NORTH-WESTERN JOURNAL OF ZOOLOGY 11 (2): 253-261
Article No.: 151503

http://biozoojournals.ro/nwjz/index.html

Vocalizations of two species of the *Hypsiboas pulchellus* group (Anura: Hylidae) with comments on this species group

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Received: 31. July 2013 / Accepted: 11. February 2015 / Available online: 31. October 2015 / Printed: December 2015

Abstract. Vocalizations are used by several vertebrates as communication mechanism. Anurans have many forms of vocalizations, such as advertisement calls, aggressive calls, and defensive calls. We herein describe two types of vocalizations (advertisement and aggressive calls) of *Hypsiboas caingua*, and the aggressive call of *H. prasinus*. The advertisement call of *H. caingua* showed a harmonic structure, and the dominant frequency averaged 3425.1 Hz. A harmonic structure was also observed in the aggressive call of *H. caingua*, whose dominant frequency averaged 3386.3 Hz. The aggressive call of the *H. prasinus* had a multipulsed structure, and the dominant frequency averaged 1699.3 Hz. Twenty-seven species of the *Hypsiboas pulchellus* group had some temporal or spectral parameter of their advertisement calls described. Bioacoustics have been employed as a useful tool for systematics and taxonomy. Vocalizations might indicate much of the difference among closely related anuran species and have been proven to be a reliable dataset to distinction among species and higher taxonomic ranks. Comparing the calls of *H. caingua* and *H. prasinus* with other species, we observe that advertisement calls within the *Hypsiboas pulchellus* group are well differentiated, which reinforces the identity of the group's comprising taxa.

Key words: advertisement call, aggressive call, Paraná, distribution, southern Brazil.

Introduction

Vocalization is used by many animal species as communication mechanisms at both intraspecific and interspecific levels (Ruxton et al. 2004, Krebs & Davies 2004). In anurans, acoustic signals are most conspicuous during the reproductive period, being that the advertisement calls are species specific and, therefore, considered as a pre-zygotic mechanism of reproductive isolation (Duellman & Trueb 1994). Aggressive calls are also common in anurans, used by conspecific males in different social contexts, such as the maintenance of territory and spacing between males (Caldart et al. 2011).

Bioacoustic studies have generated important information for taxonomy and phylogeny studies, assisting in the identification and description of cryptic species (Simões et al. 2008, Juncá et al. 2012, Carvalho & Giaretta 2013a, b). Bioacoustics have increasingly been employed as part of differential diagnoses between species, and may also support the correct designation of species that are often misidentified due to their similar morphology (Conte et al. 2009, Carvalho & Giaretta 2013a, Faria et al. 2013).

The *Hypsiboas pulchellus* group comprises 37 recognized taxa (Caramaschi et al. 2004, Carnaval & Peixoto 2004, Faivovich et al. 2004, 2005, Garcia et al. 2007, Antunes et al. 2008, Garcia et al. 2008, Kwet 2008, Caramaschi et al. 2010). This group is characterized by presenting a moderately robust body, short snout that is rounded with the top of the head flat; males have hypertrophied muscles in the forearm, and a well-developed pre-pollex. The species of the group are also characterized by a light-colored upper lip stripe and dark-colored dorsolateral line (Duellman et al. 1997). Considering that some hylid species do not have their vocalizations described in detail, herein we describe the advertisement and aggressive calls of *Hypsiboas caingua*, and the aggressive call of *Hypsiboas prasinus*, and make interspecific comparisons with other species of the *H. pulchellus* group. In addition, we provide new distributional records for *H. caingua*.

Material and methods

Field work was conducted between October 2012 and February 2013. Advertisement and aggressive calls of

Hypsiboas caingua were recorded from one male at the Reserva Biológica das Perobas (11°15′25″S, 46°56′42″W), Municipality of Cianorte; four males at the Parque Estadual do Cerrado (24°10′56.9″S, 49°41′31.4″ W), Municipality of Jaguariaíva, and two males in the Municipality of Sengés (24°09′21.9″ S, 49°30′57.4″ W), Paraná state, southern Brazil (Fig. 1). The individual of *Hypsiboas prasinus* was recorded at the same locality of *H. caingua* (Parque Estadual do Cerrado). Vocalizations were obtained from 1800h until 0000h, recorded using a Marantz PMD 222 recorder set at a sampling rate of 44.1 kHz and a 16-bit resolution (WAVE file format), coupled with a Sennheiser ME66 microphone positioned at about 50 cm from the calling anuran. After each recording session, the snout-vent length (SVL) of the individuals recorded were measured with a digital caliper (accurate to 0.05 mm). Air temperature and relative humidity were measured with a digital thermo-hygrometer with internal and external sensor (Digital-Thermo) (precision to ± 1oC and ± 3% RH).

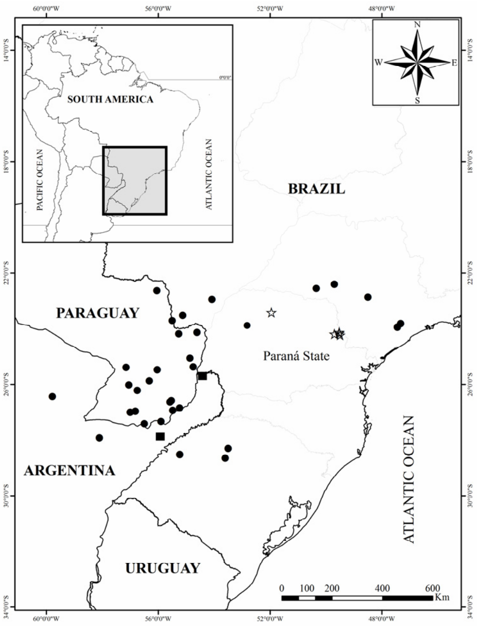

Figure 1. Map showed the distribution of *Hypsiboas caigua* (dots), type locality (squares) and new records from Paraná state (star).

