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Bioacoustics reveals two new syntopic species of *Adenomera* Steindachner (Anura: Leptodactylidae: Leptodactylinae) in the Cerrado of central Brazil

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Abstract

In this paper, we describe two syntopic species of *Adenomera* from the Chapada dos Veadeiros microregion, northern State of Goiás, central Brazil, recognized based on morphology, color patterns, and bioacoustics. Specimens and calls were obtained in the Municipality of Teresina de Goiás, central Brazil. *Adenomera cotuba* **sp. nov.** is diagnosed from the other 16 congeneric species by its 1) small size (adult male SVL 18.6–20.5 mm) and very robust body; 2) dorsum glandular/granular with no distinctive dorsal granular rows or dorsolateral folds; 3) black or very dark dorsal coloration with no distinctive color patterns (*e.g.*, dorsolateral or vertebral stripes); 4) toe tips not developed into flattened disks; 5) presence of antebrachial tubercle; and 6) advertisement call consisting of a well-defined series of pulsed calls (7–32 calls/series) with progressive increment in amplitude in the first third of each call series when it reaches a sustained plateau. *Adenomera juikitam* **sp. nov.** is diagnosed from the other 16 congeneric species by its 1) dorsum profusely glandular/granular with no distinctive dorsal granular rows or dorsolateral folds; 2) dorsum with a marble-like and red coloration with no distinctive color patterns (*e.g.*, dorsolateral or vertebral stripes); 3) toe tips not developed into flattened disks; 4) small size (adult male SVL 19.1–19.5 mm) and very robust body; and 5) long (148–202 ms) advertisement call composed of 16–21pulses. Both new taxa occur in syntopy, and our data allow us to differentiate them both in temporal (pulses/call) and spectral (frequency peaks) traits of their advertisement calls. Besides, dorsal coloration is distinctive, *Adenomera cotuba* **sp. nov.** has a black or very dark-colored dorsum, whereas *Adenomera juikitam* **sp. nov.** has a marble-like and red-colored dorsum, in addition to the presence (*A. cotuba* **sp. nov.**) or absence (*A. juikitam* **sp. nov.**) of antebrachial tubercle.

Key words: Advertisement call, Chapada dos Veadeiros microregion, State of Goiás, Syntopy, taxonomy

Introduction

The genus *Adenomera* Steindachner currently comprises 16 recognized species distributed throughout South America east of the Andes (Carvalho & Giaretta 2013; Frost 2013). Several studies have revised and discussed the definition and phylogenetic position of *Adenomera*, as well as the interrelationships of its comprising taxa (Heyer 1969a, b, 1973, 1974a). While there have been additional subsequent studies, the phylogenetic position of *Adenomera* is still disputed based upon different lines of evidence (external morphology, osteology, molecular biology, and natural history), with two current hypotheses: i) corroboration of the preferred phylogenetic relationship hypothesis in Heyer (1974a), placing *Adenomera* + *Lithodytes* as sister group of *Leptodactylus* in the narrow sense (Frost *et al.* 2006; Ponssa 2008; Ponssa *et al.* 2010), in spite to the phylogenetic position and generic status of *Leptodactylus discodactylus* (including other generic combinations, under *Lithodytes* and *Vanzolinius*; see Heyer 1974a, b; Heyer 1998; De Sá *et al.* 2005; Ponssa 2008; Pyron & Wiens 2011); ii) or rendering its comprising taxa (*L. marmoratus* group) paraphyletic in relation to *Leptodactylus*, embedded within the *L. fuscus* group (Heyer 1998), or placed as a subset of this species group (Giaretta *et al.* 2011). It worth mentioning that Frost *et al.* (2006) changed the generic status of *Adenomera* and *Lithodytes*, synonymizing the former with the latter, which was

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ranked as a subgenus of *Leptodactylus* in an endeavor to avoid a potential paraphyly based on Heyer's (1998) and Kokubum and Giaretta's (2005) evidence, discussed earlier. The two most recent phylogenetic studies (Pyron & Wiens 2011; Fouquet *et al.* 2013) recovered the genera *Lithodytes* and *Adenomera* as consisting of the sister clade of *Leptodactylus* in the narrow sense as well.

We herein report on the discovery of two syntopic species of *Adenomera* in the Chapada dos Veadeiros microregion, northern State of Goiás, central Brazil, that could not be assigned to any described species. We formally describe these two unnamed species on the basis of morphology, color patterns, and bioacoustics.

Material and methods

Field work was conducted in the Municipality of Teresina de Goiás (13°52'S, 47°15'W; approximately 840 m a.s.l.), Chapada dos Veadeiros microregion, northern State of Goiás, central Brazil.

Type specimens and additional examined specimens (Appendix 1) are housed in the following Brazilian zoological collections: Coleção de Anuros do Museu de Biodiversidade do Cerrado, Universidade Federal de Uberlândia (AAG-UFU), Uberlândia, State of Minas Gerais; Coleção Herpetológica da Universidade de Brasília (CHUNB), Brasília, Distrito Federal; Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, State of São Paulo; Museu de Zoologia da Universidade Estadual de Campinas (ZUEC), Campinas, State of São Paulo; and Museu Nacional do Rio de Janeiro (MNRJ), Rio de Janeiro, State of Rio de Janeiro.

Twelve morphometric measurements were taken by T.R.C from adult specimens using a micrometric ocular piece coupled to a stereomicroscope; snout-vent length (SVL) was measured with calipers to the nearest 0.1 mm under a stereomicroscope. Nine measurements followed Duellman (1970): snout-vent length (SVL), head length (HL), head width (HW), eye diameter (ED), tympanum diameter (TD), eye-nostril distance (END) (= snout length), internarial distance (IND), shank length (SL) (= tibia length), and foot length (FL). Four measurements followed Heyer *et al.* (1990): hand length (HAL), forearm length (FRL), thigh length (TL), and tarsus length (TSL). Head shape terminology followed Heyer *et al.* (1990). Only SVL was measured from specimen AAG-UFU 0807 due to its ill-preserved conditions. Pictures of both live and preserved specimens were slightly edited to remove flash shadows caused by camera.

Calls were recorded using digital equipment (M-Audio Microtrack II or Marantz PMD 671) set at a sampling rate of 48.0 kHz and a 16-bit resolution (mono WAVE file format), coupled to directional microphones (Sennheiser K6/ME66 or K6/ME67) and were analyzed on a personal computer with Windows XP Professional operating system using the software Raven Pro version 1.5, 64-bit version (Bioacoustics Research Program 2012). Temporal and spectral traits were measured from spectrograms; temporal traits were measured manually, spectral traits (frequency peaks) were obtained in the software (Peak Frequency measurement function). Raven Pro settings: window type = Hanning; window size (FFT) = 256 samples; time resolution = 5.3 ms; 3 dB filter bandwidth = 270 Hz; brightness = 50%; contrast = 50%; overlap = 85%; hop size = 0.79 ms; DFT size (locked) = 1024 samples; grid spacing (spectral resolution) = 46.9 Hz. Sound figures were obtained using Seewave version 1.6.4 package (Sueur *et al.* 2008) of the R platform version 2.15.1, 64-bit version (R Development Core Team 2012). Seewave settings: window name = Hanning; window length = 256 samples; overlap = 85%. Acoustic terminology mostly followed Duellman and Trueb (1994). Calls per minute and call series per minute were obtained from one minute of recordings, once we recorded each male for a period of at least one minute. Given that the calls of the present study had either the first (fundamental) or the second harmonic as the dominant frequency (*sensu* Duellman & Trueb 1994), we measured two spectral traits: 1st harmonic peak frequency and 2nd harmonic peak frequency. Mean and standard deviation (SD) given in call sections and tables were calculated from individual mean values. Within-male variation for each call trait was expressed as coefficients of variation [(CV = SD/mean) x 100]. Average coefficient of variation, for each trait, was calculated from CV values for each male. The overall thermal dependency of temporal variables of the advertisement calls of *Adenomera* **spp. nov.** was not assessed, since our recordings lack expressive temperature variation (see Tables 2–3) and based on a relatively small sample size for one species (N = 3 males). Addressing how temperature affected the recordings of both species would depend on a larger sample of recorded individuals, as well as a wider range of temperatures so that we could apply proper statistical approaches.

Acoustic data of comparative *Adenomera* species were extracted from their original descriptions, additional studies or unpublished doctoral theses. Several works present acoustic data of *Adenomera* species, yet we made an

effort to only make use of acoustic data from original descriptions, topotypes, or information available from the nearest point to type localities in an endeavor to make unequivocal comparisons with respect to the new species, inclusive of acoustic diagnoses, since we faced species identity problems. Comparative acoustic data and their respective sources are listed in Table 4. In order to avoid long citation strings, all references are provided in Table 4, and the value ranges of call traits were combined throughout the text to facilitate direct interspecific comparisons between two or more species against both the new species.

Original morphometric and bioacoustic measurements were deposited in the Dryad data repository (www.datadryad.org) under DOI 10.5061/dryad.sf40c.

Results

Taxonomic accounts

Adenomera cotuba, new species

Figures 1–3

Holotype. AAG-UFU 1400, adult male, collected in the Municipality of Teresina de Goiás (13°52'S, 47°15'W; approximately 840 m a.s.l.), northern State of Goiás, central Brazil, on 16–17 November 2012, by T. R. de Carvalho, B. F. V. Teixeira, and L. B. Martins.

Paratopotypes. Eight adult males: AAG-UFU 0808, on 18 November 2011, by A. A. Giaretta and K. G. Facure; AAG-UFU 1397–1399, 1401–1404, collected with the holotype.

Diagnosis. *Adenomera cotuba* **sp. nov.** is assigned to the genus (*L. marmoratus* species group and *Adenomera* genus definitions; *sensu* Heyer 1973, 1974a, respectively) by the following set of characters: 1) small body size (up to 34.1 mm; *sensu* Kok *et al.* 2007); 2) toes lacking fringing or webbing; 3) adult males lacking thumb spines; 4) first and second fingers of approximately equal length. The new species is diagnosed from the other 16 congeneric species by the following combination of characters: 1) small size (adult male SVL 18.6–20.5 mm; Table 1) and very robust body; 2) dorsum glandular/granular with no distinctive dorsal granular rows or dorsolateral folds; 3) black or very dark dorsal coloration with no distinctive color patterns; 4) toe tips not developed into flattened disks; 5) distal antebrachial tubercle present; 6) advertisement call consisting of a well-defined series of pulsed calls (7–32 calls/series; Table 2) with progressive increment in amplitude in the first third of each call series when it reaches a sustained plateau.

