



A new species of smooth horned frog, genus *Proceratophrys* Miranda-Ribeiro (Amphibia: Anura: Cycloramphidae), from the Atlantic Rainforest of eastern Bahia, Brazil

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Abstract

We describe a new species of smooth horned frog related to the *Proceratophrys appendiculata* complex, constituting the northernmost record of that complex for the Atlantic Forest remnants in eastern Bahia, northeastern Brazil, within a region known as Vale do Jiquiriçá. *Proceratophrys sanctaritae* **sp. nov.** is diagnosed from all congeners by the combination of medium size (snout–vent length 38.4–45.5 mm), single and long uni-cuspidate palpebral appendage, rostral appendage longer than upper lip width, presence of preocular crest, frontoparietal crest poorly developed, color of ventral surfaces, and acoustic parameters of the advertisement call.

Key words: Alsodinae, *Proceratophrys appendiculata* species complex, *Proceratophrys sanctaritae* **sp. nov.**, taxonomy, Vale do Jiquiriçá

Resumo

Descrevemos uma nova espécie de sapo-de-chifres pertencente ao complexo de *Proceratophrys appendiculata*, constituindo o registro mais setentrional desse complexo para os remanescentes de Floresta Atlântica do leste da Bahia, nordeste do Brasil, em uma região conhecida como Vale do Jiquiriçá. *Proceratophrys sanctaritae* **sp. nov.** é diagnosticada das demais espécies do gênero pela combinação do tamanho médio (comprimento rostró–cloacal 38,4–45,5 mm), apêndice palpebral único e longo, apêndice rostral mais longo que a largura do lábio superior, presença de crista pré-ocular, crista frontoparietal pouco desenvolvida, coloração das superfícies ventrais e parâmetros acústicos do canto de anúncio.

Introduction

The Neotropical genus *Proceratophrys* Miranda-Ribeiro currently comprises 20 species distributed in Brazil, northeastern Argentina, and Paraguay (Prado & Pombal 2008; Frost 2009). These species are usually ordered within two main phenetic groups, mostly characterized by the presence or the absence of a single and long palpebral (upper eyelid) appendage.

Species of *Proceratophrys* without a single and long palpebral appendage are combined in two species groups: the *P. bigibbosa* and *P. cristiceps* groups. The *Proceratophrys bigibbosa* species group occurs in southern Brazil and adjacent countries (Giaretta *et al.* 2000), and is characterized by a blunt and short snout, presence of postocular swellings, and large marginal tubercles on eyelids (Kwet & Faivovich 2001); comprises four species: *P. avelinoi* Mercadal de Barrio and Barrio, *P. bigibbosa* (Peters), *P. brauni* Kwet and Faivovich, and *P. palustris* Giaretta and Sazima. The *Proceratophrys cristiceps* species group is mainly

distributed over open and seasonally dry environments and is characterized by the absence of postocular swellings (other shared derived characters are not evident; Giaretta *et al.* 2000); currently comprises four species: *P. concavitympanum* Giaretta, Bernarde and Kokubum, *P. cristiceps* (Müller), *P. cururu* Eterovick and Sazima, and *P. goyana* (Miranda-Ribeiro). *Proceratophrys schirchi* (Miranda-Ribeiro) also lacks a single and long eyelid appendage, but it is not currently associated to a species group by its distinct external morphology (Prado & Pombal 2008).

Species of *Proceratophrys* with a single and long uni-cuspidate palpebral appendage are combined within the species complexes of *P. boiei* and *P. appendiculata* (Izecksohn *et al.* 1998; Prado & Pombal 2008). Three species lack a triangular rostral appendage and are combined in the *P. boiei* species complex: *P. boiei* (Wied-Neuwied), *P. paviotii* Cruz, Prado and Izecksohn, and *P. renalis* (Miranda-Ribeiro). The *P. appendiculata* species complex is characterized by the presence of a triangular rostral appendage, and is currently composed by seven species: *P. appendiculata* (Günther), *P. laticeps* Izecksohn and Peixoto, *P. melanopogon* (Miranda-Ribeiro), *P. moehringi* Weygoldt and Peixoto, *P. phyllostomus* Izecksohn, Cruz and Peixoto, *P. subguttata* Izecksohn, Cruz and Peixoto, and *P. tupinamba* Prado and Pombal. *Proceratophrys rondonae* Prado and Pombal presents a single and short multi-cuspidate palpebral appendage (long and uni-cuspidate in the other species), and was not associated by us to a species complex.

Recent surveys of anurans in the Santa Rita forest, an Atlantic Rainforest remnant at the Serra do Timbó, Municipality of Amargosa, State of Bahia, Brazil, led us to find a new species of *Proceratophrys* allied to the *P. appendiculata* complex, described herein.

Material and methods

Museum abbreviations of specimens used in the descriptions or examined for comparisons are MNRJ (Museu Nacional, Rio de Janeiro, Brazil) and UFBA (Museu de Zoologia da Universidade Federal da Bahia, Salvador, Bahia, Brazil).

Measurements of specimens are in millimeters: SVL (snout–vent length), HL (head length), HW (head width), ED (eye diameter), UEW (upper eyelid width), IOD (interorbital distance), IND (internarial distance), END (eye to nostril distance), THL (thigh length), TL (tibia length), and FL (foot + tarsus length). Measurements were taken with a vernier caliper. Drawings of the holotype were made using a Leica-Wild MZ6 stereomicroscope with a drawing tube. Webbing formula notation follows Savage and Heyer (1997). The nomenclature used to describe the external morphology of the genus *Proceratophrys* follows Prado and Pombal (2008). Snout–vent length comparisons between the new species and species of the *P. appendiculata* and *P. boiei* species complexes were based in measurements provided by Prado and Pombal (2008).

