Trabajo

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Diet of four lizards from an urban forest in an area of amazonian biome, eastern amazon

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ABSTRACT
This study described the diet and niche overlap of four lizards from an urban fragment in Amapá state. The samplings were performed through pitfall traps and active visual search. In the stomach analysis, Formicidae and Coleoptera represented 50.79% of the total items. The highest niche overlap value was between *Gonatodes humeralis* and *Tropidurus hispidus*, which was not expected due to habitat use. The foraging strategies of all lizards observed have been previously mentioned by several authors. Several studies cite the diet of lizards being basically composed of invertebrates, with few variations, as also demonstrated in this study.

Key words: Stomach composition; Niche overlap; Ecology.

RESUMEN
Este estudio describió la dieta y la superposición de nicho de cuatro lagartos de un fragmento urbano en el estado de Amapá. Los muestreos se realizaron a través de trampas y búsqueda visual activa. En el análisis estomacal, Formicidae y Coleoptera representaron el 50.79% del total de ítems. El valor de superposición de nicho más alto fue entre *Gonatodes humeralis* y *Tropidurus hispidus*, que no se esperaba debido a la diferencia en el uso del hábitat. La estrategia de alimentación de todos los lagartos observados ha sido mencionada anteriormente por varios autores. Varios estudios indican que la dieta de los lagartos se compone básicamente de invertebrados, con pocas variaciones, como también se demostró en este estudio.

Palabras clave: Composición estomacal; Superposición de nicho; Ecología.

Introduction

Some factors are related to the structuring of reptile communities, such as diversity, richness, and species composition (Pianka, 1967; 1974; Vitt and Zani, 1998). It is possible to consider interspecific competition and individual specialization as determining factors in structuring of a community, since there may be overlap in the use of resources between species (Pianka, 1973; Bolnick *et al*., 2003).

Studies on the diet of lizards have increased over the last fifteen years and have contributed to a better understanding of species ecology and foraging strategies (Vitt *et al*., 1997a). These foraging strategies differ in several characteristics, such as the pattern of activity, presence of prey chemical detection, and diet composition, which can be considered as extreme points on a varying scale of foraging tactics.

Lizards are commonly classified into two categories according to the foraging strategy used: active foragers and sit-and-wait foragers (Huey & Pianka, 1981). There is also an intermediate type called errant foraging, which consists of changing hunting strategies according to opportunities and prey availability (Rocha, 1994). Foraging mode in lizards has been considered fundamental in interpreting ecological characteristics and natural history, such as the type and number of prey ingested (Vitt, 1991).

In this paper, we describe the diet of a lizard assembly inserted in an urban forest of Amazonian biome, we calculated the niche breadth and niche overlap of species and we discuss the foraging strategies between them.

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Materials and methods

Samplings were carried out on an urban area of forest fragment in the Campus Marco Zero of Universidade Federal do Amapá (00°00'S, 51°04'W), municipality of Macapá, Amapá state, Brazil. This area comprises 90 hectares and presents vegetation characterized by open areas and forest fragments (Fig. 1). The study was carried out from August 2011 to July 2012, monthly and lasting five days each, totaling 12 samplings. The individuals were captured through active visual search and pitfall traps, under a permit Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio/SISBIO number 31814-2).

Five pitfalls arrays were Y-shaped (one central bucket linked to three peripheral ones, the three arms forming angles of approximately 120°) with 10 L buckets. Buckets belonging to the same pitfall array were connected by a 5 m long and 50 cm-high plastic drift fence. Pitfall arrays were set 150 m from one another along a transect, in order to provide spatially independent sample units (Greenberg *et al.*, 1994; Cechin and Martins, 2000). Each pitfall array was sampled for a total of 15 consecutive days in each month of sampling. For active searches, we delimited five transects of 1 km, separating them from each other by 50 m. These transects were traversed linearly and every 10 m of displacement, we shifted up to 5 m left and right to increase the coverage of the microhabitats used by the species (Heyer *et al.*, 1994).