We analyzed five advertisement calls from each individual of *H. caingua* (N = 35 calls analyzed), eight aggressive calls from four males of *H. cainga*; and one aggressive call from one male of *H. prasinus*. We measured nine temporal parameters in the oscillogram: call duration (ms), number of notes per call, note duration (ms), number of pulses per call, pulse duration (ms), interval between notes (ms), interval between pulses (ms), interval between calls (s), and call rate (minute). The "call" parameter was considered as a set of sounds constituted by either a single note (simple call) or a series of identical or group of different notes (composite call) emitted in defined period of time; the "note" parameter was considered a temporally uninterrupted sound element composing the call and could be made up of a pulses series; the "pulse" parameter was considered sounds of short duration (up to 0.05 ms) produced by a single energy impulses released in the temporal spectrum of a note (for more details see Martins & Jim 2003). We obtained call rate by a cross-multiplication, adding up the amount of calls recorded and multiplying for 60 seconds, then, dividing the result by total number of seconds of recording. Fundamental frequency refers to the lower harmonic in the frequency spectrum, while dominant frequency refer to the value of greatest sound energy in a given note or call (resulting from the resonating of the greater fundamental frequency or one of its harmonics) (Martins & Jim 2003, Duellman & Trueb 1994). Harmonic call was a call with waveform periodicities that are integral multiple of the fundamental frequency (Gerhardt 1998). We analyzed the spectral parameter of dominant frequency (Hz) in the spectrograms. Bioacoustic terminology follows Wells (2007).

We analyzed the calls on a personal computer using the software Raven Pro, version 1.5, 64-bit version (Cornell Lab of Ornithology Research Program Bioacoustics Workstation, 2012). Raven Pro settings: window size = 256 samples; window type = Hann; overlap = 50%; DFT size = 256 samples, grid spacing = 188 Hz. Sound figures were obtained using the Seewave version 1.6.4 package (Sueur et al. 2008) of the R platform, version 2.15.1, 64-bit version (R Development Core Team 2012). Seewave settings: window name (Fourier transform window) = Hanning; window length = 256 samples; overlap = 90%. Voucher specimens and recordings are housed in the Coleção Zoológica da Universidade Federal de Goiás (*Hypsiboas caingua*: ZUFG 7299; ZUFG 7301), and Fonoteca da Universidade Federal de Goiás (*Hypsiboas caingua*: FUFG 1480; FUFG 1481; FUFG 1482; FUFG 1483; FUFG 1484; and *Hypsiboas prasinus*: FUFG 1485) respectively.

Results

Males of *Hypsiboas caingua* were found calling perched on grasses, scrubs and cattail above the water, at an average height of 50.4 ± 37.1 cm (range: 29 – 100 cm; N = 7), calling about 3 meters from each other. Average snout-vent length of the males recorded was 33.5 ± 2.1 mm (range = 29.4 – 35.5; N = 7). Air temperature ranged from 16.8 to 21.6 ° C (X = 19.2 ± 3.0 ºC; N = 7). The first records of *H. caingua* for the municipalities of Maringá, Jaguariaíva and Sengés, Paraná state, Brazil, extending its distribution approximately 495 km northwestward from the type locality (Carrizo

1990).

We observed two distinct vocalizations for males of *H. caingua*: advertisement and aggressive calls. The advertisement call (Fig. 2) is composed of one type of non-pulsed note emitted alone or in series of up to four notes. Call duration averaged 404.8 ± 245.6 ms (range = 110.4 – 928.0 ms; N = 39 calls), and the number of notes per call averaged 2.1 ± 0.9 (range = 1 – 4; N = 39 calls); note duration averaged 120.2 ± 11.2 ms (range = 97.8 ± 143.4 ms; N = 39 calls). The interval between the calls ranged from 1.5 to 118.7 s (X = 14.0 ± 20.8 s; N = 35), the interval between the notes ranged from 149 to 241 ms (X = 150.8 ± 91.7; N = 27 calls), and the repetition rate was 4.1 ± 3.2 calls per minute (range = 1.1 – 10.8; N = 7 males). The advertisement call (Fig. 2) had a harmonic structure, ranging from two to four harmonics (N = 39 calls). The first harmonic frequency peaked from 3234 to 3843 Hz (X = 3425.1 ± 170.1 Hz; N = 39 calls), the second harmonic frequency peaked from 6356 to 7510 Hz (X = 6739.8 ± 322.1 Hz; N = 39 calls), and the third and fourth harmonics frequency peaked from 8201 to 11412 Hz (X = 9824.2 ± 1698.3 Hz; N = 39 calls) and from 12566 to 15986 Hz (X = 13746.6 ± 1000.8 Hz; N = 19 calls), respectively. Dominant frequency coincided with the fundamental frequency and varied from 3234 to 3843 Hz (X = 3425.1 ± 170.1 Hz; N = 39 calls).

Only four males of *H. caingua* emitted aggressive call, composed of one type of multipulsed note. Call duration (Fig. 3) averaged 519.2 ± 119.5 ms (range = 410.8 – 716.2 ms; N = 8 calls). The number of pulses per call averaged 34 ± 8.4 (range = 19 – 44; N = 8 calls); pulse duration averaged 7.7 ± 1.9 ms (range = 3 – 14 ms; N = 80 pulses). The interval between pulses averaged 16.0 ± 15.7 ms (range = 2 – 59 ms; N = 78 pulses), and the repetition rate was 1.6 ± 1.1 (range = 0.8 – 3.2; N = 4 males) per minute. This type of call had also a harmonic structure (harmonics issued with low energy) and the harmonic frequency peaked from 3187.5 to 3562.5 Hz (X = 3281.25 ± 187.5 Hz; N = 8 calls). The dominant frequency varied from 3234 to 3609 Hz (X = 3386.4 ± 198.5 Hz; N = 8 calls).

Only one male of *H. prasinus* emitted an aggressive call. Aggressive call (Fig. 4) was composed of one type of multipulsed note (39 pulses); call duration was 464 ms; pulse duration averaged 13.2 ± 1.3 ms (range = 11 – 15 ms; N = 10 pulses). There was no interval between pulses (Fig. 4). Dominant frequency was 1,699.3 Hz. For comparison among calls of the species of *Hypsiboas pulchellus* group, see Table 1.