Advertisement calls of the new species were recorded from the Santa Rita forest (12°25'S, 39°38'W, 800–900 m above sea level), in the Serra do Timbó mountain, Municipality of Amargosa, State of Bahia, Brazil, in 18–20 May 2009, from ca. 08h to 20h, by M.F. Napoli, P.M. Fonseca, and C.A.G. Cruz, using a Marantz Portable Cassette Recorder PMD222 with a Sennheiser ME66 directional microphone. Calls were digitized at a sampling rate of 6 kHz. Temporal parameters, number of pulses, and number of notes were measured or counted on waveforms with Avisoft SAS-Lab Light for Windows (version 3.74). Dominant frequencies were obtained with Sound Ruler Acoustic Analysis, version 0.9.6.0. Audiospectrogram was made with Fast Fourier Transform length (FFT) of 256, overlap 50%, frame 100%, window Flat Top, time resolution 21.33 ms, and frequency resolution of 88 Hz. Eight call parameters were measured: note (= call) duration (s), inter-note duration (s), note pulse rate (pulses/s), trill duration (s), pulse number, number of notes in a trill, call dominant frequency (kHz), and frequency amplitude (kHz). Note pulse rate was calculated for each note using the equation: pulse rate = pulse number/note duration (s). The terminology used for the description of advertisement calls followed Duellman and Trueb (1986). The advertisement call of the new species was compared with the following calls available from literature: *P. avelinoi* (Kwet & Baldo 2003; Lima 2007), *P. bigibbosa* (Kwet & Faivovich 2001), *P. boiei* (Heyer *et al.* 1990), *P. brauni* (Kwet & Faivovich 2001), *P. cristiceps* (Nunes & Juncá 2006), *P. cururu* (Eterovick & Sazima 1998), *P. moehringi* (Weygoldt & Peixoto

1985), and *P. paviotii* (Cruz *et al.* 2005). Additionally, we compared the advertisement call of the new species with the calls of *P. laticeps* and *P. melanopogon* (manuscript in preparation), both also belonging to the *P. appendiculata* species complex, by means of recordings kindly borrowed from J.E. Simon and P.C.A. Garcia, respectively: *P. laticeps*—100 calls analyzed from five specimens (voucher specimens: field number [FN] 163–164, 09 January 2001; FN 262 [MNRJ 30892], 16 January 2003; FN 310, 17 December 2004; FN 319, 16 January 2004), Estação Biológica de Santa Lúcia (19°56'S, 40°36'W, 650 m a.s.l.), Municipality of Santa Teresa, State of Espírito Santo, Brazil, using a Sony TCM-5000EV Pressman Professional Portable Cassette Recorder with a Sennheiser ME66 directional microphone; *P. melanopogon*—30 calls analyzed from one specimen, Parque das Neblinas (23°44'S; 46°08'W, 742 m a.s.l.), Municipality of Bertioga, State of São Paulo, Brazil, 21 October 2006.

Taxonomic account

Proceratophrys sanctaritae sp. nov.

Figures 1–3

Holotype. UFBA 8487, adult male, collected at the Santa Rita forest (13°04'S, 39°38'W, 800 m above sea level), Serra do Timbó mountain, Municipality of Amargosa, State of Bahia, Brazil, in 18–19 May 2009, by M.F. Napoli, C.A.G. Cruz, and P.M. Fonseca.

Paratopotypes. UFBA 7314, adult male, collected on 14 May 2007, by P.M. Fonseca and R.O. Abreu; UFBA 8003, adult male, collected on 17 May 2008, by M.F. Napoli, P.M. Fonseca, and C.A.G. Cruz; UFBA 8488 and MNRJ 62354–62357 (ex-UFBA 8485–8486, 8489 [cleared and stained], and 8490, respectively), adult males, collected with the holotype; MNRJ 62358–62360 (ex-UFBA 9525–9527, respectively), juveniles, collected on 20 December 2009, by M.P.D. Santos.



FIGURE 1. *Proceratophrys sanctaritae* sp. nov. Dorsal (left) and ventral (right) views of holotype, UFBA 8487, adult male, SVL 39.9 mm. Photo Rafael O. Abreu.

Diagnosis. A broad and elongate zygomatic ramus of the squamosal in sutural contact with maxilla assigns the new species to the genus *Proceratophrys*. It is associated to the *P. appendiculata* complex by

combining a single and long uni-cuspidate palpebral appendage with a triangular rostral appendage. *Proceratophrys sanctaritae* is diagnosed from other species of the *P. appendiculata* complex by the following combination of traits: (1) medium size (adult males SVL 38.4–45.5 mm); (2) rostral appendage longer than upper lip width; (3) snout rounded from above, obtuse in profile; (4) eye small, 19% of head length; (5) head wider than long; (6) presence of preocular crest; (7) frontoparietal crest poorly developed; (8) gular region blackish brown or black; (9) ventral surfaces predominantly cream, scattered with dark brown dots mainly on chest and in smaller extent on belly; and (10) advertisement call consisting of a single note with 31 to 94 pulses, pulse rate of 102.3 to 142.4 pulses/s, call duration of 0.2 to 0.9 s, peaks of dominant frequency from 0.95 to 1.29 kHz, and call note with a bowling pin-shaped or bottle-shaped waveform.

