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THE ADVERTISEMENT CALL OF *DENDROPSOPHUS NAHDERERI* (ANURA, HYLIDAE, DENDROPSOPHINI)

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Abstract. The *Dendropsophus marmoratus* group is composed of eight species known for their explosive breeding habits and morphologically characterized by a bark-like dorsum, warty skin around the lower lips and an extremely large vocal sac. Within this group, *D. nahdereri* is the only species with distribution restricted to the southern region of Brazil. Apart from the original description and its tadpole, nothing else is known about this species. Using a mechanistic definition of note, we describe the advertisement call of *D. nahdereri,* which is similar to the advertisement calls of other species of the group and frequently has "final pulseclusters" as defined in the text.

Keywords. Behavior; vocalization; *Dendropsophus marmoratus* species group; final pulse clusters.

Introduction

The *Dendropsophus marmoratus* (Laurenti, 1768) species group is composed of eight species that share a lichenous, bark-like dorsum and an extremely large vocal sac (Gomes and Peixoto, 1996; Peixoto and Gomes, 1999; Faivovich *et al.,* 2005). All of them also seem to be explosive breeders, calling usually after heavy rains and laying eggs in temporary ponds at or near to forest edges (Zimmerman and Bogart, 1984; Márquez *et al.,* 1993; Rodriguez and Duellman, 1994; Izecksohn and Carvalho-e-Silva, 2001). *Dendropsophus nahdereri* (B. Lutz and Bokermann, 1963) is the only species assigned to the *D. marmoratus* species group with distribution restricted to the southern region of Brazil (IUCN, 2008). The only known data about this species are the original adult description and the tadpole described by Peixoto and Gomes (1999).

The *D. marmoratus* species group is of difficult taxonomy (Bokermann, 1964) and call characteristics may help establish species limits. Descriptions of advertisement calls of other species of the *D. marmoratus* group are available for five of the eight species, and all of them are reported to have multipulsed notes (Table 1). An exception is the call of *D. seniculus* described by Bokermann (1967), but see discussion below. Herein we describe for the first time the advertisement call of *D. nahdereri* from two localities of the State of Santa Catarina, Brazil.

Material and Methods

Calls were obtained in the field from two municipalities of the State of Santa Catarina; Brazil. One male was recorded at Fazenda Serra da Esperança, Municipality of Lebon Régis (26°51'13"S 50°40'00"W) with a Marantz PMD-222 professional recorder coupled to a Sony ECM-MS 907 microphone (December 1st, 2005; air temperature 17°C). Voucher MCP 8976 is deposited at Coleção de Herpetologia do Museu de Ciências e Tecnologia da PUCRS, Porto Alegre, State of Rio Grande do Sul, Brazil. Four unvouchered males were recorded at the Municipality of Anitápolis; the recordings were made with a Marantz PMD-222 professional recorder, with Sennheiser – System K6 directional microphone (August 15th and 16th, 2005, 17 and 18°C respectively; September 9th, 2008, 13°C).

Recordings were digitized at a resolution of 16 bit; 44100 Hz sampling rate. Audiospectrograms and oscilograms were made using Raven Pro 1.3 (Cornell Lab of Ornithology), and analyzed with a Fast Fourier Transformation window of 512 points; Hann algorithm. All other parameters used default settings. The parameters used were note duration (s), number of pulses, pulse duration (s), number of final pulse clusters, number of pulses of the final pulse cluster, higher frequency of first harmonic (Hz), lower frequency of first harmonic (Hz), and dominant frequency (Hz). Because the pulses are sometimes overlapped, our measures of pulse duration were based on the interval between maximum amplitude of the pulses.

In this study, we followed the note definition of McLister *et al.* (1995) in which a note is the total amount of sound energy generated during a single airflow cycle. We believe that our field observations of *D. nahdereri* were enough to use this definition since trunk and vocal sac inflation/deflation movements are evident and calls from a single individual are well apart from each other temporally. Complete certainty however can only be achieved through a physiological test and direct observation of nasal cartilage opening cycle.

The McLister *et al.* (1995) note definition is a more logical approach to codify call characters than traditional approaches since it establishes a physiological basis defining the unit "note" and, therefore, facilitates interpretations of primary homology (Robillard *et al.,* 2006). This coding method has also achieved better results (*i.e.* is consistent with results from other kinds of data such as morphology) in recovering a previously "known" cladogram topology than the traditional approach (Robillard *et al.,* 2006).