In the laboratory, we euthanized the specimens with 2% liquid lidocaine, fixed in 10% formalin and preserved in alcohol at 70%. We removed the stomach contents of lizards and identified posteriorly the prey categories at the level of order and family using a stereomicroscope. Some preys were identified to the family level and others to the order level. Thus, when we talk about items that were identified to the family level, we are referring specifically to items that have been identified up to that taxonomic level. Preys were identified according to identification keys by Triplehorn and Johnson (2011) and Rafael *et al.* (2012).

We measured the maximum length and width of all prey items to obtain the prey volume through the Ellipsoid Volume Formula, where V represents prey volume, l = item length e w = item width (Magnusson *et al.*, 2003):

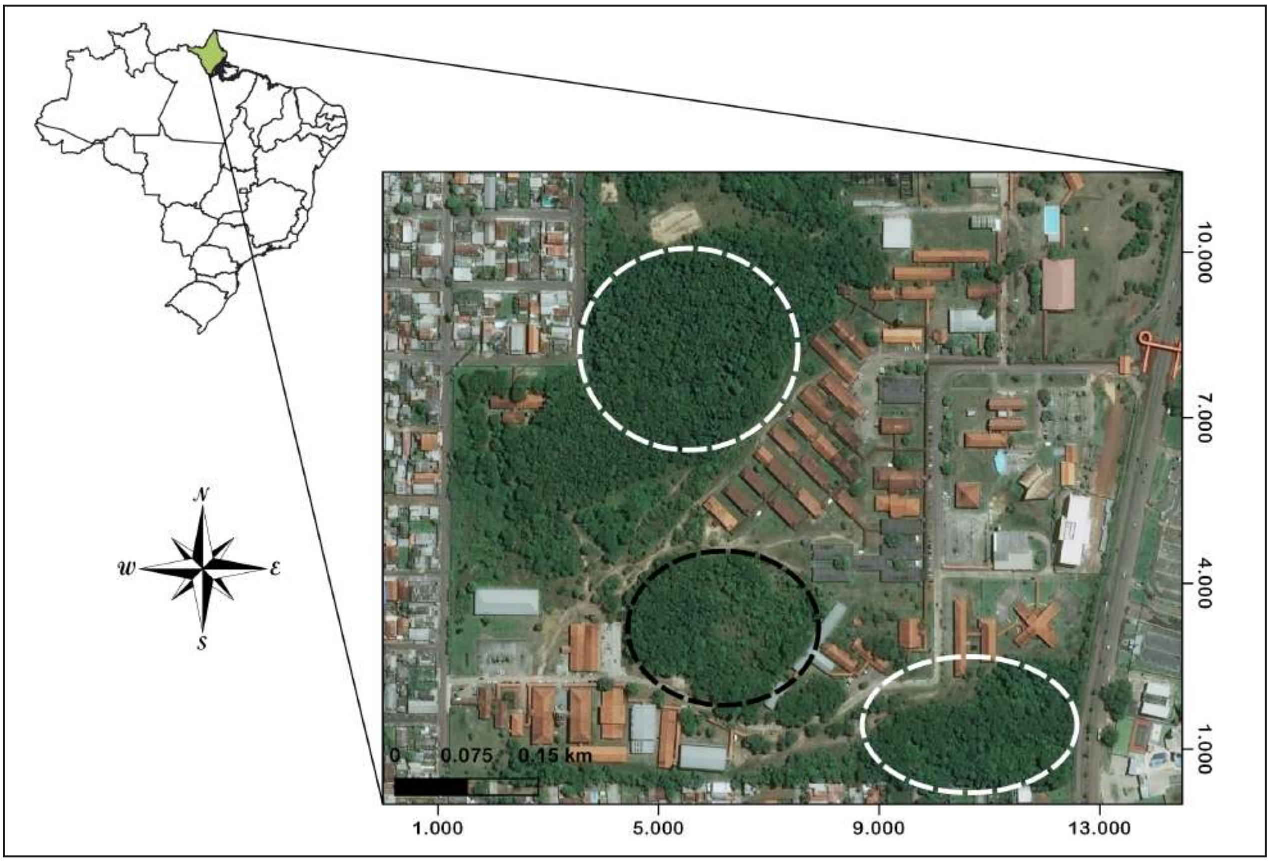

Figure 1. Urban fragment of forest located at the Universidade Federal do Amapá. Black circle: open area. White circles: forest fragment.