Discussion

Twenty-seven species of the *Hypsiboas pulchellus* group have at least one temporal and/or spectral parameter of their advertisement calls described (Table 1). Regarding the advertisement calls among the species of the *H. pulchellus* group, *H. caingua* emitted its call in note series, whereas some other species emitted isolated notes (*H. curupi* - Garcia et al. 2007, *H. ericae* - Garcia & Haddad 2008, *H. callipleura* - Köhler et al. 2010, *H. balzani* - Köhler et al. 2010, and *H. polytaenius* - Pinheiro et al. 2012; see Table 1 for more details). The individuals of *H. caingua* emitted calls at irregular intervals, similar to those issued by *H. goianus* (Guimarães et al. 2001).

The aggressive call of *H. caingua* differs from its advertisement call by having a longer duration (410.8 – 716.2 ms) and a higher number of pulses (19 – 44 pulses/note); it is emitted as a single note, whereas the advertisement call has more than one note per call (Table 1; Figs 2 and 3). The mean number of pulses in aggressive calls of *H. caingua* is different from those emitted by *H. ericae* (Garcia & Haddad 2008) and *H. beckeri* (Acioli & Toledo 2008). The dominant frequency is different from *H. beckeri* (Acioli & Toledo 2008) and *H. polytaenius* (Pinheiro et al. 2012). The aggressive call can be emitted when there are many males calling in a chorus and/or when males are calling near to each other (e.g. Bastos & Haddad 2002, Toledo & Haddad 2005, Bastos et al. 2011). In general, aggressive calls have a higher pulse rate than advertisement calls for *H. caingua*, which is typical for South American hylid species (e.g. Garcia & Haddad 2008, Antunes et al. 2008) (Table 2). Regarding the type locality of *H. caingua* (Carrizo 1990), these new records extend its distribution in the Paraná state, and fill the gap in its distribution.

The aggressive call of *H. prasinus* differs from the aggressive call of *H. caingua*, especially in relation to its lower dominant frequency. However, these calls are similar in both the average duration and the number of pulses. The aggressive call of *H. prasinus* differs from the average aggressive call duration of *H. caipora* (Antunes et al. 2008) and *H. bischoffi* (Pombal 2010). Also, it differs from agressive call of *H. ericae* in its number of pulses (Garcia & Haddad 2008).

Spectral parameters (e.g. dominant frequency)

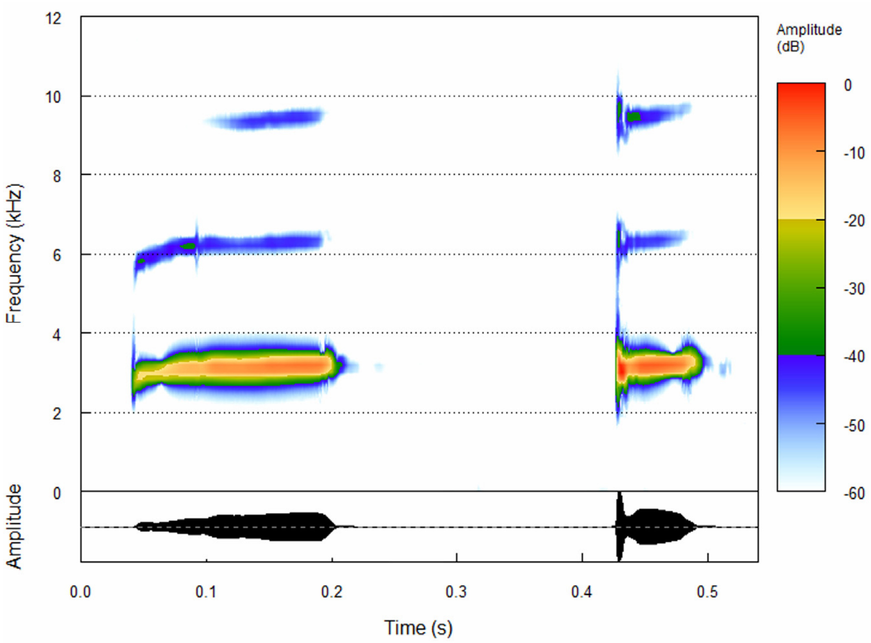

Figure 2. Advertisement call of *Hypsiboas caingua* from Municipality of Jaguariaíva, Paraná state. Above: spectrogram showing one call with two notes; below: oscillogram. (Air temperature = 16.9ºC; Air humidity = 69%; SVL = 35.6 mm). Voucher specimen: ZUFG 7299. Voucher recording: FUFG 1481.

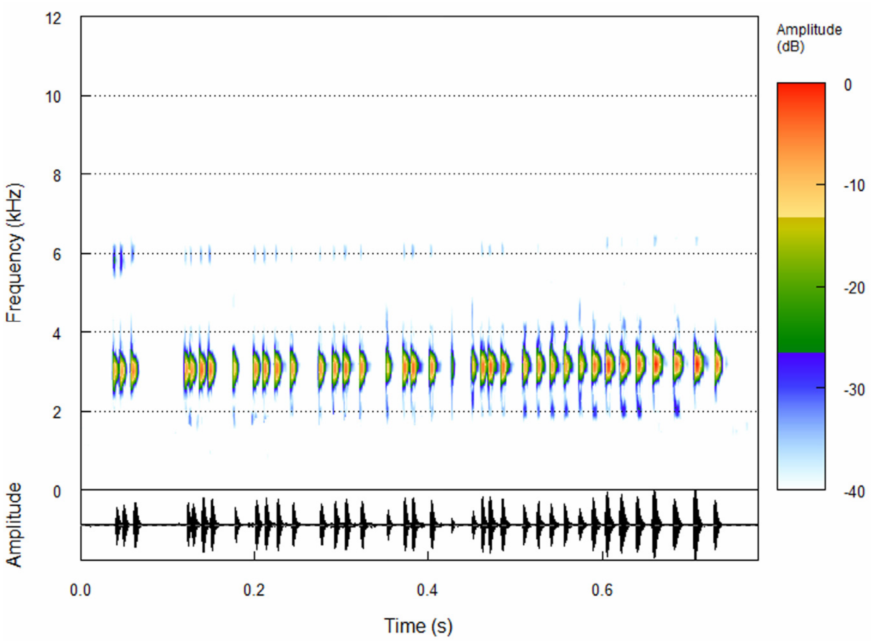

Figure 3. Aggressive call of *Hypsiboas caingua* from Municipality of Jaguariaíva, Paraná state. Above: spectrogram showing one call with note and pulse structures; below: oscillogram. (Air temperature = 16.9ºC; Air humidity = 69%; SVL = 35.6 mm). Voucher specimen: ZUFG 7299. Unvouchered recording.

