

Snakes preying on bats: new records from Brazil and a review of recorded cases in the Neotropical Region

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ABSTRACT. Predation on bats by snakes is relatively infrequently reported in the literature, though it may actually not be an uncommon phenomenon, since bat colonies represent a potential concentration of food for many medium-sized or large snakes. Herein we describe four events of bat predation by snakes and present a review of predation records of snakes on bats in the Neotropics compiled from the literature. A total of 20 species of snakes have been recorded so far as predators of bats in the New World tropics, with boiids being represented by the greatest number of cases. Due to the semi-arboreal habits of most of its species, their large size and their usual preference for mammalian prey, the Boiidae are probably the main reptilian predators of bats in the Neotropics, though predation by colubrids may also be relatively frequent. Two types of predatory events can be pointed out: (1) on active bats outside refuges or exiting them, and (2) on animals (active or inactive) inside refuges. The former strategy is apparently used mainly by boiids, whereas the latter strategy appears to be the one most used by large colubrids.

KEY WORDS. Adaptation; Boidae; Colubridae; feeding habits; predation.

RESUMO. Serpentes predando morcegos: novos registros no Brasil e uma revisão dos casos registrados na Região Neotropical. A predação de morcegos por serpentes é pouco frequente literatura, apesar de não ser um processo incomum, visto que colônias de morcegos representam uma concentração potencial de alimento para serpentes de médio porte. Descrevemos neste trabalho quatro eventos de predação de morcegos e apresentamos uma revisão de eventos publicados na Região Neotropical. Um total de 20 espécies de serpentes já foram descritas como predadoras de morcegos no Novo Mundo, com Boidae representando a maioria dos casos. Graças aos hábitos semi-arborícolas destas espécies, seu maior porte e sua preferência por mamíferos como presas, os Boidae são provavelmente os répteis mais frequentemente apontados como predadores de morcegos, apesar da predação por Colubridae ser também relativamente comum. Dois tipos de predação podem ser apontados: (1) em morcegos ativos fora de seus refúgios ou quando saem destes e (2) em animais (ativos ou inativos) dentro de seus refúgios. A primeira estratégia é aparentemente mais empregada por Boidae e a segunda mais freqüentemente por Colubridae.

PALAVRAS-CHAVE. Adaptação; Boidae; Colubridae; hábitos alimentares; predação.

Predation on bats by snakes is relatively infrequently reported in the literature, though it may actually not be an uncommon phenomenon. For many species of medium-sized to large snakes, bat colonies represent a potential concentration of food to be exploited. SCHÄTTI (1984) reviewed worldwide records of predation on bats by snakes in the literature, concluding that chiropterophagy is probably a common phenomenon in some populations of several snake species. In the New World tropics,

the most well known and best documented cases of predation on bats refer to species in the family Boiidae, and particularly in West Indian members of the genus *Epicrates* Wagler, 1830 (HARDY 1957b, RODRIGUEZ & REAGAN 1984, RODRIGUEZ-DURAN 1996, PRIOR & GIBSON 1997, KOENIG & SCHWARTZ 2003, DÁVALOS & ERIKSSON 2004). In all the aforementioned cases, the reported predatory behaviour of the snakes was similar, with one or more individuals waiting in ambush for the emerging bats at or close to the entrance of caves.

Published records of predation on bats by snakes in Brazil are scarce. HOPKINS & HOPKINS (1982) mention an attack by an unidentified snake on a bat (probably *Phyllostomus discolor* Wagner, 1843) in the region of Manaus, in northern Brazil (the snake was described as an "arboreal constrictor", and was most probably a *Corallus hortulanus* (Linnaeus, 1758); see MARTINS & OLIVEIRA 1998). MARTINS & OLIVEIRA (1998) found a bat (*Myotis* sp.) of 55 mm of total length and 7 g in the stomach of an adult *C. hortulanus* from the Rio Jaú region in Amazonian Brazil. RUFINO & BERNARDI (1999) reported one case of predation of a velvety free-tailed bat (*Molossus molossus* (Pallas, 1766)) by the large colubrid *Pseustes sulphureus* (Wagler, 1824) in the state of Pará, northern Brazil. VALDUJO *et al.* (2002) examined the stomachs of 175 specimens of the viperid snake *Bothrops pauloensis* Amaral, 1925 (formerly *B. neuwiedii pauloensis* Amaral, 1925; see SILVA 2004) from the cerrados of central Brazil and found an unidentified bat in one of them.

