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The advertisement call of the endemic *Bokermannohyla martinsi* (Bokermann, 1964) (Anura: Hylidae) from southern Espinhaço range, southeastern Brazil

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The Brazilian hylid genus *Bokermannohyla* Faivovich, Haddad, Garcia, Frost, Campbell & Wheeler, 2005 is currently composed of four (*B. circumdata*, *B. claresignata*, *B. martinsi*, and *B. pseudopseudis*) species groups (Faivovich *et al.* 2005). To date, the *Bokermannohyla martinsi* species group comprises only three species (Faivovich *et al.* 2009): *B. martinsi* (Bokermann, 1964), *B. langei* (Bokermann, 1965), and *B. juiju* Faivovich, Lugli, Lourenço & Haddad, 2009, whose advertisement calls remain unknown to science. *Bokermannohyla martinsi* is a narrowly distributed hylid frog species endemic to the southernmost portion of the Espinhaço range, known as Quadrilátero Ferrífero (QF). Located in the state of Minas Gerais, southeastern Brazil, the QF is considered an area of "special biological importance" (Drummond *et al.* 2005). Notwithstanding, because QF is one of the most important iron-ore mining districts in the world (Spier *et al.* 2003), it has increasingly been target of anthropogenic threats, being one of the most endangered Brazilian landscapes (Jacobi *et al.* 2007; Jacobi & Carmo, 2008). Herein, we describe for the first time the advertisement call of a member of *B. martinsi* group, *B. martinsi*.

Recordings from a single male were made in October 2010 at the Pico do Sol (20°6'42.5"S, 43°26'52.6"W, 1904 m a.s.l.), Private Natural Patrimony Reserve (RPPN) Serra do Caraça (type locality of *B. martinsi*; see Bokermann, 1964), municipality of Santa Bárbara, state of Minas Gerais. Additionally, four males were recorded at Serra da Calçada, municipality of Brumadinho, state of Minas Gerais (20°6'4.8"S, 43°59'19.5"W, 1439 m a.s.l.), three males were recorded in October 2009 and one male in February 2012. Vouchers specimens and their respective recordings are housed at the Coleção Herpetológica da Universidade Federal de Minas Gerais—UFMG—and calls at the accessory, vocalization collection—UFMG-V—under collection records UFMG 767–769, 5567, 10486 and UFMG-V 1–5.

Recordings were made using a Marantz PMD 660 digital recorder and a Sennheiser microphone ME66/K6. Digital recordings were carried out at a 44 kHz sampling rate, 16-bit sampling size, and saved in wav format. Calls were analyzed using the software Raven Pro 1.4 (Cornell Lab of Ornithology Research Program Bioacoustics Workstation). Spectrograms were produced with a FFT of 256 points, frame overlap = 75%, and Hann function. The parameters analyzed were: note duration (time from the beginning to the end of one note, measured on the oscillogram); number of pulses (number of pulse peaks in one note on the oscillogram); dominant frequency range (band of frequency with more energy in call, measured on the power spectrum, from the minimum to the maximum frequency of the higher energy region); dominant frequency (Cocroft & Ryan, 1995; on Raven Pro it is called peak frequency and was measured directly from the software). The note and pulse definitions follow Duellman & Trueb (1994).

The advertisement call of *Bokermannohyla martinsi* is composed of two notes, treated here as "A" and "B" (Fig. 1A). Values are presented as min–max (average ± standard deviation; n). Note A is composed of 20–28 pulses (23.9 ± 1.97; n = 42) with note duration of 49–129 ms (103 ± 20; n = 68); dominant frequency range varies from 963.7–2077.7 Hz. We found three values for dominant frequency that vary between the notes measured: 1312.5 Hz (n = 12), 1500 Hz (n = 51), and 1687.5 (n = 5). Note B is composed of 18–27 irregularly spaced pulses (22.3 ± 2.69; n = 15) with note duration varying between 350–809 ms (586 ± 140; n = 15); dominant frequency range varies from 291.4–986.9 Hz and dominant frequency is emitted at 562.5 Hz (n = 15). Note A is often emitted alone, without being followed by note B. In this case, the interval between notes A varies from 1808–10895 ms (5916 ± 1637; n = 53). When note A is followed by note B, the interval between them varies from 327–1155 ms (703 ± 227; n = 15).