Table 1. Advertisement call of species *Hypsiboas pulchellus* group. C.D. = Call Duration; N.D. = Note Duration; N.C. = Notes per Call; P.R. = Pulse Rate; D.F. = Dominant Frequency; C.R = Call Rate; S = Call structure; N = Non-pulsed; P = Pulsatile. Species in gray have more than one description. * Described in this study

Species	C.D. (ms)	N.D. (ms)	N.C.	P.R. (pulse rate/sec.)	D.F. (Hz)	C.R. (calls/min.)	S
Hypsiboas aguilari (Lehr et al. 2010)	357	315 – 440 (375)	1	55	944 – 1,086	5.6	P
Hypsiboas balzani (Duellman et al. 1997)	–	170	1	80	1,150	2.5 – 4.0	P
Hypsiboas balzani (Köhler et al. 2010)	226–237	226 – 237	1	40 – 43	1,106 – 1,132	–	P
Hypsiboas beckeri (Acioli & Toledo 2008)	90 – 130 (110 ± 10)	–	1-2	–	6,890 – 7,320	–	P
Hypsiboas bischoffi (*Hypsiboas multilineata* - Heyer et al. 1990)	70 – 450	70 – 100	1	100 – 200	1,100 – 2,000	1 – 4	P
Hypsiboas bischoffi (Kwet 2001)	80 – 110	80 – 110	1	140 – 180	1,040 – 2,880	–	P
Hypsiboas bischoffi (Pombal 2010)	50 – 100 (73,3 ± 13.1)	–	–	–	1,400 – 2,100	3 – 24	P
Hypsiboas botumirim (Caramashi et al. 2009)	37 – 64 (50 ± 5)	–	1	3 – 5	3,261.9 – 3,997.6	–	P
*Hypsiboas caingua**	110 – 928 (404 ± 245)	97 – 143 (120 ± 11)	1 – 4 (2.12 ± 0.95)	–	3,234 – 3,843	4.06	N
Hypsiboas caipora (Antunes et al. 2008)	149.3 – 408.2 (249.2 ± 73.2)	–	1–2	14 – 48	2,500 – 2,930	–	P
Hypsiboas callipleura (Köhler et al. 2010)	29 – 244 (135 ± 47)	17 – 35 (24.6 ± 5.7)	1 – 5 (3.0 ± 0.9)	–	1,070 – 1,380	–	N
Hypsiboas cipoensis (Haddad et al. 1988)	–	–	1 – 3	1 – 3	–	–	P
Hypsiboas curupi (Garcia et al. 2007)	–	132.9 – 276.2 (208.9 ± 58.1)	1 – 2	18 – 45	1,200 – 2,200	–	P
Hypsiboas ericae (Garcia & Haddad 2008)	33.6 – 92 (67.5 ± 13)	–	1	–	2,030 – 3,600	4.8	P
Hypsiboas gladiator (Köhler et al. 2010)	257 – 531 (374 ± 92)	257 – 531 (374 ± 92)	1	110 – 150	770 – 910	–	P
Hypsiboas goianus (Guimarães et al. 2001)	120 – 700 (315 ± 104)	20 – 140	1 – 4 (3 ± 1)	–	2,074.5 – 3,472.4	–	N
Hypsiboas goianus (Menin et al. 2004)	325	90 – 140 (115 ± 35)	2	–	2,295 – 3,280	–	N
Hypsiboas joaquini (Garcia et al. 2003)	670 – 1000 (790)	8 – 12	1 – 2	29 – 55	1,200 – 2,200	56 – 64	P
Hypsiboas leptolineatus (Kwet 2001)	180 – 220	40 – 80	2	100 – 190	3,660 – 5,200	7 – 12	P
Hypsiboas marginatus (Garcia et al. 2001)	–	380 – 620 (490 ± 110)	1 – 12	10 – 18	1,500 – 2,300	–	P
Hypsiboas marianitae (Duellman et al. 1997)	–	25 – 59 (36)	1	44 – 45	840 – 930	15 – 23	P
Hypsiboas marianitae (Köhler et al. 2010)	398 – 924 (590 ± 175)	8 – 15 (11.4 ± 2.1)	13 – 33 (21.1 ± 6.9)	–	790 – 1100	–	P
Hypsiboas marianitae (*H. callipleura* - Marquez et al. 1993)	–	248 – 594 (357.2 ± 136.8)	1	44 – 45	840 – 926	15 – 23	P
Hypsiboas melanopleura (Lehr et al. 2010)	343	328 – 444 (360)	1	–	795 – 928	1.9	N
Hypsiboas palaestes (Duellman et al. 1997)	–	20 – 80 (34)	4 – 5	42 – 44	4,430 – 4,450	9	P
Hypsiboas phaeopleura (Pinheiro et al. 2012)	192 – 400 (264 ± 58)	12 – 58 (29 ± 15)	2 – 5 (3 ± 1)	–	2,557.3 – 3,554.8	–	P
Hypsiboas poaju (Garcia et al. 2008)	703 – 1335 (1017 ± 180)	703 – 1335 (1017 ± 180)	1	–	2,473 – 2,885	5 – 16	P
Hypsiboas aff. polytaenius (Heyer et al. 1990)	100 – 1000	50 – 150	1 – 6	150	4,800 – 6700	5	P
Hypsiboas polytaenius (Pinheiro et al. 2012)	44 – 95 (70 ± 10)	–	1	–	5,075.1 – 8,057.4	–	P
Hypsiboas prasinus (Pombal 2010)	290 – 350 (312.8 ± 50)	20 – 90 (46.9 ± 20.6)	–	3 – 5	1,200 – 1,900	–	P
Hypsiboas pulchellus (Marquez et al. 1993)		83 – 145 (110.3 ± 17.9)	1	–	1,725 – 2,110	11 – 21	P
Hypsiboas pulchellus (Baraquet et al. 2007)	156.79 ± 50.57	15.67 ± 5.80	2	–	1,700 – 2,600	–	P
Hypsiboas riojanus (Köhler et al. 2010)	159 – 592 (309 ± 136)	16 – 77 (42 ± 22)	2 – 7 (3.7 ± 1.6)	–	1,850 – 2,210	–	N
Hypsiboas cf. riojanus (*H. andina* - Duellman et al. 1997)	–	10 – 60	2 – 3	110 – 120	1,700 – 2,300	21 – 24	P
Hypsiboas riojanus (Barrio 1965)	200	–	1 – 4	–	2,300	–	N
Hypsiboas semigutatus (Kwet 2001)	170 – 520	170 – 520	1	160 – 260	1,500 – 3,300	–	P
Hypsiboas semigutatus (Garcia et al. 2007)	–	437.7 – 917 (616.9 ± 124.2)	1 – 2	19 – 45	2,100 – 2,800	–	P
Hypsiboas stellae (Kwet 2008)	–	420 – 1850	–	6 – 14	1,100 – 1,900	–	P

