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Food habits of snakes from the RPPN Feliciano Miguel Abdala, an Atlantic Forest fragment of southeastern Brazil

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Abstract: We present data on the diet of 15 species of snakes belonging to a community from Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala, an Atlantic Forest fragment of Southeastern Brazil, based on their stomach contents. For 12 items we were able to determine the direction of the ingestion. Most snakes ingested the prey head-first. A cluster analysis was conducted with items grouped as chilopods, mollusks, adult anurans, anuran tadpoles, lizards, amphisbaenians, snakes, and rodents. The phylogenetic influence on diet preferences is discussed.

Keywords: *serpentes, diet, feeding ecology, phylogenetic influence on diet, Atlantic Forest.*

PALMUTI, C.F.S., CASSIMIRO, J. & BERTOLUCI, J. **Hábito alimentar de serpentes da RPPN Feliciano Miguel Abdala, um fragmento de Mata Atlântica do sudeste do Brasil.** Biota Neotrop., 9(1): <http://www.biotaneotropica.org.br/v9n1/pt/abstract?short-communication+bn02209012009>.

Resumo: Apresentamos aqui a dieta de 15 espécies de serpentes de uma comunidade da Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala, um fragmento de Mata Atlântica do sudeste do Brasil, com base na análise de conteúdos estomacais. Para 12 itens, pudemos determinar o sentido de ingestão da presa. A maioria das serpentes ingeriu a presa no sentido cranial-caudal. Realizamos uma análise de agrupamento reunindo os itens nas categorias quilópodes, moluscos, anuros adultos, girinos, lagartos, anfisbenas, serpentes e roedores. A influência da filogenia sobre a dieta das espécies é discutida.

Palavras-chave: *serpentes, dieta, ecologia alimentar, influência da filogenia na dieta, Mata Atlântica.*

Introduction

Studies on snake feeding ecology are becoming relatively common in recent herpetological literature. The comprehensiveness of these works is somewhat variable, with studies on diet or feeding behavior of particular species or, more frequently, involving snakes of different localities housed in herpetological collections (e.g., Amaral 1924, Lema et al. 1983, Laporta-Ferreira et al. 1986, Sazima & Martins 1990, Marques & Puerto 1994, Marques & Sazima 1997, Pinto & Lema 2002, Rodríguez-Robles 2002, Nogueira et al. 2003, Hartmann & Marques 2005). On the other hand, more comprehensive studies involving snake communities or even a limited number of species of the same locality are scarce (e.g., Vitt 1983, Vitt & Vangilder 1983, Cadle & Greene 1993, Luiselli et al. 1998, Nogueira et al. 2003, França et al. 2008, Sawaya et al. 2008). Nonetheless, such studies are crucial for the analysis of interspecific relationships and of possible factors organizing natural communities. Phylogeny was considered the major factor determining structure of a snake assemblage from the Cerrado of Central Brazil, with a strong ecological component (França et al. 2008), although co-occurrence analysis of Brazilian Cerrado species and guilds associated to snake diets and habitats suggested a lack of organization (França & Araújo 2007). Dietary preferences seem to be correlated to local distribution, which represents key information for definition of conservation areas and management plans.

The Atlantic Forest is one of the most fragmented Brazilian ecosystems (Brooks & Balmford 1996, Fearnside 1996), especially in Minas Gerais State (Machado & Fonseca 2000). Nevertheless this biome still houses a high diversity of snake species (Marques et al. 2001). We present here data on diet of 16 species of snakes of a small Atlantic Forest fragment of Minas Gerais State based on individuals collected in the field, and compare the pattern of resource use with the phylogeny of involved species.

Material and Methods

1. Study site

This study was conducted at the “Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala” (RPPN-FMA), an Atlantic forest fragment with ca. 957 ha located in the Caratinga municipality, Minas Gerais state, Southeastern Brazil (19° 43' S and 41° 49' W), at elevations between 400 and 680 m (Silva 1993) (Figure 1).

The vegetation that covers the area (the Floresta Tropical Semidecídua Mesofítica Latifoliada; Ab'Saber 1977) presents different stages of regeneration (Hatton et al. 1983) and is dominated by trees belong to the families Leguminosae, Rubiaceae, Asteraceae, Bignoniaceae, and Myrtaceae (Lombardi & Gonçalves 2000) and by pteridophytes of the families Pteridaceae, Thelypteridaceae, Tectariaceae, Polypodiaceae, Aspleniaceae, and Dennstaedtiaceae (Melo & Salino 2002).

