Prey availability influences the diet of *Scinax fuscomarginatus* in a Cerrado area, Central Brazil

G. Michelin, K. Ceron, D. J. Santana

Michelin, G., Ceron, K., Santana, D. J., 2020. Prey availability influences the diet of *Scinax fuscomarginatus* in a Cerrado area, Central Brazil. *Animal Biodiversity and Conservation*, 43.2: 169–175, Doi: https://doi.org/10.32800/abc.2020.43.0169

Abstract

Prey availability influences the diet of Scinax fuscomarginatus *in a Cerrado area, Central Brazil.* Prey availability in an environment may change seasonally and these changes should be considered as determinant factors for the diets of anurans. *Scinax* species are generalist predators that feed on arthropods, but data concerning their diet in relation to prey availability are lacking. In this study, we describe the diet of *Scinax fuscomarginatus* by evaluating its possibly generalist diet related to prey availability in its environment. We studied the diet of *Scinax fuscomarginatus* by analysing the stomach contents of 48 individuals captured in the Campo Grande municipality, Mato Grosso do Sul state, Brazil. We found eight prey categories, the most common and most representative being Hemiptera. The selectivity index of the two most important prey varied inversely between dry and wet seasons. Prey availability also varied between seasons. These results suggest a temporal pattern in prey composition and in the diet of *Scinax fuscomarginatus*.

Key words: Amphibia, Cerrado, Natural history, Trophic ecology

Resumen

La disponibilidad de presas influye en la dieta de Scinax fuscomarginatus *en una zona de Cerrado, en el centro de Brasil.* La disponibilidad de presas en un entorno puede cambiar según la temporada y este cambio debe considerarse un factor determinante para las dietas de los anuros. Las especies de *Scinax* son depredadores generalistas que se alimentan de artrópodos; sin embargo, no hay datos sobre su dieta en relación con la disponibilidad de presas. En este estudio, describimos la dieta de *Scinax fuscomarginatus* mediante la evaluación de su posible dieta generalista con respectoa la disponibilidad de presas en su entorno. Estudiamos la dieta de *Scinax fuscomarginatus* mediante el análisis del contenido estomacal de 48 ejemplares capturados en el municipio de Campo Grande del estado de Mato Grosso do Sul, en Brasil. Encontramos ocho categorías de presas, de las cuales Hemiptera fue la más abundante y representativa. El índice de selectividad de las dos presas más importantes varió inversamente entre las estaciones seca y lluviosa. La disponibilidad de presas también varió entre las estaciones. Estos resultados sugieren la existencia de una pauta temporal en la composición de las presas y en la dieta de *Scinax fuscomarginatus.*

Palabras clave: Amphibia, Cerrado, Historia natural, Ecología trófica

Received: 17 VI 19; Conditional acceptance: 22 VIII 19; Final acceptance: 06 III 20

Giuseppe Michelin, Karoline Ceron, Diego José Santana, Mapinguari Lab, Instituto de Biociências, Universidade Federal de Mato Grosso do Sul, Cidade Universitária, CEP 79070–900, Campo Grande, Mato Grosso do Sul, Brazil.

Corresponding author: K. Ceron. E–mail: adenomera@gmail.com

ORCID ID: G. Michelin: 0000–0002–8032–1810; K. Ceron: 0000–0003–2354–3756;
D. J. Santana: 0000–0002–8789–3061

ISSN: 1578–665 X
eISSN: 2014–928 X

© 2020 Museu de Ciències Naturals de Barcelona
Papers are published under a
Creative Commons Attribution 4.0 International License

