NEWS AND PERSPECTIVES

Predation of *Alouatta puruensis* by *Boa constrictor*

Erika Patrícia Quintino · Júlio César Bicca-Marques

Abstract Reports of successful predator attacks on primates are rare. Primates from all major radiations are particularly susceptible to raptors, carnivores, and snakes. Among New World primates, reports of snake predation are limited to medium- and small-bodied species. Here, we report the first documented case of successful predation of an atelid by a snake—an adult female Purús red howler monkey, *Alouatta puruensis*, that was subdued by a ca. 2-m-long *Boa constrictor* in an arboreal setting at a height of 7.5 m above the ground. The victim belonged to a group composed of six individuals (one adult male, two adult females, two juveniles, and one infant) that inhabited a ca. 2.5-ha forest fragment in the State of Rondônia, western Brazilian Amazon. The boa applied the species' typical hunting behavior of striking and immediately coiling around its prey and then killing it through constriction (probably in less than 5 min), but the entire restraint period lasted 38 min. The attack occurred around noon. The howler was swallowed head-first in 76 min. The only group member to respond to the distress vocalization emitted by the victim was the other adult female, which was closest to the location where the attack occurred. This female ran toward the snake, also vocalizing, and hit it with her hands several times, but the snake did not react and she moved off to a nearby tree from where she watched most of the interaction. The remaining group members stayed resting at a height approximately 15 m above the victim in a nearby tree without showing any overt signs of stress, except for a single whimper vocalization. This event indicates that even large-bodied atelids are vulnerable to predation by large snakes and suggests that *B. constrictor* may be a more common predator of primates.

Keywords Purús red howler monkey · Boid snake · Predator · Habitat loss · Amazon

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Introduction

Predation has played a central role in the development of theories of primate evolution, ecology, and behavior (see Cheney and Wrangham 1987; Isbell 1994, 2006; Janson 2000; Miller 2002; Gursky and Nekaris 2007; Miller and Treves 2011). However, the unpredictable, opportunistic, and fragmentary nature inherent in accounts of nonhuman primate–predator interactions reported by primatologists has resulted in an extremely limited empirical database from which to understand the effects of predation on the evolution of primate behavior. In the majority of cases, descriptions of either successful or unsuccessful predation are incomplete, and contextual details of the event are lacking and have failed to include predator–prey spatial location, the hunting strategies adopted by the predator, and prey behaviors prior to, during, and after the event (Miller and Treves 2011). Despite these limitations, it is well documented that, in addition to human hunting, the major primate predators include mammalian carnivores,

avian raptors, and snakes (Miller and Treves 2011). Snakes, particularly reticulated pythons (*Python reticulatus*), may prey on Old World primates whose adults weigh from 3 to 9 kg (*Macaca fascicularis*, *Presbytis melalophos*, and *Trachypithecus cristatus*; Shine et al. 1998; Headland and Greene 2011). The highly arboreal habits of platyrrhines are believed to decrease the vulnerability of the larger taxa—the atelids (the major targets of human hunting; Urbani 2005)—to snake predation among New World primates (Ferrari 2009).

