

## A new species of *Proceratophrys* (Anura: Odontophrynidae) from the middle São Francisco River, southeastern Brazil

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**Abstract.** A new species of the *Proceratophrys cristiceps* group is described from the middle São Francisco River, Minas Gerais state, Brazil, based on adult morphology and advertisement call. *Proceratophrys carranca* sp. n. is characterized by medium size, tubercular sagittal crests from eyelids to sacral region, subarticular tubercle of finger I sulcated, inner metacarpal tubercle oval, and a multi-noted advertisement call.

Key words. Amphibia, Cerrado, *Proceratophrys carranca* sp. n., taxonomy, vocalization.

### Introduction

The genus *Proceratophrys* MIRANDA-RIBEIRO, 1920 is distributed in Brazil, northeastern Argentina, and Paraguay, and currently comprises 30 species (PRADO & POMBAL 2008, ÁVILA et al. 2011, MARTINS & GIARETTA 2011, ÁVILA et al. 2012, CRUZ et al. 2012, TEIXEIRA JR. et al. 2012, FROST 2013) divided in four main species groups based on morphological similarities (see PRADO & POMBAL 2008, CRUZ & NAPOLI 2010), without phylogenetic support (AMARO et al. 2009). Four species [*P. schirchi* (MIRANDA-RIBEIRO, 1937); *P. rondonae* PRADO & POMBAL, 2008; *P. minuta* NAPOLI, CRUZ, ABREU & DEL-GRANDE, 2011; and *P. redacta* TEIXEIRA JR., AMARO, RECODER, DAL-VECHIO & RODRIGUES, 2012] are not included in any complex or group, based on their external morphologies (see PRADO & POMBAL 2008, NAPOLI et al. 2011, TEIXEIRA JR et al. 2012).

The *Proceratophrys boiei* group (sensu IZECKSOHN et al. 1998) is characterized by species with a single and long unicuspidate palpebral appendage and lack of a triangular rostral appendage, and includes *P. boiei* (WIED-NEUWIED, 1824), *P. renalis* (MIRANDA-RIBEIRO, 1920), and *P. pavotii* CRUZ, PRADO & IZECKSOHN, 2005. The *P. appendiculata* group is characterized by species with a single and long unicuspidate palpebral appendage and presence of a triangular rostral appendage (TEIXEIRA JR et al. 2012), and includes *P. appendiculata* (GÜNTHER, 1873), *P. melanopogon* (MIRANDA-RIBEIRO, 1926), *P. laticeps* IZECKSOHN &

PEIXOTO, 1981, *P. moehringi* WEYGOLDT & PEIXOTO, 1985, *P. phyllostomus* IZECKSOHN, CRUZ & PEIXOTO, 1998, *P. subguttata* IZECKSOHN, CRUZ & PEIXOTO, 1999, *P. tupinamba* PRADO & POMBAL, 2008, and *P. sanctaritae* CRUZ & NAPOLI, 2010. The *P. bigibbosa* species group (sensu KWET & FAIVOVICH 2001) includes species without palpebral and rostral fleshy appendages and presence of postocular swellings, and includes *P. bigibbosa* (PETERS, 1872), *P. avelinoi* MERCADAL DE BARRIO & BARRIO, 1993, *P. palustris* GIARETTA & SAZIMA, 1993, and *P. brauni* KWET & FAIVOVICH, 2001. Finally, the *P. cristiceps* species group (sensu GIARETTA et al. 2000) is made up of species without palpebral appendages and postocular swellings, and currently comprises ten species: *P. cristiceps* (MÜLLER, 1883), *P. goyana* (MIRANDA-RIBEIRO, 1937), *P. cururu* ETEROVICK & SAZIMA, 1998, *P. moratoi* (JIM & CARAMASCHI, 1980), *P. concavumpanum* GIARETTA, BERNARDE & KOKUBUM, 2000, *P. strussmannae* ÁVILA, KAWASHITA-RIBEIRO & MORAIS, 2011, *P. vielliardi* MARTINS & GIARETTA, 2011, *P. aridus* CRUZ, NUNES & JUNCÁ, 2012, *P. caramaschii* CRUZ, NUNES & JUNCÁ, 2012, and *P. huntingtoni* ÁVILA, PANSONATO & STRÜSSMANN, 2012.

During fieldwork carried out in the Buritizeiro municipality, Minas Gerais state, southeastern Brazil, we found specimens of *Proceratophrys* that differed from all other species of the genus. Herein, we describe this population as a new species belonging to the *P. cristiceps* group, based on their adult morphology, colour pattern, and advertise-

ment call. We furthermore provide information on its natural history.

### Material and methods

Fieldwork was carried from 20 November to 21 December 2011 and 8–14 November 2012 during the rainy season, in the Buritizeiro municipality. The specimens of *Proceratophrys* were observed calling along small, seasonal streams, located on the Fazenda Serra do Cristal. A total of 17 adult males were collected, killed with Xilocaine 5%, fixed in 10% formalin, preserved in 70% alcohol, and referred to the herpetological collection of the Museu de Zoologia João Moojen, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil. Specimens examined and used for comparison are from the following Brazilian herpetological collections: Coleção Zoológica de Vertebrados, Universidade Federal de Mato Grosso (UFMT), Cuiabá, Mato Grosso state; Museu de Zoologia Adão José Cardoso, Universidade Estadual de Campinas (ZUEC), Campinas, São Paulo state; Museu de Ciências e Tecnologia da PUCRS (MCP), Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul state; Universidade Federal de Uberlândia (AAG-UFU), Uberlândia and Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais state; Museu Nacional, Rio de Janeiro (MNRJ), Rio de Janeiro state; and Museu de Zoologia João Moojen, Universidade Federal de Viçosa, Viçosa (MZUFV), Minas Gerais state (Appendix I). We also used the following published literature data: ETEROVICK & SAZIMA (1998), GIARETTA et al. (2000), KWET & FAIVOVICH (2001), PRADO & POMBAL (2008), CRUZ & NAPOLI (2010), ÁVILA et al. (2011), MARTINS & GIARETTA (2011), NAPOLI et al. (2011), ÁVILA et al. (2012), CRUZ et al. (2012), TEIXEIRA JR et al. (2012).

Terminology used to describe the external morphology and diagnostic features follows PRADO & POMBAL (2008) and CRUZ et al. (2012). We took the following measurements from adult specimens (males) with digital callipers to the nearest 0.1 mm, following the terminology of HEYER et al. (1990) and PRADO & POMBAL (2008): SVL (snout-vent length), HL (head length), HW (head width), ED (eye diameter), END (eye–nostril distance), IND (internarial distance), IOD (interorbital distance), HDL (hand length), FO (forearm), THL (thigh length), TL (shank length), and FL (foot length). Additionally, the following measurement was included: IMCL (inner metacarpal tubercle length). Webbing formula notation follows SAVAGE & HEYER (1997).

