Advertisement call of the closely related species *Scinax aromothyella* Faivovich 2005 and *S. berthae* (Barrio 1962), with comments on the complex calls in the *S. catharinae* group

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We compare the advertisement calls of *Scinax aromothyella* and *S. berthae*, two closely related Neotropical hylid frogs of the *S. catharinae* group. We studied several individuals from different localities in Argentina, Brazil and Uruguay. The call parameters analyzed did not allow the discrimination between the two species. Like in other species of the *S. catharinae* group, the advertisement calls are complex, consisting of short notes with overlapping pulses; an additional trilled note is frequently present, interspersed between the short ones. This complex call structure is common in the *S. catharinae* group, whereas it is only exceptionally reported in other taxa of the *S. perpusillus* group and the *S. ruber* clade. The advertisement call in this group is a candidate target for future studies addressing social and environmental factors affecting call structure.

Key words: behaviour, bioacoustics, complex calls, *Scinax*

INTRODUCTION

Scinax aromothyella and *S. berthae* are closely related taxa of the *S. catharinae* species group (Faivovich, 2005). Although this group is mainly associated to the Atlantic Rain Forest biome (Faivovich, 2002), both species extend their ranges southwards, reaching temperate areas of Uruguay and central-eastern Argentina (Kolenc et al., 2007). *Scinax aromothyella* has less developed toe webbing, more robust forearms and larger adults than *S. berthae* (Faivovich, 2005). The tadpoles of both species develop in lentic water, with those of *S. aromothyella* being larger at equivalent developmental stages (de Sá et al., 1997; Kolenc et al., 2007). Both morphological (Faivovich, 2002; 2005) and molecular information (J. Faivovich personal communication) support a sister relationship between *S. aromothyella* and *S. berthae*. The former is distributed in the Atlantic Rain Forest in Brazil and northeastern Argentina and also in hilly formations of eastern Uruguay, whereas the latter can be found inhabiting coastal and riparian plains from São Paulo in south-eastern Brazil to central-eastern Argentina and coastal Uruguay (Barrio, 1964; Faivovich, 2005; Borteiro et al., 2007; Kolenc et al., 2007; Hartmann et al., 2008; Lucas & Fortes, 2008). Besides distributional records, little additional data about natural history are available for both species (Barrio, 1962; Faivovich, 2005; Kolenc et al., 2007). In this study we investigated and compared the advertisement calls of these closely related and allopatric frogs, recorded at several localities throughout their distributional ranges.

Fig. 1. Map showing the localities of the recorded specimens. White dots: *Scinax aromothyella*; Black dots: *S. berthae*.

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Table 1. Call recording details for *Scinax aromothyella* and *S. berthae*. Abbreviations used: A/W T, Air/Water temperature; NV, unvouchered specimen; AR, Argentina; BR, Brazil; UY, Uruguay. (*) Recording from Straneck et al. (1993)

	Acronym	Site location	Coordinates	A/W T [ºC]
S. aromothyella	MLP DB 5067	Arroyo Cuña Pirú, Misiones, AR	27 06S 54 58W	15/16.5
	NV	Arroyo Cuña Pirú, Misiones, AR	27 06S 54 58W	15/16.5
	NV	Arroyo Cuña Pirú, Misiones, AR	27 06S 54 58W	15/16
	NV	Santa Rita, Misiones, AR	27 29S 54 56W	20/–
	DZSJRP 13359	Guaraupava, Paraná, BR	25 24S 51 27W	15/–
	DZSJRP 13398	São José dos Pinhais, Paraná, BR	25 39S 49 05W	14/–
	DZSJRP 13082	General Carneiro, Paraná, BR	26 25S 51 19W	15/–
	ZVCB 14563	Quebrada de los Cuervos, Treinta y Tres, UY	32 52S 54 28W	15/17
S. berthae	NV (*)	P. N. El Palmar, Entre Ríos, AR	31 50S 58 15W	–/–
	MLP DB 1907	Villa Lanús, Misiones, AR	27 26S 55 54W	20/–
	NV	Posadas, Misiones, AR	27 22S 55 53W	–/–
	MLP DB 3929	Gobernador Virasoro, Corrientes, AR	28 00S 56 01W	20.5/–
	MLP DB 5748	Reserva Santa María, Corrientes, AR	27 31S 56 36W	15/16
	NV	Ribeirão Claro, Paraná, BR	23 11S 49 45W	18/–
	MNHN 9426	Playa Penino, San José, UY	34 46S 56 24W	15/17
	NV	Near Arroyo Pavón, San José, UY	34 29S 57 03W	21/21
	NV	Near Arroyo Pavón, San José, UY	34 29S 57 03W	21/21