$$V = \frac{4}{3}\pi\left(\frac{l}{2}\right)x\left(\frac{w}{2}\right)^2$$

We determined the Importance Value Index (IVI) of each prey category in the diet using the sum of the percentages of number (N%), frequency (F%) and volume (V%) (Gadsden & Palacios-Orona, 1997).

$$IVI = \left(\frac{F\% + N\% + V\%}{3}\right)$$

In addition, we calculated the trophic niche breadth through Levins' Trophic Niche Amplitude Index (B) described by Pianka (1986). In this case, we considered the species as a specialist when the value of *B* is between 0 - 0.50, and values between 0.51 - 1.0 represent generalist individuals:

$$B = 1 \Big/ \sum_{i=1}^{n} p_{i^2}$$

where *B* is the Levins index (niche breadth), *n* is the number of categories and *p* is the numerical or volumetric proportion of prey category *i* in the diet. We also analyzed niche overlaps by using EcoSim Professional (Entsminger, 2014), to compare the mean observed niche overlap of the assemblage to mean simulated niche overlaps through RA3 (Gotelli and Graves, 1996; Entsminger, 2014).

Results

We recorded 84 individuals distributed in four families and four species (Fig. 2): Dactyloidae (*Norops auratus* (Daudin, 1802); n=22), Teiidae (*Kentropyx striata* (Daudin, 1802); n=25), Tropiduridae (*Tropidurus hispidus* (Spix, 1825); n=25) and Sphaerodactylidae (*Gonatodes humeralis* (Guichenot, 1855); n=12). *Kentropyx striata* was only captured in pitfall traps and *G. humeralis* only by active searches.

Diet analysis

Of the 84 specimens analyzed, 81 individuals (96.43%) had prey items in their gastrointestinal contents. In the stomach analysis, we identified 19 prey categories belonging to seven orders of Arthropoda (Araneae, Coleoptera, Diptera, Hemiptera, Hymenoptera, Isoptera and Orthoptera), a class of Myriapoda (Chilopoda) and a vertebrate group (Squamata). The most important preys based on the

Figure 2. Specimens of lizards recorded at urban area of forest fragment in the Campus Marco Zero of Universidade Federal do Amapá, municipality of Macapá, Amapá state, Brazil. **(A)** *Norops auratus*; **(B)** *Kentropyx striata*; **(C)** *Tropidurus hispidus*; **(D)** *Gonatodes humeralis*.

importance value index were Formicidae (31.71%) and Coleoptera (19.08%) (Table 1).

Norops auratus (Daudin, 1802)
Ninety-four items were found within nine prey categories (Table 2). Termites presented the higher importance value (25.39%) and ants were the second most representative (18.25%) in the diet. The standardized Levins' index (Bsta) was 0.37.

Kentropyx striata (Daudin, 1802)
The diet included a variety of invertebrates and some small vertebrates. Of the 25 specimens collected, three individuals (12%) had no stomach contents. We identified 13 prey categories with one belonging to the vertebrate group (Table 3). The index of importance value showed that Coleoptera (26.46%) was more representative in the *K. striata* diet. The standardized Levins' index (Bsta) was 0.48.

Tropidurus hispidus (Spix, 1825)
Twenty-five specimens of *T. hispidus* were collected and all had stomach contents. We found 276 items within 16 prey categories (Table 4). Based on the importance value index, Formicidae (45.68%) and Coleoptera (17.45%) were the most important prey items. The standardized Levins' index (Bsta) was 0.12.

Gonatodes humeralis (Guichenot, 1855)
This lizard consumed five different types of prey and all individuals had food items in their stomachs (Table 5). Coleoptera had the highest importance value index (28.89%) in the diet, followed by Hemiptera (24.86%). The standardized Levins' index (Bsta) was 0.72.

