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Gymnotus ucamara: a new species of Neotropical electric fish from the Peruvian Amazon (Ostariophysi: Gymnotidae), with notes on ecology and electric organ discharges

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Abstract

A new species of Neotropical electric fish, *Gymnotus ucamara*, is described from floodplain habitats in the Rio Ucayali Basin, Peru. The new species is distinguishable from all congeners by the following combination of characters: a clear patch at the caudal end of the anal fin; two laterosensory canal pores (from the preopercular-mandibular series) in the dorso-posterior portion of the preopercle; a coloration pattern with 18–24 dark brown bands separated by narrow pale interbands which are less than one-third the width of the dark bands; a long head (12.2–13.4 % total length); many (10–11) scales rows over the anal fin pterygiophores; few (38-43) pored lateral-line scales to the first lateral-line ramus; and a low (75–91) total number of pored lateral-line scales.

Key Words: biodiversity, electrogenesis, Gymnotiformes, várzea

Introduction

The weakly electric Neotropical fish genus *Gymnotus* has been the subject of several taxonomic studies in recent years (Mago-Leccia 1994; Albert & Miller 1995; Campos da Paz 1996; Campos da Paz & Costa 1996; Albert *et al.* 1999; Campos da Paz 2000; Albert 2001; Albert & Crampton 2001; Campos da Paz 2002). Until recently *Gymnotus* was recognized as the only genus in the family Gymnotidae. The monotypic genus *Electrophorus* Gill, comprising the single strongly electric species *Electrophorus electricus* (L.) was recently included in the Gymnotidae (Albert 2001).

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TABLE 1. Nineteen valid species of *Gymnotus* with affiliation to species groups (see text) and geographical range. MA, Atlantic and Pacific slopes of Middle America; OR, Orinoco basin including Trinidad; GU, Guyanas and upper Rio Negro; AM, Amazon basin; NE, coastal drainages of northeast Brazil; SE, coastal drainages of southeast Brazil and Uruguay; PA, Paraguay-Paraná basin. Sources: Albert (2001), Albert & Crampton (2001), unpublished observations.

Group	Species	Geographical range
cylindricus	*Gymnotus cylindricus* La Monte, 1935	MA
	Gymnotus maculosus Albert & Miller, 1995	MA
carapo	*Gymnotus arapaima* Albert & Crampton, 2001	AM
	Gymnotus bahianus Campos da Paz & Costa, 1996	NE
	Gymnotus carapo Linnaeus, 1758	GU, OR, AM
	Gymnotus diamantinensis Campos da Paz, 2002	AM
	Gymnotus inaequilabiatus (Valenciennes, 1847)	SE, PA
	Gymnotus mamiraua Albert & Crampton, 2001	AM
	Gymnotus sylvius Albert & Fernandes-Matioli, 1999	SE, PA
	Gymnotus ucamara n. sp.	AM
pantherinus	*Gymnotus anguillaris* Hoedeman, 1962	GU, OR, AM, PA
	Gymnotus cataniapo Mago-Leccia, 1994	GU, OR, AM
	Gymnotus coatesi La Monte, 1935	AM
	Gymnotus jonasi Albert & Crampton, 2001	AM
	Gymnotus melanopleura Albert & Crampton, 2001	AM
	Gymnotus onca Albert & Crampton, 2001	AM
	Gymnotus pantherinus (Steindachner, 1908)	SE
	Gymnotus pedanopterus Mago-Leccia, 1994	GU, OR, AM
	Gymnotus stenoleucus Mago-Leccia, 1994	GU, OR, AM

Albert (2001) and Albert and Crampton (2001) summarized the diagnostic characters of *Gymnotus*. Albert and Miller (1995) and Albert (2001) recognized three species groups within the genus based on color pattern, body proportions and counts. These are the *G. cylindricus*, *G. pantherinus*, and *G. carapo* species-groups. The species composition and geographical range of these groups are summarized in Table 1. The *G. cylindricus* species-group is endemic to both Atlantic and Pacific drainages of Middle America and comprises just two species. The *G. carapo* species-group is endemic to South America and is represented by seven species distributed from the Pacific slope of Colombia to the Pampas of Argentina. The *G. pantherinus* species-group is represented by nine species with distribu-

tions from Panama to Paraguay. Species in the *G. carapo* species-group, including the new species described here, can be distinguished from species in the *G. pantherinus* and *G. cylindricus* species-groups by the possession of a clear or pale patch near the caudal end of the anal fin, and two (vs. one) laterosensory canal pores in the preopercular-mandibular series of the dorso-posterior portion of the preopercle. We use the above classification of *Gymnotus* as a basis for the differential diagnosis of the new species described in this report. There are currently 18 valid species of *Gymnotus*, of which thirteen are found in the Amazon basin. Several new species of *Gymnotus* have recently been discovered in the Brazilian portion of the Amazon basin (Albert & Crampton 2001; Campos da Paz 2002), including seven new species from whitewater floodplains or '*várzeas'* along the Amazon River's main stem (Albert & Crampton 2001). Here we describe a new species from várzea floodplains of the Rio Ucayali Basin in the Peruvian Amazon.

Materials and methods

Specimens and their electric organ discharges (EODs) were captured from a site in the Rio Ucayali floodplain, Peru (Figs. 1, 2). Additional material was acquired from museum collections. Museum acronyms follow Leviton *et al.* (1985), with the addition of IIAP (Instituto de Investigaciones de la Amazonía Peruana, Iquitos), INPA (Instituto Nacional de Pesquisas da Amazônia, Manaus), MUSM (Museo de Historia Nacional de la Universidad Nacional Mayor de San Marcos, Lima), NRM (Swedish Museum of Natural History, Stockholm), and UUZM (Uppsala University Zoological Museum, Uppsala).

Measurements and counts (Tables 2, 3) follow Albert and Crampton (2001) except for: APS, anal fin pterygiophore scales as the number of scale rows over the pterygiophores counted from an origin vertically below the base of the first lateral-line ramus; CEP, caudal electroplate rows counted (with backlighting and with overlying scales removed) as the number of horizontally aligned rows of electroplates in the electric organ at a distance of one head length from the tip of the caudal appendage; MW, mouth width at rictus; PLR, number of pored lateral-line scales in posterior lateral-line posterior to neurocranium and counted to first ramus of the lateral-line; PLS, total number of pored lateral-line scales in posterior lateral-line posterior to neurocranium. All measurements were taken with digital calipers to the nearest 0.1 mm on the left side of specimens. Measurements reported as a percentage of total length (TL) (i.e. head length, anal-fin length, body depth and body width) and anal-fin ray counts were not included for specimens with damage to the caudal appendage amounting to more than an estimated 5% of un-damaged TL. Counts of anal-fin rays and precaudal vertebrae were taken from radiographs. Osteological data were taken from specimens cleared and stained following the technique described by Dingerkus and Uhler (1977).