In the present article, we report four additional instances of snake predation on bats by three different snake species in Brazil. We also review the literature on snake predation on bats in the Neotropics, observing the differences in predatory behaviour among snake species.

The first predation event was recorded on 23 October 1990, during observations of a bat colony at the region of the Cuiabá river, in Cuiabá municipality (15°35'S, 56°05'W), state of Mato Grosso, western Brazil. A common boa – *Boa constrictor* (Linnaeus, 1758); estimated total length ca. 1 m – was found on the ground at the entrance of the colony, at 15h15min. The colony, located in the cavity of a very large fig tree (*Ficus* sp.), contained bats of two species, *Myotis nigricans* (Schinz, 1821) and *Noctilio albiventris* Desmarest, 1818. The snake's head was hidden among the roots that partly covered the tree cavity, and it suddenly emerged with an individual of *N. albiventris* in its jaws. After the bat was swallowed, the snake was captured, removed, and released unharmed at another site 50 m far.

The second case occurred in January 2001, during sampling of a colony of *Molossus rufus* E. Geoffroy, 1825 occupying the roof of a house in the Poço das Antas Biological Reserve (22°33'S, 42°16'W), in the municipality of Silva Jardim, state of Rio de Janeiro. A large individual of the colubrid *Spilotes pullatus* (Linnaeus, 1758) (2.15 m total length) was captured inside the roof. The snake was resting close to the entrance of the colony, at ca. 2 m from the major group of bats. It had a mid-body bulge, suggesting the recent ingestion of one or more bats. In April 2001 another individual of *S. pullatus* was observed near the same roof, but it was not captured. Earlier, in May 1999, one individual of the Colubrid *Pseustes sulphureus* had been captured in the same area while trying to enter one of the ventilation orifices of another roof housing a large colony of *M. rufus*. On two previous occasions, snakes of the same species (possibly the same individual) were seen entering that roof (M. Mocelin and C. E. Verona, pers. comm.).

The third event was recorded on 5 November 2001, at

17h40min, in the region of Morro de São João (22°30'S, 41°59'W), in the municipality of Casimiro de Abreu, state of Rio de Janeiro. A common tree boa (*Corallus hortulanus*) was observed on a banana tree (*Musa* sp.) near a refuge of white-lined bats, *Platyrrhinus lineatus* (E. Geoffroy, 1810). Suddenly, the reptile reached under one of the leaves where a group of bats was resting and seized one of them.

The last case was witnessed in November 2004, during sampling of bats at the Reserva Ecológica de Guapiaçu (22°24'S, 42°44'W), in the municipality of Cachoeiras de Macacu, state of Rio de Janeiro. One individual of *C. hortulanus* (1.45 m total length; body mass = 320 g), was observed at ca. two hours hanging from a tree branch close to an open mist net. The snake promptly struck at a short-tailed fruit bat, *Carollia perspicillata* (Linnaeus, 1758) that was netted and held it in its jaws.

HENDERSON (1993) reported "a minimum of nine bats" among the prey items found in stomachs of several museum specimens of *C. hortulanus* (= *C. enydris*) from throughout the species' range in mainland Central and South America; however, more than one species were likely represented in his sample, as the continental members of the *C. hortulanus* complex have since been divided into three species (HENDERSON 1997). Nevertheless, it is highly probable that most or all the records came from *C. hortulanus sensu strictu*, as it is the species with the widest distribution (HENDERSON 1997). MARTINS & OLIVEIRA (1998) reported one *Myotis* sp. and one unidentified bat from stomachs of specimens from Amazonian Brazil and Ecuador, respectively. The records of bat predation by *C. hortulanus* reported by us in the present study are the first with specific identifications of prey. HENDERSON (1993) claimed that mainland *C. hortulanus* frequently consume bats, unlike West Indian populations of that species (which have since been considered as specifically distinct from mainland forms – HENDERSON 1997). MARTINS & OLIVEIRA (1998) reported an individual hanging on the vegetation at the edge of a trail in primary Amazonian forest that was "probably foraging for bats that used the trail as a flying corridor". We consider probable that *C. hortulanus* may be a relatively frequent predator of bats in the wild, judging by its wide distribution and relatively common occurrence.

