REPTILES & AMPHIBIANS

Three Novel Prey Items and Two New Defensive Behaviors of the South American Sipo, *Chironius foveatus* (Squamata: Colubridae)

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The South American Sipo, *Chironius foveatus* Bailey 1955, is widely distributed throughout the Atlantic Forest, ranging from the central portion of the state of Bahia in the northeast to the far northeastern portion of the state of Rio Grande do Sul in the south (Dixon et al. 1993; Nogueira et al. 2019; Entiauspe-Neto et al. 2020). *Chironius foveatus* is primarily batrachophagous, with a diet comprising mainly anurans in the families Leptodactylidae and Hylidae (Dixon et al. 1993; Marques and Sazima 2004; Guimarães 2007; Hartmann et al. 2009; Roberto and Souza 2020), with hylids constituting about 84% of the anuran content found in stomachs of this species (Banci et al. 2022).

Certain morphological attributes and the high incidence of arboreal anurans in the diet infer a high degree of arboreality in *C. foveatus* (Guimarães et al. 2013; Banci et al. 2022). In fact, most of the defensive behaviors known for *C. foveatus* (e.g., lateral flattening, gaping, gular-inflation, head-triangulation and elevation, and neck S-coil) are frequent tactics in the antipredator repertoire of arboreal snakes (Greene 1979; Martins et al. 2008; Muscat and Entiauspe-Neto 2016; Banci et al. 2022).

Although the diet of *C. foveatus* consists mainly of hylids, most studies identify prey only to family; consequently, only four species of hylids are documented prey (Roberto and Souza 2020). We herein present three anuran species previously not known to be prey of *C. foveatus* and, in addition, note two novel defensive behaviors.

All observations were in the municipalities of Ubatuba and Caraguatatuba, about 30 km apart in the state of São Paulo in southeastern Brazil. Habitat at both sites is a mosaic of Atlantic Forest, an array of flooded secondary forests in

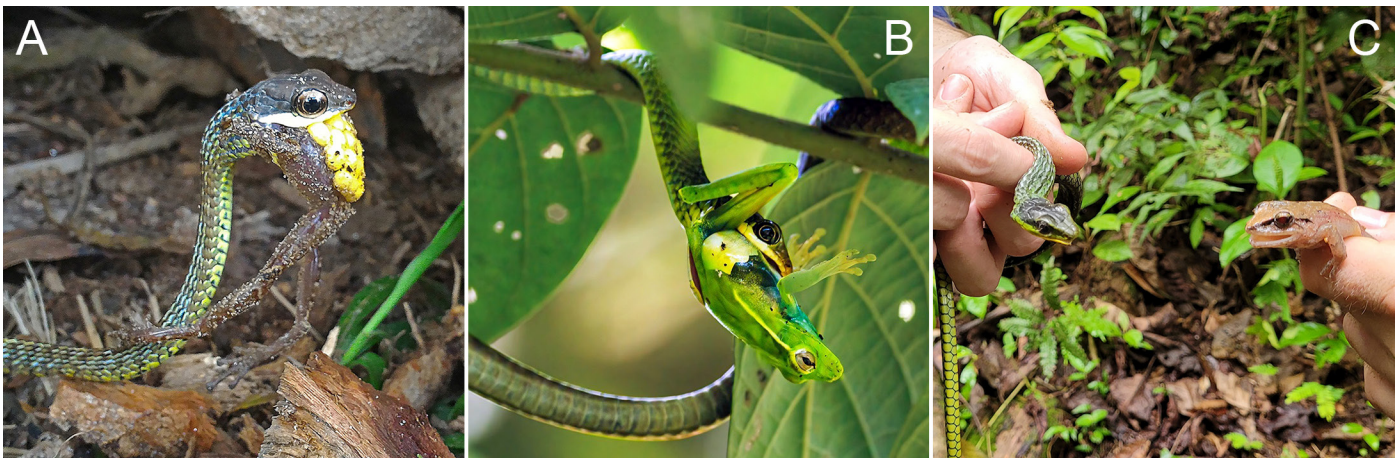

Figure 1. A juvenile South American Sipo (*Chironius foveatus*) ingesting an adult *Fritziana goeldii* on the ground (note the number of mature eggs on the back of the frog) (A); a juvenile *C. foveatus* capturing an adult *Boana albomarginata* (B); and an adult *C. foveatus* that had just regurgitated an adult *Haddadus binotatus* consumed on the ground (C). None of the animals were vouchered. Photographs by Miguel N. Neto (A), Alfonso Perez (B), and João A. Bachur (C).

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lowland areas, and patches of primary and secondary dry forests on steeper terrain. The climate in the area is characterized as humid subtropical (Cfa) with no pronounced seasonality (Rolim et al. 2007).

The first predation event took place at 1120 h on 26 August 2019 in the Parque Estadual da Serra do Mar–Núcleo Caraguatatuba (-23.59443, -45.42941; elev. 125 m asl), an approximately 36,000-hectare forest remnant. The encounter involved a juvenile *C. foveatus* ingesting an adult *Fritziana goeldii* (Boulenger 1895) (Hemiphractidae) with a number of mature eggs on its back (Fig. 1A). The snake was on the ground holding its prey by its head. Ingestion took about 10 minutes.

The second predation event was recorded at about 1030 h on 24 August 2023 about 1.8 m above the ground in a forest fragment of about 18 ha at Sítio Cantos da Floresta (-23.32922, -44.93083; elev. 50 m asl). This encounter involved a juvenile *C. foveatus* capturing an adult *Boana albomarginata* (Spix 1824) (Hylidae), which was discovered due to the frog's distress calls. The snake had its posterior body and tail around a tree branch while ingesting its prey (Fig. 1B). The frog had inflated its body and moved its hind- and forelimbs in an attempt to prevent ingestion. After about six minutes ingestion was nearly complete.

