

Advertisement call, colour variation, natural history, and geographic distribution of *Proceratophrys caramaschii* (Anura: Odontophrynidae)

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Abstract. *Proceratophrys caramaschii* was described only from a single locality in Mucuripe, Fortaleza municipality, Ceará state, Brazil. The discovery of a new population of this poorly known species facilitated the collection of new data regarding colour in life, vocalization, habitat, and geographic distribution. It has a much wider distribution than formerly thought, is considerably variable in its colour pattern, and its reproductive strategy is strongly associated with the beginning of the rainy season. Males call from the ground and hidden in vegetation. The advertisement call is a short trill of notes. Further data is necessary to evaluate the threat status of this species.

Key words. Amphibia, Anura, *Proceratophrys*, antiphonal call, colour variation, biology, Caatinga Domain.

Introduction

The genus *Proceratophrys* MIRANDA-RIBEIRO currently comprises 40 species that are distributed throughout Brazil, northeastern Argentina, and Paraguay (see FROST 2014). Among them, the *Proceratophrys cristiceps* species group is composed of species lacking palpebral appendages and postocular swellings, and inhabiting mainly seasonally dry open environments (Cerrado and Caatinga domains) of Brazil (GIARETTA et al. 2000). Fifteen species are currently included in this taxonomic group (sensu BRANDÃO et al. 2013): *Proceratophrys aridus* CRUZ, NUNES & JUNCÁ, *P. bagnio* BRANDÃO, CARAMASCHI, VAZ-SILVA & CAMPOS, *P. branti* BRANDÃO, CARAMASCHI, VAZ-SILVA & CAMPOS, *P. caramaschii* CRUZ, NUNES & JUNCÁ, *P. carranca* GODINHO, MOURA, LACERDA & FEIO, *P. concavitympanum* GIARETTA, BERNARDE & KOKUBUM, *P. cristiceps* (MÜLLER), *P. cururu* ETEROVICK & SAZIMA, *P. dibernardo* BRANDÃO, CARAMASCHI, VAZ-SILVA & CAMPOS, *P. goyana* (MIRANDA-RIBEIRO), *P. huntingtoni* ÁVILA, PANSONATO & STRÜSSMANN, *P. moratoi* (JIM & CARAMASCHI), *P. rotundipalpebra* MARTINS & GIARETTA, *P. strussmannae* ÁVILA, KAWASHITA-RIBEIRO & MORAIS, and *P. vielliardi* MARTINS & GIARETTA.

Proceratophrys caramaschii was recently described by CRUZ et al. (2012) based on 39 specimens from Mucuripe, Fortaleza municipality, coast of Ceará state. The authors stated that the known distribution was restricted to the type locality, and were unable to provide additional biological information on this species (e.g., advertisement call and natural history).

While investigating the anurofauna in a transition zone between Caatinga (dry savannah) and forest formation, in the Complexo do Planalto da Ibiapaba, Ceará state, Brazil (see LOEBMANN & HADDAD 2010), two of us (DL and CFBH) discovered a population that was previously assigned as *P. cristiceps*, but in fact represents *P. caramaschii*. Herein, we present recently gathered data pertaining to *P. caramaschii* from this population.

Materials and methods

The acronyms used in the text are CFBH (CÉLIO F. B. HADDAD Collection, Departamento de Zoologia, I.B., Universidade Estadual Paulista, Rio Claro, SP, Brazil), DL (DANIEL LOEBMANN sound recordings, stored at the Departamento de Zoologia, I.B., Universidade Estadual Pau-

lista, Rio Claro, SP, Brazil), and NHMB (Naturhistorisches Museum, Basel, Switzerland). The diagnosis of the species follows CRUZ et al. (2012), BRANDÃO et al. (2013), and our new data provided.

We found calling males of *Proceratophrys caramaschii* in disturbed areas of a relict moist forest in the municipalities of Ubajara (03°49' S, 40°55' W, 857 m above sea level), and Viçosa do Ceará (03°34' S, 41°04' W, 340 m a.s.l.; WGS84 datum), both in Ceará state, Brazil, between February of 2007 and January of 2008. We recorded advertisement calls emitted by males using a Sony cassette tape recorder (TCM-150) with an external directional microphone, Yoga (HT 81 Boom), positioned at a maximum distance of 3 m to the calling males. The resulting sound files were deposited in the CFBH Sound Library (DL 001 [8 February 2007], DL 002 [28 February 2007], DL 003 [22 January 2008], DL 004 [28 January 2008]), and voucher specimens stored in the CFBH Amphibian Collection (CFBH 16102, 16109, 16112–16114, 16119, 16120, 16125, 16126, 16131, 23455–23462, 23756–23762). The recorded calling individuals were not collected.