Additional recordings from other species were gathered from bibliography or from the Coleção Sonora Célio F. B. Haddad (CFBH sound) housed at Departamento de Zoologia of UNESP, Rio Claro, 'State of São Paulo', Brazil.

Results

The calling sites of *D. nahdereri* seemed to vary according to the vegetation structure of the ponds. In ponds with dense emerging aquatic vegetation, most males called while hidden there, near to water level. Eventually, males also called on perches or branches around the pond, mostly when there were few males calling. However, in puddles with little availability of low perches and greater amount of shrubs, males were also found in large quantities perched at heights up to 1-5 meters.

The advertisement call of *D. nahdereri* is a single multipulsed note (a trill *sensu* Wells, 1977a) with two harmonics (Fig. 1). The dominant harmonic is usually the first (fundamental) one. Statistics are summarized in Table 2. Most notes present a cyclic modulation on emission intensity (*i.e.* amplitude. see Fig. 1). The final portion of these notes can be composed of one to three spaced blocks of three to seven pulses, which are produced within the same air flow (and lung movement) of the "main note". The effect to the ear is similar to a single note, therefore the blocks were included when measuring note duration (Fig. 2). We refer to these final blocks as "final pulse clusters" hereafter. The duration of notes without final pulse clusters ($\overline{X}$ = 0.79 s, 0.74-0.84 s, N = 3) are within the range of note duration for calls with final pulse clusters ($\overline{X}$ = 0.69 s, 0.44-0.98 s, N = 57). Similarly, the number of pulses in the notes without final pulse clusters ($\overline{X}$ = 54, 51-57, N = 3) are within the range of the

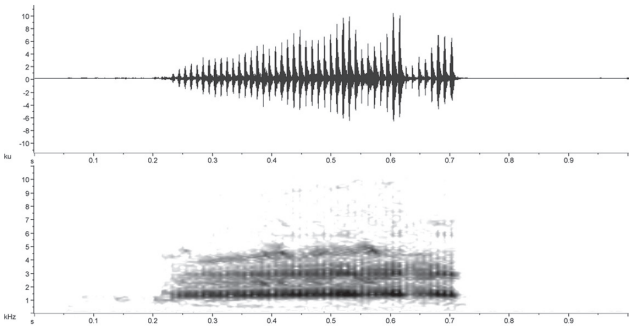

Figure 1. *Dendropsophus nahdereri* MCP 8976 single note from the advertisement call recorded at Fazenda Serra da Esperança, Municipality of Lebon Régis, State of Santa Catarina (December, 01st, of 2005; air temperature 17°C. Oscillogram (above) and audiospectogram (below); FFT = 256. Note the cyclic modulation in intensity.

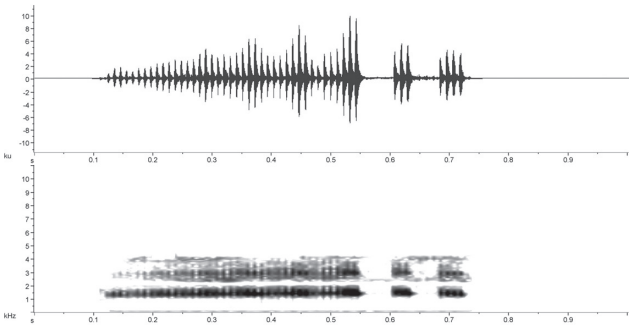

Figure 2. *Dendropsophus nahdereri* MCP 8976 advertisement call with two final pulse clusters; oscillogram (above) and audiospectrogram (below); FFT = 256.

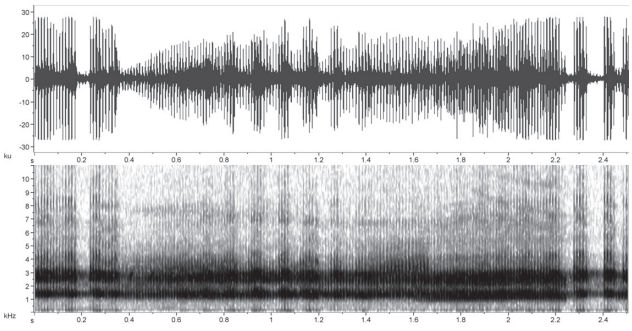

Figure 3. Chorus of unvouchered *Dendropsophus nahdereri* specimens at Anitápolis, SC (September 09, 2008, 13°C); FFT = 256.

