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REDISCOVERY, DISTRIBUTION EXTENSION AND NATURAL HISTORY NOTES OF *HYLODES BABAX* (ANURA, HYLODIDAE) WITH COMMENTS ON SOUTHEASTERN BRAZIL BIOGEOGRAPHY

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Abstract. Herein we report the rediscovery of the torrent frog *Hylodes babax,* a species considered as "Data Deficient", based on specimens from two new localities: Parque Estadual da Serra do Brigadeiro, in the Mantiqueira mountain range, and Floresta Estadual do Uaimií, in the southern Espinhaço mountain range, both conservation units in the State of Minas Gerais, southeastern Brazil. These records are the first for the species outside of its type locality. FLOE Uaimií is also the most inland record for *H. babax.* Notes on its natural history and comments about biogeography in southeastern Brazil are also presented.

Keywords. Geographic distribution; Biogeography; Conservation; *Hylodes babax;* Espinhaço mountain range; Mantiqueira mountain range.

Introduction

The genus *Hylodes* Fitzinger, 1826 currently comprises 24 species (Frost, 2009) that commonly exhibit diurnal behavior and are associated with rheophilic habitats in the Brazilian Atlantic Forest (Haddad and Pombal, 1995; Canedo, 2008), with the exception of *Hylodes otavioi* and *H. uai,* that inhabit riparian forests in rocky meadows of Serra do Cipó, State of Minas Gerais, Brazil (Sazima and Bokermann, 1982; Haddad and Pombal, 1995; Nascimento *et al.,* 2001; Canedo, 2008).

Most species of *Hylodes* are distributed in the states of Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo, Brazil. This fact might be due to the concentration of researchers in this region leading to an increment in the number of expeditions for collection purposes in these states. The distribution of this genus may also be related to the geological history of this area effecting the fauna and flora (Almeida and Carneiro 1998; Silva and Benmanman, 2008).

Hylodes babax was described based on two specimens from Parque Nacional do Caparaó, State of Minas Gerais, Brazil, *ca.* 1200 m above sea level (Heyer, 1982). This species is considered as "Data Deficient", due to the lack of information on its occurrence and biology (Rocha *et al.,* 2004).

The present study extends the distribution of *Hylodes babax,* and provides information about its natural history and biogeography.

Material and Methods

Data were collected during anuran monitoring projects in two protected areas in the State of Minas Gerais, southeastern Brazil. The Parque Estadual da Serra do Brigadeiro (PESB), located in the Mantiqueira mountain range, Zona da Mata of Minas Gerais, is part of the Atlantic Forest domain (*sensu* Ab'Sabner, 1977), including the Rio Doce and Rio Paraíba do Sul river basins. The park has an area of about 15,000 ha and includes the municipalities of Araponga, Fervedouro, Miradouro, Ervália, Sericita, Pedra Bonita, Muriaé and Divino (Feio *et al.,* 2008).

The Floresta Estadual do Uaimií (FLOE Uaimií) is located in the southern part of the Espinhaço mountain range, including the Quadrilátero Ferrífero (Alvarenga *et al.,* 1997), in the Rio São Francisco basin. This protected area covers about 4,400 ha, in a transition area of remnants of Atlantic Forest and Cerrado (rocky meadows or campos rupestres). Located in the municipality of Ouro Preto, Minas Gerais, the FLOE Uaimií is part of the Área de Proteção Ambiental (APA) Cachoeira das Andorinhas (IEF, 2008).

Measurements of the specimens were taken for the following characters: snout-vent length (SVL); head length (HL); head width (HW); eye-nostril distance (END); thigh length (THL); tibia length (TBL); foot length (FL). All measurements (in mm) were taken with calipers to the nearest 0.01 mm, and follow Cei (1980).

Vocalizations of specimens from PESB were recorded with an Aiwa tp-460® tape recorder. The recording of the advertisement call of individuals observed in FLOE Uaimií was made with a digital recorder, Panasonic RR-US450®. Calls were analyzed with AVISOFT-SASLab Light for Windows (v. 3.74) and SoundRuler (V. 0.9.4.1). Audiospectrograms were produced with the following parameters: *FFT* = 256, *Frame* = 100, *Overlap* = 75, and flat top filter. The sonogram, oscillogram, and power spectrum were analyzed in SoundRuler (V. 0.9.4.1). Terminology follows Duellman and Trueb (1994) and Tárano (2001). Voucher specimens (MZUFV 8139, 8140, 8274, 10226-10228) are housed in the herpetological collection of Museu de Zoologia João Moojen, Universidade Federal de Viçosa (MZUFV), Viçosa, state of Minas Gerais, Brazil.

