

An acoustic evaluation of the geographical distribution of *Elachistocleis cesarii* Miranda-Ribeiro 1920 (Anura, Microhylidae)

Ariovaldo Antonio Giaretta*, Felipe Silva de Andrade, Isabelle Aquemi Haga and Denici Laura Carvalho

Abstract. We present data on calls of *Elachistocleis cesarii* from Uberlândia (MG), Campinas (SP), Pontal do Araguaia (MT) and Alto Paraíso de Goiás (GO). The name *Elachistocleis bicolor* has been used in papers on frog ecology for a population from the Triângulo Mineiro region in the State of Minas Gerais, but considering recent taxonomic clarification, the proper name to be applied to this population is *E. cesarii*. We conclude this reviewing the literature and examining specimens from the Triângulo Mineiro by analyzing calls, measuring adults and examining color patterns. The aggressive call of *E. cesarii* is also described. Adult males from the Triângulo Mineiro averaged 29.4 mm SVL; preserved specimens have a uniform dark grayish or dark brown color on dorsal surfaces of body and limbs; the belly is gray or brown with white or pale yellow large spots that reach up to the flanks. Advertisement calls from all localities were a long (1.5–3.1s) sustained high-pitched humming with an approximate rate of 200 pulses/s. Dominant frequencies (= fundamental) ranged from 3.1 to 3.6 kHz. The aggressive call is a short (0.3–0.6s), high-pitched humming with an approximate rate of 230 pulses/s, its dominant frequency peaked at 3.0 kHz (2.7–3.3 kHz). Calls of all studied sites can be reliably attributed to *E. cesarii*. Two distinct calls have been attributed to Bolivian populations of *E. bicolor*, both very different from *E. cesarii* calls. Thus, morphology and call data do not support the attribution of the name *E. bicolor* to specimens of the Triângulo Mineiro to which the name *E. cesarii* should be used instead. As in some other frogs, the aggressive call of *E. cesarii* is a variant of the advertisement call, differing from it in features such as duration and pitch.

Keywords. *Elachistocleis cesarii*, *Elachistocleis bicolor*, distribution, advertisement call, aggressive call.

Introduction

As presently defined, *Elachistocleis* Paker comprises 13 species distributed from Panamá to central Argentina (Frost, 2011). The name *Elachistocleis ovalis* was widely used in the literature (e.g. Haddad, Andrade and Cardoso, 1988; De La Riva, Márquez and Bosch, 1996; Tárano, 2010), but according to Caramaschi (2010), this name cannot be applied to any Neotropical frog. In Brazil, populations from Cerrado, Pantanal, Atlantic Forest, and Caatinga domains traditionally treated as *E. ovalis* are now assigned to *E. cesarii* (Miranda-Ribeiro, 1920) (Toledo, Loebmann and Haddad, 2010; Caramaschi, 2010). Currently, the name *E. bicolor* has been applied to populations from Argentina, Bolivia, Paraguay, Uruguay, Peru, southern and southeastern Brazil (e.g. De La Riva, Márquez and Bosch, 1996; Duellman, 2005; Rodrigues, Lopes and Uetanabaro, 2003; Caramaschi, 2010). Attending to an editor request, the name *E. bicolor* was applied in a paper on frog ecology to a population of the Triângulo Mineiro of the

state of Minas Gerais by Giaretta et al. (2008) in which they were followed by subsequent authors (Araújo et al., 2009; Pires et al., 2011).

Considering these recent taxonomic clarifications and new data on advertisement calls, measurements and color patterns, herein we show that the most appropriate name to be applied to the population of the Triângulo Mineiro is *E. cesarii* (Miranda-Ribeiro, 1920). We also evaluate the specific status of some populations referred as *E. cesarii* in the literature by analyzing advertisement calls. We additionally report the existence of aggressive call (cf. Wells, 2007) in *E. cesarii*, a rare case among Neotropical Microhylidae.

Materials and Methods

To better evaluate the distribution of *E. cesarii* in Southeastern and Central Brazil, we analysed data on calls of specimens from the municipalities of Uberlândia (Triângulo Mineiro region, State of Minas Gerais), Campinas (State of São Paulo, closer the type locality), Pontal do Araguaia (State of Mato Grosso), Alto Paraíso de Goiás (Chapada dos Veadeiros, State of Goiás, around the northwest known limits of this species). We also studied specimens from the Triângulo Mineiro (municipalities of Uberlândia, Perdizes and Ituiutaba) by measuring adults and examining color patterns. Measurements were taken as in Cei (1980) and Heyer et al. (1990).