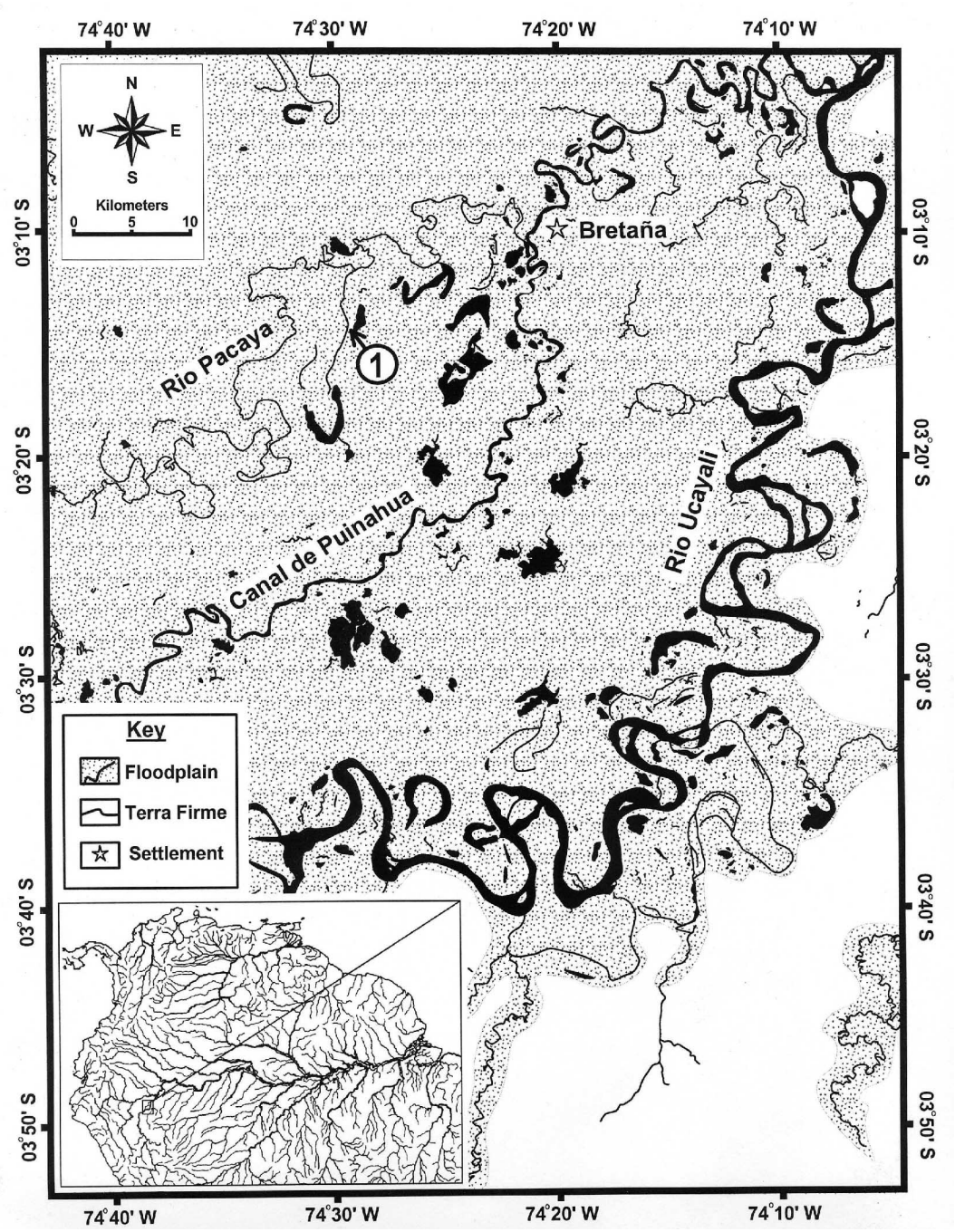

FIGURE 1. Map of part of the Pacaya-Samiria National Reserve in Loreto, Peru, illustrating the lower Rio Pacaya and the type-series locality of *Gymnotus ucamara* n. sp. (1). Floodplain areas (stippled) experience an annual flood regime of up to 7 m amplitude. Base map traced from 1998 1:300,000 Landsat TM5 images.

FIGURE 2. Type-series locality of *Gymnotus ucamara* n. sp. A small drainage channel between Rio Pacaya and Cocha Zapote, Pacaya-Samiria National Reserve, Loreto, Peru. Floating aquatic vegetation in the foreground is dominated by *Pistia stratiotes*, *Azolla* sp., and *Eichhornia crassipes*. Rooted grasses in the background include *Cyperus* sp. and *Paspalum* sp. These grasses form floating rafts during the high water season. The high-water mark from the preceding flood season is visible on the trunk of a cecropia tree in the back-left of the photograph.

EOD recording techniques follow Crampton (1998). Specimens were recorded in water from the capture locality at temperatures between 27 and 29 ºC soon after capture. Field numbers for EOD-recorded fish follow a standard format: e.g. WGRC 09.200902 (ninth gymnotiform specimen collected and recorded on September 20 2002). Recordings of pulse repetition rate during the day and night were taken from specimens isolated in large (50 l) buckets of water provided with submerged vegetation, placed in a disturbance and vibration-free place, and exposed to a subdued natural light regime. Nighttime recordings were taken between 1900 and 2100 (hours of peak swimming activity) on the day of capture. Daytime recordings were taken between 1000 and 1200 on the following day.

***Gymnotus ucamara* n. sp.**
(Fig. 3)

Holotype. — UF 126182 (156.0 mm TL, WGRC 09.200902), Peru, Loreto, Rio Ucayali, Rio Pacaya, Cocha Zapote, in Pacaya-Samiria National Reserve, 05°20.03'S, 74°29.08'W, collected by J. Albert, W. Crampton, N. Lovejoy, H. Ortega and R. Reis, 9 September 2002.

Paratypes. UF 126121 (1, 174 mm TL, WGRC 02.200902); UF 126183 (1, 172 mm TL, EOD not recorded); UF 126184 (2, 190 mm TL, WGRC 12.200902; 146 mm TL, WGRC 13.200902). All collected by J. Albert et al. with holotype.

Nontypes. MUSM 9274 (1, 134 mm TL), Loreto, Contamana, Aguas Calientes, approx. 07°02'S, 74°14'W, 3 June 1996; MUSM 10184 (7, 117–156 mm TL, 2 cleared and stained), Loreto, Contamana, Rio Ucayali, approx. 07°02'S, 74°14'W, 31 May 1996. All collected in Peru by H. Ortega et al.

FIGURE 3. Photographs of body and head of the holotype of *Gymnotus ucamara* n. sp. (UF 126182). Scale bar = 10 mm.

