Calls of five species of the *Scinax ruber* (Anura: Hylidae) clade from Brazil with comments on their taxonomy

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Abstract

As currently defined, treefrogs of the genus *Scinax* comprises the most species-rich genus within Hylinae. Although in the last decades there have been an increasing number of taxonomic studies on *Scinax*, populations of several species still deserve further studies to assess their taxonomic status. The purpose of this paper is to contribute to the taxonomy and zoogeography of some species of *Scinax* from Brazil assigned to the *Scinax ruber* clade through the description/redescription of their advertisement calls. The advertisement call of *S. duartei* from topotypic specimens and the call of *S. acuminatus* are described here for the first time. The call of *S. duartei* is in disagreement with descriptions from the literature what suggests that an unnamed species is hidden under this specific name. Redescriptions of the calls of *S. crospedospilus*, *S. eurydice*, and *S. hayii* are also provided and compared with previous studies. In order to better assess the taxonomic status of species with advertisement calls that present more than one emphasized frequency, as in some species of the *Scinax ruber* clade, we recommend special attention in the descriptions of the spectral components of these calls.

Key words: Advertisement calls, *Scinax acuminatus*, *Scinax crospedospilus*, *Scinax duartei*, *Scinax eurydice*, *Scinax hayii*

Introduction

Treefrogs of the genus *Scinax* Wagler are one of the most abundant and conspicuous groups of frogs in the Neotropics (De la Riva et al. 1994) and, as currently defined, it represents the most species-rich (104 spp.) genus within Hylinae (Frost 2011; Faivovich et al. 2010; Nunes & Pombal 2011). *Scinax* species range from southern Mexico to east-central Argentina occurring in almost all major tropical and subtropical ecosystems within this region (Faivovich 2002; Frost 2011). In the last decade there have been an increasing number of taxonomic studies on *Scinax*, with the description of 18 new species (Frost 2011; Faivovich et al. 2010; Nunes & Pombal 2011). Even though, as pointed out by various authors, populations of several *Scinax* species still deserve further studies to assess their taxonomic status (e.g. *S. alter*, Pombal et al. 1995; *S. fuscomarginatus*, Cardoso & Pombal 2010; *S. perpusillus*, Silva & Alves-Silva 2008; *S. ruber*, Fouquet et al. 2007; *S. x-signatus*, Pugliese et al. 2009), what certainly will reveal a larger number of unnamed species.

The monophyletic nature of *Scinax* is well-supported mainly by morphological and molecular characters (Duellman & Wiens 1992; Faivovich 2002; Faivovich et al. 2005; Wiens et al. 2006; Wiens et al. 2010). Within *Scinax*, two major clades have been recognized (Faivovich 2002; Faivovich et al. 2005; Wiens et al. 2010), the *S. catharinae* clade (to date 37 species), biogeographically associated with the Atlantic rain forest biome of Brazil,
and the *S. ruber* clade, a widespread group occurring in tropical and subtropical areas of Central and South America (to date 67 species) (Pombal et al. 1995; Faivovich 2002; Frost 2011).

The purpose of this paper is to contribute to the taxonomy and zoogeography of the species of *Scinax* assigned to the *Scinax ruber* clade through the description/redescription of advertisement calls of five species from Brazil based on new high quality records and new technologies of sound analysis. The advertisement call of *S. duartei* (Lutz) from toptotypic specimens and the call of *S. acuminatus* (Cope) are described for the first time. The call of *S. duartei* is in disagreement with descriptions from the literature what suggests that an unnamed species is hidden under this specific name. Redescriptions of the calls of *S. crospedospilus* (Lutz), *S. eurydice* (Bokermann), and *S. hayii* (Barbour) are also provided and compared with previous studies.

**Material and methods**

Field work was carried out sporadically between January 2009 and December 2010 in three municipalities of southeastern and Western-Center Brazil (Minas Gerais, São Paulo and Mato Grosso do Sul States). Two males of *Scinax crospedospilus*, one of *S. hayii* and one of *S. eurydice* were recorded at Parque Florestal do Itapetinga (PFI) in Atibaia, in a mid-elevation seasonal forest in the Serra da Mantiqueira mountain range of São Paulo State (SP) (area description in Giaretta et al. 1999). Two males of *S. hayii* were also recorded in Itapeva, Minas Gerais State (MG). Three males of *Scinax duartei* were recorded at its type locality, at Brejo da Lapa, in the Itatiaia National Park, part of the Mantiqueira Range, in Itamonte (MG). Two males of *S. acuminatus* were recorded in Aquidauana, Mato Grosso do Sul State (MS).