We digitalized the vocalization recordings using a PC desktop equipped with a sound card, Creative Sound Blaster Audigy 2 ZS (sampling frequency of 44.1 kHz and sample size of 16 bits). Advertisement calls were analysed using Raven Pro 1.4 software (CHARIF et al. 2010), with Fast Fourier Transform length (FFT) = 1024, Frame = 100, Overlap = 60, and window function flap top. Waveforms, au-

dio-spectrograms, and power spectra were obtained using SoundRuler v. 0.9.6.0 (GRIDI-PAPP 2007), with a changed Fast Fourier Transform length (FFT) of 256. The following descriptions are based on the advertisement calls of three males. The records DL 001, 002 and 003 represent single calling males, and DL 004 males calling antiphonally.

Results

The specimens were identified upon the presence of the following traits (according to CRUZ et al. [2012], with the addition of character states referring to the eyelids according to BRANDÃO et al. [2013], and SVL data of this study): medium size (adult males SVL 42.7–56.3 mm, adult females 53.8–68.3 mm); snout rounded in dorsal view, obtuse in profile view; HL/HW 78–86%; tympanum concealed; anterior and posterior eyelid tubercles not differentiated; one transverse crest of interocular tubercles; canthal crests poorly defined; frontoparietal crest developed; outer metacarpal tubercle divided into two oval sections, with the inner one being larger than the external one; webbing formula I 1-2 II 2+-3 III 2+-4- IV 4-2 V; inner metacarpal tubercle elongated; a few large blotches on the venter.

Advertisement call: The advertisement call of isolated males (Fig. 1) comprises one multipulsed note with 33 to 59 pulses (mean 45 ± 9.19 ; $n = 3$ males, 45 calls); call duration 0.41 to

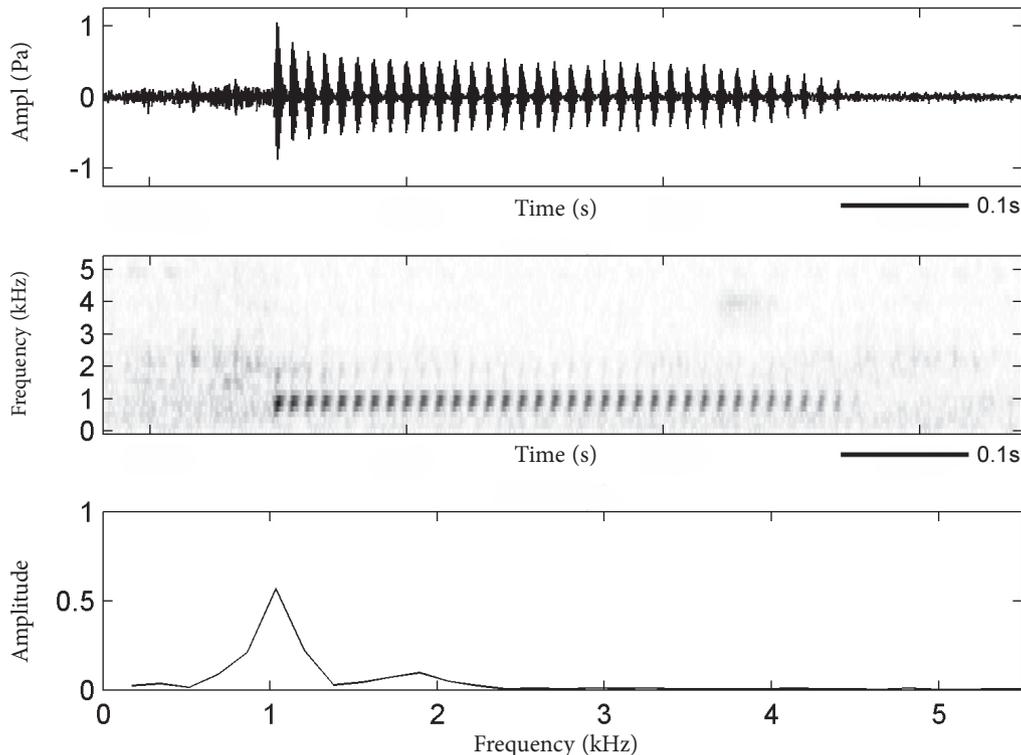


Figure 1. Wave form (top) and spectrogram (middle) of the advertisement call and power spectrum of the pulse (bottom) with a higher amplitude of a single male of *Proceratophrys caramaschii*. Recorded in the municipality of Viçosa do Ceará, Ceará state, Brazil. DL 003, 22 January 2008, air temperature not recorded.

0.74 s (mean 0.57 ± 0.11 ; $n = 3$ males, 45 calls); call interval 0.50 to 1.94 s (mean 0.93 ± 0.43 ; $n = 3$ males, 42 intervals); rate of pulse emission 78.56 to 81.82 pulses/s (mean 80.01 ± 0.86 ; $n = 3$ males, 45 calls); pulse duration 0.006 to 0.009 s (mean 0.0088 ± 0.0007 ; $n = 3$ males, 6 calls, 360 pulses); and pulse interval 0.001 to 0.007 s (mean 0.0048 ± 0.0011 ; $n = 3$ males, 6 calls, 354 intervals). The dominant frequency has two bandwidths, with the most common lying at 0.86 kHz (87% of 30 calls of 3 males). The other bandwidth is present at 1.03 kHz (13% of 30 calls of 3 males). The call has a descendant amplitude modulation, with the first pulse being much higher than the last one, and does not exhibit frequency modulation; the pulses have descendant amplitudes and frequency modulations.

