SHORT COMMUNICATION

Food niche overlap between two sympatric leaf-litter frog species from Central Amazonia

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ABSTRACT. We studied the feeding habits and similarities in the diet of two sympatric and syntopic Amazonian frog species, *Anomaloglossus stepheni* (Aromobatidae) and *Leptodactylus andreae* (Leptodactylidae) in a forested area in Central Amazonia. The breadth of the trophic niche of these species was 5.89 and 3.75, respectively, and approximately 85% of their diets were similar. Ants were main food item in the diets of both frog species. The coexistence between these frog species may be facilitated by the significant differences in the size of their mouths. This difference allows them to consume preys items of different sizes.

KEY WORDS. Anura; *Anomaloglossus stepheni*; *Leptodactylus andreae*; trophic niche; feeding habits; life in sympatry.

Niche overlap among syntopic species encompasses many different dimensions (MENIN *et al.* 2005), and food is one of the most important niche dimensions (SABAGH & CARVALHO-E-SILVA 2008) segregating species and facilitating coexistence. For this reason, analysis of the diets of sympatric, related species is essential to the understanding of the dynamics of their communities (KREBS 1999). Niche breadth and niche overlap are widely parameters used to measure how species interact given the resources available.

The leaf litter layer of the forest floor of tropical forests is usually occupied by different organisms, including invertebrates (among them many microorganisms) and vertebrates. Among the vertebrates, frogs are one of the most diverse groups occupying the leaf litter layer. Within this microhabitat, syntopic frogs have to cope with the availability of resources such as food, humidity, light, and temperature, in order to successfully maintain their populations. *Anomaloglossus stepheni* (Martins, 1989) and *Leptodactylus andreae* Müller, 1923 are two diurnal frogs living sympatrically and syntopically in the leaf-litter of the forest floor of the Central Amazonia. These frogs breed in the rainy season and have terrestrial tadpoles (TOFT 1980, 1981, LIMA *et al.* 2006). Considering the biological aspects of these syntopic species in Central Amazonia, the purpose of this study was to analyze the diets of *A. stepheni* and *L. andreae* qualitatively and quantitatively, and to evaluate the overlap in their trophic niches. Specifically, we aimed to answer the following questions: 1) To which extent do the two

frog species differ in body and mouth sizes? 2) What is the diet composition of each frog species? 3) Which are the main prey types of each species? 4) How do the two frog species differ in their trophic niche breadth? 5. To which extent does the trophic niche of these two syntopic frog species overlap?

This study was carried out at the Km-41 Reserve (2°24'S, 59°43'W), located about 80 km North of Manaus (Amazonas, Brazil), an area covered primary by Amazonian forest of Central Amazonia. This region has altitudes varying from 50 to 150 meters above sea level and a vegetation characterized by upland forest that have a mean canopy height of approximately 35 m (PIRES & PRANCE 1985). The mean annual temperature in the region is 27°C and the mean annual rainfall is 2,200 mm (RADAMBRASIL 1978).

Active individuals of *A. stepheni* and *L. andreae* were manually collected nearby "igarapé" in the leaf-litter of the forest floor during July 2006. Individuals were promptly anesthetized and euthanized in ethanol 70%. The snout-urostyle length (SUL) and jaw width (JW) of the individuals were measured using a caliper (to the nearest 0.1 mm). Only stomachs were removed and the contents were analyzed under stereomicroscope. Prey items of each frog species were identified to the level of Order, Family or Genus whenever possible, and counted.

Differences in body size (SUL) among frog species were tested using a T-test, whereas differences in relative mouth size (JW) were tested using an analysis of covariance (ANCOVA) using the SUL as covariate (ZAR 1999). For each prey item an

Table I. Prey categories, their respective absolute values, relative abundance (N and %N), occurrence (O and %O), and Index of Importance of preys (I) for *Anomaloglossus stepeni* and *Leptodactylus andreae* living in leaf-litter of Central Amazon. Numbers in parenthesis are for taxa below of Order.