The climate of the region is characterized by a marked dry season (April to September) and a rainy season (October to March) (Strier 1986). Between August 2000 and July 2001 total annual rainfall was of 865.8 mm (Figure 2). Annual mean temperature and annual mean precipitation between 1984 and 1985 were of 21.0 ± 2.8 °C and 1,133.4 mm, respectively (Hirsch 1995).

The area is considered of “very high biological importance”, being designated as priority for the conservation of reptiles and amphibians of the Atlantic Rain Forest (Haddad 2000). Several studies on primates were conducted at the site, involving the species *Brachyteles hypoxanthus* (Strier 1986, 1991, 1994, 2000), *Alouatta guariba* (Mendes 1989, Hirsch 1995), *Callithrix flaviceps* (Ferrari

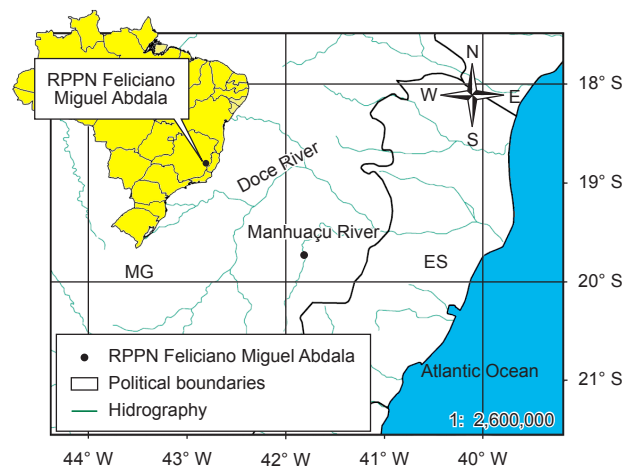


Figure 1. Location of the RPPN Feliciano Miguel Abdala, Caratinga municipality, Minas Gerais state, southeastern Brazil.

Figura 1. Localização da RPPN Feliciano Miguel Abdala, município de Caratinga, estado de Minas Gerais, sudeste do Brasil.

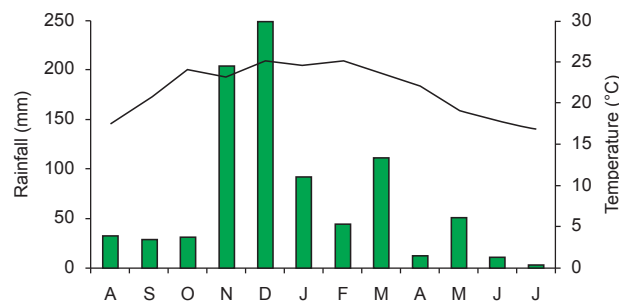


Figure 2. Mean monthly temperature (line) and accumulated monthly precipitation from August 2000 to July 2001 at RPPN-FMA (Karen B. Strier, unpubl. data).

Figura 2. Temperatura mensal média (linha) e precipitação mensal acumulada entre agosto de 2000 e julho de 2001 na RPPN-FMA (Karen B. Strier, dados não-publicados).

1988, Guimarães 1998), and *Cebus nigritus* (Lynch & Rímoli 2000). Other studies on vertebrates included small mammals (Fonseca 1988, 1989, Fonseca & Kierulff 1988), bats (Aguiar 1994), birds (Machado 1995), and herpetofaunal surveys, which recorded 38 amphibian and 38 reptile species (J. Cassimiro, unpubl. data).

2. Snake collection and stomach content analysis

Snakes were collected (by JC) at irregular intervals between July 2000 and July 2001. Specimens were obtained by visual search, casual encounters, collection by other people, and by 40 pitfall traps (volume 20 L) that remained open from December 2000 to April 2001. Immediately after collection, specimens were fixed in 10% formalin solution and preserved in 70% alcoholic solution. For the study of the stomach contents, each individual was dissected in the medium-ventral region, from the initial portion of the esophagus to the preanal region. The digestive tube was removed, dissected and preserved together with its content in 70% alcoholic solution. Despite the small

sample size, a cluster analysis was tentatively carried out based on the presence or absence of prey items grouped in the following categories: chilopods, mollusks, fishes, tadpoles, adult anurans, lizards, amphisbaenians, snakes, and rodents. We used the Euclidean Distance and the method of complete linkage; the analysis was performed with the software Statistica v. 5.0 (StatSoft®). When possible, the direction of ingestion of the prey item was determined. Vouchers were deposited in the herpetological collections of Universidade Federal de Minas Gerais (UFMG) and Museu de Zoologia da Universidade de São Paulo (MZUSP); most specimens were not deposited yet, but their field numbers are in Appendix 1, together with museum numbers. All specimens listed by their field numbers in the appendix will be deposited in the MZUSP collection.

