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Diurnal and nocturnal predators of *Crossodactylus schmidti* Gallardo, 1961 (Anura, Hylodidae) in southern Brazil

Vinícius Matheus CALDART*, Samanta IOP,
Marcelo Carvalho da ROCHA and Sonia Zanini CECHIN

Universidade Federal de Santa Maria, Centro de Ciências Naturais e Exatas, Programa de Pós Graduação em Biodiversidade Animal. Av. Roraima s/ nº, Camobi. CEP 97105-900. Santa Maria, Rio Grande do Sul, Brazil.
* Corresponding author. Email: viniciuscaldart@yahoo.com.br

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Abstract. Frogs are part of the diet of many invertebrates, fish, reptiles, birds, mammals and even other species of amphibians. However, the natural predators of many species of frogs have not been documented in published reports. We report records of predation of *Crossodactylus schmidti* occurring in Turvo State Park, located in the northwestern region of Rio Grande do Sul state, southern Brazil. Four species preyed on adults of *C. schmidti*: two pit vipers, a spider and a crab. As part of the diet of diurnally and nocturnally active vertebrate and invertebrate predators, *C. schmidti* must play an important role in the stability of its predators' populations.

Key words: predation, *Crossodactylus schmidti, Bothrops jararacussu, Bothropoides jararaca, Phoneutria nigriventer*, *Trichodactylus kensleyi.*

Anuran amphibians play an important role in trophic relationships with other organisms, since they are a component of the diet of many invertebrates, fish, reptiles, birds, mammals and even other species of amphibians (Duellman & Trueb 1994, Toledo 2005, Toledo et al. 2007). Because frogs are part of the diet of such a variety of animals, predation exerts a central role in their ecology, affecting their population dynamics and acting as a selective pressure responsible for defensive behavior, activity patterns, choice of calling and oviposition sites, and parental care of eggs and larvae (Wells 2007). Records of predation events, however, are scarce for many anuran species, making it difficult to determine their natural predators and the possible influence of predators on their life history.

With 11 species, *Crossodactylus* is the second-largest genus of the family Hylodidae, and is distributed from northeastern to southern Brazil, southern Paraguay and northern Argentina (Frost 2010). The genus comprises three groups of species (Caramaschi & Sazima 1985), with the *C. gaudichaudii* group being the most numerous (seven species), followed by the *C. trachystomus* group (three species) and the monospecific group *C. schmidti*. *Crossodactylus schmidti* Gallardo, 1961 occurs in localities of mesophytic semideciduous forest in southern Paraguay, northern Argentina and southern Brazil (Caldart et al. 2010, Lucas & Garcia 2011). It inhabits streams, where it uses rocks as calling sites and from where it emits visual signals (Caldart et al. 2010). Adult males of *C. schmidti* have a snout-vent length of about 28.33 mm (Caldart et al. 2011).

From March 2009 to April 2010, populations of *C. schmidti* were studied at Turvo State Park (27°14'34.08"S, 53°57'13.74"W), located in the northwestern region of Rio Grande do Sul, southern Brazil. The park has a total area of 17,491.4 ha of mesophytic semideciduous forest. The local climate is subtropical sub-humid with a dry summer (ST SB v of Maluf, 2000), with temperatures above 22°C in the warmest month (January) and from -3°C to 18°C in the coldest month (July). Rainfall is evenly distributed throughout the year, with an annual mean of 1665 mm (SEMA 2005). The predation records were obtained by direct observations at the streams and by analysis of the stomach contents from a snake collected at the same site. This specimen was deposited in the Herpetological Collection of the Universidade Federal de Santa Maria (voucher: ZUFSM 2787).