The calls were recorded with a digital recorder (M-Audio Microtrack II, set at 44,100 Hz and 16 bit resolution) coupled to a directional microphone (Sennheiser ME66/K6). Recordings were analyzed with the software Sound-Ruler (Gridi-Papp 2007). Sound figures were prepared (FFT = 128 or 256; overlap = 85%) in the Seewave R package (v. 1.5.5 and 1.5.9) (Sueur et al. 2008, R Development Core Team 2010). Terminology of spectral parameters of the calls followed Gerhardt (1974; 1976; 1981a) and Gerhardt et al. (2007).

Voucher specimens of *S. crospedospilus* (AAG-UFU 4942-4943), *S. hayii* (AAG-UFU 4603-04), *S. eurydice* (AAG-UFU 4940) and *S. acuminatus* (AAG-UFU 293) are housed at the collection of frogs of the Universidade Federal de Uberlândia, Uberlândia (MG), Brazil. Additional *S. acuminatus* specimens examined (SVL measure) from Corumbá (MS) are housed in the CFBH collection (Célio F. B. Haddad collection, Departamento de Zootologia, Universidade Estadual Paulista, Rio Claro, Brazil). *Scinax duartei* vouchers were not collected and its identification is based on SPCS field experience.

**Results**

The measured call parameters and temperatures (air and water) of records are summarized in Table 1. Call parameters in the text are given as mean values; for temporal parameters mean is followed (±) by standard deviation. The distances between localities are given as airline distances.

*Scinax acuminatus*

(fig. 1A).

In Aquidauana (MS), one male of *Scinax acuminatus* (38.1 mm SVL; one male) was recorded while calling hidden on grass vegetation about the soil level at the margins of a small dammed stream and another one while calling perched on a tree trunk about 0.2 m above soil at the margins of a natural swamp area (ca. 20°28'S, 55°46'W, 150 m asl).

The advertisement call (fig. 2A; Table 1) consists of a single note, with a mean of 32.6 pulses per call, practically without inter-pulse interval. The calls had a mean duration of 666±29 ms, with a call rate of 25.5 calls/min. The frequencies ranged between 0.64–5.03 kHz and the dominant frequency around 0.83–1.56 kHz. Calls also had power between 2.59–3.77 kHz, but in the most of analyzed calls this band presented much less energy than the dominant frequency band.
Table 1. Parameters of the advertisement call of *Scinax* species (*S. acuminatus, S. croscodopilus, S. duartei, S. eurydice and S. hayii*). Data already published for these species are also provided. Mean values are followed by one standard deviation (mean±SD). Ranges are given as values separated by a dash or are between round brackets. Samples sizes of calls analyzed are between square brackets. N = number of males recorded; HFB, high-frequency band; LFB, low-frequency band.

<table>
<thead>
<tr>
<th>Species</th>
<th>N</th>
<th>Call duration (ms)</th>
<th>Notes/call</th>
<th>Range of Frequency (kHz)</th>
<th>Dominant Frequency (kHz)</th>
<th>Other Emphasized Frequencies</th>
<th>Pulses/call</th>
<th>Call rate (calls/min)</th>
<th>Pulse rate (pulses/sec)</th>
<th>T °C air</th>
<th>T °C water</th>
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<td>666±287</td>
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<td>0.64–5.03</td>
<td>0.83–1.56</td>
<td>2.59–3.77</td>
<td>32.6±13.5</td>
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<td>78.4±8.6</td>
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<td>Aquirauana and Porto Murtinho (MS)</td>
<td></td>
<td>(373–1.42)</td>
<td>[9]</td>
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<td>[9]</td>
<td>(20–69)</td>
<td>(21.2–29.2)</td>
<td>[37]</td>
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<td>2</td>
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<td>0.82–5.91</td>
<td>HFB</td>
<td>5.7±06</td>
<td>25.5±19.1</td>
<td>23.8±2.5</td>
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<td>17.6</td>
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<td>5–7</td>
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<td>fundam. freq.</td>
<td>note rate</td>
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<td>1°</td>
<td>1.00–5.00= peak</td>
<td>7°</td>
<td>61.7°</td>
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<td>[5]</td>
<td>1.41±0.01</td>
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<td>[5]</td>
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<td>3</td>
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<td>0.86–4.77</td>
<td>1.72–3.09</td>
<td>9.5±0.9</td>
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Table 1 continued