The climate seasonality of inland Southeastern and Central Bra-

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Figure 1. An adult male of *Elachistocleis cesarii* in life. Specimen from Ituiutaba, Triângulo Mineiro region, State of Minas Gerais (AAG-UFU 342, SVL = 29.4 mm).

zil are similar by presenting a wet/hot season from September to March and a mild/dry season throughout the remaining months of the year (IBGE, 1978). The original vegetation of the Triângulo Mineiro, Pontal do Araguaia and Alto Paraíso de Goiás was Cerrado savanna, which is still relatively well preserved; in Campinas the original vegetation (Atlantic Forest and patches of dryer vegetational types) was removed decades ago and the present-day vegetation at the recording site was grassland beside a secondary forest.

Calls were recorded with a Marantz PMD 670, a Marantz PMD 671, a Boss 864 (all coupled to Sennheiser ME67/K6 microphones) and a M-audio Microtrack II (Sennheiser ME66/K6) digital recorders (all set at 44.1 kHz and 16 bits resolution). Sounds were analyzed using Audacity 1.3 Beta (Mazzoni, 2010); figures were generated using Seewave v.1.6 package (Sueur *et al.* 2008) on the R (v.2.13.0) platform (R Development Core Team 2011). Unless otherwise stated, call figures were made using a FFT size of 256. Three calls per individual were measured. As other Neotropical microhylids, species of *Elachistocleis* species have calls composed of many pulses released in a fast rate and pulse structure can be important to the understanding of populational differences (Oliveira-Filho and Giaretta, 2006), so we present a short-time spectrogram/oscillogram detailing pulse structure to *E. cesarii*. Calls were analyzed and described following Toledo, Loebmann and Haddad (2010). All analysed sound files are listed in Appendix 1. Original analysed calls (*.wav) will be available at

Amphibiaweb (<http://amphibiaweb.org/>) after publication.

Voucher specimens are deposited in the collection of frogs of the Museu de Biodiversidade do Cerrado, Universidade Federal de Uberlândia: AAG-UFU 340 (♂, Uberlândia), 2111 (♀, Uberlândia); 342 (♂, Ituiutaba), 2693 (♂, Perdizes), 2695 (♂, Perdizes). Two calls were vouchered (AAG-UFU 340, 342). Collection permits: ICMBio 30059-1.

Results

Adult males from the Triângulo Mineiro averaged 29.4 mm SVL; the adult female measured 29.9 mm SVL (Table 1). Preserved specimens have a uniform dark grayish or dark brown color on dorsal surfaces of body and limbs; the belly is gray or brown with white or pale yellow large spots that reach up to the flanks. Throat is darker than chest and belly. There are large light spots on inguinal region and a longitudinal light stripe on the posterior surface of thighs. In life (Figure 1), the light white/pale yellow large spots/stripes were vivid orange.

Advertisement call features of specimens from the Triângulo Mineiro, Pontal do Araguaia, Campinas and Alto Paraíso de Goiás are summarized in Table 2 and Figures 2–7. In all these localities calls were a long (1.5–3.1s) sustained high-pitched humming with an approximate rate of 200 pulses/s. The dominant frequency was coincident with fundamental and peaks ranged between 3.1 and 3.6 kHz. Calls started weak and reached maximum amplitude within around the first ten percent of their length. Zero to five harmonic bands (i.e. integer multiples of a base or fundamental frequency (Elemans, Heeck and Muller, 2008)) may be present (Fig. 7).

A male *E. cesarii* released aggressive calls ($n = 5$) when calling at close range (< 30 cm) to another calling male (Fig. 8). The aggressive call resembles the advertisement call, being shorter and lower in pitch though. It is a short high-pitched humming lasting 0.4s (0.3–0.6s), released at a rate of the 48.4 calls/minute and having an intercall interval between 8.5 and 9.3s. Pulses lasted 4.0ms, with a rate of 230/s ($n = 1$ male). The dominant (= fundamental) frequency peaked at 3.0 kHz (2.7–3.3 kHz). The call has a maximum frequency around 4.0 kHz and a minimum at 1.8 kHz; most energy (maximum dominant frequency) is around 3.6 kHz and 2.6 kHz (minimum); no harmonic was noticed.