Boa constrictor appears to be the major snake threat to New World monkeys. Although Fedigan (personal communication cited in Chapman 1986) reported cases of *B. constrictor* attempting to prey on mantled howler monkeys (*Alouatta palliata*), the largest platyrrhine so far witnessed to be successfully preyed upon by a snake was a 2–3-kg Uta Hick's cuxiú or bearded saki (*Chiropotes utahickae*; Ferrari et al. 2004). Other reports of predation attempts by *B. constrictor* on New World primates include white-faced capuchin monkeys (*Cebus capucinus*; Chapman 1986; Perry et al. 2003), golden lion tamarins (*Leontopithecus rosalia*; Kierulff et al. 2002), moustached tamarins (*Saguinus mystax*; Shahuano Tello et al. 2002), and red titi monkeys (*Callicebus discolor*; Cisneros-Heredia et al. 2005). *Boa constrictor* is described as a large-bodied (up to 5–6 m, Greene 1983; at least up to 14 kg, Sironi et al. 2000), habitat generalist (from tropical forests to cultivated fields; Greene 1983), terrestrial and semiarboreal predator (Greene 1983; Mehta and Burghardt 2008; at least up to 8 m above the ground, Ferrari et al. 2004) that employs a sit-and-wait, ambush hunting strategy (Willard 1977; Montgomery and Rand 1978; Greene 1983). Its cryptic nature may render detection by potential prey more difficult and allows *B. constrictor* to prey upon an array of species at least up to the size of vulture and deer (Sironi et al. 2000; Boback 2004; Quick et al. 2005). After striking the prey's head, *B. constrictor* subdues its victim by immediately lifting it free of the substrate and applying a constricting coil around its body (Willard 1977; Greene and Burghardt 1978; Greene 1983; Mehta and Burghardt 2008). Constriction ceases only when the prey is dead and ready to be eaten head-first (Greene 1983; Mehta and Burghardt 2008).

We report the first case of successful predation of a howler monkey by a snake—an adult female Purús red howler monkey (*Alouatta puruensis*) killed by a *B. constrictor*. *Alouatta puruensis* (formerly *A. seniculus puruensis*) is a poorly known southwestern Amazonian species of howler monkey (Gregorin 2006). Despite the absence of long-term studies, there exists one published account of an attempted predation event (Eason 1989) and one account of successful predation (Peres 1990). Both events involved harpy eagles (*Harpia harpyja*). There is no report of

A. puruensis being preyed upon by carnivores, but other *Alouatta* spp. are known to be vulnerable to wild carnivores and domestic dogs, especially when traveling on the ground to cross unforested areas (Pozo-Montuy and Serio-Silva 2007; Ferrari 2009; Cristóbal-Azcarate et al. in press).

Methods

The predation event was observed during the habituation process of a social group in a ca. 2.5-ha forest fragment at Sítio São José (11°48′40″S, 61°46′36″W) in a highly fragmented landscape in Rolim de Moura, State of Rondônia, western Brazilian Amazon (Fig. 1). The study group was composed of six individuals: one adult male, two adult females, two juveniles, and one infant. These individuals were the only howler monkeys inhabiting this degraded fragment. For most of its history, the State of Rondônia was covered by tropical forests (95 % of its area). However, between 1975 and 2010 Rondônia experienced considerable habitat loss (an approximate annual deforestation rate of 1 %), resulting in 1/3 of its native forests being cut (Bacha 2012). The remaining forested area (62 %) contains continuous forests only inside protected nature and Indian reserves. Despite the state's low rural population density (average ca. 1.7 individuals/km²; Brasil 2010), outside of these reserves there exist only forest fragments located in modified landscapes dominated by small farms such as those found in Rolim de Moura.

The estimated length of the boa of ca. 2 m suggests that it had reached or was near sexual maturity (Greene 1983). Although we have no data on the weight of the victim, considering that the minimum body weight reported for an adult female red howler monkey (*Alouatta seniculus*, subspecies not mentioned) by Ford and Davis (1992) is 4.2 kg, we infer that the weight of the female howler was, at least, 4.0 kg.

Results

In the morning of February 20th, 2013 the study group was resting at a height of approximately 15 m above the ground in the same tree where it had spent the previous night. At 11:45 am both adult females moved to a height of about 8 m in a neighboring tree. Then, the predation victim moved (ca. 5 m) ahead of the other female to a place 7.5 m above the ground in a neighboring tree where the boa snake was hiding. At about 11:56, the female emitted a distress vocalization that was heard by the first author. Although the exact moment of the attack was not witnessed, when the female howler monkey approached the snake, the snake struck at her head and immediately coiled around her neck