Antiphonal calls (Fig. 2) were emitted in “call and response” style, with partial overlapping between calls. The advertisement call of male A has the same temporal parameters as those of single calling males. The call of male B is slightly different in that it exhibits a lower range of pulse emissions while still overlapping with those of male A or

isolated males (77.50 to 79.85 pulses/s, mean 78.14 ± 0.71 ; $n = 1$ male B, 15 calls). The antiphonal call interval of male A ranges from 0.44 to 0.77 s (mean 0.54 ± 0.09 ; $n = 1$ male A, 15 intervals). The call interval of male B was not measured, because it would start just before the end or just before the beginning of the call of male A, with little overlap, which renders it difficult to pick the exact beginning or end of the call. The remarkable difference between the calls of male A and male B is the division of the acoustic space by different dominant frequencies used by each male, with male A occupying the frequency bandwidth of 0.86 kHz and male B that of 1.03 kHz.

Colour variation in life: Regarding the variation of the dorsal colouration pattern, *P. caramaschii* may be classified as a highly polychromatic species (see some examples in Fig. 3). The dorsal colour pattern is marbled with several shades of brown on a cream background. The cream background and the light brown tones may have a reddish hue. The mid-dorsal region, internal to the limits of a spear-

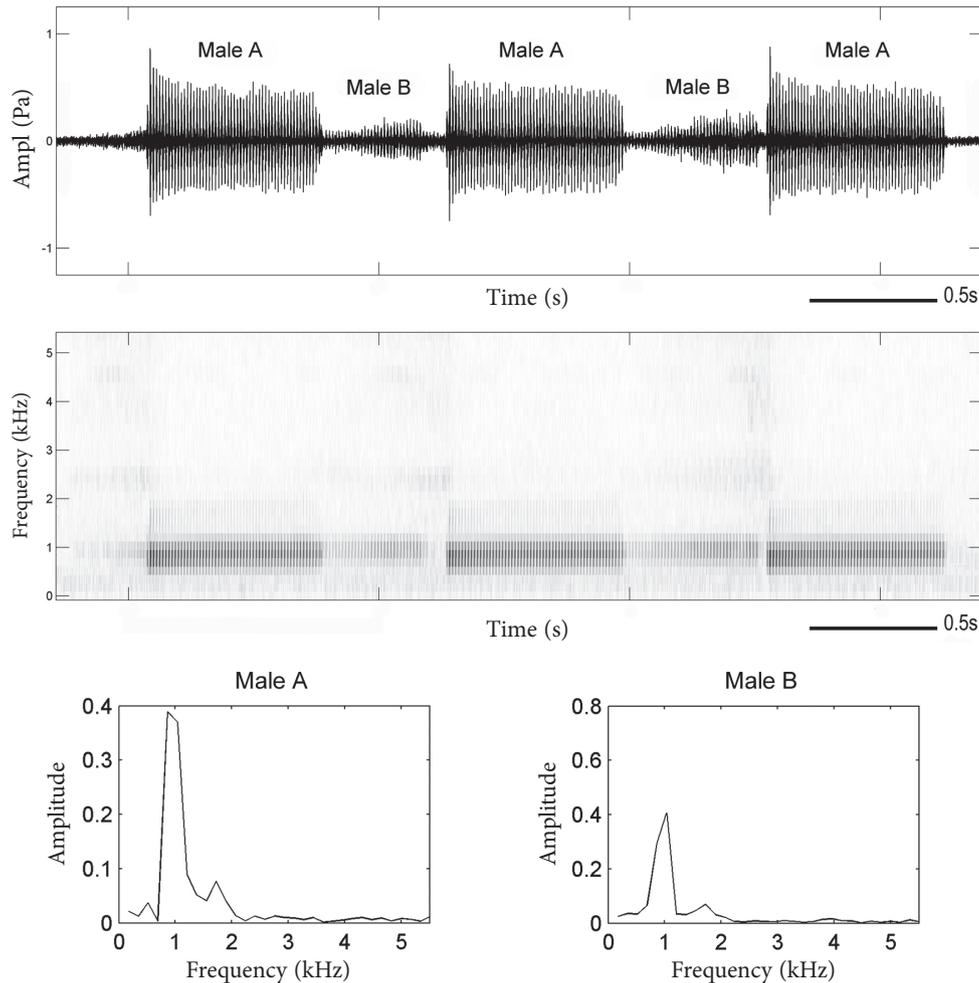


Figure 2. Wave form (top) and spectrogram (middle) of the advertisement calls and power spectrum (bottom) of the pulse with a higher amplitude of *Proceratophrys caramaschii* in antiphonal interaction. Recorded in the municipality of Viçosa do Ceará, Ceará state, Brazil. DL 004, 28 January 2008, air temperature not recorded.

shaped ornamentation, may have the same dorsal pattern, a lighter pattern, or a uniform pattern without drawings. If there is no spear-shaped ornamentation, the mid-dorsal pattern corresponds to the dorsolateral pattern. The rostral region can have a lighter smooth colouration, like a mask.

