

Diet of the lizard *Ecleopus gaudichaudii* (Gymnophthalmidae) in Atlantic Rainforest, state of Rio de Janeiro, Brazil

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ABSTRACT. In this study we analyzed the diet of the gymnophthalmid lizard *Ecleopus gaudichaudii* Duméril & Bibron, 1839, a typical inhabitant of the forest-floor leaf litter, in an Atlantic Forest area in the state of Rio de Janeiro, southeastern Brazil. The 26 individuals sampled during the study had a mean snout-vent length (SVL) of 36.2 ± 4.2 mm and a mean jaw width (JW) of 4.1 ± 0.5 mm. We did not find differences in SVL between males and females, though the sexes differed in JW when the effect of body size was factored out, with females presenting higher values. The diet of the lizards was composed exclusively of arthropods, especially isopods and orthopterans. The similarity in trophic niches among seasons (volumetric and numerical proportions of prey categories consumed) were 0.096 and to 0.43, respectively. There were also no detectable seasonal differences in mean number and mean volume of prey ingested, as well as no significant influence of lizard SVL on prey number and of lizard JW on mean prey volume, which may reflect the tendency of *E. gaudichaudii* to feed on few, relatively large prey.

KEY WORDS. Diet; Lacertilia; rainforest; seasonality; Squamata.

Gymnophthalmidae currently contains more than 200 species (UETZ & HALLERMANN 2011) of predominantly small lizards which are restricted to tropical latitudes in the New World (PIANKA & VITT 2003). Most are terrestrial, though some species may be semiaquatic and others semifossorial or fossorial, with a few species partly arboreal (PIANKA & VITT 2003). The family has undergone numerous taxonomic changes within the last decade, including the splitting or lumping of genera (DOAN 2003, DOAN & CASTOE 2005, RODRIGUES *et al.* 2007), the creation and re-delimitation (i.e., with the exclusion or inclusion of taxa) of subfamilies and tribes (PELLEGRINO *et al.* 2001, CASTOE *et al.* 2004), and the erection of new genera to accommodate some newly discovered species (RODRIGUES *et al.* 2005, 2007, 2009, RODRIGUES & SANTOS 2008, KOK 2005, 2009, PELOSO *et al.* 2011).

Currently, most of the published information on the ecology, particularly regarding feeding habits, of gymnophthalmid lizards in South America pertains to taxa from Amazonian or Andean forests (e.g., DUELLMAN 1978, ROCHA 1991, VITT & ÁVILA-PIRES 1998, VITT & ZANI 1998, VITT *et al.* 1998a,b, 2003, 2007, DOAN 2008, ANAYA-ROJAS *et al.* 2010) or from open habitats (e.g.,

VITT 1995, VITT & CARVALHO 1995, VIEIRA *et al.* 2000, ROCHA & RODRIGUES 2005, MESQUITA *et al.* 2006a,b), with few reports from Atlantic Forest species (e.g., TEIXEIRA & FONSECA 2003, EISEMBERG *et al.* 2004). The gymnophthalmid *Ecleopus gaudichaudii* Duméril & Bibron, 1839, the single species in this genus, is endemic to the Atlantic Forest of southeastern and southern Brazil (PETERS *et al.* 1986, UETZ & HALLERMANN 2011), and although it may occur also in anthropically modified habitats (see COSTA *et al.* 2009), it inhabits mainly the forest floor leaf litter. At present, the available information on aspects of its biology is restricted to a study on the feeding habits of two populations in the state of Minas Gerais, based on relatively small sample sizes (pooled sample = 17 specimens; EISEMBERG *et al.* 2004).

In the Reserva Ecológica de Guapiaçu (REGUA), in the state of Rio de Janeiro, individuals of *E. gaudichaudii* have been recently collected during herpetological surveys, thus providing an opportunity to increase the knowledge of its ecology. In the present study we provide information on the diet of *E. gaudichaudii* based on data from the population living in the area of REGUA and its surroundings. We also assess whether its

diet shows seasonal differences in composition, considering that the availability of potential prey vary seasonally in some areas of southeastern Brazil (e.g., VAN SLUYS 1995, ROCHA 1996, DEVELEY & PERES 2000).

MATERIAL AND METHODS

The lizards were collected in the forest of REGUA (22°24'S, 42°44'W) and in five forest fragments at its surroundings, in the municipality of Cachoeiras de Macacu, state of Rio de Janeiro, southeastern Brazil. The Reserve is covered by Atlantic Forest at different levels of conservation, with regions of undisturbed forests occurring in the steepest and less accessible parts of the Reserve (ROCHA *et al.* 2007). This area is inserted within one of the largest remnants of Atlantic Forest in the state (total area over 60,000 ha), has a wet and warm climate with annual rainfall varying from 2000 to 2500 mm, and the mean annual temperature is about 24°C (ROCHA *et al.* 2007).