<table>
<thead>
<tr>
<th>Species</th>
<th>N</th>
<th>Call duration (ms)</th>
<th>Notes/call</th>
<th>Range of Frequency (kHz)</th>
<th>Dominant Frequency (kHz)</th>
<th>Other Emphasized Frequencies (kHz)</th>
<th>Pulses/call</th>
<th>Call rate (calls/min)</th>
<th>Pulse rate (pulses/sec)</th>
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<td>1.18–2.62</td>
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<td>78.9</td>
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<td>21.0</td>
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<td>90–110</td>
<td>1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.50–5.80</td>
<td>2.80–3.40</td>
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<td>3</td>
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<td>43.1±1.6&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>(1.00–3.80)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>= notes/call</td>
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<td>[5]</td>
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<td><em>S. hayii</em></td>
<td>3</td>
<td>230±24</td>
<td>1</td>
<td>0.49–6.19</td>
<td>LFB</td>
<td>HFB</td>
<td>14.2±1.2</td>
<td>30.3±19.4</td>
<td>72.6±4.5</td>
<td>20.1–22.0</td>
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<td>[15]</td>
<td>1.08–2.06</td>
<td>2.35–3.43</td>
<td>(13–17)</td>
<td>(12.0–50.6)</td>
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<td><em>S. hayii</em>&lt;sup&gt;6&lt;/sup&gt;</td>
<td>200–260</td>
<td>1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00–4.50</td>
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<td>15–20</td>
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<td>60.0–70.0</td>
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<td><em>S. hayii</em>&lt;sup&gt;6&lt;/sup&gt;</td>
<td>190–320</td>
<td>1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00–6.40</td>
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<td></td>
<td>14–21</td>
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</table>

Conceição da Barra (ES)

Itapeva (MG) and

Jundiaí (SP)


<sup>a</sup> calls from the type locality; <sup>b</sup> values observed in figure or text of the original article; <sup>c</sup> value transformed from original article; <sup>d</sup> analyzed from calls in Haddad et al. 2005.
The first pulses of most calls and sometimes 2nd and 3rd pulses presented lesser intensity and energy (relative amplitude) in relation to the remaining ones. Calls were characterized by distinguishable ascendant amplitude modulation from the first to the 3rd–4th pulse.

One additional record of *S. acuminatus* (unvouchered specimen) from Porto Murtinho (MS) was kindly provided by F.L. Souza, but due to the unknown nature of the devices used in the recording, the only parameters analyzed from this call were call duration, pulse number and call rate. This call and those from Aquidauana were considered together because totally overlapped in the parameters measured (see Table 1).

**FIGURE 1.** A) An adult male *Scinax acuminatus* in life (Voucher specimen AAG-UFU 293; 38.1 mm SVL) from Aquidauana, Mato Grosso do Sul (MS) State, Brazil. B) An adult male *Scinax crospedospilus* in life (Voucher specimen AAG-UFU 4942; 30.1 mm SVL) from Atibaia, São Paulo (SP) State, Brazil, at Parque Florestal do Itapetinga (PFI). C) An adult male *Scinax duartei* in life (unvouchered specimen) from Brejo da Lapa, Itamonte municipality, Minas Gerais (MG) State, Brazil. Photo provided by I.A. Martins; D) An adult male *Scinax eurydice* in life (Voucher specimen AAG-UFU 4940; 50.1 mm SVL) from Atibaia (SP), Brazil, at PFI.

