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Diet of *Rhinella schneideri* (Werner, 1894) (Anura: Bufonidae) in the Cerrado, Central Brazil.

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Abstract. This study describes the diet of *Rhinella schneideri* based on the analysis of the stomach contents of 18 specimens from an area within the Cerrado, Central Brazil. We found 842 items belonging to 11 prey categories, including the plant material category. The most important prey categories for *R. schneideri* were Insect larvae, Coleopteran and Formicidae. Numerical and volumetric niche breadths of *R. schneideri* were 3.35 and 1.00, respectively. According to its diverse diet and abundance, *R. schneideri* may be considered a generalist and opportunist species.

Keywords. Anura, diet, Cerrado, *Rhinella*.

Introduction

The diets of amphibians may be influenced by evolutionary and ecological factors, the choice of the kind and size of prey, biomechanical structures for feeding (e.g. tongue and jaw), foraging strategies, body size and physiological constraints (Toft, 1981; Duellman and Trueb, 1994). Commonly, diets of amphibians consist mainly of insects, but others categories of invertebrates and even smaller vertebrates have been verified as stomach contents (Toft, 1980; Duellman and Trueb, 1994; Pough et al., 2004). Because of this, the majority of amphibians are considered as generalists and opportunistic feeders (Caramaschi, 1981). *Rhinella schneideri* (Werner, 1894) is a large toad included in the *Rhinella marina* group (Pramuk et al., 2007), being widely distributed in South America (Pramuk, 2006). This toads is commonly found in open areas, urban areas and has a wide distribution in South America, Brazil, from the Atlantic coast (Ceará to Rio Grande do Sul), eastern Amazon in Paraguay, Bolivia, Argentina and Uruguay (*sensu* Frost, 2010), occurring also in Brazilian Savannah (Colli, Bastos and Araújo, 2002).

In the Brazilian Savannah information on the natural history of amphibians is very scarce and the biology of most amphibians is poorly known. This makes natural history studies very important and essential to provide information about preservation and conservation of species which are threatened by the increasing economic interest and devastation of the biome (Bastos, 2007). Vasconcellos and Colli (2009) report that the biology of *R. schneideri* is poorly known. Herein, we describe the diet composition of *R. schneideri* from the Brazilian savanna. Our goal is to increase information on the natural history of amphibians of the Savannah biome and contribute to the conservation and preservation of *R. schneideri*.

Materials and Methods

Fieldwork was carried out at the Farm 'Porta do Céu' (16.230556ºS, 49.080278ºW), located just south-west of the Brasília, in the Municipality of Novo Gama, Goiás, Brazil. The area is located within the Cerrado, which constitutes of a mosaic of vegetation characteristic for the savannah biome, arboreal forest, gallery forests and swamps. Human modifications are present in the shape of pastures and artificial ponds (De-Carvalho et al., 2008). The toads were captured between April 2006 and February 2007 during two consecutive nights per week in the field. The method used was an active search in all the selected sites (Crump and Scott, 1994). The collections occurred between 06:00 p.m. and 03:00 a.m. in two areas of swamps, three ponds, two

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Table 1. Diet of *Rhinella schneideri* from Novo Gama, Goiás, Brazil with their respective absolute values and relative abundance (N and N%) frequency (F and F%) volume (V and V%) and importance value index (IVI).

Prey Categories	N	N%	F	F%	V(mm³)	V(mm³)%	IVI
Aranae	1	0.1	1	1.8	55.5	0.1	0.7
Coleoptera	235	27.9	11	20.7	7496.4	14.8	21.1
Diplopoda	6	0.7	3	5.6	1183.8	2.3	2.9
Dermaptera	1	0.1	1	1.8	38.7	0.08	0.6
Hymenoptera							
Formicidae	234	27.7	11	20.7	1973.5	3.9	17.4
Other	21	2.4	5	9.4	333.5	0.6	4.2
Isoptera	24	2.8	6	11.3	537.4	1.0	5.0
Insect Larvae	317	37.6	6	11.3	37988.5	75.3	41.4
Plecoptera	2	0.2	1	1.8	5.5	0.01	0.7
Orthoptera	1	0.1	1	1.8	778.2	1.5	1.1
Plant Material	-	-	7	13.2	-	-	4.4
Total	**842**	**100.0**	**53**	-	**50391.5**	**100.00**	-
B		**3.3**				**1.6**	