Advertisement calls were recorded with digital recorders (Olympus Digital Voice Recorder DM-420 and Olympus DM-520° digital recorder coupled with an Audio-Technica Pro 24 stereo condenser microphone). Calls were analysed using Raven 1.4 beta for Windows (Cornell Lab of Ornithology Research Program Bioacoustics Workstation), at a sampling frequency of 44.1 kHz and 16-bit resolution. A sound oscillogram and a spectrogram were produced with the following parameters: FFT = 256, Overlap =

89.8% and hamming window type. Description and terminology of acoustic properties follows DUELLMAN & TRUEB (1994).

### Description of a new species

#### *Proceratophrys carranca* sp. n.

Figs. 1–3

**Holotype:** An adult male (MZUFV 11710) collected at the Fazenda Serra do Cristal, Buritizeiro municipality, region of the middle São Francisco River, Minas Gerais state, southeastern Brazil (17°24'13" S, 45°03'36" W; 654 m a.s.l.) on 21 December 2011, by L. B. GODINHO, M. A. PEIXOTO and M. R. MOURA.

**Paratopotypes:** One adult male (MZUFV 11707) collected on 20 November 2011 by L. B. GODINHO and three adult males (MZUFV 11708–11710) collected on 17 December 2011, by L. B. GODINHO and M. A. PEIXOTO. Three adult males (MZUFV 12810–12812) collected on 8 November 2012 by L. B. GODINHO, and nine adult males (MZUFV 12809, MZUFV 12813–12820) collected on 14 November by L. B. GODINHO and M. A. PEIXOTO.

**Diagnosis:** The new species belongs to the genus *Proceratophrys* as it has nuptial pads absent, enlarged glands absent, finger webbing absent, supernumerary tubercles present on hands and feet, dorsal surfaces of fingers and toes wrinkled, and is assigned to the *P. cristiceps* species group (sensu GIARETTA et al. 2000) due to the absence of prominent palpebral and rostral appendages and postocular swellings. Regarding species from the *P. cristiceps* group, the new species can be differentiated from its other members by the following combination of traits: (1) medium size (31.6–39.9 mm SVL in males), (2) eyelids rounded, (3) snout rounded in dorsal view and obtuse/blunt in profile, (4) canthal crests poorly defined, (5) frontoparietal crest not developed, (6) presence of sagittal ridges of warts less defined from eyelids to sacral region, (7) gular region blackish and belly cream with smaller scattered light brown markings, (8) two supernumerary tubercles divided, located after the subarticular tubercle of finger I, (9) inner metacarpal tubercle oval, (10) subarticular tubercle of the hand furrowed in its frontal part, (11) webbing formula I 1–2<sup>+</sup> II 1<sup>+</sup>–3<sup>+</sup> III 2<sup>+</sup>–4<sup>+</sup> IV 4–2<sup>+</sup> V, and (12) a distinctive advertisement call with 1–10 multipulsed notes, lasting 45.0–1478.0 ms, notes with 5–21 pulses, lasting 45.0–191.0 ms and dominant frequency of 1033.6–1378.1 Hz.

**Comparison with other species:** *Proceratophrys carranca* sp. n. can be readily distinguished from all species belonging to the *P. appendiculata* and *P. boiei* groups by the absence of a single and long unicuspidate palpebral appendage (present in both other species groups). The new species differs from those belonging to the *P. bigibbosa* group



Figure 1. *Proceratophrys carranca* sp. n., adult male; holotype (MZUFV 11710) in dorsal (left) and ventral (right) views. SVL 33.7 mm. Scale bar = 10 mm. Photo: J. LINO-NETO.

by lacking postocular swellings (present in those species). Regarding those four species that are not assigned to any of the four species groups, *P. carranca* sp. n. can be readily distinguished from *P. minuta*, *P. rondonae* and *P. schirchi* by lacking the palpebral appendage [short, multicuspidate in *P. rondonae* (PRADO & POMBAL 2008); the short palpebral appendage with marginal pointed tubercles in *P. minuta* (NAPOLI et al. 2011) and also present in *P. schirchi*, TEIXEIRA JR et al. 2012], and from the recently described *P. redacta* by its larger snout-vent length (26.9–29.7 mm SVL in males of *P. redacta*; TEIXEIRA JR et al. 2012).

Within the *Proceratophrys cristiceps* group, the new species differs from all other species by a combination of traits: *Proceratophrys carranca* sp. n. differs from *P. aridus* by having the snout rounded in dorsal view (triangular in *P. aridus*), presence of sagittal ridges of warts less defined from eyelids to sacral region (sagittal ridges of warts from eyelids to urostyle region in *P. aridus*), subarticular tubercle of the hand furrowed in its frontal part (not furrowed in *P. aridus*), and gular region blackish (not blackish in *P. aridus*). *Proceratophrys carranca* sp. n. can be distinguished from *P. caramaschii* by its smaller size, SVL 31.6–39.9 mm in the male (SVL 51.6–56.5 mm in *P. caramaschii*), wider head, HL/HW 87–95% (78–86% in *P. caramaschii*), and frontoparietal crest not developed (presence of pronounced frontoparietal ridges with a depression between them in *P. caramaschii*). The new species can be distinguished from *P. concavitympanum* by its smaller size, SVL 31.6–39.9 mm in males (SVL 39.6–51.8 mm in *P. concavitympanum*), canthal crests less defined (better defined in *P. concavitympanum*), eyelids bordered with tubercles of uniform size (triangular tubercles of different sizes in *P. concavitympanum*), and belly pattern predominantly

cream with irregular, smaller, light brown blotches (scattered, larger, dark brown markings in *P. concavitympanum*). *Proceratophrys carranca* sp. n. can be differentiated from *P. cristiceps* by its smaller size, SVL 31.6–39.9 mm in males (SVL 40.6–49.1 mm in *P. cristiceps*), wider head, HL/HW 87–95% (77–84% in *P. cristiceps*), snout obtuse in profile (vertical in *P. cristiceps*), presence of sagittal ridges of warts less defined from eyelids to sacral region (sagittal ridges of warts clear defined from eyelids to urostyle region in *P. cristiceps*), subarticular tubercle of the hand furrowed in its frontal part (not furrowed in *P. cristiceps*), and webbing formula I 1–2<sup>+</sup> II 1<sup>+</sup>–3<sup>+</sup> III 2<sup>+</sup>–4<sup>+</sup> IV 4–2<sup>+</sup> V (versus I 1–2<sup>1/2</sup> II 2–3 II 2<sup>1/2</sup>–4<sup>1/2</sup> IV 4<sup>1/2</sup>–2<sup>1/2</sup> in *P. cristiceps*). From *P. cururu*, the new species differs by its smaller and uniformly sized dorsal tubercles (larger size in *P. cururu*), belly pattern predominantly cream with irregular, smaller, light brown blotches (cream with vermiculated dark brown blotches in *P. cururu*), and the presence of two supernumerary tubercles, above the subarticular callus of finger I (a single undivided tubercle in *P. cururu*). *Proceratophrys carranca* sp. n. differs from *P. goyana* by its snout being obtuse in profile (vertical in *P. goyana*), rounded eyelids (triangular in *P. goyana*), and the presence of a pair of sagittal ridges of little defined warts from eyelids to sacral region (sagittal ridges of warts well defined from eyelids to urostyle in *P. goyana*). The new species can be differentiated from *P. huntingtoni* by a transversal interocular blotch that is more evident (thinner, resembling a v-shaped marking in *P. huntingtoni*, Fig. 4), canthal crests less defined (better defined in *P. huntingtoni*), sagittal crests less defined, and dorsum adorned with smaller tubercles (sagittal crests well defined, and dorsum adorned with larger tubercles in *P. huntingtoni*), belly pattern predominantly cream with