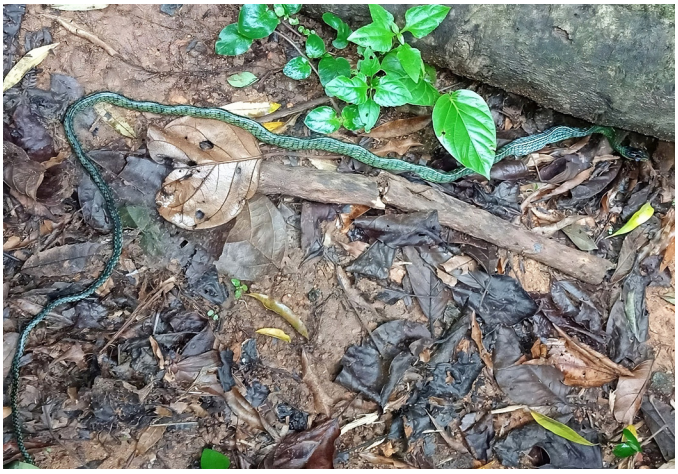

Figure 2. An adult South American Sipo (*Chironius foveatus*) (unvouchered) displaying body-bending behavior when approached closely. Photograph by Arthur D. Abegg.

Table 1. Recorded prey of the South American Sipo (*Chironius foveatus*).

Prey	Source
Amphibia: Anura	
Craugastoridae	
Haddadus binotatus (Spix 1824)	This study
Odontophrynidae	
Proceratophrys appendiculata (Günther 1873)	Rocha et al. (1999)
Hemiphractidae	
Fritziana goeldii (Boulenger 1895)	This study
Hylidae	
Boana albomarginata (Spix 1824)	This study
Boana faber (Wied-Neuwied 1821)	Hartmann et al. (2009)
Bokermannohyla circumdata (Cope 1871)	Rocha et al. (1999); Hartmann et al. (2009)
Bokermannohyla hylax (Heyer 1985)	Marques and Sazima (2004)
Itapotihyla langsdorffii (Duméril and Bibron 1841)	Marques and Sazima (2004)
Leptodactylidae	
Unidentified species	Dixon et al. (1993)
Reptilia: Squamata	
Gekkonidae	
Hemidactylus mabouia Moreau De Jonnès 1818	Guimarães (2007)
Aves: Passeriformes	
Thamnophilidae	
Drymophila squamata (Lichtenstein 1823)	Rodrigues and Noronha (2014)

The third event, at around 0930 h on 6 December 2023 in a 136-ha forest remnant at the Projeto Dacnis private reserve (-23.45916, -45.14305; elev. 25 m asl), involved both a novel defensive behavior and a new food item for *C. foveatus*. We found an adult *C. foveatus* motionless on the ground while performing body-bending behavior, an antipredator display not previously recorded for *C. foveatus* (Fig. 2). While we were recording the snake's size and weight, it regurgitated a recently ingested and still-living adult *Haddadus binotatus* (Spix 1824) (Craugastoridae) (Fig. 1C).

A second new defensive behavior for *C. foveatus* was observed on 29 October 2015, also in the Projeto Dacnis private reserve. An adult was found resting on a branch at night. It was captured in order to record morphological data and for thread-bobbin attachment (details in Banci et al. 2022). During the procedures, it exhibited five defensive behaviors: (1) repeated strikes; (2) gaping; (3) cloacal-discharge; (4) head-triangulation; and (5) body-rotation, the last of which had not been reported previously for *C. foveatus*.

These records increase the number of known prey species for *C. foveatus* to eleven (Table 1) and defensive behaviors exhibited by the species to eight (Table 2).

The observations reported herein both in arboreal and terrestrial substrates, reinforce the plasticity of microhabitat use previously reported by Hartmann et al. (2009) and Banci et al. (2022). Predation of arboreal anurans (*B. albomarginata* and *F. goeldii*; c.f., Haddad et al. 2013) both on and above the ground are of particularly interest. Although we do not yet have enough data to determine if *C. foveatus* forages primarily on or above the ground, our observations definitively confirm that this species uses both habitats when feeding.

Most of the defensive behaviors observed for *C. foveatus* in this study had been previously recorded and are expected components of the antipredator repertoire of arboreal snakes (Greene 1979; Martins et al. 2008; Banci et al. 2022). However, body-bending and body-rotation had not been reported (Marques et al. 2001, 2019; Muscat and Entiauspe-Neto 2016). The former is thought to be a mechanism in which snakes mimic branches or vines and thus evade the attention of potential predators (Edmunds 1974; Marques et al. 2006). In this case, the behavior had the desired effect, as the predominantly green snake went almost unnoticed even though it was on a partially contrasting brown substrate (Fig. 2). Although, as noted by Fagundes de França et al. (2020), our observation does not appear to support the hypothesis that body-bending is a physiological response by snakes at non-optimal body temperatures. In regard to body-rotation and considering that snakes in the genus *Chironius* have the world's highest rate of specimens in zoological collections with amputated tails (i.e., presumably due to pseudoautotomy; Moura et al. 2022), our observation is suggestive of the possibility that rotation might be responsible for those injuries.

Table 2. Recorded defensive behaviors of the South American Sipo (*Chironius foveatus*).

Defensive Behavior	Source
Biting	Marques et al. (2001)
Body-bending	This study
Body-rotation	This study
Cloacal-discharge	Marques et al. (2001)
Anterior body-elevation	Marques et al. (2001)
Gular-flattening	Marques et al. (2001)
Head-triangulation	Muscat and Entiauspe-Neto (2016)
Gaping	Marques et al. (2001)

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