Comparisons with other species. *Adenomera cotuba* **sp. nov.** (adult male SVL 18.6–20.5 mm; Table 1) can be diagnosed from *A. andreae* (mean adult SVL 23.3 mm, maximum 27.0; Heyer 1973), *A. coca* (adult male SVL 23.6–25.6 mm; Angulo & Reichle 2008), *A. diptyx* (mean adult SVL 22 mm; Boettger 1885), *A. engelsi* (adult male SVL 20.9–22.7 mm; Kwet *et al.* 2009), *A. heyeri* (adult male SVL 22.5–25.8 mm; Boistel *et al.* 2006), *A. hylaedactyla* (adult male SVL 22.2–24.3 mm; Angulo *et al.* 2003), *A. lutzi* (adult male SVL 25.7–33.5 mm; Kok *et al.* 2007), *A. marmorata* (mean adult SVL 20.8 mm, maximum 26.0; Heyer 1973), *A. martinezi* (adult male SVL 21.9–24.2 mm; Carvalho & Giaretta 2013), *A. simonstuarti* (adult male SVL 25.9–26.2 mm; Angulo & Icochea 2010) by its smaller body size. *Adenomera cotuba* **sp. nov.** has a more robust body in dorsal view compared to all the additional material examined by us (figs. 1–2; see Appendix 1). *Adenomera cotuba* **sp. nov.** possesses a glandular/granular dorsum with no distinctive dorsal rows or dorsolateral folds (figs. 1–2), whereas *A. araucaria*, *A. hylaedactyla*, *A. heyeri*, *A. martinezi*, and *A. saci* possess dorsolateral folds or distinctive granular/glandular rows (Kwet & Angulo 2002; Angulo *et al.* 2003; Boistel *et al.* 2006; Carvalho & Giaretta). *Adenomera cotuba* **sp. nov.** has a black or very dark-colored dorsum with no distinctive color patterns, whereas *A. araucaria* usually has longitudinally arranged dark marks (Kwet & Angulo 2002); *A. engelsi* has a maculated dorsal pattern, consisting of variably sized, longitudinally arranged spots and a distinctive triangle in the orbital region, followed by a chevron-like blotch forming an hourglass-shaped figure (Kwet *et al.* 2009); *A. martinezi* and *A. saci* have distinctive longitudinal rows of symmetrically arranged black spots (Bokermann 1956; Carvalho & Giaretta 2013); *A. nana* usually has a symmetrical pattern of dark marks on an orange-brown background (Kwet 2007); *A. thomei* has a mask-like pattern on the inverted triangle of the interorbital region (Almeida & Angulo 2006). The new species has no vertebral pin-stripe, whereas individuals of *A. araucaria*, *A. coca*, *A. diptyx*, *A. hylaedactyla*, *A. martinezi* and *A.*

saci always, usually, or sometimes do (Heyer 1973; De la Riva 1996; Kwet & Angulo 2002; Angulo & Reichle 2008; Carvalho & Giaretta 2013). *Adenomera cotuba* **sp. nov.** has its toe tips unflattened, whereas *A. andreae*, *A. marmorata*, and *A. nana* have toe tips developed into flattened disks (Heyer 1973; Kwet 2007). The new species can be diagnosed from all congeners (except *A. lutzi*; see Kok *et al.* 2007) by the presence of a single or a few variably-sized distal antebrachial tubercles.

TABLE 1. Morphometric measurements (mm) of the type series of *Adenomera cotuba* **sp. nov.** and *Adenomera juikitam* **sp. nov.** (including the holotypes) from Teresina de Goiás, northern Goiás, central Brazil. Mean±SD (range).

	Adenomera cotuba **sp. nov.** N=9 males	*Adenomera juikitam* **sp. nov.** N=2 males
Snout-vent length	19.7±0.6 (18.6–20.5)	19.3±0.2 (19.1–19.5)*
Head length	7.8±0.4 (7.0–8.3)	8.2±0.3 (8.0–8.4)
Head width	7.0±0.3 (6.4–7.3)	7.4±0.2 (7.2–7.5)
Eye diameter	1.9±0.1 (1.7–2.1)	2.1±0.1 (2.0–2.1)
Tympanum diameter	1.4±0.1 (1.2–1.5)	1.2
Eye-nostril distance	1.6±0.1 (1.5–1.7)	1.6±0.1 (1.5–1.7)
Internarial distance	1.7±0.1 (1.5–1.7)	1.8±0.1 (1.7–1.8)
Hand length	4.7±0.2 (4.3–5.0)	4.8
Forearm length	4.4±0.2 (4.2–4.8)	4.7±0.1 (4.6–4.7)
Thigh length	8.2±0.3 (7.6–8.6)	8.1±0.7 (7.6–8.6)
Shank length	8.3±0.4 (7.7–8.9)	8.7±0.3 (8.5–8.9)
Tarsus length	5.4±0.4 (4.8–6.0)	5.8±0.3 (5.6–6.0)
Foot length	9.0±0.5 (8.0–9.6)	9.3±0.7 (8.8–9.8)

* SVL was measured from all three specimens of *A. juikitam* **sp. nov.** type series; see Material and Methods section.

Additional morphological and color pattern features that can also diagnose *Adenomera cotuba* **sp. nov.** from congeners (comparative species with features in parentheses): from *A. ajurauna*, by the absence of dark brown throat, and little white dots on upper and lower lips, and dorsal surface of arms (Berneck *et al.* 2008); from *A. araucaria*, by having white-tipped granules on dorsal surface of shanks (dorsal surface of shanks smooth; Kwet & Angulo 2002); from *A. heyeri*, by possessing profuse tubercles on the sole of feet (smooth sole of feet with scant small tubercles), and the absence of yellow throat and belly in male specimens (Boistel *et al.* 2006); from *A. lutzi*, by the lack of a distinctive yellow, orange or red spotted/mottled pattern on posterior surface of thighs on a black background, and yellow to orangish yellow ventral surfaces in male specimens (Kok *et al.* 2007); from *A. martinezi* and *A. saci* (Carvalho & Giaretta 2013), by possessing a very robust body in dorsal view (slender body in *A. martinezi* and *A. saci*); from *A. simonstuarti*, by the absence of very dark, nearly solid stripes on undersides of arms, extending from wrist to the arm insertion (Angulo & Icochea 2010).

The advertisement call (fig. 4; Tables 2, 4) distinguishes *Adenomera cotuba* **sp. nov.** from all congeners by consisting of a well-defined series of pulsed calls with progressive increment in amplitude in the first third of each call series when it reaches a sustained plateau. The new species can additionally be diagnosed from *A. ajurauna*, *A. bokermanni*, *A. engelsi*, *A. heyeri*, *A. lutzi*, *A. marmorata*, *A. nana*, and *A. saci* by possessing a pulsed call structure (non-pulsed structure in all aforementioned species; see Table 4); from *A. andreae*, *A. hylaedactyla*, and *A. simonstuarti* (combined range 2–7 pulses/call; Table 4) by a greater number of pulses (8–14 pulses/call; Tables 2, 4), and from *A. martinezi* (15–21 pulses/call; Table 4) by a fewer number of pulses (8–14 pulses/call; Tables 2, 4); from *A. andreae*, *A. hylaedactyla*, and *A. lutzi* (combined range 16–64 ms; Table 4) by a longer call duration (69–191 ms; Tables 2, 4); from *A. andreae*, *A. diptyx*, *A. hylaedactyla*, *A. martinezi*, *A. nana*, and *A. thomei* (1st harmonic peak frequency combined range 1.88–3.05 kHz; Table 4), and *A. andreae*, *A. araucaria*, *A. diptyx*, *A. hylaedactyla*, *A. marmorata*, *A. nana*, and *A. thomei* (2nd harmonic peak frequency combined range 3.96–5.60 kHz; Table 4) by its lower frequencies (1st harmonic peak frequency 1.73–1.83 kHz, 2nd harmonic peak frequency 3.33–3.80 kHz; Tables 2, 4).

TABLE 2. Advertisement call traits and recording air temperatures of the six recorded males of *Adenomera cotuba* **sp. nov.** from its type locality (Teresina de Goiás, northern Goiás, central Brazil). Mean±SD [CV] (range). N = number of analyzed calls.

Acoustic traits	AAG-UFU 0808 N=62	AAG-UFU 1397 N=82	AAG-UFU 1398 N=91	AAG-UFU 1399 N=52	AAG-UFU 1400* N=58	Unvouchered N=52	Mean±SD (min–max)
Call duration (ms)	115.5±5.5 [4.8%] (106–129)	126.2±14.3 [11.3%] (95–191)	106.0±8.6 [8.1%] (93–133)	117.8±10.5 [8.9%] (104–157)	97.7±4.6 [4.7%] (86–110)	91.6±8.4 [9.1%] (69–110)	109.2±3.1 [7.8%] (69–191)
Intercall interval (ms)	227.5±126.0 [55.4%] (120–599)	256.1±189.2 [73.9%] (158–1000)	254.7±107.5 [42.2%] (157–511)	278.0±116.4 [41.9%] (166–513)	204.2±77.0 [37.7%] (142–455)	238.3±135.5 [56.9%] (150–664)	243.1±25.7 [51.3%] (120–1000)
Pulses/call	11.6±0.8 [6.9%] (10–14)	10.2±1.0 [9.8%] (8–12)	11.8±0.6 [5.1%] (11–13)	13.1±0.8 [6.1%] (12–14)	11.5±0.7 [6.1%] (11–13)	11.4±1.1 [9.6%] (10–14)	11.6±0.9 [7.3%] (8–14)
Calls/series	31.0±1.4 [4.5%] (30–32)	27.7±1.5 [5.4%] (26–29)	23.2±3.8 [16.4%] (17–27)	18.3±2.5 [13.7%] (16–21)	19.5±12.0 [61.5%] (11–28)	16.0±6.3 [39.4%] (7–23)	22.6±5.8 [23.5%] (7–32)
Calls/minute	37.0±7.1 [19.2%] (32–42)	27.7±1.5 [5.4%] (26–29)	23.2±3.8 [16.4%] (17–27)	18.3±2.5 [13.7%] (16–21)	19.5±12.0 [61.5%] (11–28)	16.0±6.3 [39.4%] (7–23)	23.6±7.7 [25.9%] (7–42)
Series duration (s)	10.9±0.1 [0.9%] (10.8–10.9)	10.2±0.5 [4.9%] (9.7–10.6)	8.9±0.9 [10.1%] (7.9–9.8)	7.9±1.0 [12.7%] (6.8–8.7)	6.0±3.5 [58.3%] (3.5–8.4)	6.1±1.5 [24.6%] (4.2–7.7)	8.3±2.0 [18.6%] (3.5–10.9)
Series/minute	1.5±0.7 [46.7%] (1–2)	1.0	1.0	1.0	1.0	1.0	1.1±0.2 [7.8%] (1–2)
1st harmonic peak frequency (kHz)**	1.79±0.02 [1.1%] (1.73–1.83)	1.78	1.76±0.02 [1.1%] (1.73–1.78)	1.77±0.02 [1.1%] (1.73–1.78)	1.79±0.02 [1.1%] (1.78–1.83)	1.78±0.02 [1.1%] (1.73–1.78)	1.78±0.01 [0.6%] (1.73–1.83)
2nd harmonic peak frequency (kHz)**	3.64±0.08 [2.2%] (3.33–3.70)	3.63±0.05 [1.4%] (3.56–3.70)	3.56±0.06 [1.7%] (3.47–3.66)	3.55±0.03 [0.8%] (3.52–3.61)	3.78±0.02 [0.5%] (3.75–3.80)	3.65±0.06 [1.6%] (3.47–3.70)	3.63±0.08 [2.2%] (3.33–3.80)
Temperature (°C)	25.0	21.4	25.0	25.0	25.0	25.0	(21.4–25.0)

* Holotype; ** Both 1st and 2nd harmonic frequency peaks can correspond to the dominant frequency.