Comparisons with other species (only with males). *Proceratophrys sanctaritae* is promptly diagnosed from all species of the *P. cristiceps* group (*P. concavitympanum*, *P. cristiceps*, *P. cururu*, and *P. goyana*), *P. bigibbosa* group (*P. avelinoi*, *P. bigibbosa*, *P. brauni*, and *P. palustris*), and also from *P. schirchi*, by the presence of a single large palpebral appendage (absent in those species), and from *P. rondonae* by a uni-cuspidate palpebral appendage (multi-cuspidate in *P. rondonae*). From all species of the *Proceratophrys boiei* complex (*P. boiei*, *P. paviotii*, and *P. renalis*), and also from *P. rondonae*, the new species is promptly diagnosed by the presence of a rostral appendage (absent in those species). In the *P. appendiculata* species complex, the rostral appendage longer than the upper lip width approximates *P. sanctaritae* to *P. appendiculata*, *P. melanopogon*, *P. phyllostomus*, *P. subguttata*, and *P. tupinamba*, and diagnoses it from *P. laticeps* and *P. moehringi*, in which the rostral appendage is vestigial and shorter than upper lip width. The presence of a preocular crest approximates *P. sanctaritae* to *P. appendiculata*, *P. moehringi*, and *P. tupinamba*, and promptly diagnoses it from *P. laticeps*, *P. melanopogon*, *P. phyllostomus*, and *P. subguttata*, in which such character is absent. Frontoparietal crests are poorly developed in *P. sanctaritae*, and well developed in *P. appendiculata*. The narrower head and smaller eyes diagnose *P. sanctaritae* (HL 80% of HW, ED 19% of HL) from *P. tupinamba* (HL 87% of HW, ED 23% of HL). Adult males of *P. sanctaritae* are in some extent similar in body size (SVL 38.4–45.5 mm) to adult males of *P. melanopogon* (SVL 34.9–44.9 mm), *P. subguttata* (SVL 36.7–41.8 mm), and *P. appendiculata* (SVL 40.4–59.9 mm), and shorter than *P. laticeps* (SVL 59.5–78.0 mm), *P. moehringi* (SVL 59.2–62.6 mm), *P. phyllostomus* (SVL 55.4 mm), and *P. tupinamba* (SVL 52.6–63.4 mm). Ventral surfaces of *P. sanctaritae* are predominantly cream and scattered with dark brown dots mainly on chest and, in smaller extent, on belly; belly with few irregular large dark brown markings near the chest, somewhat anastomosed, in *P. melanopogon*; ventral surfaces predominantly black with few tan blotches on belly and legs in *P. phyllostomus*; belly cream with large rounded dark brown markings in *P. subguttata*.

Description of holotype. Head wider than long, head length 79% of head width; snout nearly round (almost triangular) in dorsal view, obtuse in profile; rostral appendage larger than the upper lip width; nares elliptical, slightly prominent, internarial distance 71% of eye to nostril distance; canthal crests well marked and prominent; preocular crests distinct; loreal region concave; distinct row, almost a crest, of spatulated warts from posterior corner of eye to angle of jaw; long tubercles at angle of jaw; eye directed anterolaterally, small, 19% of head length; unique and long palpebral appendage; tympanum not clearly defined, situated in a depression dorsolaterally behind the eye, its diameter 63% of eye diameter, and equals to the distance from it to posterior corner of eye; distinct rows of warts transversally on head, joining the edge of upper eyelid appendage, and extending as symmetrical and sinuous from upper eyelid appendage up to join above sacrum; oblique rows of warts on sides of body; vocal sac not expanded externally; tongue cordiform, free posteriorly; choanae large, well separated one from other; vomerine teeth in two short transverse series lying between choanae; vocal slits large; frontoparietal crest poorly developed; arms moderately robust, forearm robust, dorsal surface of arms with four to five rows of enlarged warts; external margin of ventral surface of forearm with a row of warts extending on external margin of finger IV; upper arm enclosed by the patagium; hand robust, finger lengths $IV = II < I < III$; nuptial asperities absent; interdigital webbing absent; inner metacarpal tubercle large, elliptical; outer metacarpal tubercle divided in two oval parts; numerous small rounded supernumerary tubercles; subarticular tubercles large, rounded; legs moderately robust, thigh length longer than tibia length, the sum of thigh and tibia lengths 82% of snout–vent length; dorsal surface of tibia with four to five oblique parallel rows of enlarged warts; edges of ventral surface of tarsus with rows of warts extending

on external edges of toes I and V; foot length 58% of snout–vent length; toe lengths $I < II < V < III < IV$; webbing formula I 1–2 II 1–3 III 2⁺–4 IV 4–2 V; inner metatarsal tubercle large, elliptical; outer metatarsal tubercle absent; numerous small rounded supernumerary tubercles; subarticular tubercles large, rounded. Dorsum adorned with sinuous longitudinal ridges outlining a spear-shaped ornamentation like a hastate-shaped leaf, with flaring pointed lobes at eyes and spear point at urostyle (fig. 1). Dorsal surfaces and flanks with warts of different sizes and shapes, set in rows or scattered; ventral surfaces, except hands and feet, covered by numerous small, circular, uniform warts; skin and warts of dorsal and ventral surfaces covered by minuscule horny asperities.