Fig. 1 Location of the study site in the Brazilian Amazon: *top* fragmented landscape of Rolim de Moura, State of Rondônia; *bottom* 2.5-ha forest fragment showing the area where the predation event took place (*white circle*). Adapted from Google Earth®
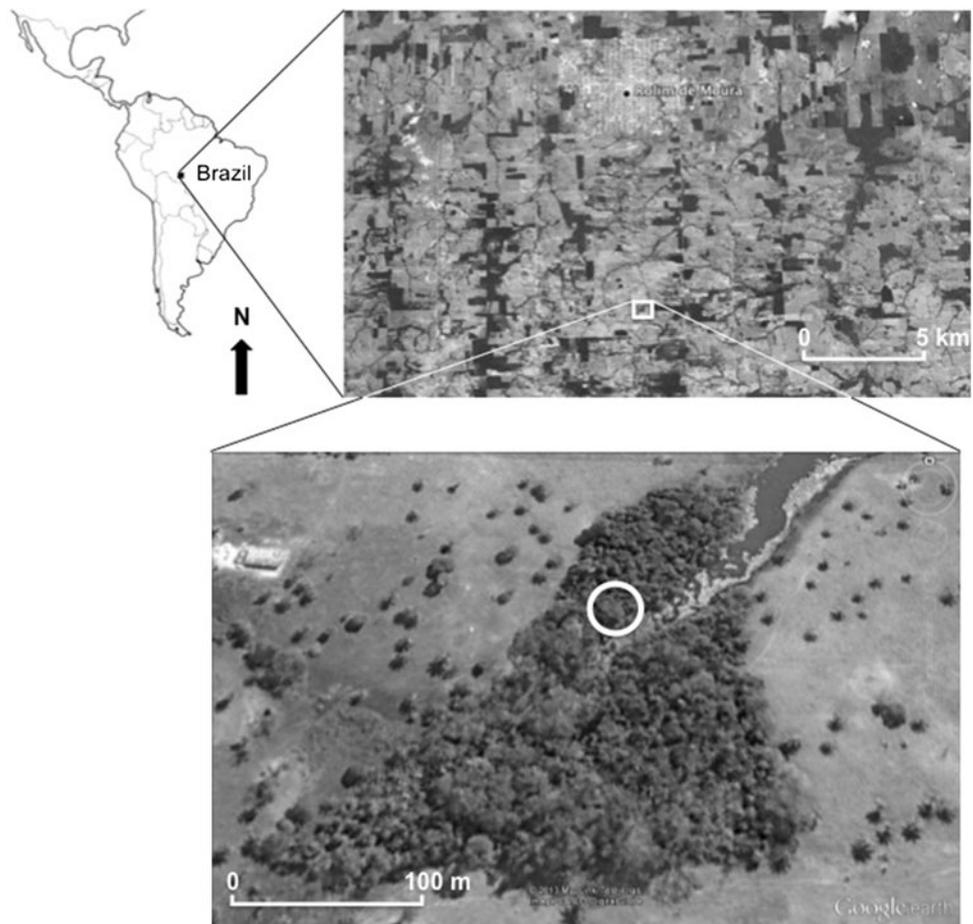
and body by applying two fully encircling loops with a vertical orientation relative to the branch where it was, keeping the monkey upside-down (11:57; Online Resource 1). The other female also vocalized and moved toward her group mate. When this second female reached the snake (11:59), she started to hit it with her hands (at least four times, but no more than 10 times) while still screaming (Online Resource 2), but the snake showed no reaction to her attacks and the howler soon moved off to a place approximately 3 m distant from where she observed the predator–prey interaction (Online Resource 3). The victim died by constriction or possibly cardiac arrest after approximately 5 min, but the snake did not relax its grip for 15 min. The boa then began to move its head around the carcass (Online Resources 4, 5). At approximately 12:15 pm, the boa held the howler by her head with its mouth, and uncoiled and stretched its body vertically while clinging to the branch with its tail (Online Resource 6). Then, it coiled again, moved its head around the victim's body, and started to swallow her head-first at 12:35 pm (Online Resources 7, 8). The period from strike to start of ingestion (restraint) lasted 38 min. During the ingestion process, the snake uncoiled, vertically stretched with the

monkey hanging from its mouth (Online Resource 9), and recoiled several times. When half of the carcass was swallowed, it uncoiled and remained stretched in a vertical position while making undulating body movements until the end of the process (Fig. 2; Online Resources 10–12). The process of swallowing the adult howler lasted 76 min.

