Herpetology Notes, volume 11: 715-718 (2018) (published online on 26 August 2018)

Snakes vs. porcupines: when preys leave mortal injuries

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Predation is one of the strongest selective pressures in natural systems, molding behaviour, ecology, morphology, and even evolutionary history of potential prey species. Therefore, it is not surprising that living organisms exhibit many different defensive strategies. Vertebrates, for instance, have been targets of numerous studies focusing on predation performance (e.g., Sazima, 1989; Greene, 1997), alternative defensive behaviours among prey species, and morphological aspects of predator avoidance (e.g., Sazima, 1992; Toledo et al., 2011). As a result of this predator-prey arms-race (e.g., Abrams, 1986) and also due to energetic trade-offs related to allometric relationships (e.g., Brodie and Brodie, 1999; Toledo et al., 2007), predators must optimally select their prey items. They should not be too small, so that they may provide enough energy (in relation to the cost of hunting, capturing, subduing, and digesting), but also not too large for the predator to deal with (see Sazima and Martins, 1990).

The Brazilian pit viper *Bothrops jararaca*, commonly known as "jararaca", is a medium size snake species reaching up to 1.2 m of snout-vent length (SVL), widespread in the Atlantic Forest, mostly recorded in forested areas (Uetz et al., 2018). This terrestrial and nocturnal snake feeds on a variety of vertebrates prey including frogs, lizards, birds, mammals and some invertebrates while juvenile (e.g., Sazima, 1989; Marques et al., 2001; Martins et al., 2002). The jararaca, as most snake species, prey and swallow animals larger than them since their skull bones have the incredible capacity to distend and to attend the preys' size (Gans, 1961; Arnold, 1980). In such context, porcupines would be suitable prey for many snake species. However, their rigid quills are efficient defensive weapons that can be lethal to several predators, including snakes (Duarte, 2003).

The "Orange-spined Hairy Dwarf Porcupine" *Sphiggurus villosus* (family Erethizontidae) is a medium-sized mammal occurring mainly in the Atlantic Forest (Wilson and Reeder, 1993; Emmons and Feer, 1997). This biome is one of the world's biodiversity hotspots (Myers et al., 2000), and one of the most human-populated regions, with fragmented remnants in Brazil (Galindo-Leal and Câmara, 2003). Despite reports indicate that porcupines are solitary, nocturnal, and arboreal (Moojen, 1952; Emmons and Feer, 1997) they are still poorly known from a natural history perspective (Montgomery and Lubin, 1978; Roberts et al., 1985; Chiarello et al., 1997).

Herein we report evidence of an interaction between a pit viper and a porcupine. On 23 January 2007 we received an adult female common Brazilian pit viper,

Figure 1. Adult male common pit viper (*Bothrops jararaca*) with 22 porcupine (*Sphiggurus villosus*) spines in its mouth.

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Table 1. Occurrences of encounters between snakes and porcupines (updated from Duarte, 2003 and Palmuti et al., 2009). An asterisk indicates that no data were available.

Snake species	Total length (m)	Prey Species	Injuries on snakes	Circumstances	References
Boidae					
Boa constrictor imperator	1.8	*Coendou rothschildi*	Quills piercing oral cavity	Hair, claws and quills defecated	Tschambers, 1949
Boa constrictor amarali	1.6	"Porcupine"	Quills in stomach and body cavity	Death due to quill injuries	Cherubini et al., 2003
Corallus hortulanus	*	*Coendou* sp.	Quills piercing the body	Dying on the ground	Argôlo, 1992
Corallus hortulanus	*	Erethizontidae	Spines along the outside of the body	Juvenile snake severely injured that may have died	Pizatto et al., 2009
Epicrates cenchria	*	Erethizontidae	Spines in stomach content	Spines in stomach content	Palmuti et al., 2009
Colubridae					
Spilotes pullatus	2.18	*Sphiggurus mexicanus*	Quills piercing oral cavity, tail and body	Trying to swallow prey	Köhler and Seipp, 1999
Elapidae					
Ophiophagus Hannah	*	*Hystrix indica*	*	*	Krishna, 2002
Pythonidae					
Python reticulatus	*	*Hystrix brachyuran*	*	Stomach content	Shine et al., 1998
Viperidae					
Bitis gabonica	*	*Atherurus africanus*	*	*	Greene, 1997
Botrhops jararaca	ca. 0.9	*Coendou* sp.	Quills piercing oral cavity	Predatory or defensive strike	Duarte, 2003
Botrhops jararaca	ca. 1.0	*Sphiggurus villosus*	Quills piercing oral cavity	Predatory or defensive strike	Present study
Crotalus durissus	ca. 0.9	*Coendou* sp.	Quills piercing oral cavity	Predatory or defensive strike	Duarte, 2003