**Scinax crospedospilus**
(fig. 1B).

In Atibaia (SP), *Scinax crospedospilus* (22.8–30.1 mm SVL; two males) was found at PFI, (ca. 23°10'S, 46°31'W, 900–1,250 m asl). The two males were recorded while calling perched on broad leaves (40–50 cm high) at the margins of an artificial permanent pond at the forest border. Syntopic hylid frogs included *Hypsiboas faber, S. eurydice, S. hayii* and *Dendropsophus minutus.*
FIGURE 2. Audiospectrogram (top) and oscillogram (below) of advertisement call of *Scinax acuminatus* (A) and *S. crospedospilus* (B). A) *Scinax acuminatus* recording from Aquidauana, Mato Grosso do Sul State; air = 27.0 °C; 19:46 h. December 2010. AAG record file: Scinax_acuminMS1aLM_AAGmt_27s. Figure settings: FFT=256 points. Unvouchered specimen. B) *Scinax crospedospilus* recording from Atibaia, São Paulo State, at PFI; air = 17.6 °C and water = 18.4 °C; 22:32 h. October 2009. AAG record file: Scinax_crospedosSP1bAAG_3s. Figure settings: FFT=128 points. Voucher specimen AAG-UFU 4942.
FIGURE 3. Audiospectrogram (top) and oscillogram (below) of advertisement call of *Scinax crospedospilus* (A) and *S. duartei* (B). A) *Scinax crospedospilus* recording from Atibaia, São Paulo State, at PFI. Another male than that in Fig. 2B to show intermale variation in dominant frequency band location; in this case the highest energy is in the lower-frequency band. Remaining data as in Fig. 2B; 22:45 h. AAG record file: Scinax_crospedosSP2bAAG_1.8s. Figure settings: FFT=128 points. Voucher specimen AAG-UFU 4943. B) *Scinax duartei* recording from Itamonte, Minas Gerais State, at Brejo da Lapa, in the Itatiaia National Park; air = 7.4 °C and water = 12.4 °C; 20:11 h. September 2009. AAG record file: Scinax_duarteiMG2aLM_AAGmt_25.4s. Figure settings: FFT=128 points. Unvoucheded specimen.
The advertisement call (figs. 2B, 3A and 4A–B; Table 1) consists of a single note, with 5–7 structurally complex pulses. The first pulse is generally poorly defined and present much lesser intensity and energy compared with the following pulses. Calls are characterized by ascendant amplitude modulation from the first to the 2nd–3rd pulses and the last pulses present a descendent amplitude modulation. The calls had a mean duration of 358±48 ms, with the last pulse longer than the previous ones and a call rate of 25.5 calls/min. The frequencies ranged between 0.82–5.91 kHz. The calls showed a complex spectral structure with inter-individual variation; two prominent bands can be present, between 1.07–1.66 kHz, the low-frequency band (LFB) and around 2.60–4.10 kHz, the high-frequency band (HFB). In most analyzed calls the dominant frequency was in the HFB (figs. 2B and 4A), but in three calls of one male the dominant frequency was in the LFB (figs. 3A and 4B). Most calls showed the dominant frequency concentrated in the pulses in the middle of the call.

**FIGURE 4.** Power spectrum of advertisement calls of *Scinax crospedospilus* and *S. hayii* showing its emphasized energy and respective peaks of frequency. (A) *S. crospedospilus*, showing the high-frequency band (HFB) as dominant; same call of fig. 2B. (B) *S. crospedospilus*, showing the low-frequency band (LFB) with higher energy; same call of fig. 3A. (C) *S. hayii*, showing the LFB with higher energy; same specimen and data of fig. 5B. (D) *S. hayii*, showing within-individual spectral variation, with the HFB with almost the same energy than the LFB; same specimen and data of fig. 5B.

*Scinax duartei* (fig. 1C).

In Itamonte (MG), *Scinax duartei* was found at its type locality (Brejo da Lapa, Itatiaia National Park, 22°21’S, 44°44’W, ca. 2,100 m asl). Three males were recorded while calling at the border of a permanent artificial pond perched on grass vegetation about 0.5 m above water. Syntopic hylid frogs included *Hypsiboas latistriatus*.

The advertisement call (fig. 3B; Table 1) consists of a single note, with 8–11 well defined pulses, regularly spaced throughout the call. The calls had a mean duration of 547±74 ms, with a call rate of 20.3 calls/min. The frequencies ranged between 0.86–4.77 kHz and the dominant frequency is between 1.70–3.10 kHz. First pulses of most calls presented lesser intensity and energy in relation to the remaining ones. Calls were characterized by slight ascendant amplitude modulations from the first to the 3rd or 4th pulses. Slight frequency modulation was generally present in the first third of the calls.
FIGURE 5. Audiospectrogram (top) and oscillogram (below) of advertisement call of *Scinax eurydice* (A) and *S. hayii* (B). A) *Scinax eurydice* recording from Atibaia, São Paulo State, at PFI; air = 22.0 °C and water = 21.0 °C; 18:58 h. December 2009. AAG record file: Scinax_eurydice1eSPAAGmt_13.4s. Figure settings: FFT=256 points. Voucher specimen AAG-UFU 4940. B) *Scinax hayii* recording from Itapeva, Minas Gerais State; air = 20.1 °C and water = 19.6 °C; 20:00 h. January 2009. AAG record file: Scinax_hayiiSP1AAGmt_21.6s. Figure settings: FFT=256 points. Voucher specimen AAG-UFU 4603.
Scinax eurydice
(fig. 1D).

In Atibaia (SP), *Scinax eurydice* (50.1 mm SVL; one male) was recorded at PFI (habitat and syntopic species as described for *S. crospedospilus* above).

