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SHORT COMMUNICATION

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Vocal repertoire of the Critically Endangered Cuban western spiny frog *Eleutherodactylus symingtoni*

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The western spiny frog *Eleutherodactylus symingtoni* Schwartz, 1957 is endemic to the forested karstic areas and caves in upland areas of western Cuba (Díaz & Cádiz, 2008; Rivalta González et al., 2014; Rodríguez-Cabrera & López-Silvero, 2022). It is one of the most threatened Cuban amphibians, listed as Critically Endangered under criterion C2a(i) due to its small population and continuing population decline caused by habitat loss. The total number of mature individuals in the population is uncertain, but it is suspected to be fewer than 250, with no more than 50 mature individuals in each subpopulation. Its mapped distribution covers an area of 4,202 km^2 (IUCN SSC Amphibian Specialist Group, 2023).

For a long time after its description *E. symingtoni* was considered mute (Schwartz & Henderson, 1991), but in 2007 different calls of its vocal repertoire were registered and described (Alonso Bosch et al., 2007; Díaz & Cádiz, 2007; Díaz et al., 2007). Males vocalise while widely separate from each other, mainly during the night, from the ground, rock walls of ancient ruins, and also from the vegetation to heights up to 1 m (Diaz & Cadiz, 2008; Henderson & Powell, 2009). However, most of the information related to its vocal activity comes from individuals from a single locality, Cueva del Basurero, Artemisa province (Alonso Bosch et al., 2007; Díaz & Cádiz, 2007; Díaz et al., 2007), where the species appears to be common and more abundant.

On 29 June 2024, during a short-term acoustic monitoring initiative for *E. symingtoni* in the Ecological Reserve El Salon in the nucleus area of the Sierra del Rosario Biosphere Reserve, Artemisa province (22° 49'48.97'' N, 82° 57'45.16" W), we detected an adult male calling in the middle of a very complex soundscape, with an intense acoustic activity of insects and other anurans (e.g. *Eleutherodactylus auriculatus*, *Eleutherodactylus eileenae* and *Eleutherodactylus olibrus*). The calls were recorded with a Zoom H1 portable digital audio recorder (sampling rate of 44100 Hz/16 bit) connected to a unidirectional microphone Sennheiser ME66/K6, located approximately 50 cm from the active male. Gain settings of the audio recorder were kept constant throughout the call recording. We obtained approximately five minutes of continuous recording of advertisement calls from the adult male *E. symingtoni*. The sound recording has been deposited in the scientific collection of the Fonoteca Zoológica of the Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain (FZ-SOUND CODE. 14860). The animal (Fig. 1A) was sighted vocalising from the ground, among the leaf litter of the evergreen forest typical of this region, at approximately 4 m from a mound of large rocks (Fig. 1B). The air temperature

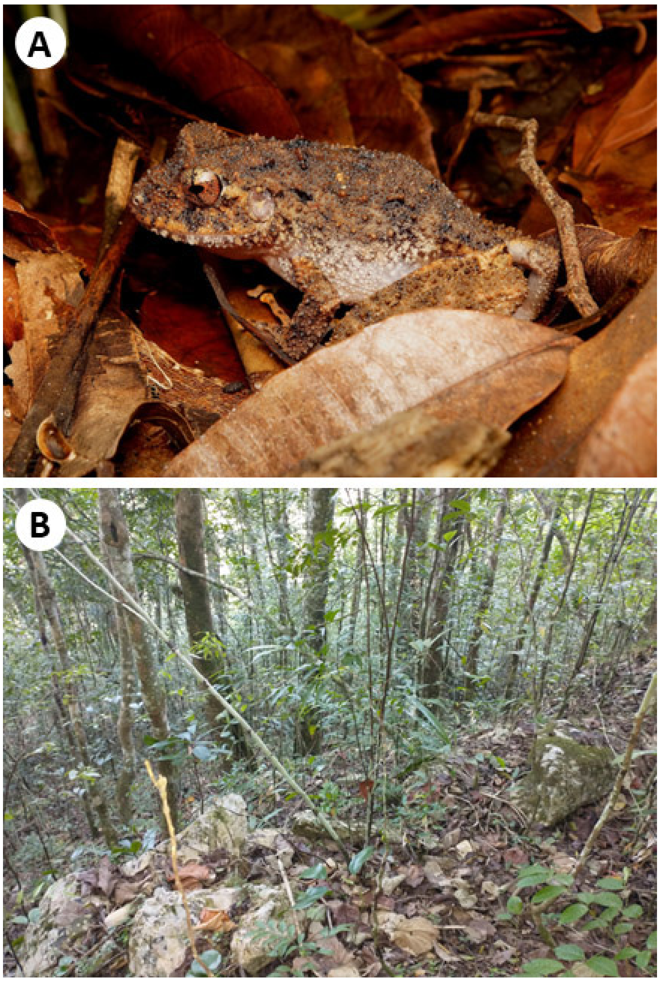

Figure 1. **A.** Calling adult male *Eleutherodactylus symingtoni* (SVL = 52.21mm), from El Salon Ecological Reserve, Sierra del Rosario, Artemisa province, Cuba, **B.** Microhabitat where this animal was observed and recorded

