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Advertisement call of Pratt's rocket frog, *Colostethus pratti*, from the western Andes of Colombia (Anura: Dendrobatidae)

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Northwestern South America is one of the biologically most diverse yet least known regions of the world. The Tropical Andes and Chocó-Tumbes-Magdalena ecoregions, two hotspots with high degrees of endemism and conservation priority (MYERS et al. 2000, RODRÍGUEZ-MAHECHA et al. 2004), are part of this region. Especially the Chocoan lowlands and the western Andes of Colombia are areas with exceptional high amphibian diversity and many endemic taxa (e.g., LYNCH et al. 1997, LYNCH & SUÁREZ-MAYORGA 2004, ARMESTO & SEÑARIS 2017). Several species of poison frogs, the family Dendrobatidae, occur here, including Pratt's rocket frog, *Colostethus pratti* (BOULENGER, 1899). Its distribution ranges from the east of Panamá far to the south including the Colombian Pacific lowlands, the foothills of the western Andes and the western foothills of the central Andes (ACOSTA-GALVIS 2019, FROST 2020).

Colostethus pratti likely represents a species complex, pending further taxonomic studies (GRANT et al. 2006, 2017, IBÁÑEZ et al. 2017). So far, and despite its relatively wide geographic range, little is known about this species. Most of the data published for *C. pratti* refer to Panamanian populations, such as the external morphology of adults and tadpoles (SAVAGE 1968) and aspects of reproductive biology (WELLS 1981, GRANT 2004, HILL et al. 2011).

Knowledge about the Colombian populations of Pratt's rocket frog is sparse. Initially, COCHRAN & GOIN (1970) provided a description of the external morphology of the two syntypes from the Departamento de Antioquia, Colombia, of which one was later designated as a lectotype by SILVERSTONE (1971). Subsequently, RIVERO & SERNA (1989 "1988") redefined the distribution of *C. pratti* in the country and classified it in their scheme of phenetic groupings. Since then, this species has been mentioned only in am-

phibian checklists (COCHRAN & GOIN 1970, RUIZ-CARRANZA et al. 1994, ACOSTA-GALVIS 2000, LYNCH & SUÁREZ-MAYORGA 2004, BALLESTEROS-CORREA et al. 2019). The most recent information on *C. pratti* in Colombia concerns its altitudinal distribution, relative abundance, and natural history in the northernmost part of the western Andes, at the Serranía de San Jerónimo, Departamento de Córdoba (ROMERO-MARTÍNEZ et al. 2008, BALLESTEROS-CORREA et al. 2019). To the best of our knowledge, there is no further information available on *C. pratti* in Colombia.

Acoustic communication constitutes a fundamental part of the studies of anuran reproductive biology and taxonomy. Advertisement calls enable males to attract females and to demarcate territories (WELLS & SCHWARTZ 2007), suggesting their function as a premating isolation mechanism in anurans (MAYR 1963, WELLS 2007). Therefore, advertisement calls are commonly utilized for anuran species delimitation and taxonomy (PADIAL et al. 2009, KÖHLER et al. 2017, FORTI et al. 2017). With regard to *C. pratti*, we consider that information on the advertisement calls of distinct populations could be useful for disentangling taxa potentially hidden behind this name, as well as for separating these from other *Colostethus* not related to *C. pratti*. In this study, we provide for the first time data on the advertisement call of this species (complex) from the Departamento de Córdoba in the northern portion of western Andes of Colombia.

Our study was conducted at the Tuis Tuis Creek (8°1'55.89" N, 76°5'4.11" W, 125 m a.s.l.; Fig. 1), a minor tributary of the Sinú River, in the municipio de Tierralta (Vereda Tuis Tuis), Departamento de Córdoba, Colombia, a buffer area of the Nudo del Paramillo National Park in the Serranía de San Jerónimo|. This is an ecologically

complex zone, representing a junction of the dry and wet zonobiomes of the Colombian Caribbean and the low Andean orobiome (HERNÁNDEZ-CAMACHO et al. 1992). Here, the annual mean temperature and relative humidity are of 27.1°C and 88%, respectively; precipitation is determined by a unimodal regime with a wet season from April to October and a dry season between November and March, with an annual mean of 2,576 mm (ROMERO-MARTÍNEZ et al. 2008).

