Diet of *Teius oculatus* (Sauria, Teiidae) in southern Brazil (Dom Feliciano, Rio Grande do Sul)

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ABSTRACT. We analyzed stomach contents of 58 specimens of *Teius oculatus* (D'Orbigny & Bibron, 1837) (20 adult males, 17 adult females and 21 juveniles) captured in Dom Feliciano, RS, Brazil, to evaluate diet composition and sexual and ontogenetic variations in prey consumption. Diet was composed of 15 prey categories, all arthropods. Orthoptera was the most frequent prey type. Quantitatively, termites were the most important prey item (59.5%). There were no significant differences between the diets of adult males and females. Ontogenetic differences were found, mainly concerning volume of prey consumed. Adult lizards ingested significantly larger prey than juveniles ($U = 170.00$; $p < 0.001$). Juveniles, although having a comparatively less diverse diet (10 prey types) consumed a larger number of items (45.7% of total). Diet similarity was higher between juveniles and adult males ($O_{jk} = 0.97$) and prey diversity was higher in the diet of adult females ($H' = 2.65$). Based on importance value index the most important item in the diet of *T. oculatus* was Orthoptera. We conclude that *T. oculatus* in Dom Feliciano has a relatively generalized diet and it is an opportunist lizard, feeding on arthropods, mainly insects.

KEYWORDS. Lizards, diet, ontogenetic variation.

RESUMO. Dieta de *Teius oculatus* (Sauria, Teiidae) no sul do Brasil (Dom Feliciano, Rio Grande do Sul). Analisamos o conteúdo estomacal de 58 espécimes de *Teius oculatus* (D'Orbigny & Bibron, 1837) (20 machos adultos, 17 fêmeas adultas e 21 jovens), coletados no município de Dom Feliciano, RS, verificando a existência de variação ontogenética e sexual. A dieta esteve composta de 16 itens, todos artrópodes, sendo que Orthoptera foi a ordem mais freqüente. Quantitativamente isópteros foram os itens mais representativos (59,5%). Não foram encontradas diferenças significativas nas dietas de fêmeas e machos adultos. Foram encontradas diferenças ontogenéticas, principalmente no volume médio de presas consumidas, sendo que em lagartos adultos foi significativamente maior que em jovens ($U = 170,00$; $p < 0,001$). Indivíduos jovens, apesar de se alimentarem de uma menor diversidade de presas (10), consumiram um número grande de itens (45,68% do total). A similaridade alimentar foi maior entre jovens e machos adultos ($O_{jk} = 0,97$), e a diversidade de presas consumidas foi maior em fêmeas adultas ($H' = 2,65$). O índice de importância relativa mostrou que o item mais importante na dieta de *Teius oculatus* foi Orthoptera. Concluímos que *T. oculatus*, em Dom Feliciano, é um lagarto generalista e oportunista, alimentando-se de artrópodes, principalmente insetos.

PALAVRAS-CHAVE. Lagartos, dieta, variação ontogenética.

Analyses about the diet composition of a lizard species generate information not only on the prey types this species feeds on, but also about the potential relative importance of each of them in the diet and about the strategies the species uses to hunt its prey (Belver & Avila, 2001).

Teiid lizards from temperate zones feed on a variety of prey types and their diets include invertebrates that remain sheltered or that are not active on surface when the lizard is foraging (Vitt, 1991).

The distribution of genus *Teius* (Merrem, 1820) is restricted to the lowlands of South America, east of the Andes and it is currently composed of three species, *T. teyou* (Daudin, 1802), *T. oculatus* (D'Orbigny & Bibron, 1837) and the parthenogenetic species *T. suquiensis* Avila & Martori, 1991. *Teius oculatus* is widely distributed in central and eastern Argentina, southernmost Brazil, Uruguay and Paraguay (Cei, 1993; Avila, 2002). In Rio Grande do Sul this species has wide distribution, occupying several habitats, from restinga of lakes and rivers to rocky formations on hills of medium altitude (Bujes, 1998).

Preliminary information on the diet composition of *T. oculatus* may be found in studies carried out on populations in Argentina (Acosta *et al.*, 1991; Álvarez *et al.*, 1992) and southern Brazil (D'Agostini *et al.*, 1997). Those studies generally mention *T. oculatus* as an opportunist carnivorous and preferentially insectivorous lizard.

