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New Rheophilic Species of Electric Knifefish from the Rapids and Waterfalls of the Lower Rio Xingu, Brazil (Gymnotiformes: Apteronotidae)

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New Rheophilic Species of Electric Knifefish from the Rapids and Waterfalls of the Lower Rio Xingu, Brazil (Gymnotiformes: Apteronotidae)

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***Sternarchogiton zuanoni*, a new species of electric knifefish, is described from the rapids and waterfalls of Cachoeira de Kaituká along the Rio Xingu at Altamira, Pará, Brazil. The new species is diagnosable from congeners by a unique combination of morphometric and meristic features, details of pigmentation, the pattern of dentition on the dentary, the possession of an edentulous premaxilla, and an unelaborated lower lip. The description of *S. zuanoni* brings the number of species in the genus to five. The presence of *S. labiatus* in the Río Orinoco basin is documented and a key to the species of the genus is provided.**

***Sternarchogiton zuanoni*, uma espécie nova de peixe elétrico é descrita da Cachoeira de Kaituká no rio Xingu, Município de Altamira, Pará, Brasil. A espécie nova é diagnosticada de todos os congêneres por uma combinação única de caracteres morfométricos e merísticos, detalhes de pigmentação, arranjo dos dentes sobre o dentário, a ausência de dentes sobre o o pré-maxilar, e a forma do lábio inferior. A descrição de *S. zuanoni* eleva o número de espécies no gênero para cinco. A presença de *S. labiatus* na bacia do rio Orinoco é documentada e uma chave para as espécies do gênero é fornecida.**

ELECTRIC knifefishes of the genus *Sternarchogiton* are medium-sized (approximately 200 to 300 mm maximum TL) inhabitants of large river channels of the Amazon and Orinoco basins (de Santana and Crampton, 2007). Species of *Sternarchogiton* generate continuous periodic wave electric organ discharges that range from 732 to 1922 Hz, with at least four characteristic discharge types termed Types C to F by Crampton and Albert (2006) and de Santana and Crampton (2007). Striking external modifications characterize a subset of the species of *Sternarchogiton*. Some sexually mature males of *S. nattereri* possess a distinct crown of external teeth on the maxilla and dentary (de Santana and Crampton, 2007:389, fig. 1a). Males bearing such secondary sexual dentition are apparently at a competitive advantage during dominance competitions in agonistic encounters (Cox-Fernandes et al., 2002:59). Males and females of *Sternarchogiton labiatus* bear a three-lobed structure on the lower jaw (de Santana and Crampton, 2007:399, fig. 7) of unknown function but possibly associated with electrolocation of potential prey (Lundberg et al., 2000:35).

de Santana and Crampton (2007) recognized four species in their recent revision of *Sternarchogiton*. These were *S. labiatus*, from the central and western portions of the Amazon basin; *S. nattereri*, distributed along much of the mainstream Amazon and portions of the Rio Negro basin; *S. porcinum*, from the western portion of the Amazon basin and the main channel of the Río Orinoco; and *S. preto*, of the Amazon and Orinoco systems. Diverse authors (Campos-da-Paz, 2000; Reis, 2004; de Santana and Nogueira, 2006) emphasized that wide-ranging analyses of genera and families of Neotropical fishes typically provide the basis for the detection of additional intrageneric diversity and for more exact estimates of the true distributional range of many recognized species. This pattern proved to be the case in *Sternarchogiton*. Analysis of a sample of the genus from the rapids and waterfalls of the Cachoeira de Kaituká at Altamira along the Rio Xingu in the eastern portion of the Amazon basin revealed a distinctive rheophilic species of *Sternarchogiton* that we describe as new herein. Other examined samples of the genus demonstrate that *S. labiatus* has a broad distribution in the lower and central sections of the Río Orinoco system, areas far beyond the originally reported range of the species in the central Amazon basin.

MATERIALS AND METHODS

Measurements were point-to-point linear distances taken using digital calipers with a precision of 0.1 mm and following the methods of Mago-Leccia (1994) and Cox-Fernandes (1998). Meristic data for the holotype appear in square brackets. Specimens cleared and double stained (CS) for bone and cartilage were prepared following Taylor and Van Dyke (1985). Removal of the neurocranium, suspensorium, and pectoral girdle from specimens followed standard methods for the dissection of small teleosts (Weitzman, 1974). Anal- and caudal-fin ray counts were made using a dissecting microscope with transmitted light or were taken from radiographs. Bone terminology follows Albert and Fink (1996) and institutional abbreviations follow Leviton et al. (1985). Abbreviations in the text are head length (HL), length to end of the anal fin (LEA), and total length (TL). Comparative material examined for this study is that listed in de Santana and Crampton (2007).