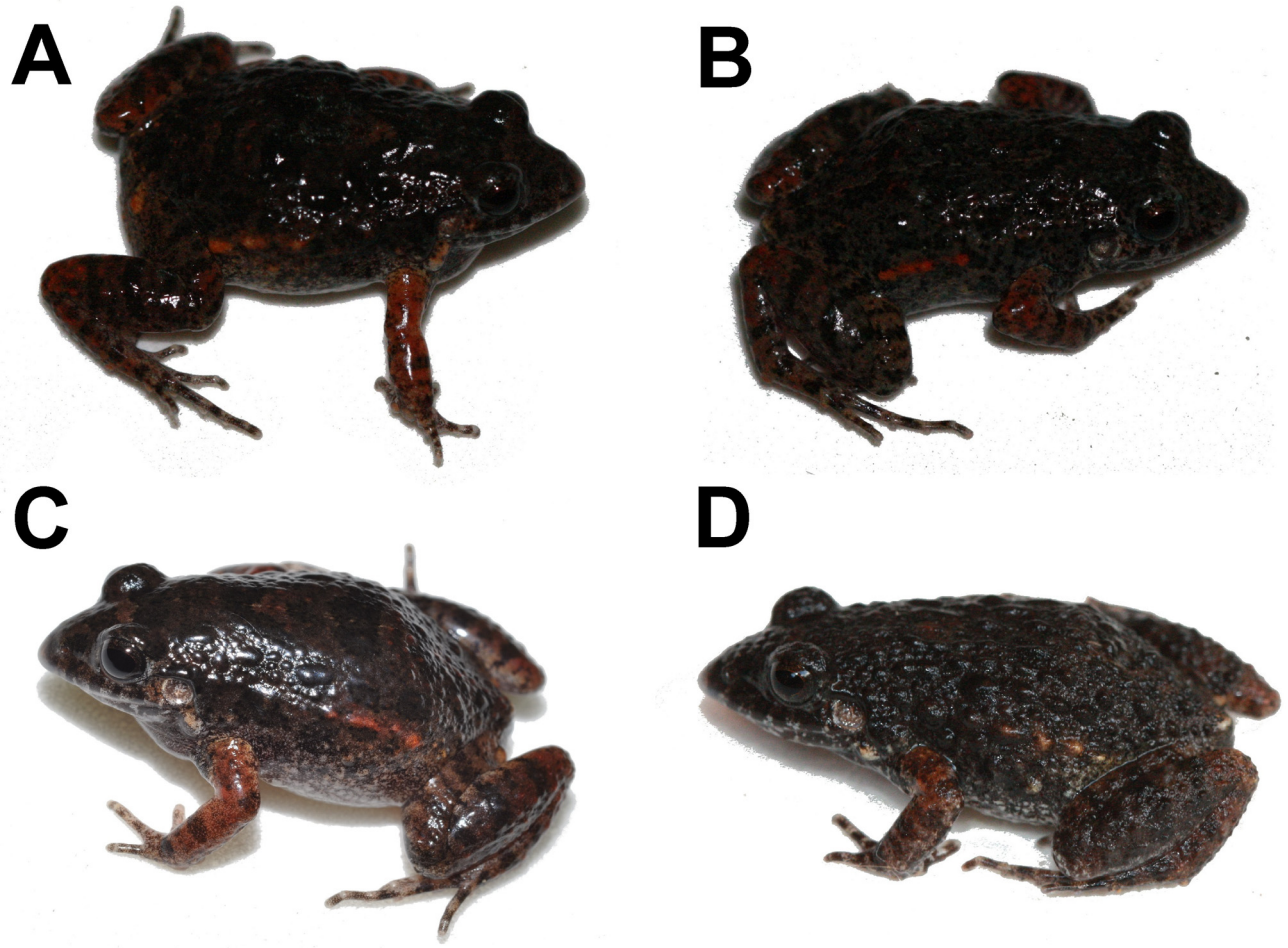

FIGURE 1. Live adult male specimens of *Adenomera cotuba* **sp. nov.** from Teresina de Goiás, northern Goiás, central Brazil (voucher specimens of call recordings), evidencing the glandular/granular dorsum with a black or very dark-colored dorsal coloration: A) holotype AAG-UFU 1400 (SVL 20.5 mm); B) paratopotype AAG-UFU 0808 (SVL 19.6 mm); C) paratopotype AAG-UFU 1397 (SVL 18.6 mm); D) paratopotype AAG-UFU 1398 (SVL 20.0 mm); E) paratopotype AAG-UFU 1399 (SVL 19.3 mm).

Description of holotype. AAG-UFU 1400 (figs. 1–3). Adult male. Body very robust in dorsal view. Snout rounded in dorsal view (fig. 3B), acuminate in lateral view (fig. 3A), head longer than wide. Nostrils closer to the snout tip than to the eyes; canthus rostralis indistinguishable; loreal region slightly concave; supratympanic fold developed; discrete, ovoid post-commissural gland; upper eyelids glandular; vocal sac subgular with a fold from jaw to forearm on each side, vocal slits present; vomerine teeth in two straight rows posterior to choanae. Tongue ovoid, free behind. Relative finger lengths IV < I $\simeq$ II < III; fingers with no webbing or fringing; finger tips rounded, slightly expanded; inner metacarpal tubercle ovoid; outer metacarpal tubercle nearly rounded (fig. 3D). Subarticular and supernumerary tubercles rounded. No thumb asperities or prepollex. Undersides of forearms bearing a few variably-sized distal antebrachial tubercles. Dorsum glandular/granular. Posterior half of dorsum, dorsal surface of shanks, and dorsal and outer surfaces of tarsi with profuse minute granules. Vertebral pin-stripe absent. Posterior half of flanks with granular rows. Throat and belly smooth. Ventral surface of thighs areolate. Posterior surface of thighs with no distinctive pattern, possessing distinctive nearly rounded glands on each side of cloaca. Relative toe lengths I < II < V < III < IV; toe tips rounded, slightly expanded (toe tip character state B; see fig. 1B in Heyer 1973), without webbing, ridged laterally. Inner metatarsal tubercle ovoid, outer rounded (fig. 3C). Tarsal fold from the inner metatarsal tubercle extending 1/3 length of tarsi, distal portion barely enlarged. Subarticular tubercles conical, supernumerary rounded.

Measurements of holotype. Morphometric characters (mm) and ratios (%) in relation to SVL (20.5 mm): HL 7.8 (38.0), HW 6.9 (33.7), ED 2.1 (10.2), TD 1.2 (5.9), END 1.5 (7.3), IND 1.7 (8.3), FRL 4.8 (23.4), HAL 5.0 (24.4), TL 8.6 (42.0), SL 8.6 (42.0), TSL 5.9 (28.8), FL 9.5 (46.3).