Natural history notes: Like almost all Odontophrynidae, *P. caramaschii* has an explosive breeding behaviour, and its reproduction is strongly associated with the beginning of the rainy season in Planalto do Ibiapaba (rainy season from January to May; LOEBMANN & HADDAD 2010). Usually, males will call from the ground, concealed in the vegetation, but in situations of vegetation being absent or male density being high, especially at the peak of the reproduction period, it will be possible to also find males

calling totally exposed (Fig. 4). The species, including recently metamorphosed juveniles, is typically nocturnal. There is no information available about tadpoles. Apparently, *P. caramaschii* exhibits the reproductive modes 1 and 2 (sensu HADDAD & PRADO 2005), that are, deposition of eggs in lentic or lotic water bodies. However, calling males were more commonly found associated with lotic waters. Amplexus is axillar like in other species of this family (see Fig. 3). There is no data available about the period during which males remain amplexed to females in the natural habitat. In captivity, however, males showed a surprising capacity of staying amplexed for a long period (up to five days), even when females buried themselves in the ground. Females are usually larger than males, with SVLs of 53.8–68.3 mm for females (CRUZ et al. 2012, present study) and



Figure 3. Colour variation of *Proceratophrys caramaschii* in life. Specimens shown were collected in the Complexo do Planalto da Ibiapaba, Ceará state, Brazil.

42.7–56.3 mm for males (CRUZ et al. 2012, present study). Females are able to produce a large number of eggs (ca 1,200–4,300; $n = 4$; D. LOEBMANN unpubl. data). Regarding habitat use, LOEBMANN & HADDAD (2010) described *P. caramaschii* (as *P. cristiceps*) as occurring in a wide range of environments, including relict moist forest (canopy



Figure 4. A male of *Proceratophrys caramaschii* (not collected) calling exposed; municipality of Viçosa do Ceará, Ceará state, Brazil.

higher than 20 m), high-altitude Caatinga, arboreal Caatinga, low-altitude Caatinga, and Cerrado.

Geographic distribution: At the time of the original description, *P. caramaschii* was known only from the type locality, in the municipality of Fortaleza, state of Ceará, northeastern Brazil ($3^{\circ}43' S$, $38^{\circ}29' W$, at sea level; WGS84 datum). Recently, ROBERTO et al. (2013) identified the population living in the coastal zone of Piauí ($2^{\circ}30' - 3^{\circ}00' S$, $41^{\circ}00' - 42^{\circ}10' W$, at sea level), a region ca 340 km straight line to the west of the type locality, as *P. cf. caramaschii* (previously assigned to *P. cristiceps* in LOEBMANN & MAI 2008, LOEBMANN et al. 2010). Herein, their record is confirmed to indeed refer to *P. caramaschii*. LOEBMANN & HADDAD (2010) described the herpetofauna of a highly diverse area of the Caatinga Domain, the Complexo do Planalto da Ibiapaba, Ceará state, Brazil, and reported the presence of *P. cristiceps* that is here re-identified as *P. caramaschii*. The area is relatively close to the coast and represents the northwesternmost fragments of moist forest in the state of Ceará ($3^{\circ}20' - 5^{\circ}00' S$ and $40^{\circ}42' - 41^{\circ}10' W$; 900 m maximum altitude). Thus, this is the third geographic record of *P. caramaschii* and extends the known distribution by ca 300 km to the southwest from the type locality, and ca 50 km straight line to the southeast of the coastal zone of Piauí, Brazil (Fig. 5). Another possibly new record is the strictly protected conservation unit of the Parque Nacional de Sete Cidades, a Cerrado area between the municipalities of Piracuruca and Brasileira ($\sim 3^{\circ}52' S$ and $41^{\circ}30' W$; 150 m

