

Interspecific behaviour between two species of *Boana* (Anura: Hylidae) from central Brazil

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Interspecific interactions are important as they may structure the community due to dispute of available niches (Thompson, 1988; Ohgushi et al., 2012). Although the occurrence of interspecific interactions in anurans is more common among closely related species (Gerhardt and Schwartz, 1995; Reichert and Gerhardt, 2014), the occurrence of physical combat between species of different genera or families has also been reported (Schwartz and Wells, 1984; Moura et al., 2010). In anuran amphibians, communication typically occurs through acoustic signals, but visual and physical interactions can also be observed through multimodal signals (Caldart et al., 2014). The emission of calls is a way to avoid high energetic expenditure during the reproduction season as physical fights could be costly in terms of energy expenditure (Wells, 2007). In tropical anuran communities the males of some species aggregate in chorus, where they simultaneously emit a signal for sexual advertisement to attract females (Toledo et al., 2015). Calling in a chorus may increase the likelihood of attracting conspecific mates (Wells 2007). However, the high density of calling males may also increase the dispute of territory between them and attract audiotively oriented predators (Wells 2007; Farina and Ceraulo, 2017).

On 21 November 2014, we recorded males of *Boana albopunctata* (Spix, 1824) and *B. raniceps* (Cope, 1862)

fighting. *Boana albopunctata* emitted aggressive calls, while *B. raniceps* emitted release calls. Both males were found at the edge of a waterbody perched on a branch at about 40 cm height, in the municipality of Caldas Novas (-17.888049; -48.691984, WGS84, 651 m a.s.l.), State of Goiás, Brazil. Recordings were obtained using a Tascam Dr-40 digital recorder coupled with a Sennheiser ME66/K6 directional microphone at a distance of 50 cm from males. Calls were recorded at 44.1 kHz with 16-bit resolution. We also used a camera Canon PowerShot SX40 HS to film the behaviour.

Bioacoustic traits were analysed using Raven Pro 64 v1.5 software from the Cornell Lab of Ornithology (Bioacoustics Research Program, 2014). Spectrograms were produced applying the following settings: window type = Hamming, window size = 256 samples, overlap = 80%, hop size = 64 samples, DFT size = 1024 samples. We obtained oscillogram and spectrogram figures using Seewave package v1.7.3 (Sueur et al., 2008) for R version 3.3.3 (R Core Team, 2016). Temporal acoustic parameters [note duration (s), pulse number, pulse duration (s)] were measured in the waveform, and spectral parameters were measured in the spectrogram selecting the following measurement functions: Peak Frequency [as dominant frequency (Hz)], Frequency 5% [as lower frequency (Hz)] and Frequency 95% [as upper frequency (Hz)]. Call description and terminology follow Toledo et al. (2015). The snout-vent length (SVL) of the individuals was measured using a digital caliper (to the nearest 0.5 mm) and the temperature was obtained using a digital thermohygrometer (to the nearest 0.1°C). Voucher specimens are housed at the Zoological Collection of Universidade Federal de Goiás, State of Goiás, Brazil (*Boana albopunctata*: ZUFG 9545, *Boana raniceps*: ZUFG 9541).

The male *B. albopunctata* was upon the male of *B. raniceps*, while the *B. raniceps* was emitting advertisement calls. The male *B. albopunctata* continued to emit aggressive calls (Figure 1, Table 1) and struck the male of *B. raniceps* with the head. When the male