Discussion

Despite the large geographic range of the analysed calls (Campinas, Pontal do Araguaia, Alto Paraíso de Goiás

Table 1. Measurements (Mean, SD, and Amplitude) of adult specimens of *Elachistocleis cesarii* from the Triângulo Mineiro region (State of Minas Gerais). Measurements in millimeters. Specimens from Uberlândia and two other close (< 130 km) municipalities (Perdizes and Ituiutaba).

Measured features	Males		Female	
		(n = 4)		(n = 1)
Snout-Vent Length	29.4	1.08	28.0 – 30.7	29.9
Head Length	6.0	0.39	5.6 – 6.4	6.5
Head Width	6.8	0.22	6.6 – 7.1	6.6
Eye Diameter	1.5	0.07	1.4 – 1.6	1.6
Eyelid Width	1.3	0.39	0.8 – 1.8	0.8
Eye-Nostril Distance	1.7	0.10	1.5 – 1.8	1.7
Snout-Eye Distance	2.1	0.48	1.4 – 2.5	2.8
Internarial Distance	1.5	0.05	1.4 – 1.5	1.6
Hand Length	6.6	0.29	6.3 – 7.0	6.7
Thigh Length	10.6	0.77	10.0 – 11.8	9.7
Tibia Length	10.6	0.82	9.4 – 11.2	11.2
Foot Length	12.1	0.45	11.5 – 12.6	12.6

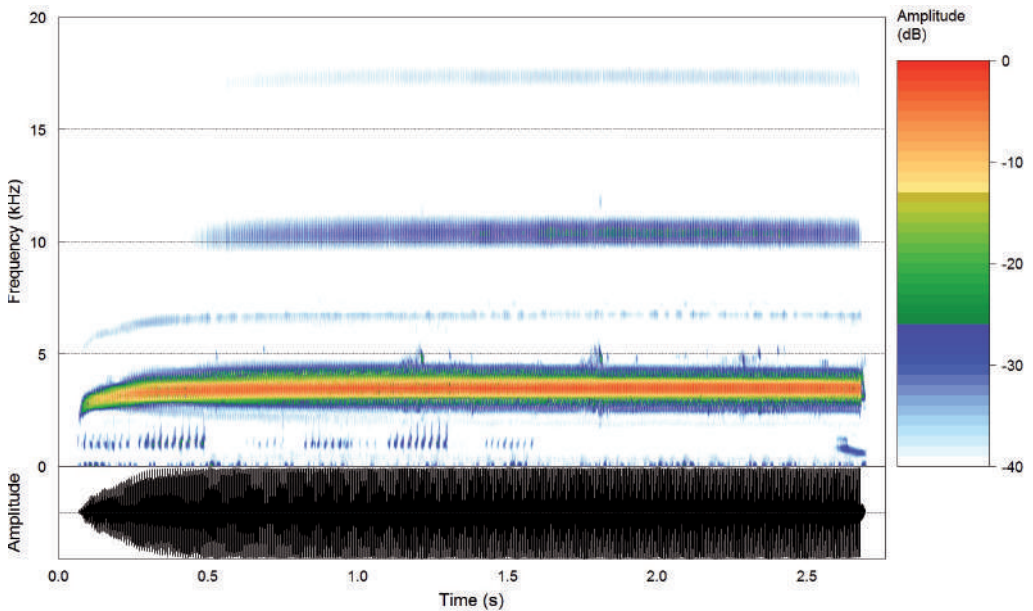


Figure 2. Audiospectrogram (above) and corresponding oscillogram (below) of the advertisement call of the *Elachistocleis cesarii* from Uberlândia, Triângulo Mineiro region, state of Minas Gerais. Record file: Elachist_cesarUberIMG5bAAGm(1.3s). February 27, 2011; 21:05 h; air = 25.1 °C, water = 26.8 °C.

