Phyllomedusa spp. (Anura, Hylidae): predation by *Leptodeira annulata* (Serpentes, Dipsadidae)

Bruno T. M. Nascimento[1,5], Manuel Mejia[2], Mike Ellis[3] e Fábio Maffei[4]

1 Universidade Sagrado Coração. Rua Irmã Arminda, nº 1.050, Vila Brunhari, CEP 17011-160, Bauru, São Paulo, Brasil. E-mail: tayarbio@gmail.com
2 Universidade de Exeter, Cornwall Campus, Penryn, United Kingdom.
3 Reserva Ecológica Jama-Coaque, Manabí, Ecuador.
4 Departamento de Zoologia, Instituto de Biociências de Botucatu, Universidade Estadual Paulista. Distrito de Rubião Júnior, CEP 18618-000, Botucatu, SP, Brasil.
5 Corresponding author.

Leptodeira annulata (Linnaeus, 1758) is one of the most common snakes in the Americas and is found from southern Mexico to Argentina under various subspecies (Dunn, 1936; Duellman, 1958; Scrocchi, 1980). It measures up to 600 mm from snout to vent and is nocturnal and semi-arboreal (Vitt, 1996; Ávila and Morais, 2007). It is a generalist known to feed on lizards (Duellman, 1958; Martins and Oliveira, 1998; Pizzatto and Singer, 2008), especially in the dry season, when the frogs are not active (Duellman, 1958), other snakes in captivity (Skehan, 1959; Petzoldh, 1969) and nature (Pizzatto and Cantor, 2008) and mainly frogs, which apparently correspond to most of the diet of this specie. *Leptodeira annulata* is known to prey on frogs at all stages of development: eggs of the subfamily Phyllomedusinae, specifically *Phyllomedusa* sp. (Duellman,

