

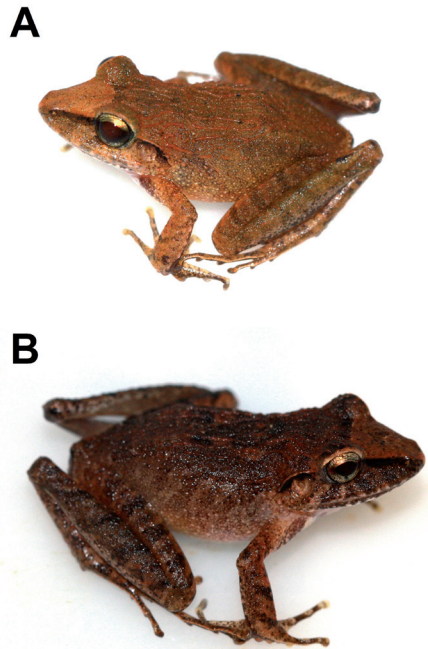
## Advertisement call of *Haddadus binotatus* (Spix, 1824) (Anura: Terrarana: Craugastoridae) from three localities in the State of Rio de Janeiro, with comments on its bioacoustic variability

Thiago Ribeiro de Carvalho <sup>1,2,3</sup> and Lucas Borges Martins <sup>1,2</sup>

*Haddadus binotatus* is a New World direct-developing frog (Terrarana) (Hedges et al., 2008) distributed throughout the Atlantic Forest from northeastern (State of Bahia) to southern (State of Rio Grande do Sul) Brazil (Sluys and Rocha, 2008). The advertisement call of *H. binotatus* was unknown until the beginning of this year, when two studies described concomitantly the advertisement call of this species from (i) southeastern Brazil, eastern State of Minas Gerais (Moura, Lacerda and Feio, 2012), and (ii) northeastern Brazil, southern State of Bahia (Dias, Lourenço-de-Moraes and Solé, 2012), so that interpopulational comparisons could not be performed.

It was hypothesized that *H. binotatus* might actually represent a species complex (Ribeiro, Egito and Haddad, 2005; Forlani et al., 2010). In this context, Dias, Lourenço-de-Moraes and Solé (2012) suggested that the acquirement of further bioacoustic data might clarify the taxonomic status of populations assigned to *H. binotatus* along its distribution range. The type locality of *H. binotatus* is still not clearly determined, it was assumed to be in the State of Rio de Janeiro according to Bokermann (1966) though. Thus, the advertisement call based on topotypes of *H. binotatus* would be essential to make conclusive comparisons concerning the taxonomic status of its populations.

Herein we describe the advertisement call of *H. binotatus* from three different localities in the State of Rio de Janeiro, its putative type locality (Bokermann, 1966), as well as from one locality in southeastern State of Minas Gerais, and make bioacoustic comparisons among topotypic populations of *H. binotatus* and additional populations with described calls from eastern State of Minas Gerais (Moura, Lacerda and Feio, 2012) and southern State