Table I presents a review of predation records of snakes on bats in the Neotropics compiled from the literature (including data from the present study). It shows that a total of 20 species of snakes (maybe 21 or 22; see comment above on *C. hortulanus*) have been recorded so far as predators of bats in the New World tropics, with boiids being represented by the greatest number of cases. Due to the semi-arboreal habits of many of its species, their large size and their usual preference for mammalian prey, the Boiidae are probably the main reptilian predators of bats in the Neotropics. Predation by colubrids may also be relatively frequent, considering the practically ubiquitous occurrence and large number of species in this family. Most of the colubrids listed in Table I are relatively large-bodied species. SCHATTI (1984) has observed, based on a compilation of published and original

Table I. Reported cases of snake predation on bats in the literature, including original data from the present study. The family to which each bat species belongs are indicated by letters (E = Emballonuridae, M = Molossidae, Na = Natalidae, No = Noctilionidae, P = Phyllostomidae, V = Vespertilionidae) For each case, the number of individuals (N) of each bat species captured by the snakes is given, with a question mark (?) representing cases in which the number of captures is unknown or was not reported.

Snake species	Bat species	N	Locality	References
Boiidae				
<i>Boa constrictor</i> (Linnaeus, 1758)	<i>Desmodus rotundus</i> (E. Geoffroy, 1810) (P)	1	Mexico	VILLA & LOPEZ-FORMENT 1966
	<i>Artibeus jamaicensis</i> Leach, 1821 (P)	1	Colombia	THOMAS 1974
	<i>Brachyphylla cavernarum</i> Gray, 1834 (P)	1	St. Lucia	ARENDT & ANTHONY 1986
	<i>Noctilio albiventris</i> Desmarest, 1818 (No)	1	W Brazil	This study
<i>Corallus hortulanus</i> (Linnaeus, 1758)	<i>Myotis</i> sp. (V)	1	N Brazil	MARTINS & OLIVEIRA 1998
	<i>Platyrrhinus lineatus</i> (E. Geoffroy, 1810) (P)	1	SE Brazil	This study
	<i>Carollia perspicillata</i> (Linnaeus, 1758) (P)	1	SE Brazil	This study
	Indeterminate	9+	Throughout mainland Central and S. America	HENDERSON 1993 ^h
? <i>Corallus hortulanus</i>	Indeterminate	1	Ecuador	MARTINS & OLIVEIRA 1998
	? <i>Phyllostomus discolor</i> Wagner, 1843 (P)	1	N Brazil	HOPKINS & HOPKINS 1982
<i>Epicrates angulifer</i> Bibron, 1840	<i>Phyllonycteris poeyi</i> Gundlach, 1860 (P)	15	Cuba	HARDY 1957b
<i>E. cenchria</i> (Linnaeus, 1758)	<i>Carollia perspicillata</i> (P)	1	Colombia	LEMKE 1978
<i>E. inornatus</i> (Reinhardt, 1843)	<i>Brachyphylla cavernarum</i> Gray, 1834 (P)	1	Puerto Rico	RODRIGUEZ & REAGAN 1984
	<i>Monophyllus redmani</i> Leach, 1821 (P)	3	Puerto Rico	RODRIGUEZ & REAGAN 1984
	Indeterminate	1	Puerto Rico	RODRIGUEZ & REAGAN 1984
	<i>Brachyphylla cavernarum</i> (P)	2	Puerto Rico	RODRIGUEZ-DURAN 1996
	<i>Erophylla sezekorni</i> (Gundlach, 1860) (P)	18	Puerto Rico	RODRIGUEZ-DURAN 1996
	<i>Monophyllus redmani</i> (P)	1	Puerto Rico	WILEY 2003
	<i>Artibeus jamaicensis</i> (P)	1	Jamaica	KOENIG & SCHWARTZ 2003
<i>E. subflavus</i> Stejneger, 1901	Indeterminate	1	Jamaica	DÁVALOS & ERIKSSON 2004
Colubridae				
<i>Alsophis cantherigerus</i> (Bibron, 1843) ^a	<i>Phyllonycteris poeyi</i> (P)	3	Cuba	HARDY 1957a
<i>Elaphe flavirufa</i> (Cope, 1867)	<i>Myotis</i> sp. (V)	1	Belize	RAINWATER & PLATT 1999
	<i>Rhogeessa tumida</i> H. Allen, 1866 (V)	1	Belize	RAINWATER & PLATT 1999
<i>Elaphe guttata</i> (Linnaeus, 1766) ^b	<i>Molossus rufus</i> E. Geoffroy, 1825 (M) ^c	1	Mexico	DAVIS 1951
<i>Philodryas viridissimus</i> (Linnaeus, 1758)	Phyllostomidae indeterminate (P) ^d	1	Peru	OTTO & MILLER 2004
<i>Pituophis melanoleucus</i> (Daudin, 1803)	<i>Natalus stramineus</i> Gray, 1838 (Na)	?	Mexico	HUTSON <i>et al.</i> 2001
<i>Pseustes sulphureus</i> (Wagler, 1824)	<i>Molossus molossus</i> (Pallas, 1766) (M)	1	N Brazil	RUFINO & BERNARDI 1999
<i>Senticolis triaspis</i> (Cope, 1866) ^e	<i>Glossophaga soricina</i> (Pallas, 1766) (P)	1	Honduras	MANKINS <i>et al.</i> 1965