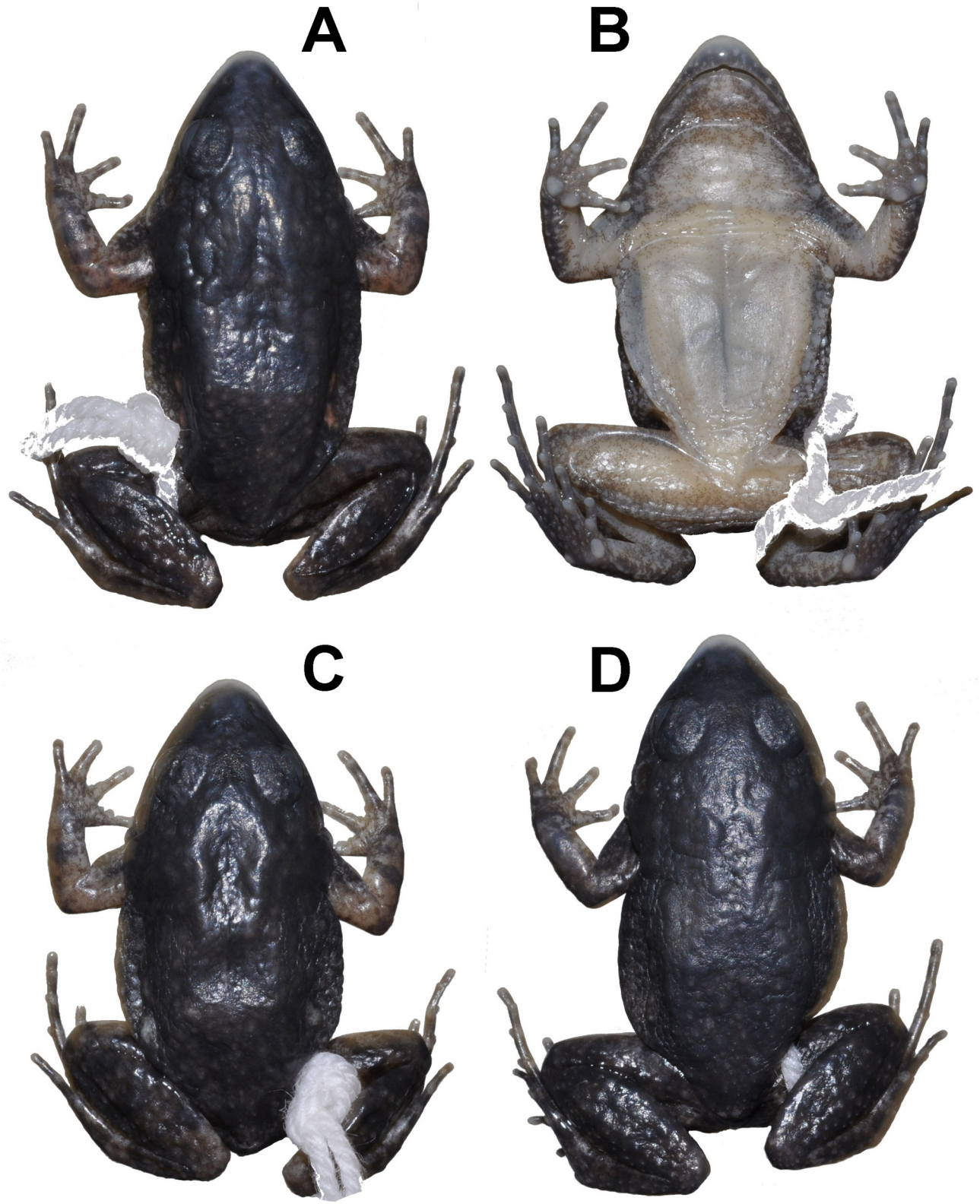

FIGURE 2. Dorsal (A) and ventral (B) views of the holotype (AAG-UFU 1400; SVL 20.5 mm), and dorsal view of two adult male paratopotype specimens of *Adenomera cotuba* **sp. nov.**, (C) AAG-UFU 1401 (SVL 19.2 mm), and (D) AAG-UFU 1402 (SVL 20.1 mm), evidencing its robust body shape with a black coloration.

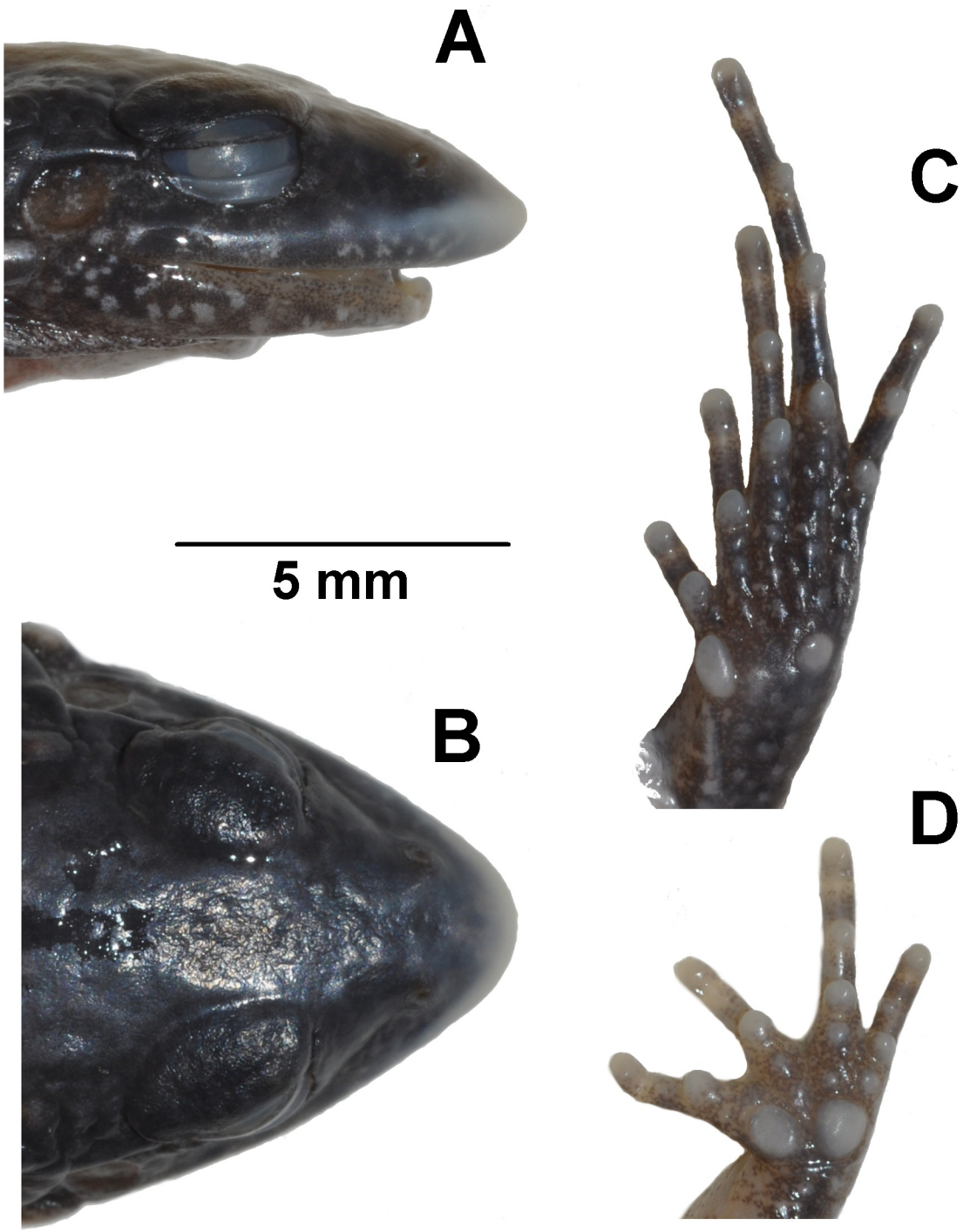

FIGURE 3. *Adenomera cotuba* **sp. nov.**, holotype (AAG-UFU 1400), adult male. Lateral (A) and dorsal (B) views of head, and ventral views of foot (C) and hand (D).

Coloration of holotype in alcohol (figs. 2A–B). Snout tip with a faded white coloration. Dorsum and flanks black with dark-colored blotches indistinguishable. Dorsal surface of limbs with dark brown stripes/blotches on a slightly lighter brown background. White-tipped granules scattered on the posterior half of dorsum, dorsal surface of shanks, and outer surface of tarsi. Larger scant pale orange granules on posterior half of body. Posterior half of flanks with orange-colored granular rows towards inguinal region. Upper and lower jaws covered with white-colored spots/blotches, white commissural gland. Tympani reddish brown. Throat, belly, and ventral surface of limbs cream, with melanophores, throat tending to a mottled pattern, dark brown laterally, coinciding with the expanded vocal sac. Posterior surface of thighs with a few dark brown spots on a medium brown background, and one white-colored tubercle on each side of cloaca. Posterior surface of tarsi and heel with several cream-colored granules. Cream-colored tarsal fold from the inner metatarsal tubercle extending to 1/3 length of tarsi.

Coloration of holotype in life (fig. 1A). Blackish brown with barely distinguishable non-uniform darker blotches. Arms, some portions of dorsum, legs, and glands (jaw and posterior surface of thighs) orange.

Variation. Within the type series, it is restricted to the extent, distribution, and coloration of the granules scattered on dorsum. The specimens AAG-UFU 1398–1399, 1401–1403 have a white faded well-developed shovel-like fleshy ridge on snout tip. Specimens have a single or a few variably-sized distal antebrachial tubercles on undersides of forearms. In life, dorsum varies from blackish brown or gray with barely distinguishable non-uniform darker blotches to an almost uniformly black coloration. Some portions of dorsum, arms, legs, interorbital region, and granules on flanks have a reddish orange coloration.

Advertisement call. Six males were recorded (N = 397 analyzed calls; see Table 2 for individual sample sizes). Advertisement call (fig. 4; Tables 2, 4) consists of well-defined series of 7–32 calls (mean 22.6; SD = 5.8) with a progressive increment in amplitude in the first third of each call series when it reaches a sustained plateau, which is emitted from 1–2 series/minute (mean 1.1; SD = 0.2). Series duration varies from 3.5–10.9 s (mean 8.3; SD = 2.0). Calls have up to 9 visible harmonics and a slight ascendant frequency modulation throughout their duration, emitted from 7–42 calls/minute (mean 23.6; SD = 7.7). Calls are composed of 8–14 pulses (mean 11.6; SD = 0.9) with deep and regular amplitude modulation. Call duration varies from 69–191 ms (mean 109.2; SD = 13.1), and intercall interval from 0.12–1.00 s (mean 0.24; SD = 0.03). Dominant frequency peaks from 1.73–1.83 kHz (mean 1.78 kHz; SD = 0.01) in the 1st harmonic, or from 3.33–3.80 kHz (mean 3.63 kHz; SD = 0.08) in the 2nd harmonic. Dominant frequency corresponds to the 2nd harmonic (67% of males recorded), or corresponds to either the 1st harmonic or the 2nd harmonic (33% of males recorded) among calls analyzed for each male. The other harmonics, if present, are increasingly weaker in sound energy.