Introduction

Understanding the diets of anurans is paramount to unveil their natural history and ecological impacts in both terrestrial and aquatic environments as amphibians help control the populations of many organisms and represent a link between terrestrial and aquatic environments (Toft, 1980, 1981; Duellman and Trueb, 1986; López et al., 2009). Despite great efforts to analyse the diets of anuran species, few approaches have considered prey availability in environments (Sabagh and Carvalho–e–Silva, 2008; Caldart et al., 2012; Araujo–Vieira et al., 2018). Some studies have already shown that prey availability can change seasonally, and these changes should be considered as a determinant factor for anuran diets (Cogălniceanu et al., 2001) as prey availability is intrinsically related to the trophic ecology of anurans (Kikuchi and Ueida, 1998; Ott and Carvalho, 2001; López et al., 2009). Amphibians are considered opportunistic and generalist predators (Vaz–Silva et al., 2005; Toledo et al., 2007; Neves et al., 2014), but some families (e.g., Microhylidae and Dendrobatidae) have specialized diets, feeding mostly on ants (Hymenoptera: Formicidae) and termites (Isoptera) (Attademo et al., 2007; Berazategui et al., 2007; Santana and Juncá, 2007; Forti et al., 2011).

Tree frogs of the genus *Scinax* are considered generalist predators, commonly feeding on arthropods such as Araneae, Hemiptera, and Orthoptera, with the most commonly preyed order varying according to the species (Solé and Pelz, 2007; Teixeira and Rödder, 2007; Kittel and Solé, 2015; Blanco Torres et al., 2017). The snouted tree frog *Scinax fuscomarginatus* (A. Lutz, 1925) is characterized by its elongated body, small size (average snout–vent length: 23 mm), and yellowish back with wide dark brown sidebands (Brusquetti et al., 2014). It occurs in southern, central, and eastern Brazil (as far north as Piauí and Ceará, west to southern Amazonas), eastern Bolivia, Paraguay, and north–western Argentina (Leite Jr et al., 2008; Lima et al., 2017). Studies performed with the species have focused on taxonomy (Brusquetti et al., 2014), reproduction (Toledo and Haddad, 2005a, 2005b) and geographic distribution (Leite Jr et al., 2008; Lima et al., 2017), with no data about the diet of the species. Given the lack of information about this species' natural history, and the importance of prey availability for anuran diets, the aim of this study was to describe the diet of *Scinax fuscomarginatus*, to verify whether the species has a generalist diet, as suggested for other species in the genus (Blanco Torres et al., 2017), and to evaluate whether this generalist diet is related to prey availability in its environment. We predicted that the diet of *Scinax fuscomarginatus* would be generalist without prey selection, as seen in most anurans.

Material and methods

Field survey

We studied the diet of *Scinax fuscomarginatus* by analysing the stomach contents of 48 individuals (27 males and 21 females) captured at the Reserva Particular do Patrimônio Natural (RPPN) Fazenda Santa Fé (–20.5131 ºS, –54.7277 ºW, 500 m a.s.l.) in the Campo Grande municipality, Mato Grosso do Sul state. We collected anurans and invertebrate specimens during the dry and wet season (July 2017 and December 2017, respectively). We sampled anurans by active search (Scott and Woodward, 1994) and visual and acoustic encounters (Zimmerman, 1994) along a swamp in the area. To estimate relative abundance of prey, we installed 20 pitfall traps (300 ml plastic cups) at the soil level in random locations around the swamp. The 70 % alcohol was used as a preservative in the traps, adding drops of detergent to break the surface tension of the solution. Pitfall traps were opened at sunset and removed at sunrise. These traps may underestimate some groups such as sedentary prey, flying insects, or Orthoptera. To avoid sampling bias, we used an entomological umbrella method for 30' to capture arboreal prey. Since invertebrates obtained in the diet are partially digested, we categorized the food items into operational taxonomic units (OTUs; Sneath and Sokal, 1962), usually to Order, except for the Formicidae family, which was separated from other Hymenoptera because of its unique morphological and ecological characteristics, and larvae, which are usually included in the same OTU (e.g., Lepidoptera larvae).

The anuran specimens were killed using topical anaesthetic (Xylocaine 5 %) and then fixed with 10 % formaldehyde before analysing the stomach contents. We removed stomachs through a small abdominal incision and stored the contents in separate vials. To access the diet of frogs, the samples were killed as part of a large research project that studies anuran trophic networks (Fundect #71/700.146/2017). We preserved the frog individuals in 70 % alcohol. The captured specimens were housed at Coleção Zoológica de Referência da Universidade Federal de Mato Grosso do Sul (ZUFMS AMP 07800–07829).