The diet of lizards may present ontogenetic, seasonal or even sexual variation (Teixeira-Filho *et al.*, 2003). Such differences occur because the prey assortment potentially available to a lizard may suffer variations due to shifts in size or behavior, or in the local availability of prey in the environment along the year.

In this study we analyzed the diet of *T. oculatus* in southern Brazil and evaluated the extent of sexual and ontogenetic variation of this diet.

MATERIAL AND METHODS

This study was carried out from August 2001 to March 2004 in Fazenda Chapada (30°25'23.5"S, 052°18'41.4"W), which area encompasses 333 ha and is located in Dom Feliciano municipality, Rio Grande do Sul. The vegetation in the region includes grasslands with sparse shrubs and small forest formations (Porto, 2002).

There is no clear dry season with rains during the whole year. During the years of study the rainfall in the area varied from 50.1 to 320.6 mm, with mean 174.4 mm. The temperature during the same period was, in general, high in the summer ($\bar{x}$ = 21.7°C ± 1.1) and it was comparatively lower in the winter (= 13.5°C ± 1.7) (Source: INMET - Oitavo Distrito de Meteorologia – Porto Alegre, for the nearest city: Encruzilhada do Sul) (Fig. 1).

In order to study the diet we analyzed 132 specimens of *Teius oculatus*, 81 were captured during the activity period of the species, from October to April and 41 were captured during the hibernation period (May to September) (pers. obs.). Ten specimens deposited in the collection of Museu de Ciências e Tecnologia of Pontifícia Universidade Católica (MCP), captured in the same area in 2000, during the activity period of the species, were added to the sample. The lizards weight was measured with spring scale (precision 0.25 g) and their snout-vent length (SVL) was measured with a caliper (accuracy 0.01 mm). The lizards were dissected in laboratory and their stomach contents were analyzed under stereomicroscope. Prey items were identified and classified to the taxonomic level of order. The food remains we could not identify were grouped as "non-identified arthropods" (NIA). The food items of each specimen were counted and measured (larger length and width) with digital caliper. The volume of each item (mm^3) was estimated by the spheroid volume formula:

$$V = \frac{4}{3}\pi.\left(\frac{length}{2}\right).\left(\frac{width}{2}\right)^2$$

The similarity degree between the diets of females and males and juveniles (SVL < 72.00 mm) and adults was determined using the O_{jk} similarity index (PIANKA, 1973):

$$O_{jk} = \frac{\sum P_{ij}P_{ik}}{\sqrt{\sum P_{ij}^2 \sum P_{ik}^2}}$$

where P_{ij} and P_{ik} are the proportion of food items of category i in the groups j and k. Values vary from 0 (no similarity) to 1 (complete similarity).

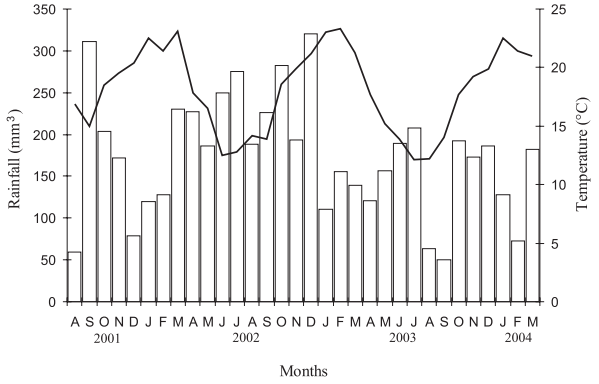

Fig. 1. Monthly mean temperature and rainfall in Encruzilhada do Sul municipality (Serra do Sudeste), Rio Grande do Sul, from August 2001 to March 2004. Temperature (line) rainfall (bars).

Trophic diversity concerning number of prey found in the stomachs of males, females and juveniles was calculated using Shannon-Wiener index (KREBS, 2001): $H' = -\Sigma p_i \log_2 (p_i)$, being p_i the relative abundance of prey i taxon in the diet of the lizards.

