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SHORT COMMUNICATION

First record of a snake call in South America: the unusual sound of an ornate snail-eater *Dipsas catesbyi*

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ABSTRACT

The auditory systems and sound dynamics in snakes are frequent objects of debate. The known frequency of sounds produced by snakes ranges from 0.2 to 9.5 kHz. Here we report the first record of a vocalization by the South American snake *Dipsas catesbyi*. The call was recorded oportunistically in June 2021 upon manipulation, and had a duration of 0.06 seconds, reaching 3036 Hz in its peak frequency with a modulated note, emitted through exhalation of air through the larynx. We hypothesize that structured vocal emissions such as this are a reaction to a predation attempt and may be a feature shared by other species of Dipsadidae and other snakes.

KEYWORDS: Amazonia, reptile, Squamata, vocalization

Primeiro registro de canto de uma cobra na América do Sul: o som incomum da dormideira *Dipsas catesbyi*

RESUMO

Os sistemas auditivos e a dinâmica do som em cobras são objetos frequentes de debate. A frequência conhecida dos sons produzidos pelas cobras varia de 0,2 a 9,5 kHz. Aqui relatamos o primeiro registro de vocalização da cobra sul-americana *Dipsas catesbyi*. O canto foi gravado oportunisticamente em junho de 2021 mediante manuseio, e teve duração de 0,06 segundos, atingindo 3036 Hz em sua frequência de pico com nota modulada, emitida por meio da exalação de ar pela laringe. Nossa hipótese é que emissões vocais estruturadas como esta são uma reação a uma tentativa de predação e podem ser uma característica compartilhada por outras espécies de Dipsadidae e outras serpentes.

PALAVRAS-CHAVE: Amazônia, réptil, Squamata, vocalização

The emission of sounds by non-avian reptiles (*i.e.*, crocodilians, turtles, lizards and snakes) is rare and often associated with defense mechanisms, territorialism, or reproduction (Colafrancesco and Gridi-Papp 2016; Russell and Bauer 2021). Air expulsion by the larynx or glottis under different levels of contraction, mechanical shock movements or friction of structures against the substrate or in themselves (e.g. friction of scales) can produce a variety of modulated or unmodulated sounds (Young 2000; Colafrancesco and Gridi-Papp 2016).

Vocal emissions of Squamata (lizards and snakes) have been most frequently studied and recorded in lizards (Russell and Bauer 2021). One of the Squamata groups more frequently studied for bioacoustics is Gekkonidae, which have a developed auditory system and specialized structures for vocalization, and an extensive vocal repertoire for courtship, defense and territoriality (Labra et al. 2013). Lizard vocalizations can be used for inter and intraspecific communication, with emissions related to courtship, defense and territorial behavior (Baeckens et al. 2019).

Honest acoustic signals can be observed in both lizards and snakes, but not all of them can be classified as true vocalizations, as not all of them are emissions of notes with spectral and temporal definition, with or without modularity (Baeckens et al. 2019). Examples of honest acoustic signals that are not classified as vocalizations for snakes are the rattling sound of *Crotalus* and *Sistrurus*, and the hissing sounds of some colubrid, viperid and boid snakes. These latter sounds are classified as white noise, mainly caused by the expulsion of air through the larynx and glottis without the presence of modified structures or a specialized resonance chamber (Kinney et al. 1998; Russell and Bauer 2021). The frequency

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of sounds produced by snakes is known to vary from 0.2 to 7.5 kHz and are associated with the inflation of the body and muscle contraction to expel air and produce sound (Young 1991; Young et al. 1995; Kinney et al. 1998; Colafrancesco and Gridi-Papp 2016; Moller et al. 2021). Due to the loss of the tympanic middle ear, vocalizations in snakes are possibly only directed to predators, as conspecifics only perceive sounds in bands from 50 to 1000 Hz, and snake vocalizations tend to be emitted from 2 to 9.5 kHz (Young 2003; Christensen et al. 2012; Russell and Bauer 2021).

Here we describe the first defensive call recorded for a South American snake, contributing to future discussions about the evolution of vocalization in Squamata and its ecological functions.

The sound recording was made unpretentiously during a nocturnal survey at 20:43h on June 13, 2021, in a secondary forest in Presidente Figueiredo municipality, Amazonas state, northern Brazil (1°45'30.2"S, 60°08'25.4"W, 100 m above sea level). A colubrid snake was found foraging perched in the vegetation 30 cm above the ground. The individual was identified as *Dipsas catesbyi* (Dipsadidae) following Harvey and Embert (2008) [13 rows of dorsal scales; temporals separated from orbit by postoculars; preocular present above loreal, excluding orbital prefrontal; dark brown to black head with a white stripe on the snout; snout labials and white nuchal bands; black bar under the eye; white nuchal stripe; dorsal body light brown to reddish brown with dark brown to black spots edged first in cream and then in dark brown; ventral scales cream to white or with varying amounts of dark spots]. The individual was a male with snout-to-vent length = 42.8 cm. All procedures were authorized by the ethics committee on animal use of Instituto Nacional de Pesquisas da Amazônia - INPA (license nº 01280.000036 / protocol 90/2021 CEUA/INPA) and Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio (license Sisbio # 75441-1).

