

Trophic niche of *Dendropsophus minutus* (Anura: Hylidae) in southern Brazil

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Abstract

Trophic niche of *Dendropsophus minutus* (Anura: Hylidae) in southern Brazil. The feeding biology of the Neotropical tree frog *Dendropsophus minutus* is described based on identification of the items consumed by the anuran. Samples were collected monthly samplings for one year in an *Araucaria* forest in the state of Paraná in southern Brazil. Of the total of 101 gastrointestines examined, 51 were empty or contained digested remains or plant items. The 50 samples of gastrointestinal contents contained three classes and 10 orders of arthropods. The results suggest that *D. minutus* is a generalist predator that feeds on arthropods, primarily those in the orders Araneae, Lepidoptera, and Diptera. The diet varies seasonally depending upon prey activity, which determines the breadth of the trophic niche of the frog.

Keywords: *Araucaria* forest, amphibian ecology, diet, predation, prey.

Resumo

Nicho trófico de *Dendropsophus minutus* (Anura: Hylidae) no sul do Brasil. A biologia alimentar da perereca neotropical *Dendropsophus minutus* é descrita a partir da identificação dos itens predados pela espécie. Amostras foram coletadas mensalmente por um ano em uma área de Floresta de Araucária no estado do Paraná, sul do Brasil. Um total de 101 estômagos foi analisado, sendo que desses 51 estavam vazios ou continham itens digeridos ou fragmentos de plantas. As 50 amostras de conteúdo gastrintestinais estudadas continham três classes e 10 ordens de artrópodes. Os resultados sugerem que *D. minutus* é um predador generalista que se alimenta de artrópodes, principalmente das ordens Araneae, Lepidoptera e Diptera. A dieta varia sazonalmente, dependendo da atividade das presas, o que determina a amplitude do nicho trófico da espécie.

Palavras-chave: dieta, ecologia de anfíbios, Floresta com Araucária, predação, presa.

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Introduction

The adults and juveniles of most anuran species are generalist predators of invertebrates and vertebrates (Toledo *et al.* 2007, López *et al.* 2009). However, some taxa, such as poison-dart frogs of the genus *Dendrobates* (Wagler, 1830), have specialized diets (e.g., Toft 1995). Irrespective of the type of diet (i.e., generalist or specialist), anurans occupy an important trophic position in terrestrial and aquatic ecosystems because they are predators invertebrates, as well as prey of vertebrates and invertebrates (Toledo *et al.* 2007, Wells 2007).

Anuran diets may be determined by behavioral factors (Maneyro *et al.* 2004, Toledo *et al.* 2007), morphological characteristics of the predator and/or prey (e.g., prey size or predator mouth size; Biavati *et al.* 2004, Toledo *et al.* 2007, Pacheco *et al.* 2017), or by the period of predator and/or prey activity (Leivas *et al.* 2012a); thus, study of their dietary habits is complex (López *et al.* 2009). The temporal variation of dietary resources associated with the physiological demands of anurans, such as energy for growth and reproduction (Grayson *et al.* 2005, Leivas *et al.* 2012b), may generate seasonal patterns in their diets (Miranda *et al.* 2006, Berzategui *et al.* 2007, Leivas *et al.* 2012a).

Male and female anurans have different energetic demands; therefore, there are differences in the diets of the sexes (Wells 2007). Males expend considerable energy in vocalization and territorial activities (Giasson and Haddad 2006, Wells 2007, Leivas *et al.* 2012b), whereas females use much of their energy to produce and develop oocytes (Wells 2007, Leivas *et al.* 2012a, Castro *et al.* 2013).

Dendropsophus minutus (Peters, 1872) is a small neotropical tree frog that is broadly distributed from Trinidad in the north of South America through Uruguay and Argentina in the south (Frost 2017). The species usually is abundant where it occurs and occupies natural, as well as anthropogenic, environments. Most

autecological studies of *D. minutus* have focused on reproductive biology (Santos and Oliveira 2007, Santos *et al.* 2012, Leivas *et al.* 2018), behavioral traits (Morais *et al.* 2012), and habitat usage (Maffei *et al.* 2011).

Dietary studies of *Dendropsophus minutus* are scarce and restricted to a few localities in the northern and northeastern regions of Brazil (Van Sluys and Rocha 1998, Santos *et al.* 2004). They do not explore the seasonal aspects of diet, the trophic niche of the species, or the regional variations, topics that we address by describing the diet of the species, and analysis of the breadth of the trophic niche and seasonal variation in prey selection.

Materials and Methods

The study was conducted in Campina Grande do Sul, state of Paraná, Brazil (25°17'09" S, 49°00'05" W; 918 m a.s.l.). The vegetation is classified as Mixed Ombrophilous Mountainous Forest (*Araucaria* forest) and the climate is temperate Cfb following Koppen's classification (Peel *et al.* 2007). The sampling sites are two permanent ponds with floating vegetation. The area has of anthropogenic disturbance.