During the entire event the other adult female remained nearby, occasionally moving to a branch 2 m higher in the tree where she was located, and sometimes returning to the tree where the snake was located (Online Resource 13). On one occasion, she approached and touched the snake before returning to the neighboring tree. The other group members, on the other hand, continued to rest in the same place without any noticeable reaction, except a single emission of a whimper vocalization, probably by the infant.

After ingesting the howler, the snake returned to the same branch where it was initially observed (Online Resource 14) and remained there. The adult female howler returned to the tree where her group was resting, and the group remained there together until, at least, 16:30 pm, when the observer left the site. There was no observation of the group during the day following the predation event, but 2 days later (February 22nd) the snake was still curled in
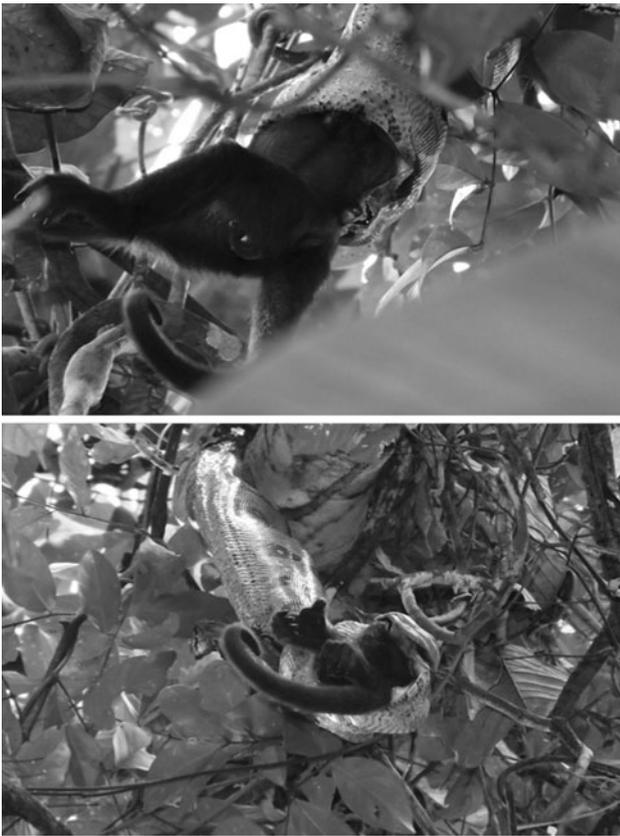
Fig. 2 *Boa constrictor* swallowing the adult female *Alouatta puruensis* head-first: *top* when half the carcass had been eaten; *bottom* closer to the end of the ingestion process (photos by Erika Patrícia Quintino)

the same tree hidden among liana leaves and stems, although it was located on a branch 9 m above the ground. On February 23rd the snake had left the tree. The howler group traveled to another portion of the forest fragment, but returned to the area where the attack occurred 9 days later (March 1st) without showing any signs of increased vigilance (although it should be noted that this evaluation might have been affected by the fact that the howlers were not habituated).

Discussion

Although adult *Boa constrictor* tend to be more terrestrial than juveniles (Greene 1983), this event of predation of an adult female *Alouatta puruensis* shows that Neotropical snakes are capable of hunting adult large-bodied platyrrhines in an arboreal setting. The observed predation event is consistent with Ferrari's (2009) contention that snake predation on New World primates is more likely to occur either on the forest floor or in the lower strata of disturbed forest habitats, but additional studies are required to test

