

Description of two previously unknown anuran vocalizations from the Caribbean rainforests of Costa Rica

Descripción de dos vocalizaciones de anuros previamente desconocidas del bosque húmedo caribeño de Costa Rica

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(Received: 05-05-2021 / Accepted: 28-06-2021 / Online: 15-10-2021)

The small Central American country of Costa Rica is known to have one of the highest diversities of amphibians per surface area on the planet, with 215 species in 51.100 km² (Savage 2002, Leenders 2016). Despite being one of the best-studied countries in Latin America for its amphibians fauna, with a long tradition of foreign and national herpetologists regularly publishing about them (summarized in Savage 2002, Leenders 2016), many aspects regarding the taxonomy and natural history of most amphibians remain poorly understood or completely unknown.

Two species of anurans from the Caribbean versant of Costa Rica, the hylid *Ecnomiophyla sukia* Savage and Kubicki, 2010 (Fig 1A) and the craugastorid *Craugastor megacephalus* (Cope 1876, Fig 2A), are the subjects of this work. While the male advertisement call (AC) of *E. sukia* has been previously described (Savage & Kubicki 2010), herein we document for the first time the female call (FC) of this species. With the FC described herein, *E. sukia* is now known to be one of the few hylids to have female calling behavior. The advertisement call of *C. megacephalus* is also documented here for the first time. We classify our recorded calls of *E. sukia* and *C. megacephalus* according to the functional categories proposed by Wells (2007) for the acoustic repertory of anurans. To describe the FC of *E. sukia* and AC of *C. megacephalus*, recorded vocalizations were extracted from the original sound files that were gen-

erated in the field (using a cell phone Wavepad app of Android in wav format), and analyzed with PRAAT 6.0.13 for Windows (Boersma & Weenink 2007). For the FC of *E. sukia* the following parameters were measured, note duration (in seconds –s–), inter-note interval (s), rate of notes per second (notes/s), and dominant frequency (Hz) were measured. Means (x) and standard deviations (SD) were calculated for each call trait. For the AC of *C. megacephalus*, the following characters were measured: call duration in seconds (s), inter-call interval (s), call repetition rate per minute (calls/m), dominant frequency (Hz), and visible harmonics. Our terminology follows that proposed and revised by Köhler *et al.* (2017) for call traits. Oscillograms and spectrograms were obtained with the Seewave package (Sueur *et al.* 2008) for the R platform.

The fringe-limbed treefrogs of the genus *Ecnomiophyla* are some of the most mysterious and elusive anurans in the Neotropics (Kubicki & Salazar 2015). *Ecnomiophyla sukia* was described in 2010 (Savage & Kubicki 2010) from the Atlantic versant of Costa Rica based on a few specimens from Guayacán de Siquirres and Fila Asunción, both localities in Limón Province. The known advertisement call consists of 13 to 20 staccato barks repeated after a time gap of up to or more than an hour. The AC of *E. sukia* was described from a single male in captivity; it consisted of 15-16 separate notes with a dominant frequency of 1.15 kHz