Sternarchogiton zuanoni, new species

Figures 1, 2; Table 1

Holotype.—INPA 28356, 178 mm TL, Brazil, Pará, Rio Xingu, Município de Altamira, Cachoeira de Kaituká, 3°12′S, 52°12′W, 9 October 1990, L. Rapp Py-Daniel and J. Zuanon.

Paratypes.—INPA 3937, 7 (2 CS), 64.9–135.5 mm TL; USNM 391712, 1, 121 mm TL; collected with holotype.

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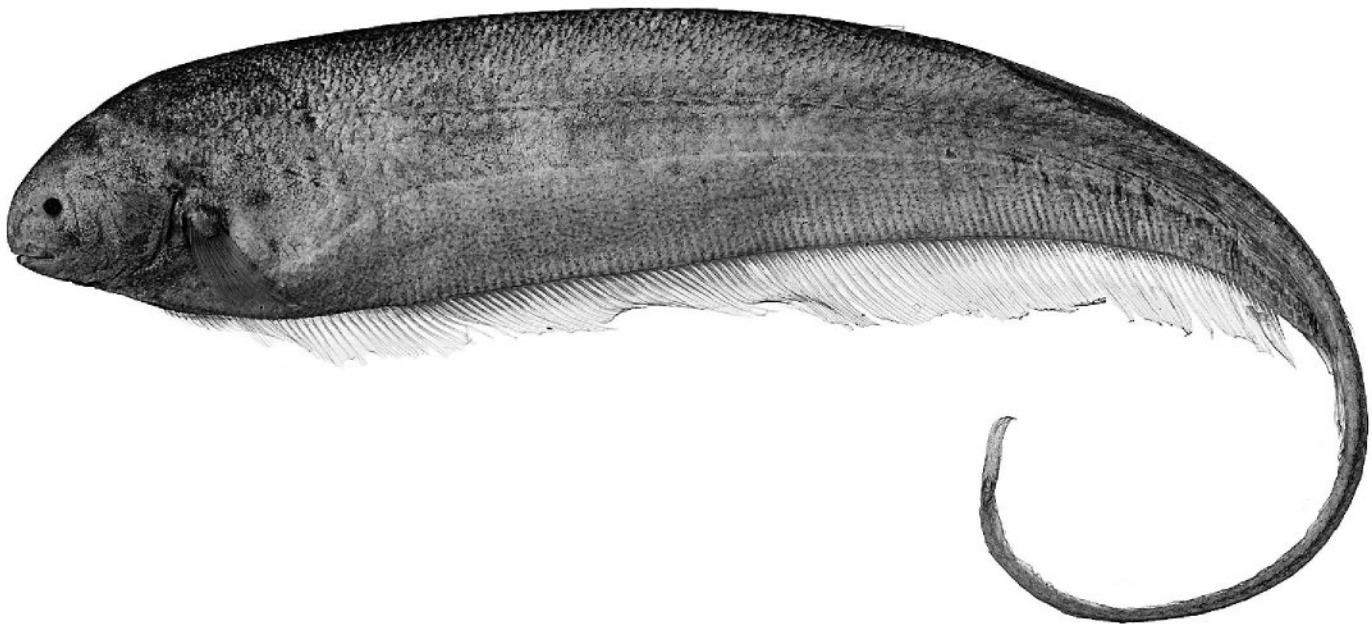

Fig. 1. Holotype of *Sternarchogiton zuanoni*, INPA 28356, 178 mm TL, Brazil, Pará, Rio Xingu, Município de Altamira, Cachoeira de Kaituká.