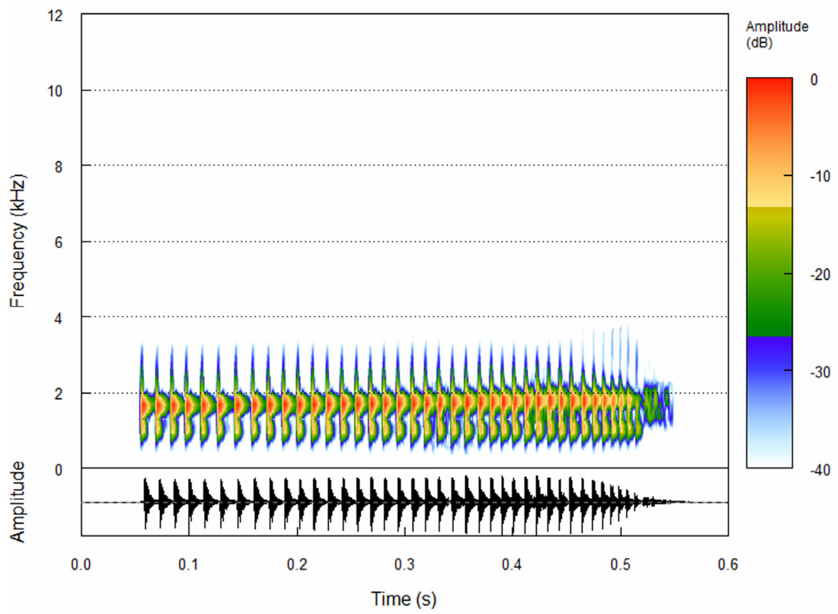

Figure 4. Aggressive call of *Hypsiboas prasinus* from Municipality of Jaguariaíva, Paraná state. Above: spectrogram showing one call with note and pulse structures; below: oscillogram. (Air temperature = 16.7ºC; Air humidity = 81%; SVL = 46.5 mm). Uncouchered specimen Voucher recording: FUFG 1485.

Table 2. Territorial/Aggressive call of species of the *Hypsiboas pulchellus* group. C.D. = Call Duration; N.D. = Note Duration; N.C. = Notes per Call; P.R. = Pulse Rate; D.F. = Dominant Frequency; C.R = Call Rate; S = Call structure; H = Harmonic; P = Pulsatile. Species in gray have more than one description.

Species	C.D (ms)	N.D. (ms)	N. C.	P.N. (pulses/seg.)	D.F. (Hz)	C.R. (calls/sec.)	S
Hypsiboas caipora (Antunes et al. 2008)	31.5 – 42.4 (36.6 ± 4.5)	–	–	–	2,070 – 2,420	–	–
Hypsiboas beckeri (Acioli & Toledo 2008)	10 – 30 (20 ± 0.0)	–	–	1 – 4 (2.2 ± 0.9)	6,460 – 7,320	–	P
Hypsiboas bischoffi (Pombal 2010)	1260	–	–	21	1,700 – 2,000	–	P
*Hypsiboas caingua**	410 – 716 (525 ± 119)	410 – 716 (525 ± 119)	1	19 – 44	3,234 – 3,609	1.57	P
Hypsiboas ericae (Garcia & Haddad 2008)	103.6 – 560.3 (239.3 ± 138.4)	–	1	2 – 11	2,120 – 3,540	3.2	P
Hypsiboas goianus (Guimarães et al. 2001)	110 – 470 (242 ± 58)	10 – 60 (20 ± 10)	1 – 10 (5 ± 1)	–	3,019.7 – 3,451	–	P
Hypsiboas goianus (Menin et al. 2004)	150 – 270 (213.7 ± 49.2)	20 – 45 (33.12 ± 6.8)	3 – 5 (4 ± 1)	–	2,230 – 3,900	–	P
Hypsiboas polytaenius (Pinheiro et al. 2012)	47 – 1168 (520 ± 220)	4 – 24 (15 ± 3)	2 – 11 (6.0 ± 1.9)	–	5,067.5 – 7,731.3	–	P
Hypsiboas semigutatus (Garcia et al. 2007)	101.3 – 605 (401.6 ± 168.6)	–	–	14 – 27	1,820 – 3,440	–	P
*Hypsiboas prasinus**	464	464	1	39	1,699	–	P

*Described in this study

are the most reliable feature to differentiate closely related frog species. They are static calling proprieties and are associated with female choice for conspecific partners (Geradt 1991, Wells 2007).