Diet composition

We analysed the stomach content under a stereomicroscope and identified each item to order level. After measuring the length and width of each prey, we estimated their volumes using the formula of an ellipsoid:

$$V = 4/3\pi * 2(W/2)2 * L/2$$

where, V is the volume, W the width, and L the length (Griffiths and Mylotte, 1987). For each item (prey category), we calculated the number, volume, and frequency of occurrence in both absolute and percentage values. We then calculated the Index of Relative Importance (IRI) to determine the relative importance of each prey item in the diet using the following formula, according to (Pinkas et al., 1971):

$$IRI = (\%N+\%P)\ \%FO$$

where % N is equal to the relative number of each prey item per sample set, % P is equal to the mass percentage of each prey item in the sample set, and % FO represents the relative frequency of occurrence

Table 1. Diet of *S. fuscomarginatus* in both seasons (total), and in the dry and wet season: N, number of prey items found in total and as a percentage, where some individuals hold multiple items; F, number of individuals containing these prey items (frequency of prey items found) in total and as a percentage; V, volume in mm³ and in percentage; IRI, index of relative importance (important prey items are in bold).

Tabla 1. Dieta de S. fuscomarginatus *en ambas estaciones (total) y en la estación seca y la estación lluviosa: N, número de presas encontradas en total y en porcentaje, ya que algunos individuos contienen múltiples presas; F, número de individuos que contienen estas presas (frecuencia de presas encontradas) en total y en porcentaje; V, volumen en mm³ y en porcentaje; IRI, índice de importancia relativa (las presas importantes se señalan en negrita).*

Prey category	V (mm³)	V %	N	N %	F	F %	IRI
Total							
Araneae	17.43	58.67	3.00	33.57	3.00	46.67	1,675.58
Blattaria	9.36	21.14	1.00	5.00	1.00	6.67	112.36
Coleoptera	2.54	5.74	2.00	10.00	2.00	13.33	70.71
Formicidae	1.59	3.59	2.00	10.00	2.00	13.33	49.25
Hemiptera	26.04	61.67	15.00	102.86	8.00	66.67	**3,623.57**
Isoptera	15.54	45.90	3.00	24.29	3.00	33.33	628.18
Lepidoptera larvae	0.96	3.29	1.00	14.29	1.00	20.00	66.98
Dry season							
Araneae	0.89	2.01	1.00	5.00	1.00	6.67	16.72
Blataria	9.36	21.14	1.00	5.00	1.00	6.67	112.36
Coleoptera	2.54	5.74	2.00	10.00	2.00	13.33	70.71
Formicidae	1.59	3.59	2.00	10.00	2.00	13.33	49.25
Hemiptera	23.60	53.31	12.00	60.00	7.00	46.67	**3,245.35**
Isoptera	6.29	14.21	2.00	10.00	2.00	13.33	155.42
Wet season							
Araneae	16.54	56.66	2	28.57	2	40.00	**1,658.85**
Isoptera	9.25	31.69	1	14.29	1	20.00	472.76
Hemiptera	2.44	8.36	3	42.86	1	20.00	378.22
Lepidoptera larvae	0.96	3.29	1	14.29	1	20.00	66.98

on the entire samples (Krebs, 1999). Higher IRI values indicate greater importance of the prey category in the diet. We performed a PERMANOVA analysis to test whether diet composition varies between sexes, with euclidian distance, using the prey frequency. Statistical analyses were conducted in the R software v.3.4.2 (R Core Team, 2017) using the 'vegan' package (Oksanen et al., 2015)

Prey selectivity

With regard to prey selection in the environment, we compared the relative abundance of each prey category in the diet with the relative abundance of the same prey sampled in the environment. For this purpose, we used Vanderploeg and Scavia's Relativized Electivity Index (Vanderploeg and Scavia, 1979). This index is calculated by first finding the selectivity coefficient for diet item *i*, *Wi*:

$$W_i = (r_i / p_i) / \Sigma (r_i / p_i)$$

where r_i is the proportion of bites taken in each category *i* and p_i is the proportional cover of each category *i*. The index W_i ranges from 0 (total avoidance) to 1 (total preference). The relativized index is:

$$E_i = (W_i - 1/n) / (W_i + 1/n)$$

where *n* represents the number of diet categories available. This index ranges from –1 to 1, with 0 indicating random selection, negative values indicating avoidance or inaccessibility of the prey item and positive values showing active selection.

