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Trophic ecology of *Scinax rostratus* (Peters, 1863) and *Scinax ruber* (Laurenti, 1768) (Anura: Hylidae) in tropical dry forests of northern Colombia

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Abstract. We describe the diet of two syntopic *Scinax* species, *S. rostratus* and *S. ruber*, from northern lowlands of Colombia. These frogs do not seem to exhibit a marked preference for the consumption of a particular type of prey. However, in their diets, orthopterans were a well-represented category. *Scinax ruber* showed a positive and significant relationship between the size of the jaw and the average volume of consumed prey. The diets of both species overlap (54%), containing orthopterans, hemipterans and acari. Considering the trophic characteristics of both species, we classify them as generalist predators that use the sit-and-wait strategy to capture their prey.

Keywords: Caribbean lowlands, diet, Insecta, tree frogs

Introduction

The study of trophic ecology in amphibians is paramount for analysis of biological interactions, because animals transfer energy intake from invertebrates to higher trophic levels (Burton and Likens, 1975), both in aquatic and terrestrial ecosystems (Stebbins and Cohen, 1995). Also, these analyses allow knowing conditions and resources required for species survival and appropriate management. Since an alteration of the natural environment can affect resource availability and the conditions for predator species, trophic information is also useful to understand the role of anurans in natural and intervened ecosystems (Martínez-Coronel and Pérez-Gutiérrez, 2011).

The diet of hylids, like other frogs, varies according to many factors such as morphology, physiology and natural history. *Scinax ruber* (Laurenti, 1768) and *Scinax rostratus* (Peters, 1863) are common tree frogs in the tropical dry forest (Acosta-Galvis 2012; Blanco-Torres et al., 2013; Acuña-Vargas, 2016). They inhabit Panama, Brazil, Colombia, Venezuela, Guyana and Ecuador. *S. ruber* has a wider distribution also being present in Bolivia, Peru, Trinidad and Tobago, St. Lucia and was introduced in Puerto Rico (Sturaro et al., 2010; Frost, 2016). There are few studies about the diet and other trophic aspects of both species (Muñoz-Guerrero et al., 2007).

The aim of the present study was to describe the characteristics of the diet of *S. ruber* and *S. rostratus* using specimens from the tropical dry forest in four sites of northern Colombia.

Materials and Methods

Sampling was conducted inside fragments of tropical dry forest and intervened areas (agriculture and livestock) in four sites in northern Colombia lowlands (0-500 altitude): site 1: La Joya 10° 4’ 18.14” N 74° 0’ 7.70” W, 82 m; Site 2: Las Delicias 10° 35’ 13.00” N 7° 8’ 32.08” W, 197 m; Site 3: El Ceibal 10° 37’ 58.01”

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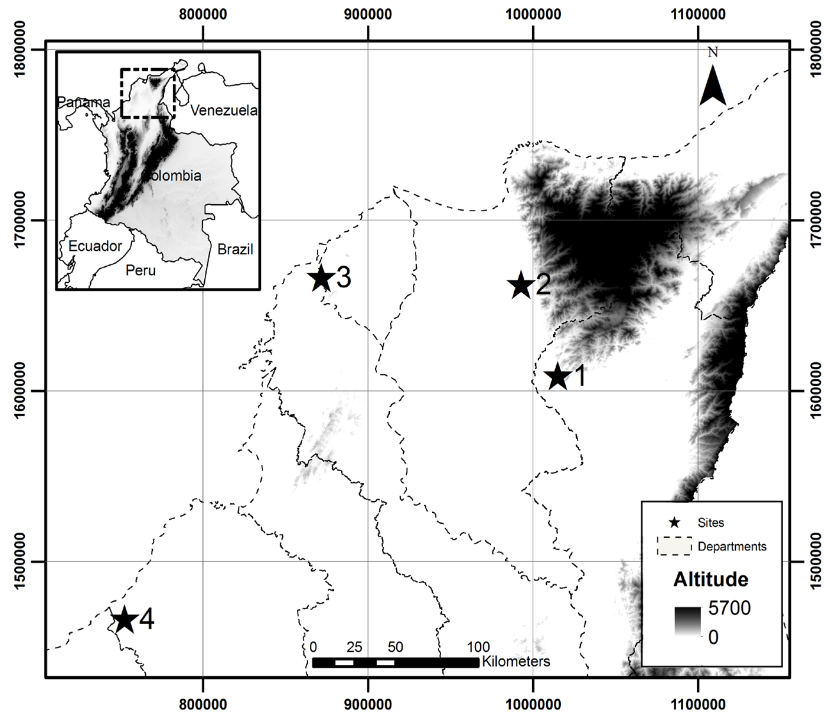

Figure 1. Location of sampling sites for *Scinax rostratus and Scinax ruber* in tropical dry forests of northern Colombia.

N 75° 14' 38.80" W, 34 m; site 4: Campoalegre 8° 47' 35.24" N 76° 19' 43.31" W, 120m (Figure 1).

