Feeding ecology of the neotropical worm snake *Atractus reticulatus* in southern Brazil

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*In memoriam

Analyses of the gut content of 126 specimens of *Atractus reticulatus* from the eastern Central Depression of Rio Grande do Sul State, southern Brazil, indicate that this species feeds exclusively on annelids, and primarily on oligochaetes of the family Megascolecidae. Thirty-two stomachs presented 52 items, of which 84.6% were oligochaetes (75.0% family Megascolecidae, 7.7% family Glossoscolecidae, and 1.9% unidentified families), 7.7% were Hirudinea and 7.7% unidentified annelids. Chaetae of oligochaetes were also found in the intestines of 40 additional specimens. Among 20 individuals of *A. reticulatus* of different size classes captured with some content in the gut, 85.0% were captured at night or in the early hours of morning, indicating foraging activity in these periods. About 83% of the ingested prey were free-living, epigeic annelids, which indicates that *A. reticulatus* forages mainly on the ground. Prior to swallowing, the annelids were usually oriented and ingested from the anterior portion of the body, a method probably related to autotomy of the prey, which may occur if they are captured from the posterior.

Key words: annelids, diet, oligochaetes, Rio Grande do Sul, snakes

The natural history of snakes frequently makes it possible to classify them as "specialists" or "generalists", based on the quantitative analysis of prey categories that form their diets. However, repeatedly, that analysis completely ignores geographic variation in the diet of snakes with wide geographic distribution, because of few representative samples or scarce data on the borders of their distributions.

The genus *Atractus* has a wide distribution in South America, occurring from western Panama to northern Argentina (Fernandes, 1995; Giraudo, 2001). This genus is included in the Central American xenodontine group that feeds on soft-bodied invertebrates (Cadle & Greene, 1993). Previous studies on species from the Amazon (Pérez-Santos & Moreno, 1990; Martins & Oliveira, 1993, 1998) and the Atlantic forest (Marques et al., 2001) identified *Atractus* as specializing on worms, but we do not know whether this feature is common to all the members of the genus. We studied the feeding ecology of a species from a temperate climate region in southern Brazil, adding information on the feeding ecology of the genus *Atractus* in another portion of its wide distribution.

The distribution of *Atractus reticulatus* is restricted to southern Paraguay, northeastern Argentina and southeastern and southern Brazil (Fernandes, 1995; Giraudo & Scrocchi, 2000), where it inhabits forest areas, savannas, transition environments and semi-urban areas (Giraudo & Scrocchi, 2000). The feeding ecology of this species is unknown.

Here we present data on the diet, feeding behaviour and foraging period of *A. reticulatus* in the eastern Central Depression of the state of Rio Grande do Sul, southern Brazil, based on the analysis of preserved specimens from collections and field observations.

All specimens were from the Central Depression of Rio Grande do Sul State. This area encompasses a portion of lowlands (10–300 m above sea level) with dark red podzol, which causes the ground to be poorly drained and creates a humid environment. The relief is homogeneous, forming hillocks. Some disjunct hills and some areas with strong anthropogenic influence are present. The climate is mesothermic temperate (IBGE, 1990).

This study was based on dissection and analysis of the gut content of 126 specimens of *A. reticulatus* preserved in the Museu de Ciências e Tecnologia of Pontifícia Universidade Católica do Rio Grande do Sul (MCP) and the Museu de Ciências Naturais of Fundação Zoobotânica do Rio Grande do Sul (MCN). Of those, 61 specimens were collected from August 2002 to December 2003 in urban and semi-urban environments. Feeding behaviour was observed in captivity on three occasions, when oligochaetes were swallowed. The direction of ingestion was determined, taking into consideration the orientation of the prey in relation to the snake. Well-digested gut contents were only analysed qualitatively. During field observations (0500–1800) we searched for snakes on the soil or sheltered under debris in cropping areas, swamp edges, cattle fields and other environments surrounding urban areas. Date, time and, if possible, activity status, were recorded for each snake we captured. All collected specimens were preserved for the MCP collection. We considered sheltered snakes that did not present any reaction immediately after being revealed as inactive, and snakes that were exposed on the surface or moving, or the sheltered ones that reacted immediately after being revealed, as active. The capture time, activity status, presence and digestion status of stomach content were analysed as a whole in order to estimate the foraging period of *A. reticulatus*.