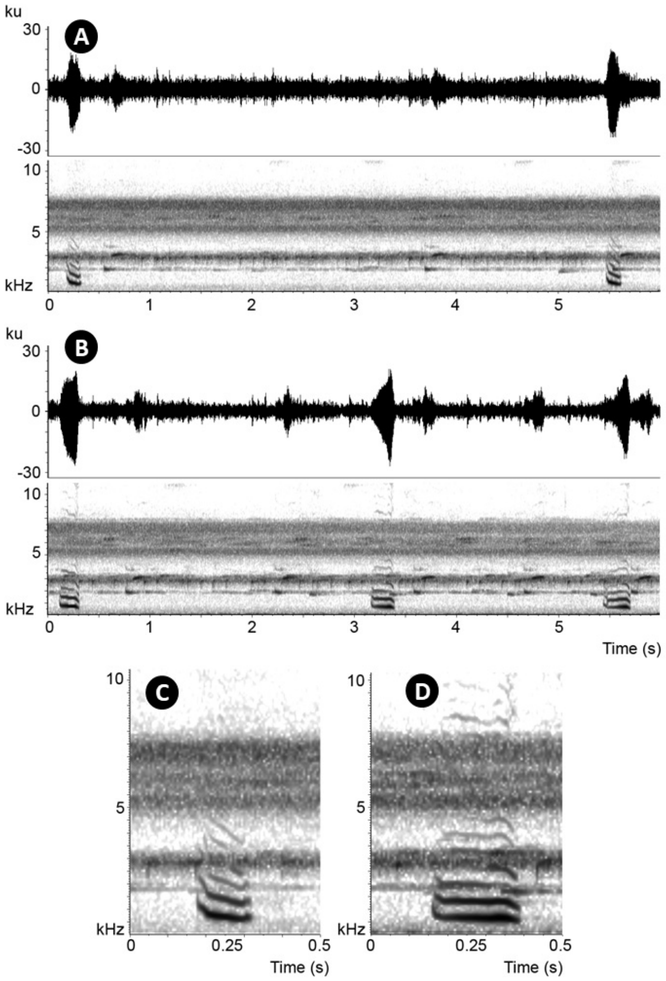

Figure 2. Oscillograms (top) and spectrograms (bottom) of a fragment of consecutive multi harmonic calls (single notes) of *Eleutherodactylus symingtoni*, from El Salon Ecological Reserve, Artemisa, Cuba - **A.** Calls from the beginning of the fragment, showing the descendent frequency modulation, **B.** Calls from the end of the fragment with notable changes in duration, call interval and frequency modulation pattern, **C.** Zoom of the first call represented in **A.**, **D.** Zoom of the second call represented in **B.** (Spectrograms produced with Raven with Hanning window function at 512 bands FFT resolution, overlap = 50%, Filter band pass 200-5000 Hz).

(26.4 °C) and relative humidity (100%) were measured using a HANNA Instruments thermohygrometer (± 0.1 °C, 1%) near the calling individual. The individual was captured and its snout-vent length (SVL) was measured using a caliper (± 0.01 mm). Then, the animal was released at the same site of capture. Recorded advertisement calls were visualised and analysed in Raven Pro 1.3 Software (Copyright 2003–2008 Cornell Lab of Ornithology Bioacoustics Research Program).

The first information about the acoustic emissions of *E. symingtoni* was provided by Alonso Bosch et al. (2007). These authors included in their Sound Guide of Calls of Amphibians of Cuba, one call emitted by an adult male from Cueva el Basurero, Artemisa province. Also, Díaz et al. (2007) offered the first acoustic characterisation of three types of call of this species based on calls produced by two individuals from the same locality. Vocalisations comprise mostly short calls (one or two notes) with a variable complex harmonic structure uttered at a relatively low rate of repetition (Díaz et al., 2007). Our observations and measurements from oscillograms and spectrograms of the advertisement calls are partially congruent with the published description of single notes by Díaz & Cádiz (2008). We followed the note-centred approach defining each call consisting of a single note (Koehler et al., 2017). The measured features fit within the wide range reported by previous authors. The beginning the calls (N = 20) consisted of multi harmonic single notes (call duration = 158.5 ± 8.0 ms, call interval = 5.20 ± 0.29 s, call rate = 32.09 calls/min, dominant frequency = 738.3 ± 43.7 Hz) with a notable descendent modulation in frequency (Fig. 2A). However, at the end of the recordings, we observed an important change in the signal structure toward longer calls (call duration = 243.3 ± 28.7 ms), shorter call intervals (call interval 3.00 ± 0.67 s), lower frequency modulation call (more flattened visually in the oscillograms), that were equally audible in terms of dominant frequency (660.5 ± 49.8 Hz) and relative intensity (Fig. 2B).

Díaz et al. (2007) noticed that when approached, males of *E. symingtoni* change the homogeneous one note calls for two note heterogeneous call sequences, or for a sporadic whistle, but the variation in the pattern of frequency modulation has not been reported previously, probably due to the difficulty of detecting and recognising these changes in complex environments. Although the calls of most Cuban amphibian species have been described, most research on acoustic spectral properties is restricted primarily to a few features, such as dominant frequency, frequency range and bandwidth, but there is little information about the relationship with the physical properties of the habitat or the social context. The environment constrains acoustic transmission when long-distance sound communication is used (Forrest, 1994; Farina, 2014). Certainly, the vocal repertoire of *E. symingtoni* is difficult to interpret in light of the acoustic adaptation hypothesis (Morton, 1975; Ey & Fischer, 2009). The variability in the temporal and spectral features of the signals, with changing patterns of frequency modulation and harmonic performance, generates problems in understanding the habitat-signal relationship in a species that may be vocally active in both very noisy forest habitats and in relatively silent environments, such as the interior of caves and karstic formations.

These observations on the vocal repertoire of *E. symingtoni* are a contribution to the design of a passive acoustic monitoring strategy that would allow the real status of the populations to be evaluated. This will contribute to mitigating the conservation threats faced by this species.

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