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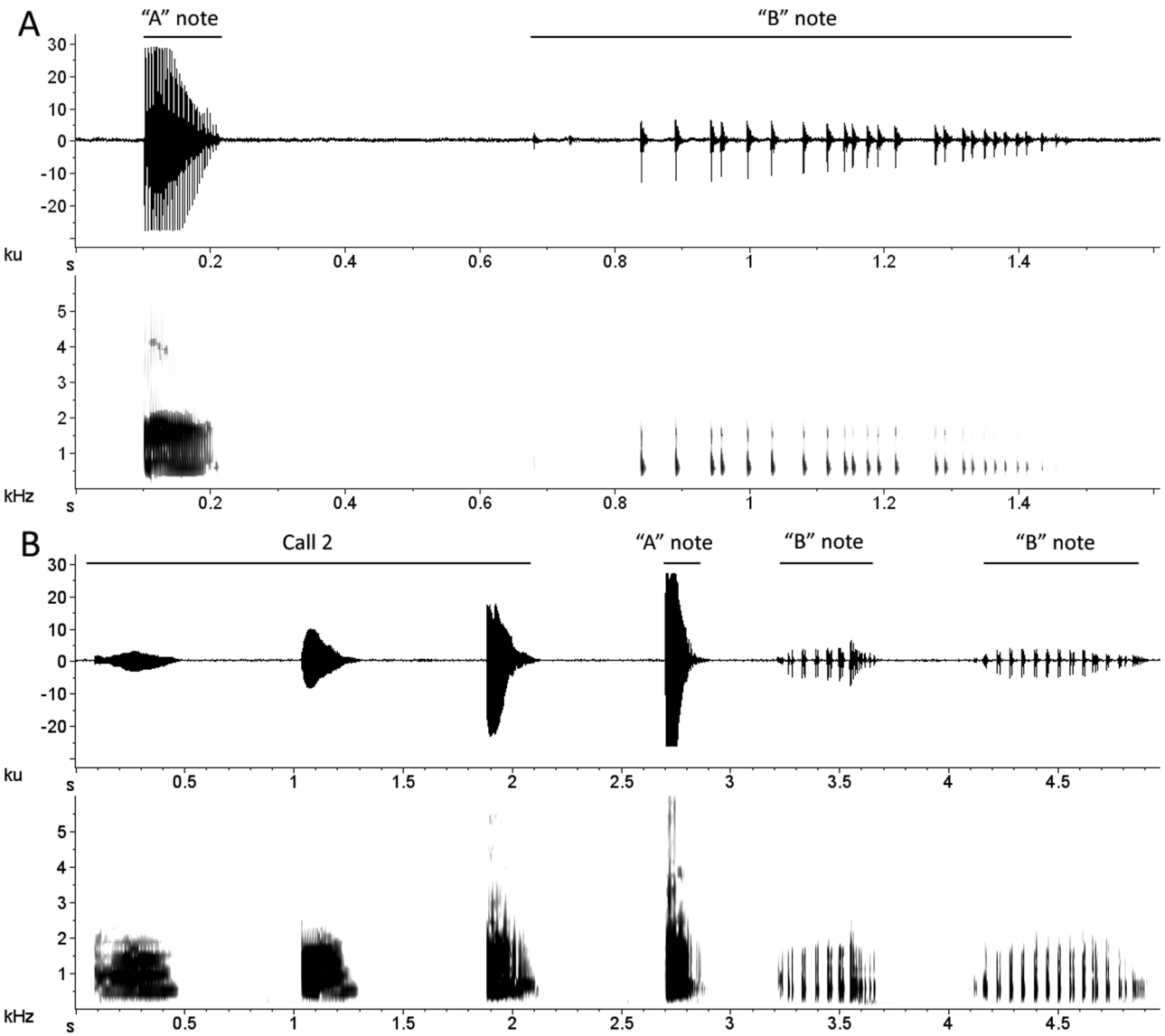

FIGURE 1. Oscillograms (above) and corresponding spectrograms (below) of the vocalizations of *Bokermannohyla martinsi* from Serra da Calçada, Municipality of Brumadinho, state of Minas Gerais. (A) "A" and "B" notes of advertisement call. Voucher specimen UFMG 767; (B) "call 2" composed by three notes followed by one "A" note and two "B" notes respectively. Voucher specimen UFMG 769.