Table 1. Species of the *Dendropsophus marmoratus* (Laurenti, 1768) with available advertisement call descriptions and respective references. * = All using the same recordings from Duellman (1978); however, each study analyzed different variables.

species	source
D. acreanus	Marquez *et al.* (1993)
D. marmoratus	Duellman (1978); Duellman and Pyles (1983); Zimmerman and Bogart (1984) and; Rodriguez and Duellman (1994)*
D. melanargyreus	Duellman and Pyles (1983) and Marquez *et al.* (1993)
D. seniculus	Bokermann (1967)
D. soaresi	Guimarães *et al.* (2001)

Table 2. Seven physical parameters analyzed for the advertisement calls of *Dendropsophus nahdereri.* Data of 60 calls of five males, four males recorded at Municipality of Anitápolis and one male at Lebon Régis, State of Santa Catarina. Statistical values are shown when convenient. * = ”0” means that the note did not have a final pulse cluster.

Parameter	Mode	Mean	Standard Deviation	Range	N
Note duration (s)	—	0.699	0.148	0.443-0.982	60
Number of pulses	44	48.1	8.2	31-66	60
Pulse duration (s)	—	0.013	0.002	0.010-0.015	451
Number of final pulse clusters	2	1.45	0.62	0*-3	60
Number of final pulse cluster pulses	6	5.8	2.2	0*-12	60
High freq. of first harmonic (Hz)	1707.9	1814.2	84.5	1625.5-1949.0	60
Low freq. of first harmonic (Hz)	930.5	1018.3	69.6	895.2-1169.5	60
Dominant frequency (Hz)	1378.1	1392.4	27.0	1378.1-1464.3	60

number of pulses for notes with final pulse clusters (X = 47, 31-61, N = 57). Calls of numerous individuals in chorus are almost impossible to discriminate in recordings and the effect achieved is similar to a single individual emitting a long call in waves of intensity (Fig. 3).

Discussion

Individual call site variability is a known phenomenon (Wells, 1977b) and possibly density related. Since males compete for territory (Wells, 1977b), as more calling males join the chorus different environmental pressures apply, such as the availability of optimal call sites, and call structure should be modified to respond to this stimuli. Other behaviors are known to be density related like satellite behavior (Wells, 1977b; Haddad, 1994) and choice of oviposition site (Touchon and Warkentin, 2008).

The cyclic modulation in intensity producing final pulse clusters is known, so far, only for *D. nahdereri.* This modulation is not cited in any *Dendropsophus* advertisement call description but, Márquez *et al.* (1993) noticed that “often [the advertisement call of *D. acreanus* was] followed by two short notes”. It is possible that they were referring to the final pulse clusters defined here. However, a re-analysis with the mechanistic approach of the other species in the *D. marmoratus* group looking for the presence of the final pulse clusters is highly recommended.

Recordings of two species from the *D. parviceps* group were available to us. Even though their advertisement calls also present a slightly cyclic modulation, the intensity of their calls had always an increasing trend (*D. microps,* CFBH sound CD 36 – track 2, Fazenda São Luiz, Municipality of Ribeirão Branco; and *D. giesleri,* CFBH sound CD 28 – track 6, Picinguaba, Municipality of Ubatuba, both within the State of São Paulo, Brazil). Also, the fundamental harmonic of those calls are higher (> 3000 Hz) while calls from the *D. marmoratus* group are below 3000 Hz.

We do not consider the final pulse clusters resulting from the cyclic intensity of *D. nahdereri* as secondary notes *stricto sensu* because they seem to be produced within the same unique air flow cycle of the “main note”. Therefore, they do not constitute a “real” note in the definition used in this study. We believe that the “final pulse clusters” are a natural phenomenon and not an artifact because they were present in recordings using two different microphones with different presettings. However, for a definitive position, a physiological test is still pending.

Probably, the note definitions summarized in Duellman (1970) where a note is “an individual uninterrupted unit” is the most widespread definition used

to date. This individual unit can be understood as the "100% [intensity] modulation" definition of note used by Heyer *et al.* (1990). Our "final pulse clusters" are individual uninterrupted units in the oscillograms, thus, fulfilling the definition requirements in Duellman (1970). It is worth noticing that trunk movements when producing notes with or without "final pulse clusters" are the same and, we understand that, under the definition used herein, secondary notes should be produced by other air flow cycles.