Table 1. Prey categories recorded and general composition in the stomach analysis of the lizards. N= number; F= frequency of prey; V= volume of prey; IVI= Importance Value Index. Values and their relative percentages.

Prey	N	%	F	%	V	%	IVI
Araneae	22	4.72	15	9.62	22.33	5.93	6.75
Chilopoda	1	0.21	1	0.64	0.19	0.05	0.30
Coleoptera	50	10.73	32	20.51	97.95	26.00	19.08
Diplopoda	1	0.21	1	0.64	2.17	0.58	0.48
Diptera	7	1.50	6	3.85	16.13	4.28	3.21
Eggs	2	0.43	2	1.28	3.17	0.84	0.85
Fruits	3	0.64	2	1.28	8.78	2.33	1.42
Hemiptera	20	4.29	17	10.90	26.16	6.95	7.38
Pentatomidae	1	0.21	1	0.64	1.56	0.41	0.42
Formicidae	189	40.56	37	23.72	116.23	30.86	31.71
Vespidae	4	0.86	3	1.92	2.85	0.76	1.18
Insecta larvae	23	4.94	4	2.56	7.17	1.90	3.13
Isoptera	105	22.53	12	7.69	20.46	5.43	11.89
Coccinellidae	2	0.43	1	0.64	2.49	0.66	0.58
Curculionidae	1	0.21	1	0.64	1.69	0.45	0.43
Tenebrionidae	5	1.07	2	1.28	3.41	0.91	1.09
Orthoptera	26	5.58	15	9.62	26.08	6.92	7.37
Sarcophagidae	1	0.21	1	0.64	6.43	1.71	0.85
Vertebrate Squamata	3	0.64	3	1.92	11.42	3.03	1.87
Total	**466**	**100**	**156**	**100**	**376.67**	**100**	**100**

Table 2. Prey categories found in the stomach analysis of the *Norops auratus* (N= 22). N= number; F= frequency of prey; V= volume of prey; IVI= Importance Value Index.

Prey	N	%	F	%	V	%	IVI
Araneae	5	5.32	4	9.52	1.24	3.95	6.26
Chilopoda	1	1.05	1	2.38	0.19	0.60	1.35
Coleoptera	6	6.38	5	11.90	6.34	20.18	12.82
Diptera	5	5.32	4	9.52	7.29	23.21	12.68
Hemiptera	4	4.26	4	9.52	1.21	3.85	5.88
Formicidae	25	26.60	11	26.21	0.62	1.97	18.25
Isoptera	38	40.43	7	16.67	5.99	19.06	25.39
Tenebrionidae	4	4.26	1	2.38	1.54	4.90	3.85
Orthoptera	6	6.38	5	11.90	7.00	22.28	13.52
Total	**94**	**100**	**42**	**100**	**31.42**	**100**	**100**

Table 3. Food items found in the stomach analysis of the *Kentropyx striata* (N= 25). N= number; F= frequency of prey; V= volume of prey; IVI= Importance Value Index.

Prey	N	%	F	%	V	%	IVI
Araneae	13	16.25	7	17.95	11.19	12.22	15.47
Coleoptera	11	13.73	10	25.66	36.61	39.97	26.46
Diplopoda	1	1.25	1	2.56	2.17	2.37	2.06
Eggs	1	1.25	1	2.56	2.35	2.57	2.13
Fruits	2	2.50	1	2.56	3.49	3.81	2.96
Hemiptera	2	2.50	2	5.13	0.82	0.90	2.84
Formicidae	6	7.50	2	5.13	0.19	0.19	4.28
Vespidae	1	1.25	1	2.56	2.03	2.22	2.01
Insecta larvae	7	8.75	3	7.69	7.06	7.71	8.05
Isoptera	16	20.00	2	5.13	3.04	3.32	9.48
Coccinellidae	2	2.50	1	2.56	2.49	2.72	2.59
Orthoptera	17	21.25	7	17.95	17.57	19.18	19.46
Vertebrate Squamata	1	1.25	1	2.56	2.58	2.82	2.21
Total	**80**	**100**	**39**	**100**	**91.59**	**100**	**100**

Table 4. Prey categories found in the stomach analysis of the *Tropidurus hispidus* (N= 25). N= number; F= frequency of prey; V= volume of prey; IVI= Importance Value Index.