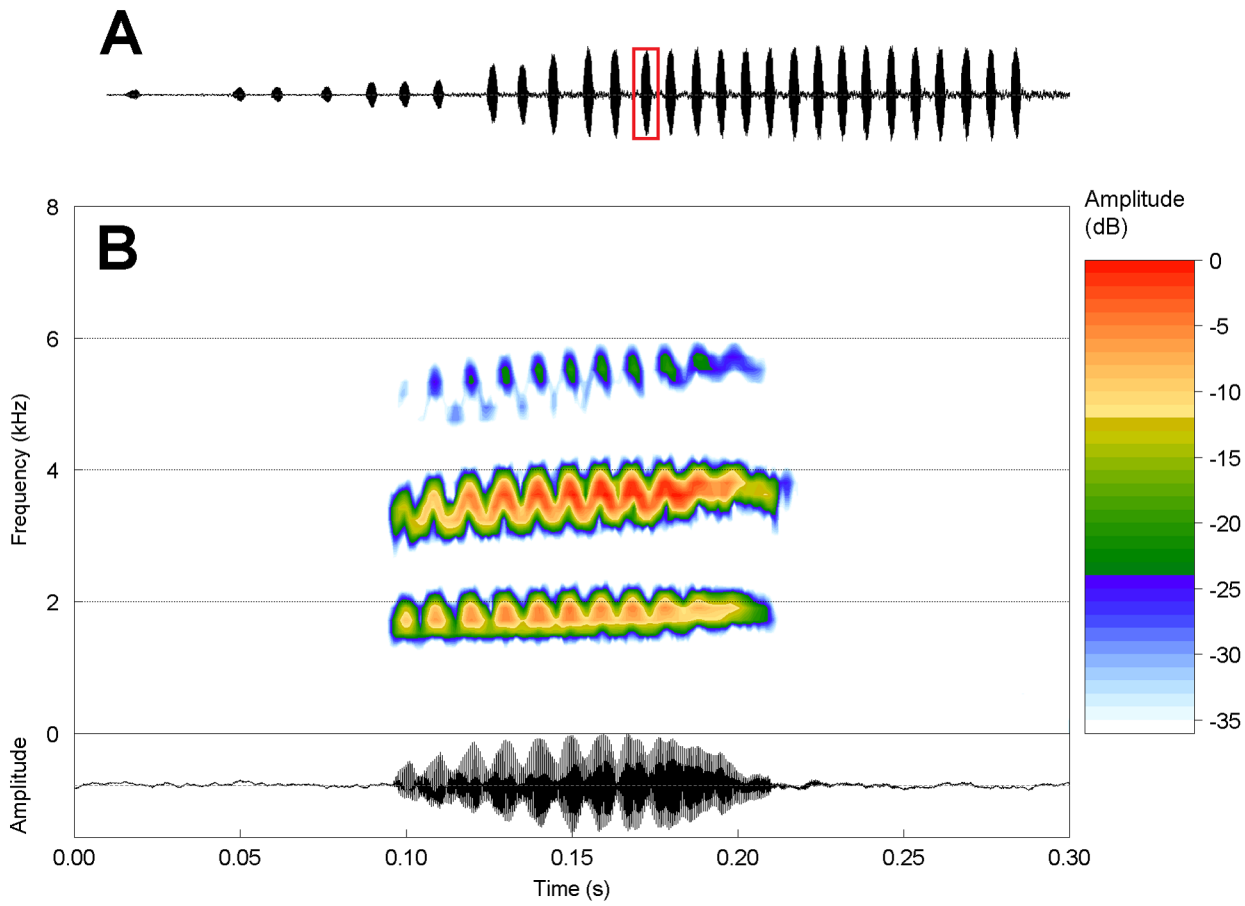

FIGURE 4. Advertisement call of *Adenomera cotuba* **sp. nov.** (AAG-UFU 1397) from Teresina de Goiás, central Brazil: A—Oscillogram of an entire advertisement call (call series of aprox. 10.5 seconds) showing the progressive increment in amplitude until reaching a sustained plateau. B—Spectrogram (above) and respective oscillogram (below) of the 13th call in A, identified by a red outline. Sound file: Adeno_cotubaTeresGoiasGO1aTRC_AAGm671; 21:53h, 16 Nov 2012, Air 21.4 °C.

Natural history. *Adenomera cotuba* **sp. nov.** occurs in Cerrado environments of central Brazil associated to rocky limestone and sandy soil at the border or inside partially shadowy environments. Males call exposed or under leaf litter. Excited calling males emit their calls in relays, so that this emission pattern can be perceived as a 'wave' passing by the observer. A calling male excites the nearest one and so on, even making it possible to predict when a given male will start its call emission based on the approaching calling wave. This phenomenon reported for *A. cotuba* **sp. nov.** might be classified as unison bout singing, previously reported for other Neotropical anurans (see Schwartz 1991).

Geographic distribution. *Adenomera cotuba* **sp. nov.** is known from its type locality (Teresina de Goiás). The species was also heard in Uruaçu (14°43'S, 49°15'W; approximately 575 m a.s.l.) (T.R. de Carvalho pers. obs.), approximately 235 km southwest of its type locality, both localities in northern Goiás, central Brazil. Preserved specimens (CHUNB collection; see Additional examined material section) from Goiânia (central Goiás) and Figueirópolis (southern Tocantins) were also assigned to *A. cotuba* **sp. nov.**, suggesting a more widespread distribution of this species in the Cerrado of central and northern Brazil.

Conservation status. *Adenomera cotuba* **sp. nov.** is currently known from its type locality, and other three localities, as discussed earlier, and we suspect a more widespread distribution for the species. However, future studies on fluctuations and potential threats at a population level are still required for a more accurate assessment of the conservation status of this species according to IUCN guidelines for the next Red List of Threatened Species (IUCN 2013), and we suggest classifying this species as Least Concern (LC) while additional data are obtained.

Etymology. The term 'cotuba' is an appositive that was borrowed from Tupi indigenous language and stands for robust, fleshy, or well-nourished, related to the very robust body shape of the species.

Additional examined material. BRAZIL: GOIÁS: GOIÂNIA (CHUNB 56517, 56452–56453); TOCANTINS: Figueirópolis (CHUNB 62864, 62897).

Adenomera juikitam, new species

Figures 5–7

Holotype. AAG-UFU 1406, adult male, collected in the Municipality of Teresina de Goiás (13°52'S, 47°15'W; approximately 840 m a.s.l.), northern State of Goiás, central Brazil, on 16–17 November 2012, by T. R. de Carvalho, B. F. V. Teixeira, and L. B. Martins.

Paratopotypes. Two adult males: AAG-UFU 0807, on 18 November 2011, by A. A. Giaretta and K. G. Facure; AAG-UFU 1405, collected with the holotype.

Diagnosis. *Adenomera juikitam* **sp. nov.** is assigned to the genus (*L. marmoratus* species group and *Adenomera* genus definitions; *sensu* Heyer 1973, 1974a, respectively) by the following set of characters: 1) small body size (up to 34.1 mm; *sensu* Kok *et al.* 2007); 2) toes lacking fringing or webbing; 3) adult males lacking thumb spines; 4) first and second fingers of approximately equal length. The new species is diagnosed from the other 16 congeneric species by the following combination of characters: 1) dorsum profusely glandular/granular with no distinctive dorsal granular rows or dorsolateral folds; 2) dorsum with a marble-like and red coloration with no distinctive color patterns; 3) toe tips not developed into flattened disks; 4) small size (adult male SVL 19.1–19.5 mm; Table 1) and very robust body; 5) long (148–202 ms) advertisement call composed of 16–21 pulses (Table 3).

Comparisons with other species. *Adenomera juikitam* **sp. nov.** possesses a profusely glandular/granular dorsum, but lacks any distinctive dorsal granular rows or dorsolateral folds (figs. 5–6), whereas *A. araucaria*, *A. coca*, *A. hylaedactyla*, *A. heyeri*, *A martinezi*, and *A. saci* possess distinctive dorsal granular rows or dorsolateral folds (Kwet & Angulo 2002; Angulo *et al.* 2003; Boistel *et al.* 2006; Angulo & Reichle 2008; Carvalho & Giaretta 2013). *Adenomera juikitam* **sp. nov.** has a dorsum with a marble-like and red coloration with no distinctive color patterns, whereas *A. araucaria* usually has longitudinally arranged dark marks (Kwet & Angulo 2002); *A. engelsi* has a maculated dorsal pattern, consisting of variably sized, longitudinally arranged spots and a distinctive triangle on the orbital region, followed by a chevron-like blotch forming an hourglass-shaped figure (Kwet *et al.* 2009); *A. martinezi* and *A. saci* have distinctive longitudinal rows of symmetrically arranged black spots (Bokermann 1956; Carvalho & Giaretta 2013); *A. nana* usually has a symmetrical pattern of dark marks on an orange-brown background (Kwet 2007); *A. thomei* has a mask-like pattern on the inverted triangle of the interorbital region (Almeida & Angulo 2006). The new species has no vertebral pin-stripe, whereas individuals of *A. araucaria*, *A.*

coca, *A. diptyx*, *A. hylaedactyla*, *A. martinezi*, and *A. saci* always, usually, or sometimes do (Heyer 1973; De la Riva 1996; Kwet & Angulo 2002; Angulo & Reichle 2008; Carvalho & Giaretta 2013). *Adenomera juikitam* **sp. nov.** has its toe tips unflattened, whereas *A. andreae*, *A. marmorata*, and *A. nana* have toe tips developed into flattened disks (Heyer 1973; Kwet 2007). *Adenomera juikitam* **sp. nov.** (adult male SVL 19.1–19.5 mm; Table 1) can also be diagnosed from *A. andreae* (mean adult SVL 23.3 mm, maximum 27.0; Heyer 1973), *A. coca* (adult male SVL 23.6–25.6 mm; Angulo & Reichle 2008), *A. diptyx* (mean adult SVL 22 mm; Boettger 1885), *A. engelsi* (adult male SVL 20.9–22.7 mm; Kwet *et al.* 2009), *A. heyeri* (adult male SVL 22.5–25.8 mm; Boistel *et al.* 2006), *A. hylaedactyla* (adult male SVL 22.2–24.3 mm; Angulo *et al.* 2003), *A. lutzi* (adult male SVL 25.7–33.5 mm; Kok *et al.* 2007), *A. marmorata* (mean adult SVL 20.8 mm, maximum 26.0; Heyer 1973), *A. martinezi* (adult male SVL 21.9–24.2 mm; Carvalho & Giaretta 2013), and *A. simonstuarti* (adult male SVL 25.9–26.2 mm; Angulo & Icochea 2010) by its smaller body size. *Adenomera juikitam* **sp. nov.** has a more robust body in dorsal view compared to all the additional material examined by us (figs. 5–6; see Appendix 1).

TABLE 3. Advertisement call traits and recording air temperatures of the three recorded males of *Adenomera juikitam* **sp. nov.** from its type locality (Teresina de Goiás, northern Goiás, central Brazil). Mean±SD [CV] (range). N = number of analyzed calls.

Acoustic traits	AAG-UFU 0807 N=42	AAG-UFU 1405 N=55	AAG-UFU 1406* N=46	Mean±SD **(min–max)**
Call duration (ms)	196.0±5.0 [2.6%] (182–202)	161.8±6.2 [3.8%] (148–177)	174.1±5.2 [3.0%] (164–188)	177.3±17.4 [3.1%] (148–202)
Intercall interval (s)	1.2±0.2 [16.7%] (1.0–1.6)	1.1±0.1 [9.1%] (1.0–1.3)	1.2±0.4 [33.3%] (0.8–2.2)	1.2±0.1 [19.7%] (0.8–2.2)
Pulses/call	20.2±0.6 [3.0%] (19–21)	16	18	18.1±2.1 [1.0%] (16–21)
Calls/minute	44.0±1.4 [3.2%] (43–45)	45	45	44.7±0.6 [1.1%] (43–45)
1st harmonic peak frequency (kHz)	1.90±0.04 [2.1%] (1.88–1.97)	2.08±0.02 [1.0%] (2.06–2.11)	1.96±0.04 [2.0%] (1.92–2.02)	1.98±0.09 [1.7%] (1.88–2.11)
2nd harmonic peak frequency (kHz)**	3.85±0.07 [1.8%] (3.70–3.94)	3.95±0.03 [0.8%] (3.89–3.98)	4.16±0.02 [0.5%] (4.13–4.17)	3.99±0.16 [1.0%] (3.70–4.17)
Temperature (°C)	25.0	25.0	25.8	(25.0–25.8)

* Holotype; ** 2nd harmonic peak frequency = dominant frequency.