The presence of final pulse clusters could be a social response with territorial function. However, once we did not make a specific study for this purpose, we can not attribute a definitive social function and more research is needed to understand the cyclic modulation function.

According to Bokermann (1967:442), the advertisement calls of *D. seniculus, D. marmoratus, D. acreanus,* and *D. novaisi* are similar and, to the human ear, the call of *D. nahdereri* is not an exception. It is interesting to notice that when Bokermann (1967) described the advertisement call of *D. seniculus,* he stated that it does not present pulses, but instead, a high number of harmonics (32). When looking at his sonogram, it becomes clear that Bokermann described side-bands sensu Vielliard (1993), although a dominant harmonic around 2500 Hz and another harmonic (perhaps the second) around 4500 Hz can be seen.

The advertisement calls of *D. melanargyreus* and *D. marmoratus* described by Duellman and Pyles (1983) present very low fundamental harmonics (120-140 Hz for *D. marmoratus* and 127-140 Hz for *D. melanargyreus*), but we believe them to be an artifact. Zimmerman and Bogart (1984) also described the advertisement call of *D. marmoratus* and although they do not state the dominant frequencies of calls from Parque Nacional dos Tapajós in their work, the lowest and highest frequencies registered by them for this species range from 1290 to 3490 Hz. Recordings of *D. melanargyreus* from other localities; of *D. acreanus* (a very similar species to *D. marmoratus*) (Marquez *et al.* 1993 from Bolívia) and the call of *D. nahdereri* described herein do not present this extremely low fundamental frequency. Duellman and Pyles (1983), however, did not present figures in their study that could help elucidate this question as was possible with Bokermann's (1967) data.

Dendropsophus nahdereri emits the longest call in the group. The minimum value for *D. nahdereri* note duration is only 5% shorter than the maximum value described for all other species (0.443 s of *D. nahdereri* vs. 0.466 s of *D. acreanus* [Márquez *et al.,* 1993]). Dominant frequency is lower than all others described except for *D. marmoratus* in Duellman and Pyles (1983), but see discussion above. The mean number of pulses per note is higher than any other described for the group (44 in *D. nahdereri* x 33 in *D. soaresi* [Guimarães *et al.,* 2001]).

Actually, this combination of advertisement call traits (multipulsed single notes, with two-harmonics; low-frequency dominant harmonics and with final pulse clusters) could be diagnostic for the *D. marmoratus* group within *Dendropsophus.* Even though the described advertisement calls for *Dendropsophus* are known to be highly variable (Cardoso and Haddad, 1984; Martins and Jim 2003; 2004) and large series are recommended to understand call variation (Cardoso and Vielliard, 1985), all descriptions of advertisement calls from the *D. marmoratus* group seem congruent.

If present in other species of the group, final pulse clusters in the advertisement call will be the single diagnostic character for the group since some species from the *D. parviceps* group also present lichenous, bark-like dorsum and an extremely large vocal sac. Bokermann (1964) using this same characters, also included in the group *Isthmohyla lancasteri* (Barbour, 1928); *Dendropsophus parviceps* (Boulenger, 1882); *D. microps* (Peters, 1872) and *D. schubarti* (Bokermann, 1963). The latter three are now in the *D. parviceps* group of Faivovich *et al.* (2005). However, the monophyly of the *D. parviceps* group is still regarded with skepticism (Faivovich *et al.,* 2005:93).

Resumo

O grupo de *Dendropsophus marmoratus* é composto por oito espécies conhecidas pelo seu hábito reprodutivo explosivo e caracterizadas morfologicamente por possuírem um dorso liquenoso, pele verrucosa sob o lábio e um saco vocal extremamente grande. Deste grupo, *D. nahdereri* é a única com distribuição restrita para a região sul do Brasil. Além da descrição original e de seu girino, nada a mais é conhecido para esta espécie. Utilizando uma definição mecanística de "nota", nós descrevemos o canto de anúncio de *D. nahdereri.* O canto de anúncio de *D. nahdereri* é similar ao descrito para outras espécies do grupo e frequentemente possui "um grupo final de pulsos", como definido no texto.

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