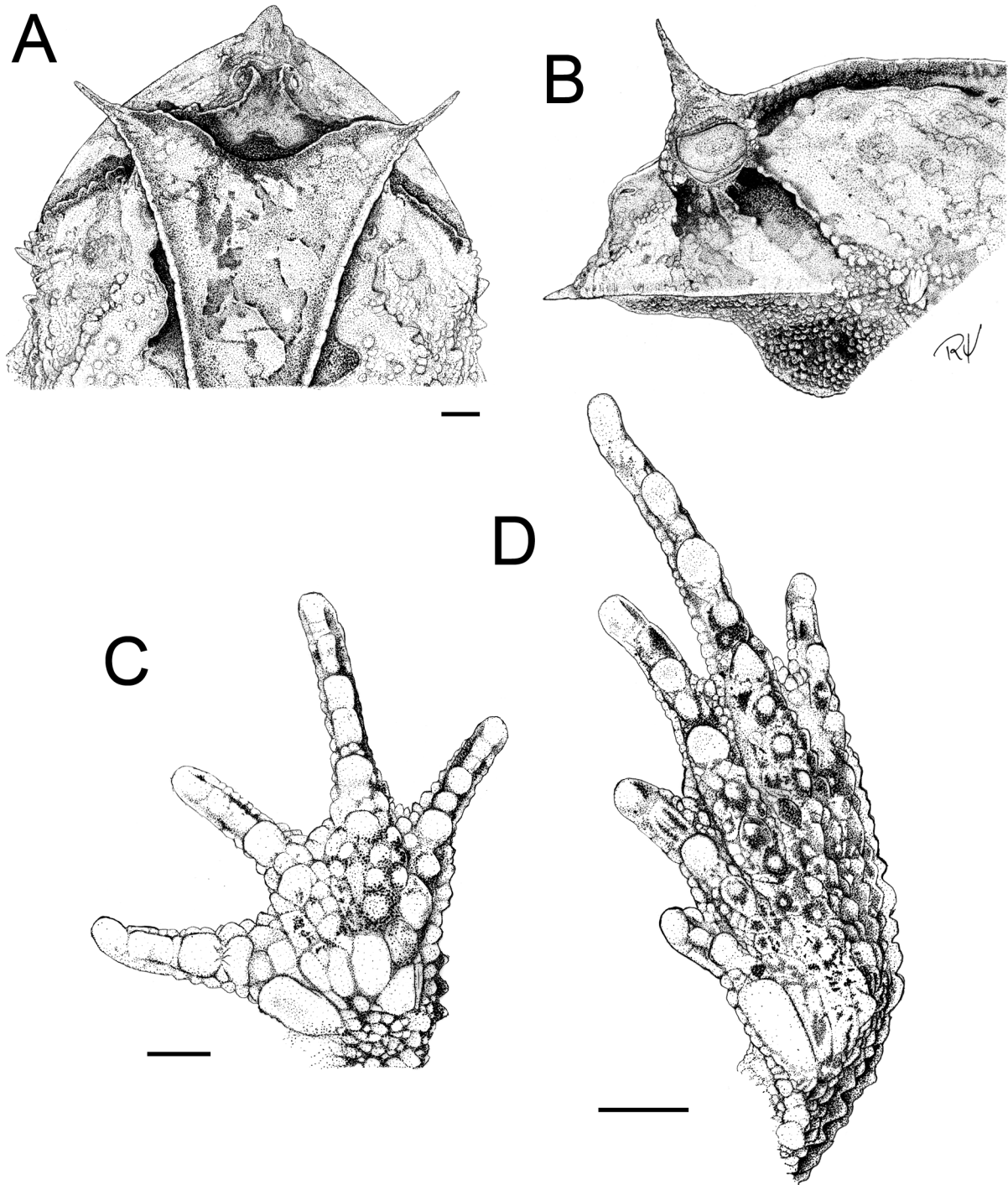


FIGURE 2. Holotype of *Proceratophrys sanctaritae* sp. nov., UFBA 8487, adult male. Dorsal (A) and lateral (B) views of head; ventral views of hand (C) and foot (D). Upper and lower horizontal lines equal 2.0 mm.