A four-hour walk following the Tuis Tuis upstream to its junction with the Tái Creek was conducted on 12 April 2017. Between 15:00 and 16:00 h, the calls of two individuals of *C. pratti* (four and five calls, respectively) were recorded for 5 min with a Sony (ICD-PX312) recorder. At that time, air temperature was 24.3°C and relative humidity was 66% (taken with an Extech 445703 portal digital thermo-hydrometer). Specimens could not be captured and collected in the given terrain and no measurements were therefore taken. The taxonomic identity of the calling specimens was verified using the descriptions provided by SAVAGE (1968), SILVERSTONE (1971), and ROMERO-MARTÍNEZ et al. (2008), and found support in the fact that several specimens of *C. pratti* had previously been collected in the vicinity of our study area (Fig. 2A) and are now deposited in the Museo Herpetológico at Antioquia University (MHUA, 18 specimens) and the Centro de Colecciones Científicas at Magdalena University (CBUMAG, one specimen). We had access through photographs to specimens MHUA-A 03384, 3387 (Fig. 2B), 3388, 3390, 3393, 3395, 3397 and 3398, and we examined the specimen CBUMAG: ANF: 00162. Specimens in these collections and the ones recorded by us share the absence of toe webbing and the presence of an incomplete oblique lateral stripe.

To describe the advertisement call of *C. pratti*, the recordings of the calls of the two individuals were extracted from the original records, made individual files, and analyzed with PRAAT 6.0.13 for Windows (BOERSMA & WEENINK 2007). For each call, the following characteristics were measured: call duration (s), number of notes per call, rate of notes per second (notes/s), note duration (s), inter-note interval (s), dominant frequency (Hz), and visible harmonics. Means and standard deviations (SD) were calculated for each call trait. Our terminology is as proposed and revised by LÖTTERS et al. (2003) for advertisement call types for Dendrobatoidea and KÖHLER et al. (2017) for call characteristics. Oscillograms and spectrograms for the advertisement call were obtained with the Seewave package (SUEUR et al. 2008) for the R platform.

Along with the two recorded males, another 13 males of *C. pratti* were detected vocalizing from cavities or the surface of the rocky substrate on the banks of the Tuis Tuis Creek (Fig. 2C). All individuals were spaced at least 2 m apart, for which reason no direct interactions were observed.

The advertisement call of *C. pratti* is a trill (Table 1, Fig. 3) of moderate duration (2.57–4.24 s), composed of a series of unpulsed notes (29–129 notes), emitted at high repetition rates (19.04–19.05 notes/s). Individual notes (0.02 s in duration) and inter-note intervals (0.04 s in duration) are short. Prevalent bandwidth ranges from 3,900–12,366 Hz, with a dominant frequency of 4,734–4,739 Hz. Additionally, the call of *C. pratti* exhibits three harmonics: one with a frequency of 7,084–7,111 Hz; one at 9,422–9,452 Hz; and one at 11,382.66–11,539.64 Hz.

The *C. pratti* trill call is composed of long series of notes produced at a rate of 19 notes/s. Other trans-Andean