irregular, smaller, light brown blotches (cream with vermiculated dark brown blotches in *P. huntingtoni*), inner metacarpal tubercle oval and slightly smaller, IMCL/HDL 12.7–17.0% (oval, slightly more elongated, IMCL/HDL 17.4–19.6% in *P. huntingtoni*), the presence of less prominent and smaller tubercles in the cloacal/ischium region (presence of several prominent and larger tubercles in the cloacal/ischium region in *P. huntingtoni*), and a webbing formula of I 1–2<sup>+</sup> II 1<sup>+</sup>–3<sup>+</sup> III 2<sup>+</sup>–4<sup>+</sup> IV 4–2<sup>+</sup> V (versus I 1–2<sup>+</sup> II 2<sup>+</sup>–3<sup>+</sup> III 3–2<sup>½</sup> IV 3<sup>+</sup>–2<sup>+</sup> V in *P. huntingtoni*; ÁVILA et al. 2012). *Proceratophrys carranca* sp. n. differs from *P. moratoi* by its larger size, SVL 31.6–39.9 mm in males (SVL 28.2–30.7 mm in *P. moratoi*), snout obtuse in profile (vertical in *P. moratoi*), canthal crests less defined (better defined in *P. moratoi*), presence of a pair of sagittal ridges of warts,

interrupted in the sacral region (absence of sagittal ridges in *P. moratoi*), and longer legs, range TH 12.1–16.4 mm (9.0–10.7 mm in *P. moratoi*). *Proceratophrys carranca* sp. n. can be distinguished from *P. strussmannae* by its smaller size SVL of 31.6–39.9 mm in males (SVL 41.1–47.3 mm in *P. strussmannae*), canthal crests less defined (better defined in *P. strussmannae*), and slightly narrower head in males with HW/SVL 44.5% (HW/SVL 46.6% SVL in *P. strussmannae*, ÁVILA et al. 2011). From *P. vielliardi*, the new species can be distinguished by the presence of sagittal ridges of warts that are interrupted in the sacral region (absence of sagittal ridges in *P. vielliardi*), less elevated warts on dorsum (elevated in *P. vielliardi*), belly pattern cream with scattered, smaller, light brown blotches (belly cream and without blotches in *P. vielliardi*), subarticular tuber-

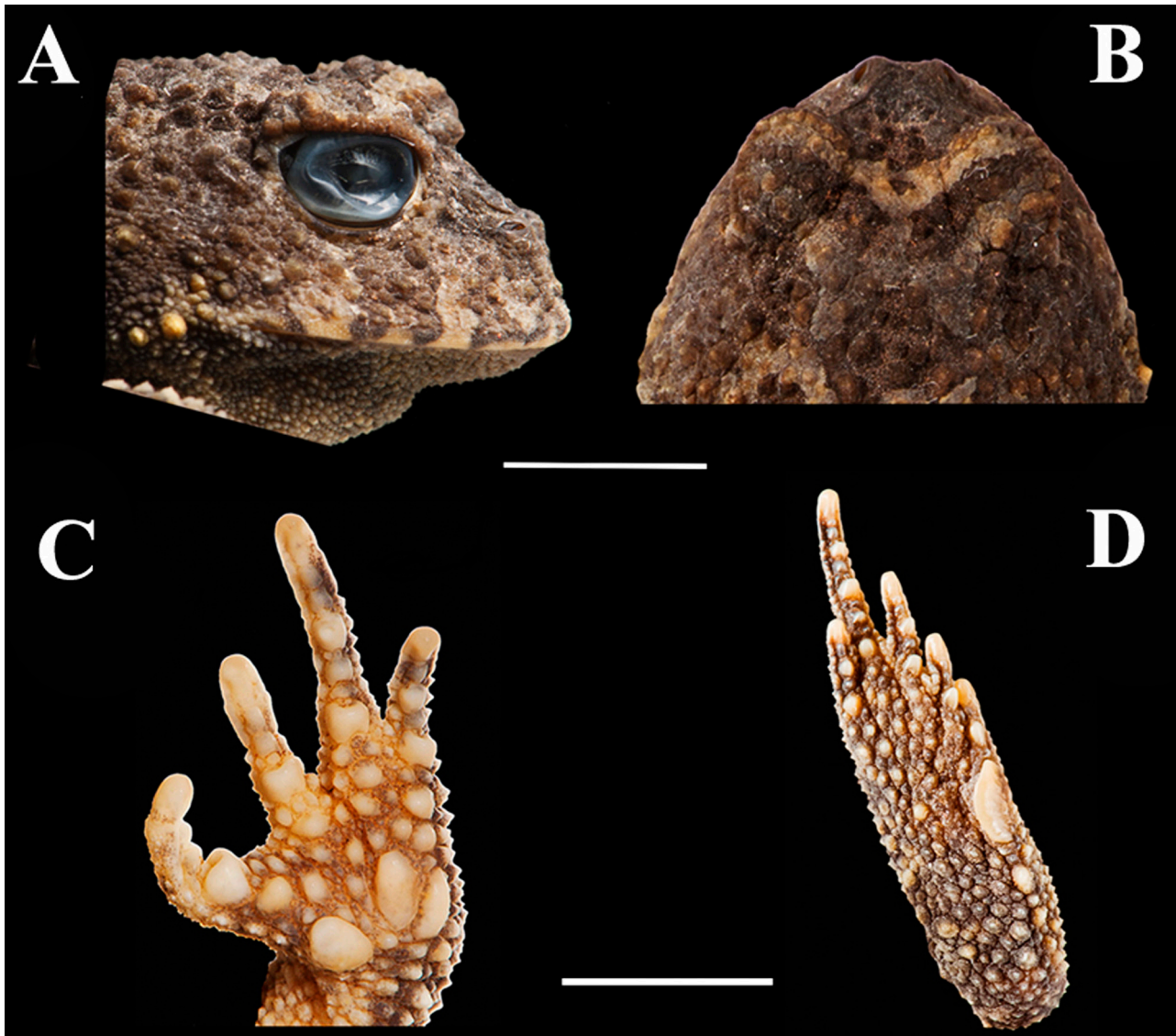


Figure 2. *Proceratophrys carranca* sp. n., adult male; holotype (MZUFV 11710). A) Lateral view of head; B) dorsal view of head; C) ventral view of left hand; D) ventral view of left foot. Scale bar = 10 mm. Photo: J. LINO-NETO.



cle of the hand furrowed in frontal part (not furrowed in *P. vielliardi*), and foot slightly smaller, FL/SVL 39% (larger, FL/SVL 43% in *P. vielliardi*).