Table 2. Seasonal variation in prey in the diet of *Scinax fuscomarginatus* and in the environment traps at the study site: n, number of items found; %, the number as a percentage; UI, unidentified invertebrate.

Tabla 2. Variación estacional de presas en la dieta de Scinax fuscomarginatus *y en las trampas colocadas en el sitio del estudio: n, número de presas encontradas; %, el número como porcentaje; UI, invertebrados sin identificar*

	Environment				Diet			
	Wet		Dry		Wet		Dry	
Prey category	n	%	n	%	n	%	n	%
Acari	1	0.38	0	0	0	0	0	0
Araneae	20	7.66	16	3.31	2	22.22	1	4.76
Blattaria	2	0.77	1	0.21	0	0	1	4.76
Coleoptera	22	8.43	12	2.48	0	0	2	9.52
Dermaptera	1	0.38	1	0.21	0	0	0	0
Diptera	23	8.81	39	8.06	0	0	0	0
Formicidae	154	59.00	226	46.69	0	0	2	9.52
Hemiptera	7	2.68	174	35.95	3	33.33	12	57.14
Hymenoptera	13	4.98	2	0.41	0	0	0	0
Isoptera	3	1.15	4	0.83	1	11.11	2	9.52
Lepidoptera	3	1.15	4	0.83	0	0	0	0
Lepidoptera larvae	1	0.38	0	0	1	11.11	0	0
Hymenoptera larvae	0	0.00	2	0.41	0	0	0	0
Orthoptera larvae	0	0.00	1	0.21	0	0	0	0
Mantodea	1	0.38	0	0	0	0	0	0
Myriapoda	2	0.77	0	0	0	0	0	0
Opiliones	1	0.38	0	0	0	0	0	0
Orthoptera	7	2.68	2	0.41	0	0	0	0
UI	0	0.00	0	0	2	22.22	1	4.76

Results

Diet composition

Diet composition did not differ between sexes (males = 27, females = 21, p = 0.1). We found eight prey categories, of which Hemiptera was the most representative group (N = 51.72%), the most important prey category (IRI = 740.09) and the most volumetric prey (V = 61.67%) (table 1). Blattaria and Lepidoptera larvae were the least frequent items, with a single occurrence. We found stomach contents in 48.93% of all analysed stomachs. A total of 23 stomachs were empty.

Prey selectivity

Environmental sampling provided a total of 746 invertebrates (484 in dry and 262 in wet seasons, respectively), representing 16 taxa in the dry season and 13 in the wet season (table 2). All prey categories found in *Scinax fuscomarginatus* stomach contents were also found in the sampled environment, suggesting that food resource estimations were represented by the use of pitfall traps and entomological umbrella. In contrast, 11 prey categories recorded in prey availability were not consumed by *Scinax fuscomarginatus*: Acari, Dermaptera, Diptera, Hymenoptera, Lepidoptera, Hymenoptera Larvae, Orthoptera Larvae, Mantodea, Myriapoda, Opiliones, and Orthoptera.

In the dry season, *Scinax fuscomarginatus* positively selected only Hemiptera and negatively selected Araneae and Blattaria. However, in the wet season, *Scinax fuscomarginatus* showed a weakly positive selection for Isoptera and Araneae, but a weakly negative selection for Hemiptera (fig. 1).