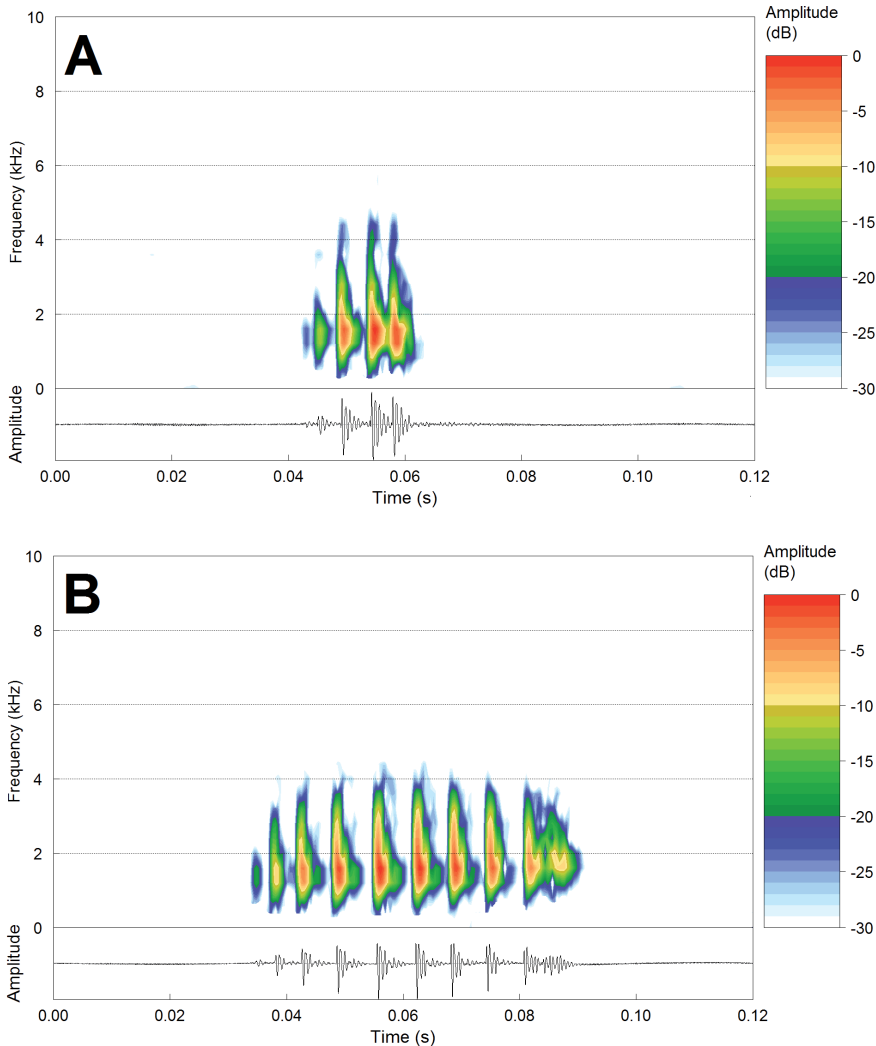


**Figure 1.** Adult male specimens of *Haddadus binotatus* in life. A - Voucher AAG-UFU 0700 (Municipality of Duas Barras, State of Rio de Janeiro, Brazil), SVL = 35.4 mm; B - Voucher AAG-UFU 0745 (Municipality of Trajano de Moraes, State of Rio de Janeiro, Brazil), SVL = 34.4 mm.

<sup>1</sup> Laboratório de Taxonomia, Sistemática e Ecologia Comportamental de Anuros Neotropicais. Faculdade de Ciências Integradas do Pontal, Universidade Federal de Uberlândia (UFU), Rua 20 n° 1.600 - Bairro Tupã, 38.304-402, Ituiutaba, MG, Brazil

<sup>2</sup> Programa de Pós-Graduação em Biologia Comparada, Universidade de São Paulo, Departamento de Biologia/FFCLRP. Avenida dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, São Paulo, Brazil.

<sup>3</sup> Corresponding author: thiago\_decarvalho@yahoo.com.br



**Figure 2.** Audiospectrograms (above) and corresponding oscillograms (below) of the advertisement call of *Haddadus binotatus* from the State of Rio de Janeiro, Brazil. A - Five-pulse call from the Municipality of Duas Barras, voucher AAG-UFU 0700. Record file: *Haddadus binotatus*Duas\_BarrasRJ1bTRC\_AAGmt, 21:06h, 6 December 2011, air 19.9°C; B - Ten-pulse call from the District of Maria Mendonça, voucher AAG-UFU 0745. Record file: *Haddadus binotatus*Maria\_MendonçaRJ1aTRC\_AAGmt, 21:03h, 14 December 2011, air 20.2°C.

of Bahia (Dias, Lourenço-de-Moraes and Solé, 2012).

Vocalizations were obtained in the Municipalities of Duas Barras (22°06'S, 42°35'W; approximately 930 m a.s.l.), Nova Friburgo (22°09'S, 42°31'W; approximately 1100 m a.s.l.), and Trajano de Morais (District of Maria Mendonça; 22°11'S, 42°11'W; approximately 870 m a.s.l.), three localities with remnants of the Atlantic Forest in the State of Rio de Janeiro, as well as in the Municipality of Chiador (21°55'S, 42°51'W; approximately 580 m a.s.l.), Serra da Mantiqueira mountain range in the State of Minas Gerais, near the Rio de Janeiro State border.