The advertisement call (fig. 5A; Table 1) consists of a single note, with 3 pulses per call, regularly spaced throughout the call. The calls had a mean duration of 110±6 ms, with a call rate of 78.9 calls/min. The frequencies ranged between 0.15–4.54 kHz and the dominant frequency around 1.20–2.60 kHz. The first pulse was generally lower in intensity with calls presenting distinguishable ascendant amplitude modulation from the first to the 2nd or last pulse. Most calls showed the dominant frequency concentrated in the last pulse with frequency modulation throughout the call.

Scinax hayii

In Itapeva (MG), *Scinax hayii* (35.9–36.8 mm SVL; two males) were recorded while calling at the border of an artificial permanent pond (ca. 22º45’S, 46º12’W, 950 m asl). The advertisement call (fig. 5B; Table 1) of *S. hayii* from this locality consists of a single note, with 13–17 mostly fused pulses per call. The calls had a mean duration of 240±22 ms, with a mean call rate of 39.5 calls/min. The frequency spectrum ranged between 0.49–6.09 kHz. The calls showed a complex spectral structure with intra- and inter-individual variation; substantial energy was present around two bands, between 1.03–2.13 kHz, the low-frequency band (LFB) and 2.41–3.49 kHz, the high-frequency band (HFB). In most analyzed calls the LFB presented substantially more energy than the HFB (fig. 4C). In just two calls of one male both frequency bands presented almost the same relative amplitude (fig. 4D). The first pulse was generally low in intensity with calls presenting amplitude and frequency ascendant modulation from the first to the 3rd–4th pulse.

In Atibaia (SP), one male of *Scinax hayii* was recorded at PFI (habitat and syntopic species as described for *S. crospedospilus*). The calls of this male (Table 1) was similar to that from Itapeva. Calls consisted of a single note, with 13–15 mostly fused pulses per call. The calls had a mean duration of 206±11 ms, with a lesser call rate of 12.0 calls/min. The frequencies ranged between 0.48–6.39 kHz, with the most energy around two bands, 1.17–1.92 kHz (LFB) and 2.23–3.30 kHz (HFB). In all of the analyzed calls in this locality the LFB showed substantially more energy than the HFB. The first pulse and modulation characteristics as described to population from Itapeva.

Discussion

*Scinax acuminatus* (Cope) is a medium-sized species (males 36.7–41.0 mm SVL; CFBH collection) without specified type specimens. It has been collected in many localities now in Brazil, northeastern Argentina, and southern Paraguay along the drainages of the Parana and Paraguay Rivers (Frost 2011). Scarce information is available for this species which includes mainly short reports in inventory studies (Frost 2011; Souza et al. 2010; Uetanabaro et al. 2008; Gordo & Campos 2003).

At present, *S. acuminatus* is considered a widespread species occurring from southern Mato Grosso and Mato Grosso do Sul States of Brazil, through Paraguay, Bolivia, and northern Argentina. In spite of this broad geographic distribution, to the best of our knowledge, calls of *S. acuminatus* were here described for the first time, i.e. for the population of Aquidauana (MS), located in the drainage of Paraguay River. Considering the discussion above, additional call recordings from different localities along the distribution range of *S. acuminatus* would allow an evaluation of the taxonomic status of different populations currently assigned to this species. Besides, the designation of a neotype and the redescription of this species seem also to be necessary.

The advertisement call of *S. acuminatus* presents one of the highest values of the combined parameters call duration (0.38–1.42 s) and pulse number (20–69) amongst the species of the *S. ruber* clade described so far, with exception of those species in the *S. rostratus* clade. Despite the longer call of *S. curicica* (1.72 s), the higher number of pulses per call (20–69 vs. 29–43 in *S. curicica*) and the lower dominant frequency of *S. acuminatus* (0.83–1.56 kHz vs. 2.44–2.72 kHz) promptly separate both species (see Pugliese et al. 2004 to *S. curicica*).
The species considered morphologically most similar to *S. acuminatus* are *S. eurydice*, *S. fuscovarius* (Lutz), *S. hayii* and *S. x-signatus* (Spix), in the *S. x-signatus* phenetic-group (Lutz, 1973; *S. longilineus* is now assigned to the *S. catharinae* clade, Faivovich et al. 2005). The advertisement call of *S. acuminatus* differs markedly from that of *S. eurydice* and *S. hayii* (for comparisons, see Table 1 and results). The call of *S. fuscovarius* presents lower values of call duration (194 ms), number of pulses per call (8–10) and dominant frequency (0.65–1.35 kHz) than that of *S. acuminatus* (L. Magrini unpubl. data from Uberlândia population, MG, Brazil; ca. 18°58’S, 48°17’W, 840 m asl). At present, the call of *S. x-signatus* remains undescribed.