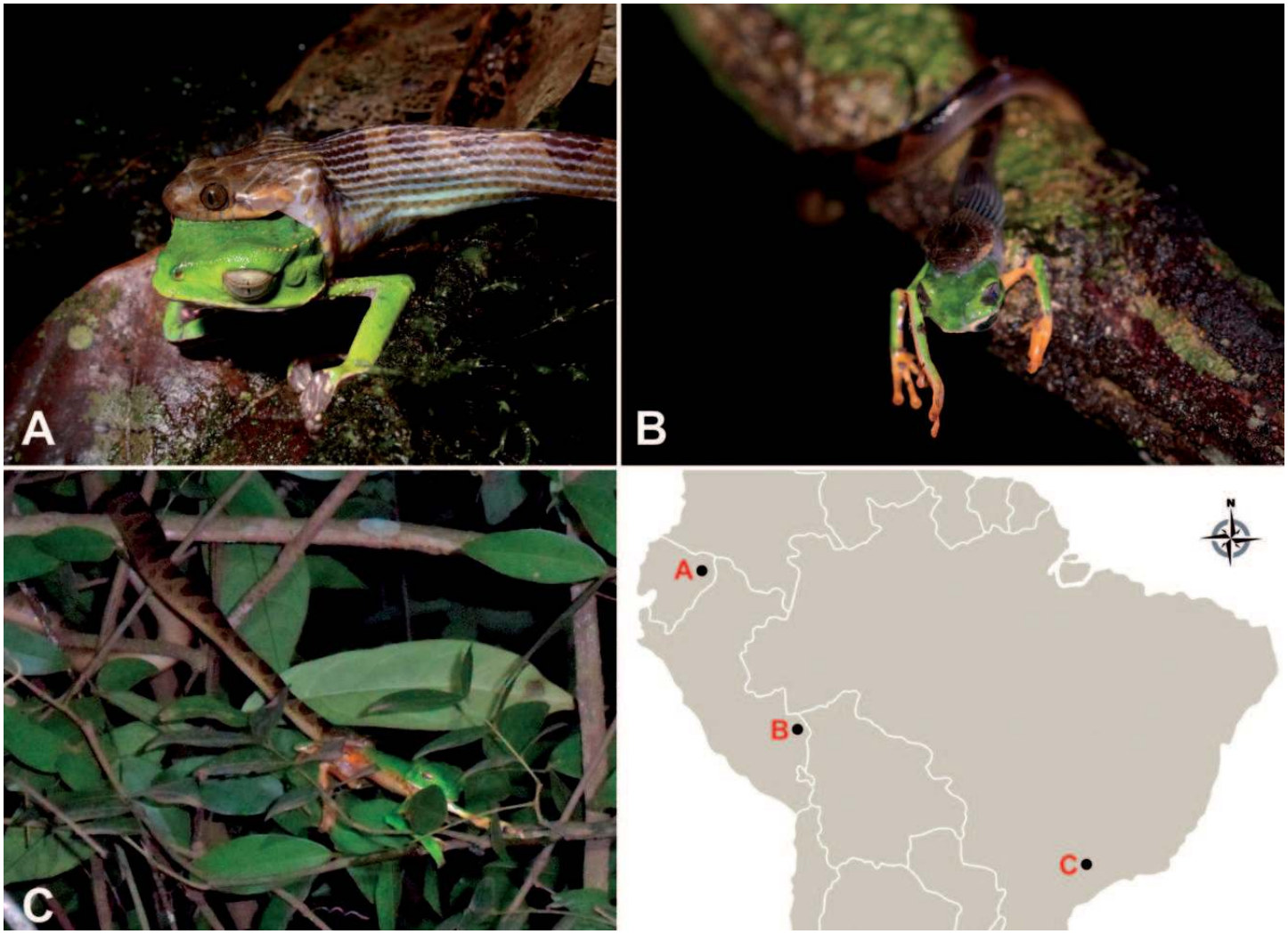

Figure 1: Preys of *Leptodeira annulata:* **(A)** *Phyllomedusa vaillanti* in Yasuni National Park, Ecuador (Photo: Manuel Mejia); **(B)** *Phyllomedusa tomopterna* in Tambopata National Reserve, Peru (Photo: Mike Ellis); **(C)** *Phyllomedusa tetraploidea* in Lençóis Paulista, Brazil (Photo: Tiago Gazoni); and map showing localities from events.

Table 1: Review adult frog species predated by *Leptodeira annulata*.