Specimens were obtained by manual capture at night in free surveys between 19:00 and 23:00 h (Angulo et al., 2006) in the dry season (February, March) and the rainy season (May, June, October and November) in 2007. All specimens were measured in the field with a digital calliper (precision: ± 0.01 mm). The morphological variables were snout-vent length (mm) and jaw width (mm). In the laboratory, we extracted the stomachs of the preserved specimens and placed the contents into separate vials. Stomach contents were preserved in 70% ethanol for subsequent taxonomic identification and stereomicroscopic measurement.

The individual volume and number of prey were recorded. Volume of each prey was estimated using the following formula for prolate spheroid bodies (Dunham, 1983): V= 4/3π (1/2 L) (1/2 W)2 where L represents the length of prey and W the width. The index of relative importance for each category of prey was also calculated (Biavati et al., 2004): IRI= F%+N%+F%/3 where F% is the frequency of occurrence, N% the numeric percentage, and V% the volumetric percentage.

The niche breadth of prey was calculated using Levins's index (Levins, 1968), Nb = (∑pij2)-1 where pij represents the probability of finding the item i in the sample j. Then this measure was standardized following the methodology suggested by Colwell and Futuyma (1971): Standardized Levins's index (Bsta) = (B – 1) / (n – 1) where n is the total number of available resources and B the value of niche breadth calculated by Levins's index. The result ranges between 0 and 1, thus allowing to compare two species that consume a different number of food items (Jaksic and Marone, 2007). Morphological predator variables (snout-vent length and jaw width) and the prey variables (number and mean volume of prey) were analysed using a random regression analysis in Ecosim Professional v1.2d (Entsminger, 2012) software. The diets of both species in forests and in disturbed areas were compared using Mann-Whitney U test via PAST software (Hammer et al., 2001).

Results

Scinax rostratus. A total of 38 specimens (7 females and 31 males) were captured, of which 27 presented

Table 1. Frequency (F), Number (N), Volume (V), and Index of Relative Importance (IRI) for each category of prey (Order and morphotype level) consumed by *Scinax rostratus* (N= 11 of 38 individuals) and *Scinax ruber* (N= 18 of 45 individuals) in tropical dry forests of northern Colombia.

Prey Category	***Scinax rostratus***				***Scinax ruber***			
	F (%)	N (%)	V(%)	IRI	F (%)	N(%)	V(%)	IRI
ACARINA	**0.05 (5.26)**	**2 (0.2)**	**0.19 (0.07)**	**12.75**				
Ameroppia	0.03 (2.63)	1 (0.1)	0.04 (0.01)					
Archegozetes	0.03 (2.63)	1 (0.1)	0.15 (0.05)					
ARANEAE	**0.05 (5.26)**	**2 (0.2)**	**11.75 (4.21)**	**14.13**	**0.04 (4.44)**	**2 (15.38)**		**9.57**
Araneae	0.03 (2.63)	1 (0.1)			0.04 (4.44)	2 (15.38)		
Lycosidae	0.03 (2.63)	1 (0.1)	11.75 (4.21)					
BLATTODEA	**0.03 (2.63)**	**1 (0.1)**	**96.34 (34.47)**	**17.85**				
Blattellidae	0.03 (2.63)	1 (0.1)	96.34 (34.47)					
COLEOPTERA	**0.03 (2.63)**			**3.03**	**0.07(6.67)**			
Coleoptera	0.03 (2.63)				0.07 (6.67)			
DIPTERA	**0.03 (2.63)**	**1 (0.1)**	**0.87 (0.31)**	**6.46**	**0.02 (2.22)**	**1 (7.69)**		**4.78**
Drosophilidae	0.03 (2.63)	1 (0.1)	0.87 (0.31)					
Tephritidae					0.02 (2.22)	1 (7.69)		
HEMIPTERA	**0.03 (2.63)**	**1 (0.1)**	**32.63 (11.68)**	**10.25**	**0.09 (8.89)**	**4 (30.77)**	**36.41 (16.57)**	**24.67**
Alydidae					0.02 (2.22)	1 (7.69)	20.54 (9.34)	
Anthocoridae					0.02 (2.22)	1 (7.69)		
Cicadellidae 1	0.03 (2.63)	1 (0.1)	32.63 (11.68)					
Cicadellidae 4					0.02 (2.22)	1 (7.69)	15.88 (7.22)	
Hemiptera					0.02 (2.22)	1 (7.69)		
HYMENOPTERA	**0.03 (2.63)**	**1 (0.1)**	**0.23 (0.08)**	**6.39**	**0.04 (4.44)**	**2 (15.38)**	**4.10 (1.87)**	**10.19**
Crematogaster	0.03(2.63)	1(0.1)	0.23(0.08)					
Monomorium					0.02 (2.22)	1 (7.69)	0.03 (0.01)	
Nomamyrmex esenbeckii					0.02 (2.22)	1 (7.69)	4.07 (1.85)	
COLEOPTERA LARVAE					**0.02 (2.22)**	**1 (7.69)**	**8.45 (3.84)**	**6.06**
L. Carabidae					0.02 (2.22)	1 (7.69)	8.45 (3.84)	
UNDETERMINED LARVAE	**0.03 (2.63)**	**1 (0.1)**		**6.36**				
L. undet.	0.03 (2.63)	1 (0.1)						
LEPIDOPTERA					**0.02 (2.22)**	**1 (7.69)**		**4.78**
Lepidoptera					0.02 (2.22)	1 (7.69)		
ORTHOPTERA	**0.03 (2.63)**	**1 (0.1)**	**137.47 (49.19)**	**22.76**	**0.04 (4.44)**	**2 (15.38)**	**170.82 (77.72)**	**35.47**
Acrididae	0.03 (2.63)	1 (0.1)	137.47 (49.19)		0.02 (2.22)	1 (7.69)	170.82 (77.72)	
Tettigonidae					0.02 (2.22)	1 (7.69)		