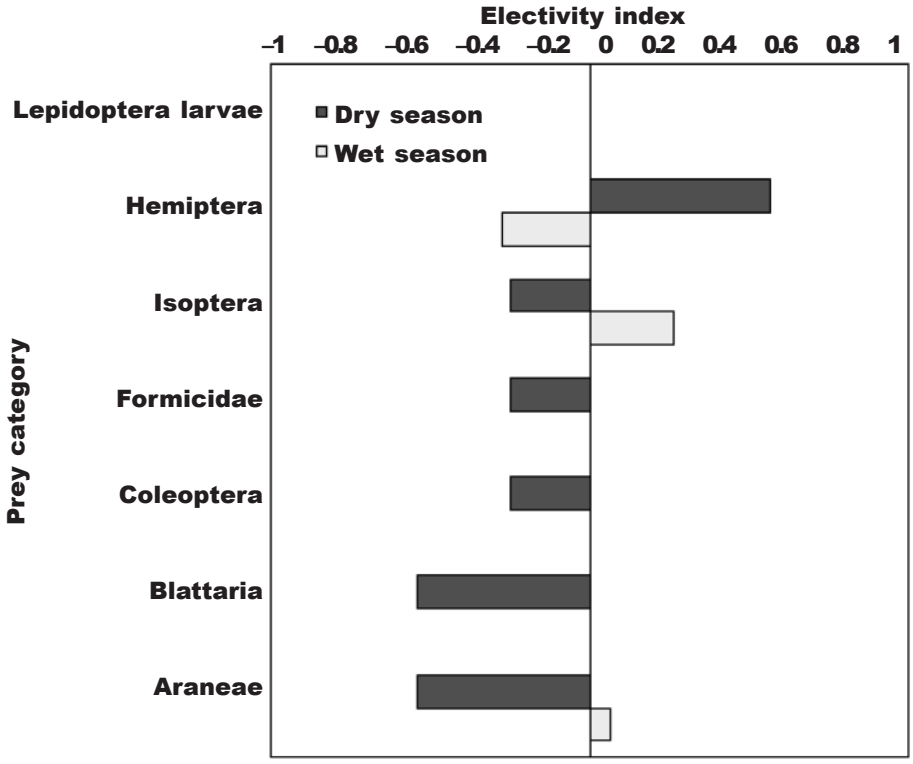

Fig. 1. Vanderploeg and Scavia's (1979) electivity index E* for prey categories of *Scinax fuscomarginatus* diet.

Fig. 1. Índice de selectividad de Vanderploeg y Scavia (1979), E, para las categorías de presas de la dieta de* Scinax fuscomarginatus.

Discussion

The diet of *Scinax fuscomarginatus* was composed of eight prey categories, with Hemiptera being the most important category, followed by Araneae and Isoptera. The selectivity index of the two most important prey items varied inversely between the dry and rainy seasons, as did prey availability, suggesting a temporal pattern in prey composition and consumption. We found stomach contents in 48.93 % of all analysed stomachs, a higher percentage than that in the diet of some other previously studied *Scinax*: *S. squalirostris* (40 %; Kittel and Solé, 2015), *S. rostratus* (≅ 29 %) and *S. ruber* (40 %; Blanco Torres et al., 2017), *S. granulatus* (≅ 36 %) and *S. perereca* (≅ 34 %; Solé and Pelz, 2007), but lower than that in *S. argyreornatus* (≅ 83 %; Teixeira and Rödder, 2007). We did not find dietary differences between sexes, possibly due to the opportunistic and generalist habits of anurans (Toft, 1980).

Hemiptera was the most important order for the diet of *Scinax fuscomarginatus*, in contrast with other *Scinax* species. Orthoptera was observed to be the most important order for *Scinax rostratus* and *S. ruber* (Solé and Pelz, 2007) and Arachnida have been found to be the most important prey for *S. squalirostris* (Kittel and Solé, 2015). Most anurans are considered generalist predators of arthropods (Toledo et al., 2007). However, the diets of *Scinax* species studied thus far exhibit different categories of important prey, frequency and prey size (Blanco Torres et al., 2017). *Scinax* species are scansorial, like most hylids, perching on herbaceous plants or shrubs at swamp edges during the breeding season (Teixeira and Vrcibradic, 2004). Furthermore, they are considered active searchers (Teixeira and Rödder, 2007). We therefore consider microhabitat segregation is responsible for the differences among diets. These differences could be related to prey availability in the environment. The irregular conditions of the studied areas certainly influence the composition of invertebrates, changing prey availability in each habitat and leading to differences in anuran diets (López et al., 2009). However, none of the compared species showed prey availability in the environment, which made comparison among species difficult, since we could not draw conclusions about how species select these prey or whether they only feed on what is available in the environment.