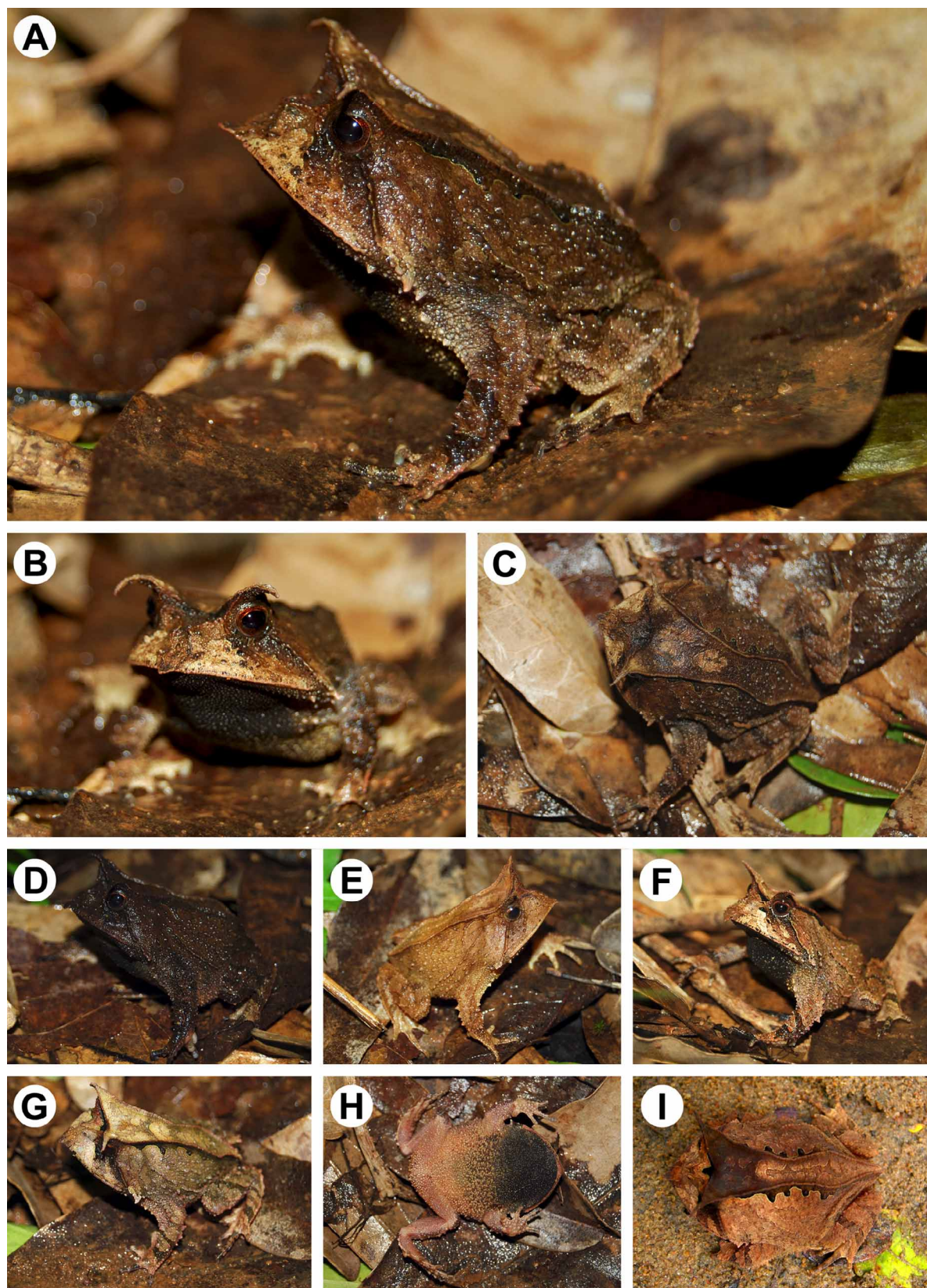


FIGURE 3. Living specimens of *Proceratophrys sanctaritae* **sp. nov.** from Santa Rita forest, Serra do Timbó, Municipality of Amargosa, State of Bahia, Brazil. Holotype: A–C, UFBA 8487, adult male, SVL 39.9 mm. Paratopotypes, adult males: D, MNRJ 62355, SVL 42.0 mm; E, UFBA 8488, SVL 40.2 mm; F, MNRJ 62356, SVL 40.0 mm; G–H, MNRJ 62357, SVL 42.0 mm. I, UFBA 7314, SVL 45.5 mm (Photos by Rafael O. Abreu: A–H, 21 May 2009; I, 12 April 2007).

Color of holotype in life. Dorsal ground color tan brown, maculated with variegated browns looking like dead leaves (fig. 3 A–C). Longitudinal ridges of the spear-shaped ornamentation on dorsum light brown, contrasting with dorsal ground color, and bordered along external sides by a wave-shaped dark brown band bordered by a greenish white thin stripe; warts at each wave crest blackish brown, differing from all other warts on dorsum, which are of a lighter brown color. Interior surfaces of the spear-shaped ornamentation on dorsum with light brown maculae, mainly on palpebral appendages, posterior surface of head, and thoracic region. Three transverse dark brown bars on forearm, thigh, tibia, and tarsus. Lorus with a triangular cream color area anterior to eye and a dark brown band from eye to upper lip. Gular region uniform blackish brown. Ventral ground color of chest, belly, arms, legs, hands, and feet fleshy color, with warts and tubercles cream; chest and anterior surfaces of belly dark brown marbled. Pupil black, iris reddish brown.

Color of holotype in preservative. Follows the color in life, but with less vivid colors (fig. 1); the greenish white thin stripe bordering the wave-shaped dark brown band along the longitudinal ridges of the spear-shaped ornamentation on dorsum became cream color; fleshy background color of ventral surfaces became buff.

Measurements of holotype (mm). SVL 39.9; HL 18.4; HW 23.2; ED 3.5; UEW 9.2; IOD 5.0; IND 2.5; END 3.5; TD 2.2; THL 17.4; TL 15.5; FL 23.0.

Variation. Specimens are congruent with respect to the morphologic characters. The dorsal background color varies in adult live specimens (fig. 3 A–I). Male MNRJ 62355 (ex-UFBA 8486) uniform dark brown and male UFBA 8488 uniform light brown, both with poor noticeable dark brown markings (fig. 3 D–E). Adult males UFBA 7314, MNRJ 62356 (ex-UFBA 8489), and MNRJ 62357 (ex-UFBA 8490) of dorsal background color cream with well marked light and dark brown maculae (fig. 3 F–G, I). Gular region and ventral markings of belly blackish brown in UFBA 8487 (holotype) and MNRJ 62357 (ex-UFBA 8490), and tan brown in UFBA 7314 (fig. 3 H). Body size of juveniles (MNRJ 62358–62360) smaller than adult males (SVL 31.3, 35.2, and 19.6 mm, respectively). Descriptive statistics of measurement variables from adult males in Table 1.

TABLE 1. Descriptive statistics of eight adult males of *Proceratophrys sanctaritae* from the Serra do Timbó, Municipality of Amargosa, State of Bahia, Brazil. \bar{x} , arithmetic mean; SD = standard deviation. Values in millimeters.

	Range	\bar{x}	SD
SVL	38.4–45.5	41.0	2.17
HL	18.0–20.0	18.4	0.66
HW	21.7–25.5	23.2	1.11
IND	2.4–2.8	2.5	0.12
END	3.2–3.7	3.4	0.16
ED	3.2–4.0	3.5	0.24
UEW	8.1–11.3	9.0	0.97
IOD	5.0–5.8	5.3	0.32
THL	16.6–18.9	17.9	0.78
TL	15.5–17.0	16.0	0.48
FL	22.0–24.8	23.0	1.83

Etymology. The specific name, a noun in apposition, refers to the type locality, Santa Rita, Serra do Timbó, Municipality of Amargosa, State of Bahia, Brazil.