Of 126 dissected stomachs, 32 (25.4%) contained 52 items, all of which were annelids. Three specimens in-

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Table 1. Prey items in the diet of *A. reticulatus* (*n*=32 stomachs) from southern Brazil. Three specimens ingested more than one prey category.

Prey items	Snakes with prey items		Prey items	
	Number	%	Number	%
Oligochaeta				
Megascolecidae	22	62.9	39	75.0
Glossoscolecidae	4	11.4	4	7.7
Unidentified families	1	2.9	1	1.9
Hirudina				
Unidentified families	4	11.4	4	7.7
Unidentified annelids	4	11.4	4	7.7
Total	35	100.0	52	100.0

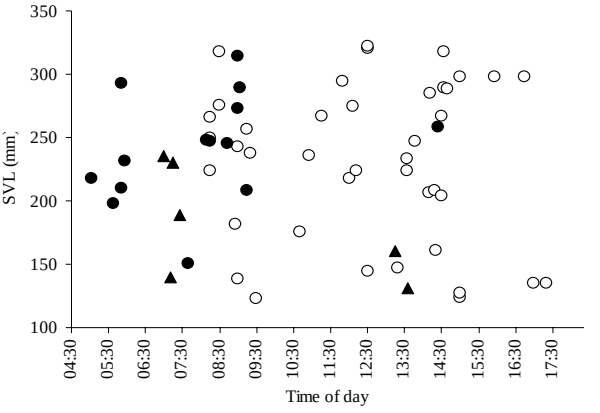

Fig. 1. Relationship between snout-vent length (SVL) and daily activity of *A. reticulatus* from southern Brazil. Closed circles = inactive with gut content; open circles = inactive without gut content; triangles = active with gut content.

gested more than one prey category (Table 1). The gut content of 40 snakes that did not have oligochaetes in the stomach included chaetae in the intestines (together with quartz grains and remains of vegetal and animal tissue), which demonstrates that they had ingested oligochaetes (Martins & Oliveira, 1998). Thus, 72 (57.1%) of the 126 individuals analysed had fed on annelids, 67 (53.2%) of them on oligochaetes.

Two specimens had, respectively, one (1.6 mm) and five (0.6–0.8 mm, mean=0.7 mm, SD=0.1) entire mites in the the final portion of the intestine. Remains of other arthropods were found in the intestines of four snakes.

In preserved specimens 82.7% of the ingested items were megascolecid oligochaetes and terrestrial hirudine, free-living annelids that dwell in the superficial layers of the soil. Among 37 annelids for which the direction of ingestion was identified, 32 (86.4%) were swallowed head first. Three specimens of *A. reticulatus* were fed in captivity with megascolecid oligochaetes. In two cases the prey were entirely swallowed head first. In the third case, the prey was bitten on the posterior portion of the body, which was then autotomized, and only this portion was swallowed by the snake.

Most specimens captured during the day were classified as inactive (*n*=55; 90.2%), except for three adults and one juvenile captured in the early morning, and two juveniles captured in the afternoon. Among the 20 specimens of *A. reticulatus* of different body size (SVL) classes captured with stomach contents, 17 were captured at night or in the early morning. From mid-morning (about 0930) until late afternoon (about 1730), only three of 35 specimens captured (8.6%) had any prey content in their stomachs. Inactive individuals were found at every sampling period, but only one of 28 snakes captured during the afternoon (3.6%) had prey in the stomach (Fig. 1).

These results show that within the study area, *A. reticulatus* is a specialist predator, feeding exclusively on annelids, and primarily on oligochaetes. Oligochaetes are known to be the primary prey of other *Atractus* species (Pérez-Santos & Moreno, 1990; Martins & Oliveira, 1993, 1998). Hirudines were recorded in the diet only for species from southeastern (Marques et al., 2001) and southern (this article) Brazil. Some captive specimens of *Atractus* cf. *taeniatus* from Machadinho municipality (Rio Grande do Sul) frequently fed on oligochaetes and terrestrial hirudines (Balestrin, unpubl. data).