Results and Discussion

Three males of *Hylodes babax* were captured on 20 December 2007 (first and second specimens) and 28 January 2008 (third) in a permanent stream of sandy and stony bed, named Riacho do Moinho, in Parque Estadual da Serra do Brigadeiro (20°43'13"S, 42°28'43"W; 1350 m a.s.l.), near the administrative building, in the central region of the park. The margins of the stream present a predominantly bushy vegetation with a prominence of ferns besides a superficial leaf litter. Individuals were observed from 13:00 to 16:00 h. When they were collected, the sky was cloudy (it had rained throughout the week), and the air temperature was 18°C. Males called hidden beneath rocks, in wet places on the margins of the stream.

On 14 December 2009, at approximately 10:00 h, in Floresta Estadual do Uaimií (20°29'66"S, 43°57'47"W; 1021 m a.s.l.), six individuals of *H. babax* were observed calling on the leaf litter along the margins of a permanent stream with a sandy and stony bed named Riacho do Mata Pau, one of the tributaries of Rio das Velhas, in a secondary forest area. The margins present predominantly bushy vegetation, with presence of grass and leaf litter. Specimens were calling about 12 meters from each other. We collected three specimens (MZUFV 10226-10228). Although air temperature was not registered, the climatic conditions were similar to the previous day, that had a maximum temperature of 20.2°C.

Specimens from PESB (Fig. 1A and 1B) and FLOE Uaimií (Fig. 2A and 2B) showed the same characteristics presented in the diagnosis of *Hylodes babax* (Heyer, 1982). They were also compared with the species holotype (MZUSP 57949) to confirm identification. Both specimens from PESB and FLOE Uaimií possess ventral surfaces of the body predominantly dark with large irregular white blotches, and the lower surface of the thigh brick red, the gular region the same color as vent, demarcated from the dorsal coloration by light pinstripes extending from the tip of the snout over the eye to the upper groin. Despite the similarities found among specimens, we noted a small variation in the morphology of the species. Individuals from PESB and FLOE Uaimií presented a more smooth dorsal texture, with small pebble-like granulations, than the holotype. However, due to the preservation conditions and the time kept in preservative some characteristics of the holotype may not be easily visualized and identified. The morphometric characters are present in Table 1.

Advertisement calls were recorded for a specimen from PESB (Fig. 3) and another from FLOE Uaimií (Fig. 4). The call from PESB has the following characteristics: duration of 0.33-0.43 s ($\overline{X}$ = 0.399 ± 0.0381, n = 12), five to seven notes ($\overline{X}$ = 5.8) with harmonic structure, each note with duration of 0.02-0.06 s ($\overline{X}$ = 0.045 ± 0.007, n = 17) and mean note rate of 13.55 (notes/s). The dominant frequency is between 4652-5005 Hz ($\overline{X}$ = 4755.4 ± 118.2, n = 12). The call from FLOE Uaimií presented a duration of 0.24-0.28 s ($\overline{X}$ = 0.27 ± 0.013, n = 10) and three or four notes ($\overline{X}$ = 3.9 ± 0.01 n = 13), each one with a duration of 0.03-0.07 s ($\overline{X}$ = 0.053), and mean rate of notes of 14.4 (notes/s). The dominant frequency is between 4318-5065 Hz ($\overline{X}$ = 4630.7 ± 263.4, n = 10) .

Advertisement calls of individuals from PESB and FLOE Uaimií are similar to that described by Heyer (1982) (Table 2). However, the call of *H. babax* from the new localities has fewer notes per call (5-7 and 3-4 notes, respectively) in relation to the type series from Caparaó (4-8 notes). Despite the differences in the number of notes per call, the dominant frequency is similar for all three populations. The dominant frequency is species-specific, and is a characteristic of anuran calls considered to be stable (Gerhardt and Davis, 1998; Bee *et al.,* 2001). The differences in the number of notes may be the result of distinct populations related to environmental conditions, and/or behavioral characteristics of the individuals recorded, as observed in *Hylodes phyllodes* (Hartmann *et al.,* 2006). Besides the morphologic similarities and the characteristics of the advertisement call, biogeographically, the populations from PESB and Caparaó

Table 1. Characters: snout-vent length (SVL); head length (HL); head width (HW); eye-nostril distance (END); thigh length (THL); tibia length (TBL); foot length (FL). Measurements were taken for the following. (A) Parque Nacional do Caparaó (holotype), (B) Parque Estadual da Serra do Brigadeiro, (C) Floresta Estadual do Uaimií.

Specimens	Characters						
	SVL	HL	HW	END	THL	TBL	FL
MZUSP – 57949 (A)	29.9	11.1	9.5	2.5	15.7	16.9	15.2
MZUFV – 8139 (B)	31.7	10.1	9.2	3.8	14.9	18.5	16.7
MZUFV – 8140 (B)	32.3	9.7	10.0	3.4	16.8	19.0	17.2
MZUFV – 8274 (B)	33.2	11.8	10.2	2.5	16.6	18.6	17.0
MZUFV – 10226 (C)	30.8	11.1	9.3	2.4	22.1	18.1	16.7
MZUFV – 10227 (C)	31.6	11.2	9.7	2.5	16.6	17.5	15.6
MZUFV – 10228 (C)	31.0	11.2	9.7	2.5	16.4	19.0	17.1

are linked by a continuous elevation from 700 to 1000 m above sea level.

