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Advertisement and aggressive calls of *Ischnocnema oea* (Heyer, 1984) (Anura, Brachycephalidae)

FABIO HEPP[1,2] & CLARISSA CANEDO[1]

[1]*Universidade Federal do Rio de Janeiro, Departamento de Vertebrados, Museu Nacional, CEP 20940-040, Rio de Janeiro, Rio de Janeiro, Brazil.*
[2]*Corresponding author. E-mail: fabiohepp@gmail.com*

Ischnocnema oea (Heyer, 1984) is one of the 10 species recognized within the *I. guentheri* series (Canedo & Haddad 2012). Within this series, the advertisement call is known for: *I. gualtheri* (Heyer 1984); *I. guentheri* (Heyer 1984, Heyer 1990, Kwet & Solé 2005, and Gehara *et al.* 2013); *I. henselii* (Kwet & Solé 2005, and Gehara *et al.* 2013); *I. izecksohni* (Taucce *et al.* 2012); and *I. nasuta* (Heyer 1984). The aggressive call is known for *I. guentheri* and *I. henselii* (Kwet & Solé 2005). Here, we provide the first description of the advertisement and aggressive calls of *I. oea*.

Vocalizations of *Ischnocnema oea* were recorded with Marantz PMD-660 digital recorder, at a sample rate of 48000 Hz and sample size of 16 bit, using a Sennheiser ME-66 microphone. We analyzed the calls with the software Raven Pro 1.4 from the Cornell Laboratory of Ornithology (Bioacoustics Research Program). Measured parameters are: number of pulses per call; pulse duration; pulse periods [measured from the beginning of one pulse to the beginning of the following one, thus encompassing the pulse duration and the interpulse interval]; call duration; call rise time, measuring the duration (in seconds) of the rise period and the percentage of the rise time in respect to the call duration; pulse rate; dominant frequency; and fundamental frequency. Numerical call parameters are given as range followed by mean ± SD and mode (Mo). Temporal parameters were measured directly from the oscillogram and spectral parameters were measured directly from the audiospectrogram (using window function Hann, amplitude logarithmic, window size 512 samples, overlap 99%). The terms and definitions adopted of the acoustic structures follow Heyer (1984), Taucce *et al.* (2012), and Gehara *et al.* (2013). A voucher specimen (CFBH 24778) was deposited at the Collection Célio F. B. Haddad (CFBH), Rio Claro, São Paulo, Brazil; and the recordings examined (MNVOC 043:1-3; eleven advertisement calls and eight aggressive calls) are housed in the voice collection of the Museu Nacional (MNVOC) Rio de Janeiro, Rio de Janeiro, Brazil.

The advertisement call (Fig. 1A-C) was composed of a sequence of 25 to 41 notes ($\bar{x}$ = 31.9 ± 4.1; Mo = 34; n = 13) repeated quasi-periodically (Fig. 1A and B). Eventually (n = 2), single notes were emitted between complete calls. The average call energy increases gradually over time until reaches the amplitude peak near to the end of the call (Fig. 1A). However the amplitude increase is not always regular since sometimes the amplitude slightly decreases between consecutive notes. Call duration ranged from 4.557 to 8.488s ($\bar{x}$ = 6.022 ± 0.965; n = 13). The call rise ranged from 4.304 to 8.487 s ($\bar{x}$ = 5.891 ± 1.084; n = 10), with 24 to 41 notes per call ($\bar{x}$ = 31.1 ± 4.5; Mo = 33; n = 10), corresponding to 90–99 % of the call duration ($\bar{x}$ = 96.0 ± 3.3; n = 10). Note duration ranged from 0.001 to 0.003 s ($\bar{x}$ = 0.002 ± 0.000; Mo = 0.002; n = 415). There was no increase or decrease in note duration throughout the call. Note periods varied from 0.150 to 0.327 s ($\bar{x}$ = 0.194 ± 0.022; Mo = 0.185; n = 400). The duration of these periods slightly decrease around the third quarter of the call, and thenceforth the periods increase slightly (or even suddenly) at the end of the call. Note rate ranged from 4.8 to 5.7 notes per second ($\bar{x}$ = 5.3 ± 0.2; n = 13). Apparently, the call showed harmonic structure though some deterministic chaos (Wilden *et al.* 1998) between the harmonics turned them less highlighted (Fig. 1B and C). The dominant frequency corresponded to the fundamental one and ranged from 3093.8 to 4125 Hz ($\bar{x}$ = 3367.8 ± 277.2; Mo = 3468.8; n = 13) (Fig. 1C). Ten calls (77 %) present upward frequency modulation, starting in the second half of the call.

The aggressive call (Fig. 1D-F) was composed of a sequence of 8–9 notes ($\bar{x}$ = 8.4 ± 0.5; Mo = 8; n = 8) repeated quasi-periodically (Fig. 1D). The call mean energy increases significantly over the first third of the call (Fig. 1D). The call rise time was proportionally shorter than the advertisement call and ranged from 0.211 to 0.446 s ($\bar{x}$ = 0.348 ± 0.074; n = 8), with 4–7 notes per call ($\bar{x}$ = 5.9 ± 1.0; Mo = 6; n = 8), corresponding to 38–71 % of the call duration ($\bar{x}$ =

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