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Correspondence

Circumstances and bioacoustics of the distress call of *Leptodactylus chaquensis* (Anura: Leptodactylidae) during predation by *Thamnodynastes chaquensis* (Serpentes: Dipsadidae) in the Brazilian Pantanal

Tainá Figueras Dorado-Rodrigues [1], Vitor Azarias Campos [1], Marina Meireles dos Santos [2], André Pansonato [3] & Christine Strüssmann [1,4]

[1)] Programa de Pós-Graduação em Ecologia e Conservação da Biodiversidade, Instituto de Biociências, Universidade Federal de Mato Grosso – UFMT. Av. Fernando Corrêa da Costa 2367, Boa Esperança. CEP 78060–900. Cuiabá, Mato Grosso, Brazil

[2)] Programa de Pós-Graduação em Zoologia, Universidade Federal do Pará / Museu Paraense Emílio Goeldi – MPEG/UFPA. Av. Perimetral 1901, Terra Firme. CEP 66077–530. Belém, Pará, Brazil

[3)] Pós-Graduação em Biologia Animal, Universidade Estadual Paulista – UNESP. Rua Cristóvão Colombo 2265, Jardim Nazareth. CEP 15054–000. São José do Rio Preto, São Paulo, Brazil

[4)] Departamento de Ciências Básicas e Produção Animal, Faculdade de Agronomia, Medicina Veterinária e Zootecnia, UFMT

Corresponding author: Tainá Figueras Dorado-Rodrigues, e-mail: tainadorado@gmail.com

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Amphibians are known to represent important prey for many vertebrate and invertebrate groups, which may be related to a high efficiency of converting ingested energy into biomass, the lack of indigestible materials, and usually high population densities (Duellman & Trueb 1994, Wells 2007). Indeed, several short notes, original articles and reviews deal with this subject (e.g., Toledo et al. 2007, 2011, Wells 2007).

Snakes are among the most important predators of adult anurans, and several Neotropical species are exclusively batrachophagous (Vitt 1983, Cadle & Greene 1993). Invertebrates (both immature and adults), fishes, other amphibians and reptiles, birds, and mammals have also been reported to feed on anurans opportunistically (e.g., Haddad & Bastos 1997, Toledo 2003, 2005, Forti et al. 2007, Toledo et al. 2007, Wells 2007, Wizen & Gasith 2011).

Although widely distributed and locally abundant in many parts of South America (Heyer & Giaretta 2009), *Leptodactylus chaquensis* Cei, 1950 is only occasionally mentioned as a prey item in the literature. Among the scarce reports are those of predation by the snake *Clelia clelia* and the heron *Tigrisoma lineatum* (Prado 2003), and by the snake *Philodryas patagoniensis* (Carreira-Vidal 2002). *Leptodactylus chaquensis* is particularly abundant in the Brazilian Pantanal (see Valério-Brun et al. 2010), an immense alluvial plain, which, together with wet areas of the Gran Chaco, forms one of the world's largest freshwater wetland ecosystems. Also abundant in the humid Chaco region and in the neighbouring Pantanal wetlands (see Strüssmann & Sazima 1993) is the nocturnal opisthoglyphous snake *Thamnodynastes chaquensis* Bergna & Alvarez, 1993. Snakes of the genus *Thamnodynastes* are usually small-sized, terrestrial or subarboreal, and widely distributed throughout South America (Peters & Orejas-Miranda 1970, Pérez-Santos & Moreno 1989, Bellagamba & Vega 1996, Franco & Ferreira 2003, Bailey et al. 2005). Many of the 19 valid species (according to Uetz 2012), including *T. chaquensis*, are batrachophagous and only occasionally predate upon fishes, lizards, lizard eggs, and rodents (Vanzolini 1948; Vanzolini et al. 1980; Lema et al. 1983, Amaral 1924, 1976, Strüssmann & Sazima 1993, Yanosky et al. 1996, Rocha & Vrcibradic 1998, Bernarde et al. 2000a, Bernarde et al. 2000b, Ruffato et al. 2003, Diaz et al. 2004, Bailey et al. 2005).