However, temporal parameters (e.g. call duration, pulse rate) can indicate differences among some groups of closely related frog species (see Padial et al. 2007, 2008, Brown & Twomey 2009, Padial & De La Riva 2009; Gambale et al. 2014). Therefore, they may also be used as characters for distinguishing among clades and may suggest a case of independent evolution (see Köhler et al. 2010). In *H caingua*, for example, the frequency parameters are similar to those of *H. botumirim*, but the call duration is diferent. Advertisement calls within the *Hypsiboas pulchellus* group are well-differentiated, which can reinforce the identity of the anuran species in this group (Márquez et al. 2005). According to Köhler et al. (2010), basal species of the *H. pulchellus* group emit pulsed calls.

The knowledge about the vocal repertoire of species is very important because the anurans emit different types of calls in distinct social contexts (Gambale et al. 2014). The advertisement call, for example, is relevant for mate recognition, contributing to premating isolation among sympatric species (e.g. Duellman & Pyles 1983, Amézquita et al. 2006, Carvalho & Giaretta 2013b) and allows comparisons at both intraspecific and interspecific levels (Pröhl et al. 2007, Kaefer & Lima 2012). The advertisement call is the most often call type emitted, and consequently more frequently described (e.g. Morais & Kwet 2012, Roberto & Ávila 2013, Teixeira et al. 2013). Comparing different call descriptions, we found some discrepancies among different acoustic definitions and terminology of the 'advertisement call' for a particular species, as was observed for *H. marianitae* (e.g. duration note and number of notes), *H. pulchellus* (e.g. duration note and number of notes), and *H. semigutatus* (e.g. duration of note and number of pulses). This could be due to many factors, such as differences between populations living in different conditions, different species, differences in the way in which recordings are obtained and analyzed, and the reference used for the description of the advertisement call (see discussion in De la Riva et al. 1997).

Comparison of advertisement calls represent an alternative way of determining differences and affinities based on a quantifiable parameter (Carvalho & Giaretta 2013a, b). However, to make this possible, it is necessary that the descriptions of the calls become more common and clear. The most common and serious problems with respect to call descriptions are not always associated with the reference from which a study is based on (assuming that these references are good cited), but the lack of rigorous methodological procedures. Frequently, definitions of acoustic parameters are vague and the ways of measuring them (acoustic standards) are not explicit, making it difficult to compare call characteristics among species. Furthermore, it is very important to develop rigorous surveys on describing calls, in order to assist future comparisons among bioacoustic studies.

In the *Hypsiboas pulchellus* group, we can observe that many of the advertisement calls were described in the last 20 years, most of them being after the year 2000. Furthermore, as most of the species in the group were reclassified after the year 2000, we can note that ecological and phylogenetic data have been evaluated together in order to solve the problems regarding the classification of the groups (Faivovich et al. 2004, 2005), enabling a more accurate classification. Thus, we can compare the vocal communication of species with greater fidelity. Additionally, researchers have been more interested in the roles of amphibian vocalization in a social context. Here, we emphasized the importance of describing the calls of species, because the results can be used in association with molecular data to improve comparisons in this species group.

Acknowledgements. Alessandro R. Morais for critical reading and valuable comments on the manuscript. Thanks to Priscilla C. Silveira for the English revision. We thank the anonymous reviewers for their careful reading of our manuscript and their many insightful comments and suggestions. VB, PG and RC thanks CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) and PROEX (Programa de Excelência Acadêmica) for financial support. RLM thanks CNPq (Conselho Nacional de Desenvolvimento Cientifico e Tecnológico) for scholarship (process 140710/2013-2). RPB thancks CNPq (process 10-2/563075) for financial support.

References

Acioli, E.C.S., Toledo, L.F. (2008): Amphibia, Anura, Hylidae, *Hypsiboas beckeri*: filling gap and description of its advertisement call. Check List 4: 182-184.

Amézquita, A., Hodl, W., Lima, A.P., Castellanos, L., Erdtmann, L., Carmozina, A.M. (2006): Masking interference and the evolution of the acoustic communication system in the Amazonian dendrobatid frog *Allobates femoralis*. Evolution 60: 1874-1887.

Andrade, F.S., Carvalho, T.R. (2013): A new species of *Pseudopaludicola* Miranda-Ribeiro (Leiuperinae: Leptodactylidae: Anura) from the Cerrado of southeastern Brazil. Zootaxa 3608(5): 389-397.

Antunes, A.P., Faivovich, J., Haddad, C.F.B. (2008): A new species of *Hypsiboas* from the Atlantic Forest of Southeastern Brazil (Amphibia, Anura, Hylidae). Copeia 2008(1): 177-188.

Baraquet, M., Salas, N., Di Tada, I. (2007): Variación geográfica en el canto de advertencia de *Hypsiboas pulchellus* (Anura, Hylidae) en Argentina. Revista Española de Herpetología 21: 107-118.

Barrio, A. (1965): La subespecies de *Hyla pulchella* Dumeril & Bibron (Anura, Hylidae). Physis 25: 115-128.

Bastos, R.P., Haddad, C.F.B. (2002): Acoustic and aggressive interactions in *Scinax rizibilis* (Anura: Hylidae) during the reproductive activity in southeastern Brazil. Amphibia-Reptilia 23(1): 97-104.

Bastos, R.P., Signorelli, L., Morais, A.R., Costa, T.B., Lima, L.P., Pombal, J.P. (2011): Advertisement Calls of Three Anuran Species (Amphibian) from the Cerrado, Central Brazil. South American Journal of Herpetology 6: 67-72.

Brown, J. L., Twomey, E. (2009): Complicated histories: three new species of poison frogs of the genus *Ameerega* (Anura: Dendrobatidae) from north-central Peru. Zootaxa 2049: 1-38.

Caldart, V.M., Iop, S., Cechin, S.Z. (2011): Vocalizations of *Crossodactylus schmidti* Gallardo, 1961 (Anura, Hylodidae): advertisement call and aggressive call. North-Western Journal of Zoology 7: 118-124.

