

SHORT COMMUNICATION

# Novel predator-prey interactions of *Rhinella major* (Anura: Bufonidae) from an urban area in northern Brazil

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Direct field observations of predator-prey interactions improve our knowledge about species niches and the ways in which vertebrate and invertebrate assemblages are structured, as well as aiding in the conservation of species (Vitt and Caldwell 2009, van den Burg and Miguel 2020). As anurans grow, the degree of capture specialization by type and size of prey changes (Donnelly 1991, Simon and Toft 1991), but the increase in prey size with ontogeny is more than a passive effect of selection for larger prey in some species of leaf-litter frogs (Lima *et al.* 2000). An organism's diet is influenced by its morphology, physiology, and behavior in response to selective pressures and phylogenetic constraints (Toft 1981, Duellman and Trueb 1994, Wells 2007, Solé *et al.* 2009). Anurans have been shown to be flexible predators in trophic chains (Toledo *et al.* 2007, Oliveira *et al.* 2013). Data on anuran's diet inform us about their life history, environmental conditions, and

the possible consequences of habitat alterations, in addition to as well as instructing us about the distributions of prey species and the reasons for fluctuations in anuran populations (Lips *et al.* 2005, López *et al.* 2015).

We report observations of feeding behavior of the Granular Toad, *Rhinella major* (Müller and Helmich, 1936), during its breeding season. Included in diet of this toad in an urban area in the municipality of Macapá, state of Amapá, Brazil are the anomalepidid blindsnake, *Typhlophis squamosus* (Schlegel, 1839), the Napo Tropical Bullfrog, *Adenomera hylaedactyla* (Cope, 1868), and the millipede *Asiomorpha coarctata* (De Saussure, 1860), and we provide additional comments on a possible potential prey item for this toad as a supplier of alkaloids.

*Rhinella major* is a terrestrial species of moderate size (SVL 35.8–72.8 mm in adult males and 33.9–81.1 mm in adult females); the species is a member of the *R. granulosa* Group and is widespread in the Chaco Region of Argentina, Paraguay, and Bolivia, and in open formations along the rivers Madeira, Beni, Amazonas, Tapajos, and Xingu in Brazil

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(Narvaes and Rodrigues 2009, Frost 2020). In Amapá state, the species is abundant in urban and disturbed areas (Pedroso-Santos pers. obs.). Although relatively abundant throughout Amazonia, data on diet of *R. major* are sparse in the literature; however, predatory activity in this species has been reported (Pedroso-Santos *et al.* 2019).

*Typhlophis squamosus* (Schlegel, 1839) is a small snake no longer than about 30 cm (Fraga *et al.* 2013); it is widely distributed across the Guiana Shield (Hoogmoed 1979) and abundant in the Amazon Basin (Amaral 1978) and in urban areas (Marques *et al.* 2009). In the municipality of Macapá, this species has been observed leaving its fossorial habitats in urban areas at the end of the rainy season. Predation of this species is poorly described in the literature (Sazima and D'Angelo 2011). The leptodactylid *Adenomera hylaedactyla* (Cope, 1868) is a nocturnal frog ranging across Amazonian forests through the Guianas, in Colombia, Venezuela, Ecuador, Peru, Bolivia and Brazil (Frost 2020). According to Kokubum and Sousa (2008), this species usually is associated with primary and secondary forest, forest edges, and savannah, but it can be found in areas of open vegetation, such as stream and river edges.

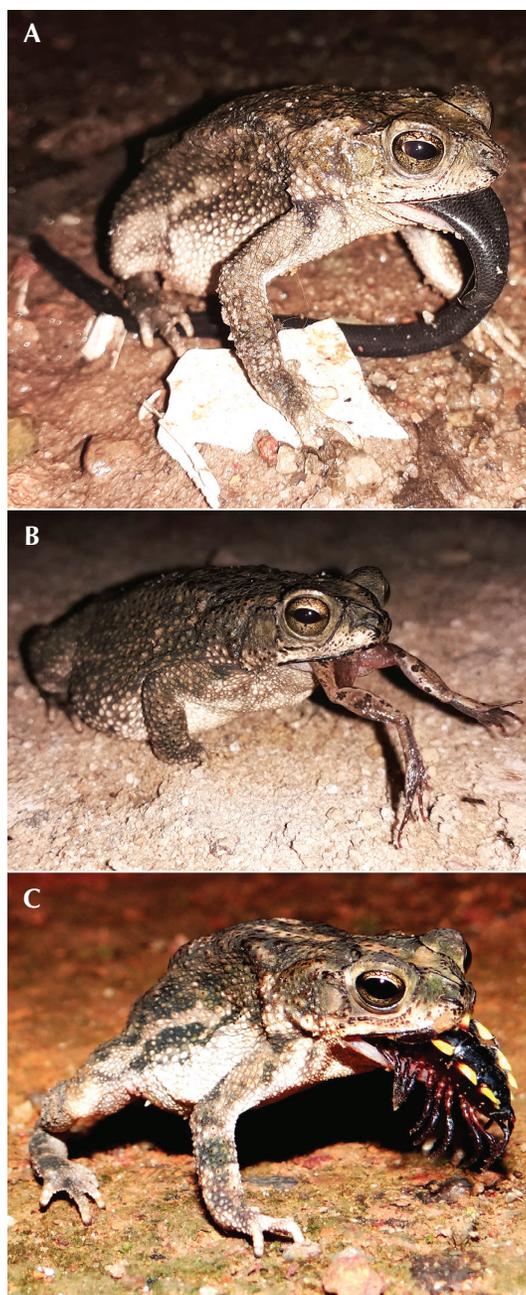
The predator-prey interactions of *Rhinella major* were observed during its breeding period on 27 October and 17 November 2019 in a auditory survey of amphibians in an urban area in the municipality of Macapá in the state of Amapá (0.0083° S, 51.0953° W; datum: WGS84; 7 m a.s.l.) in the extreme north of Brazil. According to the Köppen-Geiger classification (Alvares *et al.* 2013), the area is characterized by an equatorial climate with annual precipitation of 2850 mm, concentrated between February and May (average ~ 400 mm per month) and average annual temperatures ranging from 27.6–41.0 °C.