The relative importance of each item was described calculating the Importance Value of prey (GADSDEN & PALACIOS-ORONA, 1997):

$IV = V'_{ij} + N'_{ij} + F'_{ij}$

where: $V'_{ij} = V_{ij} / SV_{ij;} N'_{ij} = N_{ij} / SN_{ij;} F'_{ij} = F_{ij} / SN_j$

IV = Importance Value; V_{ij} = Volume of food item i in predator j; SV_{ij} = Total Volume of stomach content; N_{ij} = Number of elements of food item i in predator j; SN_{ij} = Total number of prey in the sample; F_{ij} = Number of stomachs of predator j in which food item i was found; N_j = Total number of stomachs of predator j.

Differences in number and mean volume of prey consumed by adults and juveniles were tested using Mann-Whitney test.

The specimens analyzed were deposited in the Herpetological Collection of Museu de Ciências e Tecnologia of Pontifícia Universidade Católica do Rio Grande do Sul (MCP) under numbers: MCP 12508–12514, MCP 12606–12612, MCP 12824, MCP 12825, MCP 12827–12830, MCP 12833, MCP 12835, MCP 12846, MCP 12847, MCP 13191–13203, MCP 13322–13327, MCP 13485–13487, MCP 13489–13492, MCP 13494–13496, MCP 13822–13833, MCP 14353–14358, MCP 14360–14368, MCP 14370–14383, MCP 14605–14609, MCP 14611–14617, MCP 15896–15899, MCP 15900–15911, MCP 15913–15922.

RESULTS

Among 132 specimens of *Teius oculatus* analyzed, those captured during the inactivity period (41) did not present food content. Among the 91 lizards captured during the activity period, 58 (20 adult males, 17 adult females and 21 juveniles) had food content in their stomachs.

The diet of *Teius oculatus* was composed of 15 categories of food items and all of them were arthropods. Orthoptera was the most frequent order, being present in 66% of the stomachs and corresponding to 8.7% of the total number of ingested prey (n = 948) and to 33% of the total volume of prey (Tab. I). The second most frequent item was Coleoptera (65%), corresponding to 11% of the total number of prey and to 15.4% of the total volume (Tab. I). Isoptera was the most important item regarding number of items (59.5% of the total number of prey), followed by Coleoptera (11%) (Tab. I). Regarding volume, the most important items were Orthoptera (33% of the total volume), Coleoptera (15.4%) and Araneae (10.6%) (Tab. I).

The mean diversity of prey per stomach was 2.8 ± 1.6 and the maximum richness found in one stomach was eight taxa. The maximum number of items found in one stomach was 95, and the general mean was 16.2 ± 19.9 items. The mean number of prey consumed by adult males was 14.8 ± 15.5, whereas by females was 13.1 ± 23.9; the difference was not statistically significant (U = 142.0; p = 0.3934). The mean volume of prey consumed by adult males (1297.0 ± 1175.8 mm^3) was not significantly different

from that of females (1375.8 ± 1231.0 mm^3) (U = 164.0; p = 0.8549).

Despite juveniles fed on a smaller richness of prey types (10) compared to adult males (12) and females (13), they consumed a high number of items (n = 433), which corresponded to 45% of the total items (Tab. 1). The most frequent item in the diet of juveniles was Isoptera (67%), which was also the numerically most important item, with 76.9% of the total number of items. Among adults, either for males or for females, the most important item regarding volume was Orthoptera, with 31% of the total volume. In stomachs of adult males, regarding number of items, Isoptera was the most important prey (65%) and Coleoptera was the most frequent (85%). In females, Formicidae was the most abundant (40%) and Orthoptera was the most frequent item (94%) in the stomachs (Tab. I).

The trophic similarity (concerning number of prey categories) was higher between juveniles and adult males (O_{jk} = 0.97) than between adult males and females (O_{jk} = 0.52) or between juveniles and adult females (O_{jk} = 0.43). Regarding volume, the feeding similarity was also higher between juveniles and adult males (O_{jk} = 0.91) than between adult males and females (O_{jk} = 0.81) or between juveniles and adult females (O_{jk} = 0.84).

Trophic diversity was higher in the diet of adult females (H' = 2.65) than in the diet of males (H' = 1.80) and juveniles (H' = 1.28).

