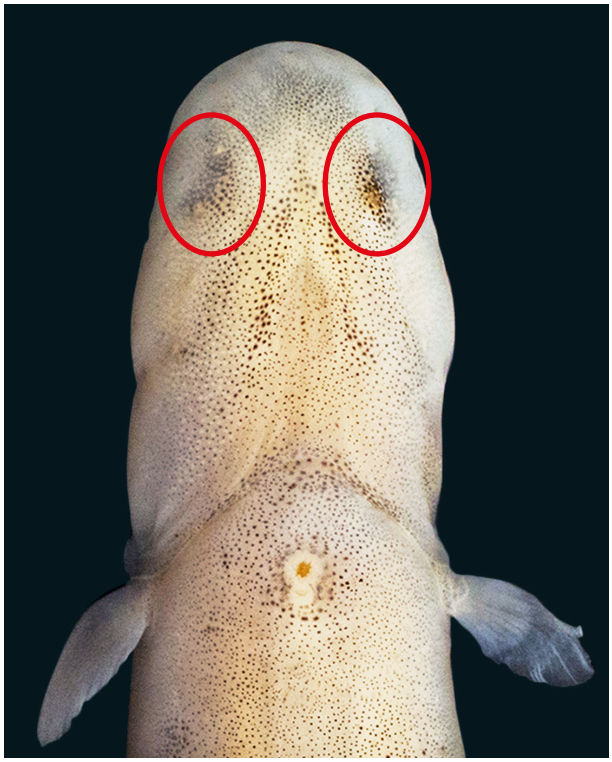

Fig. 2. Ventral view of the head of *Gymnotus capitimaculatus*. The red circles put in evidence the pair of ventral blotches, a diagnostic character for this species. Photo: Axel M. Katz.

Fig. 3. Sample of the tail colouration in *Gymnotus capitimaculatus*, where the spots are disposed in a unique series. UFRJ 9625, paratypes, 127.1–157.7 mm TL, Brazil: Bahia: Itamaraju. Photo: Axel M. Katz.

Ecology. The specimens were collected in a clear water stream which topical width was about 1.5 m, depth ranged from 0.1 to 1 m and the bottom was composed of sand and small gravel. The matrix through where the stream flowed was composed of a mix of grass pasture and scarce riparian forest. Individuals were found deeply hidden among marginal vegetation and roots, mostly where the water flow was faster. Another species of the genus *Gymnotus*, belonging to the *G. carapo* species

Fig. 4. Range of colouration pattern in *Gymnotus capitimaculatus*, where the precaudal portion of trunk is found without bands or with rounded and/or vermiculated spots scattered all over it. UFRJ 9625, paratypes, 127.1 – 157.7 mm TL, Brazil: Bahia: Itamaraju. Photo: Axel M. Katz.

group, was found sympatrically, but not syntopically, since it was caught where the water flow was slower.

Conservation. *Gymnotus capitimaculatus* is known solely from a topic population. Furthermore, no other populations belonging to the *G. pantherinus* species-group were found in this basin or in its neighboring (Sarmento-Soares *et al*., 2009; 2010; Sarmento-Soares & Martins-Pinheiro, 2009; 2010), what allows to consider *G. capitimaculatus* as a very rare and endangered species. This somewhat relictual distribution is probably a consequence of the historical deforestation suffered by the natural habitats found in the rio Jucuruçu basin. Nevertheless, proposals aiming the foundation of an environment protection area to preserve the remaining natural habitats of this basin are already available (MMA/SBF/NAPMA, 2006).

Discussion

Prior to this publication, populations of the *G. pantherinus* species-group occurring in southern Bahia state were often identified as *G. pantherinus, G.* cf. *pantherinus* or *G.* aff. *pantherinus* either in collections or papers (e.g. Sarmento-Soares & Martins-Pinheiro, 2009). Nevertheless, besides geographical distance, the species here described can be easily distinguished from *G. pantherinus* by possessing a colour pattern on tail where the spots or irregular bands form a unique series (Fig. 3), while the second has a tail with randomly disposed spots never forming a unique series. In addition, in a recent analysis of the populations of *Gymnotus* from southern Bahia state, a third species was recognized and its description is already in progress.