Diagnosis. *Gymnotus ucamara* differs from other species in the *Gymnotus carapo* species-group in possessing the following unique combination of characters: a coloration pattern with 18-24 dark brown bands separated by narrow pale interbands which are less than one-third the width of the dark bands (a pattern that is readily distinguishable from all other described species of the *G. carapo* species-group except *G. mamiraua*); a long head (12.2–13.4 % total length vs. 7.9–11.8 % in all other species except *G. carapo* and *G. arapaima*); many (10–11) scales over anal fin pterygiophores (vs. 4–9 in all other species except *G. arapaima*); few (38–43 [median 42]) pored lateral-line scales to first ramus (vs. 32–38 [median 37] in *G. mamiraua*, vs. 42–52 [median 48] in *G. carapo*, and vs. 50–64 in all other species); a low (75-91 [median 82]) total number of pored lateral-line scales (vs. 93–108 [median 98] in *G. carapo*, and vs. 106–140 in all other species except *G. mamiraua* with 75–79 [median 78]), and a relatively large eye (orbital diameter 0.09–0.10 % HL vs. 0.06–0.07 % in *G. carapo*). *G. ucamara* is superficially most similar to *G. mamiraua* from which it can be readily distinguished on the basis of the following characters; a long head (12.2–13.4 % total length vs. 9.7–10.7 % total length in *G. mamiraua*) and relatively more pored lateral line scales to first ramus (38–43 [median 42] vs. 32–38 [median 37] in *G. mamiraua*).

TABLE 2. Morphometric data for adults of eight species of *Gymnotus* in the *G. carapo* species-group. Abbreviations: TL, total length; HL, head length; PR, preorbital distance; PO, postorbital distance; IO, interorbital distance; MW, mouth width; HD, head depth; HW, head width; BD, body depth; BW, body width; PA, preanal distance; P1, pectoral-fin length; AF, anal-fin length. TL and HL expressed in mm. Percentage measurements in HL or, if marked with an asterisk, in TL. BW/BD expressed as a ratio. N values (in parentheses) vary because measurements were excluded from some specimens with damage (see text) or unusual preservation artifacts. NA, data not available. †, data from original published description. All data from specimens collected in the region of the type localities.

Species	max. TL	HL	%HL*	Mean	%PR	Mean	%MW	Mean
G. arapaima	545 (32)	14.9-31.9 (25)	12.5-15.0 (30)	13.6	32.2-38.5 (32)	35.2	31.2-36.7 (24)	34.2
G. bahianus †	241 (13)	14.8-25.5 (13)	11.9-12.9 (13)	12.4	32.4-35.7 (13)	34.2	26.0-28.0 (13)	27.3
G. carapo	317 (17)	17.7-38.9 (15)	11.8-13.7 (14)	12.3	34.6-39.1 (15)	36.6	31.1-47.6 (15)	42.0
G. diamantinensis †	125 (3)	11.5-13.5 (3)	10.8-11.5 (2)	11.2	33.0-34.4 (3)	33.6	26.9-28.1 (3)	27.6
G. inaequilabiatus	998 (15)	18.7-82.0 (13)	8.2-12.3 (13)	10.5	30.2-37.3 (11)	35.0	34.9-44.2 (10)	40.5
G. mamiraua	228 (13)	18.1-22.4 (7)	9.7-10.7 (7)	10.4	31.3-35.5 (7)	33.3	34.3-41.6 (7)	37.5
G. sylvius †	307 (6)	20.5-38.5 (6)	11.9-14.0 (6)	12.9	33.9-36.1 (6)	34.9	NA	NA
G. ucamara n. sp.	190 (13)	15.2-23.1 (13)	12.2-13.4 (10)	12.7	33.3-38.2 (13)	35.9	37.2-46.8 (13)	41.5

TABLE 2. cont.

Species	%PO	Mean	%IO	Mean	%HD	Mean	%HW	Mean
G. arapaima	58.6-64.4 (32)	62.0	29.0-36.5 (32)	33.1	50.7-56.6 (32)	54.1	46.0-57.9 (31)	51.5
G. bahianus †	58.6-66.2 (13)	63.7	32.8-40.3 (13)	35.8	55.1-59.8 (13)	56.7	52.4-58.0 (13)	54.5
G. carapo	59.2-62.9 (15)	61.1	36.0-42.3 (15)	38.5	52.1-65.4 (15)	57.5	56.6-64.1 (15)	60.8
G. diamantinensis †	63.8-65.2 (3)	64.5	41.1-42.9 (3)	42.2	65.2-69.6 (3)	67.1	NA	NA
G. inaequilabiatus	59.4-67.1 (11)	62.8	37.0-45.7 (11)	42.5	61.7-73.8 (10)	66.0	64.9-72.0 (9)	67.6
G. mamiraua	61.9-64.5 (7)	63.6	32.4-43.2 (7)	37.8	60.9-70.7 (6)	67.1	55.6-68.6 (6)	60.7
G. sylvius †	58.7-60.9 (6)	59.8	36.4-38.2 (6)	37.5	57.1-60.5 (6)	58.4	59.5-61.8 (6)	61.0
G. ucamara n. sp.	58.4-62.3 (13)	60.4	32.9-43.2 (13)	36.5	56.5-65.0 (13)	59.1	53.9-65.5 (13)	58.6

TABLE 2. cont.

Species	PA%	Mean	%P1	Mean	%AF*	Mean	%BD*	Mean
G. arapaima	51.4-80.6 (30)	65.1	39.6-47.9 (32)	43.5	71.4-82.9 (31)	79.2	8.9-11.6 (31)	10.3
G. bahianus †	77.5-86.9 (13)	83.4	38.3-45.9 (13)	42.3	80.0-82.3 (13)	81.2	11.3-12.6 (13)	12.0
G. carapo	67.8-89.6 (15)	79.6	37.4-55.0 (15)	43.2	71.1-88.9 (15)	79.7	10.1-11.7 (15)	10.8
G. diamantinensis †	79.8-83.7 (3)	81.7	36.3-41.1 (3)	39.4	81.8-82.3 (2)	82.1	10.6-10.9 (2)	10.8
G. inaequilabiatus	57.6-92.7 (9)	77.1	36.8-51.0 (10)	45.7	77.8-85.2 (9)	81.7	7.5-12.0 (12)	10.6
G. mamiraua	63.7-81.5 (7)	74.3	41.6-49.5 (7)	45.1	72.4-87.7 (7)	82.2	9.2-12.6 (7)	10.8
G. sylvius †	NA	NA	41.6-46.7 (6)	45.1	74.5-79.2 (6)	77.7	10.3-13.1 (6)	11.7
G. ucamara n. sp.	64.5-75.0 (13)	70.1	46.2-55.3 (13)	49.7	75.7-87.2 (11)	80.1	10.0-12.2 (11)	11.2

TABLE 2. cont.