Items	*Anomaloglossus stepheni*					*Leptodactylus andreae*				
	N	%N	O	%O	I	N	%N	O	%O	I
Arthropoda										
Arachnida										
Acari	3	4.23	3	20.00	12.11	5	6.41	5	31.25	18.83
Araneae	10	14.08	8	53.33	33.71	2	2.56	2	12.50	7.53
Salticidae	(2)	–	–	–	–	–	–	–	–	–
Camponidae	–	–	–	–	–	(1)	–	–	–	–
Opiliones	–	–	–	–	–	1	1.28	1	6.25	3.77
Pseudoscorpiones	1	1.41	1	6.67	4.04	1	1.28	1	6.25	3.77
Hexapoda	–	–	–	–	–	–	–	–	–	–
Collembola	1	1.41	1	6.67	4.04	2	2.56	2	12.50	7.53
Poderidae	(1)	–	–	–	–	–	–	–	–	–
Entomobryidae	–	–	–	–	–	(2)	–	–	–	–
Hemiptera	2	2.82	2	13.33	8.08	1	1.28	1	6.25	3.77
Isoptera	3	4.23	3	20.00	12.11	13	16.67	3	18.75	17.71
Termitidae	(3)	–	–	–	–	(13)	–	–	–	–
Blattodea	2	2.82	2	13.33	8.08	1	1.28	1	6.25	3.77
Psocoptera	1	1.41	1	6.67	4.04	2	2.56	2	12.50	7.53
Hymenoptera	23	32.39	9	60.00	46.20	37	47.44	13	81.25	64.34
Formicidae	(2)	–	–	–	–	(22)	–	–	–	–
Myrmicinae	(21)	–	–	–	–	(11)	–	–	–	–
Hypoponera	–	–	–	–	–	(1)	–	–	–	–
Ponerinae	–	–	–	–	–	(2)	–	–	–	–
Attinae	–	–	–	–	–	(1)	–	–	–	–
Coleoptera (adulto)	6	8.45	4	26.67	17.56	6	7.69	3	18.75	13.22
Staphylinidae (larva)	2	2.82	2	13.33	8.08	–	–	–	–	–
Diptera (adulto)	8	11.27	8	53.33	32.30	1	1.28	1	6.25	3.77
Diptera (larva)	6	8.45	6	40.00	24.23	1	1.28	1	6.25	3.77
Lepidoptera (larva)	–	–	–	–	–	1	1.28	1	6.25	3.77
Trichoptera	–	–	–	–	–	1	1.28	1	6.25	3.77
Myriapoda										
Chilopoda	–	–	–	–	–	1	1.28	1	6.25	3.77
Geophilomorpha	–	–	–	–	–	(1)	1.28	–	–	–
Polydesmida	3	4.23	1	6.67	5.45	1	1.28	1	6.25	3.77
Mollusca										
Gastropoda	–	–	–	–	–	1	1.28	1	6.25	3.77

importance index was calculated using $I = (N\% + O\%)/2$, where I = importance index, $N\%$ = prey relative abundance, and $O\%$ = prey relative occurrence. The trophic niche breadth was calculated for each species using the formula proposed by Levins and the overlap in diet among the two frog species was calcu-

lated using the Morisita's index of similarity (KREBS 1999). Prior of using each statistical test, we evaluated the normality of the data distribution and used non-parametric statistics when the data did not meet the assumption of normality. The diets of *A. stepheni* and *L. andreae* were compared using Kolmogorov-

Smirnov test for two independent samples (based on prey frequency) (ZAR 1999). We used a non-metric multidimensional scaling analysis (NMDS) with Euclidean distance for ordination of the occurrence of prey items for both frog species. For all indexes and statistics, we used the taxonomic level of Order.

Thirty-one frogs were collected, being 15 *A. stepheni* and 16 *L. andreae*. The mean of SUL of these species was 15.2 ± 1.26 mm for *A. stepheni* (range 13.4-17.5 mm) and 16.3 ± 1.49 mm for *L. andreae* (range 14.7-19.1 mm). LIMA *et al.* (2006) suggested that these two species have a similar body size. Our data show that the sizes of these two species are statistically slightly different ($T_{SUL} = 2.06$, df = 28, p = 0.049). The mean JW of *A. stepheni* was also significantly smaller (4.46 ± 0.64, range 3.7-5.9 mm, N = 15) than that of *L. andreae* (5.73 ± 0.79 mm, range 4.9-7.0 mm, N = 15) (ANCOVA: $F_{JW} = 13.72$, df = 28, p < 0.001).

One-hundred-and-fifty preys were identified, of which 78 were found in the stomachs of *L. andreae* and 71 were consumed by *A. stepheni* (Tab. I). We found one individual of *L. andreae* with an empty stomach (or 6.3%). Table I shows the prey types, their respective numbers, occurrence and importance index of each prey type consumed by both frogs species.