Caramaschi, U., Pimenta, B.V.S., Feio, R.N. (2004): Nova espécie do grupo de *Hyla geographica* Spix, 1824 da Floresta Atlântica, Brasil (Amphibia, Anura, Hylidae). Boletim do Museu Nacional, Rio de Janeiro 518: 1-14.

Caramaschi, U., Cruz, C.A.G., Segalla, M.V. (2010): A new species of *Hypsiboas* of the *H. polytaenius* clade from the state of Paraná, southern Brazil (Anura: Hylidae). South American Journal of Herpetology 5: 169-174.

Carnaval, A.C.O.Q., Peixoto, O.L. (2004): A new species of *Hyla* from northeastern Brazil (Amphibia, Anura, Hylidae). Herpetologica 60: 387-395.

Carvalho, T.R., Giaretta, A.A. (2013a): Taxonomic circumscription of *Adenomera martinezi* (Bokermann, 1956) (Anura: Leptodactylidae: Leptodactylinae) with the recognition of a new cryptic taxon through a bioacoustic approach. Zootaxa 3701: 207-237.

Carvalho, T.R., Giaretta, A.A. (2013b): Bioacoustics reveals two new syntopic species of *Adenomera steindachner* (Anura: Leptodactylidae: Leptodactylinae) in the Cerrado of central Brazil. Zootaxa 3731: 533-551.

Carrizo, G.R. (1990). Sobre los hílidos de Misiones, Argentina, con la descripción de una nueva especie *Hyla caingua* n. sp. Cuadernos de Herpetología 5: 32-39.

Conte, C.E., Garey, M.V., Lingnau, R., da Silva, M.X., Armstrong, C., Hartmann, M.T. (2009): Amphibia, Anura, *Limnomedusa macroglossa*, *Dendropsophus anceps*, *D. berthalutzae*, *D. seniculus*, *Scinax littoralis*: New state records, distribution extension and filling gaps. Check List 5(2): 202-209.

De la Riva, I., Márquez, R., Bosch, J. (1997): Description of the advertisement calls of some South American Hylidae (Amphibia, Anura): taxonomic and methodological consequences. Bonner Zoologische Beiträge 47: 175-185.

Duellman, W.E., Trueb, L. (1994): Biology of Amphibians. Baltimore, The Johns Hopkins University Press.

Duellman, W.E., De La Riva, I., Wild, E.R. (1997): Frogs of the *Hyla armata* and *Hyla pulchella* groups in the Andes of South America, with definitions and analyses of phylogenetic relationships of Andean groups of *Hyla*. Natural History Museum, University of Kansas 3: 1-41.

Faivovich, J., Garcia, P.C.A., Ananias, F., Lanari, L., Basso, N.G., Wheeler, W.C. (2004): A molecular perspective on the phylogeny of the *Hyla pulchella* species group (Anura, Hylidae). Molecular Phylogenetics and Evolution 32: 938-950.

Faivovich, J., Haddad, C.F.B., Garcia, P.C.O., Frost, D.R., Campbell, J.A., Wheeler, W.C. (2005): Systematic review of the frog family Hylidae, with special reference to Hylinae: Phylogenetic analysis and taxonomic revision. Bulletin of the American Museum of Natural History 294: 1-240.

Faria, D.C.C., Signorelli, L., Morais, A.R., Bastos, R.P., Maciel, N. (2013): Geographic structure and acoustic variation in populations of *Scinax squalirostris* (A. Lutz, 1925) (Anura: Hylidae). North-Western Journal of Zoology 9: 329-336.

Gambale, P.G., Signorelli, L., Bastos, R.P. (2014): Individual variation in the advertisement calls of a Neotropical treefrog (*Scinax constrictus*). Amphibia-Reptilia 35: 1-11.

Garcia, P.C.A., Vinciprova, G., Haddad, C.F.B. (2001): Vocalização, girino, distribuição geográfica e novos comentários sobre *Hyla marginata* Boulenger, 1887 (Anura, Hylidae, Hylinae). Boletim do Museu Nacional (N. S.) Zoologia 460: 1-19.

Garcia, P.C.A., Vinciprova, G., Haddad C.F.B. (2003): The taxonomic status of *Hyla pulchella joaquini* (Anura: Hylidae) with description of its tadpole and vocalization. Herpetologica 59: 350-363.

Garcia, P.C.A., Faivovich, J., Haddad, C.F.B. (2007): Redescription of *Hypsiboas semiguttatus*, with the description of a new species of the *Hypsiboas pulchellus* group. Copeia 4: 933-951.

Garcia, P.C.A., Haddad, C.F.B. (2008): Vocalizations and comments on the relationships of *Hypsiboas ericae* (Amphibia, Hylidae). Iheringia 98(1): 161-166.

Garcia, P.C.A., Peixoto, O.L., Haddad, C.F.B. (2008): A new species of *Hypsiboas* (Anura: Hylidae) from the Atlantic Forest of Santa Catarina, Southern Brazil, with comments on its conservation status. South American Journal of Herpetology 3(1): 27-35.

Gerhardt, H.C. (1998): Acoustic signals of animals: recording, field measurements, analysis and description. pp. 1-25. In: Hopp, S.L., Owren, M.J., Evans, C.S. (Eds.), Animal acoustic communication. Springer Verlag, Berlin.

Gerhardt, H.C., Huber, F. (2002): Acoustic Communication in Insects and Anurans: common problems and diverse solutions. University of Chicago Press, Chicago and London.

Guimarães, L.D., Lima, L.P., Juliano, R.F., Bastos, R.P. (2001): Vocalizações de espécies de anuros (Amphibia) no Brasil Central. Boletim do Museu Nacional (N. S.) Zoologia 474: 1-14.

Haddad, C.F.B, Andrade, G.V., Cardoso, A.J. (1988): Anfíbios anuros no Parque Nacional da Serra da Canastra, Estado de Minas Gerais. Brasil Florestal 64: 9-20.