When attacked by predators or upon manual capture, anurans sometimes emit distress calls. The function of these calls remains unclear, but both warning nearby conspecifics and startling the predator have already been suggested, with little direct evidence (e.g., Hödl & Gollmann 1986, Duellman & Trueb 1994, Leary & Razafindrat-

sita 1998, Wells 2007). We here describe physical aspects of the distress call emitted by an adult individual of *Leptodactylus chaquensis* while being predated upon by an adult *Thamnodynastes chaquensis* (Fig. 1), in the Brazilian Pantanal, on 06 October 2010, at 14:20 h.

The distress call of *L. chaquensis* was recorded with a compact digital camera Sony DSC-HX1. At the laboratory, the call was digitised with Raven Pro 1.3 at 44.1 kHz, resolution of 16 bits (FFT 1024). It is archived as a wave file in the "Banco de Registros Bioacústicos" at the "Laboratório de Herpetologia do Instituto de Biociências" of the "Universidade Federal de Mato Grosso" (Cuiabá, Mato Grosso), under accession number SM 180. After the call recordings, both the snake and the frog were captured (permit number IBAMA/SISBio #25488–1), euthanised, preserved in 70% ethanol, and deposited in the "Coleção Zoológica de Vertebrados" of the "Universidade Federal de Mato Grosso" – UFMT (UFMT 11395, *L. chaquensis*; UFMT 9917, *T. chaquensis*). Our terminology for acoustic parameters follows Martins & Jim (2003) and Heyer et al. (1990). The following seven call parameters were analysed for 21 calls: note duration, inter-note intervals, mean note repetition rate, mean low, high and dominant frequency.

Predation occurred amidst seasonally flooded native grasslands at the Fazenda Malhada (16°34' S, 57°01' W), Poconé municipality, Mato Grosso state, Brazil. The frog (52.7 mm snout–vent length; 14 g body mass) had been seized by the posterior right leg, at the level of the knee. The snake (397 mm snout–vent length; 26 g body mass) repeatedly pressed the posteriormost region of its maxillae against the frog's leg, inflicting successive bites and trying to conduct it to the posterior region of its mouth. The frog remained vocalizing and attempting to escape for 19 minutes, during which the only perceivable reaction by the snake was to press its maxillae even stronger against the leg of the frog, trying to envenom it by using the opisthoglyph rear fangs. At 14:42 h, the snake released the by-now dead frog and was captured by the observer. Being noticeably large and strong in relation to the snake, the frog possibly could not be ingested without previous envenomation and immobilisation.

Subduing prey by envenomation is usually reported when the prey is potentially dangerous (see Marques & Puorto 1994), or when envenoming can help to subdue the anuran prey, avoiding its movements and facilitating ingestion (Bernarde et al. 2000b). In a previous study on a snake assemblage of a locality very near to the Fazenda Malhada (see Strüssmann & Sazima 1993), two individuals of *Leptodactylus chaquensis* were observed dying about 10 minutes after having been captured by individuals of *Thamnodynastes chaquensis*, and gut contents of five out of seven examined individuals of *T. chaquensis* contained partially digested specimens of *L. chaquensis* (C. Strüssmann unpubl. data). In southern Brazil, a congener of *T. chaquensis*, *T. strigatus*, was reported to largely feed on *L. ocellatus* (a

Figure 1. An adult individual of the Chaco frog, *Leptodactylus chaquensis* (UFMT 11395) being predated upon by the snake *Thamnodynastes chaquensis* at the Fazenda Malhada, Poconé municipality, Mato Grosso state, Brazil, on 6 October 2010 (14:20 h).

species closely related to *L. chaquensis*). In that study, both relatively large and relatively small frogs were consumed, suggesting an opportunistic feeding behaviour, largely independent of prey size (Ruffato et al. 2003).