Species	%BW*	Mean	BW/BD	Mean
G. arapaima	5.3-9.4 (31)	6.4	0.52-0.72 (26)	0.62
G. bahianus †	NA	NA	NA	NA
G. carapo	6.7-8.5 (15)	7.5	0.63-0.81 (15)	0.70
G. diamantinensis †	NA	NA	NA	NA
G. inaequilabiatus	5.8-8.6 (12)	6.7	0.54-0.77 (12)	0.64
G. mamiraua	4.8-6.7 (7)	6.2	0.53-0.72 (7)	0.58
G. sylvius †	7.0-7.8 (6)	7.4	0.67-0.72 (6)	0.69
G. ucamara n. sp.	7.0-8.7 (11)	7.7	0.63-0.73 (11)	0.69

Description. Body shape and pigment patterns illustrated in Fig. 3. Morphological and meristic data presented in Tables 2 and 3. Cephalic sensory canal pore configurations summarized in Fig. 4. Size up to 190 mm TL. Size at maturity unknown. Sexual dimorphism unknown. Scales cycloid, ovoid, present on entire post-cranial portion of body from nape to tip of caudal appendage. Scales on dorsal surface relatively large at mid-body, six rows from lateral-line to dorsal midline. Scales small over pterygiophores, 10–11 scale rows. Lateral-line scales (in holotype) approximately 1.3 mm high by 1.5 mm long in humeral region, 2.3 mm high by 2.6 mm long at midbody, 1.4 mm high by 2 mm long dorsal to

anterior margin of clear patch on anal fin. Gape size in mature specimens large, extending beyond posterior nares. Mouth position superior, lower jaw longer than upper, rictus decurved. Chin fleshy and bulbous with thick pad of electroreceptor organs and support tissues overlying tip of snout and oral jaws. Anterior narial pore included within gape in large narial fold. Anterior nares large, subequal to diameter of eye. Branchial opening moderate (32–40 % in HL). Circumorbital series ovoid. Ethmoid region between anterior nares moderate, its anterior margin rounded. Eye position lateral, lower margin of eye slightly ventral to rictus. Eye relatively large, orbital diameter 0.09–1.0 % HL. Premaxilla and dentary with one or two rows of large, slightly recurved, conical teeth. Premaxilla with 11-12 (mode 12, n = 3) teeth disposed in single row along outer margin. Dentary with 16 (n = 2) teeth disposed in single row along outer margin.

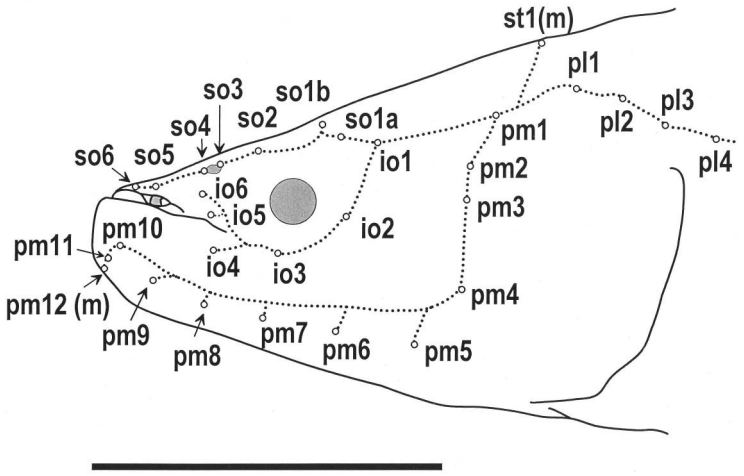

FIGURE 4. Head of the holotype of *Gymnotus ucamara* n. sp. illustrating organization of cephalic sensory canals and pores. Centerline of canals (ossified and unossified) indicated by dashed lines. Pores indicated by small circles. Eye and anterior and posterior nares shaded gray. Abbreviations: so, supraorbital; io, infraorbital; pl, posterior lateral-line; pm, preopercular-mandibular; st, supratemporal; m, medial. Scale bar = 5 mm. Pore S01b is absent in some specimens.

Rib 5 approximately same width as rib 6. Body cavity of moderate length with 32–34 (mode 33) precaudal vertebrae. Hemal spines present. Gas bladder not extending beyond first hemal spine. Displaced hemal spines absent. Multiple anal-fin ray branching posterior to rays 10–17. Variable number (11-19) of asymmetrically arranged lateral-line rami extending posteroventrally at posterior end of lateral line. Dorsal lateral-line rami absent in all specimens examined. Anal-fin pterygiophores at posterior portion of body cavity shorter than first hemal spine. Caudal appendage short, less than half pectoral-fin length in undamaged and unregenerated specimens. Single hypaxial electric organ, extending along entire ventral margin of body. Three or four (mode 4) rows of electroplates at one HL distance from end of caudal appendage.

TABLE 3. Meristic data for eight species of *Gymnotus* in the *G. carapo* species-group. Abbreviations: BND, dark bands; AFR, anal-fin rays; P1R, pectoral-fin rays; SAL, scales above lateral line; CEP, caudal electroplate rows; APS, anal-fin pterygiophores scales; PCV, precaudal vertebrae; PLR, pored lateral-line scales to first ramus; PLS, total pored lateral-line scales; LRV, lateral-line ventral rami (left or right); LRD, lateral-line dorsal rami (left or right). Med., median value. N values (in parentheses) vary because measurements were excluded from some specimens with damage (see text) or unusual preservation artifacts. NA, data not available. †, data from original description. All data from specimens collected in the region of the type localies.

Species	BND	Med.	AFR	Med.	P1R	Mode	SAL	Mode
G. arapaima	20-24 (20)	22	225-265 (17)	235	15-17 (20)	15	6-9 (18)	7
G. bahianus †	0 (13)	0	201-226 (NA)	203	17-18 (NA)	17	NA	NA
G. carapo	16-21 (8)	19	225-245 (6)	240	14-16 (10)	16	6-7 (8)	6
G. diamantinensis †	16-19 (2)	NA	195-210 (3)	201	14-15 (3)	14	8-10 (3)	9
G. inaequilabiatus	19-24 (10)	22	170-260 (6)	220	13-16 (11)	15	6-9 (10)	6
G. mamiraua	17-21 (11)	20	195-265 (11)	225	15 (13)	15	5-9 (11)	5
G. sylvius †	21-24 (5)	22	220-230 (6)	224	16 (2)	16	8 (2)	8
G. ucamara n. sp.	18-24 (13)	21	220-245 (13)	235	15-16 (13)	15	6 (13)	6

TABLE 3. cont.