Lizards were collected during herpetological surveys carried out between July 2007 and March 2010, at altitudes between 40 and 500 m. Surveys were performed during the dry (April-September) and wet (October-March) seasons, and two sampling methods were employed: visual encounter surveys (hereafter VES; CRUMP & SCOTT 1994), and pitfall traps with drift fences (CORN 1994). The VES method was performed by time-constrained transects (30 minutes), totaling 1,250 hours of active search. Pitfall-trap systems consisted each of eleven 60-liter buckets buried on the ground and set approximately 10 m apart from each other, with soft plastic drift fences about 50 cm high extended between them. A total of 15 pitfall-trap systems (165 buckets) were established (12 in fragments and three in the reserve) and were surveyed during six days in each season (a total of 30 days) totaling 4950 bucket-days of sampling effort (pitfall trapping was not used during the 2010 wet season).

After preservation in 10% formalin and storage in 70% alcohol, the snout-vent length (SVL) and jaw width (JW) of collected lizards were measured with a digital caliper (precision of 0.1 mm). Specimens were dissected, and their stomach contents were analyzed qualitatively and quantitatively. Prey items found in stomachs were identified under a stereomicroscope to the level of Order (or Family in the case of Formicidae). Diet was quantified using number, volume (mm³) and frequency (%) of occurrence of items. Prey items were counted and measured (greatest length and width) with a digital caliper (precision of 0.1 mm) and their volume was estimated using the formula for a prolate spheroid [$V = 4/3 \cdot \pi \cdot (L/2) \cdot (W/2)^2$], where L is the length and W is the width of the food item (DUNHAM 1983). The frequency of occurrence of each category of prey in the diet was expressed as the proportion of stomachs that contained that category.

To assess the degree of similarity of the trophic niche of *E. gaudichaudii* between the dry and wet seasons (considering the possibility of seasonal differences in local arthropod avail-

ability), we compared the patterns of prey consumption (based on volumetric/numerical proportions of prey categories) among seasons using the niche overlap index of MacArthur and Levins (PIANKA 1973) $O_{jk} = \sum p_{ij} p_{ik} / \sqrt{(\sum p_{ij} \sum p_{ik})}$, where p_{ij} and p_{ik} are the volumetric/numerical proportion of prey category *i* in the diet in seasons *j* and *k*, respectively.

We evaluated whether there were differences in the number of prey and in the mean volume of the three largest prey consumed per lizard between seasons (again, assuming the possibility of seasonal variation in prey availability) using One-Way Analysis of Variance (ANOVA) (ZAR 1999); mean prey volume per lizard was estimated as the mean volume of the three largest prey items consumed (or all items, when stomachs contained less than three). To analyze if the number of ingested items and the volume of individual prey are affected as a result of the lizards' body size and mouth width, respectively, we tested for relationships between prey number and lizard body size (expressed as SVL) and between mean prey volume and jaw width (JW) by performing Simple Regression Analyses. To assess if there is sexual dimorphism in body size and head dimensions in this population of *E. gaudichaudii*, we tested for differences in SVL and in JW between males and females using ANOVA and Analysis of Covariance (ANCOVA, with SVL as covariate; ZAR 1999), respectively.

Descriptive statistics are presented throughout the text as mean \pm one standard deviation. All data were tested for homoscedasticity of variances and for the normality of distribution before performing statistical analyses.

RESULTS

A total of 26 individuals of *E. gaudichaudii* (13 at each season) were collected during the surveys: 18 males, seven females, and one individual whose sex could not be determined. The mean SVL of *E. gaudichaudii* in our sample was 36.2 ± 4.2 mm (26.7-43.2 mm; N = 26), with females averaging 38.7 ± 3.5 mm (33.1-43.2 mm, N = 7) and males 35.3 ± 4.2 mm (26.7-42.4 mm, N = 18). The mean JW was 4.1 ± 0.5 (3.1-5.0 mm, N = 26), with females averaging 4.3 ± 0.5 mm (4.6-5.0 mm, N = 7) and males 4.0 ± 0.4 mm (3.1-4.9, N = 18). No significant difference was detected between males and females in SVL (ANOVA, $F_{1,23} = 3.509$, $p = 0.074$), but the sexes differed significantly in JW (ANCOVA, $F_{1,1,22} = 19.460$, $p < 0.001$), with females having proportionally wider jaws.

Three individuals (23.1%; two males and one female) of *E. gaudichaudii* from dry season months and four (30.8%, four males) from wet season months had empty stomachs. A total of seven orders of arthropods were consumed in the dry season, but only three during the wet season (Tab. I). Plant remains had low proportions in the diet in both seasons and usually corresponded to small parts of dry leaves from the leaf litter.