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Table I. Continued.

Snake species	Bat species	N	Locality	References
<i>Siphlophis cervinus</i> (Laurenti, 1768)	<i>Myotis</i> sp. (V)	1	Bolivia	PRUDENTE <i>et al.</i> 1996
<i>Spilotes pullatus</i> (Linnaeus, 1758)	<i>Artibeus jamaicensis</i> (P)	? ?		MORRISON <i>apud</i> SCHÄTTI 1984
	<i>Molossus rufus</i> (M)	?	SE Brazil	This study
<i>Trimorphodon biscutatus</i> Cope, 1886	<i>Carollia perspicillata</i> (P)	1	Costa Rica	STASHKO <i>apud</i> FLEMING 1988
	<i>Desmodus rotundus</i> (P)	1	Costa Rica	FLEMING 1988
	<i>Natalus stramineus</i> (Na)	2	Mexico	SÁNCHEZ-HERNÁNDEZ & RAMÍREZ-BAUTISTA 1992
	<i>Balantiopteryx plicata</i> Peters, 1867 (E)	?	Mexico	LÓPEZ <i>et al.</i> 2005
Viperidae				
<i>Bothriechis schlegelii</i> (Berthold, 1846) ^f	<i>Glossophaga soricina</i> (P)	1	? Honduras	GROVES 1961
	Indeterminate	1	Costa Rica	HARDY 1994
<i>Bothrops asper</i> (Garman, 1884) ^g	<i>Glossophaga soricina</i> (P)	1	Mexico	VILLA & LOPEZ-FORMENT 1966
<i>Bothrops pauloensis</i> Amaral, 1925	Indeterminate	1	Central Brazil	VALDUJO <i>et al.</i> 2002
<i>Crotalus pusillus</i> Klauber, 1952	<i>Eptesicus fuscus</i> (Beauvois, 1796) (V)	1	Mexico	DUELLMAN 1961

a) referred as *A. angulifer*, b) referred as *E. laeta*, c) referred as *M. nigricans*, d) possible case of necrophagy, e) referred as *Elaphe triaspis*, f) referred as *Bothrops schlegelii*, g) referred as *B. atrox*, h) up to three different species (*C. hortulanus*, *C. annulatus* and *C. ruschenbergerii*) may have been represented in the studied sample.

records from many parts of the world, that the snakes most often reported as bat predators tend to be boiids (including pythons) and large scansorial colubrids.