Rather than collecting the toads, we photographed them and deposited the images in the Herpetological Collection of the Universidade Federal do Amapá (photographic vouchers CECCAMPOS 0001-0002). The species could

be identified confidently by its diagnostic characters (Narvaes and Rodrigues 2009) evident in these photographs and in our field notes. The prey items were identified as *Typhlophis squamosus* applying the diagnosis of Kok and Fuenmayor (2008) and *Adenomera hylaedactyla* following the morphological traits described by Angulo and Icochea (2010).

The first observation occurred at 20:35 h. It took place approximately 10 m from the margin of a small puddle, and lasted about 11 min. One of us observed a female *Rhinella major* with a *Typhlophis squamosus* in its mouth (Figure 1A) on the ground and close to fragments of PVC pipe. The body parts of the blindsnake protruding from the toad's mouth were moving. During the observation, the toad moved only a few times, positioning itself on the ground and positioning the prey in its mouth for consumption. After swallowing the prey, the toad inflated its lungs and blinked its eyes repeatedly, perhaps in response to expanding its gastrointestinal tract to accommodate the prey. At the same place, at about 21:57 h, FPS observed a female *R. major* preying on an *Adenomera hylaedactyla* in the vicinity of conspecific vocalizing males. The prey must have been ingested headfirst because when we observed it, only the posterodorsal portion of the frog's body was visible (Figure 1B). While swallowing the frog, the toad quickly stretched one of its legs and blinked its eyes several times. This successful predation event lasted at about 8 min. In neither predation event was the prey regurgitated.

Bufonidae is one of the most widely distributed anuran families in the world (Sabagh and Carvalho-e-Silva 2008). Members of the family feed on arthropods and vertebrates such as amphibians, snakes, and rodents and bats occasionally; the toads also may ingest plant parts (pieces of leaves) (e.g., Quiroga *et al.* 2009, Silva *et al.* 2010, Chaves *et al.* 2012, Oliveira *et al.* 2017, Pedroso-Santos *et al.* 2019). Although invertebrates of the Class Diplopoda have been reported as prey items for *Rhinella* [e.g., *R. scitula* (Maragno and Souza 2011), *R. icterica*



**Figure 1.** Female *Rhinella major* ingesting (A) a blindsnake *Typhlophis squamosus* (CECCAMPOS 0001), (B) the leptodactylid frog *Adenomera hylaedactyla* (CECCAMPOS 0002), and (C) the millipede *Asiomorpha coarctata*.

(Sabagh and Carvalho-e-Silva 2008), and *R. schneideri* (Batista *et al.* 2011)], the authors do not discuss the importance of these invertebrates in the diets of these toads. Diets composed of ants and mites have been widely cited as a specialization in anurans to facilitate the uptake of alkaloids (Biavati *et al.* 2004, Wells 2007). However, some species of millipedes, including those with aposematic coloration, have toxic substances such as alkaloids and hydrogen cyanide (Roberts and Wink 1998) that also might be used by anurans.

We observed a female *Rhinella major* preying upon a millipede *Asiomorpha coarctata* (De Saussure, 1860) (Diplopoda: Paradoxosomatidae) with aposematic coloration (Figure 1C). We do not know if this invertebrate species has the potential to supply alkaloids to anurans in order to retain these toxins in their skin or in paratoid glands. The millipede was identified following the descriptions of Shelley and Lehtinen (1998) and Decker and Tertilt (2012). This millipede is known to cause epidermal lesions in humans (Haddad *et al.* 2000, Cardoso *et al.* 2003) and is widely distributed in urban areas (Shelley and Lehtinen 1998, 1999).

*Rhinella major* has been reported to prey on a lizard (*Hemidactylus mabouia*) in an urban area (Pedroso-Santos *et al.* 2019); no other reports of predation events were found. To our knowledge, the only other predator reported for *Typhlophis squamosus* is a bird (*Turdus leucomelas*; Sazima and D'Angelo 2011), also in a disturbed area, and *Adenomera hylaedactyla* is a prey item for snakes and spiders (e.g., Tavares-Pinheiro *et al.* 2019a,b), with few records for anurans. We suggest that in urban areas, *R. major* may forage opportunistically on larger prey, as observed by Pedroso-Santos *et al.* (2019), and that the practice may be more frequent during the toad's breeding period when the energy demand is higher. There may be a relationship between the consumption of larger prey and ontogeny, as well as quality of the composition of its diet (De-Carvalho *et al.* 2008, Sugai *et al.* 2012).

These observations may encourage future studies on the feeding ecology of *Rhinella major* because the potential of *Asiomorpha coarctata* as a prey supplying alkaloids will only be confirmed by additional diet data. We encourage researchers to seek additional information on the trophic ecology of *R. major*, particularly with regard to ontogenetic changes in the toad's diet. This report shows the importance of using opportunistic sampling methods to describe natural history by direct observations in the field and photographic records (Cullen *et al.* 2006).

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