The presence of small mites and remains of other arthropods in the intestine of *A. reticulatus* is likely to be due to accidental or secondary ingestion. Righi (1990) mentioned mites (Acari) and springtails (Collembola) in the diet of some species of oligochaetes. Pérez-Santos & Moreno (1990) found entire ants and other arthropods in the gut content of *Atractus badius*, but these items were also found in the gut content of the non-digested oligochaetes found in the gut content of those same snakes. Martins & Oliveira (1993, 1998) found small mites and remains of insects in the final portion of the intestine of five species of *Atractus* (*A. latifrons*, *A. major*, *A. poeppigi*, *A. schach* and *A. torquatus*) whose primary prey were also oligochaetes. However, Starace (1998) mentioned arthropods as a component of the diet of *A. badius*, *A. flammigerus*, *A. latifrons*, *A. schach* and *A. zidoki*. The vegetal remains and quartz grains found in the intestine of the snakes in this work are likely to be secondarily ingested from oligochaetes, since they were together with many chaetae (Pérez-Santos & Moreno, 1990), and correspond to the gut content found in some oligochaetes that are prey of *A. reticulatus*.

Some large species of *Atractus* (e.g. *A. badius* and *A. flammigerus*) include snakes and small gymnophthalmid lizards in their diet (Pérez-Santos & Moreno, 1990; Starace, 1998). The absence of this prey category in the diet of *A. reticulatus* may be related to the small size of this species and to the great abundance of oligochaetes in the peri-urban areas studied here in comparison to the abundance of other squamates (Di-Bernardo, unpubl. data). Body size is one of the major determinants (but not the only one) of the prey types that a given species is able to consume (Cadle & Greene, 1993; Rodrígues-Robles & Greene, 1999), and the availability of prey may determine which prey categories are present in the diet (Shine et al., 1998; Santos et al., 2000). Historical factors should also be considered on discussing the specificity of diet in *A. reticulatus* in the study area, but there is no information on this subject.

The great abundance of *A. reticulatus* in the urban and peri-urban environments studied here may be the result of adaptation to a new prey category within Annelida, including mainly exotic species of Oligochaeta of the family Megascolecidae, brought from Asia (Fragoso et al., 1999). Most of the megascolecids introduced by man in America and most of the terrestrial hirudines dwell in the superficial layers of the soil (Moreno, unpubl. data), and in peri-urban environments are easily found under debris, where *A. reticulatus* is also frequently present. Most species of the family Glossoscolecidae dwell deeper in the soil (Moreno, unpubl. data), which probably makes them less available as prey items.

Terrestrial epigeic oligochaetes may autotomize under predation, leaving part of their body for the predator, while they escape. It is common to collect only posterior portions of the body of oligochaetes in field work due to this autotomic mechanism (Moreno, unpbl. data). *Atractus reticulatus* avoids the autotomy and can swallow the entire prey as a result of capturing oligochaetes by the anterior portion of their body.

Most *A. reticulatus* captured during the night and early morning contained entire or partly digested prey in their stomachs, whereas most specimens captured during the day had empty stomachs. These findings indicate that *A. reticulatus* forages during the night. All the active snakes found during the day had stomach contents and were captured during the reproductive season of this species (Balestrin & Di-Bernardo, 2005); they were probably maximizing resources for reproduction. The movements of snakes may be related to factors other than their natural activity period. Floods in badly drained soils may force the snakes to move to non-flooded areas. Several authors suggest diurnal–nocturnal activity for many species of *Atractus* from forest regions at low latitudes, such as Silva & Valdez (1989) for *A. lancinii* and Martins & Oliveira (1993, 1998) for *A latifrons*, *A. major*, *A. schach* and *A. torquatus*. However, the high insolation that occurs in semi-urban areas due to the decrease of forest coverage, and hence the higher exposure of the snakes to predation, may favour a nocturnal activity pattern in *A. reticulatus* in the study area. The foraging period of *A. reticulatus* may also be related to the activity period of its prey, since annelids, as a general rule, have a nocturnal activity pattern to avoid exposure to ultraviolet radiation (Moreno, unpubl. data).

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