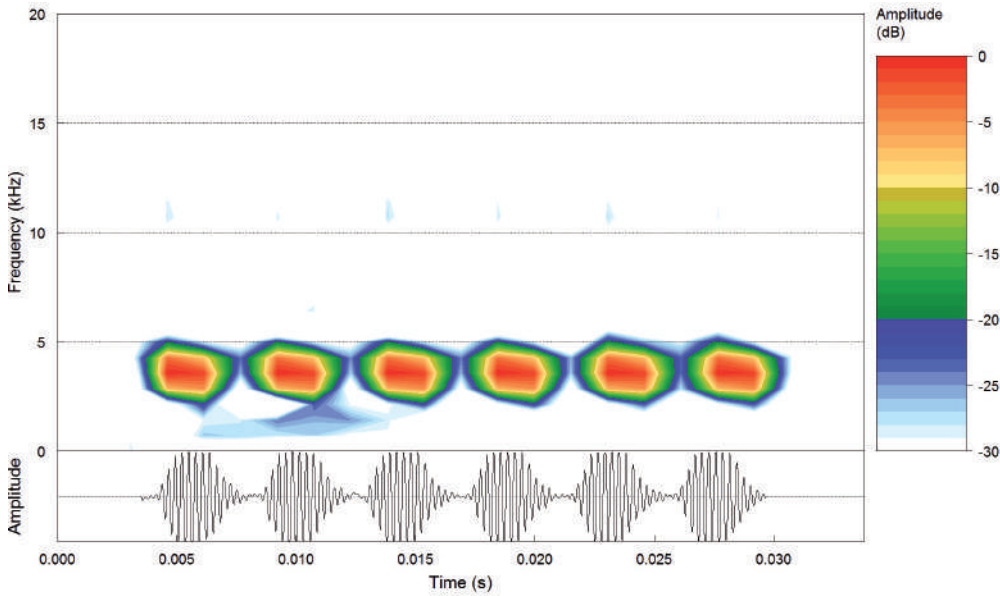


Figure 3. Audiospectrogram (above) and corresponding oscillogram (below) of a short section (mid portion) of the advertisement call presented in Figure 2 emphasizing the temporal structure of six pulses. FFT = 64 points.

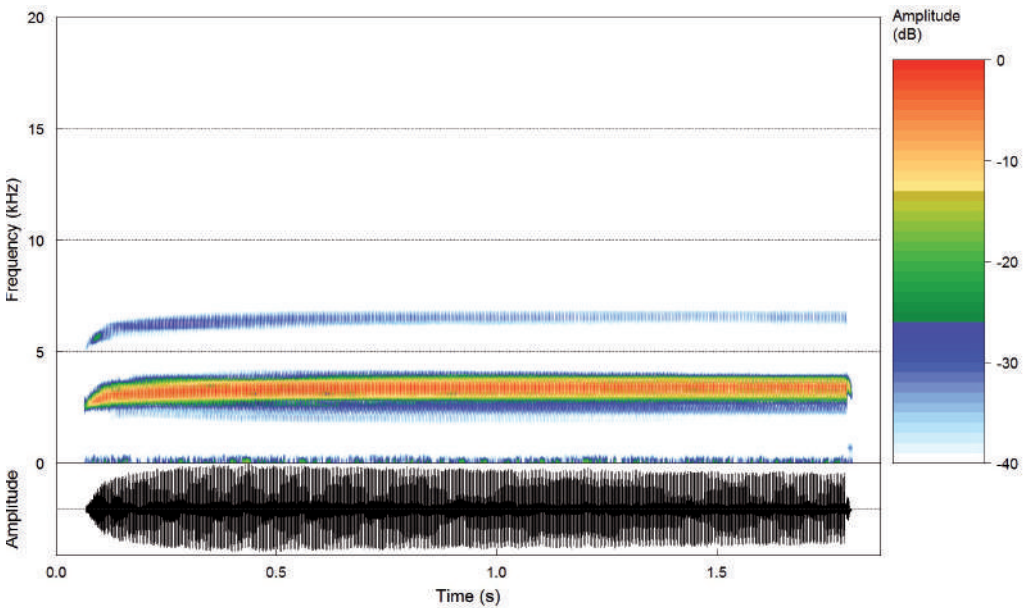


Figure 4. Audiospectrogram (above) and corresponding oscillogram (below) of the advertisement call of *E. cesarii* from Campinas, State of São Paulo. Record file: Elachist_cesarCampinSP1aAAGb (17.5s). December 28, 2003; 19:10 h; air = 20.7 °C, water = 26.1 °C.