Species	CEP	Mode	APS	Mode	PCV	Mode	PLR	Med.
G. arapaima	3-4 (16)	4	9-13 (31)	12	33-37 (21)	35	53-64 (27)	57
G. bahianus †	3-5 (NA)	NA	NA	NA	33-34 (NA)	NA	NA	NA
G. carapo	3-4 (7)	4	7-9 (7)	8	33-34 (8)	33	45-52 (7)	48
G. diamantinensis †	NA	NA	NA	NA	NA	NA	NA	NA
G. inaequilabiatus	3-5 (10)	4	NA	NA	31-33 (6)	32	35-37 (4)	36
G. mamiraua	3-4 (6)	4	5-6 (6)	6	31-34 (8)	33	32-38 (8)	37
G. sylvius †	NA	NA	6-8 (5)	NA	32-35 (5)	33	NA	NA
G. ucamara n. sp.	4 (5)	4	10-11 (13)	10	32-34 (13)	33	38-43	42

TABLE 3. cont

Species	PLS	Med.	LRV	Med.	LRD	Med.
G. arapaima	99-108 (17)	102	10-22 (11)	15	0 (11)	0
G. bahianus †	79-93 (NA)	90	NA	NA	NA	NA
G. carapo	93-103 (8)	98	8-22 (8)	12	0 (8)	0
G. diamantinensis †	NA	NA	NA	NA	NA	NA
G. inaequilabiatus	82-115 (4)	90	7-16 (6)	15	0 (6)	0
G. mamiraua	75-103 (12)	78	1-14 (6)	10	0 (6)	0
G. sylvius †	85-100 (5)	93	NA	NA	NA	NA
G. ucamara n. sp.	75-91 (13)	82	11-19 (13)	15	0 (13)	0

Color in life. 18–24 (median 21, n = 13) broad, dark, chocolate-colored bands, separated by narrow, pale interbands (sensu Albert *et al.* 1999) less than one-third the width of the dark bands. Slight countershading in specimens longer than 150 mm TL, more pronounced anteriorly. Pale interbands extend from pectoral-fin base to tip of caudal appendage and oriented obliquely (anterior-ventral to posterior-dorsal). Dark bands occur singly (never divided into band pairs sensu Albert *et al*. 1999) and are occasionally divided into Y or inverted-Y shapes but never divided into X shapes on anterior two-thirds of body. Pale interbands sometimes interrupted. Pigment density slightly greater at the dark band margins than in the middle at mid-body. Band-interband margins wavy and highly contrasted with one another. Pale interbands irregular in shape and width, narrower and more regularly shaped anteriorly. Pale interbands usually do not extend to mid-dorsum along anterior 2/3 of body. Incomplete pale interband present in middle of some dark bands. Three pale interbands from either side terminate near ventral midline, often not meeting, between the anus and anal-fin origin. One or two bands lie posterior to last anal-fin ray.

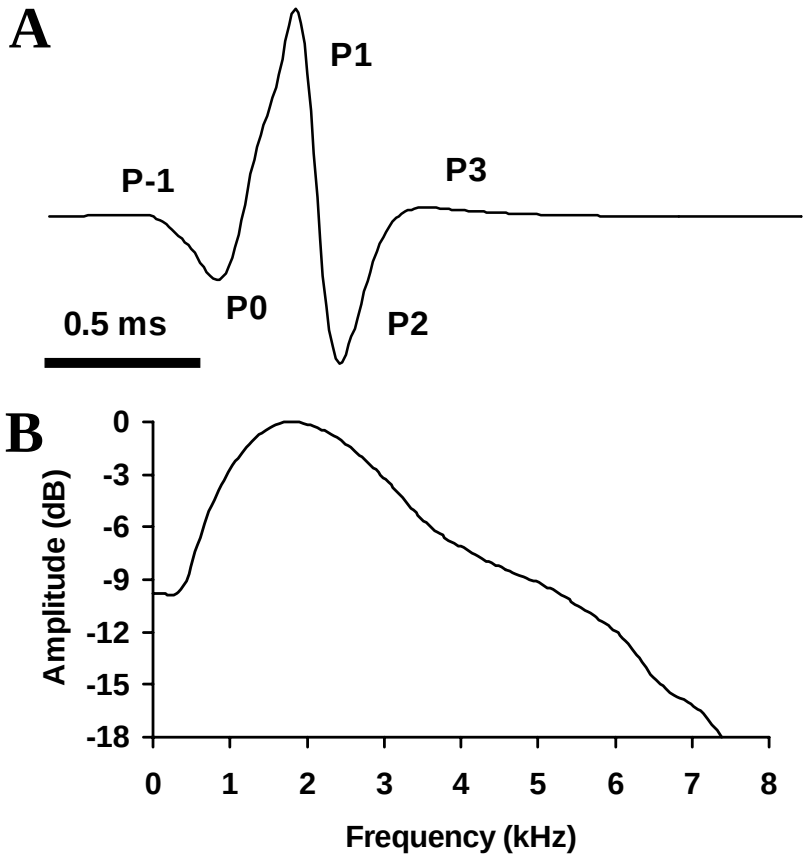

FIGURE 5. EOD waveform (A) and Fourier Power Spectrum (B) of holotype of *G. ucamara* n. sp. The EOD is plotted with head-positivity upwards and its component phases labeled P-1 through P3. P1 represents the dominant positive component. The Power Spectrum was computed from a 2048 point Fast-Fourier-Transform and the Peak-Power-Frequency scaled to the minimum attenuation of 0 dB.

Head never banded, spotted or blotched, uniformly dark brown but slightly paler in gular region. Numerous minute chromatophores speckled over branchiostegal membranes and ventral surface of head. Pectoral-fin rays dark brown or black, interradial membranes hyaline. Anal fin never blotched, spotted or marked. Anal fin rays and membrane dark gray or black on anterior 80% of fin length, translucent on posterior 20%. Color variation is not known to be correlated with size, sex or EOD waveform. Specimens fixed in 10% formalin and preserved for 1-6 years in 70% ethanol maintain approximate colors of life, although the darker pigments sometimes pale with time.

Electric organ discharge. *G. ucamara* n. sp. generates EODs as discrete pulses of 1.25 –1.73 ms duration (mean 1.51, n = 5). These comprise four or five phases (Fig. 5). The waveform comprises a dominant tri-phasic component (P0, P1, P2) with a duration of approximately 0.78–0.92 ms (mean 0.87, n = 5) followed by a low-voltage positive final phase (P4). A very low-voltage initial positive phase (P-1) precedes P0 in most specimens. The Peak Power Frequency (PPF) (Fig. 4) of the Fourier Transform of EODs of *G. ucamara* n. sp. ranges from 1.71–1.95 kHz (mean 1.78, n = 5).