Samples were collected each month from January to December 2012 at night; two persons spent 3 hr using acoustic and visual survey methods to search for frogs (Crump and Scott Jr. 1994). After capture, specimens were transported immediately to the laboratory and euthanized following current guidelines of the Conselho Federal de Biologia (CFBIO-Resolution 308). Voucher specimens are deposited at the Museu de História Natural do Capão da Imbuia, Curitiba, Paraná, Brazil.

We measured the snout–vent length (SVL) of each frog with digital calipers (mm) and the body mass (BM) with a precision balance (0.001 g). The specimens were sectioned ventrally for the extraction of gastrointestinal contents. Prey items were quantified and identified (to the lowest possible taxonomic level) under stereoscope microscope. The body mass of each prey

was measured with a precision balance (0.001 g). The diet of specimens of *D. minutus* was not differentiated according to sex and to the ontogenetic stage.

The composition of gastrointestinal contents was quantified by calculating the frequency of occurrence (FO) from $FO = ei / E$, where ei = number of stomachs with item i , and E = total number of stomachs analyzed. The numerical frequency (NF) was calculated from $NF = ni / N$, where ni = the number of prey items i in all stomachs, and N = total number of items found in all stomachs. Prey weight (PW) was calculated from $P = pi / P$, where pi = weight of item i in all stomachs, and P = weight of all items in all stomachs. The index of relative importance (IRI) of each food item was derived from $IRI = (N + P) \times FO$. Values of IRI were standardized in percentage following Cortés (1997).

To detect seasonal differences in prey consumption, we applied a cluster analysis (UPGMA) based on the Bray-Curtis similarity index, which varies from 0–1, with 0 signaling no similarity between groups, and 1 meaning that the groups share all prey items consumed. These analyses were performed using the IRI values obtained for each food item from each season of the year. Subsequently, the significance of the groupings was tested with analysis of similarities (ANOSIM).

Trophic niche breadth was calculated for each season using Levin's standardized niche breadth index. The values vary between 0 and 1; values close to 0 represent narrow niches and values close to 1 indicates wide niches (Krebs 1999). Seasons are defined as follow: summer (January–March); autumn (April–June); winter (July–September); and spring (October–December). Analyses were performed using ECOSIN (Entsminger 2014).

Results

We sampled 101 *Dendropsophus minutus*, there were 89 adult males, 4 young males, 4 adult females and 4 juveniles of undetermined

sex. SVLs range from 12.7–24.3 mm, and BM from 0.09–1.15 g. Of the 101 stomachs, 51 were excluded from the analyses because 13 were empty, 11 contained only plant material, and 27 contained digested items that could not be identified. The 50 stomachs examined were from adult males and contained exclusively arthropods of three different classes and 10 orders (Table 1).

The greatest diversity and abundance of prey items are from the Class Insecta; seven orders (Blattodea, Hemiptera, Orthoptera, Diptera, Coleoptera, Lepidoptera, and Hymenoptera) are represented. There are two orders (Acari and Araneae) of Arachnida and one order (Enterobryomorpha) of Collembola. Most of the prey items are from Araneae, Lepidoptera, and Diptera, which have higher NF, FO and IRI values (Table 1). The highest PW values occur in Lepidoptera, Blattodea, and Orthoptera. Acari, Enterobryomorpha, and Hymenoptera are characterized by smaller IRI% values (Table 1).

Seasonal variation in prey items can be summarized as follow: Diptera, Lepidoptera, and Araneae had the highest IRI% in the summer; Lepidoptera and Araneae predominated in the autumn and Araneae and Diptera in the winter, whereas Araneae had the highest value in the spring. Araneae had high IRIs in all seasons; in contrast, dipterans were poorly represented in the spring and lepidopterans were absent in the winter (Figure 1). The analysis of seasonal similarity of prey items indicated that the winter and spring diets were more similar to one another (70%), than were summer and autumn (58%), although the results of the groupings did not show significant values (ANOSIM; $p = 0.58$) (Figure 2).

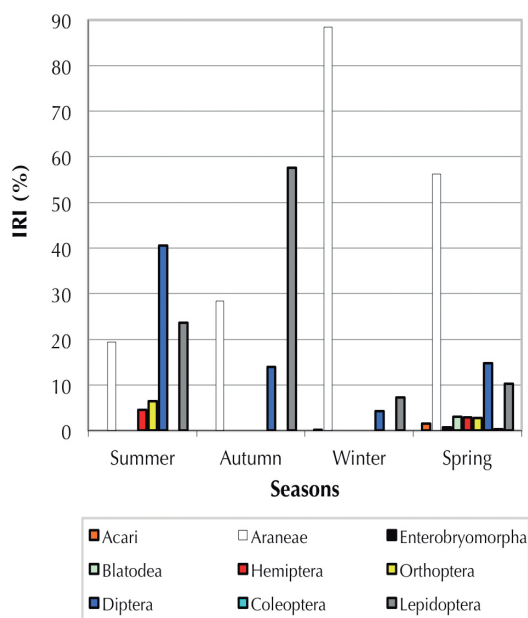
Niche breadth seems to vary seasonally. The greatest niche breadth occurred in the spring, (Levin's Index = 0.717), followed by summer (Levin's Index = 0.240), winter (Levin's Index = 0.043), and autumn (Levin's Index = 0.004).