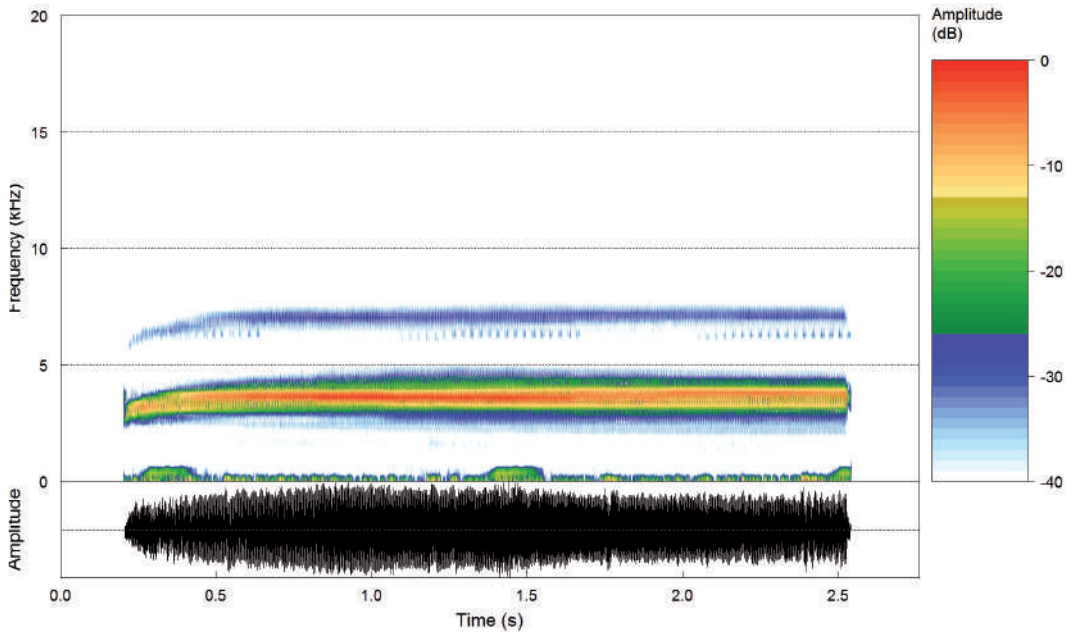


Figure 5. Audiospectrogram (above) and corresponding oscillogram (below) of the advertisement call of *E. cesarii*. Specimen from Pontal do Araguaia, State of Mato Grosso. Record file: Elachist_cesarPontAraguMT1bAAGm(21s). January 16, 2011; 20:12 h; air = 26.5 °C, water = 27.5 °C.

