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Diet of *Dermatonotus muelleri* (Anura: Microhylidae) in a semi-deciduous forest in western Brazil

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ABSTRACT

Anurans are important predators and preys in neotropical food webs linking different trophic levels. A small portion of them are specialist predator what is related with moth size and morphology. Herein, we report the diet of *Dermatonotus muelleri* (Microhylidae) from a semi-deciduous forest in Western Brazil. We collected a total of 63 adults of *D. muelleri* (females and males) from the Selvíria municipality, Mato Grosso do Sul State, Brazil. We did not find differences between male and female diet composition. The most frequent preys found were isopterans (63.34%) and hymenopterans (26.67%). All hymenopterans identified belong to the Formicidae family. Our results defined *Dermatonotus muelleri* as an ant-specialist predator and agree with previous studies about the diets of neotropical Microhylid frogs like *Chiasmocleis albopunctata*, *C. bassleri*, *C. capixaba*, *C. hudsoni*, *C. jimi*, *C. leucosticta*, *C. shudikarensis*, *C. ventrimaculata*, *Ctenophryne geayi*, *Elachistocleis bicolor*, *E. ovalis*, *E. pearsei*, and *E. panamensis*.

Key Words: Trophic ecology; ant-specialist; Microhylid.

Anurans are fundamental in trophic networks (Stănescu *et al.*, 2014), as they consume several arthropods and efficiently control insect populations (McCormick and Polis, 1982; Wells, 2007). Besides, adults, larvae and eggs are preyed on by both vertebrates and invertebrates such as birds (Poulin *et al.*, 2001), mammals (Lawrence *et al.*, 2018), snakes (Carrillo, 2017), other anurans (Ceron *et al.*, 2018), fishes (Hecnar and M'Closkey, 1997), spiders (Menin *et al.*, 2005a), water bugs (Toledo, 2005), diving beetle (Santos-Silva and Ferrari, 2012), ants (Lingnau and Di-Bernardo, 2006) and wasps (Warkentin, 2000). Due to their intermediate positions in trophic networks, frogs are an important link between arthropods and large sized vertebrate predators, allowing nutrients to dislocate between trophic levels (Beard *et al.*, 2002).

Although most anurans really behave as generalist predators, some lineages are considered specialists which is strongly related with mouth morphology and size (Toft, 1981). Microhylids and dendrobatids, for example, are classified as ant-specialists since they feed mainly on ants and termites (Parmelee, 1999; Darst *et al.*, 2004). Among the neotropical microhylids, *Dermatonotus muelleri* (Boettger, 1885) is a burrowing species with nocturnal habits, which builds subterranean chambers as refugees where it remains during the dry season in estivation, only emerging in the rainy season for explosive reproduction (Nomura *et al.*, 2009; Nomura and Rossa-Feres, 2011). *Dermatonotus muelleri* is endemic to the South American Diagonal of open formations, including ecosystems as the Cerrado, Caatinga, Chaco and Pantanal characterized with savanna like vegetation and a seasonal climate (Duellman, 1999). Its distribution includes eastern Bolivia, Paraguay, Northern Argentina and several Brazilian states with open formations (Frost, 2020).

Given that more studies about anuran natural history and ecology are needed (Silvano and Segala, 2005), diet studies are fundamental for understanding life history, trophic networks and their ecological implications (Hirai and Matsui, 1999), such as nutrient flow and parasite lifecycles (Beard *et al.*, 2002; Campião *et al.*, 2015). Herein, we report the diet of a population of *Dermatonotus muelleri* from

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a semi-deciduous forest in Mato Grosso do Sul State, Western Brazil.

On 26 of November 2015, we collected 63 adults of *Dermatonotus muelleri* (28 females and 35 males) from a riparian forest of the Véstia stream at the Fazenda de Ensino, Pesquisa e Extensão da Universidade Estadual Paulista, Campus de Ilha Solteira, located in the Selvíria municipality (20° 23' 44.00" S; 51° 23' 40.09" W; DATUM = WGS84), Mato Grosso do Sul State, Brazil. The region presents a tropical weather, with a rainy summer and a dry winter, average annual temperature of 24.5° C and average relative humidity of 64.8% (Moura *et al.*, 2011; Alvares *et al.*, 2014). Vegetation is considered as a remnant of transitional forest between Cerrado and Seasonal Semi-deciduous forest. Cerrado areas varies from dense grassland with shrubs and trees to woodland with a canopy of 12–15 m high, while Semi-deciduous forest presents canopy of 15-18 m high with emergent trees up to 25 m (Grombone-Guaratini and Rodrigues, 2002; Bridgewater *et al.*, 2004).

We killed the specimens through overdose of liquid lidocaine, fixed them in formaldehyde 10% and preserved them in ethanol 70%. We separated stomachs for posterior diet analysis by ventral dissection. All individuals are housed at Coleção Zoológica of the Universidade Federal de Mato Grosso do Sul (ZUFMS-AMP 10788-10850).

For diet analysis, we determined the prey species to their Order using a stereomicroscope. We measured every prey item's width (w) and length (l) to estimate the ellipsoid volume per prey using Griffiths and Mylotte (1987) formula: $V=(4\pi/3)(w/2)^2(l/2)$. To determine the importance of each prey item for *D. muelleri,* we used Pinkas *et al.* (1971) importance index using occurrence percentage (F%), numeric percentage (N%) and volumetric percentage as follow: IRI= F% x (N%+V%).

To test whether the diet of the sexes is similar or different, we performed a permutational analysis of variance (PERMANOVA) using the frequency of occurrence of food items in the R program, version 3.2 (R Core Team 2017), with the packages "vegan" (Oksanen *et al.*, 2019). However, the diet did not differ between males and females ($p= 0.117$; $F= 2.04$).