MATERIALS AND METHODS

We analyzed 44 advertisement calls obtained from eight males of *Scinax aromothyella* and 17 males of *S. berthae*, recorded at several localities in Argentina, Brazil and Uruguay (Fig. 1; Table 1). Calls were recorded with the following tape recorders/microphones: Sony WMD6C/ Sennheiser LR 6, Marantz PMD 222/Sennheiser ME 66, and Sony TCM 5000/Shure. Recordings were analyzed employing Sound Forge 5.0 software, with a FFT of 512 points, at a sampling rate of 44.1 kHz and 16-bit precision. The following temporal parameters were measured from the waveform: call duration, number of notes per call, note duration, number of pulses per note, pulse duration and internote interval. Mean power spectra of the selected notes were obtained with a FFT of 512 points, overlap 93%, Hamming's sampling window and spectrogram resolution of 10,000 samplings. The frequency bands and dominant frequencies were obtained from spectrograms. The note rate (notes per second) and the pulse rate (pulses per second) were calculated. Terminology for advertisement call descriptions follow Heyer et al. (1990). We analyzed one to six calls for each individual studied. Additionally, we included in the analyses the recordings of *S. berthae* available from Straneck et al. (1993).

Specimens collected for the present study are deposited in the following institutions: DZSJRP (Coleção Científica de Anfíbios do Departamento de Zoologia e Botânica da Universidade Estadual Paulista; UNESP, São José do Rio Preto, São Paulo, Brazil); MLP DB (Diego Baldo Collection, deposited at Museo de La Plata); MNHN (Museo Nacional de Historia Natural, Montevideo, Uruguay); and ZVCB (Colección de Batracios, Departamento Zoología Vertebrados, Facultad de Ciencias, Universidad de la República, Montevideo, Uruguay)

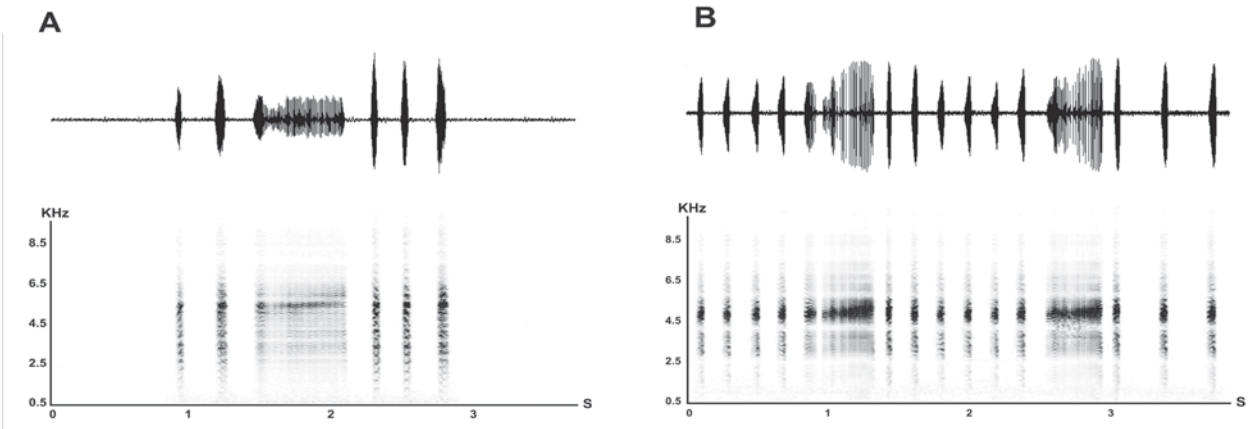

Fig. 2. Oscillogram and spectrogram of a call fragment of (A) *Scinax aromothyella*, and (B) *S. berthae*