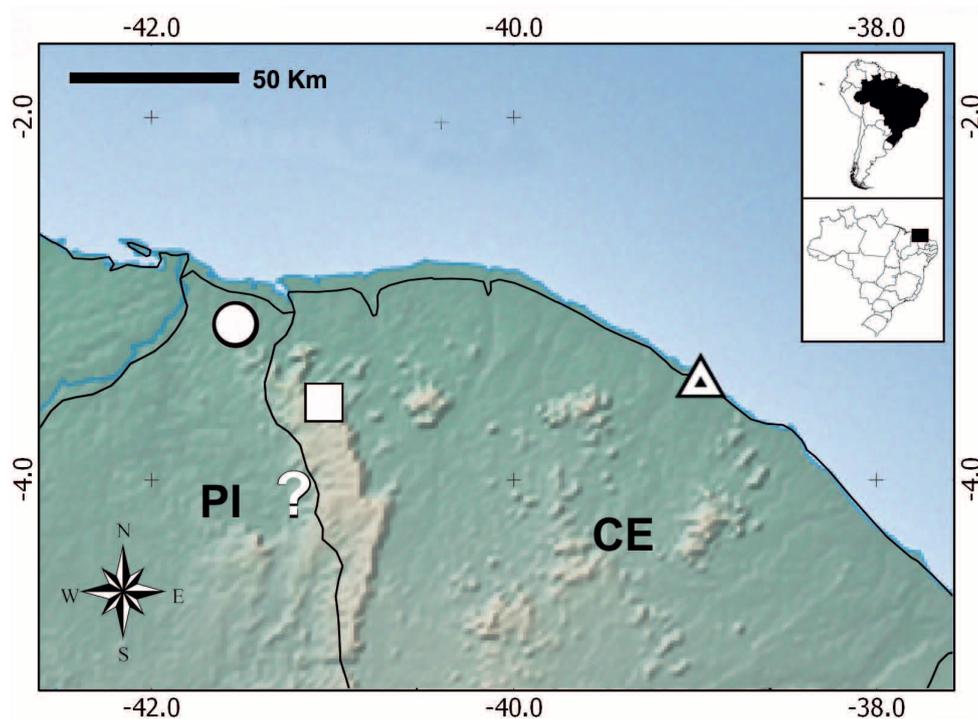


Figure 5. Geographic distribution of *Proceratophrys caramaschii*. Open circle – coastal zone of Piauí state; square – region of the Complexo do Planalto da Ibiapaba, CE; Triangle – type locality; Question mark – Parque Nacional de Sete Cidades, PI; CE – Ceará state; PI – Piauí state.

Table 1. Summary of the described advertisement calls of the species of the *Proceratophrys cristiceps* group. The data are presented as mean \pm standard deviation (range). Diagnostic characteristics of the other species compared to *P. caramaschii* are marked in bold. * – Present work, based on published data; ** – middle notes as per MARTINS & GIARETTA (2013). States acronyms: BA – Bahia; CE – Cará; GO – Goiás; MG – Minas Gerais; MT – Mato Grosso; RO – Rondônia; SP – São Paulo.

Species	Note duration (ms)	Notes/call	Pulses/s	Pulses/note	Dominant frequency (Hz)	Provenance	Source
<i>P. caramaschii</i>	570 \pm 11 (410–740)	1	80.01 \pm 0.86 (78.56–81.82)	45 \pm 9.19 (33–59)	860 or 1030	Planalto do Ibiapaba, CE	Present work
<i>P. carranca</i>	107.4\pm36.1 (45.0–191.0)	1–10	111.1–109.9*	12.2\pm3.9 (5.0–21.0)	1178.0\pm65.5 (1033.6–1378.1)	Buritizeiro, MG	GODINHO et al. (2013)
<i>P. concavitympanum</i>	367 \pm 58 (230–500)	1	106.3\pm3.1 (100–112.27)	38.7 \pm 7.4 (23–51)	948.17 \pm 66.66 (850.99–1116.35)	Aripuanã, MT	SANTANA et al. (2010)
<i>P. concavitympanum</i>	278\pm40 (178–326)	1	110.95\pm5.24 (100.67–119.27)	30.85 \pm 4.81 (19–37)	819.18 \pm 62.20 (754.63–874.51)	Espigão do Oeste, RO	SANTANA et al. (2010)
<i>P. cristiceps</i>	660 \pm 50 (520–790)	1	89.54\pm1.20 (87.43–91.85)	57.46 \pm 6.02 (46–69)	940\pm20 (900–990)	Feira de Santana, BA	NUNES & JUCÁ (2006)
<i>P. cururu</i>	600–1000	1	45	40	900 (600–1000)	Serra do Cipó, MG	ETEROVICK & SAZIMA (1998)
<i>P. goyana</i>	103.7\pm14.7** (71.0–195.0)	1–34	99.3\pm4.4 (83.3–120.5)	10.2\pm1.4 (7–18)	1005.9 \pm 28.4 (937.5–1125.0)	Chapada dos Veadeiros, GO	MARTINS & GIARETTA (2013)
<i>P. huntingtoni</i>	270.0\pm10.0 (200.0–320.0)	1	78–95*	21.3\pm1.2 (19.0–25.0)	1250.2\pm49.9 (1095.0–1344.5)		ÁVILA et al. (2012)
<i>P. moratoi</i>	245.4\pm28.7 (185.0–307.0)	1	81–85*	20.5\pm2.5 (15.0–26.0)	1342.0\pm73.7 (1174–1444)	Itirapina, SP	BRASILEIRO et al. (2008)
<i>P. moratoi</i>	206.8\pm17.6 (146.0–238.0)	1	82–84*	17.5\pm1.5 (12.0–20.0)	1348.7\pm86.6 (1153–1420)	Botucatu, SP	BRASILEIRO et al. (2008)
<i>P. moratoi</i>	232.0 \pm 21.0 (181.0–268.0)	1	77–86*	19.0\pm3.0 (14.0–23.0)	1440\pm50 (1406–1594)	Ituiutaba, MG	MARTINS & GIARETTA (2012)
<i>P. moratoi</i>	253.0\pm36.0 (179.0–335.0)	1	69–78*	19.0\pm2.0 (14.0–23.0)	1327\pm108 (1219–1464)	Uberlândia, MG	MARTINS & GIARETTA (2012)
<i>P. rotundipalpebra</i>	93.4\pm20.2** (50.0–200.0)	1–24	101.0 \pm 8.9 (78.1–130.4)	9.3\pm1.7 (5–19)	1287.9\pm54.4 (1125.0–1453.1)	Chapada dos Veadeiros, GO	MARTINS & GIARETTA (2013)
<i>P. vielliardi</i>	59.2\pm8.3 (40.2–84.7)	3–20	107.7\pm6.2 (95.6–118.8)	6.4\pm0.9 (4.0–9.0)	1133.8 \pm 93.3 (1022.0–1291.0)	Caldas Novas, GO	MARTINS & GIARETTA (2011)