Remarks. Izecksohn *et al.* (2005) studied the osteocranium of *Proceratophrys boiei*, *P. appendiculata*, *P. melanopogon*, and *P. laticeps*, and considered the former three as members of a single phenetic species group by sharing higher lateral crests on the frontoparietals, quadratojugal corners similarly positioned in relation to the vertical level of the occipital condyles, cranial bones with granules and tubercles, and maxillaries with ventro-posterior pits; *P. laticeps* was considered a member of a distinct species group (not formerly named) by

the presence of temporal arcades similar to *Ceratophrys* Wied-Neuwied, quadratojugal corners posterior to the vertical level of occipital condyles, wrinkled skull bones, and maxillaries without ventro-posterior pits. *Proceratophrys sanctaritae* shares with *P. boiei*, *P. appendiculata*, and *P. melanopogon* lateral crests on the frontoparietals, and quadratojugal corners similarly positioned in relation to the vertical level of the occipital condyles, but with maxillaries lacking ventro-posterior pits, condition similar to that observed in *P. laticeps*. It is important to note that the monophyly and intrageneric relationships of the genus *Proceratophrys* remain unresolved. Furthermore, some “synapomorphies” proposed by Lynch (1971) for *Proceratophrys* are currently not sustained (Prado & Pombal 2008). Only the presence of a broad and elongate zygomatic ramus of the squamosal in sutural contact with maxilla remains as a valid character (Prado & Pombal 2008), which led us to conclude the generic relationships of *P. sanctaritae*.

Natural history. All specimens of *Proceratophrys sanctaritae* were captured inside the forest. The adult males UFBA 8488 and MNRJ 62357 (ex-UFBA 8490) were collected approximately at 12h, the former sheltering in a cavity under a rock and the latter near herbaceous vegetation, both inside a forest brook of shallow waters, with approximately 2–3 m wide, and with direct sunlight. The male UFBA 8488 released advertisement calls in the plastic bag from the time it was captured in the forest to the next day, mainly in response to human voices. The adult males UFBA 8487 (holotype) and MNRJ 62354–62357 (ex-UFBA 8485–8486, 8489, and 8490, respectively), were collected at night (19–22h) on the margins of a small rivulet of mud and sand bed, ca. 1 m wide, 10 cm depth, and without direct sunlight. These males were emitting sporadic advertisement calls and were ca. 2 m long from each other. All males cited above emitted advertisement calls in their plastic bags during the returning trip to the Municipality of Salvador, Bahia State, Brazil, during ca. 10 hours (from 8h to 18h), forming duets and choruses. The adult male UFBA 7314 was captured in the morning (between 7h and 9h), and UFBA 8003 was captured at night (ca. 20h), both in the same place of the holotype. The juveniles MNRJ 62358–62360 (ex-UFBA 9525–9527, respectively) were captured at afternoon on the leaf litter in a forest trail far from water bodies. The forest ranger Manoel P.D. Santos (personal communication) stated that *P. sanctaritae*, which is known by him as leaf toad (“sapo-folha”), is usually seen in the morning and in the afternoon on the leaf litter of forest trails, mainly during rainy days. The available data lead us to assume that *P. sanctaritae* is active during all day, mainly in rainy seasons.

Advertisement call. Based on calls of four adult males, UFBA 8487 (holotype), UFBA 8488 (paratopotype), and MNRJ 62354–62355 (ex-UFBA 8485–8486, paratopotypes). The advertisement call of *Proceratophrys sanctaritae* consists of one multi-pulsed note (31–94 pulses, $\bar{x} = 46.7 \pm 6.4$, $n = 690$ notes) (fig. 4 A). Calls (= notes) are produced in groups (trills) of 2 to 44 notes ($\bar{x} = 11.6 \pm 1.1$, $n = 60$ call groups), with energy increasing from first to last note (fig. 4 B–C). A trill varies from 1.0 s (two notes) to 29.6 s (44 notes). Note duration ranges from 0.2 to 0.9 s ($\bar{x} = 0.4 \pm 0.1$, $n = 695$ notes), note interval from 0.2 to 1.2 s ($\bar{x} = 0.3 \pm 0.6$ s, $n = 636$), and pulse rate from 102.3 to 142.4 pulses/s ($\bar{x} = 126.0 \pm 7.4$, $n = 695$ calls). Peaks of dominant frequency range from 0.95 to 1.29 kHz ($\bar{x} = 1.13 \pm 0.04$, $n = 695$ calls). Note with increasing frequency modulation, from about 0.8 kHz in the beginning of the note to about 1.3 kHz in the end of the note. The lower frequency in the first fourth of the note coincides with a smaller amount of energy in the first pulses, which usually leads to a bowling pin-shaped or bottle-shaped waveform (fig. 4 D).