The advertisement call of *Proceratophrys carranca* sp. n. (1–10 notes) is most similar to that of *P. vielliardi* (3–20 notes), as the other species of the genus with described vocalization have calls with only a single note (Table 3). These two species are also similar regarding the duration of the last note (last note longer than the others in *P. vielliardi* and last note longer in 44 out of the 52 calls in *P. carranca* sp. n.). However, the new species has a lower number of notes/call (3–20 notes/call,  $9.1 \pm 5$ ,  $n=35$  calls in *P. vielliardi*) and, without considering the lasts notes, *P. carranca* sp. n. produces longer notes with more pulses (Table 3).

Description of the holotype: Male with an ovoid, stout and warty body. Head wider than long (HW/SVL 45.5%; HL/SVL 43.4%); snout rounded in dorsal view and obtuse in profile; nostrils elliptic and directed dorsolaterally (END/

ED 58.5%); eyes prominent, directed anterolaterally; eyes small (ED/HL 36.2%; ED/SVL 15.7%); canthal crests not evident on the canthus rostralis (barely distinct); loreal region concave; interocular crest absent; eyelids oval and short, bordered with tubercles of uniform size, and without a horn-like appendage; tympanum indistinct; no postocular swellings; vocal sac single, subgular and blackish. External side of the forearms with a row of triangular tubercles to the hand; relative finger lengths  $IV < II < I < III$ ; interdigital webbing absent; outer metacarpal tubercle divided in two oval parts; inner metacarpal tubercle oval and larger than the external part of the outer metacarpal tubercle, supernumerary tubercles present; subarticular tubercles prominent, sulcate in frontal part, aspect bifid. Legs moderately robust, thigh slightly longer than tibia (THL/SVL 40.5%; TL/SVL 37.4%); relative 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, spatulate; outer metatarsal tubercle small and rounded; supernumerary tuber-

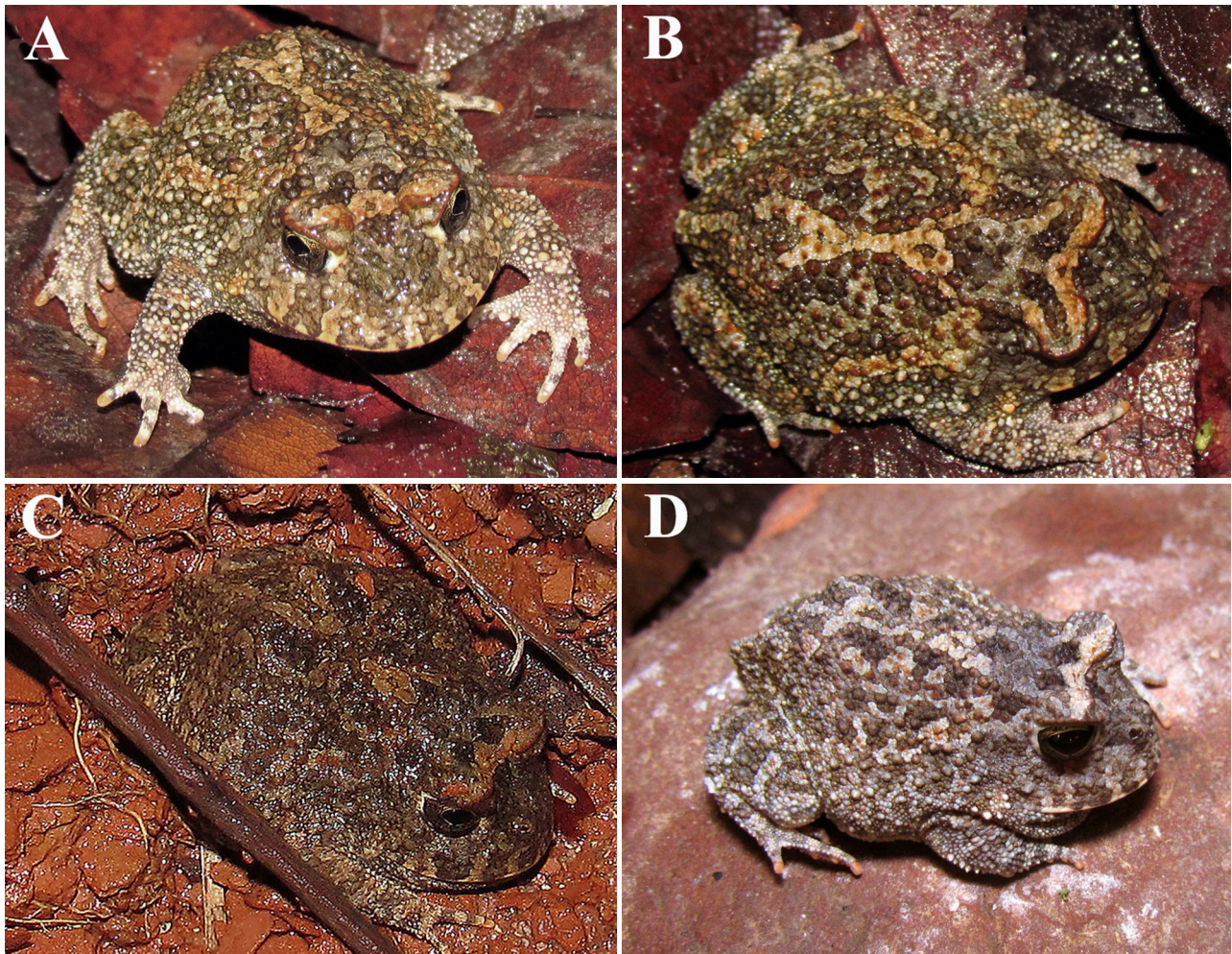


Figure 3. Adult males of *Proceratophrys carranca* sp. n. in life. A–B) holotype (MZUFV 11710); C) paratopotype (MZUFV12811); D) paratopotype (MZUFV11708). Photos: A–B: M. R. MOURA, C–D: L. B. GODINHO.



cles present; subarticular tubercles large and conical. Dorsal surfaces with rough conical tubercles of varying size, distributed regularly (more on the dorsum than on the flanks); two or more prominent tubercles near the corner of the buccal commissure; dorsum adorned with sinuous longitudinal ridges that extend to the sacral region, outlining an X-shaped ornamentation; ventral surfaces warty, granules circular and uniform in size and with blackish blotches; frontoparietal crest not developed.