The EOD pulse repetition rate of *G. ucamara* n. sp. is relatively low and less variable during the day when this species lodges itself into the submerged root mats of floating plants (range 44.5–45.9 Hz, mean 45.3, standard deviation [SD] 0.3, n = 4). *G. ucamara* n. sp. can instantaneously increase its EOD pulse repetition rate to around 90–110 Hz in response to a sudden stimulus such as a loud underwater noise or a light prod with a glass rod. Following such a 'fright response' the EOD repetition rate returns to close to the normal resting rate within a few milliseconds and back to the normal resting rate within a few seconds. The EOD pulse repetition rate is usually higher and more variable at night. The highest pulse rates occur during swimming (range 62.5–76.9 Hz, mean 69.4, SD 6.2, n = 4) and the lowest rates occur when a specimen stops swimming, usually by resting its body against a submerged structure, or wedging itself between submerged roots (range 50.0–66.7 Hz, mean 59.7, SD 8.7, n = 4).

Distribution. Known only from the lowland Rio Ucayali basin in Peru, at sites near Contamana and in the Rio Pacaya-Samiria National Reserve near the confluence of the Rio Ucayali and Rio Marañon.

Habitat and Ecology. All the type specimens were captured from static, vegetation-choked water in a shallow (maximum depth 0.5 m) channel connecting a floodplain lake (Cocha Zapote) to the Rio Pacaya (Figs. 1,2). The habitat structure, vegetation and water quality of the locality are typical of whitewater floodplains of the Central and Upper Amazon (Ayres 1993; Junk 1997). The type specimens were captured during the low-water month of September. Aquatic vegetation at the site consisted of plants typical of floating meadows, an important substrate for floodplain gymnotiform fish communities throughout the year (Crampton 1996; Albert & Crampton 2001). The dominant species were *Cyperus* sp., *Eichhornia crassipes* Solms., *Pistia stratiotes* (L.), *Ludwigia* sp., *Salvinia* spp., and *Utricularia* sp. Water quality at the locality was recorded as: dissolved oxygen, 2.4 mg/l;

electrical conductivity, 240 μScm^{-1} at 25ºC; transparency with Sechhi disc 0.6 m, surface temperature 31.2 ºC. Other gymnotiform electric fish collected from the same locality and habitat were *Gymnotus carapo* (L.), *Eigenmannia* sp., and three undescribed species of *Brachyhypopomus*. One of the two non-type lots from Contamana (MUSM 10184) was collected in rafts of floating vegetation along the edge of the Rio Ucayali. These rafts may have been swept out of nearby floodplain lakes (H. Ortega pers. comm.). The other non-type lot (MUSM 9274) was collected from floating vegetation along the edge of a sediment-laden 'whitewater' stream near its confluence with the Rio Ucayali. Water temperature was reported as 28ºC. This stream flows out of hot springs from nearby mountains, but gymnotiforms were only found well downstream of the influence of unusually warm waters (H. Ortega pers. comm.). *G. ucamara* n. sp. feeds on aquatic invertebrates. Stomach content analyses of the paratype and non-type series are summarized in Table 4.

TABLE 4. Proportional composition of food items in stomachs of *Gymnotus ucamara* n. sp. Autochthonous food items are aquatic invertebrates living in submerged roots and in the benthos. Allochthonous food items have fallen into the water from the foliage of overhanging or floating vegetation.

	Paratypes				MUSM 10184						Mean %
	1	2	3	4	1	2	3	4	5	6	
Estimated % fullness	75	75	100	100	100	100	100	100	50	50	85%
Autochthonous:											
Conchostraca (adults)						25			10		3.5
Coleoptera (larvae)	50				100			100		100	35
Coleoptera (adults)			100	50							15
Odonata (naiads)	50	100					75		90		31.5
Unidentified invertebrates						75					7.5
Allochthonous:											
Lepidoptera (larvae)				50							5
Orthoptera (adult)							25				2.5

Etymology. Named for the geological term "Ucamara Depression" describing the low-lying region between the lower reaches of the Ucayali and Marañon Rivers caused by subsidence in the Upper Amazon foreland basin.

Additional materials examined.

Materials examined follow Albert *et al.* (1999), Albert (2001), and Albert & Crampton (2001), with the addition of:

Gymnotus arapaima (56 specimens, 48–460 mm). — Brazil: Amazonas: Rio Solimões, Lago Calado, Município Manaus, approx. 03°07'S, 60°01'W, INPA 6387 (2,

255–395); Cidade de Manaus, Igarapé do Quarenta, Município Manaus, approx. 03°06'S, 60°01'W, INPA 10376 (1, 255); Rio Solimões-Japurá confluence, Mamirauá Sustainable Development Reserve (MSDR), Cano do Lago Mamirauá, 03°05.22'S, 64°48.03'W, INPA 11514 (5, 145–457), INPA 18389 (1, 55); Rio Tefé, Lago Tefé, Igarapé Curupira, 03º26.02'S, 64º43.78'W, INPA 18390 (1, 55); Rio Tefé, Lago Tefé, Estrada Agrovila, swamp in forest nr. Igarapé Curupira, 03º26.02'S, 64º43.78'W, INPA 18391 (2, 48-51); Rio Negro, Lower Rio Demini, c. 30 km upstream mouth Rio Aracá, Município Barcelos, approx. 00°23'N, 62°51'W, MCP uncat (1, 272); Rio Tefé, nr. Cabeçeira do Lago Tefé, 03°41.39'S, 64°59.13'W, MZUSP 75165 (1, 190); Rio Solimões-Japurá confluence, MSDR, Jarauá lake system, Ressaca do Caetono, 02°50.22'S, 64°55.79'W, MZUSP 75166 (1, 133); Rio Tefé, same locality as INPA 18390, MZUSP 75169 (1, 102); Rio Tefé, same locality as MZUSP 75165, MZUSP 75170 (1, 147), MZUSP 75171 (1, 128), MZUSP 75172 (1, 158), MZUSP 75173 (1, 160), MZUSP 75174 (1, 128), MZUSP 75175 (1, 129), MZUSP 75176 (1, 141); Rio Tefé, same locality as INPA 18390, MZUSP 75177 (1, 129); Rio Tefé, Lago Tefé, Igarapé Repartimento, 03º24.46'S, 64º44.17'W, MZUSP 75178 (1, 123); Rio Solimões-Japurá confluence, MSDR, Ressaca do Pau, 03º02.30'S, 64º51.96'W, MZUSP 75179 (1, 107). All localities from Rio Tefé and MSDR in the municipalities of Tefé and Alvarães respectively. Mato Grosso: Rio Aripuanã, Igarapé do Castanhal, Município Aripuanã, INPA 6390 (part) (11, 128–460). Rondônia: Rio Madeira, Rio Jamari, nr. UHE Samuel, Município Porto Velho, approx. 08°26'S, 63°30'W, INPA uncat. (POLO 463) (2, 115–195), INPA uncat. (POLO 482) (2, 435-460); Rio Machado, Nazaré, Município Jí-Paraná, 10°4'59"S, 62°17'59"W, INPA uncat. (POLO 626) (1, 147); Rio Madeira, same locality as INPA uncat. (POLO 463), INPA uncat. (POLO 872) (11, 160–252), INPA uncat. (POLO 895) (1, 185), INPA uncat. (POLO 951), (2, 183-187).