fragments of gallery forest and two temporary ponds during the first night of sampling. Transects of about four kilometers were conducted in an open field, in a gallery forest and in an arboreal forest during the second night of sampling of each week, to increase the sampling effort of collecting in areas of the Cerrado. *Rhinella schneideri* is a medium to large species characterized by the presence of cranial crests, parotoid glands behind the tympanum and paracnemis glands in the region of the tibia. Identification of the specimens based on was Cei (1980), Bastos et al. (2003), Maciel et al. (2007).

We opened anuran stomachs and contents were carefully removed and spread on a petri dish. Prey items were counted, identified to the lowest taxonomic category possible (usually order). Length and width were measured to the nearest 0.01 mm with digital calipers. The prey volume was estimated using the ellipsoid volume formula (Magnusson et al., 2003):

$$V = \frac{\pi \cdot \text{Length} \cdot \text{Width}^2}{6}$$

We calculated numeric and volumetric percentages of each prey category. In addition we calculated the importance value index, based on the sum of the frequencies, numbers and volumes of the prey, all in percentage, divided by three. We used Simpson's diversity measure (Simpson, 1949) to estimate trophic niche breadth (number and volume):

$$B = \frac{1}{\sum_{i=1}^{n} p_i^2}$$

where p is the proportional utilization of prey item *i,* and n is the number of resource categories. B varies from 1 (exclusive use of a single resource type) to n (even use of all resource types).

To investigate the relationship between prey dimensions and morphological head measurements, we performed a canonical correlation analysis (Tabachnick and Fidell, 1996) between two variable groups (maximum prey length and width versus head length, width and height). All linear morphological variables, as well as dimensions of prey used by the toads, were $\log_{10}$-transformed to minimize scale effects (Zar, 1998). We carried out statistical analyses using Bioestat 5.0 for Windons (Ayres et al. 2007) with significance level of 5% to reject null hypotheses. All toads were deposited in the Herpetological Collection of the University of Brasília (CHUNB).

Results

We analyzed the stomach contents of 18 *R. schneideri*, five of which were empty. We found 842 items belonging 11 prey categories including the plant material category (Table 1). The plant material was found in seven individuals. The most frequent appearing items were Coleopteran (20.7%) and Formicidae (20.7%), and the items most numerous were Insect Larvae (37.6%), Coleopteran (27.9%) and Formicidae (27.7%). Insect larvae (75.3%) were a volumetrically more relevant prey category. The most important prey category for *R. schneideri* were Insect Larvae (IVI = 41.4; Table 1). The value of niches breadths for number and volume was 3.3 and 1.6 respectively (Table 1).

Canonical correlation analysis showed significant associations between head measurements and prey dimensions for *R. schneideri* (Table 2). Considering the first canonical variable, positive relationships were obtained for head length and prey width, and inverse ones for head width and prey lengths (Table 2).

Discussion

Bufonids are considered generalists concerning food resources (Duellman and Trueb, 1994), which can be evidenced by the large number of items consumed by species of this family. The diet of *R. schneideri* presents a wide variety of items similar to those found in other studies (Strüssmann, Meneguini and Magnusson, 1984; Lajmanovich, 1994; Vitt and Caldwell, 1994; Hirai and Matsui, 2002; Duré, Kehr and Schaefer, 2009). Ingestion of insect larvae, beetles and ants by *R. schneideri* in this area may reflect the greater availability of these items in the environment, thereby facilitating a higher availability of the same prey. In a study conducted in the same area, De-Carvalho et al. (2008) showed that males of *Leptodactylus fuscus* and *L. mystacinus* also consumed Insect Larvae, Coleopteran and Formicidae, respectively. A high intake of Coleoptera and Formicidae by species of the genus *Rhinella* was also observed in other areas of Brasilia and Argentina (Maragno, 2008; Sabagh and Carvalho-e-Silva, 2008; Duré, Kehr and Schaefer, 2009; Quiroga, Sanabria and Acosta, 2009).