maximum altitude). In this area, specimens were observed by one of us, but not collected (DL pers. obs.).

Discussion

Species delimitation in taxonomically difficult groups, like those of the *Proceratophrys cristiceps* species group, needs characters to differentiate between related species. CRUZ et al. (2012) stated the presence of a depression between the frontoparietals in *P. caramaschii* and smooth frontoparietals in *P. cristiceps*. Figure 2 of CRUZ et al. (2012) shows the holotype of *P. cristiceps* (NHMB 1503), which has a conspicuous depression between the anterior portion of the frontoparietals and nasals. However, the eyes are undoubtedly compressed towards the central region, which is an artefact from the preservation process. The recently collected specimens of *P. cristiceps* do not exhibit this characteristic (see the diagnosis in CRUZ et al. 2012). Thus, the diagnoses presented by CRUZ et al. (2012) with improvements of BRANDÃO et al. (2013) are adequate to identify the species.

The advertisement call of *Proceratophrys caramaschii* is characterized by a short trill of pulses. The large number of described advertisement calls in the *P. cristiceps* species group makes it possible to compare it widely and outline some differences. The call amplitude modulation of *P. caramaschii* (slightly elevated in amplitude in the beginning) is different from that of *P. cristiceps* (remarkably elevated in amplitude in the beginning, with a descendant structure throughout the call; NUNES & JUNCÁ 2006). The call duration of *P. caramaschii* (410 to 740 ms) is longer compared to the calls of *P. carranca* (45 to 191 ms; GODINHO et al. 2013), *P. concavitympanum* (178 to 326 ms; population from Espigão do Oeste, RO; SANTANA et al. 2010), *P. goyana* (71 to 195 ms; MARTINS & GIARETTA 2013), *P. huntingtoni* (200 to 320 ms; ÁVILA et al. 2012), *P. moratoi* (146 to 335 ms; combined results of BRASILEIRO et al. 2008 and MARTINS & GIARETTA 2012), *P. rotundipalpebra* (50 to 200 ms; MARTINS & GIARETTA 2013), and *P. vielliardi* (40.2 to 84.7 ms; MARTINS & GIARETTA 2011). The number of notes contained in a call by *P. caramaschii* (1 note) is lower than in *P. vielliardi* (3 to 20 notes; MARTINS & GIARETTA 2011). The number of

pulses (33 to 59) per note is higher in *P. caramaschii* than in *P. carranca* (5 to 21 pulses; GODINHO et al. 2013), *P. goyana* (7 to 18 pulses; MARTINS & GIARETTA 2013) *P. huntingtoni* (19 to 25 pulses; ÁVILA et al. 2012), *P. moratoi* (12 to 26 pulses; combined results of BRASILEIRO et al. 2008 and MARTINS & GIARETTA 2012), *P. rotundipalpebra* (5 to 19 pulses; MARTINS & GIARETTA 2013), and *P. vielliardi* (4 to 9 pulses; MARTINS & GIARETTA 2011). The rate of pulse emission (78.56 to 81.82 pulses/s) is lower in *P. caramaschii* than in *P. carranca* (111.1 to 109.9 pulses/s; GODINHO et al. 2013), *P. concavitympanum* (100 to 119.27 pulses/s; combined results of SANTANA et al. 2010), *P. cristiceps* (87.43 to 91.85 pulses/s; NUNES & JUNCA 2006), and *P. goyana* (83.3 to 120.5 pulses/s; MARTINS & GIARETTA 2013), and higher than in *P. cururu* (40 pulses/s; ETEROVICK & SAZIMA 1998). The dominant frequency of a *P. caramaschii* call (860 or 1030 Hz) is lower than in *P. carranca* (1033.6 to 1378.1 Hz; GODINHO et al. 2013), *P. huntingtoni* (1095 to 1344.5 Hz; ÁVILA et al. 2012), *P. moratoi* (1153 to 1594 Hz; combined results of BRASILEIRO et al. 2008 and MARTINS & GIARETTA 2012), and *P. rotundipalpebra* (1125 to 1453.1 Hz; MARTINS & GIARETTA 2013). A summary of the acoustic parameters of the advertisement calls of the species of the *P. cristiceps* group is presented in Table 1.