The distress call of *Leptodactylus chaquensis* consists of single notes with a complex harmonic structure (at least twelve emphasized harmonics). Mean duration of each note was 0.39 ± 0.05 s (0.3–0.5 s; n = 21), duration of intervals between notes was 2.6 ± 1.3 s (0.95–6.1 s), and the average rate of notes per minute was 185.5 ± 35.2 notes/min. Mean dominant frequency was 1609.3 ± 142.9 Hz (1464.3–1981.1 Hz), usually concentrated in the third harmonic (Fig. 2). Mean low frequency (first harmonic or fundamental frequency) was 338.2 ± 26.3 Hz (263.5–373.4 Hz), and mean high frequency was 6098.1 ± 364.4 Hz (5424.7–6654.5 Hz).

The structure of the distress call emitted by our individual of *Leptodactylus chaquensis* in response to a natural predatory attack is very similar to the one described and figured by Padial et al. (2006) for a manually restrained (and pressed) individual of the same species. As far as acoustic parameters are concerned, differences were noted in the variation of the dominant frequency (2600–5800 Hz, with most of the energy concentrated in the fifth or eighth harmonic, in Padial et al. 2006), and in the fundamental frequency (600–800 Hz in Padial et al. 2006). Our findings also corroborate the observations by Padial et al. (2006) on the complex harmonic and modulated structure in distress calls of species of *Leptodactylus*. This overall similarity is remarkable insofar as even the advertisement calls of *L. chaquensis* are highly variable and may consist of at least three types of calls, quite distinctive from one another in temporal parameters (Heyer & Giaretta 2009). In leptodactylids, intraspecific variations in distress calls were also observed at least in *Leptodactylus pentadactylus* and *L. fuscus* (Hödl & Gollmann 1986, Martins & Haddad 1988). When reporting high variation in the pulse repetition rate, frequency, and in duration of distress calls elicited by shaking and compression of individuals of the hylid *Hypsiboas faber*, Martins & Haddad (1988) suggested that intraspecific and individual variability in distress calls of anurans may represent variations in the degree of distress. Additional field and laboratory experiments could provide a better understanding of the degree and functional role of variation in distress calls of *Leptodactylus chaquensis*.

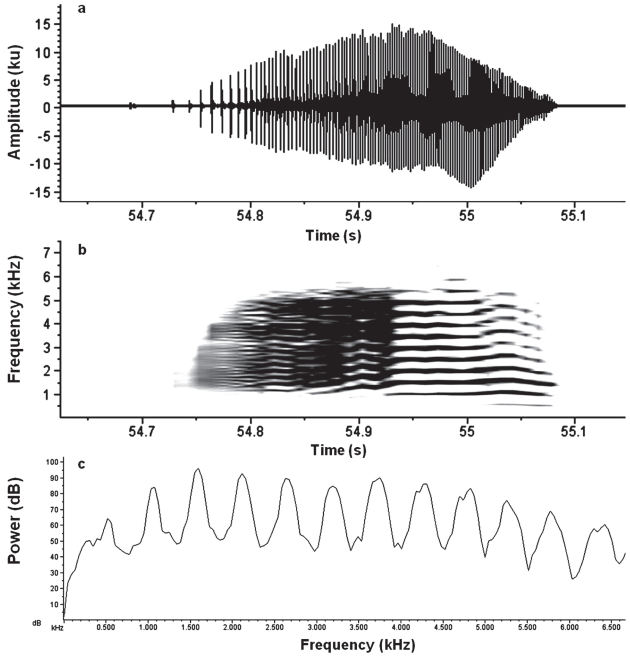

Figure 2. Oscillogram (A), audiospectrogram (B) and power spectrum (C) of the distress call of *Leptodactylus chaquensis* (UFMT 11395), recorded at the Fazenda Malhada, Poconé municipality, Mato Grosso state, Brazil, on 6 October 2010 (14:20 h).

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