Vocalizations were recorded with a digital recorder (M-audio Microtrack II) set at 48.0 kHz sample rate and 16 bits resolution, coupled to a directional microphone (Sennheiser K6/ME66). Bioacoustic variables were analyzed with Soundruler software v. 0.9.6.0 (Gridi-Papp, 2007). Settings were Hanning window, 90% overlap, and 256 points resolution (FFT); sound graphs were obtained with Seewave version 1.6 (Sueur, Albin and Simonis, 2008), R (version 2.13) package (R Development Core Team, 2011); Seewave settings were Hanning window, 85% overlap, and 128

**Table 1.** Advertisement call variables of *H. binotatus* from six Brazilian localities: State of Rio de Janeiro, Municipalities of Duas Barras, Nova Friburgo, and Trajano de Moraes; State of Minas Gerais, Municipality of Chiador (Serra da Mantiqueira mountain range), and Serra do Brigadeiro mountain range [extracted from Moura, Lacerda and Feio (2012)]; State of Bahia, Municipality of Camacan [extracted from Dias, Lourenço-de-Moraes and Solé (2012)]. Values are Mean  $\pm$  Standard Deviation (Minimum–Maximum); N = Number of males recorded (number of advertisement calls analyzed).

Bioacoustic variables	Rio de Janeiro		Maria Mendonça N=1 (13)	Minas Gerais		Bahia Camacan N=3 (60)
	Duas Barras N=2 (35)	Nova Friburgo N=1 (11)		Chiador N=2 (10)	Brigadeiro N=1 (16)	
Call duration (ms)	23.7 $\pm$ 2.2 (18–34)	25.8 $\pm$ 3.8 (20–33)	46.7 $\pm$ 13.3 (21–57)	20.3 $\pm$ 3.4 (16–25)	14.94 $\pm$ 1.44 (10–16)	21 $\pm$ 6 (12–33)
Intercall interval (s)	23.0 $\pm$ 10.7 (2–47)	32.0 $\pm$ 14.1 (17–61)	10.7 $\pm$ 17.6 (2–46)	47.3 $\pm$ 21.7 (24–111)	—	31.9 $\pm$ 17.1 (16–100)
Pulses/call	5.2 $\pm$ 0.9 (4–8)	4.1 $\pm$ 0.8 (3–6)	7.9 $\pm$ 2.1 (3–10)	4.1 $\pm$ 0.1 (4–5)	3.93 $\pm$ 0.2 (3–4)	(3–6)
Call rate (calls/minute)	2.3 $\pm$ 0.5 (1–4)	2.0 $\pm$ 0.8 (1–3)	2.0 $\pm$ 0.0 (2)	1.3 $\pm$ 0.4 (1–2)	—	1.3 $\pm$ 0.4 (1–2)
Dominant frequency (kHz)	1.58 $\pm$ 0.16 (1.41–1.69)	1.31 $\pm$ 0.10 (1.22–1.41)	1.44 $\pm$ 0.10 (1.22–1.59)	1.62 $\pm$ 0.04 (1.59–1.78)	1.68 $\pm$ 0.17 (1.55–2.23)	1.17 $\pm$ 0.12 (1.33–1.46)

points resolution (FFT). Call terminology follows Duellman and Trueb (1994). Voucher specimens of the recordings are deposited in the Collection of frogs of the Universidade Federal the Uberlândia (AAG-UFU) as follows: AAG-UFU 0676–0677 (Chiador, Minas Gerais); AAG-UFU 0700 (Duas Barras, Rio de Janeiro); AAG-UFU 0735 (Nova Friburgo, Rio de Janeiro); and AAG-UFU 0745 (Trajano de Moraes, Rio de Janeiro).

Males of *H. binotatus* (Figure 1) were calling after nightfall, perched on vegetation at approximately 0.5–1.5 m in height at the border or inside the forest. We visited all localities in September and December/2011, and March/2012, but we only heard males in calling activity in December/2011, peak of the rainy season at those localities.

Advertisement call description was based on recordings of six males (N = 69 advertisement calls). Advertisement call of *H. binotatus* (Table 1; Figure 2) consists of a short note with very low sound intensity composed of 3–10 pulses/call (mean 5.1, SD = 1.5). Advertisement call is emitted at a rate of 1–4 calls/minute (mean 1.8, SD = 0.5). Call duration was 16–57 ms (mean 26.7, SD = 10.2) with intercall interval of 2–111 s (mean 30.6, SD = 18.2). Dominant frequency was 1.22–1.78 kHz (mean 1.52, SD = 0.14). Pulses have a descendent amplitude modulation along their extent. In contrast, notes have an ascendant amplitude modulation, similarly to the call description presented in Moura et al. (2012), except in longer notes, in which the peak of sound amplitude is centered, and the last half of notes have a descendent amplitude modulation. We observed that some males emitted several calls per minute (>15 calls/minute) at the study localities. It is important to report this variability, since it could not been registered among our recordings.