Measurements of holotype (mm): SVL 33.7; HL 15.3; HW 14.6; ED 5.3; IOD 3.2; IND 2.8; END 3.1; THL 13.6; TL 12.6; FL 13.0; HDL 9.0; FO 8.2.

In preservative, the background colour of the dorsal surface varied from light brown to dark brown. Longitudinal ridges of the X-shaped ornamentation on dorsum dark brown to reddish brown, not contrasting with the dorsal ground colouration. The mid-dorsal region, within the

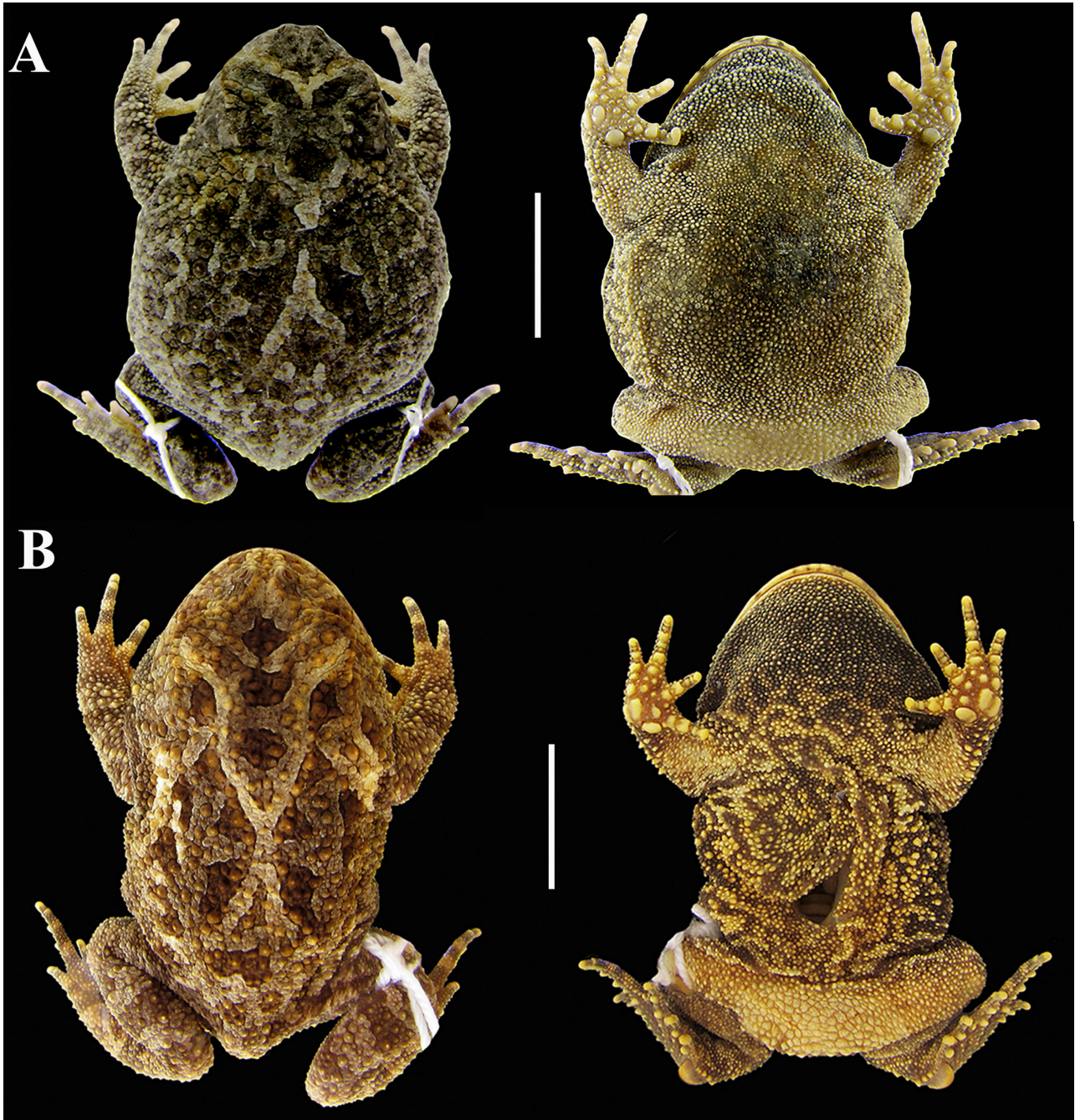


Figure 4. Preserved specimens of *P. carranca* sp. n. and *P. huntingtoni*. A) *P. carranca* sp. n. (MZUFV 11708, paratopotype); B) *P. huntingtoni* (UFTM A 1743, paratopotype). Scale bar = 10 mm.

limits of the X-shaped ornamentation, is predominantly cream. Irregular dark brown markings distributed over the dorsum and along the flanks. Warts on dorsum vary from light brown to dark brown. Palpebral appendages reddish brown, with a cream transversal bar between the eyelids. Upper lip cream-coloured, with several dark brown stripes along the canthus rostralis from posterior corner of eye and nostril to upper lip. Ventral ground colour yellowish brown; darker brown on throat and limbs, and with irregular dark brown markings distributed on chest and belly. Ventral surfaces of arms with a cream background colour. Palms and soles dark brown; subarticular and supernumerary tubercles cream-coloured. Colouration in life is similar to that in preservative, but colours are more vivid.

Variation: Some specimens present a sagittal crest on the dorsum, and their X-shaped ornamentation is little evident. Descriptive statistics of measurement variables from adult males are presented in Table 1. Some specimens (29.5%) have the gular region with smaller dark blotches, whereas 70.5% show a blackish gular region.