As far as is known, *Gymnotus capitimaculatus* can be considered as a species with a relictual distribution, occurring in a single recorded locality. However, although the lack of records is a fact, the existence of other small populations is quite possible. The sampling process for certain populations belonging to *G. pantherinus* species-group can be very laborious. Availed by their slender and flexible body, individuals tend to hide very deeply into the substratum, making the capture almost impracticable by traditional sampling methods for small freshwater fishes. The first formally published equipment for finding electric fishes was designed by Crampton *et al*. (2007). This kind of gadget can be used to simply infer the presence of electric fishes in a water course, but also to precisely locate individuals if they are sheltered in a dense matrix of substratum. The user of an electric fish finder is therefore allowed to optimize efforts, thus improving chances of capture. Unfortunately, despite being widely recognised and employed among Gymnotiformes specialists (Westby, 1988; Crampton, 1998; Giora & Fialho, 2009; Giora *et al*., 2012), much of researching teams committed to surveys of fish fauna do not make use of this equipment, what turns the records of gymnotid populations very rare in species-lists for some basins.

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Table 1. Morphometric and meristic data of *Gymnotus capitimaculatus*.

***Gymnotus capitimaculatus* (n = 10)**				
	Holotype	**Range**	**Mean**	**SD**
TL	131.4	100.7 – 158.4		
Percents of TL				
Head length	9.3	8.8 – 9.9	9.3	0.3
Length to end of anal fin	95.8	94.5 – 96.8	95.6	0.7
Anal fin base length	76.9	75.2 – 78.6	77.1	1.2
Body depth	7.2	7.2 – 8.9	7.7	0.6
Pre-anal fin lenght	20.1	17.7 – 20.7	19.6	0.9
Pre-pectoral fin lenght	9.8	9.0 – 10.4	9.7	0.4
Tail length	4.2	3.2 – 5.5	4.4	0.7
Percents of HL				
Preorbital length	32.9	31.9 – 34.4	33.2	0.8
Mouth	27.1	26.0 – 28.3	27.0	0.8
Eye diameter	8.6	8.6 – 11.7	9.7	0.8
Interorbital width	42.1	39.8 – 43.4	41.8	1.1
Snout to occiput	81.4	78.9 – 82.3	81.0	1.1
Postorbital distance	62.1	60.2 – 64.6	61.8	1.8
Pectoral-fin length	42.9	37.5 – 49.6	45.2	3.3
Snout to anus	104.3	96.6 – 106.6	102.3	3.5
Anus-anal fin	101.4	101.4 – 122.8	109.0	6.1
Anter-poster nare	15.0	13.0 – 15.5	14.0	0.9
Poster nare-eye	12.1	11.4 – 12.6	12.1	0.4
Head depth at eye	41.4	40.2 – 43.7	41.9	1.1
Head depth at nape	60.0	58.0 – 61.9	59.5	1.1
Branchial opening	40.7	38.5 – 45.0	42.1	2.0
Greatest head width	67.9	62.6 – 67.9	64.7	1.6
Meristics	**Holotype**	**Range**	**Mode**	**SD**
Pored scales on lateral line	63	56 – 74	65	5.9
Pored scales to 1º lateral line ventral ramus	29	21 – 36	28	4.06
Ventrally oriented lateral line ramus	21	21 – 26	25	1.73
Scales over lateral line	9	9	9	0
Cleared and stained	n = 2			
Anal fin rays	227 – 243			
Pectoral fin rays	15			
Pre-caudal vertebrae	45			

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References

Albert, J.S. & Crampton, W.G.R. (2003): Seven new species of the neotropical electric fish *Gymnotus* (Teleostei, Gymnotiformes) with a redescription of *G. carapo* (Linnaeus). – Zootaxa, **287**: 1 – 54.

Albert, J.S. & Crampton, W.G.R. (2005): Diversity and phylogeny of Neotropical electric fishes (Gymnotiformes). – In: Bullock, T.H., Hopkins, C.D., Popper, A.N. & Fay, R.R., (eds.): Electroreception. – Springer Handbook of Auditory Research. New York, pp 360 – 409.

Albert, J.S., Crampton, W.G.R., Thorsen, D.H. & Lovejoy, N.R. (2005): Phylogenetic systematics and historical biogeography of the Neotropical electric fish *Gymnotus* (Teleostei: Gymnotiformes). – Systematic and Biodiversity, **2**: 375 – 417.

Campos-da-Paz, R. & Costa, W.J.E.M. (1996): *Gymnotus bahianus* sp. nov., a new gymnotid fish from Eastern Brazil (Teleostei: Ostariophysi: Gymnotiforms), with evidence for the monophyly of the genus. – Copeia, **4**: 937 – 944.

Campos-da-Paz, R. (2002): *Gymnotus diamantinensis*, a new species of electric knifefish from upper rio Arinos basin, Brazil

(Ostariophysi: Gymnotidae). – Ichthyological Exploration of Freshwaters, **13**: 185–192.