The Importance Value index of food items revealed that Orthoptera (IV = 1.48) was the most important food item in the diet of adult females, whereas in the diet of males it was Coleoptera (IV = 1.25) and for juveniles, Isoptera (IV = 1.58) was the most important food item. In general, Orthoptera (IV = 1.15) was the most important food item (Tab. I).

The relation between the number of prey in the stomach and the size of the lizard was not significant (ANOVA, F_{56} = 1.02; p = 0.31). The relation between the volume of prey in the stomach and the SVL of the lizard was positive and significant (ANOVA, R^2 = 0.22; F_{56} = 15.01, p < 0.01) (Fig. 2).

Table I. Number (N), volume (in mm^3) (V), frequency (F) and importance value (IV) of prey in the diet of juveniles, adult males and adult females of *Teius oculatus* in Dom Feliciano, Rio Grande do Sul (NIA, Non-identified Arthropods).

	Juveniles (n = 21)				Adult Males (n = 20)				Adult Females (n = 17)			
Item	N (%)	V (%)	F (%)	IV	N (%)	V (%)	F (%)	IV	N (%)	V (%)	F (%)	IV
INSECTA												
Isoptera	333 (76.9)	1175.98 (13.9)	14 (66.0)	1.58	194 (65.7)	891.12 (3.3)	10 (50)	1.20	37 (16.8)	157.82 (0.6)	4 (23.5)	0.41
Hemiptera					5 (1.7)	541.52 (2.0)	3 (15)	0.19	4 (1.8)	298.02 (1.1)	3 (17.6)	0.07
Hymenoptera												
Formicidae	1 (0.2)	14.18 (0.2)	1 (4.8)	0.05	7 (2.5)	14.97 (0.1)	3 (15)	0.17	89 (40.5)	61.12 (0.2)	3 (17.6)	0.58
Coleoptera	40 (9.3)	1303.88 (15.5)	16 (76.2)	0.26	38 (12.9)	6041.73 (23.3)	17 (85)	1.25	27 (12.3)	1869.33 (7.4)	5 (29.4)	0.51
Coleoptera Larvae	6 (1.4)	290.45 (3.4)	2 (9.5)	0.15	2 (0.6)	27.18 (0.2)	2 (10)	0.11	4 (1.8)	223.92 (0.9)	3 (17.6)	0.21
Orthoptera	29 (6.8)	3646.41 (43.2)	8 (38.1)	0.91	24 (8.2)	7999.69 (31.0)	15 (75)	1.18	30 (13.6)	8012.74 (31.5)	16 (94.1)	1.48
Plecoptera					1 (0.3)	222.68 (0.8)	1 (5)	0.06	1 (0.4)	539.81 (2.1)	1 (5.9)	0.09
Blattodea	3 (0.7)	160.38 (1.9)	2 (9.5)	0.04	1 (0.3)	839.91 (3.2)	1 (5)	0.09	7 (3.2)	4474.08 (17.6)	4 (23.5)	0.49
Lepidoptera	1 (0.2)	77.01 (0.9)	1 (4.7)	0.04	3 (1.0)	2222.08 (8.5)	2 (10)	0.21				
Lepidoptera Larvae									3 (1.3)	1795.88 (7.0)	2 (11.7)	0.22
CRUSTACEA												
Isopoda	1 (0.2)	28.97 (0.4)	1 (4.7)	0.05	3 (1.0)	176.94 (0.6)	3 (5)	0.17	7 (3.2)	619.41 (2.4)	4 (23.5)	0.30
ARACHNIDA												
Araneae	18 (4.1)	913.94 (10.8)	11 (52.3)	0.68	16 (5.5)	3619.74 (14.0)	10 (50)	0.71	9 (4.1)	1820.97 (7.1)	8 (47.1)	0.60
Scorpiones	1 (0.2)	290.14 (3.4)	1 (4.7)	0.09					1 (0.5)	251.95 (0.9)	1 (5.9)	0.08
Acari									1 (0.5)	0.12 (<0.0)	1 (5.9)	0.06
Opiliones					1 (0.3)	61.24 (0.3)	1 (5)	0.06				
NIA		535.8 (6.4)				3143.16 (12.7)				5416.74 (21.2)		
Total	433	8434.14			295	25801.96			220	25541.91		