Advertisement call: The advertisement call of *P. carranca* sp. n. is described on the basis of three adult males: one recorded on 21 December 2011, at 19:30 h (MZUFV 11710, holotype) at an air-temperature of 24°C; one on 08 November 2012, at 20:00 h (MZUFV 12810), at an air-temperature of 23.8°C, and one male recorded calling on 14 November 2012, at 20:00 h (MZUFV 12813), at an air-temperature of

Table 1. Descriptive statistics of adult specimens of the type series of *Proceratophrys carranca* sp. n. from the Fazenda Serra do Cristal, Buritizeiro municipality, Minas Gerais state, Brazil. Mean  $\pm$  standard deviation (minimum–maximum). Measurements are in millimetres.

| Character                        | Males (n = 17)             |
|----------------------------------|----------------------------|
| Snout–vent length                | 35.0 $\pm$ 2.4 (31.6–39.9) |
| Head width                       | 15.6 $\pm$ 1.4 (13.2–18.7) |
| Head length                      | 14.3 $\pm$ 1.3 (12.3–17.5) |
| Eye diameter                     | 4.9 $\pm$ 0.5 (4.0–5.9)    |
| Internarial distance             | 2.4 $\pm$ 0.6 (1.7–3.2)    |
| Interorbital distance            | 3.3 $\pm$ 0.5 (2.4–4.5)    |
| Eye–nostril distance             | 2.8 $\pm$ 0.3 (2.3–3.6)    |
| Thigh length                     | 14.1 $\pm$ 1.2 (12.1–16.4) |
| Shank length                     | 12.8 $\pm$ 1.0 (11.2–15.7) |
| Foot length                      | 13.8 $\pm$ 1.1 (12.3–16.6) |
| Hand length                      | 9.4 $\pm$ 0.9 (8.1–12.2)   |
| Forearm                          | 8.4 $\pm$ 0.9 (7.0–10.9)   |
| Inner metacarpal tubercle length | 1.4 $\pm$ 0.1 (1.3–1.5)    |

24.8°C. All calling males were found on the ground (not buried), between small shrubs, at the margin of a small, seasonal rocky stream (17°24'13" S, 45°03'36" W).

The recorded advertisement calls of *Proceratophrys carranca* sp. n. are composed of 1–10 multipulsed notes ( $4.0 \pm 1.9$ ;  $n = 76$  calls) of 45.0–1478.0 ms in duration (Table 2) and in-

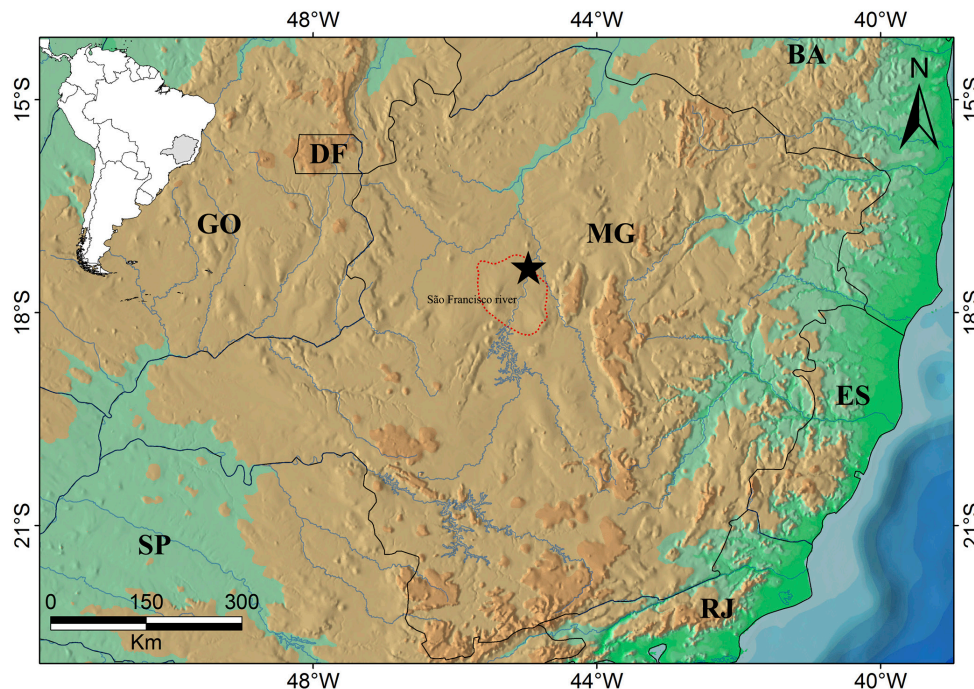


Figure 5. Map showing the geographic distribution of *Proceratophrys carranca* sp. n. Asterisk indicates type locality. Red dashed line: boundaries of the “Buritizeiro/Pirapora” region, a priority area for herpetofaunal conservation in Minas Gerais state. Abbreviations indicate the Brazilian states. MG: Minas Gerais state; BA: Bahia state; GO: Goiás state; ES: Espírito Santo state; RJ: Rio de Janeiro state; SP: São Paulo state; DF: Distrito Federal state.



Table 2. Vocalization of *Proceratophrys carranca* sp. n. from the Fazenda Serra do Cristal, Buritizeiro municipality, Minas Gerais state, Brazil. N = 73 calls, 3 males.

| Notes/call | Number of calls | Call duration (ms)    | Note/sec                 |
|------------|-----------------|-----------------------|--------------------------|
| 1          | 3               | 45; 45; 80            | –                        |
| 2          | 15              | 291–406 (370 ± 32)    | 4.92–6.87 (5.34 ± 0.525) |
| 3          | 15              | 397–606 (480 ± 62)    | 4.95–7.55 (6.34 ± 0.81)  |
| 4          | 16              | 462–681 (550 ± 40)    | 5.87–8.65 (7.23 ± 0.62)  |
| 5          | 13              | 575–861 (691 ± 89)    | 5.80–8.69 (7.33 ± 0.875) |
| 6          | 7               | 749–859 (810 ± 47)    | 6.98–8.01 (7.42 ± 0.44)  |
| 7          | 4               | 929–1197 (1094 ± 128) | 5848–7535 (6472 ± 799)   |
| 10         | 3               | 1470; 1478; 1478      | 6765; 6765; 6802         |

Table 3. Advertisement calls described for the genus *Proceratophrys*. Modified table from ÁVILA et al. (2012), with data added from the present study. Values are presented as mean ± SD (range), SD = standard deviation.