Results and Discussion

We have dissected 90 specimens representing 20 snake species, recording the data on ingestion direction and stomach contents

(Table 1). In this sample, 34 individuals (38%) of 15 species contained identifiable stomach items. Contents were not found in representatives of two families (15.0%): the anomalepidid *Liotyphlops wilderi* (n = 2) and the colubrids *Chironius exoletus* (n = 1), *Elapomorphus quinquelineatus* (n = 2), *Pseustes sulphureus* (n = 5), and *Tantilla boipiranga* (n = 2). This relatively high proportion of stomachs with food may be related to the fact that snakes were obtained directly from the field, as already pointed out by Nogueira et al. (2003) for *Bothrops moojeni* in the Brazilian Cerrado, where such proportion was 65.7%.

The 15 snake species feed on nine categories of prey (Table 1). The number of prey categories varied from one (12 snake species) to three (*Liophis poecilogyrus*, *Bothrops jararaca*). Rodents, adult anurans and lizards were the most common prey; this pattern is exactly the same detected by França et al. (2008) in the Cerrado of Distrito Federal, Central Brazil. Invertebrates were consumed by *B. jararaca* (Chilopoda) and *Sibynomorphus newwiedi* (Mollusca).

Table 1. Stomach contents and ingestion direction of snakes from the RPPN Feliciano Miguel Abdala, southeastern Brazil. N = number of snakes; Ns = number of stomachs with contents.

Tabela 1. Conteúdo estomacal e sentido de ingestão da presa em serpentes da RPPN Miguel Feliciano Abdala, sudeste do Brasil. N = número de serpentes; Ns = número de estômagos com conteúdo.

Snake	N	Stomach contents	Ns	Ingestion direction
BOIDAE - BOINAE				
<i>Corallus hortulanus</i> (Linnaeus, 1758)	1	Rodent	1	
<i>Epicrates cenchria</i> (Linnaeus, 1758)	1	Rodent (porcupine spine)	1	
COLUBRIDAE - Colubrinae				
<i>Chironius fuscus</i> (Linnaeus, 1758)	6	<i>Haddadus binotatus</i>	1	vent-first
<i>Drymoluber dichrous</i> (Peters, 1863)	2	Leptodactylid frog	1	vent-first
<i>Spilotes pullatus</i> (Linnaeus, 1758)	3	Rodent	1	
COLUBRIDAE - Dipsadinae				
<i>Sibynomorphus newwiedi</i> (Ihering, 1911)	5	Veronicellidae (Mollusca) ¹	3	
<i>Taeniophallus affinis</i> (Günther, 1858)	2	Lizard	1	
COLUBRIDAE - Xenodontinae				
<i>Erythrolamprus aesculapii</i> (Linnaeus, 1766)	4	<i>Elapomorphus quinquelineatus</i>	1	head-first
		Colubrid snake	1	tail-first
<i>Liophis miliaris</i> (Linnaeus, 1758)	2	Tadpoles ²	1	
<i>Liophis poecilogyrus</i> (Wied-Neuwied, 1825)	12	<i>Physalaemus</i> sp.1	2	head-first
		<i>Physalaemus</i> sp.2	1	head-first
		Leptodactylid frog	1	head-first
		Undetermined anuran	1	
		Newly hatched tadpoles ³	? ⁴	
		Fish	1	
<i>Oxyrhopus petola</i> (Linnaeus, 1758)	2	Lizard	1	
<i>Pseudoboa nigra</i> (Duméril, Bibron & Duméril, 1854)	6	Lizard	1	
		Rodent	1	
ELAPIDAE				
<i>Micrurus corallinus</i> (Merrem, 1820)	5	Amphisbaenidae	1	
VIPERIDAE				
<i>Bothrops jararaca</i> (Wied-Neuwied, 1824)	25	<i>Scolopendra</i> sp. (Chilopoda)	1	
		<i>Haddadus binotatus</i>	1	head-first
		<i>Leptodactylus</i> sp. (gr. <i>notoaktites</i>)	2	head-first
		<i>Leptodactylus</i> sp.	1	
		Hylid frog	1	head-first
		Rodent	8	
<i>Bothrops jararacussu</i> Lacerda, 1884	2	Rodent	1	

¹*Sarasinula* sp. (n = 4), undeterm. (n = 2); ²Leptodactylidae (n = 6), Hylidae (n = 2), undeterm. (n = 3); ³undeterm. (n = 214); ⁴missing data.