Additional morphological and color pattern features that can also diagnose *Adenomera juikitam* **sp. nov.** from congeners (features of comparative species in parentheses): from *A. ajurauna*, by the absence of dark brown throat, and white dots on upper and lower lips, and dorsal surface of arms (Berneck *et al.* 2008); from *A. araucaria*, by having white-tipped granules on dorsal surface of shanks (dorsal surface of shanks smooth; Kwet & Angulo 2002); from *A. heyeri*, by possessing profuse tubercles on the sole of feet (smooth sole of feet with scant small tubercles), and the absence of yellow throat and belly in male specimens (Boistel *et al.* 2006); from *A. lutzi*, by the lack of a distinctive yellow, orange or red spotted/mottled pattern of posterior surface of thighs on a black background, yellow to orangish yellow ventral surfaces in male specimens, and prominent row of tubercles on distal portion of forearms (Kok *et al.* 2007); from *A. martinezi* and *A. saci*, by possessing a very robust body in dorsal view (slender body in both *A. martinezi* and *A. saci*; Carvalho & Giaretta 2013); from *A. simonstuarti*, by the absence of very dark, nearly solid stripes on undersides of arms, extending from wrist to the arm insertion (Angulo & Icochea 2010). The following set of morphological/color characters diagnoses *Adenomera juikitam* **sp. nov.** from *Adenomera cotuba* **sp. nov.** (data for the latter species in parentheses): dorsum with a marble-like and red

coloration (black or very dark-colored dorsum); undersides of forearms with no antebrachial tubercles (undersides of forearms bearing a single or a few variably-sized distal antebrachial tubercles).

The advertisement call (fig. 8; Tables 3–4) distinguishes *Adenomera juikitam* **sp. nov.** from *A. ajurauna*, *A. bokermanni*, *A. engelsi*, *A. heyeri*, *A. lutzi*, *A. marmorata*, *A. nana*, and *A. saci* by its pulsed call structure (non-pulsed structure in all aforementioned species; Table 4); from *A. andreae*, *A. araucaria*, *A. coca*, *A. hylaedactyla*, and *A. simonstuarti* (combined range 2–15 pulses/call; Table 4) by a greater number of pulses (16–21 pulses/call; Tables 3–4). Additionally, *Adenomera juikitam* **sp. nov.** can be diagnosed from *A. andreae*, *A. araucaria*, *A. coca*, *A. diptyx*, *A. hylaedactyla*, *A. lutzi*, *A. marmorata*, *A. nana*, and *A. simonstuarti* (combined range 16–145 ms; Table 4) by a longer call duration (148–202 ms; Tables 3–4); from *A. andreae*, *A. diptyx*, *A. nana*, and *A. thomei* (1st harmonic peak frequency combined range 2.15–3.05 kHz; Table 4), and *A. andreae*, *A. araucaria*, *A. diptyx*, *A. marmorata*, *A. nana*, and *A. thomei* (2nd harmonic peak frequency combined range 4.20–5.60 kHz; Table 4) by its lower frequencies (1st harmonic peak frequency 1.88–2.11 kHz, 2nd harmonic peak frequency 3.70–4.17 kHz; Tables 3–4); and from *A. bokermanni* and *A. lutzi* (combined 1st harmonic peak frequency combined range 1.64–1.83 kHz, 2nd harmonic peak frequency combined range 3.27–3.62 kHz; Table 4) by its higher frequencies (1st harmonic peak frequency 1.88–2.11 kHz, 2nd harmonic peak frequency 3.70–4.17 kHz; Tables 3–4).

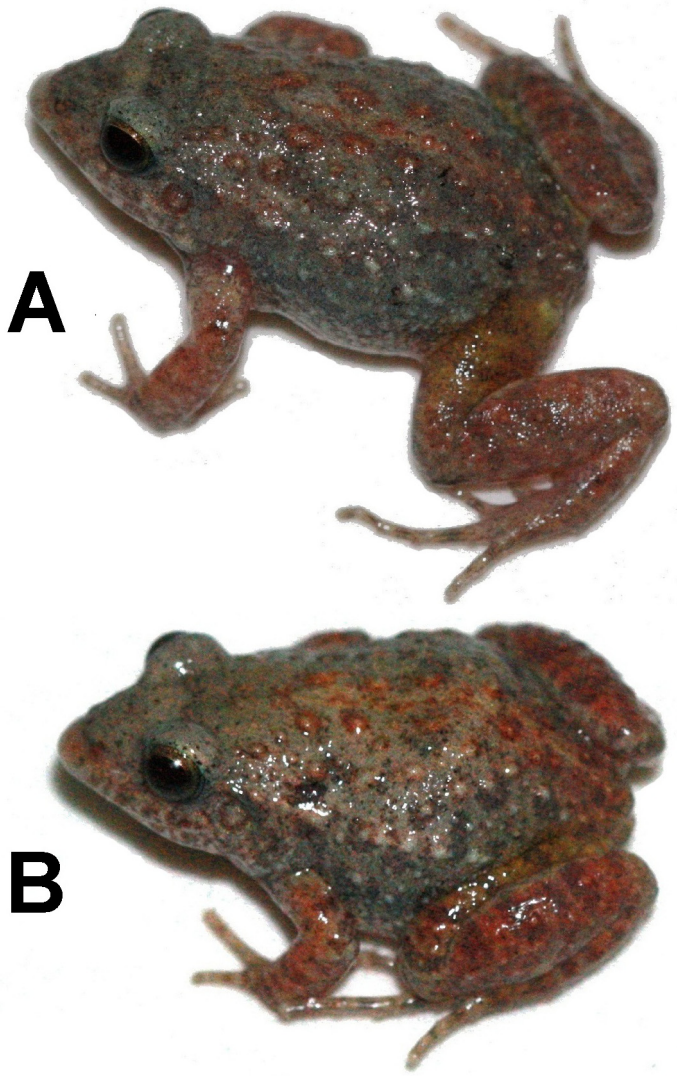

FIGURE 5. Live adult male specimens of *Adenomera juikitam* **sp. nov.** from Teresina de Goiás, northern Goiás, central Brazil (voucher specimens of call recordings), evidencing the profusely glandular/granular dorsum with a marble-like and red coloration: A) paratopotype AAG-UFU 1405 (SVL 19.2 mm); B) holotype AAG-UFU 1406 (SVL 19.1 mm).

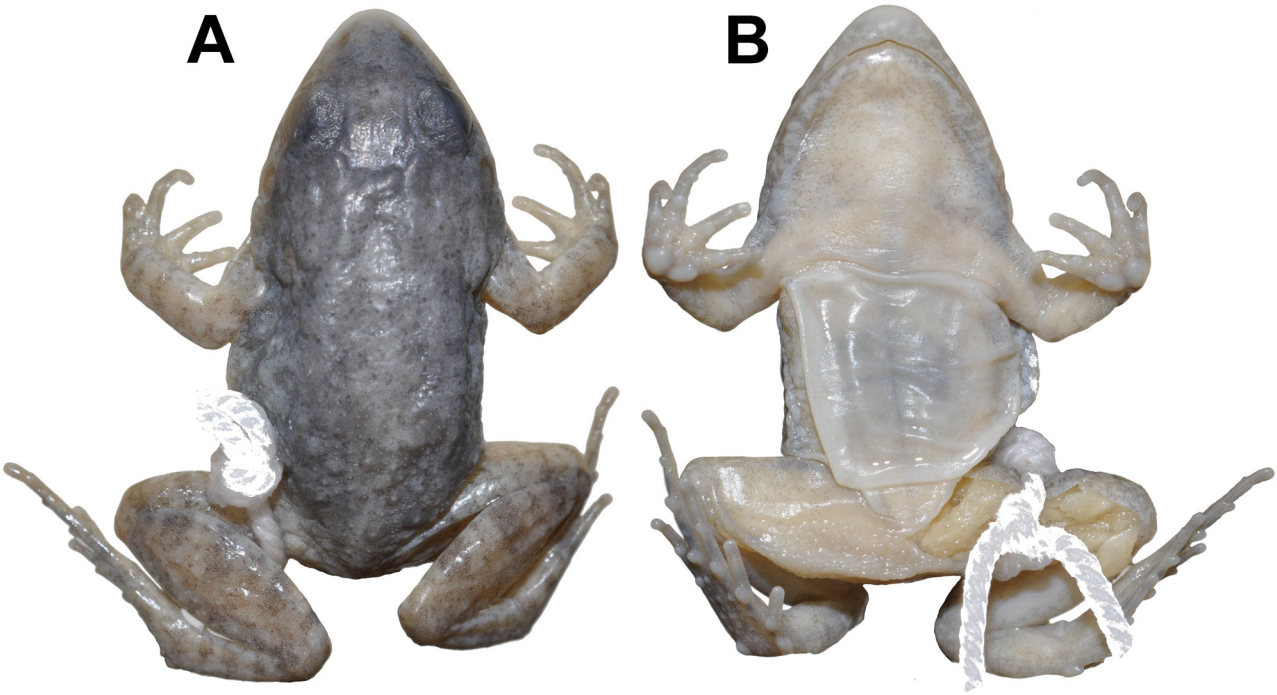

FIGURE 6. Dorsal (A) and ventral (B) views of the holotype of *Adenomera juikitam* **sp. nov.** (AAG-UFU 1406; SVL 19.1 mm), evidencing its robust body shape.

Both temporal and spectral traits of advertisement calls (Tables 2–4) diagnose *Adenomera juikitam* **sp. nov.** from the syntopic *Adenomera cotuba* **sp. nov.** (acoustic data for the latter species in parentheses): 16–21 pulses/call (versus 8–14 pulses/call); 1st harmonic peak frequency 1.88–2.11 kHz, and 2nd harmonic peak frequency 3.70–4.17 kHz (versus 1st harmonic peak frequency 1.73–1.83 kHz; 2nd harmonic peak frequency 3.33–3.80 kHz). Furthermore, *Adenomera cotuba* **sp. nov.** call consists of a well-defined series of pulsed calls with progressive increment in amplitude in the first third of each call series when it reaches a sustained plateau (fig. 4A), whereas *Adenomera juikitam* **sp. nov.** call is emitted in an intermittent pattern (fig. 8A).