Discussion

Regional dietary differences observed *Dendropsophus minutus* (e.g., richness of prey taxa

Table 1. Food items found in stomachs of *Dendropsophus minutus*. NF, numerical frequency; FO, frequency of occurrence; W, weight; IRI, index of relative importance. Values are shown as percentages.

Class	Order	NF	FO (%)	W (g)	IRI (%)
ARACHNIDA	Acari	2.99	3.00	0.05	0.46
	Araneae	28.36	25.00	12.62	49.59
COLLEMBOLA	Enterobryomorpha	1.49	2.00	0.02	0.11
INSECTA	Blattodea	1.49	2.00	22.32	1.80
	Hemiptera (Cicadomorpha and Fulgoromorpha)	5.97	8.00	0.96	1.33
	Orthoptera	4.48	5.00	15.32	4.49
	Diptera	14.93	18.00	1.95	12.77
	Coleoptera (Cucujiformia, Chrysomelidae)	8.86	10.00	4.29	1.67
	Lepidoptera	8.96	10.00	33.36	19.20
	Hymenoptera (Formicidae)	1.49	2.00	0.02	0.11
UNDETERMINED		20.98	15.00	9.09	8.47

**Figure 1.** Seasonal analysis of the *Dendropsophus minutus* diet based on the Index of Relative Importance (IRI%) of food items in the diet.

and abundance of each prey taxon) may be related to the climatic and vegetation characteristics of the sites (Toft 1981, Toledo *et al.* 2007, Solé and Pelz 2007, Leivas *et al.* 2012a). Our results indicated that *D. minutus* in Ombrophilous Mixed Forest (southern Brazil) have a diet composed mainly of arthropods; this corroborates the findings of Van Sluys and Rocha (1998) and Santos *et al.* (2004) in the Ombrophilous Forest in the Amazon and in the Semi-deciduous Rainforest of northeastern Brazil, where there was a high frequency of arachnids in the diet.

The abundance and size of small prey items ingested may be associated with morphological characteristics of *Dendropsophus minutus*—i.e., owing to the small size of the frogs, they may select small-sized prey (Toledo *et al.* 2007) that are most abundant in the season (Toledo *et al.* 2007, Leivas *et al.* 2012a). The grouping winter-spring and summer-autumn similarity groupings of prey are not statistically significant because Araneae, Lepidoptera, and Diptera are

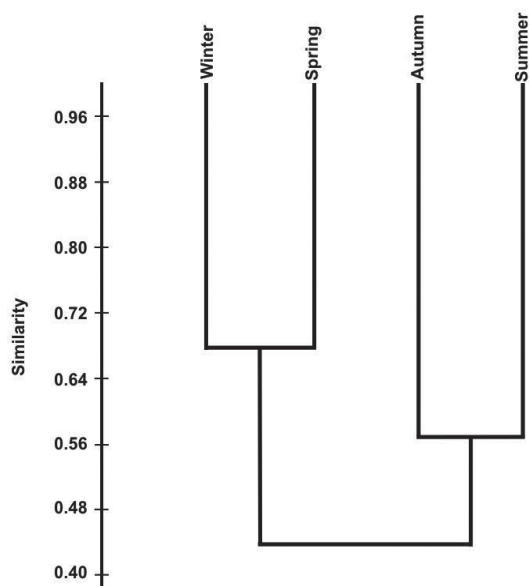



Figure 2. Analysis of seasonal similarity of prey items of *Dendropsophus minutus* with Bray-Curtis distance index.

predominant prey items all year long. However, the other food items were important determinants of seasonal variation in trophic niche breadth.

Because *Dendropsophus minutus* is a dietary generalist, it has a wide trophic niche (Van Sluys and Rocha 1998, Santos *et al.* 2004) and seasonal variation in the size of the trophic niche may be related to the reproductive process of the species. The most males with developed testes were found in the hottest periods of the year, spring and summer (Leivas *et al.* 2018); these are the seasons with the highest trophic niche-breadth values. Thus, food items with the lowest IRI supplement the diets of the frogs, and increase the available energy to them; this may be associated with greater reproductive process (Wells 2007, Leivas *et al.* 2012b). Moreover, a greater variety of food resources in spring and summer also may be advantageous for the successful development of post-metamorphic anurans (Leivas *et al.* 2012b).

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