empty stomachs. Snout-vent length averaged 38.08 ± 4.77 mm (min= 26.92 mm, max= 47.30 mm, N= 38) and mouth width averaged 12.47 ± 1.62 mm (min= 8.28 mm, max= 17.02 mm, N= 38). This species was observed in sites 2, 3 and 4, both inside the forest and the disturbed areas. Diet did not differ between these two types of habitat at order level (U= 14, p= 0.06, N=11), but did at morphotype level (U= 27.5, p= 0.03, N=11). The species consumed 11 types of prey, which were represented equally among Acarina, Araneae, Blattodea, Coleoptera, Diptera, Hemiptera, Hymenoptera and Orthoptera (Table 1). The most important order was Orthoptera (IRI= 22.76). Acarina had the highest number and frequency of occurrence and Orthoptera was the highest volumetric contribution (Table 1). The main types of prey in volumetric importance were Acrididae, Blattellidae and Cicadellidae 1; in numerical importance, all prey had the same value (Table 1). The Levins' Index of Niche Breadth was 7.14, and Bsta was 0.87.

Scinax ruber. A total of 45 specimens (32 males and 13 females) were captured, of which 27 had empty stomachs. Average snout-vent length was 32.77 ± 5.34 mm (min= 15.04 mm, max= 44.24 mm, N= 45) and mouth width was 10.93 ± 1.61 mm (min= 5.76 mm, max= 13.76 mm, N= 45). This species was observed at all sampling sites, both inside the forest and the disturbed areas. Diet did not differ between these two types of habitat neither in order level (U= 23 p= 0.89, N=18) nor in morphotype (U= 78 p= 0.75, N=18). The species consumed 13 types of prey, of which 30.7% were Hemiptera and Coleoptera. The most important order was Orthoptera (IRI= 35.47) for its volumetric contribution. The Hemiptera order had the highest contribution in number and frequency of occurrence (Table 1). The main morphotypes with volumetric importance were Acrididae, Alydidae and Cicadellidae; Araneae had the highest numerical importance (Table 1). *Scinax ruber* showed a Levins' Index of Niche Breadth of 4.59, and Bsta was 0.63.

None of the tree frog species showed a significant relationship between snout-vent length and number of ingested prey (p> 0.05 in both cases). Only *S. ruber* showed a relationship between mouth width and mean volume of ingested prey (R_{obs}= 0.81, p= 0.02, N=15). There was no significant difference between the diets of the two species (U= 129.5, p= 0.59, N= 21).

Discussion

Hylids, due to their foraging mode, consume fewer individuals compared to those species that employ active search. However, they tend to exhibit wider trophic niches. The species analysed in this investigation have a type of diet according to sit-and-wait predators with a generalist diet, characterized by a high percentage of empty stomachs in the sample. Both species are predators of limited displacement and consume mobile prey (Duré, 1999; Solé and Pelz, 2007; Teixeira and Rodder, 2007; Kittel and Solé, 2015).

For both species, arachnids, hemipterans and orthopterans play an important role as prey (Muñoz-Guerrero et al., 2007). The structure of the diet described for *S. rostratus* is consistent with previously reported data for this species in other region of the Colombian Caribbean (Muñoz-Guerrero et al., 2007), endorsing that orthopterans constitute the predominant prey in this species. Moreover, mite consumption found in our research is consistent with that reported for this species in the study of Muñoz-Guerrero et al. (2007), corroborating the importance of this prey category in the diet of *S. rostratus*. Its consumption has also been reported by *Scinax granulatus* in a subtropical area at an elevation of 1000 meters (Solé and Pelz, 2007).

The diet composition of *S. granulatus* and *S. rostratus* reported in this study is similar to that previously found for both species and other congener taxa (Duré, 1999; Parmelee, 1999; Solé and Pelz 2007; Teixeira and rodder, 2007; Kittel and Solé, 2015). However, here we extend the dietary spectrum reported by Muñoz-Guerrero et al. (2007). While both studies found similar types of prey, such as Orthoptera and Coleoptera, it is likely that the high representation of these categories at all study sites could be linked to their high environmental availability. Moreover, despite investing less energy in prey search, sit-and-wait predators normally have higher handling costs and thus tend to consume large, nutritive and easily digestible prey such as Orthoptera (Vitt and Caldwell, 2014).

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