this hypothesis adequately. Howler monkeys may be particularly vulnerable to snake predation under certain circumstances. Not only can they cope well with forest fragments (even those smaller than 1 ha), where they may reach high population densities ($>$100 individuals/km^2; Peres 1997; Ferrari 2009), but they also forage across all strata and travel over shorter distances (rarely above 1 km) on a daily basis (Bicca-Marques 2003) along habitual pathways (Bicca-Marques and Calegaro-Marques 1995; Hopkins 2011) using slow above-branch quadrupedal locomotion (Prates and Bicca-Marques 2008). Howlers' routine trichromatic color vision (Jacobs et al. 1996) may further increase their vulnerability to boas by potentially compromising their ability to detect these camouflaged predators, a task in which dichromatic individuals outperform trichromats (Morgan et al. 1992).

The restraint and ingestion times reported herein are similar to those reported by Cisneros-Heredia et al. (2005) for a boa preying on *Callicebus discolor* (respectively, 45 min and about 60 min). Our observation confirms that boas exhibit a highly stereotypic set of predatory behaviors (Mehta and Burghardt 2008). The sit-and-wait hunting strategy of a boa (where it may remain in the same spot for a few days or even a month; Montgomery and Rand 1978; Greene 1983) may be particularly profitable in small forest fragments due to the fact that monkeys repeatedly use the same routes to travel between feeding sites. The recent history of forest loss and the attendant mosaic landscape of the State of Rondônia (Fig. 1), coupled with its low rural population density, create a scenario favorable to increased boa density and increased encounter rates with potential prey. These encounters are less likely to occur in more populated regions with longer histories of habitat loss, where forest remnants are more sparsely distributed within the anthropogenic matrix, and where snake killing by rural inhabitants is common.

Despite its probable rarity, snake predation may hamper the long-term viability of howler monkeys in small forest fragments immersed in similar landscapes. The cryptic and primarily crepuscular or nocturnal activity of *B. constrictor* (Greene 1983) may reduce the opportunity for other group members to witness and learn from predatory attempts and successful attacks. In the reported event, without the distress vocalization of the victim (and the survivor adult female), the interaction would have been quite discreet and very likely missed by the researcher. Although Ferrari (2009) suggests that primates in fragments may experience lower exposure to predators and therefore may remain naïve and vulnerable to them, the reaction of the survivor adult female suggests that she was aware of the potential consequences of a boa attack on a howler monkey. The return of the group to the area where the event took place without any signs of increased vigilance, however, is

compatible with the risk of future casualties even by the same individual boa.

Although conspecific collective responses to snake attacks, including more than one individual hitting, pulling, uncoiling, snapping at, and biting the predator, have been reported as successful in freeing *Saguinus mystax* (Shahuano Tello et al. 2002), *Cebus capucinus* (Perry et al. 2003), and *Microcebus murinus* (Eberle and Kappeler 2008) individuals, the reaction of single individuals or collective mobbing without physical aggression to the snake were not successful in other situations (*C. capucinus* Chapman 1986; *Tarsius spectrum* Gursky 2002). Reports of howler monkey reaction to the presence of potential raptor and carnivore predators range from group avoidance (*Alouatta* spp.; Ferrari 2009) and vocalization (e.g., single adult male *A. belzebul* upon the attack on an infant by two tayras, *Eira barbara*, Camargo and Ferrari 2007; about 10 group members after the successful attack on a juvenile *A. arctoidea* by a harpy eagle, Urbani et al. 2012) to two adult female *A. palliata* successfully mobbing a group of four tayras (Asensio and Gómez-Marín 2002). This paper is the first report of the reaction of howler monkeys to snake predation.

In sum, our observations indicate that snakes successfully prey on platyrrhines from all major taxonomic radiations, both on the forest floor and in the canopy. The characteristics of the study site and surrounding matrix, including its recent history of forest loss, together with the ample ecological tolerance and the hunting strategy of *B. constrictor* raise the possibility that boas may act as particularly important predators of howler monkeys and other primates in small forest patches immersed in fragmented landscapes. As we continue to expand the empirical database and contextual descriptions of attempted and successful predation attacks, we will better understand the effects of predation risk on primate behavior.

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