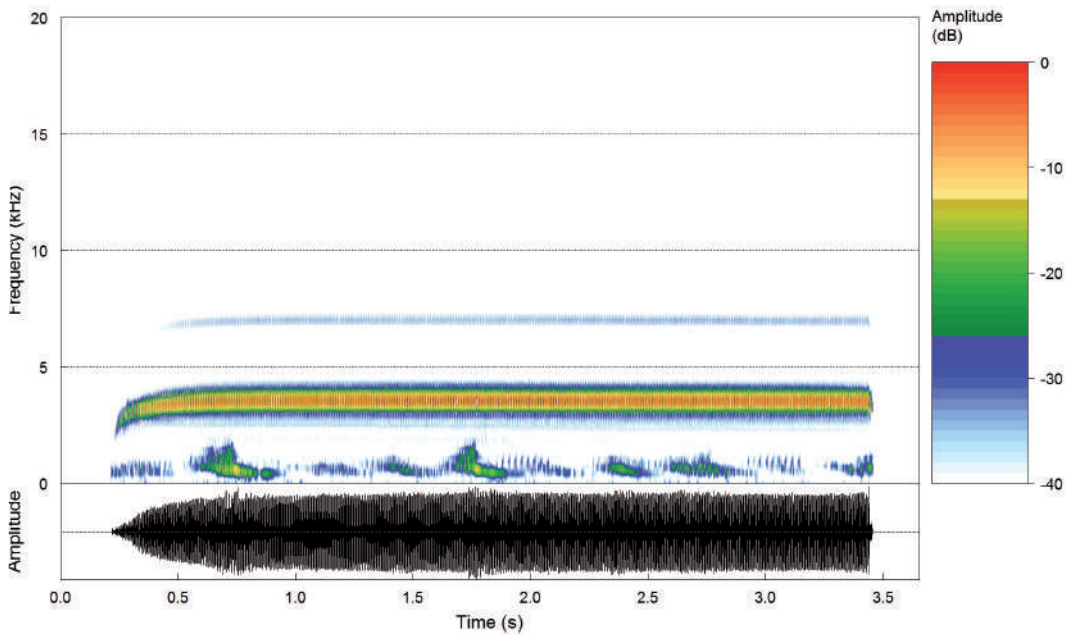


Figure 6. Audiospectrogram (above) and corresponding oscillogram (below) of the advertisement call of *E. cesarii* from Alto Paraíso de Goiás, State of Goiás. Record file: Elachist_cesarVeadGO6bAAGm671(32.1s). December 13, 2011; 21:15 h; air = 19.0 °C, water = 20.0 °C.

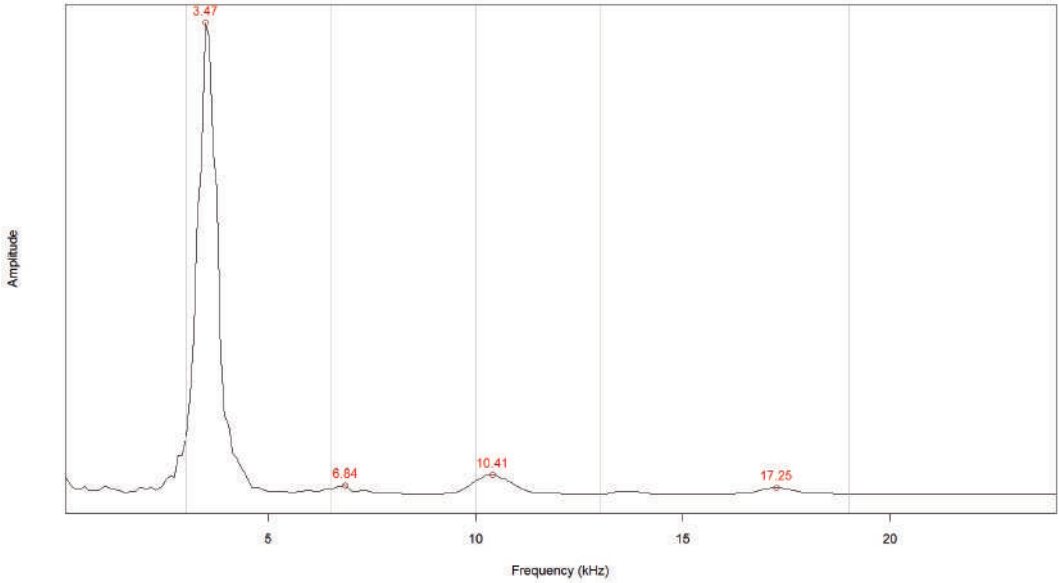


Figure 7. Power spectrum highlighting harmonic bands in the advertisement call of the *Elachistocleis cesarii* from Uberlândia, Triângulo Mineiro region, state of Minas Gerais. Five bands were expected but the fourth one is so weak that could not be detected. Record file: Elachist_cesarUberIMG5bAAGm(1.3s). February 27, 2011; 21:05 h; air = 25.1 °C, water = 26.8 °C.