In our study, prey composition showed a seasonal pattern, reflected in prey selectivity varying during wet and dry seasons. The composition of invertebrates in an environment can change throughout a year in

relation to climatic variations, different requirements among species, and life history stages (Kikuchi and Ueida, 1998; Ott and Carvalho, 2001; Santana et al., 2015). During the dry season, *S. fuscomarginatus* showed no reproductive activity, which allowed it to hunt by the active search method and select prey items. In the dry season, *S. fuscomarginatus* positively selected Hemiptera, a common anuran prey. On the other hand, in the wet season, when individuals are focused on reproduction (males calling and females choosing males), predation was opportunistic. In the wet season, *S. fuscomarginatus* positively selected Isoptera (winged individuals), an easier prey as it lives in colonies and forms termite flocks (Rafael et al., 2012). In addition, Isoptera are a greater source of protein for anurans than other sclerotized prey such as Hemiptera and Coleoptera (Biavati et al., 2004). Proteins are essential in this season because anuran reproduction demands a greater amount of energy (Taigen and Wells, 1985). There is therefore a temporal pattern in prey availability and in anuran reproduction. As emphasized by Pough et al. (1992), besides the morphology and physiology of *Scinax fuscomarginatus*, prey availability and reproductive activity lead to the seasonal differences in hunting approaches and thus in diet.

Acknowledgements

This study was conducted with permission from the Brazilian wildlife regulatory service (SISBIO#56729–1) and with the approval of the Animal Ethics Committee of the Universidade Federal de Mato Grosso do Sul (CEUA#838/2017). The authors are grateful to Marina and João for giving their permission to study the area of RPPN Fazenda Santa Fé. GM thanks UFMS for his scholarship (PIBIC 095/2018). KC is grateful to Fundect (Fundação de Apoio ao Desenvolvimento de Ensino, Ciência e Tecnologia do Mato Grosso do Sul) for her scholarship (# 71/700.146/2017). DJS thanks CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for his research fellowship (311492/2017–7).

References

Araujo–Vieira, K., Gonçalves, U., Guedes dos Santos J., Gomes Ferreira, T., Skuk, G., 2018. Feeding habits of the bromeligenous treefrog *Phyllodytes edelmoi* Peixoto, Caramaschi & Freire, 2003 (Anura: Hylidae) from the State of Alagoas, Northeastern Brazil. *Cuadernos de Herpetologia,* 32: 5–13.

Attademo, A. M., Peltzer, P. M., Lajmanovich, R. C., 2007. Feeding habits of *Physalaemus biligonigerus* (Anura, Leptodactylidae) from soybean field of Córdoba Province, Argentina. *Russia Journal of Herpetology,* 14: 1–6.

Berazategui, M., Camargo, A., Maneyro, R., 2007. Environmental and seasonal variation in the diet of *Elachistocleis bicolor* (Guérin–Méneville 1838) (Anura: Microhylidae) from northern Uruguay. *Zoological Science,* 24: 225–231.

Biavati, G. M., Wiederhecker, H. C., Colli, G. R., 2004. Diet of *Epipedobates flavopictus* (Anura: Dendrobatidae) in a Neotropical savanna. *Journal of Herpetology,* 38: 510–518.

Blanco Torres, A., Duré Pitteri, M. I., Bonilla, M. A., 2017. Trophic ecology of *Scinax rostratus* (Peters, 1863) and *Scinax ruber* (Laurenti, 1768) (Anura: Hylidae) in tropical dry forests of northern Colombia. *Herpetology Notes,* 10: 405–409.

Brusquetti, F., Jansen, M., Barrio–Amorós, C., Segalla, M., Haddad, C. F. B., 2014. Taxonomic review of *Scinax fuscomarginatus* (Lutz, 1925) and related species (Anura; Hylidae). *Zoological Journal of the Linnean Society,* 171: 783–821.