Description of holotype. AAG-UFU 1406 (figs. 5–7). Adult male. Body very robust in dorsal view. Snout rounded in dorsal view (fig. 7B), acuminate in lateral view (fig. 7A), head longer than wide. A well-developed shovel-like fleshy ridge on snout tip. Nostrils closer to the snout tip than to the eyes; canthus rostralis indistinguishable; loreal region slightly concave; supratympanic fold developed; discrete, ovoid post-commissural gland; upper eyelids smooth; vocal sac subgular with a fold from jaw to forearm on each side, vocal slits present; vomerine teeth in two straight rows posterior to choanae. Tongue ovoid, free behind. Relative finger lengths IV < I ≃ II < III; finger tips rounded, slightly expanded, and with no webbing or fringing; inner metacarpal tubercle ovoid; outer metacarpal tubercle nearly rounded (fig. 7D). Subarticular tubercles conical, supernumerary tubercles rounded. No thumb asperities or prepollex. Dorsum profusely glandular/granular. Posterior half of dorsum, dorsal surface of shanks, and outer surface of tarsi with several minute tubercles. Vertebral pin-stripe absent. Posterior half of flanks with ill-defined granular rows. Throat and belly smooth. Ventral surface of thighs areolate. Posterior surface of thighs with no distinctive pattern, possessing distinctive nearly rounded glands on each side of cloaca. Relative toe lengths I < II < V < III < IV; toe tips rounded, slightly expanded (toe tip character state B; see fig. 1B in Heyer 1973), and with no webbing, ridged laterally. Inner metatarsal tubercle ovoid, outer nearly rounded (fig. 7C). Tarsal fold from the inner metatarsal tubercle extending about 1/2 length of tarsi. Subarticular tubercles conical, supernumerary rounded.

Measurements of holotype. Morphometric characters (mm) and ratios (%) in relation to SVL (19.1 mm): HL 8.2 (44.0), HW 7.4 (39.3), ED 2.1 (11.0), TD 1.2 (6.3), END 1.6 (7.9), IND 1.8 (9.4), FRL 4.7 (24.1), HAL 4.8 (25.1), TL 8.1 (45.0), SL 8.7 (46.6), TSL 5.8 (31.4), FL 9.3 (51.3).

Coloration of holotype in alcohol (figs. 6A–B). Snout tip with a faded white coloration. Dorsum and flanks with a marble-like pattern, varying from pale cream to brownish gray. Granules have the same coloration of

dorsum. White-tipped granules scattered on the posterior half of dorsum, dorsal surface of shanks, and outer surface of tarsi. Dorsal surface of limbs with brownish gray stripes/blotches on a faded light brown background. Upper and lower jaws covered with white-colored and marble-like spots/blotches alternately. Tympani light brown. Throat, belly, cream and ventral surface of limbs cream-colored, with melanophores. Posterior surface of thighs immaculate, and one white-colored tubercle on each side of cloaca.

Coloration of holotype in life (fig. 5A). Dorsum with a marble-like and red coloration with some dark gray blotches/dots. White granules on dorsum and flanks. Glands on posterior surface of thighs yellow. Thighs with a medium brown coloration.

Variation. No remarkable variation concerning morphology and color patterns was observed within *Adenomera juikitam* **sp. nov.** type series.

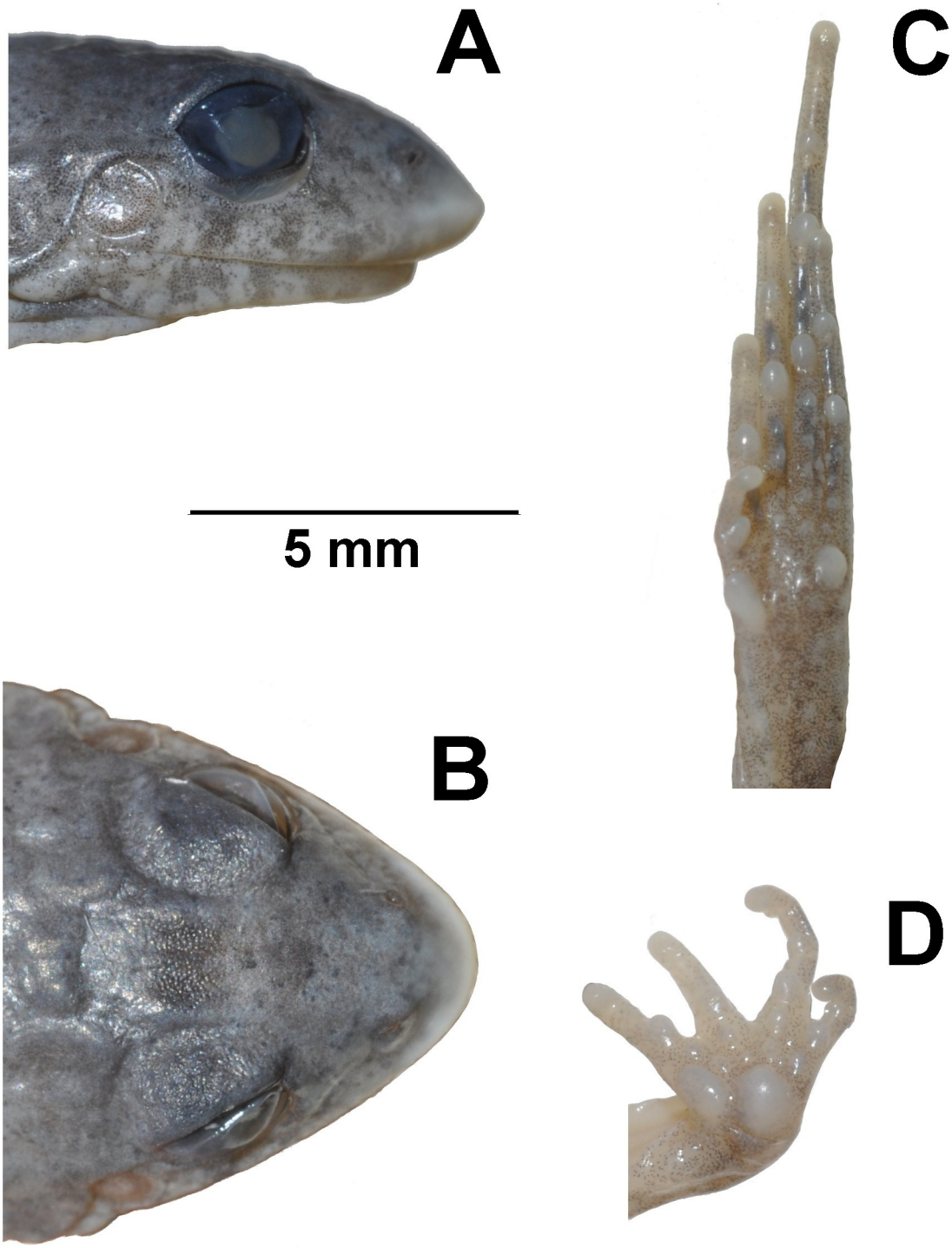

FIGURE 7. *Adenomera juikitam* **sp. nov.**, holotype (AAG-UFU 1406), adult male. Lateral (A) and dorsal (B) views of head, and ventral views of foot (C) and hand (D).

TABLE 4. Advertisement call data (range of values) of comparative *Adenomera* species from original descriptions, topotypes, unpublished theses, or information available from the nearest point to type localities, and their respective sources. For each species, the number of males recorded is provided between parentheses.

Species	Call duration (ms)	Pulses/call	1st harmonic peak frequency (kHz)	2nd harmonic peak frequency (kHz)	Source
***A. ajurauna* (4)**	130–190	No pulses	3.72–5.43	----------	Berneck *et al.* (2008)
***A. andreae*[1] (9)**	16–30	2–7	2.82–3.05	4.61–5.16	Kokubum (2008)
***A. araucaria* (4)**	86–140	5–11	1.72–3.36	4.63–5.40	Kwet & Angulo (2002)
***A. bokermanni*[1] (8)**	99–152	No pulses	1.79–1.83	3.40–3.57	Kokubum (2008)
***A. coca* (2)**	110–145	10–15	1.69–1.91	3.45–3.75	Angulo & Reichle (2008)
***A. cotuba* sp. nov. (6)**	69–191	8–14	1.73–1.83	3.33–3.80	Present study
***A. diptyx*[2] (?)**	57–88	Pulsed	2.18–2.28	4.20–4.50	Marquez *et al.* (1995)
***A. engelsi* (7)**	96–163	No pulses	~2.00	3.46–4.29	Kwet *et al.* (2009)
***A. heyeri* (1)**	137–185	No pulses	1.82–1.88	3.57–3.84	Boistel *et al.* (2006)
***A. hylaedactyla* (5)**	35–62	4–6	1.95–2.21	3.96–4.48	Angulo *et al.* (2003)
***A. juikitam* sp. nov. (3)**	148–202	16–21	1.88–2.11	3.70–4.17	Present study
***A. lutzi* (2)**	41–61	No pulses	1.64–1.81	3.27–3.62	Kok *et al.* (2007)
***A. marmorata*[3] (1)**	100	No pulses	<1.00	4.50–5.60	Straughan & Heyer (1976)
***A. martinezi* (15)**	63–151	15–21	1.88–2.06	3.38–4.13	Carvalho & Giaretta (2013)
***A. nana* (10)**	67–122	No pulses	2.30–2.70	4.62–5.44	Kwet (2007)
***A. saci* (19)**	90–241	No pulses	1.69–2.25	3.38–4.41	Carvalho & Giaretta (2013)
***A. simonstuarti* (1)**	57–71	3–4	1.81–2.03	3.71–4.05	Angulo & Icochea (2010)
***A. thomei* (8)**[4]	120–210	10–21	2.15–2.81	4.57–5.56	Almeida & Angulo (2006)

[1] Acoustic data were based on topotypes (Kokubum 2008);
[2] In Marquez *et al.* (1995) as *A. andreae*; see also De la Riva *et al.* (2000); pulsed structure of *A. diptyx* call was described in Zaracho (2011), and was based on recordings in our database (T.R. de Carvalho pers. comm.). The number of males recorded was not mentioned;
[3] Non-pulsed structure of *A. marmorata* call was based on fig. 28 in Heyer (1973), P.P.G. Taucce pers. comm., and recordings in our database (T.R. de Carvalho pers. comm.);
[4] Pulses per call were obtained from seven males (Almeida & Angulo 2006).