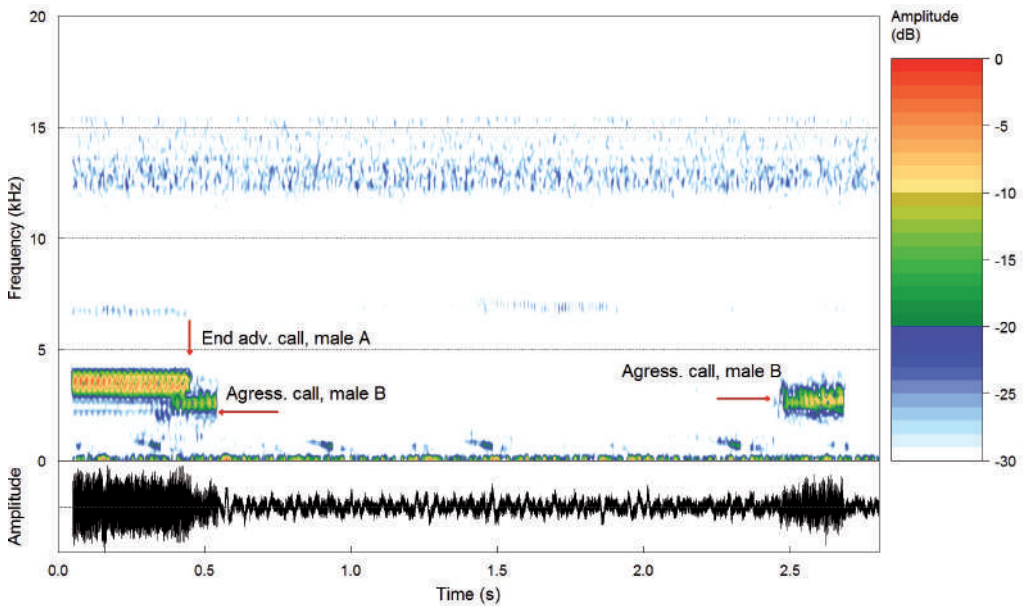


Figure 8. Audiospectrogram (above) and corresponding oscillogram (below) of the advertisement (male A) and aggressive (male B) calls of *E. cesarii*. Two successive aggressive calls are shown. Specimens from Ituiutaba (MG). Record file: Elachist_cesarItuiutMG1aAAGm (38s). A short silence section was inserted at left. March 04, 2011; 19:55 h; air = 22.0 °C, water = 24.0°C.

Table 2. Measurements of advertisement call features (mean and SD) of our sample of *Elachistocleis cesarii*. n = number of recorded males; three calls per individual were measured.

Call features	Campinas	Triângulo	Pontal Araguaia		Alto Paraíso
	(SP)	Mineiro (MG)	(MT)		(GO)
	(n = 1)	(n = 8)	Ind. 1	Ind. 2	(n = 5)
Call duration (s)	2.3	2.1 (0.5)	2.4	0.905	3.3 (1.0)
Calls/minute	13.4	4.9 (0.5)	7.1	^a	3.9 (0.4)
Intercall interval (range, s)	4.9	14.3–40.1	8.4–21.6	^a	8.8–30.5
Pulse duration (ms)	4.0	4.0 (0)	4.0	5.0	5.0 (0)
Pulses/second	215	232 (21.8)	225	220	185 (6.1)
Peak of dominant frequency (kHz)	3.3	3.4 (0.1)	3.6	3.3	3.2 (0.1)
Max. dominant freq. (kHz)	3.8	3.9 (0.3)	3.8	3.85	3.9 (0.1)
Min. dominant freq. (kHz)	3.1	3.0 (0.2)	3.3	2.7	2.9 (0.4)
Maximum reached frequency (kHz) ^c	4.3	4.7 (0.2)	4.7	4.65	4.1 (0.2)
Minimum reached frequency (kHz) ^c	2.3	1.9 (0.4)	2.4	1.8	2.4 (0.4)
Range of air temperature (°C)	20.7	22.0–26.2	26.5	23.0	19.0

^a Calls released sporadically. ^b one out of eight individuals did not present harmonics.

^c regarding the entire call.

(Uberlândia being around midway)), our sample of the advertisement calls of *E. cesarii* were quite similar to one another in the measured features, indicating a specific identity among all populations. Unfortunately, calls from the type locality remain unknown. *Elachistocleis* species referred in taxonomic studies to Southeastern Brazil are *E. cesarii* and *E. bicolor* (Caramaschi, 2010). Our sample of *Elachistocleis* from the Triângulo Mineiro is coherent with the morphometric and color features of *E. cesarii* presented by Toledo, Loebmann and Haddad (2010). These authors also described a similar call to *E. cesarii* from municipality of Rio Claro, São Paulo state (about 75 km west from our sample from the state of São Paulo). The call Haddad, Andrade and Cardoso (1988) described from Poços de Caldas (state of Minas Gerais) and attributed to *E. ovalis* is also in accordance

with the calls attributed to *E. cesarii*. Our data support the statement of Caramaschi (2010, Appendix) and Toledo, Loebmann and Haddad (2010) who referred to *E. cesarii* as occurring in the State of Mato Grosso.