Four species preyed on adults of *C. schmidti*: two species of pit vipers, *Bothrops jararacussu* Lacerda, 1884 and *Bothropoides jararaca* (Wied, 1824); a spider, *Phoneutria nigriventer* (Keyserling, 1891); and a crab, *Trichodactylus kensleyi* Rodríguez, 1992 (Fig. 1). Predation by *B. jararacussu* occurred on 13 October 2009, at 15:00 h (air temperature: 22.3°C). The record of predation by *B. jararaca* was obtained by analysis of the stomach contents of a specimen collected on 18 March 2009, at 18:20 h (air temperature: 21°C). Both snakes were juve-

niles (*B. jararacussu*: snout-vent length = 296 mm, caudal length = 42 mm, total length = 338 mm, mass = 11.5 g; *B. jararaca*: snout-vent length = 313 mm, caudal length = 45 mm, total length = 358 mm, mass = 18 g). The remaining predation records were made at night. Predation by a spider, *P. nigriventer*, occurred on 17 January 2010, at 02:30 h (air temperature: 24.2°C); and predation by a crab, *T. kensleyi*, was observed on 18 January 2010, at 22:11 h (air temperature: 23.7°C).

Spiders and crabs are among the most important invertebrate predators of amphibians, along with many aquatic bugs, larvae and adults of aquatic beetles, dragonfly naiads and several families of flies (Wells 2007). In the Neotropics, spiders that prey on adult and juvenile frogs include species of the families Pisauridae, Ctenidae, Lycosidae, Sparassidae and Theraphosidae (Menin et al. 2005). Spiders of the family Ctenidae, genus *Cupiennius*, were observed preying on adults of *Hylinobatrachium fleischmanni* (Boettger, 1893), *Espadarana prosoblepon* (Boettger, 1892) and species of *Eleutherodactylus* in Costa Rica (Hayes 1983, Szeliskowski 1985). In Brazil, the few records of ctenid spiders preying on frogs include the predation of *Anomaloglossus stepheni* (Martins, 1989) and *Leptodactylus andreae* Müller, 1923 by spiders of the genus *Ctenus* (Menin et al. 2005), and predation of *Dendropsophus elegans* (Weid-Neuwid, 1824) by the spider *P. nigriventer* (Santana et al. 2009). Spiders of the genus *Phoneutria* are nocturnal and capture their prey by waiting for them to approach (Rego et al. 2005). Due to their habits, these spiders likely feed on more frog species than are currently documented (Santana et al. 2009).

There is little information available about the biology and ecology of crabs of the family Trichodactylidae, which, in addition to marine species, comprises a wide variety of freshwater and semiterrestrial species occurring in the Neotropical region (Melo 2003). These crabs are considered omnivorous and nocturnal (Melo 2003). The freshwater crab *T. kensleyi* occurs along the basins of the Uruguay and lower Paraná rivers, in localities in Paraguay, Argentina and Uruguay, and in the Brazilian states of Santa Catarina and Rio Grande