Diagnosis.—*Sternarchogiton zuanoni* is diagnosed from *S. labiatus* in the number of total anal-fin rays (129–153 versus 156–168, respectively), the interorbital width (28.8–39.4% of HL versus 19.5–24.6%, respectively), the body depth (13.3–17.3% of LEA versus 10.3–12.0%, respectively), the coloration of the anal fin (completely hyaline versus the presence of scattered brown speckling and a dark distal margin, respectively), the form of the lower lip (unelaborated versus the presence of a prominent tri-lobed structure, respectively), and the number of rows of conical teeth on the dentary (one versus two rows, respectively). *Sternarchogiton zuanoni* is distinguished from *S. nattereri* in the number of total anal-fin rays (129–153 versus 180–198, respectively), the interorbital width (28.8–39.4% of HL versus 19.9–27.6%, respectively), the length of the caudal appendage (22.4–30.7% of LEA versus 14.6–20.4%, respectively), and the premaxillary dentition (teeth absent versus present in some sexually dimorphic males, respectively). *Sternarchogiton zuanoni* is diagnosable from *S. porcinum* in the number of total anal-fin rays (129–153 versus 182–216, respectively), the interorbital width (28.8–39.4% of HL versus 18.8–23.9%, respectively), the head width (46.2–57.3% of HL versus 39.1–44.6%, respectively), the orbital diameter (9.3–14.1% of HL versus 4.5–7.7%, respectively), the coloration of the pectoral and anal fins (completely hyaline versus with black margins, respectively), and the dorsal profile of the head (distinctly convex [Fig. 1] versus straight or slightly convex, respectively). *Sternarchogiton zuanoni* is distinguished from *S. preto* in the number of total anal-fin rays (129–153 versus 189–210, respectively), the interorbital width (28.8–39.4% of HL versus 17.8–25.9%, respectively), the orbital diameter (9.3–14.1% of HL versus 2.9–8.3%, respectively), the coloration of the pectoral and anal fins (completely hyaline versus with black margins, respectively), and the premaxillary dentition (teeth absent versus present, respectively).

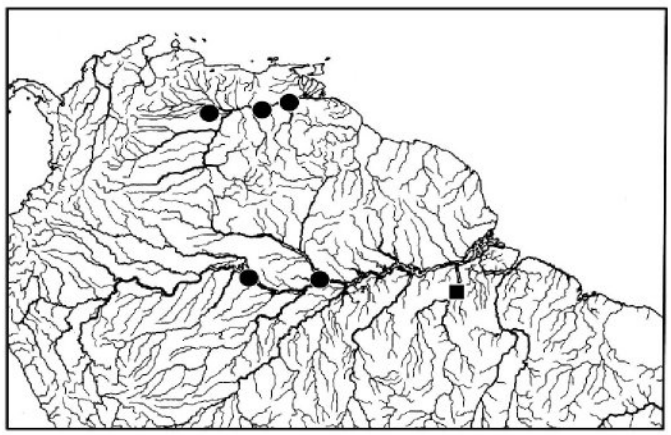

Fig. 2. Map of northern South America showing distribution of *Sternarchogiton zuanoni* (square = type locality) and *S. labiatus* (dots; localities in Amazon basin based on data in de Santana and Crampton [2007]).

Description.—Head and body shape and pigmentation illustrated in Figure 1. Morphometrics presented in Table 1. Body laterally compressed. Greatest body depth located along posterior section of abdominal cavity or slightly posterior to that area. Dorsal profile of body nearly straight. Lateral line extending to base of caudal fin, but absent on fin. Anteriormost perforated scale located above pectoral-fin origin.

Head laterally compressed, widest at opercular region. Dorsal profile of head convex, more so in area anterior to vertical through orbit. Eye small, located laterally on head, and completely covered by thin membrane. Mouth relatively small and terminal. Upper and lower jaws of equal length. Rictus located at vertical through, to slightly posterior of, anterior margin of eye. Anterior naris located at end of short tube. Base of tube positioned approximately one-half of orbital diameter from tip of snout. Posterior naris ovoid, without tubular extension, and positioned distinctly dorsal of horizontal through anterior nostril and approximately one-half of orbital diameter from anterior margin of eye. Branchial opening located slightly anterior to pectoral-fin origin. Aperture extends ventral of horizontal through middle of pectoral-fin base for distance greater than its extent dorsal of that line. Branchial membranes completely

Table 1. Morphometric Data for Specimens of *Sternarchogiton zuanoni*. Number of examined specimens indicated in parenthesis. Ranges and means include holotype and paratypes.