Prey	N	%	F	%	V	%	IVI
Araneae	3	1.09	3	4.69	5.34	2.24	2.67
Coleoptera	27	9.78	13	20.31	53.00	22.28	17.45
Diptera	2	0.72	2	3.13	8.84	3.71	2.52
Eggs	1	0.36	1	1.56	0.82	0.34	0.76
Fruits	1	0.36	1	1.56	5.29	2.22	1.38
Hemiptera	12	4.35	9	14.06	17.27	7.26	8.56
Pentatomidae	1	0.36	1	1.56	1.56	0.66	0.86
Formicidae	154	55.80	21	32.81	115.28	48.43	45.68
Vespidae	3	1.09	2	3.13	0.82	0.34	1.52
Insecta larvae	16	5.80	1	1.56	0.11	0.05	2.47
Isoptera	48	17.39	2	3.13	9.36	3.93	8.15
Tenebrionidae	1	0.36	1	1.56	1.87	0.79	0.90
Curculionidae	1	0.36	1	1.56	1.69	0.71	0.88
Orthoptera	3	1.09	3	4.69	1.51	0.63	2.14
Sarcophagidae	1	0.36	1	1.56	6.43	2.70	1.54
Vertebrate Squamata	2	0.72	2	3.13	8.84	3.71	2.52
Total	**276**	**100**	**64**	**100**	**238.03**	**100**	**100**

Diet overlaps ranged from 0.44 (*K. striata* and *T. hispidus*) to 0.71 (*G. humeralis* and *T. hispidus*) (Table 6). The highest values of diet overlap were found among species that preferentially feed on Coleoptera (*G. humeralis* and *K. striata*) and Formicidae (*T. hispidus* and *N. auratus*). Food niche breadth ranged between 0.72 (*G. humeralis*) to 0.12 (*T. hispidus*).

Discussion

This study showed that the lizards sampled were mainly insectivorous. Coleoptera was the most important item in the diets of *Gonatodes humeralis* and *Kentropyx striata* and Formicidae for *Tropidurus hispidus*. This food preference is reported in the diet of congeners of lizards studied here, suggesting a niche pattern with respect to diet (Vitt, 1991; Miranda & Andrade, 2003; Ferreira *et al*., 2017).

The low number of ants in the diet of *K. striata* is not expected, considering that ants are among the most abundant arthropods in the Amazon region. Vitt *et al*. (2011) proposed that the low number of ants found in the diet of *K. altamazonica*, would be due to the ability of teiid lizards to discriminate prey by chemical cues. This could apply to this study, in which ants did not present significant values in the prey spectrum of *K. striata*. On the other hand, this food item was the most frequent in the diet of *T. hispidus*, which is consistent with other studies within the *Tropidurus* genus (Colli *et al*., 1992; Perez-Mellado, 1993; Van Sluys, 1993; Fialho *et al*., 2000; Van Sluys *et al*., 2004; Kolodiuk *et al*., 2010).

The consumption of other vertebrates by *T. hispidus* and *K. striata* was recorded in this study, which has been observed in several studies in the genus *Tropidurus* (Ribeiro and Freire, 2011; Siqueira *et al*., 2013) and *Kentropyx* (Vitt and Carvalho, 1995; Vitt *et al*., 2011; Franzini *et al*., 2017), that also documented the consumption of frogs and lizards.

Regarding foraging strategies, it had already been suggested the sit-and-wait foraging strategy for *G. humeralis* (Huey and Pianka, 1981) and *T. hispidus* (Ferreira *et al*., 2017), the active foraging for *K. striata* (Vitt, 1991) and opportunistic tactics for *Norops auratus* (Vitt *et al*., 2003).

