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Distress calls of *Leptodactylus knudseni* Heyer, 1972 (Anura, Leptodactylidae)

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Abstract

We describe distress calls of *Leptodactylus knudseni* recorded in Colombia and Brazil. These calls share similar acoustic features with previous records from other species of *L. pentadactylus* group.

Key Words

vocalisation; defensive behaviour; anurans

Anurans are recognised by their particular vocalisations, used as the major method of communication, predominantly between male and female conspecifics during the reproductive season (Toledo et al. 2015). Calls can transmit a range of messages for different contexts and represent several forms of interaction (Duellman and Trueb 1994; Köhler et al. 2017).

These vocalisations can be classified into four contexts: reproductive, aggressive, defensive and feeding (reviewed in Toledo et al. 2015 and updated in Köhler et al. 2017). Most studies of anuran vocalisations are focused on advertisement calls (reproductive call), often as part of species descriptions, since these calls are species-specific and subject to variation by pressures such as sexual selection and environmental determinants (Köhler et al. 2017) and because they can be easily observed during the reproductive season. On the other hand, other types of calls are often unknown, as a consequence of lower recording probability and lesser relevance for taxonomic purpose (e.g. Lingnau and Bastos 2007).

The distress call falls into the defensive category, as it is generated as an answer to attack or approach by a potential predator (Hödl and Gollmann 1986; Toledo et al. 2011). This behaviour is an ancestral defensive mechanism, which is part of the acoustic repertoire of many anuran species (Forti et al. 2018). Such defensive vocalisation is a loud and high-pitched signal, similar to a scream and emitted usually with an open mouth (Bogert 1960; Köhler et al. 2017). The function of this behaviour is unclear, although evidence points to a warning call for conspecifics (Forti et al. 2017a), to provide time to escape, to startle predators or maybe to call for help (Wells 2007; Toledo and Haddad 2009). The description of distress calls and other vocalisations may help in clarifying defensive behaviour functions and comprehending vocal communication between conspecifics and non-conspecifics. In this study, we describe the distress call of *Leptodactylus knudseni* (Leptodactylidae).

The family Leptodactylidae contains more than 200 species and is widely distributed throughout the Americas (Frost 2019). The genus *Leptodactylus* accommodates 72 species, exhibiting a great variety of reproductive modes and vocalisations (Wells 2007; Frost 2019). From those, only 13 species of this genus have distress call descriptions (Hödl and Gollmann 1986; Toledo et al. 2005; Padial et al. 2006; Toledo and Haddad 2009; Forti et al. 2017b) and only four of them are from the *Leptodactylus pentadactylus* group: *L. labyrinthicus*, *L. pentadactylus*, *L. savagei* and *L. vastus*.

Leptodactylus knudseni Heyer, 1972 is a neotropical frog from the *L. pentadactylus* group (de Sá et al. 2014). Breeding activity occurs throughout the wet season, with nest building and egg laying being synchronised with heavy rainfalls (Gascon 1991). Reproductive behaviour includes foam nest spawn placed in water-filled depressions and, after hatching, exotrophic tadpoles move to flooded larger ponds (Prado et al. 2002). The species distribution includes Amazon and part of the Orinoco basin (Acosta-Galvis 2017). It can be found in Bolivia, Brazil, Ecuador, Colombia, Venezuela, Trinidad, Surinam and the Guianas (Ortiz et al. 2015; Frost 2019).

Leptodactylus knudseni distress calls were obtained by human handling (as described in Toledo and Haddad 2009) of three individuals, which were recorded using a Sony alpha nex-3 digital camera with built-in microphones. All samples were deposited in the audio collection Fonoteca Neotropical Jacques Vielliard (FNJV – Museu de Zoologia da Universidade Estadual de Campinas "Adão José Cardoso", Campinas, Brazil). The recordings were made in Puerto Gaitan, Meta, Colombia (4°18'49.67"N, 72°5'17.62"W, 149 m above sea level) on 17 May 2018 at 21:40 h and 21:43 h (FNJV 37662 – FNJV 37663) and on 20 May 2018 at 20:40 h (FNJV 37664). Temperature and humidity conditions were not recorded. We used additional distress call recordings deposited at FNJV: *Leptodactylus knudseni*, recorded by Diego José Santana on 2 February 2015 in Óbidos, Pará, Brazil, using unspecified equipment (FNJV 34166).

