Habitat use by the pumpkin toadlet, *Brachycephalus ephippium* (Anura, Brachycephalidae), in the Atlantic Rain Forest of Brazil

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Resumen: La ocupación del hábitat y el comportamiento circadiano de las especies a menudo están relacionados con las condiciones ambientales. El objetivo de este trabajo es describir el uso de los hábitats y la actividad circadiana en el anuro *Brachycephalus ephippium* en el estado de Rio de Janeiro, Brasil. Se observó la frecuencia de ocupación de seis hábitats y se analizaron las diferencias entre las estaciones seca y lluviosa. El análisis causal de ocupación mostró un período de actividad de siete horas, con diferencias según los hábitats. La incidencia de luz natural resultó un factor importante en el período de actividad de la especie. Sugerimos que la especie es un buen bioindicador ya que las características del hábitat (e.g., cobertura arbórea) afectan directamente la incidencia de luz natural y ello puede afectar la ocupación de *B. ephippium*.

Originally, the Atlantic Forest occupied 1.5 million km^2 and in mid-2000 it was reduced to only 7% of its original area (Myers *et al.*, 2000; Tabarelli *et al.*, 2005). Scientific concerns over ecosystems and biomes disappearance made researchers discover in frogs natural allies that can indicate the quality of the environment (Becker *et al.*, 2007; Dixo *et al.*, 2009; Hayes *et al.*, 2010; Toledo *et al.*, 2010). The amphibian *Brachycephalus ephippium* (Spix, 1824) is a small orange or chrome-yellow frog (Figure 1), with about 2 cm in snout-vent length and only two functional fingers and three toes (Izecksohn & Carvalho-e-Silva, 2001), and has its type locality in the municipality of Piquete, São Paulo, Brazil (Bokermann, 1966).

The genus *Brachycephalus* is endemic from the region ranging from the state of Espírito Santo to Paraná (Pombal-Jr *et al.*, 1998;

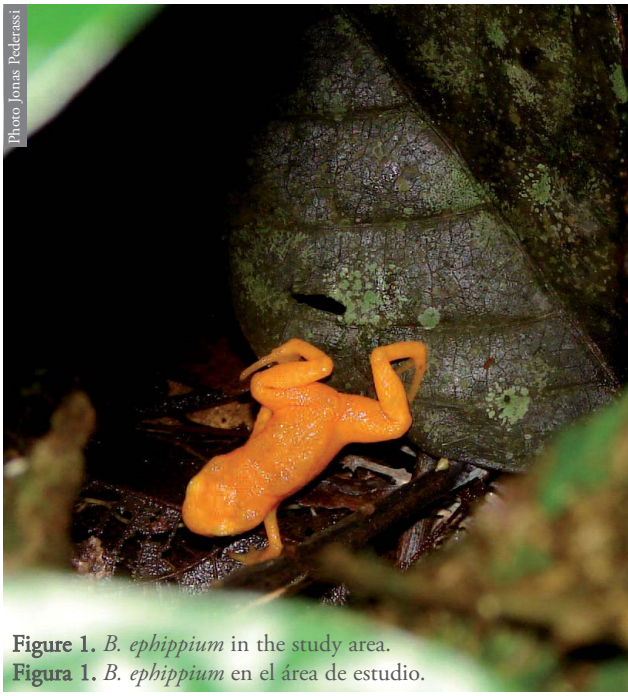

Figure 1. *B. ephippium* in the study area.
Figura 1. *B. ephippium* en el área de estudio.

Pombal-Jr & Izecksohn, 2011), being the species *B. ephippium* currently distributed in mountainous regions of the Atlantic Forest in Rio de Janeiro, São Paulo and Minas Gerais (Frost, 2013). As for its natural history, it is a species restricted to mature forests where it inhabits the leaf litter (Pombal-Jr *et al.*, 1994; Pombal-Jr, 1999, 2003, 2010; IUCN, 2011).

Although the basic natural history of *B. ephippium* has been studied in Brazil, its dynamic behavioral occupation of the environment has not been examined yet. In this study, we describe habitat uses of *B. ephippium*, to identify and determine the relationship between the abiotic elements and the occupational behavior of *B. ephippium*.