Gymnotus bahianus (25 specimens, 55–275 mm). — Brazil: Bahia: Uruçuca, Fazenda Almada, Município Ilheus, approx. 14°34'59"S, 39°15'59"W, MNRJ 4188 (2, 200–207), MNRJ 4346 (10, paratypes, 133–240), MNRJ 4381 (3, 84–168); Pirataquice, Município Ilheus, approx. 14°34'59"S, 39°15'59"W, MNRJ 4382 (10, 55–275).

Gymnotus carapo (185 specimens, 32–367 mm, referring only to populations from region of type locality [Surinam] and from the Upper Amazon). — Brazil: Amazonas: Rio Tefé, Ilha do Martelo, 03°46.82'S, 64°59.48'W, MZUSP 75168 (1, 119); Rio Tefé, Cabeçeira do Lago Tefé, 03°34.59'S, 64°59.32'W, MZUSP 76061 (1, 260); Rio Tefé, Lago Tefé, Ressaca do Socorro, 03°19.18'S, 64°41.76'W, MZUSP 76062 (1, 94); Rio Solimões-Japurá confluence, Mamirauá Sustainable Development Reserve (MSDR), Ressaca da Vila Alencar, 03º07.70'S, 64°48.03'W, MZUSP 76063 (1, 298); MSDR, Cano do Lago Mamirauá, 03º04.43'S, 64º48.65'W, MZUSP 76064 (1, 253); MSDR, Lago Secretaria, 03º06.74'S, 64°48.02'W, MZUSP 76066 (2, 97–136); Rio Solimões, Rio Cayari, Município Benjamin Constante, approx. 04°22'S, 70°02'N, UMMZ 230734 (2, 190–210). All localities from Rio Tefé and MSDR in the municipalities of Tefé and Alvarães respectively. — Ecuador: Napo: Rio Napo, Rio Tiputini, approx. 00°49'S, 75°31'W, FMNH

103329 (10, 33–320); Rio Napo, Rio Aguarico, Laguna Zancudococha, approx. 00°17'S, 75°52'W, FMNH 103334 (2, 48–64). – Peru: Loreto: Rio Amazonas, Maynas, nr. Iquitos (no locality data): IAAP (uncat.) (1, 367); Rio Ucayali, Contamana, Aguas Calientes, approx. 07°02'S, 74°14'W, MUSM 9274 (1, 136); Rio Napo, Rio Aguarico, Maynas, PV Castaña, 00°48.22'S, 75°14.40'W, MUSM 14482 (7, 118–198); Rio Samiria, Maynas, right bank stream tributary to R. Samiria between Caño Pastos and Hamburgo, 05°12'S, 75°08'W, NRM 27650 (1, 305); Rio Maniti, Maynas, 50 km NE of Iquitos, 03°29'S, 72°44'W, NRM 40772 (1, 91); Rio Amazonas, Maynas, reportedly Rio Nanay (procured from ornamental fish exporting company in Iquitos), UF 116573 (2, 189–279), UF 122820 (1, 275), UF 122822 (1, 330), UF 122825 (1, 158), UF 122847 (1, 188), UF 122848 (1, 112), UF 122849 (1, 132), UF 122850 (1, 188), UF 122851 (1, 107), UF 122852 (1, 92); Rio Nanay, Maynas, 3 km upstream Mishana, Reserva Allpahuayo-Mishana, 03°52.08'S, 73°29.05'W, UF 116665 (1, 298); Rio Pacaya, Cocha Zapote, 05°20.03'S, 74°29.08'W, UF 126181 (2, 245–272); Rio Nanay, Rio Momon, Amazon camp near Iquitos, approx. 03°42'S, 73°16'W, UMMZ 228998 (4, 38–172); Rio Tahuayo, 04°10'S, 73°12'W, UMMZ 228999 (1, 162); Rio Javari, Buen Suceso, Quebrada Carana, approx. 04º08'S, 70º26'W, UMMZ 230733 (1, 251). Ucayali: Rio Ucayali, Pucallpa, Estación del IVITA, Quebrada Piscigranja, approx. 08°23'S, 74°32'W, MUSM 529 (7, 83-109), MUSM 532 (1, 181), MUSM 537 (2, 222-260); Rio Ucayali, Rio Huacamayo km 155, 12°46'S, 69°52'W, MUSM 1547 (1, 122); Rio Ucayali, Pucallpa, Utuguinia, approx. 08°23'S, 74°32'W, MUSM 1757 (3, 154–267); same locality as MUSM 529, MUSM 2691 (5, 132–222), MUSM 2971 (1, 187). – Surinam: unknown localities: NRM 8224 (1,331 Linnean syntype), UUZM 56 (1,331 Linnean syntype). Brokopondo District: Suriname River, Tapeoeripa creek nr. Brokopondo village, 05°04'N, 54°58'W, UMMZ 190414 (6, 71–260). Nickerie District: Lucie River, creek, upstream of Amotopo-Camp Geologie Rd., 03º36'N, 57º37'W, USNM 225274 (8, 81–318); Corantijn River, E bank creek, 350 m downstream from Wilhelm II Falls, 03º34'N, 57º15'W, USNM 225275 (11, 81–270); Corantijn River, Dalbana Creek, ca. 3 km upstream from Amotopo-Camp Geologie Rd., 04º20'N, 57º37'W, USNM 225276 (16, 75–148); Corantijn River, Lana Creek, ca. 4 km from intersection with W. Corantijn River, 05º28'N, 57º15'W, USNM 225284 (10, 54–143); Corantijn River, creek south of Matapi, approx. 2 km downstream of Cow Falls, 04º59'N, 57º38'W, USNM 225285 (12, 85–257); Corantijn River, Koekwie creek, 05º31'N, 57º10'W, USNM 225286 (15, 80-319); Corantijn River, Dalibane Creek, Camp Dacclemmen, 05º34'N, 57º11'W, USNM 225290 (19, 14–157); Corantijn River, stream on S. side Lucie River, 03º35'N, 57º39'W, USNM 225297 (14, 53–137).