Prior to analysis, frequencies lower than 100 Hz were filtered out (Butterworth function, in Adobe Audition). Calls were normalised, removing DC offset (mean amplitude displacement from zero), centring on 0.0 vertically and to the maximum amplitude of -3.0 dB, using Adobe Audition and standardised at the same sample rate of 44.1 kHz and sample size of 16 Bits. We analysed these recordings in Raven Pro 1.4 (Charif et al. 2008). Configurations adopted were: 65% brightness, 70% contrast and Fast Fourier Transform length (FFT) of 512.

We followed the terminology and definitions presented by Köhler et al. (2017). Spectral parameters were measured in the spectrogram and temporal parameters were measured in the oscillogram. We measured the following acoustic parameters (see Table 1): call duration, intercall interval, call rate, peak of dominant frequency, minimum frequency (frequency 5% function in Raven), maximum frequency (frequency 95% function in Raven) and frequency bandwidth (BW 90% function in Raven).

We analysed 106 distress calls from four adult males of *Leptodactylus knudseni*. This species produced short distress calls, medium pitched (reaching almost 10 kHz – Óbidos population), ascending and descending frequency modulation and a variable number of harmonics, following the pattern encountered in other *Leptodactylus* distress call descriptions (Hödl and Gollmann 1986; Toledo et al. 2005; Padial et al. 2006; Toledo and Haddad 2009; Forti et al. 2017b). The averages of call duration, intercall interval and peak dominant frequency were similar between recordings from Óbidos (Pará – Brazil) and Puerto Gaitan (Meta – Colombia), however, minimum, maximum and bandwidth frequencies were different between localities (Table 1). The Brazilian individual showed longer calls and more calls per second than males from Colombia. It is possible that these geographic differences on acoustic parameters are linked to intraspecific variation in intrinsic characteristics, such as body size (Stănescu et al. 2018).

Leptodactylus knudseni distress calls present a harmonic structure with mean dominant frequency varying amongst the second, third and fourth harmonics (in 79% of the calls, the third was the dominant harmonic) (Fig. 1). We observed 4 to 14 visible harmonic bands. This complex harmonic structure of recorded vocalisations is coincident with references in literature for other *Leptodactylus* species (Toledo et al. 2005; Padial et al. 2006; Toledo and Haddad 2009; Forti et al. 2017b).

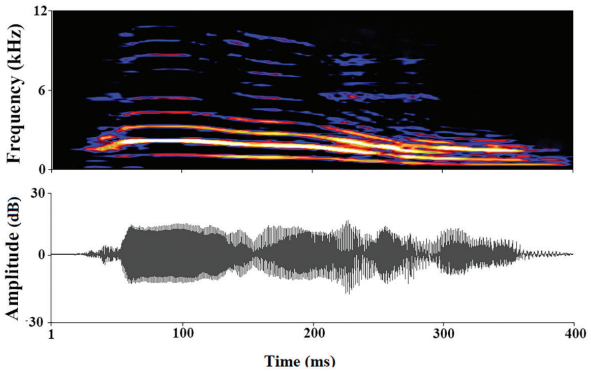

Figure 1. Spectrogram (above) and oscillogram (below) of *Leptodactylus knudseni* distress call (SVL: 97 mm). Puerto Gaitan, Meta Colombia (17 May 2018).

Leptodactylus knudseni presented shorter call duration when compared with the other species from *L. pentadactylus* group, with the exception of *L. savagei*. The intercall interval was shorter in *L. pentadactylus* and *L. savagei*. Regarding call rate (calls/s), *L. knudseni* showed more than *L. pentadactylus* and *L. savagei,* but less than *L. vastus* (Table 1). The dominant frequency of *L. labyrinthicus* calls was higher than calls emitted by Colombian males of *L. knudseni* and lower than calls of the Brazilian individual, while distress calls of *L. pentadactylus*,

Table 1. Temporal and spectral parameters of distress calls of *Leptodactylus pentadactylus* species group. Values are presented as average ± SD (range); n = number of frogs; c= number of analysed calls.