Species with restricted distributions, related physiologically, occupying the same environmental physiognomy in different mountain ranges (Espinhaço and Mantiqueira), suggest biogeographic homologies and raise speculations about the influence of the geomorphologic evolution in the speciation patterns of anurans (Nascimento *et al.,* 2005; Cruz and Feio, 2007). Although separated by the slope of the Rio Doce valley, the septentrional portion of the Serra da Mantiqueira may be closer to the Quadrilátero Ferrífero. Similarities among the distribution of the amphibians in these mountain ranges are evident, such as *Physalaemus maximus* (Baeta *et al.,* 2005), *Scinax luizotavioi* (Nascimento *et al.,* 2004) and now *Hylodes babax*. The Atlantic Forest populations of the genus *Thoropa* (Cope, 1865) inhabiting occur in the mountains of the interior of the State of Minas Gerais, are now isolated from the coastal Atlantic Forest, suggesting that these two regions were contiguous during the mid-Oligocene (Maxson and Heyer, 1982). Retraction events of the Atlantic Forest provoked the isolation of the populations from the

Figure 1. (A) Dorsal view and (B) ventral view of an adult male of *Hylodes babax* (MZUFV 8139; SVL 31,75 mm) collected in Parque Estadual da Serra do Brigadeiro, State of Minas Gerais, Brazil. Photos by D. J. Santana.

Figure 2. (A) Dorsal view and (B) ventral view of an adult male of *Hylodes babax* (MZUFV 8139; SVL 31.75 mm) collected in Floresta Estadual do Uaimií, State of Minas Gerais, Brazil. Photos by S. Mângia.

Table 2. Acoustic comparison between populations of *Hylodes babax* in Parque Estadual da Serra do Brigadeiro, in Floresta Estadual do Uaimií and Serra do Caparaó, State of Minas Gerais, Brazil.

Character	(PESB)	(FLOE Uaimií)	(Caparaó)
Call Duration (s)	0.33-0.43 ($\bar{X}$ = 0.39)	0.24-0.28 ($\bar{X}$ = 0.27)	0.23-0.48 ($\bar{X}$ = 0.36)
Num. Note/Call	5-7 ($\bar{X}$ = 5.8)	3-4 ($\bar{X}$ = 3.9)	4-8 ($\bar{X}$ = 6)
Rate notes (note/sec)	10.5-16.4 ($\bar{X}$ = 13.55)	14.4	16
Note duration	0.02-0.06 ($\bar{X}$= 0.048)	0.03-0.07 ($\bar{X}$ = 0.053)	0.04-0.05
Call structure	Harmonic	Harmonic	Harmonic
Dominant Frequency (Hz)	4652.30-5005.83 ($\bar{X}$ = 4755.41)	4318.41-5064.76 ($\bar{X}$ = 4630.69)	(4690-5420)
Note modulation	Ascending modulation	Ascending modulation	Ascending modulation

Espinhaço Complex, which could have contributed to the speciation of a new species, *Thoropa megatympanum,* assuming a relictual distribution for this species, as suggested by Maxson and Heyer (1982). Around the middle of the Oligocene, the Espinhaço arose in the Atlantic rainforest domain, and would have been covered by extensive forests (Maxson and Heyer, 1982; Heyer, 1999).

The discovery of *Hylodes babax* in PESB and FLOE Uaimií, ca. 28 years after its description, provides the first records of the species outside its type locality, extending ca. 80 km southeast and ca. 180 km west the distribution of the species, respectively. FLOE Uaimií is the most inland record, and specimens from PESB were found at 1,350 m above sea level, 150 m higher than Caparaó (1200 m a.s.l.) (Fig. 5). Nascimento *et al.* (2001) consider *Hylodes otavioi* and *H. uai* as the most inland species of the genus. Herein we include *H. babax* in this group, since it occurs in the Espinhaço mountain range. With