Caldart, V. M., Iop, S., Bertaso, T. R. N., Cechin, S. Z., 2012. Feeding ecology of *Crossodactylus schmidti* (Anura: Hylodidae) in southern Brazil. *Zoological Studies*, 51: 484–493.

Cogălniceanu, D., Palmer, M. W., Ciubuc, C., 2001. Feeding in anuran communities on islands in the Danube floodplain. *Amphibia–Reptilia,* 22: 1–19.

Duellman, W. E., Trueb. L., 1986. *Biology of Amphibians*. Baltimore: The Johns Hopkins University Press, Baltimore.

Forti, L. R., Tissiani, A. S. O., Mott, T., Strüssmann, C., 2011. Diet of *Ameerega braccata* (Steindachner, 1864) (Anura: Dendrobatidae) from Chapada dos Guimarães and Cuiabá, Mato Grosso state, Brazil. *Brazilian Journal of Biology,* 71: 189–196.

Griffiths, R., Mylotte, V., 1987. Microhabitat selection and feeding relations of smooth and warty newts, *Triturus vulgaris* and *T. cristatus*, at an upland pond in mid–Wales. *Ecography*, 10: 1–7.

Kikuchi, R., Ueida, V. S., 1998. Composição da comunidade de invertebrados de um ambiente lótico tropical e sua variação espacial e temporal. *Oecologia Brasiliensi,* 5: 157–173.

Kittel, R. N., Solé, M., 2015. Diet of the striped snouted treefrog *Scinax squalirostris* (Anura: Hylidae) in southern Brazil. *Herpetology Notes*, 8: 157–160.

Krebs, C. J., 1999. *Ecological methodology*. Menlo Park, Addison Wesley Longman, New York.

Leite Jr., J. M. A., Sampaio, J. M., Silva–Leite, R. R., Toledo, L. F., Loebmann, D., Leite, J. R. S., 2008. Amphibia, Anura, Hylidae, *Scinax fuscomarginatus*: Distribution extension. *Check List*, 4: 475–477.

Lima, J. R. F., Lima, J. D., Lima, S. D., Silva, R. B. L., Andrade, G. V. de., 2017. Amphibians found in the Amazonian Savanna of the Rio Curiaú Environmental Protection Area in Amapá, Brazil. *Biota Neotropica*, 17: e20160252.

López, J. A., Scarabotti, P. A., Medrano, M. C., Ghirardi, R., 2009. Is the red spotted green frog *Hypsiboas punctatus* (Anura: Hylidae) selecting its preys? The importance of prey availability. *Revista de Biologia Tropical,* 57: 847–857.

Neves, M. de O., Morais, C. J. da S., Garda, A. A., 2014. Sexual dimorphism and diet of *Pseudis tocantins* (Anura, Hylidae, Pseudae). *South American Journal of Herpetoly,* 9: 177–182.

Oksanen, J. F., Blanchet, G., Kindt, R., Legendre, P., Minchin, P. R., O'Hara, R. B., Wagner, H., 2015.

Vegan: community ecology, R package. Available online at: http://CRAN.R–project.org/package=vegan [Accessed on: 16 June 2019].

Ott, A. P., Carvalho, G. S., 2001. The assembly of the Homopteran (Hemiptera: Auchenorrhyncha) of grasslands at Viamao County, Rio Grande do Sul State, Brazil. *Neotropical Entomology,* 30: 233–243.

Pinkas, L., Oliphant, M. S., Iverson, I. L. K., 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. *California Department of Fish and Game's Fish Bulletin,* 152: 1–105.

Pough, F. H., Magnusson, W. E., Ryan, M. J., Wells, K. D., Taigen, T. L., 1992. Behavioral energetics. In: *Environmental Physiology of the Amphibians*: 395–436 (M. E. Feder, W. W. Burggren, Eds.). University of Chicago Press, Chicago.

Rafael, J., Melo, G. A., Carvalho, C., Casari, S., Constantino, R., 2012. *Insetos do Brasil: diversidade e taxonomia*. Ribeirão Preto (SP), Holos.