In the dry season, in numerical terms, lizards fed predominantly on orthopterans (36%), followed by isopods (28%).

Volumetrically, orthopterans (59% of the total ingested) and isopods (18.9%) were also the most important items. In terms of frequency of occurrence, isopods were the main prey, being found in 38.5% of the specimens analyzed, followed by orthopterans (30.8%) (Tab. I).

In the wet season, lizards fed predominantly on isopods, which were the most important among the three prey categories consumed in that season. Isopods corresponded to 73.3% of the total prey ingested, 91.6% of the total volume consumed, and were found in 46.2% of the stomachs (Tab. I).

The values of trophic niche overlap (O_{ij}) between seasons, in terms of volumetric and numerical proportions of prey categories consumed, were 0.096 and 0.43, respectively. The mean number of prey consumed per individual of *E. gaudichaudii* was 2.3 ± 1.5 (range = 1-7, N = 18) and did not differ significantly (ANOVA, $F_{1,16} = 1.400$, $p = 0.254$) between dry (2.6 ± 1.7 , 1-7, N = 10) and wet (1.9 ± 1.1 , 1-4, N = 8) seasons. The mean volume of the three largest items consumed per lizard was $21.3 \pm 19.7 \text{ mm}^3$ ($0.1\text{-}65.2 \text{ mm}^3$, N = 18) and also did not vary significantly (ANOVA, $F_{1,16} = 0.508$, $p = 0.490$) between dry ($17.8 \pm 14.8 \text{ mm}^3$, $0.1\text{-}46.8 \text{ mm}^3$, N = 10) and wet ($25.7 \pm 25 \text{ mm}^3$, $1.5\text{-}65.2 \text{ mm}^3$, N = 8) seasons. The number and mean volume of prey ingested were not significantly related, respectively, to SVL (Regression Analysis, $R = 0.216$, $p = 0.389$, N = 18), and to JW (Regression Analysis, $R = 0.006$, $p = 0.770$, N = 18).

DISCUSSION

Despite the comparatively intense sampling effort employed in this study, only 26 individuals of *E. gaudichaudii* were collected. The secretive habits of this species may render it dif-

ficult to detect in the habitat (which could lead to an underestimation of its local abundance). EISEMBERG *et al.* (2004) referred to *E. gaudichaudii* as a "rare" lizard when reporting data on its diet in two areas in the state of Minas Gerais, southeastern Brazil. Studies carried out in other areas of Atlantic Forest reported *E. gaudichaudii* as an abundant species (e.g., DIXO & VERDADE 2006, CONDEZ *et al.* 2009, COSTA *et al.* 2009). Indeed, CONDEZ *et al.* (2009) and DIXO & VERDADE (2006) mentioned that *E. gaudichaudii* was the most abundant lizard species in areas of Atlantic Forest in the state of São Paulo, southeastern Brazil, where they carried out herpetological inventories. Actually, *E. gaudichaudii* was the second most abundant lizard species found during surveys in REGUA, after the leiosaurid *Enyalius brasiliensis* (Lesson, 1828) (M. Almeida-Gomes, unpub. data). Hence, *E. gaudichaudii* seems to be an abundant species in at least some of the areas of Atlantic Forest it inhabits.

Our data did not support evidence for sexual dimorphism in body size in *E. gaudichaudii*, although relative head width differed between the sexes, with females presenting greater values. The occurrence of sexual dimorphism in body size and/or relative head dimensions has been reported for some gymnophthalmid lizards (e.g., PIANKA & VITT 2003, DOAN 2008), although in those cases males had the larger heads. However, in some other species in this family sexual size dimorphism may be very slight or non-existent (VITT & ÁVILA-PIRES 1998, VITT *et al.* 2007). Our limited data for this study suggest that sexes may not differ significantly in size in *E. gaudichaudii*, but our sample size for females was too low and thus we cannot make a definite statement. Analysis of a larger sample would be useful to verify if this species indeed lacks sexual size dimorphism, and if it actually is sexually dimorphic in relative head width.

Table I. Number (N), volume (V, mm^3), and frequency of occurrence (F) of each category of prey in the diet of *Ecleopopus gaudichaudii* from the Atlantic Forest in the Reserva Ecológica de Guapiáçu and its surroundings, in southeastern Brazil, during the dry and wet seasons. Percentages values are in parentheses.