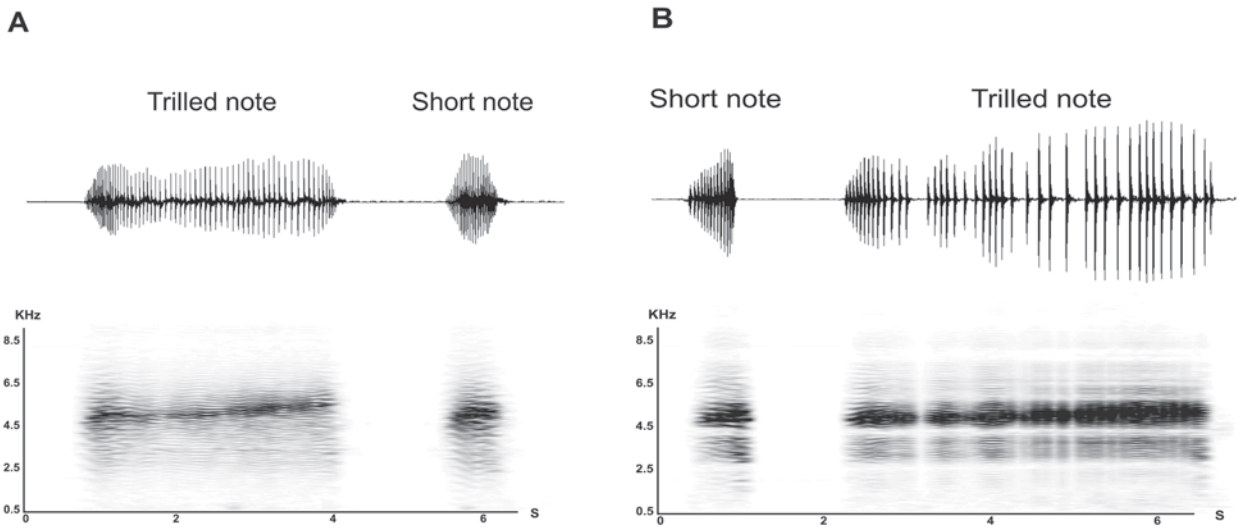

Fig. 3. Oscillogram and spectrogram of the two different notes of the advertisement call emitted by (A) *Scinax aromothyella*, and (B) *S. berthae*

RESULTS

The advertisement calls of *Scinax aromothyella* and *S. berthae* (Figs. 2 and 3) are complex, and similar in structure, spectral and acoustic parameters. The call of both species lasts from a few to several seconds and consists of two kinds of notes. The most frequent type is a short one, composed mainly of superposed pulses, and is usually clustered in groups. The other type of note is longer, and composed of discrete pulses; it resembles a short trill and is irregularly emitted. Both types of notes present similar spectral structure, a wide frequency band that clearly peaks at the dominant frequency, amplitude modulation and no noticeable harmonics. The calls of both species are composed of either a series of identical short notes or, more frequently, a combination of short and long notes. In the last case, trills are always flanked by groups of short notes. Trills present slight frequency modulation: they have a dominant frequency similar to that of the short notes until close to their end, in which their dominant frequency increases. The calls of one specimen of *S. aromothyella* (ZVCB 14563) and two *S. berthae* (MLP DB 5748 and an unvouchered specimen from Posadas, Misiones, Argentina) were exclusively composed of long series of short notes. Data of studied advertisement calls are detailed in Table 2.

DISCUSSION

The advertisement calls of *Scinax aromothyella* and *S. berthae*, although complex, are very alike, and the studied acoustic parameters do not allow the unambiguous differentiation between these two closely related species. No significant differences were noticed when compared with the call of *S. berthae* described by Barrio (1962), except for the fact that the harmonics reported by him were not evident in our spectrograms (Figs. 2 and 3). Call duration is usually longer in *S. berthae* than in *S. aromothyella* but this parameter greatly varies from one individual to another due to the social context and other environmental stimuli (Bosch & de la Riva, 2004; Wells, 2007). As in our case, the lack of divergence in the advertisement calls of closely related anuran species has previously been found associated to allopatric distributions (Duellman & Pyles 1983; Cocroft et al., 1990; Kwet et al., 2005).