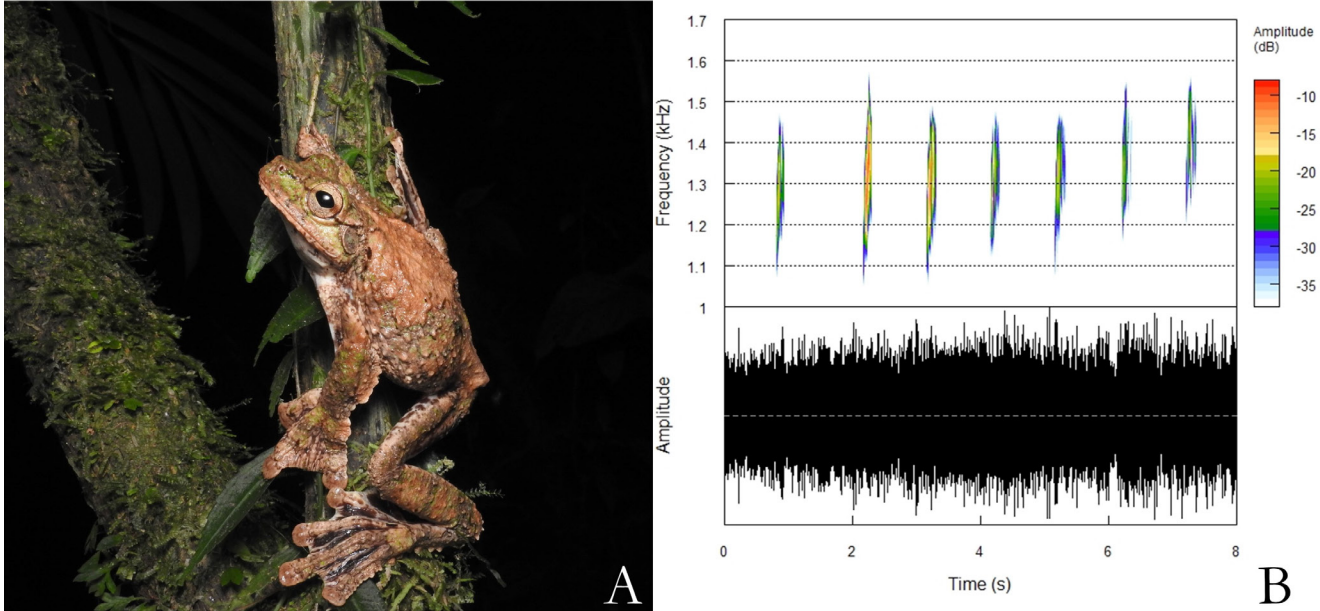


Figure 1. Calling female of *Ecnomiophyla sukia* (A) and the courtship call (B).

(Savage & Kubicki 2010). Vocalizations used for the description of the AC for this taxon were taken at 22.15h and 22.52h (Savage & Kubicki 2010). Until now, a female vocalization has never been described for any species of the genus *Ecnomiophyla* (Duellman, 2001, Mendelson *et al.* 2015, Wells 2007). Our description of the FC of *E. sukia* (Fig. 1B) is based on a single vocalization emitted by an individual located approximately 17 m above the ground in the forest canopy (thus the low quality of the recording) at Finca la Guacamaya, near Santa Clara (N 10.219, W 83.949). Due to the distance of the female individual from the cellphone microphone at the time she emitted the recorded vocalization analyzed herein, the overall quality is less than optimal, but of sufficient enough intensity to perform our analysis. This call consists of a series of seven tonal short notes (call duration = 6.643 s; note duration = 0.222–0.295 s, $X = 0.257$ s, $SD = 0.031$ s) emitted in an inter-note of 0.710–1.145 s ($X = 0.9808$, $SD = 0.167$) and a note repetition rate of 1.054 notes/s. Bandwidth ranges between 822–1749 Hz, with a dominant frequency of 1274.97–1337.14 Hz ($X = 1305.18$, $SD = 20.01$), and an apparent ascendant modulation frequency. This vocalization does not have detectable harmonics. The FC of *E. sukia* is like that of a bird, differing from the dog-like AC reported by Savage & Kubicki (2010). The AC of *E. sukia* described by Savage & Kubicki (2010) is very similar to the FC; in general terms, the FC and AC of *E. sukia* share the same structure of a series of short tonal short notes. Even though the AC and FC have notes of similar duration (AC = 0.220–0.252 s, FC = 0.222–0.295), the AC has twice as

many notes (AC = 15–16 notes, FC = 7 notes) in shorter intervals (AC = 0.287–0.302 s, FC = 0.710–1.145 s), so the rate of repetition of the notes is higher (AC = 1.93–1.94 notes/s, FC = 1.054 notes/s). Additionally, the dominant frequency of the AC is slightly lower than that of the FC (AC = 1150 Hz, FC = 1274.97–1337.14 Hz). Female *E. sukia* call more often than males, and therefore, they are easier to find in the high vegetation. Females of *E. sukia* have been observed vocalizing from the bark of the trunk and branches of trees, in addition to the surrounding vegetation in the canopy, while males have only been seen calling from in and around reproductive tree holes (pers. obs. SS). The peak of activity is during dusk and early hours of the night (17–19 h). When the weather is drier and there is a fair amount of moonlight, females of *E. sukia* can be heard calling even until midnight. As many as 20 different females have been heard calling from the margins of a single forest clearing (pers. obs. SS), but none seemed to be specifically calling in a reciprocal fashion to male vocalizations, which are much more sporadic. A single female individual was recorded while vocalizing and subsequently collected on 04 June 2015 at Finca la Guacamaya in Sarapiquí, Heredia province. It was calling from a site in the canopy located 17 m above the ground. The sex of this individual of *E. sukia* was confirmed after its collection by the examination of its internal organs by Brian Kubicki.

Few female anurans are known to produce vocalizations (Wells 2007). Several functions of female calling have been proposed, including easing males to locate them by stimulating an increase of calling from close males, identification

