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First account of distress calls in leiuperid frogs with a description of the advertisement call of topotypic *Physalaemus maximus*

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Physalaemus maximus Feio, Pombal & Caramaschi, 1999 (Fig. 1) is a leiuperid frog endemic to the Brazilian Atlantic Forest. It belongs to the *Physalaemus olfersii* species group (Nascimento et al. 2005) and is distinguished mainly by its larger size (see Feio et al. 1999, Cassini et al. 2010). *Physalaemus maximus* is restricted to the montane forest of southeastern Brazil and known only from two localities: the Serra do Brigadeiro Mountains, municipality of Araponga, and the Serra do Ouro Branco Mountains, between the boundaries of the municipalities of Ouro Preto and Ouro Branco (Baeta et al. 2005), both in the State of Minas Gerais, Brazil.

Anuran advertisement calls are species-specific (Gerhardt & Davis 1988) and their acoustic analysis can significantly contribute to resolving taxonomic issues (e.g., Duellman & Trueb 1986). In the behavioural repertoire of frogs and toads, calls are used in different contexts, and the same species may present different signals (e.g., Wells 1977). A distress call is characterized by loud, explosive sounds emitted in response to disturbance or potential predators (Duellman & Trueb 1986). Baêta et al. (2007) described the advertisement call of *P. maximus* from a locality ca. 120 km distant from the type locality, but other vocalizations of this species have remained unknown. Herein, we describe the advertisement and the distress calls of *P. maximus* from its type locality.

Individuals of *Physalaemus maximus* were calling on 4 December 2009, from after sunset until about 22:00 hrs, in a permanent pond inside a forested area in the Serra do Brigadeiro State Park (PESB) (20°43'19"S; 42°28'43"W, datum SAD1969, 1,320 m elevation), municipality of Araponga, State of Minas Gerais, Brazil. Advertisement calls of a topotypic male were recorded on site, calling from the grass at the margin of a permanent pond, with the recorder being positioned about 50 cm from the individual. On the following day in the laboratory, we elicited by handling several distress calls from a male collected the day before and recorded these using a Panasonic RR-US450® digital recorder. The recordings were then analysed with AVISOFT-SASLab Light for Windows (v. 3.74) and SoundRuler (V. 0.9.4.1). Audiospectrograms were produced with the following parameters: FFT = 256, frame = 100, overlap = 75 and flat top filter. A sound spectrogram, oscillogram and power spectrum were generated in SoundRuler (V. 0.9.4.1). Description and terminology of the calls' acoustic properties follows Duellman & Trueb (1986). A voucher specimen is deposited at the herpetological collection of the Museu de Zoologia João Moojen, Universidade Federal de Viçosa, Viçosa, State of Minas Gerais (MZUFV 10200).

Males of *P. maximus* are reproductively active at the beginning of the rainy season between October and December. The advertisement call is emitted sporadically, apparently more frequently in high-density choruses. Playbacks of the advertisement call were frequently responded to by nearby males. The advertisement call (Fig. 2) of the topotypic specimen is composed by one single multipulsed note, with a non-harmonic structure and a frequency modulation at the beginning; it has a mean duration of 2.05 ± 0.16 s (range 1.8-2.4 s; n = 7); intervals between pulses range between 0.005 and 0.007 s (mean 0.006 ± 0.001 s; n = 7); the call shows a mean of 332 ± 30 pulses per note (range 312-398; n = 7); pulse rate ranges from 158 to 167 pulses per second (161 ± 3.4; n = 7), and the dominant frequency lies at 1.07 kHz. The recorded males of *P. maximus* called in a multi-species chorus with the following other anuran amphibians: *Aplastodiscus leucopygeus*, *Dendropsophus decipiens*, *D. minutus*, *D. elegans*, *Hypsiboas faber*, *Phyllomedusa burmeisteri*, *Physalaemus feioi*, *Rhinella pombali*, *Scinax eurydice* and *S.* aff. *pereneca*.

Several distress calls (Fig. 3) were emitted by one male *P. maximus* (MZUFV 10200) during handling. The call was produced with an open mouth, and consists mainly of two single (rarely one), harmonic, unpulsed notes with a duration of 0.05-0.14 s (mean 0.09s ± 0.03 s; n = 19). The domi-

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Figure 1. An adult male *Physalaemus maximus* (MZUFV 10200, 46.3 mm snout-vent length) whose call was recorded in the Serra do Brigadeiro State Park, municipality of Araponga, Minas Gerais, Brazil. Photo: M. Ribeiro Moura.