High call diversity was previously reported for species of the *S. catharinae* group, which produce simple calls composed by discrete or superposed pulses, and complex calls with at least two note types, consisting of superposed, discrete or isolated pulses. The complex advertisement calls of *S. aromothyella* and *S. berthae* are consistent with these reports, with the described calls resembling those of *S. argyreornatus* (Bokermann, 1964; Pombal et al., 1995), *S. heyeri* (Peixoto & Weigoldt, 1987), and *S. ranki* (Andrade & Cardoso, 1991). Isolated notes composed by one or few pulses can also be present in *S. hiemalis* (Haddad & Pombal, 1987) and *S. ranki* (Andrade & Cardoso, 1987; 1991). These complex advertisement calls with distinct primary and secondary notes have been reported in several species of other anuran taxa and can play a dual role, conveying an aggressive message to males with one type of note while attracting females with the other (Narins & Capranica, 1978; Backwell, 1988; Larson, 2004). This can be the reason for the different patterns of note combinations observed in *S. aromothyella* and *S. berthae*. Similar observations were made in other species of the *S. catharinae* group (Barrio 1962; Cardoso & Haddad, 1982; Haddad & Pombal, 1987; Peixoto & Weygoldt, 1987; Andrade & Cardoso, 1987, 1991; Pombal et al., 1995; Nunes et al., 2007), whereas distinct types of vocalizations to attract females and to defend calling sites against conspecifics were reported in two species of this group [*S. centralis* (Bastos et al., 2011) and *S. rizibilis* (Bastos & Haddad, 2002)].

Within the genus *Scinax*, there are further cases of allopatric species pairs with similar advertisement calls: *Scinax granulatus*/*S. perereca* (Kwet, 2001); *S. auratus*/*S. crospedospilus* (Bevier et al., 2008); *S. boulengeri*/*S. garbei*/*S. nebulosus* (Duellman & Pyles, 1983); and *S.*

Table 2. Acoustic parameters of analyzed calls of *Scinax aromothyella* and *S. berthae*. * Values considering both types of notes. Data are given as mean±SD (interval)

Variables	*S. aromothyella*		*S. berthae*	
	short note	trilled note	short note	trilled note
Frequency Band [Hz]	1477–8777	1513–9109	2235–7727	2275–7289
Dominant Freq [Hz]	5127±298 (4769–5414)	5068±311 (4842–5534)	4886±285 (4477–5285)	4917±275 (4410–5361)
Call duration [s]	4.49±2.41 (1.04–20.76)*		22.21±19.23 (3.2–52.04)*	
Notes/call	11.09±12.37 (2-74)	0.68±0.60 (0-3)	87.67±155.60 (4-620)	7.87±14.74 (0-52)
Note duration [s]	0.11±0.05 (0.04–0.22)	0.42±0.17 (0.30–0.61)	0.07±0.02 (0.03–0.14)	0.39±0.06 (0.13–0.59)
Note rate [notes/s]	1.97±1.25 (1.02–4.36)	0.12±0.13 (0–0.37)	3.87±2.86 (1.18–9.35)	0.34±0.33 (0–0.86)
Pulse/note	29.36±11.00 (18-49)	74.57±20.17 (33–102)	21.62±5.58 (12-39)	62±3.54 (40–88)
Pulse duration [s]	0.003±0.001 (0.001-0.005)	0.004±0.002 (0.002-0.006)	0.003±0.001 (0.002-0.005)	0.005±0.002 (0.002-0.007)
Pulse rate [pulses/s]	332.18±61.77 (220.72-420.10)	173.3±31.9 (137.3–216.8)	315.07±42.48 (262.71-421.53)	142.3±57.4 (101.4–225.6)
Internote interval [s]	0.20±0.09 (0.05–0.48)*		0.18±0.04 (0.06–0.60)*	

pinima/*S. uruguayus* (Kolenc et al., 2003). A thorough phylogenetic hyphotesis of *Scinax* would allow to interpret the significance in advertisement call similarity and the evolution of call patterns in this genus. The advertisement call variation in species of the *S. catharinae* group is a candidate target for studies addressing social and environmental factors that affect call structure. Controlled playback experiments would help to investigate the possible functions of single and trilled notes in this group. The lack of a clear understanding of their role and the complexity of the calls presently hamper the use of these acoustic signals in taxonomic and phylogenetic studies.

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