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Diet of *Melanophryniscus devincenzii* (Anura: Bufonidae) from Parque Municipal de Sertão, Rio Grande do Sul, Brazil

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This study describes the diet of *Melanophryniscus devincenzii* based on the analysis of stomach contents of 46 specimens from the Parque Municipal de Sertão, south Brazil. We found 935 items belonging to 33 prey categories (excluding plant material). The most important prey categories were Acari, ants (subfamilies Myrmicinae and Ponerinae) and beetles (mainly Polyphaga). These taxonomic categories showed the highest percentage by volume (Acari: 3.94%, Myrmicinae: 16.32%, Ponerinae: 12.17%, undetermined Polyphaga: 13.83%) and the highest index of relative importance (5810.05; 1871.06; 756.47 and 784.57, respectively). The rarefaction curves indicated that females have richer diets than males. According to dietary composition, *M. devincenzii* may be considered a specialist species, as expected for an active forager.

Key words: Brazil, *Melanophryniscus devincenzii*, trophic niche

The genus *Melanophryniscus* is widespread in Brazil and Bolivia, Paraguay, Uruguay and north Argentina (Kwet et al., 2005). To date, 25 species are known, belonging to three phylogenetic groups: *stelzneri*, *tumifrons* and *moreirae* (Cruz & Caramaschi, 2003; Frost, 2011). *Melanophryniscus devincenzii* is included in the *tumifrons* group, which comprises eight species with distributions in Paraguay, Argentina and Brazil (Caramaschi & Cruz, 2002; Brusquetti & Lavilla, 2006). It is known from localities in Argentina, Paraguay and Uruguay (Maneyro & Carreira, 2012), as well as from Rio Grande do Sul, Brazil (Zanella et al., 2007).

In amphibians, diets are usually related to prey availability in the environment (Duellman & Trueb, 1994), largely consisting of arthropods, molluscs and occasionally small vertebrates (Díaz-Páez & Ortiz, 2003; Maneyro et al., 2004). Prey selection can be influenced by intrinsic factors such as demand for nutrients at different life stages (ontogeny), or by extrinsic factors such as abundance of food and/or presence of competitors (Duellman & Trueb, 1994). Therefore, knowing the food habits of amphibians is one of the priorities for understanding their natural history, life cycles and population fluctuations (Wells, 1978).

Although the genus *Melanophryniscus* currently receives significant conservation attention (see Maneyro & Angulo, 2009; Silvano & Garcia, 2010) we have only limited knowledge about the diet of individual species (but see Bokermann, 1967; Felipello & Crespo, 1994; Mebs et al., 2005; Bonansea & Vaira, 2007). The aim of the present study is to determine the diet of *M. devincenzii* on the basis of the relative importance of prey types, to evaluate the relationship between predator size and prey size, and to describe possible sex-related differences in diet.

The study was carried out in the Parque Municipal de Sertão (28°02´31´S, 52°13´28´W), located in the municipality of Sertão, north of Rio Grande do Sul, Brazil. Specimens were captured in December 2010 at night (n=46), weighed, and measured for snout vent length (SVL), head width (HW), and jaw width (JW). Immediately after capture, stomach contents were extracted by stomach flushing. Stomach contents were analyzed in the laboratory with a binocular microscope (Solé et al., 2005). Each prey item was identified to the lowest possible taxonomic level (order and family). The volume (V) of each prey was calculated using the formula for an ellipsoid: $V=4/3\pi(L/2)(W/2)^2$), where L is the maximum length and W the maximum width. For fragmented prey that could be identified, the length was estimated using regression equations (for example ants: $Y=4.75X-0.62$, where X is head width; see Hirai & Matsui, 2001). Trophic diversity was analyzed for the whole sample, and for males and females separately with the standardized Shannon-Weaver index $J=H/\log(s)$, where $H=\sum[p_i*\log(p_i)]$, p_i is the proportion of type of prey i in a sample, and s is the total number of prey items. Rarefaction curves were plotted to compare the expected richness of food items consumed by males and females (Magurran, 1988). The index of relative importance (Pinkas et al., 1971) was calculated as: IRI= %FO*(%V+%N), where %FO is the

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Table 1. Prey types consumed by *Melanophryniscus devincenzii* captured in Sertão, Rio Grande do Sul, Brazil. FO%= frequency of occurrence; V%=percentage by volume; IRI=index of relative importance. T=total; M=males; F=females; Nd= unidentified items; *n*=number of prey items.