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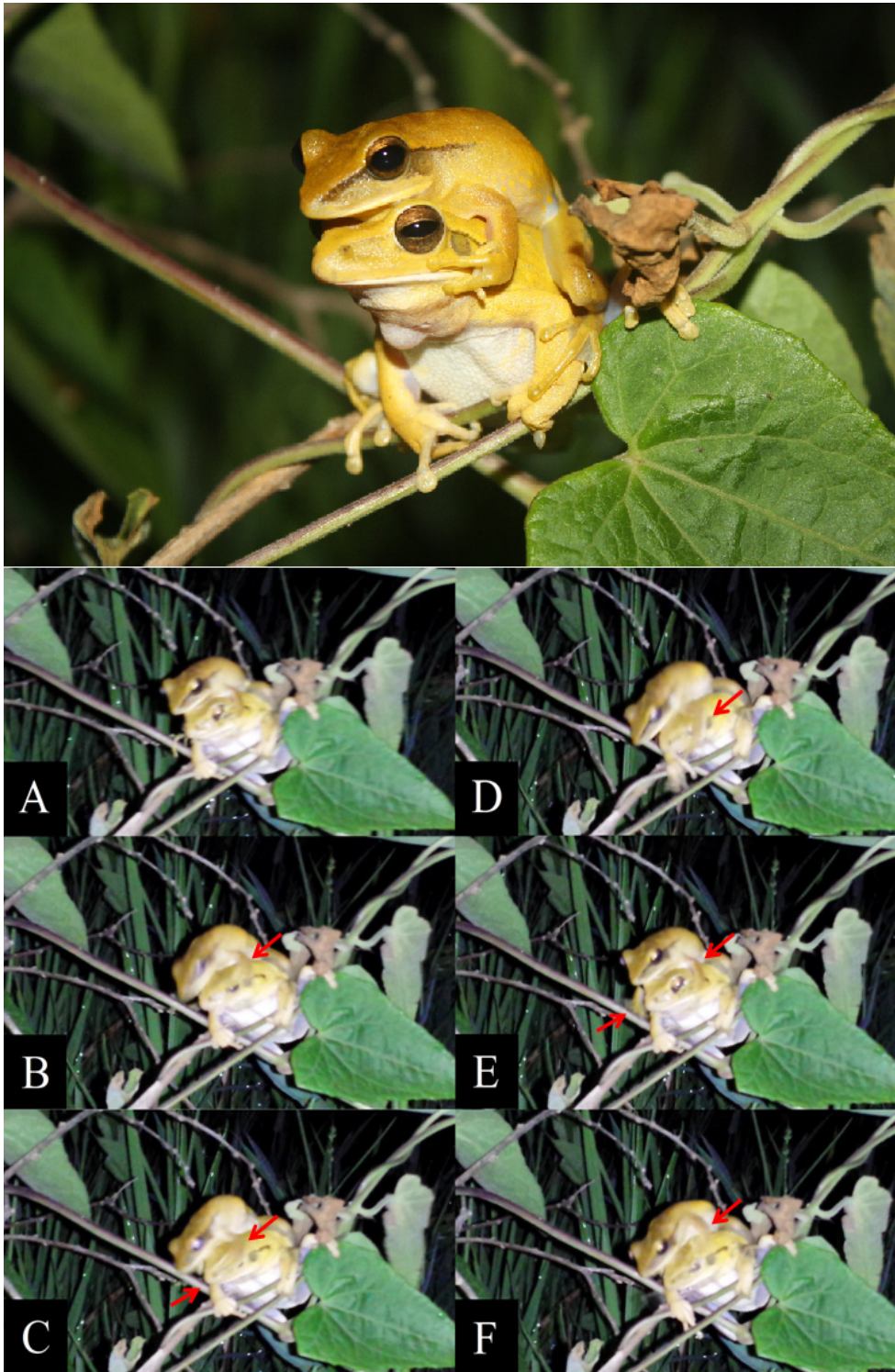


Figure 1. Aggressive behaviour between *Boana albopunctata* and *B. raniceps* in the municipality of Caldas Novas, State of Goiás, central Brazil. A–F show the sequence in which a male of *B. albopunctata* moved its front feet up and down on the vocal sac of *B. raniceps*. The red arrows show the front feet of *B. albopunctata*. Photos by Vinicius Guerra.

Table 1. Call parameters of the aggressive call of *Boana albopunctata* and the release call of *B. raniceps*. Abbreviations: ND: note duration; PN: pulse number; PD: pulse duration; DF: dominant frequency; UpF: Upper frequency; LwF: Lower frequency. Measurements are presented as the mean \pm SD (minimum–maximum).

Species	<i>B. raniceps</i> (10 calls)	<i>B. albopunctata</i> (20 calls)
ND	0.050 \pm 0.027 (0.026 – 0.109)	0.273 \pm 0.072 (0.139 – 0.408)
PN	—	27.95 \pm 11.64 (8 – 54)
PD	—	0.009 \pm 0.003 (0.005 – 0.018)
DF	758.00 \pm 202.20 (516.80 – 1205.90)	723.54 \pm 70.67 (689.10 – 861.30)
UpF	1550.38 \pm 269.33 (1205.90 – 1894.90)	1524.56 \pm 218.44 (1205.9 – 2067.20)
LwF	516.80 \pm 0.00 (516.8 – 516.8)	516.80 \pm 0.00 (516.80 – 516.80)

B. raniceps began to call (advertisement calls), the male *B. albopunctata* moved its front feet up and down, rubbing them on the vocal sac of the male *B. raniceps* (Figure 1). The male *B. albopunctata* also moved the body forward, moving its hind legs over the body of the male *B. raniceps*. The male *B. raniceps* emitted release calls when grasped by the male *B. albopunctata* (Figure 1, Table 1). All behaviours were observed for about 10 minutes and ended with a failed predation event when an adult *Leptodactylus* aff. *latrans* jumped on both males, probably attracted by their movement. The aggressive call of *B. albopunctata* is a multipulsed note (without harmonics) and had a note duration of 0.273 \pm 0.072 s and dominant frequency of 723.54 \pm 70.67 Hz (Figure 2, Table 1). The release call of *B. raniceps* is a non-

pulsed harmonic note, call duration was 0.050 \pm 0.027 s and had a dominant frequency of 758.00 \pm 202.20 Hz (Figure 3, Table 1).