Anomaloglossus stepheni consumed 12 different prey types whereas *L. andreae* consumed 17 different types (Tab. I). The most frequent prey category consumed by the two species was Formicidae (47.4% for *L. andreae* and 31.9% for *A. stepheni*) (Tab. I). Based on the importance index, ants were also the most important prey category (I = 64.4 for *L. andreae* and I = 46.2 for *A. stepheni*). The two species differed in the second (mites I = 18.8 for *L. andreae* and spiders I = 33.7 for *A. stepheni*) and third more important prey category (termites I = 17.7 for *L. andreae* and adults of flies I = 32.3 for *A. stepheni*).

There are some divergences regarding the trophic preference of *L. andreae*. According to some authors, this species is considered as a non-ant specialist (TOFT 1980). Others, by contrast, have concluded that, mites and ants predominate in the diet of *L. andreae* (LIMA & MAGNUSSON 1998). Our data suggest that this species can behave as generalist predator.

Other prey items such as orthopterans, lepidopteran larvae, non-Formicidae hymenopterans, Chilopoda, Thysanura and Zoraptera have been found in the diet of *A. stepheni* (LIMA & MOREIRA 1993, JUNCÁ & ETEROVICK 2007). However, we did not find them in the present study. Nevertheless, we observed Blattodea and Pseudoscorpiones in the stomachs of *A. stepheni*, items not recorded by previous studies. Given these findings, we suggest that food resource availability is what determines the diet of this opportunistic species.

The trophic niche breadth of *A. stepheni* (B = 5.89, B_A = 0.35) was wider than that of *L. andreae* (B = 3.75, B_A = 0.16). Levins index formula resumed information on the richness of preys consumed and evenness (see KREBS 1999), thus, it would be expected that the niche breadth *A. stepheni* was wider, because its diet was more equitable with regards to prey distribution even this species consumed a lower number of prey. The high diversity of food

items found in the stomach contents of *A. stepheni* and *L. andreae* is consistent with that found by LIMA & MAGNUSSON (1998).

The data indicates that the two species did not differ in prey frequencies ($D_{max} = 0.20$, p = 0.75) and had a wide food niche overlap (Morisita's index = 88.0%). Figure 1 shows the ordination of the occurrence of prey items for the two frog species, which can be interpreted as a considerable feeding overlap for individuals of both species (stress = 0.0391). The similar trends in diet between the two syntopic frog species, the relatively high similarity, and the considerable overlap in their trophic niche does not necessarily mean that competition is occurring between them, especially if food is not limited in the environment (KUZMIN 1995). There is a high relative diversity and abundance of leaf-litter invertebrates in Central Amazonia (VASCONCELOS 1990). Additionally, different foraging modes (historically determined) tend to decrease competition. They have been recorded for *A. stepheni* and *L. andreae*, using movement, distance and velocity as activity parameters (LIMA & MAGNUSSON 1998).
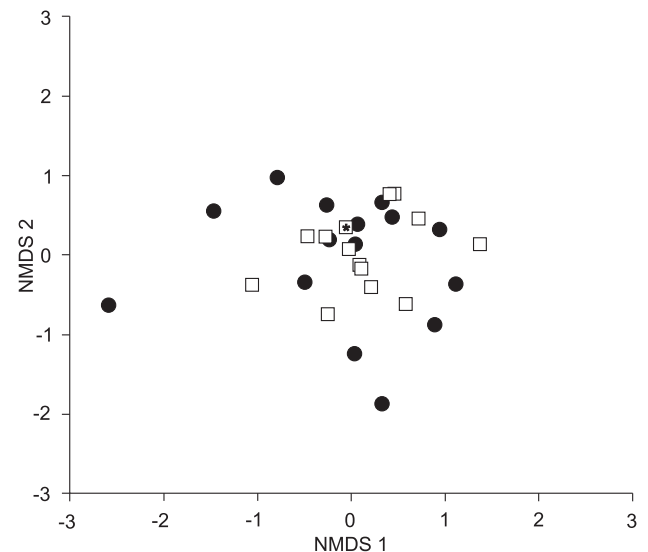

Figure 1. Multidimensional scaling analyses of the diet overlap in individuals of *Anomaloglossus stepheni* (black dots) and Leptodactylus andreae (white squares) living in the leaf-litter of Central Amazon. * Two individuals of *L. andreae* the same point. Stress configuration = 0.0391.

We conclude that: 1) the syntopic leaf litter frogs *L. andreae* and *A. stepheni* differ morphologically; 2) these two species are predominantly insectivorous frogs; 3) ants were the most important prey item of both species; 4) *A. stepheni* had the widest value for trophic niche breadth; and 5) the diet overlap between these species was 88%.

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