It is not possible to ascertain if some of the records (mainly those based on stomach content analyses) of bats being consumed by snakes result from actual predation on live bats or if they represent consumption of animals found previously dead (necrophagy). The latter possibility is by no means far-fetched, considering the opportunistic food habits of many snake species, which include occasional necrophagy (SAZIMA & STRUSSMAN 1990). The event mentioned by OTTO & MILLER (2004), for instance, could have been a case of attempted necrophagy instead of (as stated by them) 'an instance of predation': the snake was already found with the bat in its mouth and the authors mentioned the presence of flies and wasps around the bat's carcass and remarked on its strong odour of decay, stiff joints, and decomposed state, which suggests it had been dead for some time. RODRIGUEZ-DURAN (1996) reported four cases of consumption of *Erophylla sezekorni* (Gundlach, 1860) carcasses (including one in an advanced state of decay) by Puerto Rican boas, *Epicrates inornatus* (Reinhardt, 1843), in addition to 18 events of actual predation on live bats of the same species. There is even a record of a rat snake, *Elaphe flavirufa* (Cope, 1867), swallowing a stuffed skin of a vampire bat (VILLA & LOPEZ-FORMENT 1966).

Two types of predatory events can be pointed out: (1) on active animals outside refuges or exiting them, and (2) on animals (active or inactive) inside refuges. In the former case, the snakes usually position themselves close to sites where there is a

high probability of passage of bats, such as the entrances to caves. This type of predation is best documented for boiids of the genus *Epicrates* in the Caribbean (HARDY 1957b), but may be also a common behavior for boiids in Brazil, where there are numerous caves housing large bat colonies (TRAJANO 1995). Boiids have prehensile tails, which can aid them in hanging from the entrances or ceilings of caves to wait in ambush for bats. It is probable that the arboreal boiid *Corallus hortulanus* may present this behavior, though it has not been documented yet. Opportunistic predation on bats at or near the entrance of caves is not restricted to boiids, and has been also reported for colubrids (HERREID 1961, HAMMER & ARLETTAZ 1998). Unlike boiids, which normally strike at flying bats exiting the caves, it seems that the main strategy employed by colubrids foraging at or near cave entrances is to attack bats that are lying on the ground or clinging to cave walls, with captures of bats on the wing being occasional (HERREID 1961, HAMMER & ARLETTAZ 1998). Nevertheless, there are reports of colubrids preying on bats as they exit refuges (MORRISON *apud* SCHÄTTI 1984, HUTSON *et al.* 2001, LÓPEZ *et al.* 2005).

In the second type of predatory strategy, adopted by species of both Colubridae and Boiidae, snakes enter the refuge to capture bats. This strategy may be frequently used by large colubrids, as pointed out by reports involving specimens of *Pseustes* and *Spilotes* (RUFINO & BERNARDI 1999, this study). HANDLEY *et al.* (1991) reported an observation of an individual of *Spilotes pullatus* with the anterior part of the body inside a refuge of bats in Panama (although no actual predation event was mentioned). The refuges of molossid and vespertilionid bats usu-

ally have high internal temperatures and high humidity (LEWIS 1995). Those refuges are, in most cases, provided with few openings or a single opening, which ends up being an advantage for snakes that enter them to capture bats. Refuges located in roofs may contain great aggregations of molossid bats, especially during the reproductive period (ESBÉRARD 2002) and it is probable that individual snakes may benefit from such an abundant prey source during a long time (i.e. repeatedly returning to the same refuge to feed on its residents). Bat species that use the underside of leaves for resting (modified as "tents"), such as the stenodermatines (Phyllostomidae), are probably less vulnerable to snake predation, since they are not confined to a limited space and can thus flee more easily after sensing the presence of a predator. Nevertheless, they are sometimes taken by surprise, as illustrated by our record of *Corallus hortulanus* preying on resting *Platyrrhinus lineatus*.

Preying on bats may incur in some risks of retaliation by those animals, as it would be expected for any kind of mammalian prey armed with pointed teeth. VILLA & LOPEZ-FORMENT (1966) mentioned two individuals of *Elaphe flavirufa* found inside a cave housing colonies of vampire bats, *Desmodus rotundus* (E. Geoffroy, 1810) and *Diphylla ecaudata* (Spix, 1823), both of which bore marks on the dorsum that had apparently been inflicted by the sharp teeth of the vampires, probably while defending themselves from the reptilian predators.

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