	Holotype	Range	Mean
Total length [mm]	178.0	64.9–178.0 (n = 9)	–
Length to end of anal fin [mm]	137.0	45.1–137.0 (n = 9)	–
Head length [mm]	15.6	8.0–15.6 (n = 9)	–
Caudal-fin length [mm]	42.1	11.9–42.1 (n = 6)	–
Percent of length to end of anal fin			
Anal-fin length	91.2	79.4–91.2 (n = 9)	85.9
Preanal length	9.0	9.0–19.9 (n = 9)	13.5
Pectoral-fin length	10.0	9.5–11.7 (n = 9)	10.5
Body depth	16.4	13.3–17.3 (n = 9)	15.2
Head length	11.3	11.3–18.9 (n = 9)	14.0
Caudal-appendage length	30.7	22.4–30.7 (n = 6)	25.4
Percent of head length			
Head depth	71.0	61.9–79.3 (n = 9)	68.8
Head width	57.3	46.2–57.3 (n = 9)	49.4
Snout length	36.2	26.1–36.2 (n = 9)	29.7
Mouth length	25.7	17.8–30.9 (n = 9)	22.7
Internarial distance	8.0	8.0–11.8 (n = 9)	9.3
Orbital diameter	11.4	9.3–14.1 (n = 9)	11.8
Interorbital width	35.0	28.8–39.4 (n = 9)	34.6
Postorbital length	62.6	50.5–73.9 (n = 9)	63.5
Percent of caudal-appendage length			
Caudal-appendage depth	6.2	6.2–7.2 (n = 2)	6.7

joined along isthmus. Anus and urogenital papilla adjacent, located along vertical running through dorsal portion of anterior limit of opercle and about two and one-half orbital diameters posterior of rear margin of eye. Anus and urogenital papilla do not demonstrate anterior ontogenetic displacement across examined size range of specimens, contrary to such shifts in some apteronotids. Premaxilla of moderate size and edentulous. Maxilla crescent-shaped, with ossified anterodorsal head and anteroventral shelf. Ventral margin of descending blade of maxilla sharply angled. Dentary with one tooth row formed of 7–11 tiny, conical teeth.

Pectoral fin broad and distally pointed, with 2 [2] unbranched and 11–12 [12] branched rays (n = 7). Anal-fin origin located slightly anterior to vertical through posterior margin of opercle. Unbranched anal-fin rays 18–21 [21] (n = 7). Total anal-fin rays 129–153 [138] (n = 6). Anal fin terminating posteriorly distinctly anterior to tip of tail. Scales lacking along entire middorsal region of body. Scales above lateral line to middorsal line 6–7 [7] (n = 9). Origin of dorsal mid-saggital electroreceptive structure located at 48–49% [48%] of LEA. Dorsal electroreceptive structure inserted into narrow middorsal groove on body and terminating posteriorly ten scales beyond vertical through base of posterior most anal-fin ray. Elongate compressed caudal filament ending in small, lanceolate caudal fin. Caudal-fin rays 9–16 [13] (n = 6). Precaudal vertebrae 15 (12 anterior, 3 transitional; n = 2).

Coloration in alcohol.—Overall coloration of head light tan to tan with pigmentation more intense along dorsal surface. Some specimens with scattered small brown chromatophores on posterior portion of opercle. Anterior surface of snout with vertically elongate, more lightly colored region extending posterodorsally from tip of snout to vertical through posterior border of anterior nares. Body tan to brown with dorsal region darker overall. Lateral surface of body with scattered small brown chromatophores. Chromatophores more concentrated along margins of myomeres associated with proximal pterygiophores of anal fin. Some individuals with increased concentrations of dark chromatophores in area surrounding pectoral-fin base and in region posteroventral to margin of opercle. Pectoral and anal fins hyaline. Caudal fin dark basally and hyaline distally.

Distribution.—The single known sample of *Sternarchogiton zuanoni* originated in the rapids and waterfalls of Cachoeira de Kaituká in the Município de Altamira along the lower Rio Xingu in the eastern portions of the Amazon basin (Fig. 2).

Habitat.—Available specimens of *Sternarchogiton zuanoni* were captured in Cachoeira de Kaituká at locations in rapids and in pools at the base of waterfalls. *Sternarchogiton zuanoni* is the sole species known to be associated with rapidly-flowing rivers with rocky beds, whereas the examined samples of other congeners originate from main channels of deep-water rivers, often in benthic settings (de Santana and Crampton, 2007). Three other species of the Apteronotidae, *Megadontognathus kaitukaensis* (Campos-da-Paz, 1999) and two undescribed species of *Sternarchorhynchus* (de Santana and Vari, in press), were also captured within Cachoeira de Kaituká.