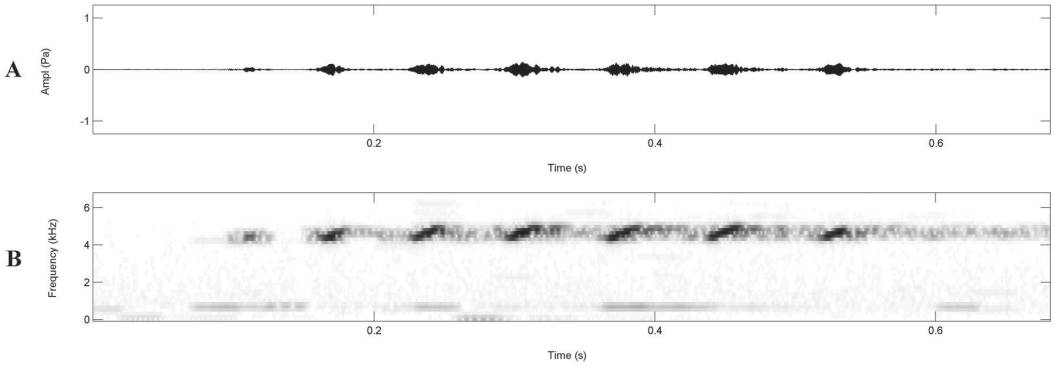

Figure 3. Advertisement call of *Hylodes babax* from Parque Estadual da Serra do Brigadeiro, State of Minas Gerais, Brazil: (A) oscillogram and (B) audiospectrogram of a single call (air temperature 18°C).

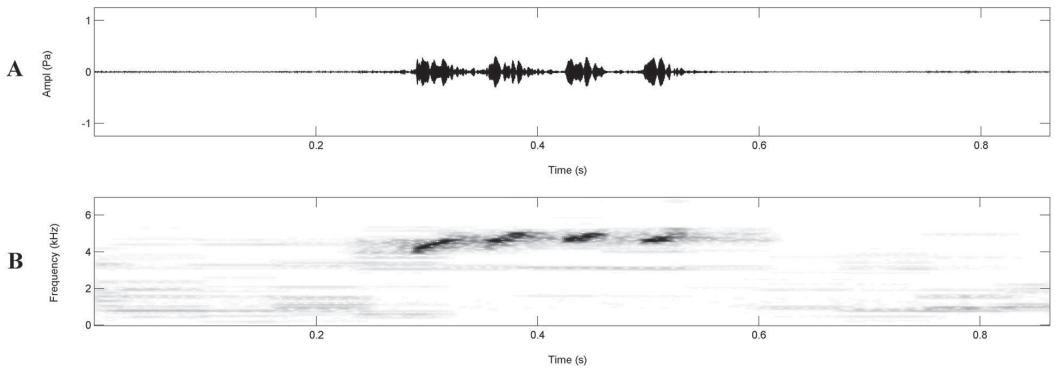

Figure 4. Advertisement call of *Hylodes babax* from Floresta Estadual do Uaimií, State of Minas Gerais, Brazil: (A) oscillogram and (B) audiospectrogram of a single call.

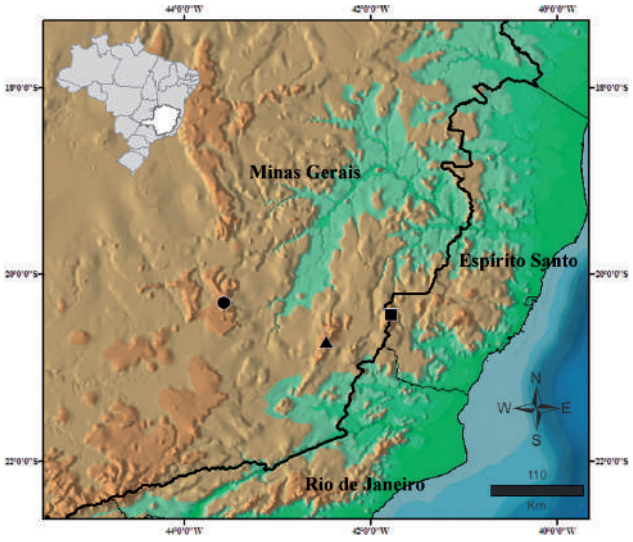

Figure 5. Distribution map of *Hylodes babax* in southeastern Brazil. ■ (Parque Nacional do Caparaó (Type locality), ▲ Parque Estadual da Serra do Brigadeiro and ● Floresta Estadual do Uaimií (new records), State of Minas Gerais, Brazil.

the data presented here, we add information to the knowledge of *Hyodes babax,* a data deficient species (Rocha *et al.,* 2004).

Resumo

No presente trabalho relatamos a redescoberta de *Hylodes babax,* uma espécie considerada "deficiente de dados", baseados em espécimes provenientes de duas novas localidades: Parque Estadual da Serra do Brigadeiro, na Serra da Mantiqueira, e Floresta Estadual do Uaimií, no sul da Serra do Espinhaço, ambas são unidades de conservação no Estado de Minas Gerais, sudeste do Brasil. Estes registros são os primeiros para a espécie fora da sua localidade tipo. FLOE Uaimií é também o registro mais interiorano para *H. babax.* Notas sobre a sua história natural e comentários sobre a biogeografia no sudeste do Brasil também são apresentadas.

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