The number of pulses of the advertisement call of *P. sanctaritae* (31–94 pulses) is higher than for *P. brauni* (24–28 pulses) and *P. melanopogon* (21–29 pulses), and much lower than for *P. moehringi* (136–156 pulses; estimated from the data in Weygoldt & Peixoto 1985). The call duration of *P. sanctaritae* (0.2–0.9 s) is shorter than in *P. bigibbosa* (1.6–1.9 s) and *P. cururu* (1.2 s), and much shorter than in *P. moehringi* (3.5–4.0 s). The pulse rate of *P. sanctaritae* (102–142 pulses/s) is much faster than in *P. avelinoi* (64–72 pulses/s), *P. bigibbosa* (23–27 pulses/s), *P. boiei* (45 pulses/s), *P. brauni* (35–40 pulses/s), *P. cristiceps* (87–91 pulses/s), *P. cururu* (45 pulses/s), *P. laticeps* (46–62 pulses/s), *P. melanopogon* (50–54 pulses/s), and *P. moehringi* (33–40 pulses/s). Peaks of dominant frequency for *P. sanctaritae* (0.9–1.3 kHz) are lower than in *P. avelinoi* (1.6 kHz), and higher than in *P. laticeps* (0.4–0.7 kHz); peaks of dominant frequencies not available for *P. boiei*, *P. cururu*, and *P. moehringi*. The bowling pin-shaped or bottle-shaped waveform of *P. sanctaritae*, with energy concentrated from about the second half of the call, is different from that of *P. bigibbosa*, *P. brauni*, *P.*

laticeps, *P. melanopogon*, and *P. paviotti* (ovoid-shaped waveform), and from *P. avelinoi* and *P. cristiceps* (energy greatly concentrated in the first half of the call); oscillograms of the calls of *P. boiei*, *P. cururu*, and *P. moehringi* are not available from published data.

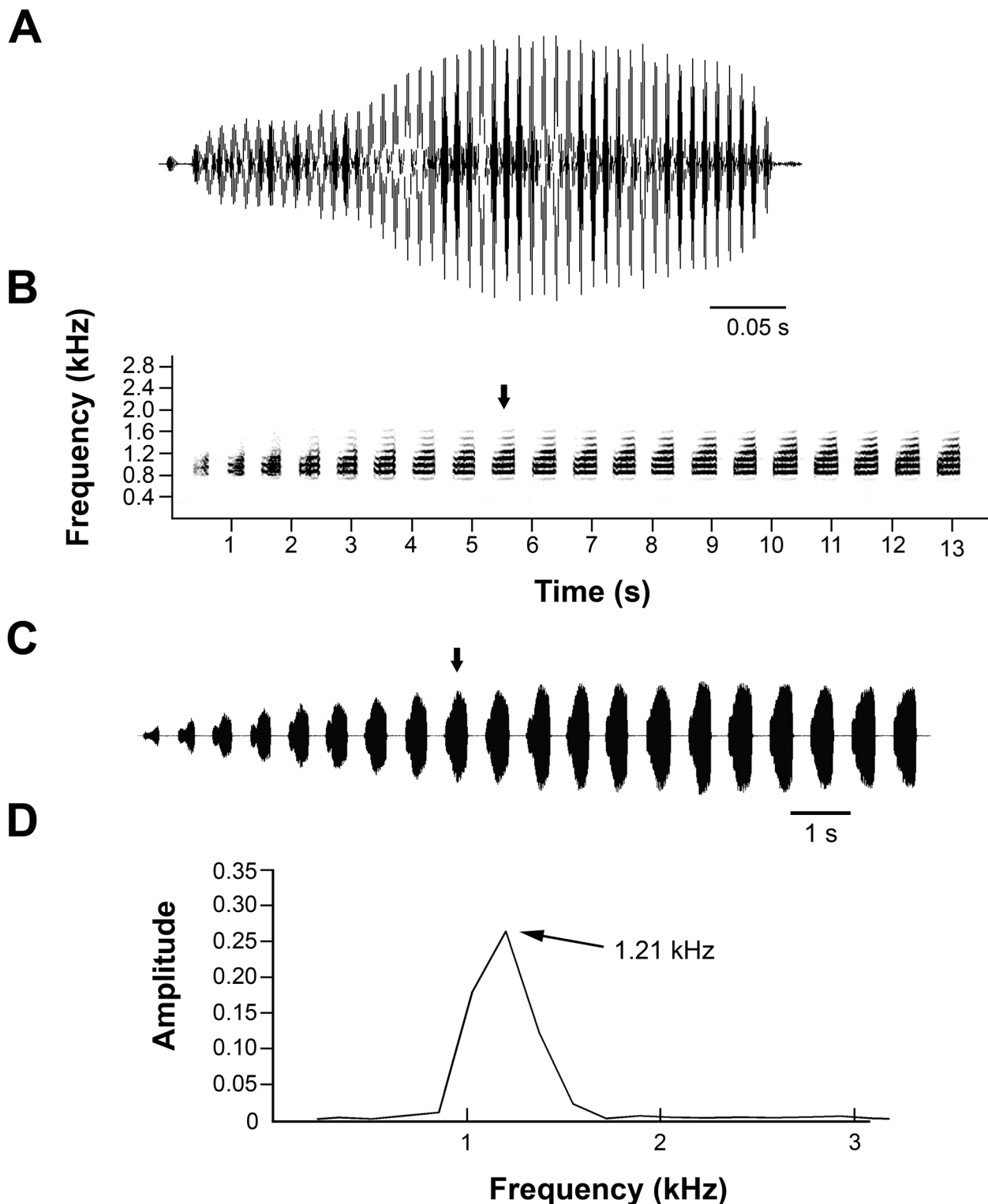


FIGURE 4. Advertisement call of *Proceratophrys sanctaritae*. Oscillogram (A) of a multi-pulsed call (= note) emitted by the paratopotype UFBA 8488 featuring a bowling pin-shaped waveform. The audiospectrogram (B) and oscillogram (C) represent a complete trill of 20 calls. Arrows indicate the call used to build the oscillogram (A) and power spectrum (D). Vocalization recorded on 19 May 2009, at 12h; air temperature 22.5°C.