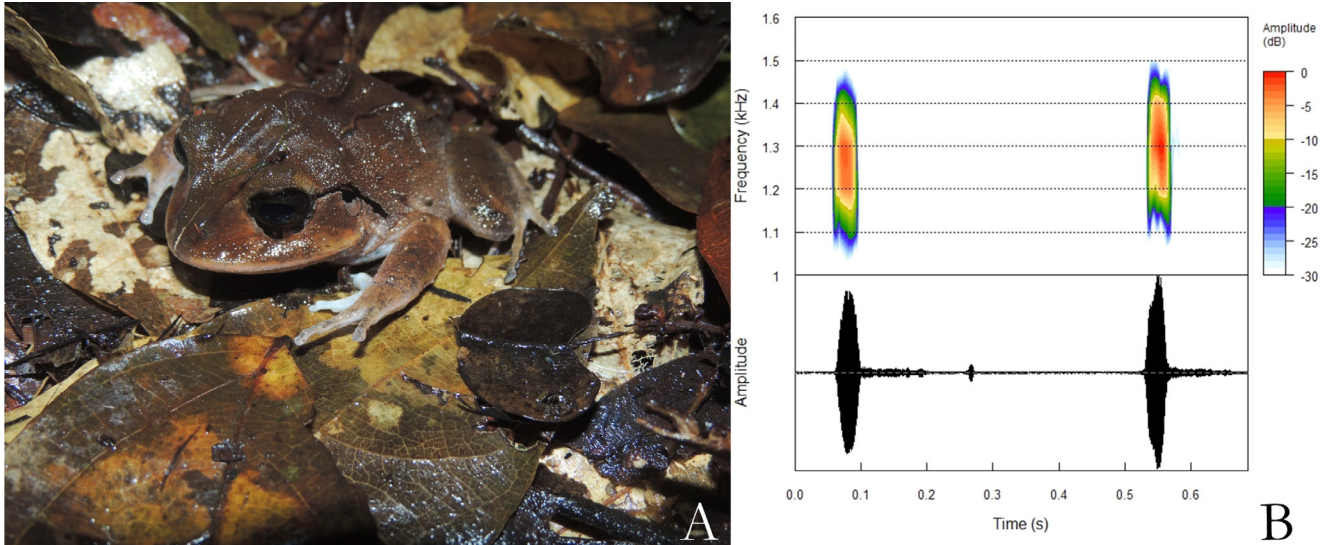


Figure 2. Calling male of *Craugastor megacephalus* (A) and the advertisement call (B).

of territorial and satellite males, and identification of other females as competitors (Emerson & Boyd 1999). The case reported herein is the first FC described from the genus *Ecnomiophyla*, although, we are aware of at least one other species producing it (Víctor Jiménez-Arcos, pers. comm.). Currently, we are not sure about the function of the female vocalization in this species.

Some species of the genus *Craugastor* are very secretive or have suffered extensive declines (Savage 2002, Leenders 2016). Their elusive habits are not well-known, and most act as sit and wait predators. An intermittent and untraceable call was heard a multitude of times in the forest by SS at Finca la Guacamaya, near Santa Clara (N 10.219, W 83.949), but we were unable to locate the source of the vocalization, until a single recording was made at a horizontal distance of about seven meters; the individual responsible for this call was located under the leaf-litter, it was a male *C. megacephalus*. Male *C. megacephalus* are typically difficult to locate, compared to juveniles (which are the most common) and females (common in certain areas), and are always hidden under leaf litter or rotten logs. The hours of calling activity are restrained to dusk. *Craugastor megacephalus* males appear to be actively calling during the drier months (March through May) of the Caribbean versant of Costa Rica. The description of the AC of *C. megacephalus* is based in a series of nine calls. The AC of *C. megacephalus* consists of a single tonal short note (call duration = 0.038–0.052 s, $X = 0.042$ s, $SD = 0.004$ s, Fig. 2B) emitted at irregular intervals. Notes can be emitted with pauses between them of less than a half second or as infrequent as having pauses lasting more than ten seconds (inter-call interval = 0.492–13.755 s, $X = 8.640$ s,

$SD = 5.282$ s). The call series last 69.5 s, with a repetition rate of 7.7 calls/minute. The prevalent bandwidth ranges between 286–2870 Hz, with a dominant frequency of 1050.11–1205.23 Hz ($X = 1154.82$ Hz, $SD = 52.45$ Hz). In addition, the AC of *C. megacephalus* exhibits two visible harmonics, the first at 1550.59–1844.45 Hz ($X = 1730.50$ Hz, $SD = 87.51$ Hz), and the second at 2088.81–2436.32 Hz ($X = 2311.94$ Hz, $SD = 110.32$ Hz).

According to Savage and Myers (2002), no advertisement calls of any member of the *Craugastor gulosus* species group (*sensu* Hedges *et al.* 2008) is known. Padial *et al.* (2014) situated *C. megacephalus* in a more comprehensive *Craugastor punctariolus* species group. One of the characteristics of the former is the absence of vocal slits and a vocal sac. Nevertheless, the absence of these organs does not necessarily represent the inability to vocalize (which has also been evidenced for other groups such as the former *Craugastor laticeps* species group; Ibáñez *et al.* 2012, Salazar-Zúñiga & García-Rodríguez 2014). The description of the AC of *C. megacephalus* included herein opens new perspectives for future bioacoustic studies, as well as questions about the evolution of acoustic communication of craugastorid frogs.

ACKNOWLEDGEMENTS

SS wants to thank Brian Kubicki for his help in determining the sex of the female specimen of *Ecnomiophyla sukia* mentioned in the publication. He also was a mindful referee, which along with another anonymous one helped to improve this work.

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