Item	Dry season (N = 13)			Wet season (N = 13)		
	N (%)	V (%)	F (%)	N (%)	V (%)	F (%)
Arachnida						
Araneae	3 (12)	12.6 (3.7)	2 (15.4)	2 (13.3)	4.6 (1.9)	2 (15.4)
Malacostraca						
Isopoda	7 (28)	64.5 (18.9)	5 (38.5)	11 (73.3)	216.4 (91.6)	6 (46.2)
Hexapoda						
Ephemeroptera (nymph)	2 (8)	41.5 (12.2)	1 (7.7)	–	–	–
Orthoptera	9 (36)	200.8 (59.0)	4 (30.8)	2 (13.3)	14.9 (6.3)	2 (15.4)
Isoptera	1 (4)	0.05 (0.01)	1 (7.7)	–	–	–
Hemiptera	1 (4)	19.4 (5.7)	1 (7.7)	–	–	–
Hymenoptera						
Formicidae	2 (8)	0.77 (0.2)	2 (15.4)	–	–	–
Plant remains	–	0.68 (0.2)	1 (7.7)	–	0.29 (0.1)	1 (7.7)
Total	25 (100)	340.3 (100)	–	15 (100)	236.2 (100)	–

The results of our study indicated that *E. gaudichaudii* has a diet exclusively composed of small arthropods, with isopods, orthopterans and spiders being the main prey. We found plant remains in the diet, such as pieces of twigs and leaves, but due to its low volumetric importance and the type of plant matter present in stomachs (small dry pieces of leaves from leaf-litter) we considered it as a result of accidental ingestion during prey capture by the lizards. In another study carried out in the state of Minas Gerais, the diet of *E. gaudichaudii* was numerically dominated by isopterans and spiders, and the most frequently consumed prey were spiders, followed by orthopterans and isopods (EISEMBERG *et al.* 2004). In our study, there was high consumption of isopods and low consumption of isopterans, suggesting that the local availability of food items may be an important factor affecting prey ingestion by these lizards. Nevertheless, the diet of *E. gaudichaudii* was rather similar in both studies, with isopods and orthopterans being among the most frequently consumed items in studied areas in both states of Rio de Janeiro and Minas Gerais. Isopods have also been reported as the main prey item in the diet of other gymnophthalmids such as *Leposoma scincoides* Spix, 1825 in a Brazilian Atlantic Forest area in the state of Espírito Santo (TEIXEIRA & FONSECA 2003), and *Ptychoglossus bicolor* (Werner, 1916) in a coffee plantation in Colombia (ANAYA-ROJAS *et al.* 2010). However, judging from most dietary surveys so far carried out on gymnophthalmids, it seems that spiders and orthopterans are, in general, the predominant prey types in the diets of such lizards (e.g., DUELLMAN 1978, VITT 1995, VITT & ZANI 1998, VITT *et al.* 1998a,b, 2003, 2007, VIEIRA *et al.* 2000, ROCHA & RODRIGUES 2005, MESQUITA *et al.* 2006a,b, DOAN 2008).

The low similarity of trophic niches between the dry and wet seasons was apparently due to the substantial predominance of isopods in the diet during the wet season, as compared to the dry season, when a greater variety of prey types was consumed. Additionally, spiders and orthopterans had a higher proportional contribution to the diet of *E. gaudichaudii* in the dry season comparing to the wet season. Optimal foraging models predict more generalized diets as a result of food shortage, leading predators to consume more “sub-optimal” prey than in periods of greater resource abundance (SCHOENER 1971). The availability of potential food resources (i.e., arthropods) for lizards may be higher during the wet than during the dry season in some seasonal tropical areas (e.g., VAN SLUYS 1995, ROCHA 1996). Thus, *E. gaudichaudii* may fit the optimal foraging model in the present study, having fed on more types of prey in the dry season and consuming predominantly one prey type in the wet season. However, as we have no data on arthropod availability in the environment during the period of study we cannot say if a seasonal fluctuation in arthropod abundance actually occurs in the study area and if it is sufficiently pronounced in order to influence the feeding habits of *E. gaudichaudii*.

The observed lack of seasonal differences in mean number and mean volume of prey per individual may reflect the

tendency of *E. gaudichaudii* to feed on few, relatively large prey (EISEMBERG *et al.* 2004, this study). We also found no significant relationships between SVL and number of prey and between JW and prey size for *E. gaudichaudii*. This also may result from the low variation in the size of prey consumed by this lizard (mainly the most consumed, i.e., isopods), whose small body size limits the range of prey sizes that it can swallow. Body size and head dimensions are intrinsic factors that may affect strongly the patterns of prey consumption in lizards, with larger body and head sizes enabling an individual to consume more prey of a given size and prey of larger sizes, respectively (e.g., TOFT 1985, MAGNUSSEN & SILVA 1993, MENEZES *et al.* 2008).

Our results showed that *E. gaudichaudii* has a diet exclusively composed of arthropods, with isopods and orthopterans being the most consumed prey, and with some variation in prey consumption patterns among seasons. Analysis of a larger sample would be useful to more consistently assess this apparent seasonal trend, as well as verify if *E. gaudichaudii* indeed lacks sexual size dimorphism, and if females actually tend to have relatively wider heads than males (which is opposite to what has been observed so far in other gymnophthalmid lizards).

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