Geographic distribution. *Proceratophrys sanctaritae* is known only from the locality of Santa Rita (13°04'S, 39°38'W) at the Serra do Timbó, a mountain range characterized by a rugged relief covered mainly by tropical semi-deciduous forests, and reaching elevations from 800 to 900 m above sea level. This is the northernmost record for a species belonging to the *P. appendiculata* complex. The locality of Santa Rita lies within the Municipality of Amargosa, in the State of Bahia, Brazil, and belongs, with the Serra da Jibóia (12°52'S, 39°28'W), to a set of disjunct mountains located north of the Serra Geral mountain range. The Serra do Timbó is placed in the Vale do Jiquiriçá, western part of the geographic region known as Recôncavo Baiano, and is ca. 95 km northeast from the city of Maracás (13°26'S, 40°25'W). This region was considered by Ab'Sáber (1977) as a transitional area between the Caatinga, Cerrado, and Tropical Atlantic domains. The tropical-humid climate prevails in the Serra do Timbó, but the region is surrounded by sub-humid and semi-arid climates.

Conservation. The forest cover of Serra do Timbó is currently threatened by human activities, mainly by deforestation for the development of banana and cacao cultivations, pastures, and selective logging of species of commercial interest. Concomitantly, the springs that rise in Serra do Timbó and support the water supply of the municipalities of Amargosa, Ubaíra, Matuípe, and Jiquiriçá are also endangered. Currently, the Serra do Timbó is the object of a conservation movement (Timbó's Project) that seeks to protect natural resources including plant and animal species as well as their habitat. The Timbó's Project is developed by the Centro Sapucaia, Núcleo Mata Atlântica (Ministério Público), and by the municipal government of Amargosa. This action includes the creation of a conservation unit with 674 ha of tropical semi-deciduous forest, which will be supported by the Ministério do Meio Ambiente (data obtained from Centro-Sapucaia, 2008, accessible at <http://www.centrosapucaia.org.br>).

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References

- Ab'Sáber, A.N. (1977) Os domínios morfoclimáticos na América do Sul. *Geomorfologia*, 52, 1–21.
- Cruz, C.A.G., Prado, G.M. & Izecksohn, E. (2005) Nova espécie de *Proceratophrys* Miranda-Ribeiro, 1920 do sudeste do Brasil (Amphibia, Anura, Leptodactylidae). *Arquivos do Museu Nacional*, 63, 289–295.
- Duellman, W.E. & Trueb, L. (1986) *Biology of Amphibians*. McGraw Hill, New York, 670 pp.
- Eterovick, P.C. & Sazima, I. (1998) New species of *Proceratophrys* (Anura: Leptodactylidae) from southeastern Brazil. *Copeia*, 1998, 159–164.
- Frost, D.R. (2009) Amphibian Species of the World: an Online Reference. Version 5.3 (12 February, 2009). Electronic Database accessible at <http://research.amnh.org/herpetology/amphibia/> American Museum of Natural History, New York, USA (accessed 04 December 2009)
- Giaretta, A.A., Bernarde, P.S. & Kokubum, M.N.C. (2000) A new species of *Proceratophrys* (Anura: Leptodactylidae) from the Amazon Rain Forest. *Journal of Herpetology*, 34, 173–178.
- Heyer, W.R., Rand, A.S., Cruz, C.A.G., Peixoto, O.L. & Nelson, C.E. (1990) Frogs of Boracéia. *Arquivos de Zoologia*,

31, 231–410.

- Izecksohn, E., Cruz, C.A.G. & Peixoto, O.L. (1998) Sobre *Proceratophrys appendiculata* e algumas espécies afins (Amphibia; Anura; Leptodactylidae). *Revista da Universidade Rural, Série Ciências da Vida*, 20, 37–54.
- Izecksohn, E., Carvalho-e-Silva, S.P. & Deiss, I. (2005) O osteocrânio de *Proceratophrys boiei* (Wied-Newied), *P. appendiculata* (Günther), *P. melanopogon* (Miranda-Ribeiro) e *P. laticeps* Izecksohn & Peixoto (Anura, Leptodactylidae). *Revista Brasileira de Zoologia*, 22, 225–229.
- Kwet, A. & Baldo, D. (2003) Advertisement call of the leptodactylid frog *Proceratophrys avelinoi*. *Amphibia-Reptilia*, 24, 104–107.
- Kwet, A. & Faivovich, J. (2001) *Proceratophrys bigibbosa* species group (Anura: Leptodactylidae), with description of a new species. *Copeia*, 2001, 203–215.
- Lima, A.M.X. (2007) *Proceratophrys avelinoi* (Cow Frog). Advertisement call. *Herpetological Review*, 38, 191.
- Lynch, J.D. (1971) Evolutionary relationships, osteology, and zoogeography of leptodactyloid frogs. *Miscellaneous Publication, Museum of Natural History, University of Kansas*, 53, 1–238.
- Nunes, I. & Juncá, F.A. (2006) Advertisement calls of three leptodactylid frogs in the State of Bahia, northeastern Brazil (Amphibia, Anura, Leptodactylidae), with considerations on their taxonomic status. *Arquivos do Museu Nacional*, 64, 151–157.
- Prado, G.M. & Pombal, J.P. (2008) Espécies de *Proceratophrys* Miranda-Ribeiro, 1920 com apêndices palpebrais (Anura; Cycloramphidae). *Arquivos de Zoologia*, 39, 1–85.
- Savage, J.M. & Heyer, W.R. (1997) Digital webbing formulae for anurans: a refinement. *Herpetological Review*, 28, 131.
- Weygoldt, P. & Peixoto, O.L. (1985) A new species of horned toad (*Proceratophrys*) from Espírito Santo, Brazil (Amphibia: Salientia: Leptodactylidae). *Senckenbergiana Biologica*, 66, 1–8.