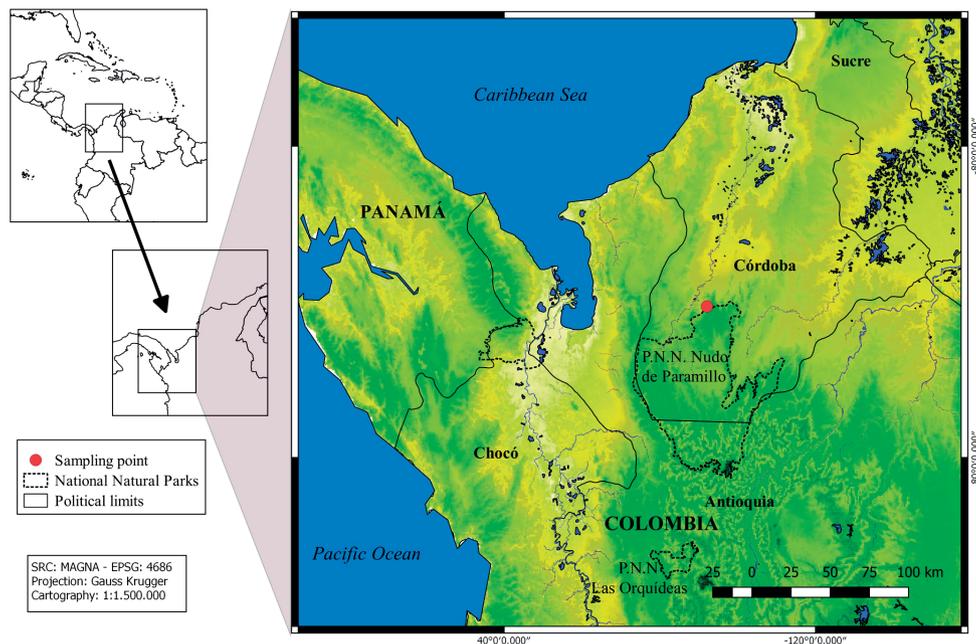


Figure 1. Map showing the locality of the recorded specimens from the Tuis Tuis Creek, Serranía de San Jerónimo, Tierralta, Departamento de Córdoba, Colombia.

dendrobatoids like *Allobates ignotus* ANGANOY-CRIOLLO, 2012, *Allobates niputidea* GRANT, ACOSTA-GALVIS & RADA, 2007, *Rheobates palmatus* (WERNER, 1899), and the “*Colostethus*” *ruthveni* KAPLAN, 1997 group also produce long series of notes. However, there are differences in repetition rates and dominant frequencies compared to *C. pratti*. In the case of *A. ignotus* and *A. niputidea*, calls can be comprised of long series of notes, but with much lower repetition rates and a higher dominant frequencies (*A. ignotus*: 6–116 notes/call, 2.32–4.46 notes/s, 5,312–6,662 Hz, GRANDA-RODRÍGUEZ et al. 2018; *A. niputidea*: 12–62 notes/call, 1.3–1.9 notes/s, 4,700–5,600 Hz, OSPINA-L. et al. 2019), while *R. palmatus* and “*C.*” *ruthveni* sensu stricto exhibit large series of rapidly emitted notes. However, the dominant frequencies of these species’ calls are considerably lower than that of *C. pratti* (*R. palmatus*: 165–296 notes/

call, 7.125–8.70 notes/s, 2,000–2,800 Hz, LÜDDECKE 1999; BERNAL et al. 2005; “*C.*” *ruthveni* sensu stricto: 5–52 notes/call, 2.643–12.95 notes/s, 4,157–5,944 Hz, JIMÉNEZ-BOLAÑO et al. 2019). The advertisement call of *C. pratti* is easily distinguishable from that of the sympatric species, *Allobates talamancae* (COPE, 1875 “1976”) in that the latter emits shorter calls with far fewer notes at a much lower dominant frequency (5–15 notes/call, 3.4 notes/s, 4,062–4,532 Hz, LECHULT et al. 2014).

In contrast, the few species that are phylogenetically close to *C. pratti* (sensu GRANT et al. 2017) and whose advertisement calls have been described vocalize with highly different structures. For example, the advertisement calls of *C. panamensis* (DUNN, 1933) and *C. fraterdanieli* (SILVERSTONE, 1971) consist of short series of notes at low frequencies (*C. panamensis*: 2–5 notes/call, 4,126–4,547 Hz,