When handled for measurement, the individual displayed the typical movements of rolling and head hiding. We started to stimulate this display by gently touching the individual until it unrolled and stayed suspended perched in the researcher's hand and, after some seconds, displayed a short and high-pitched sound.

We recorded a short video of this behavior with a smartphone (available at https://youtu.be/3FMJc4jlkys). The original audio (in MPEG-4 format (.mov)) was later converted to WAVE (.wav) format. We analyzed the following temporal parameter (call duration), spectral parameters (maximum, minimum, and fundamental frequencies), and structural parameters (number of harmonics and frequency range of harmonics). The acoustic analysis was performed using the power spectrum tool to discern the sound of interest from background noise. We used a 20 dB threshold from the peak amplitude to select our sound of interest using the Raven Pro Software. All measured analyses were performed using the Raven Pro Software program. *Seewave* package was used to create the graph in R (R Core Team 2021).

In the video, the individual was caught in the 12th second, and, at the 16th second, it unrolled and stayed suspended perched in the researcher's hand. At the 18th second, the individual displayed the sound. The vocalization had a duration of 0.06 seconds, reaching 3036 Hz in its peak frequency, with a range of 2761 to 4152 Hz in its main emission (Figure 1). The sound had a descendent spectral modulation beginning with a higher frequency, close to 3700 Hz, that decays to approximately 3200 Hz. The sound is composed of a set of five harmonics ranging from 6200 Hz to 12300 Hz that lose their shape and power as frequency rises (Figure 1). It has to be noted that the frequency values

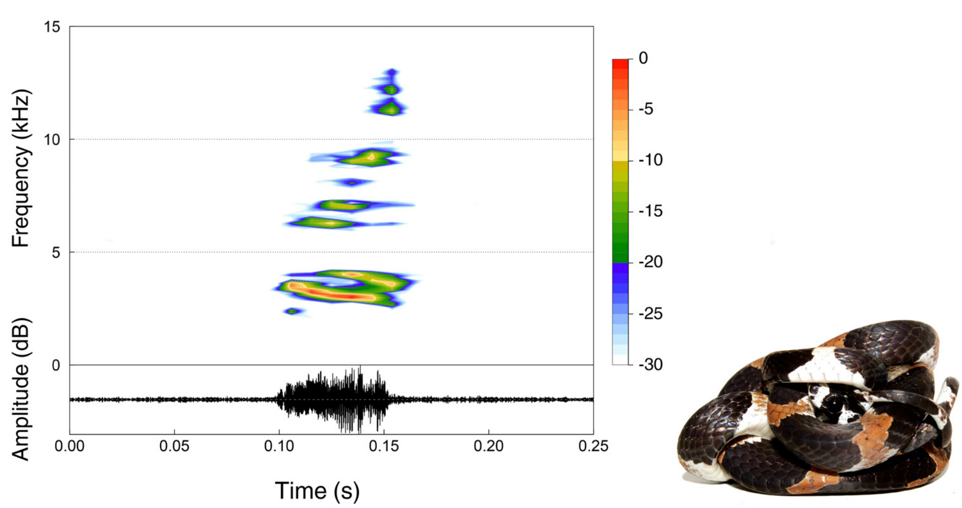

Figure 1. Spectrogram (frequency over time) and oscillogram (amplitude over time) of the first record of a defensive call of *Dipsas catesbyi*. This figure is in color in the electronic version.

may have undergone small changes due to video format compression.

The arrangement of the harmonic structure of the vocalization is apparently related to the energy bands, suggesting that the vocal emission may be related to the laryngeal structures, as observed in other species of snakes (Young et al. 1995; Young 2000; Russell and Bauer 2021). *Pituophis melanoleucus* (Daudin, 1803) (Colubridae) presents defensive vocalization with a frequency of 2.0 - 9.5 kHz, and has specialized structures, referred as vocal cords (Young et al. 1995), which suggests that such structures may be present and responsible for the modulation and complexity of vocalization exhibited by *D. catesbyi*. However, no study details the structure of the larynx in *D. catesbyi* or in other species of the genus.

Since there are no studies on snake vocal repertoire, we used anuran studies (Toledo et al. 2009) as a base to categorize the recorded snake sound. Considering that in our recording the vocal emission only happened after handling the individual (which would simulate capture by a predator), we categorized it as defensive. The frequency of the vocalization may not be perceptible to snakes, thus not acting as an intraspecific signal (Christensen et al. 2012; Russell and Bauer 2021). However, the frequency range of defensive vocalization in snakes (from 2 to 9.5 kHz) is audible to most predators of these animals, mammals and birds (Baeckens et al. 2019). The defensive call, designated due to its association with the behavior displayed during the interaction with a potential predator, can also be observed on video.

Many species of Lacertilia have a diverse vocal repertoire, with reproductive, territorial and defensive functions (Russell and Bauer 2021). Thus, it is possible that snake vocalizations are a remaining feature from their lizard ancestry (Russell and Bauer 2021). The vocalization seems to be highly costly for these animals, which do not have developed vocal cords and probably is rarely displayed due to the more frequent use of passive defensive behaviors that have lower energy expenditure (e.g. hiding the head and rolling over). Our record contributes to the body of knowledge on snake vocalizations, especially about defensive behavior.

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DATA AVAILABILITY
The data used in this work are available on the YouTube platform (link in the text).