Prey type						*n*			FO%			V%			IRI		
						T	M	F	T	M	F	T	M	F	T	M	F
Arachnida	Acari					484	422	62	91.17	92.31	88.57	13.94	16.7	6.27	5,991	6,448	4,478
	Araneidae				Agelenidae	1	1	-	2.94	3.85	-	0.39	0.52	-	1.47	2.51	-
					Theridiidae	1	1	-	2.94	3.85	-	0.04	0.06	-	0.44	0.71	-
					Aradidae	1	-	1	2.94	-	2.86	5.63	-	23.18	16.89	-	68.26
					Amaurobiidae	2	1	1	5.88	3.87	5.71	0.24	0.21	0.34	2.68	1.3	6
					Araneidae Nd	1	1	-	2.94	3.85	-	0.26	0.35	-	1.08	1.84	-
Insecta	Hymenoptera	Apocrita	Aculeata	Vespoidea	Formicidae Myrmicinae	118	98	20	61.76	61.54	62.5	16.32	16.03	12.59	1,787.67	1,746.28	1,679.67
					Formicinae	94	94	-	14.7	19.23	-	11.25	15.12	-	313.25	518.6	-
					Ponerinae	58	33	25	41.18	34.62	40	12.17	8.6	23.74	756.47	343.83	1,641.43
					Cerapachyinae	1	-	1	2.94	-	2.86	0.01	-	0.044	0.35	-	2.17
					Formicidae Nd	3	3	-	8.82	11.54	-	0.94	1.27	-	11.17	16.07	-
			Parasitica	Prototrupoidea	Diapriidae	1	1	-	2.94	3.85	-	0.015	0.02	-	0.36	0.56	-
				Chalcidoidea	Chalcidoidea Nd	11	7	4	20.59	19.23	11.42	0.34	0.34	0.35	31.24	23.57	28.49
	Coleoptera	Polyphaga		Staphylinoidea	Staphylinidae	6	6	-	8.82	11.54	-	1.66	2.23	-	20.27	34.4	-
					Staphylinoidea Nd	5	5	-	8.82	11.54	-	0.45	0.6	-	8.67	14.2	-
				Curculionoidea	Curculionidae	1	1	-	2.94	3.85	-	0.45	0.6	-	1.64	2.81	-
				Cucujoidea	Cucujoidea Nd	8	5	3	8.82	7.69	8.57	0.99	0.6	1.15	16.32	12.25	28.2
				Tenebrionoidea	Tenebrionidae	9	9	-	14.7	19.23	-	1.62	2.17	-	37.92	63.6	-
				Bostrichoidea	Dermestidae	3	1	2	8.82	3.85	8.57	2.48	1.01	7.1	24.7	4.37	73.16
				Polyphaga Nd		37	28	9	44.12	42.3	42.86	13.83	16.49	6.48	784.57	846.8	551.8
		Adephaga		Caraboidea	Carabidae	13	11	2	20.6	23.08	20	2.48	2.92	1.27	79.6	99.27	53.92
	Hemiptera	Stenorrhyncha				1	1	-	2.94	3.85	-	0.31	0.41	-	1.21	2.07	-
		Auchenorryncha				1	1	-	2.94	3.85	-	0.12	0.17	-	0.66	1.09	-
		Hemiptera Nd				1	1	-	2.94	3.85	-	0.15	0.2	-	0.75	1.25	-
	Diptera	Brachycera				2	2	-	5.89	7.69	-	0.13	0.18	-	2.03	3.29	-
	Neuroptera	Hemerobiiformia			Mantispidae	1	1	-	2.94	3.85	-	0.39	0.53	-	1.47	2.52	-
	Insecta Nd					1	1	-	2.94	3.85	-	0.35	0.47	-	1.36	2.3	-
	Larva Nd					3	1	2	5.88	3.85	5.71	4.42	5.64	0.94	27.89	22.16	13.56
Parainsecta	Collembola	Entomobryomorpha		Entomobryoidea	Entomobryidae	59	53	6	20.58	15.38	20	3.69	4.46	1.55	205.96	171.32	116.79
				Isotomoidea	Isotomidae	1	1	-	2.94	3.85	-	0.008	0.01	-	0.34	0.53	-
Entognata	Diplura	Rhabdura			Projapygidae	1	1	-	2.94	3.85	-	0.02	0.03	-	0.37	0.59	-
Chilopoda	Scolopendromorpha					2	1	1	5.88	3.85	5.71	1.45	0.38	4.8	9.79	1.95	31.51
	Chilopoda Nd					4	2	2	5.88	3.85	5.71	3.45	1.3	10.23	22.83	5.98	66.6