After analyzing 63 stomachs, we found 33 empty stomachs (52.38%) and 30 stomachs with at least one prey item (47.62%). 24.32% of the prey found were at a high level of decomposition, making their proper identification impossible. We identified 2,630 prey items (Table 1), divided in two Insecta orders (Isoptera and Hymenoptera) and one mite order (Trombidiformes). Additionally, it is relevant to mention that, all Hymenopterans identify in *D. muelleri* diet belong to the Formicidae family.

Isoptera was the most frequent item in 19 stomachs (63.34%), corresponding to 98.75% of the total prey ingested and to 39.03% of the total prey volume. The second most important item was Hymenoptera (Formicidae), found in 8 stomachs (26.67%), representing 0.87% of the total prey ingested and 1.01% of the total prey volume. Overall, the most important item, based on important relative index (IRI), was Isoptera followed by Hymenoptera (Formicidae) and Trombidiformes (Table 1). Undetermined items where present in the 30% of the analysed stomach and represented the 59.95% of the total volume of ingested prey.

The diet of *Dermatonotus muelleri* was composed of termites, ants and mite. This kind of diet is classified as ant specialist by Toft (1980). Our results agree with the diet reported for fossorial Microhylid species with explosive reproduction, such as *Chiasmocleis albopunctata (Boettger, 1885)*, *C. bassleri* Dunn, 1949, *C. capixaba* Cruz, Caramaschi, and Izecksohn, 1997, *C. hudsoni* Parker, 1940, *C. jimi* Caramaschi and Cruz, 2001, *C. leucosticta* (Boulenger, 1888), *C. shudikarensis* Dunn, 1949, *C. ventrimaculata* (Andersson, 1945), *Ctenophryne geayi* Mocquard, 1904, *Elachistocleis bicolor* (Guérin-Méneville, 1838), *E. ovalis* (Schneider, 1799), *E. panamensis* (Dunn, Trapido, and Evans, 1948), *E. pearsei* (Ruthven, 1914), *Hamptophryne alios* (Wild, 1995), *H. boliviana* (Parker, 1927), *Kaloula pulchra* Gray, 1831, *Microhyla fissipes* Boulenger, 1884 and *M. heymonsi* Vogt, 1911 (Berry, 1965; Duellman, 1978; Schluter and Salas, 1991; Parmelee, 1999; Caramaschi and Cruz, 2001; Solé *et al.*, 2002; Van Sluys *et al.*, 2006; Berazategui *et al.*, 2007; López *et al.*, 2007; Araújo *et al.*, 2009; Norval *et al.*, 2014; Blanco-Torres *et al.*, 2015; Lopes *et al.*, 2017; da Silva *et al.*, 2019).

The most important alimentary item was Isoptera, which was also found for others species of microhylids like *Elachistocleis panamensis* (Blanco-Torres *et al.*, 2015). These colonial insects fly during the first half of the rainy season, when large numbers of alates actively search for primary reproduction (Pinheiro *et al.*, 2002; Nomura, 2005; Bignell *et al.*, 2010). On the other hand, *D. muelleri* is a fossorial species whose explosive reproduction only occurs at the beginning of the rainy season (Nomura *et al.*,

Table 1. Diet of *Dermatonotus muelleri* from Selvíria municipality, Mato Grosso do Sul State, Brazil. Absolute and relative volume (V and V%), number of individuals (N and N%), absolute and relative frequency (F and F%) and important relative index (IRI) per prey item.

Prey item	V (mm^3)	V%	N	N%	F	%F	IRI
ARTHROPODA							
Arachnida							
Trombidiformes	0.39	<0.01	1	0.04	1	2.70	0.11
Insecta							
Hymenoptera (Form†)	259.19	1.01	23	0.87	8	21.62	40.64
Isoptera	10014.49	39.03	2597	98.75	19	51.35	7075.00
UNDETERMINED	15381.92	59.95	9	0.34	9	24.32	1466.25

† Form=Formicidae

2009, Nomura and Rossa-Feres, 2011). *Dermatonotus muelleri* and isopterans share peak reproductive activities, resulting in high abundance of this food item available for to this frog species.

Another important alimentary item was Hymenoptera (Formicidae), with high abundance in leaf litter in neotropical environments (Barberena-Arias and Aide, 2002). Although it is not the main food item, Formicidae is an important item in the diet of microhylids, including *D. muelleri* and other species such as *Elachistocleis bicolor*, *E. pearsi* and *E. panamensis* (Berazategui *et al.*, 2007; López *et al.*, 2007; Blanco-Torres *et al.*, 2015). Similar to our results, arachnids like spiders and mites have been reported with low importance for *Chiasmocleis hudsoni*, *C. shudikarensis*, *Elachistocleis bicolor* and *E. pearsi* (Berazategui *et al.*, 2007; Blanco-Torres *et al.*, 2015; da Silva *et al.*, 2019).

Diet of anurans can changes depending on prey availability, which in turn depends on the season (Menin *et al.*, 2005b). However, *D. muelleri* proved to be a specialist species with fossorial habits, which is always active during the beginning of the rainy season with explosive reproduction, avoiding prey availability changes. *Dermatonotus muelleri* morphology indicates clear specialization for Isoptera, presenting a small head, small mouth opening and no teeth (Trueb and Grans, 1983; Isacch and Barg, 2002). Furthermore, the species presents specific behavior to reach Isoptera and can change from sit and wait to active predation according to the spatial distribution of its resources (Nomura and Rossa-Feres, 2011). Finally, as we expected, *D. muelleri* presented a specialist diet, mainly based on Isopterans and Hymenopterans from the Formicidae family. Our results agree with previous reports for the species and suits the known morphology and behavior of microhylids.

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