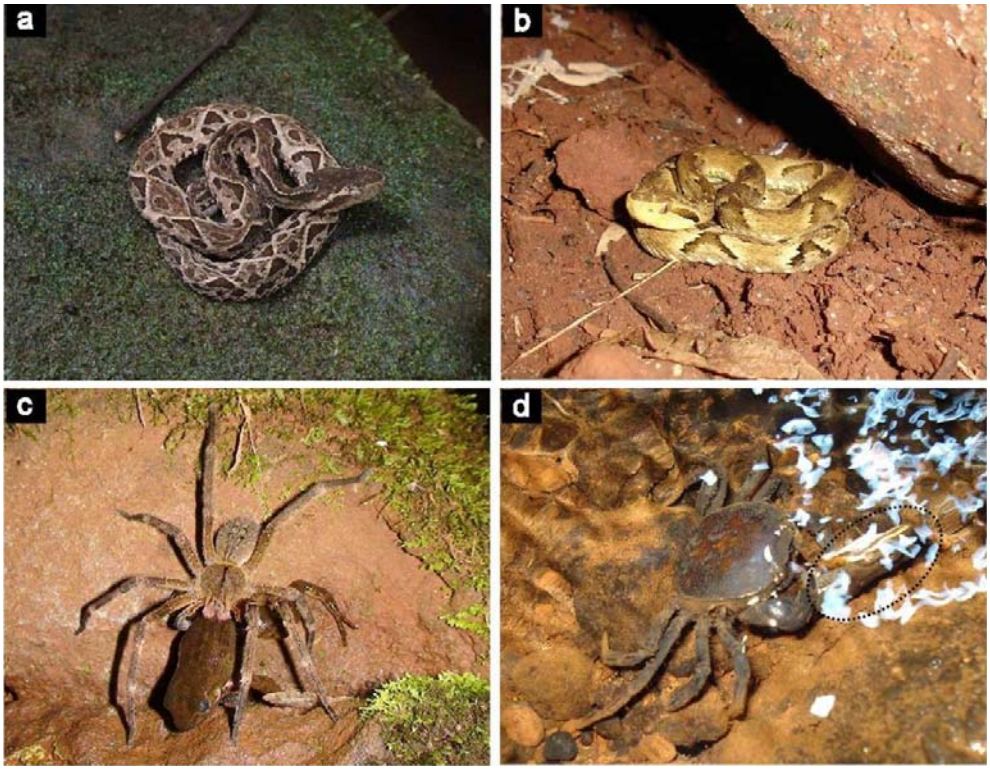

Figure 1. Predators of *Crossodactylus schmidti* in Turvo State Park, Rio Grande do Sul, southern Brazil: a) *Bothrops jararacussu*; b) *Bothropoides jararaca*; c) *Phoneutria nigriventer*; d) *Trichodactylus kensleyi*. Detail with the dashed circle indicating the individual of *C. schmidti* being preyed upon by the crab.

do Sul (Melo 2003). Because both *T. kensleyi* and *C. schmidti* have similar distributions and inhabit streams, it is possible that *T. kensleyi* often preys on *C. schmidti* in other localities.

Snakes that feed on frogs may capture their prey in different ways (Hartmann et al. 2009). Juveniles of the pit vipers *B. jararaca* and *B. jararacussu*, for example, prey on diurnal frogs on stream banks in southeastern Brazil (Hartmann et al. 2003). The same authors found species of *Hylodes*, in the stomachs of juveniles of *B. jararacussu* and *B. jararaca*. Later, Sazima (2006) studied the predator-prey relationship between *B. jararacussu*, *B. jararaca* and *Hylodes asper* (Müller, 1924), and suggested that the tail-luring behavior used by these juvenile pit vipers to attract frogs is favored by the visual signals that these frogs emit, since *H. asper* uses visual communication. The author suggested that this relationship may occur with other species of frogs that use visual communication and diurnal snakes that feed on frogs using tail-luring. We did not observe the behavior of tail-luring by juvenile pit vipers that preyed on *C. schmidti* (as explained above, one of the records was obtained by analysis of stomach contents; and in the other instance the snake had already caught the frog when found). However, it is likely that the snakes use tail-luring to attract individuals of *C. schmidti*, since these frogs use visual communication and are active during the day, the period in which they were preyed on by the juvenile pit vipers. In the municipality of Dona Francisca, Rio Grande do Sul, a juvenile of *B. jararaca* was observed performing tail-luring at the edge of a pond (Cechin, pers. comm. 2011). Future studies may clarify to what extent juveniles of pit vipers use tail-luring or ambushing to capture individuals of *C. schmidti*, and whether the type of behavior used is related to the abundance of *C. schmidti* in the streams.

Our records show that *C. schmidti* has natural predators that exhibit both diurnal and nocturnal activity. Although the species of Hylodidae are traditionally considered diurnal, our records of nocturnal predation of *C. schmidti* reinforce the idea that these frogs are active at night as well as during the day (Caldart et al. 2010, Caldart et al. 2011). This information is important for understanding the life history of *C. schmidti*, since individuals that are active both during the day and at night are exposed to a wider range of potential predators. Moreover, as part of the diet of both diurnally and nocturnally active vertebrate and invertebrate predators, *C. schmidti* must play an important role in the stability of their predators' populations.

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