percentage of occurrence (number of stomachs that have the same type of prey/total number of stomachs*100), %V is the volumetric percentage (total volume of prey i/ total volume*100) and %N is the numerical percentage (number of individuals of prey i/total number of prey*100).

Of 46 *M. devincenzii* (8 females and 38 males), 34 (73.9%) had content in their stomachs (8 females and 26 males). A large number of arthropods (*n*=935) belonging to 33 different taxonomic categories were found (Table 1). The mean volume of prey per stomach was $\overline{X}$ = 8.5±13.23 mm^3 (minimum of 0.02 and maximum of 48.94 mm^3). Acari, Myrmicinae, Ponerinae and Polyphaga showed the highest frequency (FO=91.17%; FO=61.76%; FO=41.18% and FO=44.12% respectively). Moreover, these four taxa had the highest volumetric percentage (Acari V=13.94%; Myrmicinae V=16.32%; Ponerinae V=12.17% and Polyphaga V=13.83%) and the highest index of relative importance (IRI=5,810.05; IRI=1,871.6; IRI=756.47; IRI=784.57, respectively; Table 1).

The general diversity of prey was *J*=0.79 (*J*=0.80 for females and *J*=0.76 for males). The rarefaction curves indicated that females have a higher trophic diversity than males (Fig. 1). A significant relationship was found between SVL and HW (*F*=16.4; *p*=0.0004), SVL and mean length of the prey (*F*=11.4623; *p*=0.0019), as well as JW and mean length of the prey (*F*=8.8; *p*=0.005). However, SVL did not show a significant relationship with minimum (*p*=0.660) and maximum prey length (*p*=0.5914). Males consumed a higher number of prey items than females (males: $\overline{X}$ =22.68±73.39; females: $\overline{X}$ =4.02±11.39) (*t*=1.75; *p*=0.04).

Females (SVL $\overline{X}$ =25.84±2.76 mm; 32.53–23.07 mm) were significantly larger than males (SVL =23.33±1.15 mm; 27.39–17.70 mm; *t*=2.5; *P*=0.02). Mean length of prey items differed significantly between sexes (males: $\overline{X}$ =1.22±0.44; females: $\overline{X}$ =1.84±0.38) (*t*=2.04; *P*=0.03).

Many authors consider bufonid toads as specialists that feed on ants (Toft, 1980; Da Rosa et al., 2002), while some regard them as generalists as demonstrated by the number and type of food items consumed (Duellman & Trueb, 1994; Sabagh & Carvalho-e-Silva, 2008). High plasticity among bufonid species has also been demonstrated (for example *Rhinella gr. granulosa* changes the composition of its diet according to season: Da Rosa et al., 2002). Bokermann (1967) observed that Formicidae, Orbatidae and Coleoptera are the main food items in the diet of *M. moreirae* (FO: 94%, 66% and 35%, respectively). Filipello & Crespo (1994) obtained similar results for *M. stelzneri*, with a higher occurrence of ants, mites, and beetles (92%, 70% and 65%, respectively). Although Bonansea & Vaira (2007) found geographic variability in the diet of *M. rubriventris*, the three groups of arthropods mentioned above are almost always the dominant prey.