In fact several species of *Bothrops* feed on chilopods (Martins et al. 2002, Valdujo et al. 2002, Nogueira et al. 2003), and *Sibynomorphus* spp. are specialized on mollusks (Laporta-Ferreira et al. 1986, Oliveira 2001, França et al. 2008). The fact that most species ingested a single type of prey should be viewed as a result of our small sample size, but some of these species are really food specialists, including *S. neuwiedi* (mollusks; Laporta-Ferreira et al. 1986, Marques et al. 2001), *Chironius fuscus* (anurans; Strüßmann & Sazima 1993, Marques et al. 2001, Sawaya et al. 2008), *Pseudoboa nigra* (lizards; Vitt & Vangilder 1983), *Erythrolamprus aesculapii* (snakes; Greene 1976, Marques & Puerto 1994, Marques et al. 2001), and *Micrurus corallinus* (amphisbaenians and snakes; Marques et al. 2001). Ingestion of fishes by *L. poecilogyrus* was rarely reported in the literature (e.g. Giraudo et al. 2007), and several works failed to detect ichthyophagy in this species (e.g., Marques et al. 2001, Pinto & Fernandes 2004, França et al. 2008, Sawaya et al. 2008); this food habit is common in *L. miliaris* (e.g., Marques et al. 2001). The presence of spines of a porcupine (Erethizontidae, Rodentia) in the stomach of the boid *Epicrates cenchria* represents a novelty for the diet of this genus (Cassimiro et al., in press), although it has already been observed for other boid genera and even in other families (Duarte 2003).

The direction of ingestion was determined for 12 prey items, two of which were snakes and nine were anuran amphibians. One snake and two anurans had been ingested tail-first (vent-first in the case of anurans), while one snake and seven anurans had been ingested head-first. Most snakes swallow prey head-first (e.g., Klein & Loop 1975, Greene 1976, Mori 1996), and this behavior seems to be related to a decrease in both swallowing time and probability of injury during prey handling (Greene 1976). The tail-first ingestion of snakes, *L. poecilogyrus*, by individuals of the colubrid *E. aesculapii* registered two times during the field work (JC) corroborates the observations of Greene (1976) and Marques & Puerto (1994). In this species, tail-first ingestion seems to be a specialization to ophiophagy, associated to the opisthoglyph dentition and hypertrophied Duvernoy's glands (Marques & Puerto 1994).

In some cases, the result of the cluster analysis (Figure 3) suggests an influence of phylogeny on diet – e.g. in the boids *Corallus hortulanus* and *Epicrates cenchria* (mammals) and in the colubrines *C. fuscus* and *Drymoluber dichrous* (anurans). The two boids also prey on birds (Henderson 1993, Marques et al. 2001). Although many colubrines typically feed on anurans, the ingestion of lizards and snakes by *D. dichrous* was previously reported (Cunha & Nascimento 1978, Cunha et al. 1985, Dixon & Soini 1986, Martins 1994, Borges-Nojosa & Lima 2001, Pinto 2006). For the Xenodontinae, the separation of the species studied in different groups may reflect the capture behavior and subjugation of prey, an effect of body size (Cadle & Greene 1993). A larger sample size would probably bring separate groups together.

Our data are not conclusive regarding the analysis of the inter-specific relationships within the community. França & Araújo (2007) suggested that the importance of certain ecological factors (in this case, diet, which reflects predator-prey relationship and intra- and interspecific competition) becomes clearer in communities with sympatric species of great abundance. In a more robust study, França et al. (2008) concluded that phylogeny is the most important factor determining the structure of a snake community of Central Brazil Cerrado, with ecological factors also playing an important role. The influence of both historical and ecological factors on squamate assemblages was already suggested for snakes (Guyer & Donnelly 1990), *Bothrops* spp. (Martins et al. 2001, 2002), and lizards (Mesquita et al. 2007).

Thus, studies involving larger numbers of individuals and considering ontogenetic variation in diet could provide insights into the relative influence of ecological and historical factors on snake community structure.