Heyer, W.R., Rand, A.S., Cruz, C.A.G., Peixoto, O.L., Nelson, C.E. (1990): Frogs of Boracéia. Arquivos de Zoologia 31: 231-410.

Juncá, F.A., Röhr, D.L., Lourenço-de-Moraes, R., Santos, F.J.M., Protázio, A.S., Mercês, E.A., Solé, M. (2012): Advertisement call of species of the genus *Frostius* Cannatella 1986 (Anura: Bufonidae). Acta Herpetologica 7(2): 189-201.

Kaefer, I.L., Lima, A.P. (2012): Sexual signals of the Amazonian frog *Allobates paleovarzensis*: geographic variation and stereotypy of acoustic traits. Behaviour 149: 15-33.

Köhler, J., Koscinski, D., Padial, J.M., Chaparro, J.C., Handford, P., Lougheed, S.C., De la Riva, I. (2010): Systematics of Andean gladiator frogs of the *Hypsiboas pulchellus* species group (Anura, Hylidae). Zoologica Scripta 39: 572-590.

Krebs, J.R., Davies, N.B. (2004): An introduction to behavioral ecology. The Alden Press Oxford. UK.

Kwet, A. (2001): Frösche im Brasilianischen Araukarienwald. Anurengemeinschaft des Araukarienwaldes von Rio Grande do Sul: Diversität, Reproduktion und Ressourcenaufteilung. Münster. Natur und Tier-Verlag.

Kwet, A. (2008): New species of *Hypsiboas* (Anura: Hylidae) in the pulchellus group from southern Brazil. Salamandra 44: 1-14.

Lehr, E., Faivovich, J., Jungfer, K.H. (2010): A new Andean species of the *Hypsiboas pulchellus* group: adults, calls, and phylogenetic relationships. Herpetologica 66: 296-307.

Márquez, R., De La Riva, I., Bosch, J., (1993): Advertisement calls of Bolivian species of *Hyla* (Amphibia, Anura, Hylidae). Biotropica 25: 426-443.

Márquez, R., Moreira, C., Amaral, J.P.S., Pargana, J.M., Crespo, E.G. (2005): Sound pressure level of advertisement calls of *Hyla merdionalis* and *Hyla arborea*. Amphibia–Reptilia 26: 391-395.

Menin, M., Silva, R.A., Giaretta, A.A. (2004): Reproductive biology of *Hyla goiana* (Anura, Hylidae). Iheringia 94(1): 49-52.

Morais, A.R., Batista, V.G., Gambale, P.G., Signorelli, L., Bastos, R.P. (2012): Acoustic communication in a Neotropical frog (*Dendropsophus minutus*): vocal repertoire, variability, and individual discrimination. Herpetological Journal 22: 249-257.

Morais, A.R., Kwet, A. (2012): Description of the advertisement call of *Physalaemus lisei* (Anura: Leiuperidae). Salamandra 48: 227-229.

Padial, J.M., Castroviejo-Fischer, S., Köhler, J., Domic, E., De la Riva, I. (2007): Systematics of the *Eleutherodactylus fraudator* species group (Anura: Brachycephalidae). Herpetological Monographs 21: 214-241.

Padial, J.M., Köhler, J., Muñoz, A., De la Riva, I. (2008): Assessing the taxonomic status of tropical frogs through bioacoustics: geographical variation in the advertisement calls in the *Eleutherodactylus discoidalis* species group (Anura). Zoological Journal of the Linnean Society 152: 353-365.

Padial, J.M., De la Riva, I. (2009): Integrative taxonomy reveals cryptic Amazonian species of *Pristimantis* (Anura). Zoological Journal of the Linnaean Society 155: 97-122.

Padial, J.M., Miralles, A., De La Riva, I., Vences, M. (2010): The integrative future of taxonomy. Frontiers in Zoology 7: 16.

Pinheiro, P.D.P., Pezzuti, T. L., Garcia, P.C.A. (2012): The Tadpole and vocalizations of *Hypsiboas polytaenius* (Cope, 1870) (Anura, Hylidae, Hylinae). South American Journal of Herpetology 7: 123-133.

Pombal Jr, J.P. (2010): O espaço acústico em uma taxocenose de anuros (Amphibia) do Sudeste do Brasil. Arquivos do Museu Nacional 68(1-2): 135-144.

Pröhl, H., Hagemann, S., Karsch, J., Höbel, G. (2007): Geographic Variation in Male Sexual Signals in Strawberry Poison Frogs (*Dendrobates pumilio*). Ethology 113: 825-837.

R Development Core Team (2012): R: a language and environment for statistical computing. R Foundation for Statistical Computing. http://www.R-project.org

Roberto, I.J., Ávila, R.W. (2013): The advertisement call of *Phyllodytes gyrinaethes* Peixoto, Caramaschi & Freire, 2003 (Anura, Hylidae). Zootaxa 3669: 193-196.

Ruxton, G.D., Sherratt, T.N., Speed, M.P. (2004): Avoiding attack: The evolutionary ecology of crypsis, warning signals, and mimicry. Oxford University Press Inc., New York.

Sueur, J., Aubin, T., Simonis, C. (2008): Seewave: a free modular tool for sound analysis and synthesis. Bioacoustics 18: 213-226.

Simões, P.I., Lima, A.P., Magnusson, W.E., Hödl, W., Amézquita, A. (2008): Acoustic and morphological differentiation in the frog *Allobates femoralis*: Relationships with the upper Madeira River and other potential geological barriers. Biotropica 40: 607-614.

Teixeira, B.F.V., Giaretta, A.A. Pansonato, A. (2013): The advertisement call of *Dendropsophus tritaeniatus* (Bokermann, 1965) (Anura: Hylidae). Zootaxa 3669: 189-192.

Toledo, L.F., Haddad, C.F.B. (2005): Acoustic repertoire and calling site of *Scinax fuscomarginatus* (Anura, Hylidae). Journal of Herpetology 39(3): 455-464.

Wells, K.D. (2007): The Ecology and Behavior of Amphibians. Chicago: The University of Chicago Press.