Prey	Locality	Reference
Bufonidae		
Bufonidae spp.	Southeastern and Central Brazil	Cantor and Pizzatto, 2008
Incilius coccifer	Guanacaste, Costa Rica	McDiarmid and Foster, 1981
Incilius marmoreus	Tehuantepec, Oaxaca, Mexico	Turner, 1958
Incilius valliceps	Santa Cecilia, Ecuador	Duellman, 1958
Rhinella (Bufo) granulosa	Amazon	Vitt, 1996
Rhinella granulosa	Corumbá, Mato Grosso do Sul State, Brazil	Ávila and Morais, 2007
Rhinella margaritifera	Not specified	Duellman, 1958
Rhinella marina	Not specified	Duellman, 1958
Rhinella ornata	Guapimirim, Rio de Janeiro State, Brazil	Vrcibradic *et al.,* 2007
Rhinella sp.	Not specified	Duellman, 1958
Hylidae		
"Hyla" spp.	Not specified	Duellman, 1958
Cruziohyla craspedopus	Amazon Peru	Lamar, 2007
Dendropsophus bokermanni	Santa Cecilia, Ecuador	Duellman, 1978
Dendropsophus marmoratus	Santa Cecilia, Ecuador	Duellman, 1978
Dendropsophus parviceps	Santa Cecilia, Ecuador	Duellman, 1978
Dendropsophus robertmertensi	Not specified	Duellman, 1958
Hylidae spp.	Southeastern and Central Brazil	Cantor and Pizzatto, 2008
Hypsiboas boans	Not specified	Duellman, 1958
Hypsiboas lanciformis	Santa Cecilia, Ecuador	Duellman, 1978
Hypsiboas rosenbergi	Costa Rica	Kluge, 1981
Osteocephalus sp.	Manaus, Amazonas State, Brazil	Martins and Oliveira, 1998
Osteocephalus taurinus	Lucas do Rio Verde, Mato Grosso State, Brazil	Campos *et al.,* 2011
Osteocephalus taurinus	Tarapoto, Peru	Hagman and Schulte, 2007
Phyllomedusa tetraploidea	Lençóis Paulista, São Paulo State, Brazil	Present study
Phyllomedusa tomopterna	Tambopata N. R., Puerto Maldonado, Peru	Present study
Phyllomedusa vaillanti	National Park Yasuni, Orellana, Ecuador	Present study
Scinax boesemani	Amazon	Vitt, 1996
Scinax ruber	Espigão do Oeste, Rondônia State, Brazil	Bernarde and Abe, 2010
Scinax ruber	Not specified	Duellman, 1958
Scinax ruber	Urupá, Rondônia State, Brazil	Silva and Silva, 2010
Scinax staufferi	Not specified	Duellman, 1958
Smilisca baudinii	Catemaco Lake, Veracruz, Mexico	Turner, 1958
Trachycephalus typhonius	Not specified	Duellman, 1958
Leptodactylidae		
Leptodactylidae spp.	Southeastern and Central Brazil	Cantor and Pizzatto, 2008
Leptodactylus andreae	Amazon	Vitt, 1996
Leptodactylus bufonius	Not specified	Duellman, 1958
Leptodactylus fuscus	Amazon	Vitt, 1996
Leptodactylus fuscus	Not specified	Duellman, 1958
Leptodactylus latrans	Not specified	Duellman, 1958
Leptodactylus melanonotus	Not specified	Duellman, 1958
Leptodactylus mystaceus	Amazon	Vitt, 1996
Leptodactylus mystaceus	São Gabriel da Cachoeira, Amazonas State, Brazil	Carvalho *et al.,* 2007
Leptodactylus sp.	Manaus, Amazonas State, Brazil	Martins and Oliveira, 1998
Leptodactylus spp.	Not specified	Duellman, 1958
Microhylidae		
Chiasmocleis panamensis	Gamboa, Panama	Crawford, 2007
Elachistocleis magnus	Espigão do Oeste, Rondônia State, Brazil	Bernarde and Abe, 2010
Synapturanus rabus	Amazon	Vitt, 1996
Ranidae		
Lithobates palmipes	Not specified	Duellman, 1958
Lithobates pipiens	Not specified	Duellman, 1958
Lithobates vaillanti	Laguna Escondida, Veracruz, Mexico	Ramirez *et al.,* 1998
Lithobates vaillanti	Not specified	Mora, 1999
Strabomantidae		
"Eleutherodactylus" sp.	Amazon	Vitt, 1996
Pristimantis altamazonicus	Santa Cecilia, Ecuador	Duellman, 1978

1978), *P. tarsius* (Martins and Oliveira, 1998), *P. camba* (Bernarde and Abe, 2010) and *Agalychnis spurelli* (Vargas and Bolaños, 1999); tadpoles such as *Osteocephalus oophagus* (Jungfer and Weygoldt, 1999) and adult individuals from several species. Here we report the first records of *Leptodeira annulata* preying on adult individuals of three *Phyllomedusa* species and review of adult frog species predated by this snake.

On 24 October 2009 at 21:31 h, an individual *L. annulata* was found preying an adult *Phyllomedusa vaillanti*. The record was made next to a temporary pond within Yasuní National Park (00°40'16.7"S 76°24'1.8"W, a.s.l. 238 m) in Orellana Province, Ecuador. The snake was on the ground, swallowing the treefrog from behind (Figure 1A). The frog was still alive and dragging the snake. After about 15 minutes, the frog was completely swallowed by the snake. The water body was 1 m deep in the rainy season and the marshy bank was primarily composed of grasses, shrubs and trees in primary Amazon forest. Many frogs were regularly found in this puddle, including *Engystomops petersi, Rhinella margaritifera, Hypsiboas geographicus, H. fasciatus, H. lanciformis, Osteocephalus* sp., *Pristimantis* spp., *Bolitoglossa* sp. and several individuals of *P. vaillanti* and frogspawn.