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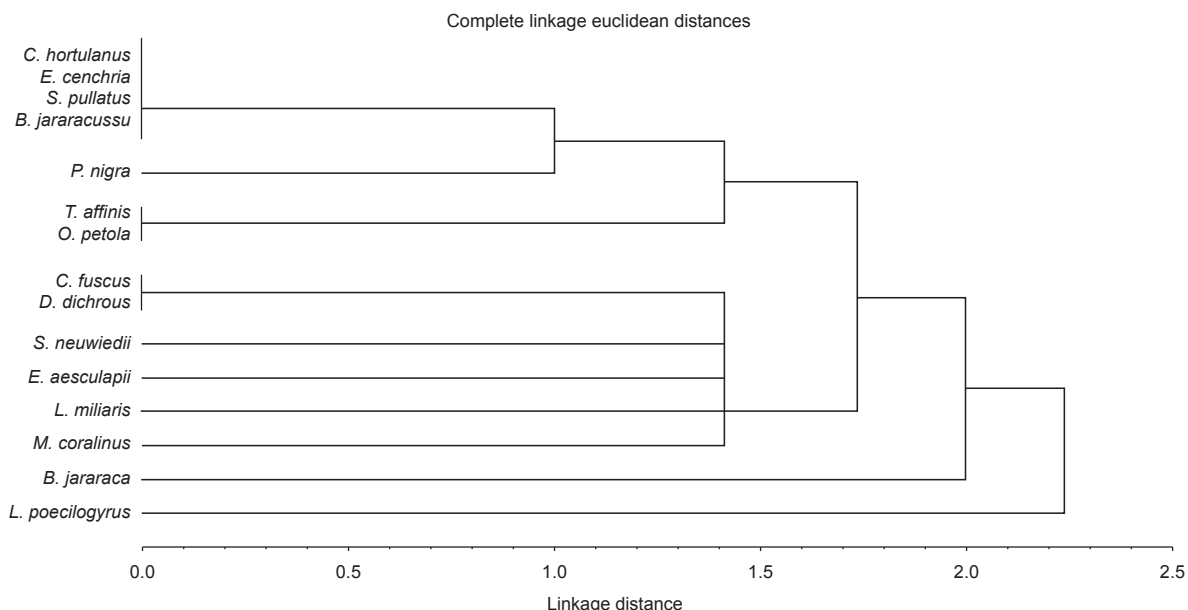


Figure 3. Cluster analysis (complete linkage, Euclidean distances) of diet items grouped as chilopods, mollusks, fishes, tadpoles, adult anurans, lizards, amphisbaenians, snakes, and rodents.

Figura 3. Análise de agrupamento (ligação completa, distâncias Euclidianas) dos itens da dieta agrupados como quilópodes, moluscos, peixes, girinos, anuros adultos, lagartos, anfisbenas, serpentes e roedores.

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Appendix 1. Material Examined**Apêndice 1. Material Examinado**

Bothrops jararaca: JC 3, 28, 49, 113, 116–8, 125, 147, 176, 233, 275, 278, 281–2, 298, 321, 523–6, 730, 736–7. *Bothrops jararacussu*: JC 50, 518. *Chironius exoletus*: JC 126. *Chironius fuscus*: JC 29, 30, 33, 115, 279, 452. *Corallus hortulanus*: JC 25. *Drymoluber dichrous*: UFMG 1397 (= JC 122), UFMG 1398 (= JC 541). *Elapomorphus quinquelineatus*: JC 27, 114. *Epicrates cenchria*: MZUSP 14474 (= JC 517). *Erythrolamprus aesculapii*: JC 26, 127, 522, 738. *Liophis miliaris*: JC 260, 357. *Liophis poecilogyrus*: JC 32, 234–5, 274, 280, 322, 473, 537–9, 710, 739. *Liotyphlops wilderi*: JC 119–20. *Micrurus corallinus*: JC 136, 228–9, 318, 527. *Oxyrhopus petola*: JC 62, 231. *Pseudoboa nigra*: JC 121, 138, 390, 520–1, 459. *Pseustes sulphureus*: JC 146, 284, 316, 408, 454. *Sibynomorphus neuwiedi*: JC 34, 63, 236, 530, 735. *Spilotes pullatus*: JC 112, 460, 519. *Taeniophallus affinis*: JC 61, 457. *Tantilla boipiranga*: UFMG 1402 (= JC 299), JC 531.

JC = field number of José Cassimiro; MZUSP = Museu de Zoologia da Universidade de São Paulo. UFMG = herpetological collection of Universidade Federal de Minas Gerais