Gymnotus mamiraua (122 specimens, 33–244 mm). — Bolivia: Beni: Rio Madeira, Rio Beni, Tributary to Lago Tumi, 26 km SSW Riberalta, 10°59'S, 66°05'W, AUM 23644 (1, 154). — Brazil: Amazonas: Rio Japurá, Ilha da Arauacá, Município Maraã, approx. 02°04'S, 65°10'W, INPA (uncat.) (1, 121); Rio Solimões, Ilha da Marchantaria, Município Manaus, approx. 03°06'S, 60°01'W, INPA 13609 (1, 46); Rio Purus, Sacado da Santa

Luzia, 04°42.3'S, 62°22.4'W, INPA 17177 (1, 146); Rio Solimões-Japurá confluence, Mamirauá Sustainable Development Reserve (MSDR), Lago Periquito Redondo, 03º05.00'S, 64°46.57'W, INPA 18392 (1, 210); INPA 18393 (1, 181), INPA 18401 (2, 178–205); MSDR, Cano do Lago Arauaé, 03º03.82'S, 64º50.08'W, INPA 18394 (1, 234); MSDR, Lago Araçazinho, 02º59.27'S, 64º51.46'W, INPA 18395 (1, 165), INPA 18408 (3, 210–243); MSDR, Cano do Lago Sapucaia, 03º04.11'S, 64°48.53'W, INPA 18396 (25, 33–210), INPA 18397 (1, 192); MSDR, Cano do Lago Rato, 03º02.97'S, 64º51.52'W, INPA 18398 (3, 207–225); MSDR, Ressaca da Vila Alencar, 03º07.70'S, 64°48.03'W, INPA 18399 (1, 57), INPA 18418 (1, 160); MSDR, Jarauá lake system, Ressaca Caetono, 02º50.22'S, 64º55.79'W, INPA 18400 (2, 75-86); MSDR, Lago Promessa, 03º04.38S, 64°46.97'W, INPA 18403 (1, 160); MSDR, Lago Geraldo, 03º06.95'S, 64°49.16'W, INPA 18404 (2, 194–194); MSDR, Lago Curuça Comprido, 03º05.50'S, 64°48.98'W, INPA 18405 (1, 227); MSDR, Lago Miratinin, 03º04.61'S, 64°50.28'W, INPA 18406 (1, 121); MSDR, Lago Promessinha, 03º04.83S, 64°47.13'W, INPA 18407 (4, 132–183); MSDR, Lago Tracajá, 03º05.67'S, 64°46.57'W, INPA 18409 (1, 100); MSDR, Lago Matá-Matá, 03º06.68'S, 64°47.36'W, INPA 18410 (6, 182–222), INPA 18415 (1, 203); MSDR, Paraná do Apara, 03º02.52'S, 64º51.01'W, INPA 18411 (2, 212–215); MSDR, Lago Secretaria, 03º06.74'S, 64°48.02'W, INPA 18412 (1, 204), INPA 18413 (2, 163–215), INPA 18414 (1, 217); INPA 18416 (5, 95–244), INPA 18419 (1, 205), INPA 18421 (1, 215); MSDR, Cano do Lago Mamirauá, 03º06.62'S, 64°47.81'W, INPA 18417 (3, 50–217); MSDR, Lago Apolônia, 03º07.35'S, 64°49.82'W, INPA 18420 (1, 177); MSDR, Cano do Lago Sapucaia, 03º04.11'S, 64°48.53'W, MCP 1131 (2, 180–187), MCP 29805 (35, 39–50); Rio Amazonas at Manaus, Município Manaus, approx. 03°07'S, 60°01'W, MCZ 78146 (1, 198). All localities from MSDR in the municipalities Alvarães. — Pará: Lago Uruirá, Município, approx. 01°45'S, 55°52'W, MUSM 0536 (1, 146). — Peru: Madre de Dios: Rio Madre de Dios, Tambopata, L. Copamanu, approx. 12°44'S, 69°11'W, MUSM 16711 (1, 180); Rio Madre de Dios, Rio de Los Amigos, approx. 12°35'S, 70°04'W, MUSM 19993 (2, 133–148).

Gymnotus inaequilabiatus (51 specimens, 77–998 mm). — Argentina: Rio Bermejo, 26°52'0"S, 58°22'59"W, UF 125973 (6, 191–241). — Brazil: Rio Grande do Sul: Rio Uruguai, Santana Velha, Uruguaina, 29°45'0"S, 57°4'59"W, MCP 6956 (1 [2], 602); Rio Maquine, Uruguaina, 29°44'0"S, 50°7'59"W, MCP 7155 (1, 245). — São Paulo: Rio Paraná, Porto Primavera, 22°30'0"S, 53°0'59"W, MZUSP 46001 (1, 998); Rio Capivara, trib. of Rio Paranapanema, 22°47'59"S, 50°58'0"W, MZUSP 51268 (1, 270). Paraibo do Sul, Jacarei, 23°19'0"S, 45°58'0"W, MZUSP 51667 (1). — Paraguay: Alto Paraná: Puerto Max, 22°40'59"S, 57°44'0"W, BMNH 1910.5.26.50 (1); Rio Paraguay, Alto Paraguay, Bahia Negra, 58°0'0"W, 20°0'0"S, NRM 22850 (1, 80); Concepcion, Estancia Laguna Negra, 23°4'0"S, 57°7'0"W, NRM 23121 (1, 275); Rio Paraguay, Alto Paraguay, Riacho Mosquito, 22°12'0"S, 57°57'0"W, NRM 43303 (1, 83), NRM 43790 (1, 165); Rio Parana, Rio Guyraugua, Caaguazu, 25°27'0"S, 56°0'59"W, NRM 45257 (1, 118); Alto Paraná, Pedro Juan Caballero, 22°34'0"S, 55°37'0"W, UMMZ 206703 (4, 113–280); Alto Paraná,

near Pto. Stroessner, Arroyo Venecia, 25°34'0"S, 54°49'59"W, UMMZ 206939 (1, 154); Rio Paraná, Rio Confuso, Presidente Hayes, Estancia la Golondrina, approx. 25°8'59"S, 57°33'59"W, UMMZ 206971 (2, 255–261), UMMZ 207096 (3, 132–210), UMMZ 215183 (1, 170), UMMZ 216576 (1, 322); Rio Paraná, Rio Confuso, Presidente Hayes, 34 km NW Pt. Remaro bridge, approx. 25°8'59"S, 57°33'59"W, UMMZ 207025 (17, 215–235); Rio Paraná, Rio Confuso, Presidente Hayes, Rio Pilcomayo near Puerto Falcon, 25°15'0"S, 57°43'00"W, UMMZ 207564 (2, 220–242); Rio Paraná, Rio Confuso, Presidente Hayes, Riachuelo Pilco, 26°6'0"S, 56°14'0"W, UMMZ 207619 (1, 144); Alto Paraná, Arroyo Peguajho, Ypan, 25°27'0"S, 57°31'59"W, UMMZ 207760 (2, 77–78).

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