According to Clarke (1974) beetles and ants play an important role in the diet of anurans, since they are the most frequent prey worldwide. Hirai & Matsui (2002) suggested that the consumption of unpalatable substances, as quinoses and formic acid presents in the compositions of Coleoptera and Formicidae, leads the animals to invest large amounts of energy to metabolize the chemicals ingested (Zug, Vitt and Caldwell 2001) and consuming items with little energy gain. According to Damasceno (2005), after these substances were metabolized by bufonids, they would be used to assist in the production of toxin. However, Zug, Vitt and Caldwell, (2001) emphasize that this procedure can take animals to invest large amounts of energy to metabolize these substances. Therefore, it is necessary to consume large quantities to offset energy costs. This behavior, however, needs further investigation.

The high consumption of insect larvae by *R. schneideri* is probably due to the fact that this class is abundant in wet environments where *R. schneideri* is found. Another factor that should be taken into consideration is the energy gain that this prey offers, due to the small energy used to capture them, having in view that they occur grouped. Moreover, insect larvae have fewer structures lined with exoskeletons when compared to other insects such as ants and termites. According to Zug, Vitt and Caldwell (2001) and Damasceno (2005) ants have a low energy value due to the large amount of exoskeleton when compared to larger insects such as larvae of some insects (e.g. caterpillars). This highlights the importance of the maggot category compared to the other categories in the diet of *R. schneideri*.

Ingestion of Plecoptera possibly indicates feeding near a body of water, considering the fact that this order is aquatic (Sabagh and Carvalho-e-Silva, 2008). The consumption of plant material may have occurred by chance due to the simultaneous intake of prey and plant material on the substrate (Evans and Lampo, 1996; Anderson and Mathis, 1999; Teixeira, Schineider and Giovanelli, 1999; Van Sluys, Rocha and Souza, 2001). Anderson, Haukos and Anderson (1999) suggest that the ingestion of plant material is performed actively, with the purpose of aiding in the elimination of exoskeletons and intestinal parasites. Another factor suggested by these authors is that plant material would contribute to a nutritional portion in the diet, serving as an extra source of water to prevent dehydration.

The relationship between ecology and morphology has been demonstrated as important for several groups of vertebrates, especially in relation to food and seasonal resources (Scheibe, 1987). According to Lima and Moreira (1993) and Duellman and Trueb (1994) the size of the head of a frog is important to determine the maximum size of prey being consumed by it. Thus,

Table 2. Canonical correlation between prey and head dimensions of from *Rhinella schneideri* Novo Gama, Goiás, Brazil. Note: *P* (p-value <0.05); X^2 (Qui-square).

Rhinella schneideri			
Canonical coefficients			
Head measurements	**First canonical variable**	**Second canonical**	
Head length	0.43	1.58	
Head width	-2.95	-6.87	
Head height	3.39	4.84	
Prey measurements			
Maximum prey length	-1.42	3.89	
Maximum prey width	2.31	-3.43	
Canonical variable	Canonical correlation	χ^2	***P***
I	0.94	16.5	0.01
II	0.32	0.79	0.67

the ability of gaping in relation to the size of the frog is a limiting factor in the selection of prey (Toft, 1980; 1981; Strüssman et al., 1984; Zug, Vitt and Caldwell, 2001; Pough et al., 2004). In the current study the relationship between head proportion of *R. schneideri* and prey size was significant, indicating that head size can influence the type of prey ingested. Strüssmann, Meneguini and Magnusson (1984) suggested that body size or capacity of gaping are important factors in the selection of suitable prey sizes. The amphibians of the families Bufonidae, Leptodactylidae and Cycloramphidae have a greater capacity to ingestion of prey of various types and proportions due to its ability to opening mouth (Duellman and Trueb, 1994; Pough et al., 2004). Similar patterns were reported by Toft (1980; 1981).

Rhinella schneideri can be considered as a generalist in relation to the use of food resources. A high intake of larval insects in the study area may have occurred due to the large energy value that the prey contains. Consumption of coleopterans and ants may reflect the greater availability of these items in the environment, but might also be related to the reduction of competition with others predators as showed by Clarke (1974). The ingestion of plant material may have occurred accidentally or purposely. The relationship between measures of head and prey size for *R. schneideri* were significant, indicating that head size can influence the type and sizes of prey ingested.

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