The high values of the call parameters of *S. acuminatus* (combined call duration and number of pulses per call) mostly resemble those of some species in the *S. rostratus* clade (Faivovich 2002): *S. jolyi* Lescure & Marty, mean note duration 2.35 s and mean 95 pulses of the main note (pulses measured from two calls provided by C. Marty); *S. proboscideus* (Brongersma), mean duration 1.46 s and 113 pulses (analyzed from Marty & Gaucher 1999) and *S. rostratus* (Peters), mean duration 1.06 s and 63.5 pulses (analyzed from Ibáñez et al. 1999). Considering the closer relatedness between *S. acuminatus* and the *S. rostratus* clade proposed in recent systematic studies (Faivovich 2002; Faivovich et al. 2005; Wiens et al. 2010), the call characters aforementioned could provide additional evidence supporting this cluster of species.

*Scinax crosopedosphilus* (Lutz) is a small-sized species (25–32 mm SVL; Lutz 1973) described from Campo Belo (= Itatiaia; ca. 400 m asl), Rio de Janeiro State (RJ), southeastern Brazil. Heyer et al. (1990) described its advertisement call from Boracéia (SP), in the Serra do Mar mountain range (ca. 23°38’S, 45°52’W; 900 m asl). Parameters of the call from Boracéia specimens (notes per call, call duration, frequency range, pulses per call and call rate) overlap almost completely with our data (Table 1). Discrepancies were found just in dominant frequency, which was lower in Boracéia specimens (1.20–1.50 kHz) in relation to individuals recorded from Atibaia, whereas those values overlapped considerably with one of the emphasized frequency bands observed in our calls, the LFB (1.07–1.66 kHz). Calls of one specimen from São Luiz do Paraitinga (SP) (Haddad et al. 2005) showed the same spectral structure presented here, with both bands of emphasized energy presenting almost the same power.

Bevier et al. (2008) described some call parameters (Table 1) from specimens of *S. crosopedosphilus* recorded in Ribeirão Branco (SP), at the Parque Estadual Intervales (PEI) (24°12’–24°32’S, 48°03’–48°32’W). Most call parameters from PEI showed great similarity with the recordings from Atibaia (see Table 1). Dominant frequency reported for specimens from PEI (provided as peak of frequency = 1.41 kHz) corresponds to the LFB found in our recordings.

The greatest difference between these populations was the call rate (61.7 calls/min. in PEI; see Table 1) but at present we can not evaluate the relevance of these differences. Variation in spectral structure, intra-individual and/or inter- populational variation could be responsible for the differences found (see S. *perereca* in Magrini & Giaretta 2010 and *S. hayii*, present study) among those studies, besides differences in the devices (e.g. tape x digital recorders) and technologies employed in the recordings and analysis. Furthermore, the small sample size of these studies (including the present) also make hard to assure the main emphasized frequency band (= dominant frequency) of the species.

*Scinax duartei* (Lutz, 1951) is a medium-sized species (28–37 mm SVL; Lutz 1973) described from Itatiaia Mountains (Macieiras = Brejo da Lapa, 2,200 m asl, see Lutz, 1973) (MG), Brazil. To the best of our knowledge, calls of *S. duartei* specimens from the topotypic population were here described for the first time.

Bokermann (1967) provided the only published call description attributed to *S. duartei*, based on a single record of one specimen from Campos do Jordão (SP) (ca. 100 km south from the type locality). Despite the dominant frequency, pulses per call and call rate reported by Bokermann (1967) were within the range of our totopotypic recordings (see Table 1), the call duration was markedly different between these populations (200 ms at Campos do Jordão vs. mean of 547 ms at type locality). The shortest call recorded at the type locality (420 ms) was more than twice longer than that reported from the Campos do Jordão population. Whereas the call duration is considered a gross temporal property (dynamic property) that often change considerably within a single calling bout (Gerhardt 1994), we are unaware of such a large variation between populations of a single species, once that one is not accompanied by a variation in the pulses number.