The current improper name *E. ovalis* has been applied to a Bolivian population (De La Riva, Márquez and Bosch, 1996; De La Riva et al., 2000); a comparison of its call with those attributed to *E. cesarii* (Toledo, Loebmann and Haddad, 2010; present study) indicates that differences are minor and should represent the same species. These findings are in agreement with Caramaschi (2010), who based on museum specimens, referred to *E. cesarii* at a locality close to the Brazil-Bolivia border. The name *E. ovalis* also was applied to a Venezuelan population by Tárano (2010), the call presented there has an expressively higher frequency

(5.0 kHz) and longer (5.0 ms) pulse duration, differences large enough to preclude the application of *E. cesarii* to that population.

Lavilla *et al.* (2003) stated that *E. bicolor* was apparently described from Buenos Aires (Argentina), and in Southeastern Brazil reaches the São Paulo State (Caramaschi, 2010). Two distinct calls have been attributed to Bolivian populations (ca. 2000 km north from the type locality) of *E. bicolor* (De La Riva, Márquez and Bosch, 1996; Lavilla, Vaira and Ferrari, 2003), both very different (e.g. in dominant frequency) from *E. cesarii* calls (Toledo, Loebmann and Haddad, 2010; present work). Morphology (Caramaschi, 2010) and call data do not support the attribution of the name *E. bicolor* to the population of the Triângulo Mineiro, as previously referred by Giaretta *et al.* (2008), Araújo *et al.* (2009) and Pires *et al.* (2011); the name *E. cesarii* should be used to it instead.

We are not aware of previous reports of aggressive calls in Neotropical Microhylidae frogs. As in some other frogs, the aggressive call of *E. cesarii* is a variant of the advertisement call (Wells, 2007; Gerhardt and Huber, 2002), differing from it in features such as duration and pitch.

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Appendix 1

Sound file names of the analyzed calls (“*.wav”) in the present work; all files from the senior author collection:

Elachist_cesarUberlMG3bAAGm,	Elachist_cesarUberlMG4aAAGm,
Elachist_cesarUberlMG4bAAGm,	Elachist_cesarUberlMG4cAAGm,
Elachist_cesarUberlMG4dAAGm,	Elachist_cesarUberlMG4eAAGm,
Elachist_cesarUberlMG5aAAGm,	Elachist_cesarUberlMG5bAAGm,
Elachist_cesarUberlMG5cAAGm,	Elachist_cesarUberlMG5dAAGm,
Elachist_cesarUberlMG6aAAGm,	Elachist_cesarUberlMG7aAAGm,
Elachist_cesarUberlMG8aAAGm671,	Elachist_cesarUberlMG8bAAGm671,
Elachist_cesarUberlMG9aAAGm671,	Elachist_cesarUberlMG9bAAGm671,
Elachist_cesarVeadGO1aAAGm671,	Elachist_cesarVeadGO2bAAGm671,
Elachist_cesarVeadGO3aAAGm671,	Elachist_cesarVeadGO3bAAGm671,
Elachist_cesarVeadGO4aAAGm671,	Elachist_cesarVeadGO5aAAGm671,
Elachist_cesarVeadGO5bAAGm671,	Elachist_cesarVeadGO6aAAGm671,
Elachist_cesarVeadGO6bAAGm671,	Elachist_cesarAraguariMG3aAAGmt,
Elachist_cesarCampinSP1aAAGb,	Elachist_cesarItuiutMG1aAAGm,
Elachist_cesarItuiutMG1bAAGm,	Elachist_cesarItuiutMG2aAAGm,
Elachist_cesarPontAraguMT1aAAGm,	Elachist_cesarPontAraguMT1bAAGm,
Elachist_cesarPontAraguMT2aAAGm,	Elachist_cesarPontAraguMT2bAAGm,
Elachist_cesarUberlMG1aAAGb,	Elachist_cesarUberlMG2aAAGm,
Elachist_cesarUberlMG2bAAGm,	Elachist_cesarUberlMG2cAAGm,
Elachist_cesarUberlMG3aAAGm.	