	Size (SVL mm)	Call duration (s)	Intercall interval (s)	Call/second	Peak of dominant frequency (kHz)	Minimum frequency (kHz)	Maximum frequency (kHz)	Frequency bandwidth (kHz)	Reference
Leptodactylus knudseni. Brazil. n=1 c= 27	-	0.39 ± 0.04 (0.33 - 0.48)	0.72 ± 0.74 (0.23 - 2.48)	0.92	2.93 ± 0.30 (2.33 - 3.79)	1.69 ± 0.23 (0.86 - 2.07)	9.71 ± 2.26 (3.36 - 14.13)	8.02 ± 2.27 (1.81 - 13.26)	Present study
Leptodactylus knudseni. Colombia. n=3 c=79	96 ± 11	0.33 ± 0.03 (0.23 - 0.4)	0.95 ± 1.85 (0.15 - 8.71)	0.80 ± 0.06 (0.74 - 0.86)	2.43 ± 0.51 (0.86 - 3.62)	0.97 ± 0.21 (0.34 - 1.38)	3.31 ± 0.76 (2.24 - 7.75)	2.34 ± 0.76 (1.21 - 6.55)	Present study
Leptodactylus labyrinthicus. n=2	-	0.86 ± 0.07 (0.81 - 091)	-	-	2.503	0.3	9.37	-	Toledo et al. (2005)
Leptodactylus pentadactylus. n=1 c=17	150	0.40 ± 0.09 (0.25 - 0.58)	0.16 ± 0.06 (0.03 - 0.25)	0.54 ± 0.11 (0.43 - 0.75)	1.91 ± 0.42 (0.52 - 2.24)	0.18 ± 0.07 (0.10 - 0.36)	6.15 ± 0.46 (5.44 - 7.33)	-	Toledo and Haddad (2009)
Leptodactylus savagei. n=1 c=29	160	0.35 ± 0.07 (0.25 - 0.54)	0.24 ± 0.04 (0.17 - 0.34)	0.52 ± 0.05 (0.45 - 0.57)	2.07 ± 0.36 (1.55 - 2.58)	0.21 ± 0.06 (0.09 - 0.38)	18.95 ± 1.50 (16.98 - 20.92)	-	Toledo and Haddad (2009) Toledo and Haddad (2009)
Leptodactylus vastus. n=1 c= 18	140	0.75 ± 0.23 (0.25 - 1.26)	-	0.99 ± 0.15 (0.80 - 1.17)	1.64 ± 0.27 (1.21 - 2.15)	0.17 ± 0.04 (0.12 - 0.22)	7.42 ± 1.07 (5.86 - 9.74)	-	Toledo and Haddad (2009)

L. savagei and *L. vastus* have a dominant frequency lower than *L. knudseni* and *L. labyrinthicus* (Table 1). All samples of *L. knudseni* had distress calls with high minimum frequencies, only surpassed by distress calls of *L. savagei*. Meanwhile, distress calls of *L. savagei* registered the higher maximum frequency follow by distress calls of *L. knudseni* from Brazil.

Distress calls of *L. knudseni* are short, harmonic and with the dominant frequency located at the third harmonic most of the time. They have a similar acoustic structure to the call of other species from the *L. pentadactylus* group. Moreover, the dominant frequency of *L. knudseni* distress calls from Colombia was one of the highest of all, probably as a result of their small body sizes (Müller 1984; Stănescu et al. 2018).

Toledo and Haddad (2009) established a positive relationship between body size and call duration for several anuran species. However, the species from the *L. pentadactylus* group do not corroborate this model since they have shorter distress calls than expected due to a selective pressure that affects the call duration (Toledo and Haddad 2009). This is also the case for the *Leptodactylus knudseni* distress call.

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