In relation to niche breadth, *T. hispidus* consumed the largest number of prey among the sampled species and showed the lowest value, being considered the most specialist lizard in this study. This characteristic indicates ants specialist habits, which has already been reported in other *Tropidurus*

Table 5. Prey categories found in the stomach analysis of the *Gonatodes humeralis* (N=12). N= number; F= frequency of prey; V= volume of prey; IVI= Importance Value Index.

Prey	N	%	F	%	V	%	IVI
Araneae	1	6.25	1	9.09	4.56	29.17	14.84
Coleoptera	6	37.50	4	36.37	2.00	12.80	28.89
Formicidae	4	25.00	3	27.27	0.14	0.90	17.72
Hemiptera	2	12.50	2	18.18	6.86	43.89	24.86
Isoptera	3	18.75	1	9.09	2.07	13.24	13.69
Total	**16**	**100**	**11**	**100**	**15.63**	**100**	**100**

Table 6. Dietary Niche overlap values between sampled species in an urban area of a forest fragment in the Campus Marco Zero of Universidade Federal do Amapá, municipality of Macapá, Amapá state, Brazil.

Species	*Kentropyx striata*	*Norops auratus*	*Tropidurus hispidus*
Gonatodes humeralis	0.70	0.69	0.71
Kentropyx striata	---	0.67	0.44
Norops auratus		---	0.70

species (Fialho *et al*., 2000; Kolodiuk *et al*., 2010; Ribeiro and Freire, 2011). *K. striata* also showed a narrow niche breadth value, representing a specialized diet, with Orthoptera being the most abundant prey category, similar to found for *K. altamazonica* (Vitt *et al*., 2001) and *K. calcarata* (Vitt, 1991). The low consumption of ants by teiid lizards is expected (Acosta and Martori, 1990; Schall, 1990; Vitt and Carvalho, 1995; Vitt and Zani, 1996) and is similar to found in our observation. Previous studies also cite niche breadth values similar to those found in our study for *G. humeralis* (Vitt *et al*., 1997b; 2000). The low consumption of termites observed here by this species was expected and has been recorded by Miranda and Andrade (2003) in a population of *G. humeralis* from Maranhão, since this lizard is a sit-and-wait forager and termites are clumped and unpredictably distributed prey (Huey and Pianka, 1981). The niche breadth and importance value index of *N. auratus* indicated termites specialist, but this is not consistent with previous studies on *Norops* species, which mentioned other types of prey as dominant food items, such as ants and spiders (Vitt *et al*., 2008; Mesquita *et al*., 2015). Teixeira and Giovanelli (1999), studied the ecology of *T. torquatus* and concluded that this species invests in small and aggregate prey in order to save energy. This could explain the fact that *N. auratus* and *T. hispidus* ingested large quantities of termites. Another explanation would be the abundance of these invertebrates in the studied environment, but this statement is only speculative because we did not carried out a study to evaluate it.

Regarding food overlap, the overlap value between *N. auratus* and *K. striata* does not reflect direct competition. Teiids, in general, are heliothermic, using forest borders, which receive more direct sunlight (Vitt and Colli, 1994), whereas *Norops* uses the leaf litter of the forest floor. The high overlap of *G. humeralis* with three of the studied species suggests a similarity in the diets. This is not expected, since this lizard was the only species to be recorded in the forest area and foraging strategies differ among individuals. Shenbrot *et al*. (1991), suggested that the greater niche overlap of lizards was due to body size differentiation. This could explain the high niche overlap in our case, showing that body size may contribute to the coexistence of sympatric species, despite the microhabitat use be considered a predominant factor allowing coexistence within lizards assemblages.

Typically, natural history data forms the basis for understanding relationships between species. The processes that organize lizard assemblages are complex and include historical and current factors. The high prey availability allows a large overlap and the use of shared resources indicated that assemblage of lizards studied does not appear to be trophically structured. We encourage other studies capable of classifying the variables identified here, with sufficient data to allow appropriate comparisons.

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