Remarks.—Different authors have proposed diverse diagnostic features for *Sternarchogiton*, with only a subset of these characters evaluated within a phylogenetic context (see summary and discussion by de Santana and Crampton,

2007). *Sternarchogiton zuanoni* shares the following derived characters proposed by de Santana and Crampton (2007:388) as delimiting the genus: a sharp angle along the ventral margin of the descending blade of the maxilla positioned about two-thirds of the distance to its tip, the broad descending blade of the maxilla with an anterior shelf, the dumbbell-shaped ossicles associated with the mandibular laterosensory canal segment of the lower jaw, the possession of one or two ossified postcleithra, and the broadening of the proximal pterygiophores anteriorly and posteriorly into the ventral median septum.

Etymology.—The species name, *zuanoni*, is in honor of Jansen Zuanon of the Instituto Nacional de Pesquisas da Amazônia, who has contributed enormously to our knowledge of the ecology and taxonomy of fishes from the Amazon basin.

***Range extension for* Sternarchogiton labiatus.**—Analysis of additional samples of *Sternarchogiton* in the course of this study revealed that the distribution of *S. labiatus* encompasses a significantly greater area than documented by material examined in previous studies. In their description of *S. labiatus*, de Santana and Crampton (2007:400) commented that the then known samples of the species originated in two areas of the central portions of the Amazon; the region of the type locality in the Rio Tefé and one location in the lower Rio Negro. Newly examined samples of *Sternarchogiton* from the Río Orinoco result in a considerable expansion northward of the known range of *S. labiatus* (see Material Examined). The known distribution of *S. labiatus* in the Río Orinoco (Fig. 2) ranges from the state of Delta Amacuro in the east (USNM 233363, USNM 233366, MCZ 59513) westward to the upper reaches of the Río Arauca in the western portions of the state of Apure (MCNG 19916; MCNG 25178). A similar distribution of a species in both the Orinoco and Amazon systems also occurs in two congeners (*S. porcinum* and *S. preto*; de Santana and Crampton, 2007:fig. 3).

KEY TO SPECIES OF *STERNARCHOGITON*

1a. Total anal-fin rays 129–153; interorbital width 28.8–39.4% of HL ..... ***S. zuanoni*, new species** (Rio Xingu, Brazil)

1b. Total anal-fin rays 156–216; interorbital width 17.8–27.6% of HL 2

2a. Prominent tri-lobed structure present on lower lip; total anal-fin rays 156–168 ..... ***S. labiatus*** (Rio Tefé region and lower Rio Negro, Amazon basin, Brazil; Río Orinoco system, Venezuela)

2b. Tri-lobed structure absent from lower lip; total anal-fin rays 180–216 3

3a. Body coloration uniformly dark brown; pectoral and anal fins very dark distally ..... ***S. preto*** (Amazon basin from Pará, Brazil, upriver to Peru and Bolivia; central and upper Río Orinoco, Venezuela)

3b. Body coloration pale tan to yellow overall, but pale brown or brown dorsally; pectoral and anal fins uniformly hyaline or hyaline at base and dusky distally 4

4a. Preanal-fin length 9.9–13.7% of LEA; HL13.2–15.1% of LEA; pectoral and anal fins hyaline at base and dusky distally ..... ***S. porcinum*** (Amazon basin from Pará, Brazil, upriver to Río Napo and Río Huallaga in Peru; lower and central portions of Río Orinoco in Venezuela)

4b. Preanal-fin length 6.0–9.3% of LEA; HL 9.8–12.4% of LEA; pectoral and anal fins uniformly hyaline ..... ***S. nattereri*** (large river channels across much of Amazon basin)

MATERIAL EXAMINED

Sternarchogiton labiatus: All from Venezuela. USNM 233363, 1, 159 mm, Anzoátegui, Río Orinoco, La Providencia, N side of Isla Fajardo, opposite Palua, 08°22′N, 62°42′W; USNM 233366, 2, 136–138 mm, Anzoátegui, Isla Tres Caños, Río Orinoco, 08°22′N, 62°42′W; MCNG 25178, 1 (not measured), Apure, Pavoncito, approximately 7°48′N, 68°26′W; MCNG 19916, 1 (not measured), Apure, Rio Arauca, in Paso Arauca, 7°26′55″N, 68°26′W; MBUCV 19985, 1 (not measured), Apure, Río Apure, between Cueva del Sapo and Isla del Medio; MBUCV 12179, 4 (not measured; 2 CS), Bolivar, Río Orinoco, Laguna of Isla La Isabela between cities of Palua and Bolivar; USNM 233366, 2, 125–164 mm, MCZ 59513, 2, 192–198 mm, Delta Amacuro, Río Orinoco, Isla Tres Caños, 08°39′48″N, 62°01′00″W.

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