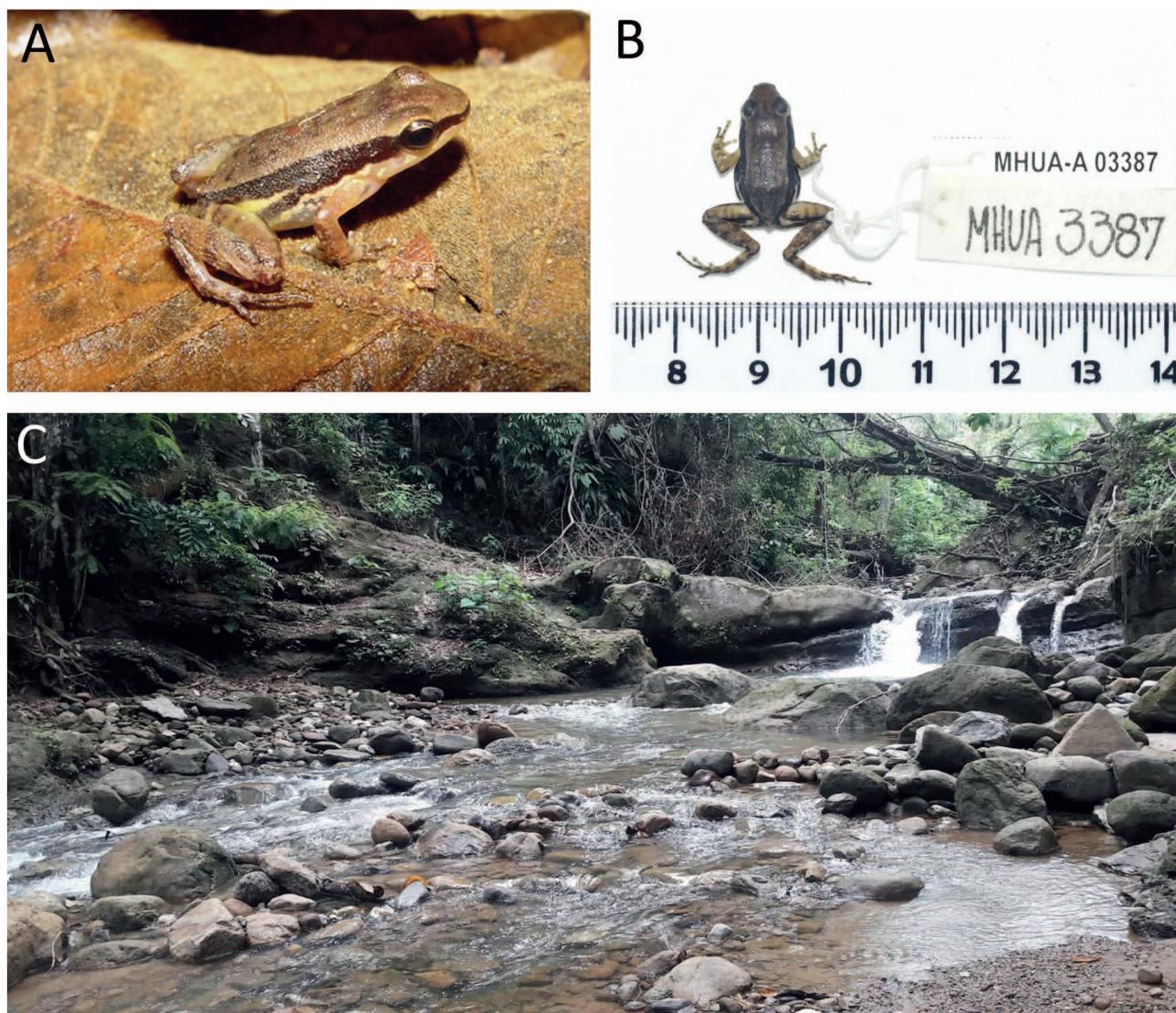


Figure 2. *Colostethus pratti* A) in life and B) in preservative from Tuis Tuis Creek, Serranía de San Jerónimo, Tierralta, Departamento de Córdoba; C) the Tuis Tuis Creek where the species was recorded. Photographs by (A) C. VIDAL-PASTRANA, (B) J. M. DAZA, (C) J. D. JIMÉNEZ-BOLAÑO.

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Table 1. Characteristics of the advertisement call of *Colostethus pratti* from Tuis Tuis Creek, Serranía de San Jerónimo, Tierralta, Departamento de Córdoba. Mean \pm SD (range; N).