R Core Team, 2017. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available online at: https://www.R–project.org/ [Accessed on: 16 June 2019].

Sabagh, L. T., Carvalho–e–Silva, A. M., 2008. Feeding overlap in two sympatric species of *Rhinella* (Anura: Bufonidae) of the Atlantic Rain Forest. *Revista Brasileira de Zoologia,* 25: 247–253.

Santana, A., Juncá, F., 2007. Diet of *Physalaemu*s cf. *cicada* (Leptodactylidae) and *Bufo granulosu*s (Bufonidae) in a semideciduous forest. *Brazilian Journal of Biology,* 67: 125–131.

Santana, H., Silva, L., Pereira, C., Simião–Ferreira, J., Angelini, R., 2015. The rainy season increases the abundance and richness of the aquatic insect community in a Neotropical reservoir. *Brazilian Journal of Biology*, 75: 144–151.

Scott, N. J., Woodward, B. D., 1994. Surveys at breeding sites. Measuring and monitoring biological diversity: standard methods for amphibians. In: *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians:* 118–125 (R. Heyer, A. Maureen, M. Donnelly, F. Mercedes, R. Mcdiarmid, Eds.). Smithsonian Books, Washington.

Sneath, P. H., Sokal, R. R., 1962. Numerical taxonomy. *Nature,* 193: 855–860.

Solé, M., Pelz, B., 2007. Do male tree frogs feed during the breeding season? Stomach flushing of five syntopic hylid species in Rio Grande do Sul, Brazil. *Journal of Natural History,* 41: 2757–2763.

Taigen, T. L., Wells, K. D., 1985. Energetics of vocalization by an anuran amphibian (*Hyla versicolor*). *Journal of Comparative Physiology B,* 155: 163–170.

Teixeira, R., Rödder, D., 2007. Diet, foraging strategy and reproduction of *Scinax argyreornatus* (Miranda–Ribeiro, 1926) from a mountainous region of the Atlantic rainforest in southeastern *Brazil. Herpetozoa*, 19: 161–173.

Teixeira, R. L., Vrcibradic, D., 2004. Ecological aspects of *Scinax argyreornatus* (Anura, Hylidae) from a cacao plantation in Espírito Santo state, southeastern Brazil. *Boletim do Museu de Biologia Mello Leitão*, 17: 35–43.

Toft, C. A., 1980. Feeding ecology of thirteen syntopic species of anurans in a seasonal tropical environment. *Oecologia*, 45: 131–141.

– 1981. Feeding ecology of Panamanian litter anurans: patterns in diet and foraging mode. *Journal of Herpetology,* 15: 139–144.

Toledo, L., Haddad, C., 2005a. Reproductive biology of *Scinax fuscomarginatus* (Anura, Hylidae) in south–eastern Brazil. *Journal of Natural History,* 39: 3029–3037.

– 2005b. Acoustic repertoire and calling behavior of *Scinax fuscomarginatus* (Anura, Hylidae). *Journal of Herpetology,* 39: 455–464.

Toledo, L. F., Ribeiro, R. S., Haddad, C. F. B., 2007. Anurans as prey: an exploratory analysis and size relationships between predators and their prey. *Journal of Zoology,* 271: 170–177.

Vanderploeg, H., Scavia, D., 1979. Two electivity indices for feeding with special reference to zooplankton grazing. *Journal of the Fisheries Research Board of Canada,* 36: 362–365.

Vaz–Silva, W., Frota, J., Prates–Júnior, P. H., Silva, J. S. B., 2005. Dieta de *Lysapsus laevis* Parker, 1935 (Anura: Hylidae) do médio rio Tapajós, Pará, Brasil. *Comunicações do Museu de Ciências e Tecnologia da PUCRS Série Zoologia,* 18: 3–12.

Zimmerman, B. L., 1994. Audio strip transects. In: *Measuring and monitoring biological diversity. Standard methods for amphibians*: 92–97 (R. Heyer, A. Maureen, M. Donnelly, F. Mercedes, R. McDiarmid, Eds). Smithsonian Books, Washington.