Advertisement call. Three males were recorded (N = 143 analyzed calls; see Table 3 for individual sample sizes). Advertisement call (fig. 8; Tables 3–4) consists of a pulsed signal with deep and regular amplitude modulation emitted in an intermittent pattern from 43–45 calls/minute (mean 44.7; SD = 0.6). Calls have up to 9 visible harmonics and a slight ascendant frequency modulation throughout their duration, and are composed of 16–21 pulses (mean 18.1; SD = 2.1). Call duration varies from 148–202 ms (mean 177.3; SD = 17.4), and intercall interval from 0.76–2.16 s (mean 1.18; SD = 0.05). Fundamental frequency (1st harmonic) peaks from 1.88–2.11 kHz (mean 1.98 kHz; SD = 0.09), and dominant frequency corresponds to the 2nd harmonic, peaking from 3.70–4.17 kHz (mean 3.99 kHz; SD = 0.16). The other harmonics, if present, are increasingly weaker.

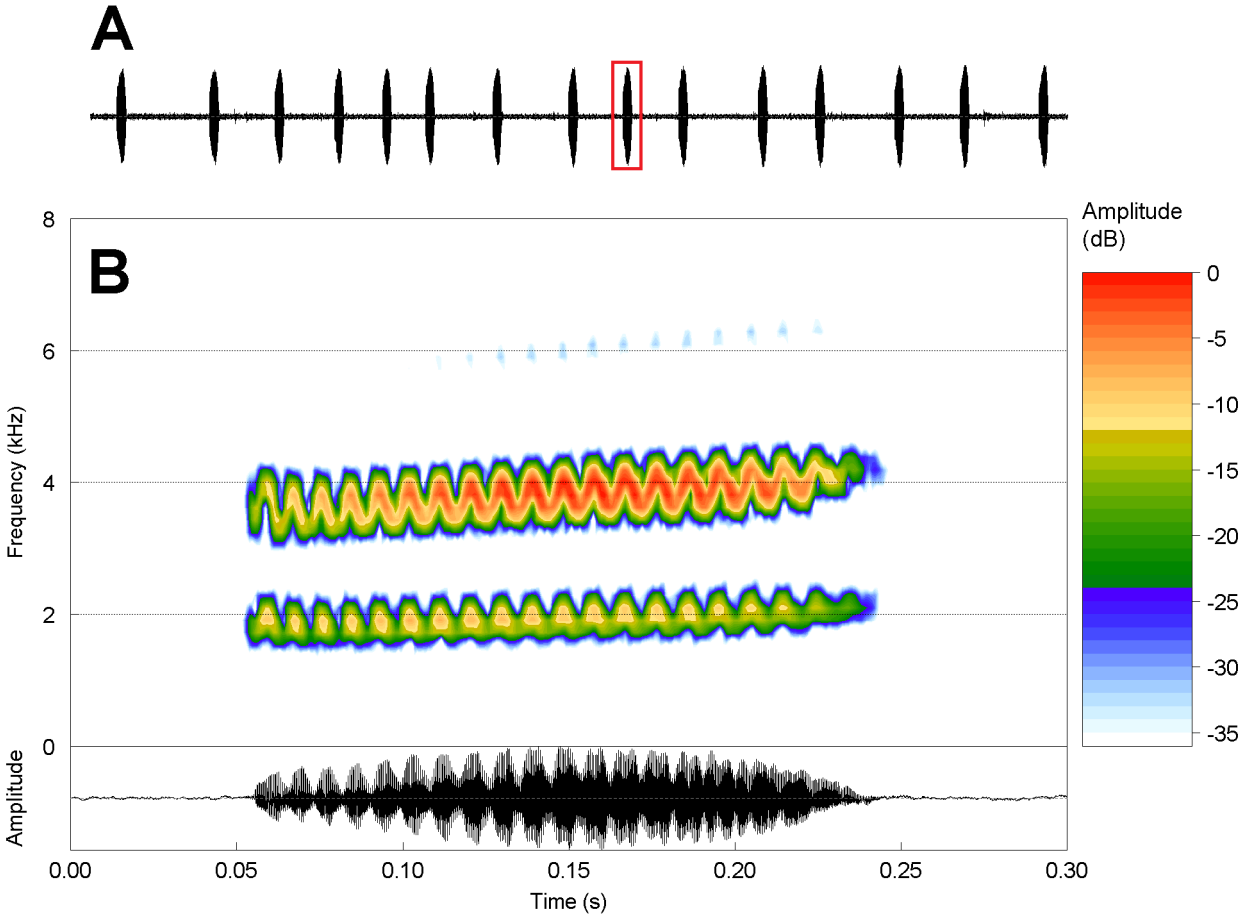

FIGURE 8. Advertisement call of *Adenomera juikitam* **sp. nov.** (voucher AAG-UFU 0808) from Teresina de Goiás, central Brazil: A—A section of 15 calls (~ 20 seconds); B—Spectrogram (above) and respective oscillogram (below) of the 9th call in A, identified by a red outline. Sound file: Adeno_juikitamTeresGoiasGO1bAAGm671; 18:48h, 18 Nov 2011, Air 25.0 °C.

Natural history. *Adenomera juikitam* **sp. nov.** occurs in association with rocky limestone and sandy soil in open Cerrado environments. Males call exposed or under leaf litter.

Geographic distribution. In addition to the type locality (Teresina de Goiás), *Adenomera juikitam* **sp. nov.** specimens were collected in Colinas do Sul (CHUNB collection; see Additional examined material), approximately 95 km southwest of its type locality, both located in the Chapada dos Veadeiros microregion, northern Goiás, central Brazil.

Conservation status. The distribution of *Adenomera juikitam* **sp. nov.** is currently restricted to two localities in the Chapada dos Veadeiros microregion, as discussed earlier. Given this, we propose that the species be preliminarily assessed as Data Deficient (DD) according to the IUCN Red List Categories and Criteria (2012). In this respect, future studies on its distribution, population status and potential threats, as well as additional data collection efforts must be performed to be able to better assess its extinction risk.

Etymology. The epithet 'juikitam', used in apposition, is the combination of the terms 'jui', meaning frog, and 'kitam', meaning wart, both borrowed from Tupi indigenous language, and refers to the warty skin texture of the species.

Additional examined material. BRAZIL: GOIÁS: Colinas do Sul (CHUNB 36029–36030).

Remarks and discussion. Both newly described species occur in syntopy, and our acoustic data distinguish one from the other in call emission pattern, temporal (pulses/call) and spectral (frequency peaks) traits of their advertisement calls (see Table 4). Besides, both the dorsal coloration pattern [*A. cotuba* **sp. nov.** (black or very dark-colored dorsum), *A. juikitam* **sp. nov.** (marble-like and red dorsum)], and the presence (*A. cotuba* **sp. nov.**) or absence (*A. juikitam* **sp. nov.**) of antebrachial tubercles are distinctive between both taxa. Given that the localities from where we heard calling males have no association with water bodies, we assume that both *A. cotuba* **sp. nov.** and *A. juikitam* **sp. nov.** possess a terrestrial reproductive mode with non-feeding larvae.

An in-depth morphological and distributional revision of *Adenomera* (*L. marmoratus* species group) was performed by Heyer (1973), who covered the various names that are currently placed under synonymy in other *Adenomera* species. All morphological variability and color patterns available to Heyer (1973) at that time were classified into three morphotype groups. In this respect, neither do *Adenomera cotuba* **sp. nov.** nor *Adenomera juikitam* **sp. nov.** fit any of these groups by the combination of i) lack of any distinctive dorsal coloration pattern, such as longitudinally arranged spots or dots, dorsolateral or vertebral stripes; ii) lack of dorsolateral folds or dorsal granular rows; iii) lack of toe tips developed into flattened disks. Thus, none of the available names listed by Heyer (1973) might be applied to both newly described *Adenomera* species.

The assessment of the phylogenetic positions of *Adenomera cotuba* **sp. nov.** and *A. juikitam* **sp. nov.** (an ongoing project) would be a good opportunity to better understand the evolutionary scenario of their co-occurrence, at least at the type locality: a case of closely related taxa (sister species); or a case of taxa more distantly related (recovered in different clades, more closely related to other taxa than to each other). Other cases of pairs of *Adenomera* species with co-occurrence include two undescribed forest dweller species of *Adenomera* (referred as Forest Calls I and II) in the Amazon rainforest of southeastern Peru (Angulo *et al.* 2003), *A. marmorata* and *A. ajurauna* (Berneck *et al.* 2008), and *A. araucaria* and *A. engelsi* in the Atlantic Forest (Kwet *et al.* 2009).

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APPENDIX 1. Additional examined specimens.

Adenomera andreae—BRAZIL: PARÁ: Porto Trombetas (MNRJ 52886–52887); *Adenomera* cf. *andreae*—BRAZIL: RONDÔNIA: Cacoal (AAG-UFU 2550–2556); Espigão d'Oeste (AAG-UFU 2284–2285); *Adenomera diptyx*—BRAZIL: MATO GROSSO: Chapada dos Guimarães (AAG-UFU 2138–2139); Cuiabá (AAG-UFU 2123); Santo Antônio do Leverger (AAG-UFU 1435–1438); *Adenomera engelsi*—BRAZIL: SANTA CATARINA: Rancho Queimado (MNRJ 72637, 72543–44); *Adenomera* cf. *hylaedactyla*—BRAZIL: MATO GROSSO: Rondolândia (AAG-UFU 2621); *Adenomera marmorata*—BRAZIL: RIO DE JANEIRO: Bangu (MNRJ 51091, 53817–53818, 53820, 54081–54082, 55684, 58132–58138, 58140–58142); Macaé (AAG-UFU 0529, 0756–0757); Saquarema (MNRJ 76775, 76778–76779); *Adenomera* cf. *marmorata*—BRAZIL: MINAS GERAIS: Chiador (AAG-UFU 0688); SÃO PAULO: Santo André (AAG-UFU 3031); São Sebastião (AAG-UFU 3007); *Adenomera martinezi*—BRAZIL: PARÁ: Novo Progresso: Cachimbo (AAG-UFU 1515–1525); *Adenomera saci*—BRAZIL: GOIÁS: Alto Paraíso de Goiás (Holotype: AAG-UFU 1339; Paratypes: AAG-UFU 0108–0109, 0762–0763, ZUEC 3287); *Adenomera* sp.—BRAZIL: MATO GROSSO: Pontal do Araguaia (AAG-UFU 0201, 0203); MINAS GERAIS: Perdizes (AAG-UFU 0609); Uberlândia (AAG-UFU 4633); GOIÁS: Caldas Novas (AAG-UFU 0018); *Lithodytes lineatus*—BRAZIL: AMAZONAS: Itacoatiara (MNRJ 56699); Barcelos (MNRJ 36243); PARÁ: Piçarra (MNRJ 67289–67290).