The antiphonal calling by *P. caramaschii* deserves some comments since the partial overlapping of call emission seems to be a complex situation in anurans. WELLS (2007) discussed two types of call emission between neighbouring males: (1) a very rapid response to calls by other males that produces a synchronizing effect and results in a partial overlap of calls by neighbouring males, or (2) a precisely timed alternation of calls. The call emission described for *P. caramaschii* is of the partially overlapping type and can be related to mask some attractive characteristics of the leader call or to anti-predator behaviour based on misidentification of males in the field (e.g., WELLS & SCHWARTZ 1984). The calling male A appears to be the leader, because his advertisement call characteristics equal those of a single calling male and his calls begins before that of the other male. However, a conclusive judgement on the functions of the partially overlapping vocalizations in *P. caramaschii*, and the identification of which male is the leader and which is the follower, will depend on more observations and, perhaps, an experimental approach.

Polychromatism has been recorded in several anuran species (see HOFFMAN & BLOUIN 2000). Among the species recognized as polychromatic, the variation in colouration may serve distinct functions such as disruptive camouflage (e.g., in *Leptodactylus fuscus*), aposematism (e.g., in *Dendrobates tinctorius*), sexual identification (e.g., in *Rhinella icterica*), ontogenetic variation (e.g., in *Hypsiobas raniceps*, *H. crepitans*, *H. albopunctatus*), and others (see the brief review in WELLS 2007 for other examples). Polychromatism may also vary throughout species distribution. For example, in *Leptodactylus fuscus*, the overall proportion of individuals with a vertebral stripe is smaller than of individuals without stripe, but the proportional representation of these chromotypes within a single pop-

ulation can range from 1:2 to 1:4.2 (HEYER 1978, KAKAZU et al. 2010). However, the functional role of polychromatism still remains poorly understood in most anuran species, especially in those with cryptozoic behaviour. This is the case in the *P. cristiceps* species group in which dorsal polychromatism is observed in all species, from those considered being highly polychromatic (e.g., *P. aridus*, *P. caramaschii*, *P. cristiceps*, *P. redacta*; CRUZ et al. 2012, TEIXEIRA JR. 2012) to species with lower individual variation (e.g., *P. concavitympanum*, *P. cururu*, *P. moratoi*; SANTANA et al. 2010, ETEROVICK & SAZIMA 1998).

The two new geographic records for *P. caramaschii* (Complexo do Planalto da Ibiapaba, Ceará state, and coastal zone of Piauí state, both Brazil) extend considerably the known distribution of this species. In fact, we expect this species to have a wider distribution in the Caatinga domain, including forest patches (e.g., arboreal Caatinga, relict moist forests) as well as open areas (savannas of Caatinga and Cerrado, palm tree forests, and the coastal zone). The possible new geographic record in the strictly protected conservation unit of the Parque Nacional de Sete Cidades (Piauí state; DL pers. obs.) needs confirmation through the collection of specimens and analysis of advertisement calls. Our findings corroborate the comments by CRUZ et al. (2012) about the estimated distribution of *P. caramaschii*. The authors discussed the existence of conserved areas near the type locality that could harbour this species and was classified as Data Deficient (DD) as per the IUCN Red List categories and criteria (Version 3.1; 2007). ROBERTO et al. (2013) emphasized that *P. caramaschii* was among the anuran species of the state of Piauí without a Red List status. Despite the new biological and geographic data presented herein, we refrain from changing the species status DD because of the absence of significant data about habitat fragmentation, reproduction, and demography variation. These data are significant to use the IUCN's criteria.

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References

- ÁVILA, R. W., A. PANSONATO & C. STRÜSSMANN (2012): A new species of *Proceratophrys* (Anura: Cycloramphidae) from mid-western Brazil. – *Journal of Herpetology*, **46**: 466–472.
- BRANDÃO, R. A., U. CARAMASCHI, W. VAZ-SILVA & L. A. CAMPOS (2013): Three new species of *Proceratophrys* Miranda-Ribeiro 1920 from Brazilian Cerrado (Anura, Odontophrynidae). – *Zootaxa*, **3750**: 321–347.