Bokermann (1967) also reported slight differences in size (SVL) between totopotypes (mean 32.5 mm SVL; based on 9 adults, ♂♀ and ♀♀) and specimens from Campos do Jordão (mean 30.4 mm SVL; based on 32 adults, ♂♂ and ♀♀). Recent taxonomic studies showed that populations or subspecies previously referred to as *S. duartei* (Bokermann 1967; Lutz 1973) deserve indeed full species status. Pugliese et al. (2009) actually recognized four species assigned to the *S. duartei* complex: *S. duartei*, *S. caldarum* (Lutz 1968), *S. curicica* Pugliese et al. 2004 and *S. rogerioi* Pugliese et al. 2009, all of them endemic from highlands in central and southeastern Brazil.
Pugliese et al. (2004) provided some call parameters (call duration, pulses per call, pulse interval and dominant frequency) of the advertisement call of *S. duartei* presumably from its type locality. However, as the call duration and pulses per call of these records differ markedly from our calls, and as in the bioacoustic comparison of *S. rogerioi* with species of the *S. ruber* clade Pugliese et al. (2009) did not mention the call of *S. duartei*, we prefer to not consider these data herein.

The advertisement call of *S. duartei* from its type locality differs from that of *S. caldarum* (see Magrini & Gia- retta 2010) by its longer call duration (547 ms vs. 231 ms in *S. caldarum*), lower call rate (19.1–21.8 vs. 25.0–36.3) and pulse rate (31.4 vs. 55.5) and in the bandwidth of the dominant frequency (1.72–3.09 kHz vs. 2.42–3.69 kHz). In comparison with *S. curicica* (see Pugliese et al. 2004) the call of *S. duartei* differs by its lower duration (1.72 s in *S. curicica*), lower number of pulses per call (8–11 vs. 29–43) and pulse rate (31.4 vs. 100) and in the range of dominant frequency (2.58–3.63 kHz in *S. curicica*). The call of *Scinax duartei* mostly resembles that of *S. rogerioi*, presenting considerably overlap in most call parameters. Slight differences include a longer call duration, lower pulse rate and higher frequency maximum in the advertisement call of *S. duartei* (see Table 1); bioacoustic parameters for *S. rogerioi*: call duration 460 ms; 6–12 pulses per call; pulse rate ca. 33.3; frequency range 0.95–3.96 kHz and dominant frequency 1.38–3.19 kHz; calls from the type locality of *S. rogerioi*, at Chapada dos Veadeiros, in Alto Paraíso, Goiás State, in Pugliese et al. (2009).

In summary, the call difference (call duration) reported here between totopotypic *S. duartei* and the population from Campos do Jordão, besides differences in morphological characters (as SVL), suggest that the population from Campos do Jordão might represent an unnamed species hidden under the name *S. duartei*. Further studies are necessary to assure the taxonomic status of this population what is beyond the scope of this study.

*Scinax eurydice* (Bokermann, 1968) is a large sized-species (males 44–52 mm SVL) described from Maracás (plateau of Maracás, ca. 1,350 m asl), central portion of the State of Bahia (BA), northeastern Brazil. At present, *S. eurydice* has been reported for Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo States (Pombal et al. 1995; Hartmann 2002; Canelas & Bertolucci 2007; Feio et al. 2008; Araujo et al. 2009). Herein we report a new locality for São Paulo State, in the municipality of Atibaia. This record extends the geographic distribution of *S. eurydice* about 170 km to inland in the Mantiqueira range, northwest from Ubatuba (SP), the closest population previously known (Hartmann 2002). *Scinax eurydice* is extremely rare at the PFI; only three individuals in almost twenty years of research have been heard in the area (AAG unpubl. data).

In spite of the broad geographic distribution of *S. eurydice*, its advertisement call has been described just from Conceição da Barra, Espírito Santo State (ES) by Pombal et al. (1995) (ca. 18°25’S, 39º42’W, sea level). Despite the large distance between both populations from Conceição da Barra and Atibaia (ca. 900 km), most bioacoustic parameters of the calls (pulses per note, call duration, frequency range and pulse rate) are considerably similar (see Table 1). Slight differences seem to exist in the pulse structures of the calls, but the different devices and softwares used in both studies make detailed comparisons difficult. Pombal et al. (1995) reported two different values of dominant frequency for *S. eurydice* (1.0–3.8 kHz in the text description; and 2.8–3.4 kHz in table values). Considering the large range of dominant frequency reported by these authors, our records from Atibaia (1.18–2.62 kHz) are within the range of those from Conceição da Barra. Furthermore, the general appearance of the spectrogram figured in Pombal et al. (1995) is markedly similar with that provided here.

Even though small call differences exist between the populations from Conceição da Barra and Atibaia, the type locality of *S. eurydice* lies about 575 km North from Conceição da Barra (ES). Future studies, particularly including the call description of totopotypic specimens of *S. eurydice* will be useful to evaluate the taxonomic status of populations from southeastern Brazil.