| Taxa                      | Notes/call  | Dominant Frequency (Hz)            | Note Duration (ms)            | Pulses/call                 | Reference                 |
|---------------------------|-------------|------------------------------------|-------------------------------|-----------------------------|---------------------------|
| <i>P. avelinoi</i>        | Single note | 1600.0<br>(1050.0–2300.0)          | 1600.0–1900.0                 | 37.5 ± 9.4<br>(23.0–70.0)   | KWET & BALDO (2003)       |
| <i>P. bigibbosa</i>       | Single note | 1050<br>(500.0–1400.0)             | 1600–1900                     | 40.0–45.0                   | KWET & FAIVOVICH (2001)   |
| <i>P. boiei</i>           | Single note | 600<br>(350.0–1350.0)              | 700–800                       | 30.0–35.0                   | HEYER et al. (1990)       |
| <i>P. brauni</i>          | Single note | 1350.0<br>(800.0–1800.0)           | 790.0<br>(700.0–900.0)        | 26.0<br>(24.0–28.0)         | KWET & FAIVOVICH (2001)   |
| <i>P. carranca</i> sp.n.  | 1–10 notes  | 1178.0 ± 65.5<br>(1033.6–1378.1)   | 107.4 ± 36.1<br>(45.0–191.0)  | 12.2 ± 3.9<br>(5.0–21.0)    | Present work              |
| <i>P. concavitympanum</i> | Single note | 948.0 ± 67.0<br>(851.0–1186.0)     | 367.0 ± 58.0<br>(230.0–500.0) | 30.85 ± 4.81<br>(19.0–37.0) | SANTANA et al. (2010)     |
| <i>P. cristiceps</i>      | Single note | 940.0 ± 20.0<br>(900.0–990.0)      | 660.0 ± 50.0<br>(520.0–790.0) | 57.46 ± 6.02<br>(46.0–69.0) | NUNES & JUNCÁ (2006)      |
| <i>P. cururu</i>          | Single note | 900.0<br>(600.0–1000.0)            | 1200.0                        | 40.0                        | ETEROVICK & SAZIMA (1998) |
| <i>P. huntingtoni</i>     | Single note | 1250.2 ± 49.9<br>(1095.0–1344.5)   | 270.0 ± 10.0<br>(200.0–300.0) | 21.3 ± 1.2<br>(19.0–25.0)   | ÁVILA et.al. (2012)       |
| <i>P. melanopogon</i>     | Single note | 1179.0 ± 66.66<br>(999.12–1274.10) | 390.0 ± 60.0<br>(170.0–480.0) | 28.9 ± 4.6<br>(12.0–41.0)   | MÂNGIA et al. (2010)      |
| <i>P. moehringi</i>       | Single note | 450.0<br>(200.0–700.0)             | 3500.0–4000.0                 | 140.0                       | WEYGOLDT & PEIXOTO (1985) |
| <i>P. moratoi</i>         | Single note | 1342.0 ± 73.7<br>(1174.0–1444.0)   | 245.0 ± 20.0<br>(100.0–300.0) | 20.5 ± 2.5<br>(15.0–26.0)   | BRASILEIRO et al. (2008)  |
| <i>P. moratoi</i>         | Single note | 1327±108<br>(1219–1464)            | 253.0 ± 36.0<br>(179.0–335.0) | 19.0 ± 2.0<br>(14.0–23.0)   | MARTINS & GIARETTA (2012) |
| <i>P. paviotii</i>        | Single note | 660.0–1280.0                       | 387.0 ± 28.0<br>(347.0–427.0) | 28.14 ± 2.12<br>(26.0–32.0) | CRUZ et al. (2005)        |
| <i>P. sanctaritae</i>     | Single note | 1130.0<br>(950.0–1290.0)           | 400.0<br>(200.0–900.0)        | 46.70 ± 6.40<br>(31.0–94.0) | CRUZ & NAPOLI (2010)      |
| <i>P. vielliardi</i>      | 3–23 notes  | 1133.8 ± 93.3<br>(1022.0–1291.0)   | 59.0 ± 8.3<br>(40.0–84.0)     | 6.4 ± 0.9<br>(4.0–9.0)      | MARTINS & GIARETTA (2011) |

tervals between calls of 568.0–16014.0 ms (3397.9 ± 3234.3; n = 65 intervals). Note duration of 45.0–191.0 ms (107.4 ± 36.1; n = 229 notes), 5–21 pulses/note (12.2 ± 3.9; n = 229 notes), 95.2–131.5 pulses/sec (114.8 ± 6.4; n = 229 notes),

interval between notes 31.0–105.0 sec (48.4 ± 11.7; n = 175 intervals), and a dominant frequency of 1033.6–1378.1 Hz (1178.0 ± 65.5; n = 229 notes). In 21 out of the 76 analysed calls, we measured only the call duration and numbers of



notes per call as the recordings were not appropriate for other analyses due to the presence of stream noise, neighbouring calling males, and the long distance of the recorded males from the recorder. Therefore, measurements of note duration, number of pulses/note, intervals between notes, and dominant frequency were taken only from 55 calls. Fifty-two of these calls had more than one note of which the last one lasted 117.0–191.0 ms ( $151.4 \pm 18.9$ ) and with 13–21 pulses/note ( $16.9 \pm 1.8$ ). In almost 85% ( $n = 44$ ) of these calls, the last note was the longest one. Figure 6 shows the sonogram of 3 calls emitted by a single male and sonograms and spectrograms of each of these calls.

**Natural history:** The specimens were collected calling at night after heavy rains (November and December) along small (50 cm wide, 0–60 cm deep), seasonal, rocky streams. We did not observe the presence of females or mating pairs. Syntopic species included *Dendropsophus minutus* (Peters, 1872), *Odontophrynus cultripes* REINHARDT &

LÜTKEN, 1862, *Hypsiboas crepitans* (WIED-NEUWIED, 1824), and *Physalaemus cicada* BOKERMANN, 1966.

**Distribution:** *Proceratophrys carranca* sp. n. is known only from the type locality, at the Fazenda Serra do Cristal, Buritizeiro municipality, Minas Gerais state, Southeastern Brazil (Fig. 5).

**Etymology:** The specific epithet “*carranca*” is used as a noun in apposition to the generic name. It refers to a sculpture being of human or animal form that is a historical symbol for safe navigation on the São Francisco River and also serves as a symbol of the artisan and commercial culture of many riverine human populations, including those in the municipality in which the new species was discovered.

## Discussion

In recent descriptions of species of the *Proceratophrys cristiceps* group, the character “presence or absence of a sagittal crest” has been considered the main character for the diagnosis of the group (ÁVILA et al. 2011, MARTINS & GIARETTA 2011). However, CRUZ et al. (2012) suggested the futility of this character for definition of the genus, due to the high degree of variation found in the specimens analysed.

Among the 11 species of the *Proceratophrys cristiceps* group, six species (i.e., *P. goyana*, *P. cururu*, *P. moratoi*, *P. vielliardi*, *P. huntingtoni*, and *P. carranca* sp. n.) occur in the Cerrado biome. However, ÁVILA et al. (2011) reported also on the occurrence of *P. goyana* in the Caatinga biome, representing the northern limit of its geographic distribution. *Proceratophrys concavitympanum* is restricted to the Amazon Forest (GIARETTA et al. 2000, SANTANA et al. 2010, BARROS et al. 2011), but has also been reported from the Cerrado of central Brazil (PAVAN 2007), and *P. strussmannae* is distributed in transitional areas between the Amazon Forest and Cerrado (ÁVILA et al. 2011). The species *P. cristiceps* and *P. caramaschii* occur in lowlands of the Atlantic Forest coast, while *P. aridus* is restricted to the Caatinga region (CRUZ et al. 2012). Nonetheless, in their recent review of the distribution of the species of *Proceratophrys*, TEIXEIRA JR et al. (2013) reported on the occurrence of *P. cristiceps* in areas in the Caatinga and Cerrado biome.