Caputi, A.A., Carlson, B.A. & Macadar, O. (2005): Electric organs and their control. – In: Bullock, T.H., Hopkins, C.D., Popper, A.N. & Fay, R.R. (eds.): Electroreception. – Springer Handbook of Auditory Research. New York, pp 410–451.

Crampton, W.G.R. (1998): Effects of anoxia on the distribution, respiratory strategies and electric signal diversity of gymnotiform fishes. – Journal of Fish Biology, **53**: 502–520.

Crampton, W.G.R., Wells, J.K., Smyth, C. & Walz, S.A. (2007): Design and construction of an electric fish finder. – Neotropical Ichthyology, **5**: 425–428.

Davis, J.I. & Nixon, K.C. (1992): Populations, genetic variation, and the delimitation of phylogenetic species. – Systematic Biology, **41**: 421–435.

Fundação Sos Mata Atlântica & Instituto Nacional de Pesquisas Espaciais (2009): Atlas dos Remanescentes Florestais da Mata Atlântica Período 2005–2008: www.mapas.sosma.org.br/site_media/download

Giora, J., Tarasconi, H.M. & Fialho, C.B. (2012): Reproduction and feeding habits of the highly seasonal *Brachyhypopomus bombilla* (Gymnotiformes: Hypopomidae) from southern Brazil with evidence for a dormancy period. – Environmental Biology of Fish, **94**: 649–662.

Giora, J. & Fialho, C.B. (2009): Reproductive biology of weakly electric fish *Eigenmannia trilineata* López & Castello, 1966 (Teleostei, Sternopygidae). – Brazilian Archives of Biology and Technology, **52**(3): 617–628.

Hopkins, C.D. (2005): Passive Electrolocation and the Sensory Guidance of Oriented Behavior. – In: Bullock, T.H., Hopkins, C.D., Popper, A.N. & Fay, R.R. (eds.): Electroreception. – Springer Handbook of Auditory Research. New York, pp 264–289.

Laurance, W.F. (2009): Conserving the hottest of the hotspots. – Biological Conservation, **142**: 1137.

Mago-Leccia, F. (1978): Los peces de la família Sternopygidae de Venezuela. – Acta Científica Venezolana, **29**: 1–89.

Maxime, E.L., Lima, F.C.T. & Albert, J.S. (2011): A New Species of *Gymnotus* (Gymnotiformes: Gymnotidae) from Rio Tiquié in Northern Brazil. – Copeia, **1**: 77–81.

MMA – Ministério do Meio Ambiente/ SBF/NAPMA- Núcleo dos Biomas Mata Atlântica e Pampa (2006): Proposta da Equipe Técnico-científica para Ampliação da Rede de Unidades de Conservação de Proteção Integral no Sul e Extremo Sul da Bahia. Governo Federal, Brasília, Brazil.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. & Kent, J. (2000): Biodiversity hotspots for conservation priorities. – Nature, **403**: 853–858.

Sarmento-Soares, L.M. & Martins-Pinheiro, R.F. (2009): Diversidade e endemismo de peixes de riacho no extremo sul da Bahia. – Boletim da Sociedade Brasileira de Ictiologia, **97**: 10–12.

Sarmento-Soares, L.M. & Martins-Pinheiro, R.F. (2010): A microbacia de Cumuruxatiba, BA. – Boletim da Sociedade Brasileira de Ictiologia, **99**: 9-12.

Sarmento-Soares, L.M., Mazzoni, R. & Martins-Pinheiro, R.F. (2009): A fauna de peixes na bacia do Rio Jucuruçu, leste de Minas Gerais e extremo sul da Bahia. – Pan-American Journal of Aquatic Sciences, **4**(2): 193–207.

Sarmento-Soares, L.M., Mazzoni, R. & Martins-Pinheiro, R.F. (2010): A fauna de peixes na bacia do Rio Itanhém, leste de Minas Gerais e extremo Sul da Bahia. – Pan-American Journal of Aquatic Sciences, **5**(1): 47–61.

Tabarelli, M., Pinto, L.P., Silva, J.M.C., Hirota, M. & Bedê, L. (2005): Challenges and opportunities for biodiversity conservation in the Brazilian Atlantic Forest. – Conservation Biology, **19**: 695–700.

Taylor, W.R., & Van Dyke, G.C. (1985): Revised procedures for staining and clearing small fishes and other vertebrates for bone and cartilage study. – Cybium, **9**: 107–119.

Westby, G.W.M. (1988): The ecology, discharge diversity and predatory behaviour of gymnotiforme electric fish in the coastal streams of French Guiana. – Behavioral Ecology and Sociobiology, **22**: 341–354.