Call trait	Male 1	Male 2
Call duration (s)	4.24 \pm 2.21 (1.88–6.80; 5)	2.57 \pm 1.19 (1.54–4.23; 4)
Notes per call (n)	80.80 \pm 42.04 (35–129; 404)	48.74 \pm 21.95 (29–79; 198)
Note duration (s)	0.02 \pm 0.004 (0.01–0.03; 404)	0.02 \pm 0.003 (0.01–0.03; 198)
Inter-note interval (s)	0.04 \pm 0.004 (0.02–0.04; 399)	0.04 \pm 0.003 (0.03–0.04; 194)
Rate of notes per second (notes/s)	19.04 \pm 0.32 (18.67–19.53; 5)	19.05 \pm 0.35 (18.69–19.48; 4)
Dominant frequency (Hz)	4,739.12 \pm 67.01 (4,631–4,969; 399)	4,733.66 \pm 90.82 (4,631–4,969; 194)
Harmonic 1 (Hz)	7,111.51 \pm 204.94 (6,793–7,540; 369)	7,083.59 \pm 204.74 (6,804–7,472; 198)
Harmonic 2 (Hz)	9,451.54 \pm 195.12 (8,803–9,818; 369)	9,421.91 \pm 212.65 (8,803–9,795; 198)
Harmonic 3 (Hz)	11,539.64 \pm 449.27 (10,540–12,366; 369)	11,382.66 \pm 485.23 (10,540–12,366; 198)

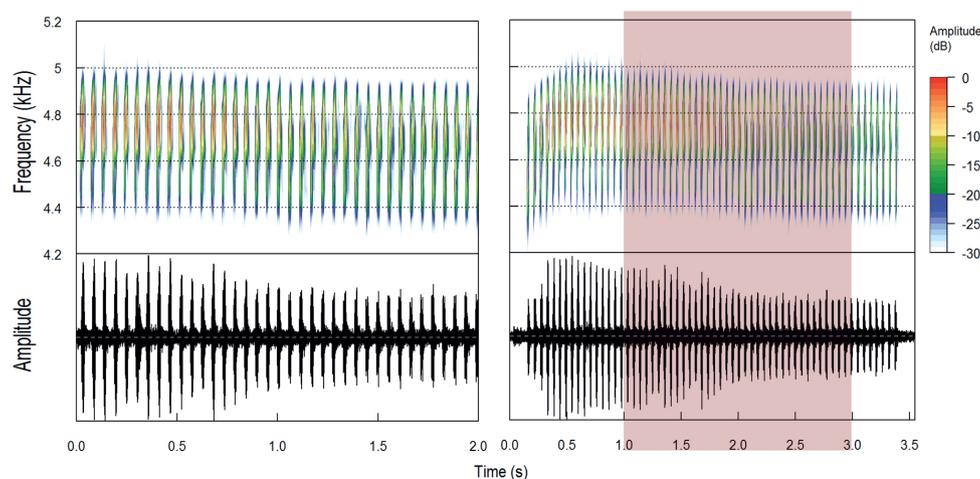


Figure 3. Spectrogram and oscillogram of the advertisement call of *Colostethus pratti* (male 1, see text) from the Tuis Tuis Creek, Serranía de San Jerónimo, Tierralta, Departamento de Córdoba. Recorded on 12 April 2017, 15–16 h, at air temperature 24.3°C, relative humidity 66%.

WELLS 1980; *C. fraterdanieli*: 3–5 notes/call, 3,593–3,656 Hz, GRANT & CASTRO 1998). Other species, like *C. latinasus* (COPE, 1863), emit slightly longer series of notes at slightly faster rates (4–18 notes/call, 11.3 notes/s) than the previously mentioned species, but are shorter, slower and have lower dominant frequencies (2,658–2,673 Hz) than the call of *C. pratti* (IBÁÑEZ et al. 2017).

This study demonstrates the remarkable acoustic divergence between *C. pratti* and closely related species (i.e., *C. panamensis*, *C. latinasus*, and *C. fraterdanieli*), as well as other cryptically colored dendrobatoids from the trans-Andean region. One of the most unique characteristics of the advertisement call of this population of *C. pratti* is the very high repetition rate of notes at which it is emitted, which, at an average of 19 notes/s, is much faster than any of the calls described thus far for species of Colombian cryptic dendrobatoids. Our results provide an additional example of the great acoustic diversity of the superfamily Dendrobatoidea in Colombia.

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