The competition among species and individuals is shaped by the abundance of available resources (Ohgushi et al., 2012). For anurans, oviposition and calling sites are disputed by males (Wells, 2007). *Boana raniceps* is a species of the *B. albopunctata* group, and utilises the same oviposition and calling sites as *B. albopunctata* and also dispute the acoustic niche in a temporal (time in which calling takes place) and spatial (sound propagation environment) dimension (Guimarães et al., 2003; Vieira et al., 2016). Aggressive interactions were observed in conspecific males of *B. raniceps*, with males defending their vocalisation sites against invaders through chase,

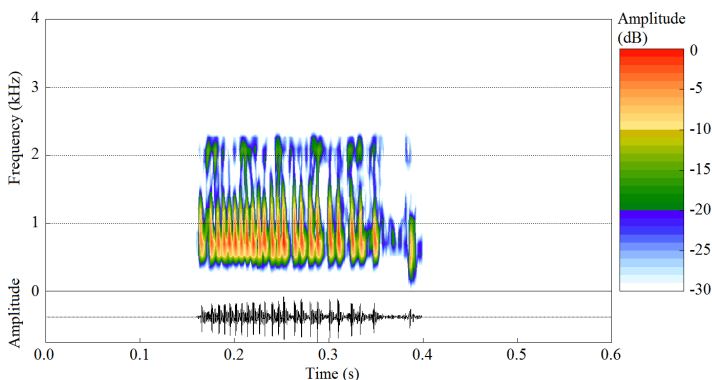


Figure 2. Aggressive call of *Boana albopunctata* in the municipality of Caldas Novas, State of Goiás, Brazil. Spectrogram (above) and respective oscillogram (below) (air temperature = 20.60°C; air humidity = 96.52%; SVL = 53.72 mm). Voucher specimen: ZUFG-9545.

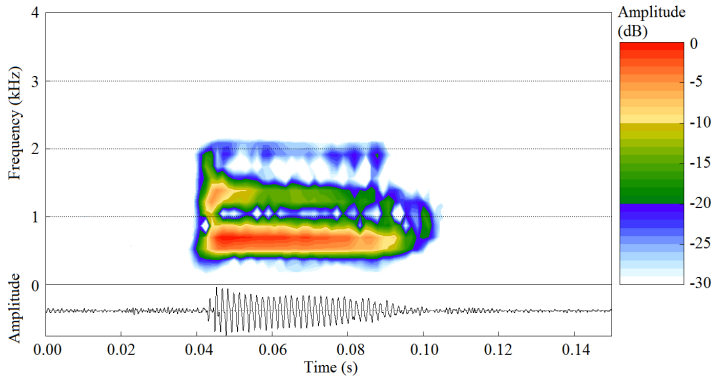


Figure 3. Release call of *Boana raniceps* in the municipality of Caldas Novas, State of Goiás, Brazil. Spectrogram (above) and respective oscillogram (below) (air temperature = 20.60°C; air humidity = 96.52%; SVL = 63.68 mm). Voucher specimen: ZUFG-9541.

acoustic interactions and physical combat (Guimarães *et al.*, 2003). However, male *B. raniceps* have floating territories and can change the calling site at the same night or into different nights (Guimarães *et al.*, 2003). The interspecific combat behaviour observed may be a result of a territorial dispute, since both species use shrubs as vocalisation sites.

The aggressive call of *B. albopunctata* was previously described by Vieira *et al.* (2016). However, the aggressive call recorded by us presents a somewhat different structure (see Figure 2 in Vieira *et al.*, 2016). The parameters of call duration, dominant frequency, lower and upper frequency differs from the aggressive call described by Vieira *et al.* (2016), indicating that these two aggressive calls are different and may be emitted in different situations. Field experiments should be performed to confirm this hypothesis. The release call of *B. raniceps* have a longer call duration and lower dominant frequency relative to *B. goiana* (Dias *et al.*, 2014). Only a few species of the Family Hylidae have the release call described (e.g. Nali *et al.*, 2015; Mângia *et al.*, 2017).

Vocalisations are reported to be the main defensive behaviour during territorial disputes in anurans, however, they can also engage in physical fights when the calls are not efficient to keep competitors away. Although physical fighting is most commonly observed among conspecific males, there have been a small number of studies that described fighting behaviour involving different amphibian species (e.g. Schwartz and Wells, 1984; Moura *et al.*, 2010). Whilst the vocal repertoire of *B. albopunctata* and *B. raniceps* is well

known (Guimarães and Bastos, 2003; Souza *et al.*, 2016; Vieira *et al.*, 2016), the release call of *B. raniceps* was previously unreported. Punctual naturalistic observations such as those reported here are important to reveal the reproductive behaviour of the species and to understand the processes responsible for avoiding the niche overlap between species.

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