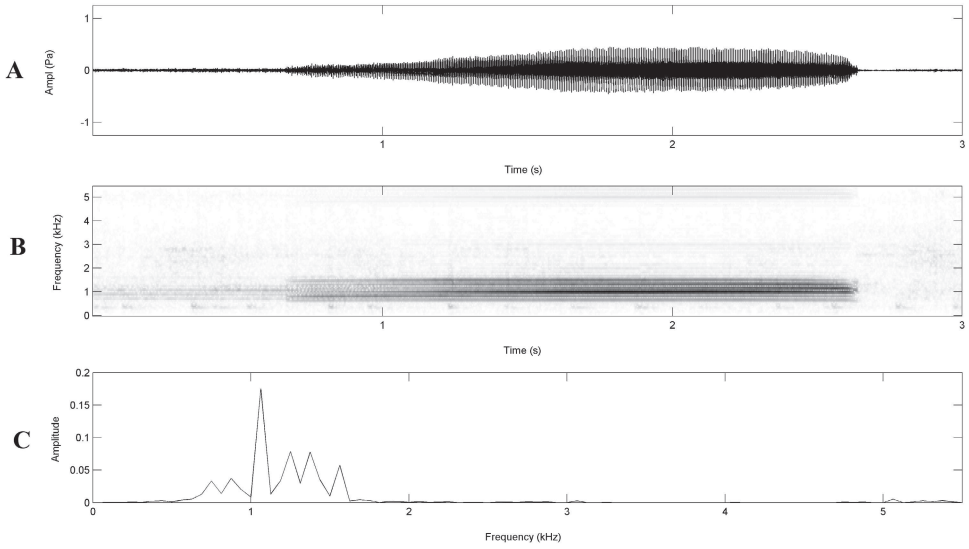

Figure 2. *Physalaemus maximus*: advertisement call (A) oscillogram, (B) audiospectrogram and (C) power spectrum of a single call (air temperature 21°C).

nant frequency (taken at the point of maximum energy in the oscillogram) was 1.06-1.75 kHz (mean 1.39 ± 0.16 kHz; n = 19).

The advertisement call parameters of individuals from PESB are similar to those previously described by Baêta et al. (2007). However, in contrast to these authors, who found intercall intervals (mean 2.39 ± 1.04; range 1.19-6.23), the present study shows that the advertisement call *P. maximus* is emitted sporadically, often stimulated by the presence of conspecific calling males. Moreover, this result is confirmed by the focal males' response to playbacks and call imitations by the researcher. Cassini et al. (2010) summarized the advertisement calls of the members in the *P. olfersii* species group and stated that the 'harmonics' of Baêta et al. (2007) were actually 'side bands' sensu Vielliard (1993). Our results (i.e., a multipulsed call with

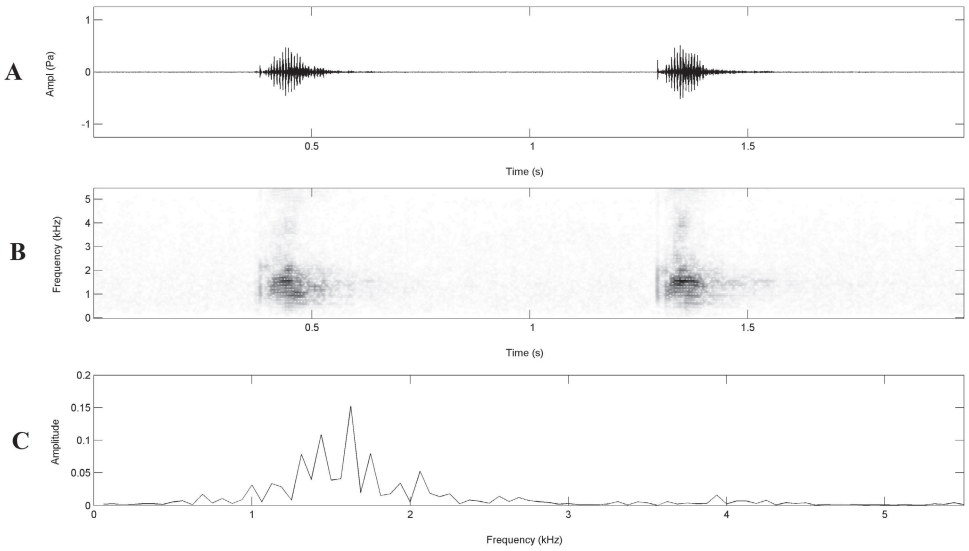

Figure 3. *Physalaemus maximus*: distress call (A) oscillogram and (B) audiospectrogram of two calls (air temperature 21ºC).

a mean of 332 pulses per note and a pulse rate of 161) corroborate the findings of Cassini et al. (2010).

Toledo & Haddad (2009) described distress calls as a plesiomorphic character in anurans, assuming that some groups lost the capability of emitting distress calls. While this is true for the genus *Scinax* (Toledo & Haddad 2009) and several members of the families Leiuperidae (Toledo & Haddad 2009), Myobatrachidae and Limnodynastidae (Williams et al. 2000), according to our findings, a distress call is present in at least one leiuperid species. Nevertheless, the presence of this kind of call within the Leiuperidae can be related to the fact that *P. maximus* is the largest species in its genus and one of the largest in its family. Anuran body size (i.e., snout-vent length) has been directly related to the success of acoustic defensive strategies, since according to Toledo & Haddad (2009), larger frogs emit more distress calls. Therefore, it is likely that other leiuperid frogs that match *P. maximus* in size, may also produce distress calls (e.g., *Eupemphix nattereri*, *Physalaemus marmoratus* and *Physalaemus centralis*).

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