Until now, another four species of the *Proceratophrys cristiceps* group have been reported from Minas Gerais state: *Proceratophrys cururu*, *P. goyana*, *P. moratoi*, and *P. vielliardi*. *Proceratophrys cururu* was the only species within this group that had been described from the Serra do Cipó mountains (ETEROVICK & SAZIMA 1998). Currently, its known distribution is associated with the highlands of the Espinhaço mountain range (CRUZ et al. 2012). Concerning other members of the *P. cristiceps* group, the distribution ranges of *P. goyana* and *P. vielliardi* touch Minas Gerais state in their easternmost parts (MARTINS & GIARETTA 2011, BRANDÃO et al. 2012), whereas *P. moratoi* ranges

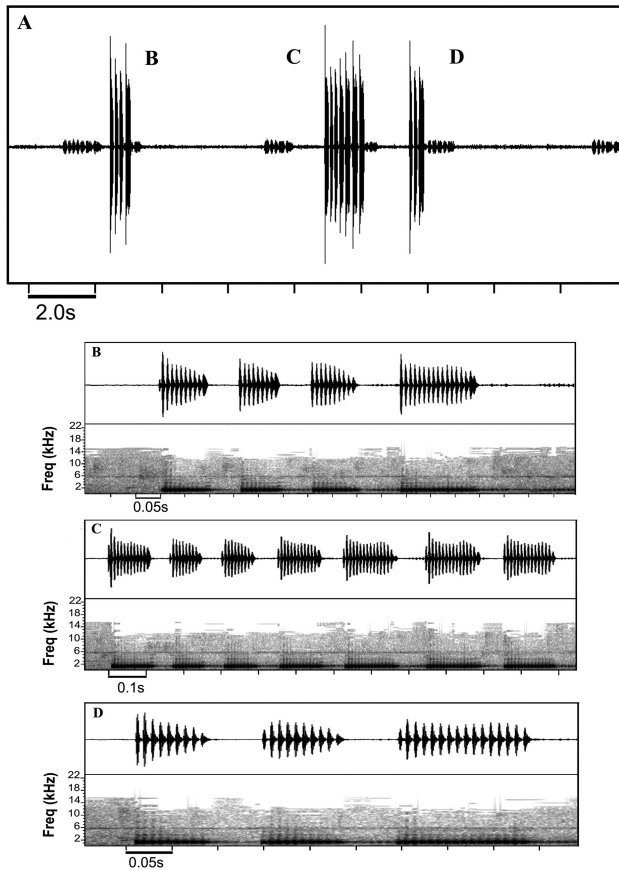


Figure 6. *Proceratophrys carranca* sp. n. (MZUFV 11710, holotype) vocalization: (A) sonogram of three calls emitted by a single male; (B–D) sonogram and spectrogram of these three calls; B) first call composed of four multipulsed notes; C) second call composed of seven multipulsed notes; D) third call composed of three multipulsed notes. Air-temperature: 24°C. Recording obtained at 19:30 h on 21 December 2011.

northward only to the western part of the state. Therefore, *P. carranca* sp. n. is not known to occur sympatric with any species in *P. cristiceps* group.

The type locality of *Proceratophrys carranca* sp. n. is located in the Cerrado biome on the left bank of the São Francisco River. This area is located in the Buritizeiro/Pirapora region (Fig. 5), a priority area for herpetofaunal conservation that is classified as “potential” with regard to its biological importance (DRUMMOND et al. 2005). The Buritizeiro/Pirapora priority area suffers from intense anthropogenic pressures like livestock farming and agriculture, which have already greatly reduced natural landscapes. It is insufficiently known and still deserving of scientific research (DRUMMOND et al. 2005). The present description reinforces the Buritizeiro municipality as an important conservation priority area for herpetofauna. Continued research and the development of new studies will increase not only the possibility of finding other populations of *P. carranca* sp. n., but also improve the knowledge on local amphibians.

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- Proceratophrys moratoi* (n = 4 males): BRAZIL: São Paulo state: Botucatu (ZUEC 7031, MNRJ 15872) São Carlos (ZUEC 17407), Itarapina (ZUEC 16954), Botucatu (MNRJ 15872).
- Proceratophrys cururu* (n = 7 males): BRAZIL: Minas Gerais State (UFMG AMPHIBIA 3946–3947, UFMG AMPHIBIA 3949–3950, UFMG AMPHIBIA 3952, UFMG AMPHIBIA 3954, UFMG AMPHIBIA 10770).
- Proceratophrys concavitympanum* (n = 9 males). BRAZIL: Mato Grosso state, Aripuanã (MZUFV 9550 MZUFV 9552–9557, MZUFV 10477, MZUFV 9548).
- Proceratophrys huntingtoni* (n = 5 males). BRAZIL: Mato Grosso state, Chapada dos Guimarães (UFMT A1746–1747, UFMT 11133–11135, paratopotypes).

## Appendix

### Additional species and specimens examined

- Proceratophrys cristiceps* (n = 8 males): BRAZIL: Bahia State, Feira de Santana (MNRJ 47839). Paraíba state, Areia (MNRJ 50378); Maturéia (MNRJ 54756–54758). Pernambuco state: Arco Verde (MNRJ 58030). Sergipe state: Brejo Grande (MNRJ 50376); São Cristóvão (MNRJ 50377).
- Proceratophrys goyana* (n = 8 males): BRAZIL: Goiás State, Colinas do Sul (MCP 2603, MNRJ 68292–68294, MNRJ 66527); Rio São Miguel (MNRJ 296, lectotype); Veadeiros (MNRJ 297, paralectotype); UHE Serra da Mesa (MNRJ 20212).
- Proceratophrys aridus* (n = 5 males): BRAZIL: Ceará state, Mi-lagres (MNRJ 55782, holotype, MNRJ 75156–75157, MNRJ 75164, MNRJ 75167, paratopotypes).
- Proceratophrys caramaschii* (n = 5 males): BRAZIL: Ceará state, Fortaleza (MNRJ 16592, holotype, MNRJ 16596–16598, MNRJ 1420, paratopotypes).
- Proceratophrys strussmannae* (n = 3 males): BRAZIL: Mato Grosso state, Vale de São Domingos (UFTM 7885, UFTM 8377, UFTM 8380, paratype).
- Proceratophrys vielliardi* (n = 2 males): BRAZIL: Goiás state, Caldas Novas (AAG–UFU4 314, AAG–UFU 3206, paratopotypes).