*Scinax hayii* (Barbour) is a medium-sized species (males 39–42 mm SVL; Lutz 1973) described from Petrópolis (RJ), Brazil. Calls of *S. hayii* have been recorded from two localities in São Paulo State, at Boracéia (Heyer et al. 1990) and at Serra do Japi, in Jundiaí (ca. 23°15’S, 46º52’W; Pombal et al. 1995). Considering our call recordings from Atibaia and Itapeva (see Table 1), the call duration totally overlapped with the range reported from Serra do Japi, and the call duration of Boracéia specimens was within the call range of our records (see Table 1). Number of pulses per call and frequency range of our records also overlapped considerably with those from Boracéia (Heyer et al. 1990) and Serra do Japi (Pombal et al. 1995); small differences included calls with lesser number of pulses per call and a lower minimum of about 0.5 kHz on the call frequency range in the populations recorded by us. Calls from Boracéia presented a narrower range of dominant frequency (1.2–2.8 kHz, just one band) compared with those from Atibaia/Itapeva that showed two emphasized frequency bands, the LFB (1.08–2.06 kHz) which pre-
presented substantially more energy, and another one between 2.35–3.43 kHz, the HFB. Although Heyer et al. (1990) reported the presence of prominent side bands in the calls from Boracéia, they did not provide the frequency range of these bands. Pombal et al. (1995) did not report the presence of side bands in the calls of S. hayii from Serra do Japi, but considering their values of dominant frequency provided in the text (1.8–4.1 kHz), it is probable that side bands have been combined. Even so, there are considerable differences in the range of dominant frequencies between populations from Serra do Japi and Atibaia/Itapeva, despite of the proximity between Serra do Japi and Atibaia (ca. 35 km), both in the Serra da Mantiqueira mountain range, São Paulo State.

Differences in size and dorsal color pattern among specimens from different populations pointed out by Lutz (1973) and Haddad & Sazima (1992) suggest that more than one species is hiding under the specific name Scinax hayii. Additional call recordings from different localities along the distribution range of S. hayii, including the still undescribed call from its type locality, would allow a statistical evaluation of these differences and the taxonomic status of different populations currently assigned to this species.

At present, the differences found among populations mainly concerning spectral features can not be appropriately evaluated, due to limitations referred to the different technologies employed in recording and preparing audiospectrograms, besides the small sample size of these studies. Differences found in spectral parameters can reflect populational/individual variation (Magrini & Giaretta 2010; present study), and these parameters also are affected by size and proximity of neighbouring calling males and females (Narins et al. 2007; Wells 2007).

Additional remarks

In the advertisement calls of some North-American treefrogs (e.g. Hyla arenicolor, H. chrysoscelis, H. versicolor), two emphasized frequency bands (harmonically related) are typically present (Gerhardt 1974; Oldham & Gerhardt 1975; Gerhardt 1981b; Gerhardt et al. 2007). With the exception of H. cinerea that presents both frequency bands of about the same relative amplitude (Gerhardt 1976; 1981a), the other species usually present the higher-frequency band (HFB) with substantially more energy than the lower-frequency band (LFB) (Oldham & Gerhardt 1975; Gerhardt et al. 2007). Several experimental studies have shown that females do not merely base their male preferences on the frequency of the dominant HFB (e.g. Gerhardt 2005; Gerhardt et al. 2007), and even though the LFB has a much less amplitude (lower energy), this frequency band also play a significant role in mediating preferences and signal recognition (Gerhardt et al. 2007). Furthermore, it was found that the two frequency peaks in these species have species-specific locations and both peaks are important for the mating call recognition by female frogs (Gerhardt 1974; Oldham & Gerhardt 1975; Gerhardt 1981a; Gerhardt 2005; Gerhardt et al. 2007). Some species of the Scinax ruber clade (e.g. S. crespedospilus, S. hayii and S. perereca) also present such calls with a frequency spectrum containing more than one emphasized component. Even though these spectral bands generally are not harmonically related, as in North-American treefrogs, we also expect a taxonomic (species-specific location) and intraspecific (mating call recognition) relevance of these bands for Scinax species, once it has been shown a rough correspondence of the tuning of the two inner ear organs of frogs (basilar and amphibian papilla) with the two bands of frequency in conspecific calls (Gerhardt 2005). Thus, we recommend special attention in the descriptions of spectral components for the calls from species that present more than one emphasized frequency (spectral peaks), to better assess their populational and specific status.

Closer to the submission of this manuscript for publication we became aware that the Scinax population from Campos do Jordão (SP) is currently being described as a new species (Itamar Alves Martins, pers. com. to LM), what is supported by our present observations.

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A cladistic analysis of


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