Bothrops jararaca (about 1 m in SVL) collected in the Santa Genebra reserve, municipality of Campinas, state of São Paulo, Brazil (-22.824153°S, -47.110415°W). The snake is deposited in the Museu de Zoologia "Prof. Adão José Cardoso" (ZUEC), Unicamp, Campinas, Brazil (ZUEC-REP 3964). The specimen was already dead and presented 22 spines in its mouth (Figure 1).

The spines averaged 1.8 ± 0.39 cm long (ranging from 1.1 to 2.8 cm; n = 22), and were associated to a *Sphiggurus villosus*. While we are unable to precisely estimate the porcupine's size, we suggest it was an adult based on spines measurements and comparisons made from six individuals deposited in the ZUEC (ZUEC-MAM 1508, 1636, 1885, 1887, 2300, 2192).

Porcupines seem to be occasional food items for snakes worldwide, with spines having been encountered in the stomachs of several species (Duarte, 2003). However, given the risk associated with such interactions, our observation raises an intriguing question in the snake perspective: was it a failed predation attempt or a defensive strike with an unfortunate disclosure? The answer is not obvious, as we might normally assume a predation attempt. Besides that, this question can be the starting point of experiments that will address: snakes' perception (vision and neural system), selective pressures (as those related to predator-prey interactions), correlated behaviours (as the origin and maintenance of fake strikes), and learning skills (as the difference between young and mature snakes).

It is obvious that porcupines represent a high-risk food for any predator, and besides being difficult to manage initially, spines can be indigestible and potentially cause injuries in the digestive system. Despite that, there are reports documenting several encounters between snakes and porcupines, including species of the families Boidae, Pythonidae, Colubridae, Elapidae, and Viperidae (Table 1). In all cases, snakes were injured in different sections of their bodies. Based on such reports, we estimated only 33% of survival after the predatory/defensive interactions with porcupines. After examining the stomach and intestine of the pit viper, and found no items on it, we conclude that our report adds one more

interaction with a possible successful porcupine escape and a dead snake.

The most reported encounters between snakes and porcupines are those with snakes of the families Boidae and Viperidae (Table 1). This could be due to the shared microhabitat (on vegetation, as: arboreal branch, tree forks, and amidst dense lianas) between these species and porcupines (Sazima, 1992; Passamani, 2010), and the heavy body of these snakes.

This subject raises some intriguing questions: Are snakes able to recognize (in any way) porcupine spines? If so, can they evaluate the predation risk of such spiky prey? Is there a differential allometric relationship when the prey has spines? Are snakes that attempt to prey upon porcupines negatively selected against (as they are most likely killed by the spines and removed from the population)? Would snakes therefore avoid porcupines as an innate characteristic? Does such potential harm favour the selection of defensive fake strikes (those that do not reach the target)? If young vipers are even less selective (e.g., Sazima and Martins, 1990), is avoidance of porcupines higher in adult than in young snakes? Do (and how) the snakes estimate the size of its prey before the attack or is it just an instinctive reflex for survival? Could attempted predation on porcupines be a desperate survival strategy in the absence of more suitable preys?

Pursuing answers to these questions remains an open avenue in the field of vertebrate natural history, and can provide information about predator-prey evolution. Our observation is inspiring and, most of all, we argue that we should be open-minded when reporting and interpreting such rare events, because our initial interpretations may be incorrect.

Acknowledgments. We are thankful to Karina R. E. Gomes, who facilitated our access to the specimens deposited in the Museu de Zoologia "prof. Adão José Cardoso"; and to Rodrigo Lingnau, Jeffrey Beane and an anonymous reviewer for suggestions to improve the manuscript. São Paulo Research Foundation (FAPESP) provided a fellowship to LRF (#2013/21519–4) and a grant to LFT (#2016/25358-3). National Council of Scientific and Technological Development (CNPq) provided a fellowship to LRF (#150041/2017-9) and a fellowship to LFT (#300896/2016-6). This research is registered in SisGen A6F8978.

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Accepted by Mirco Solé