A second type of call ("call 2"; Fig. 1B), which we could not associate to any behavioral context, was recorded two times, with the same sequence of three different notes. The first note duration lasts 263–381 ms (322 ± 83; n = 2); dominant frequency range varies from 720–1094.3 Hz and dominant frequency is emitted at 937.5 Hz (n = 2). The second note duration lasts 192–260 ms (226 ± 48; n = 2); dominant frequency range varies from 356.9–900 Hz and dominant frequency is emitted at 562.5 Hz (n = 2). The third note is pulsed and similar to note A described above, with 28–33 pulses (30,5 ± 3,53; n = 2); note duration lasts 126–244 ms (185 ± 83; n = 2); dominant frequency range varies from 949.5–1945.6 Hz and dominant frequency is emitted at 1312.5 Hz (n = 1) or 1500.0 Hz (n = 1). The interval between the first and second notes is 546–571 ms (558 ± 17; n = 2); between the second and third notes is 591–689 ms (640 ± 69; n = 2). There was one situation in which the "call 2" was emitted immediately followed by one note A and two notes B of the advertisement call (Fig. 1B).

Considering species of the *Bokermannohyla circumdata* group, the call of *B. martinsi* differs from *B. circumdata* (Cope, 1871), *B. luctuosa* (Pombal & Haddad, 1993) and *B. napolii* Carvalho, Giaretta & Magrini, 2012 by presenting no juxtaposed harmonic structure (*sensu* Carvalho *et al.* 2012). The call of *B. martinsi* differs from *B. capra* Napoli & Pimenta, 2009, *B. hylax* (Heyer, 1985), *B. lucianae* (Napoli & Pimenta, 2003) and *B. sazimai* (Cardoso & Andrade,

1982) by having the pulses of "A" note arranged on a single structure, whereas these four species have its pulses arranged in several groups of pulses (Napoli & Pimenta, 2003; Napoli & Pimenta, 2009; Carvalho *et al.* 2012). The advertisement call of *B. martinsi* is composed of one pulsed note followed by another composed of pulses irregularly spaced. In *B. feioi* (Napoli & Caramaschi, 2004) and *B. nanuzae* (Bokermann & Sazima, 1973) the irregularly spaced type of note comes first, followed by the pulsed one (Napoli & Caramaschi, 2004; Carvalho *et al.* 2012). The advertisement calls described for other species of *B. circumdata* group—*B. carvalhoi* (Peixoto, 1981), *B. diamantina* Napoli & Juncá, 2006 and *B. ibitipoca* (Caramaschi & Feio, 1990)—are generally composed by a series of repetition of one type of note (up to four notes per call), whereas *B. martinsi* emits one note "A" alone or followed by the "B" type. The call of *B. martinsi* differs from the call of *B. vulcaniae* (Vasconcelos & Giaretta, 2005) by having more pulses both in "A" note and in "B" note (average number of pulses 23.9 and 22.3 respectively in *B. martinsi*; 4.5 and 10 in *B. vulcaniae*; Gaiga *et al.* 2013; mean value was used in this comparison because the authors did not provide range values of this parameter for *B. vulcaniae*).

From the *Bokermannohyla pseudopseudis* species group, the dominant frequency range of the call of *B. martinsi* overlaps the dominant frequency of the call of *B. alvarengai* (Bokermann, 1956) (400Hz; Sazima & Bokermann, 1977). Because the only call description available from this species has little data, it is difficult to establish differences between the call of *B. alvarengai* and the present call description. From *B. itapoty* Lugli & Haddad, 2006a, *B. oxente* Lugli & Haddad, 2006b, *B. pseudopseudis* (Miranda-Ribeiro, 1937) and *B. saxicola* (Bokermann, 1964), the call of *B. martinsi* differs by having pulsed structure (*B. itapoty*, *B. oxente*, *B. pseudopseudis* and *B. saxicola* has non-pulsed structure; Eterovick & Brandão, 2001; Lugli & Haddad, 2006a; Lugli & Haddad, 2006b). It differs from the call of *B. ibitiguara* (Cardoso, 1983) by having one short note "A" (49 –129 ms) with pulses arranged on a single structure ("A" note longer, 435–1208 ms, and with pulses arranged in 7–17 groups in *B. ibitiguara*; Carvalho *et al*. 2012). The call of *B. martinsi* also differs from the call of *B. sapiranga* Brandão, Magalhães, Garda, Campos, Sebben & Maciel, 2012 by the interval between notes, consisting on longer intervals (taking into account both types of notes, 327–10895 ms in *B. martinsi,* 75–116 ms in *B. sapiranga*, Brandão *et al.* 2012).

Bokermannohyla martinsi has a distinct vocalization that does not resemble directly any other known call of *Bokermannohyla*. It is grouped with *B. langei* and *B. juiju* based on a putative morphological synapomorphy (ventral humeral crests developed into a hook-like; Faivovich *et al.* 2009) and the present advertisement call description is the first for the group. The knowledge of vocalizations of these species would be quite important to help us in understanding the taxonomy of *Bokermannohyla*.

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