The study area was included inside the Parque Estadual Cunhambebe (Cunhambebe State Park), in the state of Rio de Janeiro, Brazil. The Park has an area of 380 km^2, corresponding to four municipalities: Mangaratiba, Angra dos Reis, Rio Claro and Itaguaí. The specific area of study corresponds to 1 km^2 within the park located in Angra dos Reis (22°53'S / 44°14'W – Datum UD55; 635 masl). Eight field visits per year were conducted between 2008 and 2009, on January (rainy season) and July (dry season), accumulating a total of 192 hours of sampling effort. During the fieldwork, we recorded the habitat type where individuals were observed, considering for the study six different categories: (1) shrubs, (2) litter, (3) bromeliads, (4) tree trunks on soil, (5) under leaf litter, and (6) in burrows. Additionally, two abiotic conditions were recorded: relative humidity and temperature. Relative humidity (RH) and temperature were measured using the thermo-hygrometer Instrutherm® with a precision ± 5% RH and ± 1°C respectively.

The constancy of habitat occupation of *B. ephippium* was determined by C = (*p*.100) / N, where *p* is the number of times the species was found in one specific habitat and N is the total sample that was made in transects (Bodenheimer, 1955 Apud Neto *et al.* 1976). The presence of the species per habitat was considered Constant (C > 50%), Accessory (50% > C > 25%) and Accidental (C < 25%). To test if habitat use differed between dry and wet season, constancy of habitat occupation was analyzed using a Student's *t*-test. For casual or probabilistic analysis of the occupational behavior, we modeled the variables using Poisson distribution ($pr(x) = \mu^x e^{-\mu} / x!$) in Excel. The decay of the hypothesis was measured through a χ^2 test. Biotic and abiotic correlations were tested using the nonparametric Spearman correlation coefficient.

With the biotic and abiotic data collected during the rainy season we developed an ecological model of habitat occupation for *B. ephippium*. The model was developed using the software Vensim® (Ventana Systems, 2013), which created the mathematical equations, algorithms and the causal diagram.

We observed 37 individuals of *B. ephippium* and its habitat use in the study area was constant under leaf litter, accessory on shrub and litter, and accidental on bromeliads, tree trunks on soil, and in burrows. The record of two amplexus under the leaf litter supports the condition of this habitat as the most common for the species in the area. According to Student's t-test, the constancy of occupation of habitats by *B. ephippium* was not different between the dry and rainy season ($t_{15} = 0.28$; $P = 0.57$). This result is partially in concordance with a previous study which showed that these diurnal frogs occupied bushes, drifting over the burlap when the RH reaches 100% and remaining in the leaf litter during the dry season (Pombal-Jr. *et al.*, 1994). Our measures of RH varied between 77.1% and 98% (dry and wet season respectively). No

correlations were detected between the habitat categories considered and the abiotic factor measured (R^2 = 0.19 to temperature and R^2 = 0.057 to relative humidity).

The two amplexus observed were like the ones previously described: initially inguinal and later becoming axillary (Pombal-Jr *et al.*, 1994). The exposure period of the species was only diurnal (between 8 a.m. and 3 p.m.) indicating a correlation between daily temperature increases and the species exposure to the environment which, in this study, ranged between 16.5ºC and 26.9°C (R^2 = 0.93, 21.48 ± 3.37°C).

When we applied the observation period of each occupied habitat to the Poisson model, we grouped a seven-hour probability of occurrence where *B. ephippium* would be successively viewed in each habitat: 1.16 hour on shrubs, 0.19 hour on the litter, 0.05 hour on bromeliads, 0.66 hour on tree trunk on soil; 3.67 hours under leaf litter and 1.33 hour in burrow.

When we compare the exposure periods to the habitat constancy of occupation, we found equivalent results. However, the use of the term "accidental" should be considered as a consequence of the short-time occupation and not a randomness condition. The values predicted by the model did not differ in relation to the observed data (χ^2_6 = 0.47; P = 0.92). When we build the ecological model based on the collected data, we observed that rainy or dry conditions do not interfere in the species occurrence. According to the Poisson probability model for both sampling periods, the specimen occupation, as a function of the environments, did not present any changes. The habitat behavior of occupancy for the sample period of drought and increased rainfall across the two years of study is linked to the course of a 24-h day.

A causal diagram of occupational dynamics by *B. ephippium* is supported by the model, which features key elements (daytime and night time) and the period element limited to a 24-hour cycle. The causal diagram shows the circadian cycle of *B. ephippium* in the studied area (Figure 2). The ecological interaction dynamics of *B. ephippium*, over a 24-hour cycle, points, according to the model, to a daily cycle that starts at 8 a.m. in the morning and continues until 3 p.m., reducing the activity in the afternoon (Figure 3). Interestingly, the light starts to reduce at 3 p.m. because of the forest canopy and, meanwhile, the activity of the species is reduced. The habitat occupa-