On 2 February 2011 at around 23:00 h, we recorded one individual *L. annulata* preying an individual *Phyllomedusa tomopterna* from behind (Figure 1B). The event occurred in Tambopata National Reserve (12°50'12.16"S 69°17'36.31"W, a.s.l. 206 m), Puerto Maldonado, Peru, in an area of primary lowland Amazon forest. The snake was on a branch 2 m above the water of a temporary rainwater pond. The water body was about 2 m wide by 13 m long and 70 cm deep.

On 29 November 2011 at 23:12 h an individual *L. annulata* was found preying an individual *Phyllomedusa tetraploidea*. The snake was on a branch 4 m over water, swallowing the frog from behind (Figure 1C). The frog resisted for several minutes, holding tightly to a small branch, but was eventually swallowed. The record was made at Rio Claro Farm in Lençóis Paulista, São Paulo State, Brazil (22°46'35.47"S 48°53'52.54"W, a.s.l. 650 m) in riparian forest at the edge of a semi-permanent water body, in a transition area between the Cerrado and Atlantic Forest. *Phyllomedusa tetraploidea* are plentiful at the site and about 20 males were vocalizing the night of this record.

On December 04, 2012, at 23:15 h, in this same location a young male *L. annulata* was found chasing a male of *P. tetraploidea*. The treefrog was at a height of 1.5 m vocalizing over a wide sheet of a typical plant of the flooded areas. The snake slowly chased behind the anuran. After about 5 min the snake struck the bite, but the frog jumped turning back hitting the ground. After about 2 min, the snake fell to the ground where it went in the opposite direction of the treefrog. Minutes later, the treefrog returned to vocalize normally.

Records in the literature describe about 40 adult frog species in the diet of *L. annulata* (Table 1). These species are distributed in six families (Bufonidae, Hylidae, Leptodactylidae, Microhylidae, Ranidae, and Strabomantidae). Apparently, *L. annulata* has no preference for animals of arboreal or terrestrial habit. When it comes to the family Hylidae, most of species predated do not have large poison glands, but *Cruziohyla craspedopus, Smilisca baudinii* and *Trachycephalus typhonius,* which possess numerous well-developed venom glands (Duellman, 1956). *Leptodeira annulata* predation on adult *Phyllomedusa* spp. has not previously been reported and this may be associated with the poison found in the skin of these species. By releasing odors and fluid these frogs are considered highly unpleasant and are avoided by predators usual amphibians (Sazima, 1974). Treefrogs of Phyllomedusinae possess venom glands in the skin and secrete peptides such as bradykinin, which modifies cardiac function (Sazima, 1974; Zug et al, 1993), and dermorphin, a peptide that causes analgesia and catalepsy (Negri *et al.,* 1992). Sazima (1974) described in detail an experiment where most individuals of *Liophis miliaris* refused to consume *P. rhodei,* since those individuals that the snake showed visible signs of discomfort, and some later regurgitated the prey.

Toxins found in the skin of the three species of *Phyllomedusa* presented in this work may not be sufficient to avoid predation by *L. annulata*. This snake is an opisthoglyphous species, with relatively simple venom composition when compared with other poisons (Mebs, 1968). Thirteen species present on the list of prey have chemical defense. This snake is probably to the frogs' secretions, allowing predation on these species of frogs. Reports in the literature show that some snakes of the genus *Chironius* apparently have adaptations that minimize or eliminate the effects of peptides secreted by *Phyllomedusa*. Bernarde and Abe (2010) reported predation by *Chironius scurrulus* on *P. camba* and Castanho (1996) recorded *Chironius exoletus* preying on *P. distincta,* being some of the few known cases where snakes prey on adult frogs of the genus *Phyllomedusa*.

Our reports support current knowledge about both groups, but further studies are necessary to determine the relative contribution of *Phyllomedusa* spp. to *L. annulata* diets in the wild, and the mechanisms used by this species to avoid the effects of the frogs' chemical defenses.

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Aparasphenodon arapapa, Acuipe, Ilhéus, BA (Foto: M. Solé)