Izecksohn and Carvalho-e-Silva (2001) reported the advertisement call of *H. binotatus* from the State of Rio de Janeiro as consisting of ‘whistled calls’, but a formal description or sound graphs were not provided. Based on recordings from three populations of *H. binotatus* in the State of Rio de Janeiro (and unrecorded males - Municipality of Macaé; 22°18’S, 41°59’W; at approximately sea level), we can assure that the advertisement call of *H. binotatus* is actually pulsed, quite different from the description provided by these authors.

Our data is in accordance with those recently published in Dias, Lourenço-de-Moraes and Solé (2012) and Moura, Lacerda and Feio (2012), and the possibility raised in Dias, Lourenço-de-Moraes and Solé (2012) that the advertisement call of *H. binotatus* from the State of Rio de Janeiro should possibly differ from that from the State of Bahia might probably be an issue caused by the previous brief and inconclusive description of the advertisement call of *H. binotatus* provided in Izecksohn and Carvalho-e-Silva (2001).

Bioacoustic information available until the present moment might support the assumption that populations with advertisement calls described should probably be assigned to *H. binotatus* (our data; Dias, Lourenço-de-Moraes and Solé, 2012; Moura, Lacerda and Feio, 2012). The slight differences among the advertisement calls available of all six populations (Table 1), such as the longer call duration in the specimen from Maria Mendonça, the shorter call duration in the specimen from the Serra do Brigadeiro mountain range, and the relatively lower dominant frequency among the specimens from Camacan (State of Bahia), with the frequency bandwidth often divided in two bands (only one band in the others), should probably

be attributed to individual/population variability.

A more thorough bioacoustic evaluation of the advertisement call variability along the distribution range of *H. binotatus* taking into account other sources of taxonomic evidence (morphology and molecular approaches), as well as a better characterization of *H. plicifer* (Boulenger, 1888) (known only from the holotype), should be performed so as to determine whether the name *H. binotatus* in fact represent a species complex.

**Acknowledgements.** Grants by Coordenação de Aperfeiçoamento de Pessoal do Nível Superior (CAPES) (TRC) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (LBM). Special thanks go to Mirco Solé and Ariovaldo A. Giaretta for reading critically the manuscript.

## References

- Bokermann, W.C.A. (1966): Lista Anotada das Localidades Tipo de Anfíbios Brasileiros. São Paulo, Serviço de Documentação RUSP.
- Dias, I.R., Lourenço-de-Moraes, R., Solé, M. (2012): Description of the advertisement call and morphometry of *Haddadus binotatus* (Spix, 1824) from a population from southern Bahia, Brazil. *North-western Journal of Zoology* **8**(1): 107-111.
- Duellman, W.E., Trueb, L. (1994): *Biology of Amphibians*. Baltimore, Maryland, The Johns Hopkins University Press.
- Forlani, M.C., Bernardo, P.H., Haddad, C.B.F., Zaher, H. (2010): Herpetofauna of the Carlos Botelho State Park, São Paulo State, Brazil. *Biota Neotropica* **10**: 265-309.
- Gridi-Papp, M. (2007): Sound Ruler, version 0.9.6.0. Available at: <http://soundruler.sourceforge.net>. Last accessed on 4 May 2012.
- Hedges, S.B., Duellman, W.E., Heinicke, M.P. (2008): New World direct-developing frogs (Anura: Terrarana): Molecular phylogeny, classification, biogeography, and conservation. *Zootaxa* **1737**: 1-182.
- Izecksohn, E., Carvalho-e-Silva, S.P. (2001): *Anfíbios do Município do Rio de Janeiro*. Rio de Janeiro, Editora UFRJ.
- Moura, M.R., Lacerda, J.V.A., Feio, R.N. (2012): The advertisement call of *Haddadus binotatus* (Spix, 1824) (Anura: Craugastoridae). *Zootaxa* **3224**: 67-68.
- R Development Core Team (2011) R Foundation for Statistical Computing. Vienna, Austria. Available at: <http://www.R-project.org>. Last accessed on 4 May 2012.
- Ribeiro, R.S., Egito, G.T.B.T., Haddad, C.F.B. (2005): Chave de identificação: anfíbios anuros da vertente de Jundiá da Serra do Japi, Estado de São Paulo. *Biota Neotropica* **5**: 235-247.
- Sluys, M.V., Rocha, C.F. (2008): *Haddadus binotatus*, IUCN Red List of Threatened species. Available at: <http://www.iucnredlist.org/apps/redlist/details/56463/0>. Last accessed on 4 May 2012.
- Sueur, J., Aubin, T., Simonis, C. (2008): Seewave, a free modular tool for sound analysis and synthesis. *Bioacoustics* **18**: 213-226.