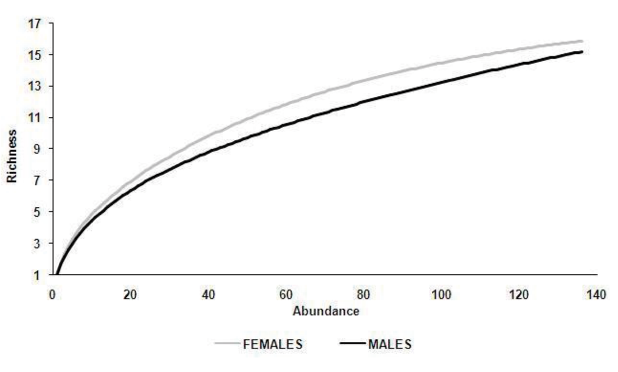

Fig. 1. Rarefaction curve for the richness of the diet of *Melanophryniscus devincenzii* males and females captured in Sertão, Rio Grande do Sul, Brazil.

Beetles and ants play the most important role in the diet of anurans (Clarke, 1974). Data from this study corroborate, in part, the results found by other studies. The large quantities of mites in the diet of *M. devincenzii* may have been due to opportunistic feeding on items abundant in the environment. Also, dendrobatids consume a large number of mites (Cajade et al., 2010; Staudt et al., 2010) which have been identified as a source of alkaloids (Takada et al., 2005; Saporito et al., 2007), and ants may be associated with toxins produced by mantellids (Clark et al., 2005; Mebs et al., 2010). The diet of *M. devincenzii* may also be a potential source of the pumiliotoxins described for this species (Mebs et al., 2005; 2007).

Additionally, plant parts were found in the stomachs, but were not quantified in the present study. Guiurcă & Zaharia (2005) found that 29.82% of the stomachs of *Bombina variegata* contained plant remains, suggesting accidental consumption. Anderson et al. (1999) considered that the ingestion of plant material aids in the elimination of intestinal parasites, in addition to contributing nutritionally and acting as an additional water resource to avoid dehydration. The presence of plant remains in the stomachs of *M. devincenzii* was considered accidental. Bufonids are known as active foragers (Duellman & Trueb, 1994), consuming large amounts of small and less mobile prey, which was also observed for *M. devincenzii* (Maragno & Souza, 2011).

Studies on intersexual differences in the diet of anurans are scarce, due to the difficulty in capturing females of many species (Lopez et al., 2009). *Melanophryniscus devincenzii* females had a higher diversity of food items, and ate bigger and fewer prey items than males, suggesting a possible tendency towards specialization. When large prey is scarce, females feed on food items such as ants. Studies on *Rana arvalis* also showed that the food items of males and females differ in their composition (Sas et al., 2005), and Maneyro et al. (2004) also observed that the diet of *Leptodactylus latrans* females is more diverse than that of males. The diet of juveniles, adult males and females of *Litoria nannotis* further showed significant differences in numerical composition, size, and selectivity of preys (Hodgkison & Hero, 2003). Active predators feed mainly on small and slow animals, especially those that can be captured from aggregations such as nests of ants and termites (Dietl et al., 2009). The variation in the diet of male and female anurans may reflect different requirements of each sex (Donnelly, 1991; Maneyro et al., 2004) or different foraging strategies (Brasileiro et al., 2010), since males need more energy for vocalization and territory defence (Woolbright, 1982; Taigen & Wells, 1985), while females need energy for egg production (Gilbert, 2005; Maneyro & Kwet, 2008).

A proportionally higher number of Acari, Hymenoptera-Formicidae and Coleoptera in the diet of *M. devincenzii* resulted in a narrow prey niche and a low diversity index, which reflects a strategy of active foraging. In comparison, *Ophaga pumilio* presented a diversity of 0.47 and *Dendrobates auratus* a diversity of 0.36 (values recalculated to the level of order from Cajade et al., 2010). Standardized Shannon-Weaver index values vary depending on whether prey items are identified to order or to family level, which in the present study would lead to an enlarged niche (*J*=0.79). Different sizes of prey in the diet may be related to ontogenetic factors (Strüssman et al., 1984; Lima & Moreira, 1993; Maneyro et al., 2004; Rodrigues et al., 2004); as organisms grow, they can eat larger prey (Hodgkison & Hero, 2003). The size of the head determines the maximum size of prey that can be eaten (Duellman & Trueb, 1994).

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