- BRASILEIRO, C. A., I. MARTINS & J. JIM (2008): Amphibia, Anura, Cycloramphidae, *Odontophrynus moratoi*: distribution extension and advertisement call. – *Check List*, **4**: 382–385.
- CHARIF, R. A., A. M. WAACK & L. M. STRICKMAN (2010): Raven Pro 1.4 User's Manual. – Cornell Lab of Ornithology, Ithaca, New York.
- CRUZ, C. A. G., I. NUNES & F. A. JUNCÁ (2012): Redescription of *Proceratophrys cristiceps* (Müller, 1883) (Amphibia, Anura, Odontophrynidae), with description of two new species without eyelid appendages from northeastern Brazil. – *South American Journal of Herpetology*, **7**: 110–122.
- ETEROVICK, P. C. & I. SAZIMA (1998): New species of *Proceratophrys* (Anura: Leptodactylidae) from southeastern Brazil. – *Copeia*, **1998**: 159–164.
- FROST, D. R. (2014): Amphibian Species of the World: an Online Reference. Version 6.0 (15 May 2014). – American Museum of Natural History, New York, USA. – <http://research.amnh.org/vz/herpetology/amphibia/index.php/> Accessed: 15 May 2014).
- GIARETTA, A. A., P. S. BERNARDE & M. N. C. KOKUBUM (2000): A new species of *Proceratophrys* (Anura: Leptodactylidae) from the Amazon Rain Forest. – *Journal of Herpetology*, **34**: 173–178.
- GODINHO, L. B., M. R. MOURA, J. V. A. LACERDA & R. N. FEIO (2013): A new species of *Proceratophrys* (Anura: Odontophrynidae) from the middle São Francisco River, southeastern Brazil. – *Salamandra*, **49**: 63–73.
- GRIDI-PAPP, M. (2007): Sound Ruler acoustic analysis. Version 0.9.6.0. – <http://soundruler.sourceforge.net>. Accessed: 10 June 2013.
- HADDAD, C. F. B. & C. P. A. PRADO (2005): Reproductive modes in frogs and their unexpected diversity in the Atlantic Forest of Brazil. – *Bioscience*, **55**: 207–217.
- HOFFMAN, E. A. & M. S. BLOUIN (2000): A review of colour and pattern polymorphism in anurans. – *Biological Journal of the Linnean Society*, **70**: 633–665.
- KAKAZU, S., L. F. TOLEDO & C. F. B. HADDAD (2010): Color polymorphism in *Leptodactylus fuscus* (Anura, Leptodactylidae): a defensive strategy against predators? – *Herpetology Notes*, **3**: 69–72.
- LOEBMANN, D. & C. F. B. HADDAD (2010): Amphibians and reptiles from a highly diverse area of the Caatinga domain: composition and conservation implications. – *Biota Neotropica*, **10**: 227–256.
- LOEBMANN, D. & A. C. G. MAI (2008): Amphibia, Anura, Coastal Zone, Piauí state, Northeastern Brazil. – *Check List*, **4**: 161–170.
- LOEBMANN, D., V. G. D. ORRICO, C. CASSINI & L. O. M. GIASSON (2010): Anfíbios. – pp. 182–211 in: MAI, A. C. G. & D. LOEBMANN (eds): *Guia Ilustrado: Biodiversidade do Litoral do Piauí*. – Grafica e Editora Paratodos, Sorocaba.
- MARTINS, L. B. & A. A. GIARETTA (2011): A new species of *Proceratophrys* Miranda-Ribeiro (Amphibia: Anura: Cycloramphidae) from central Brazil. – *Zootaxa*, **2880**: 41–50.
- MARTINS, L. B. & A. A. GIARETTA (2012): Advertisement calls of two species of *Proceratophrys* (Anura: Odontophrynidae) from Minas Gerais, Brazil, with comments on their distribution, taxonomy and conservation status. – *South American Journal of Herpetology*, **7**: 203–212.
- MARTINS, L. B. & A. A. GIARETTA (2013): Morphological and acoustic characterization of *Proceratophrys goyana* (Lissamphibia: Anura: Odontophrynidae), with the description of a sympatric and related new species. – *Zootaxa*, **3750**: 301–320.
- NUNES, I. & F. A. JUNCÁ (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.
- RABINOWITZ, D. (1981): Seven forms of rarity. – pp. 205–217 in: SYNGE, H. (ed.): *The biological aspects of rare plant conservation*. – John Wiley & Sons, Chichester.
- ROBERTO, I. J., S. C. RIBEIRO & D. LOEBMANN (2013): Amphibians of the state of Piauí, northeastern Brazil: a preliminary assessment. – *Biota Neotropica*, **13**: 321–329.
- SANTANA, D. J., V. A. SÃO-PEDRO, P. S. BERNARDE & R. N. FEIO (2010): Descrição do canto de anúncio e dimorfismo sexual em *Proceratophrys concavitympanum* Giaretta, Bernarde & Kokubum, 2000. – *Papéis Avulsos de Zoologia*, **50**: 167–174.
- WELLS, K. D. (2007): *The ecology and behavior of amphibians*. – The University of Chicago Press, Chicago and London.
- WELLS, K. D. & J. J. SCHWARTZ (1984): Vocal communication in a Neotropical treefrog, *Hyla ebraccata*: advertisement calls. – *Animal Behavior*, **32**: 405–420.