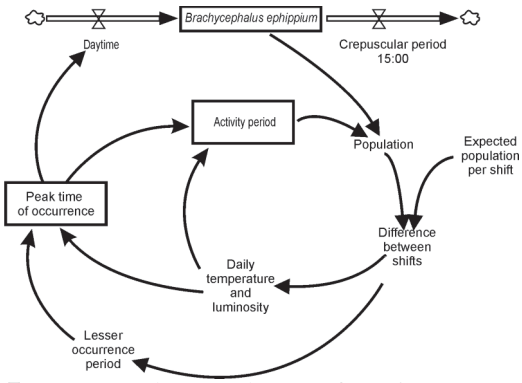

Figure 2. Causal activity diagram of *B. ephippium*.
Figura 2. Diagrama de actividad causal de *B. ephippium*. Flux/flujo: ⧗→; Connectors/-es: ⤳; Stock: ▭

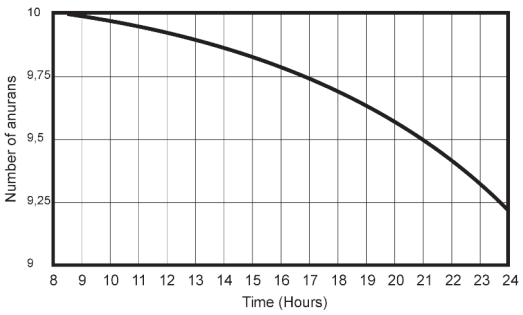

Figure 3. Activity model of *B. ephippium* in a 24-h cycle.
Figura 3. Modelo de actividad de *B. ephippium* en un ciclo de 24 h.

tion systematically starts at 8 a.m. in the morning of the following day, when the light penetrates the canopy and reaches the litter. It is not possible to record the presence of this species until 8 a.m. next morning.

The presence and absence of light seems to influence the circadian rhythm of *B. ephippium*, affecting its occupational behavior of a submontane tropical moist Atlantic Forest covered with leaf litter. Several species exhibited circadian behavior, i.e. 24 hours cycles related to light and dark phases during the day (Murphy & Campbell, 1996). These cycles are influenced by photoperiod oscillations that reflect the endogenous aspect of the intrinsic circadian behavior together with endogenous oscillations that reflect intrinsic expressions of the circadian behavior, also called biological clocks (Oster *et al.*, 2003). The physiologies of many species may alter, before the environmental changes, through their endogenous cycles related to light and dark phases (Daan *et al.*, 2001). The endogenous circadian rhythms makes physiological and behavioral resources necessarily / efficiently projected, providing responses for the imminent environmental changes (Shine & Lambeck, 1990; Paranjpe & Sharma, 2005).

The dynamics of occupation by *B. ephippium*, its intricate relationship with forests and its diurnal behavioral activity cycle attest to the condition of this species as an environmental indicator of occupied areas: the modification of these environments (i.e. canopy) may affect light and dark phases consequently impacting the perpetuation of the species.

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Depredación de *Malpolon mospessulanus* sobre *Tarentola chazaliae*

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Malpolon monspessulanus es un ofidio que se distribuye por el Mediterráneo Occidental. Se trata de un depredador que en la región del Magreb habita principalmente en ambientes mediterráneos, evitando las zonas desérticas del este y sureste de Marruecos (Jiménez & Martínez del Marmol, 2013).

El día 6 de abril de 2013 se localizó un ejemplar adulto de *M. monspessulanus* atropellado recientemente en la carretera entre las localidades de SidiR'bat y Massa, Agadir, Marruecos (UTM 29R 0436044-3328266). La zona está situada a unos 3 km de la línea costera y a 70 msnm, en un ambiente de llanos semidesérticos costeros dominados por arbustos de pequeño y mediano porte pertenecientes a los géneros *Ononis*, *Suaeda*, *Launaea*, *Artemisia* y *Helianthemum*. El ejemplar poseía una longitud hocico – cola de 71 cm de y una coloración típica de los ejemplares de la forma del sur de país, *M. m. saharatlanticus*, descrita por Geniez, Cluchier & De Haan, (2006). En su estómago se halló un ejemplar de *Tarentola chazaliaeaun* sin digerir (Figura 1).

T. chazaliaees una especie endémica de la región oceánica del Sahara Occidental, distribuida desde Agadir hasta el norte de Senegal (González de la Vega, 2013; Wilms, *et al.*, 2013). De esta forma la distribución de ambas especies se solapan en su límite meridional para *M. monspessulanus* y septentrional para *T. chazaliae* (Bons & Geniez, 1996). En la Península Ibérica, la dieta de *M. monspessulanus* es muy

Figura 1. Ejemplar de *T. chazaliae* hallado en el interior de un ejemplar de *M. monspessulanus*.