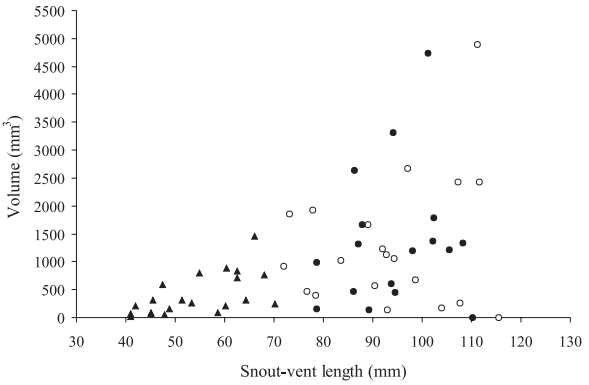

Fig. 2. Relation between the volume of prey in each stomach and the snout-vent length of *Teius oculatus* in Dom Feliciano, Rio Grande do Sul (triangles, juveniles; closed circles, females; open circles, males).

DISCUSSION

Our data indicate that *Teius oculatus* is a generalist and opportunist lizard that feeds on arthropods, mainly insects, which corroborates other studies about this species in other areas (ACOSTA *et al.*, 1991; ÁLVAREZ *et al.*, 1992; D'AGOSTINI *et al.*, 1997).

Data obtained from the lizards during their inactivity period revealed no food content, which indicates that during the period from May to September, when they are hibernating, they do not feed. Several lizards captured during the activity period had no food content; this is maybe because during this period the daily activities are restricted to sunny days, with no activity being recorded in cloudy or too windy days. The same was observed for this species in Porto Alegre region, Rio Grande do Sul, by BUJES (1998). That author has also observed a peculiar behavior for *T. oculatus*: many lizards were active at a given day and during the following day none was seen, even with similar climatic conditions in both days. Such observation partially explains the capture of specimens during the annual activity period with no food content and suggests that the lizards are not necessarily active and feeding every day.

Isoptera and Hymenoptera were found in large number in the diet of *T. oculatus* in comparison to the other prey categories. However, the volumetric analysis revealed that these items are less volumetrically important in the diet than they are numerically frequent, probably due to the small individual size of termites and ants. The high numerical importance of Isoptera in the diet of lizards is frequently associated to active foraging species because such insects, as a general rule, present aggregated and unpredictable distribution in the environment (HUEY & PIANKA, 1981; MAGNUSSON *et al.*, 1985). *Ameiva ameiva* (Linnaeus, 1758), an active forager teiid, also presents high numerical but low volumetric importance of Isoptera in its diet (ZALUAR & ROCHA, 2000; VITT & PIANKA, 2004) and probably captures those prey when they are aggregated in their nests since capturing these insects is less probable when they are dispersed in the environment (VITT & PIANKA, 2004). *Teius oculatus* actively forages digging the soil, turning rocks, surveying the litter and looking for prey using the tongue (BUJES, 1998).

Although Isoptera was an important part of the diet of juveniles and adult males, this food item was less consumed by females. During the activity period after hibernation, females of *T. oculatus* are generally gravid (pers. obs.). Since gravid females of lizards tend to reduce their movement rate in the environment to avoid the risks of predation (SHINE, 1980), the lower consumption of Isoptera by females, in comparison to adult males and juveniles, may be a result of such decrease on movements. On the other hand, due to the same reason, the consumption of more mobile prey such as ants could be increased and, in fact, ants were present in the diet of gravid females. Although ants were a numerically important item in the diet of *T. oculatus*, they do not seem to be a relevant item in the diet of the species, being only opportunistically consumed. In general, ants were little frequent, being present in the content of only seven specimens, and 86 (or 88.7%) of the 97 ants consumed were in the stomach of one single female (the only vitellogenic one among the three females containing this food item). We cannot determine at which extent the high consumption of ants by the only gravid female could be related to decrease on the movement rate due to pregnancy since gravid females tend to reduce their movements (SHINE, 1980), which could favor the consumption of highly mobile prey like ants. According to TEIXEIRA & GIOVANELLI (1999) predation of small prey such as ants and termites involves low expenditure of energy because the predator generally attacks these social insects when they are available in large amount. Besides the low energetic costs to capture gregarious insects, gravid females are more susceptible to predation and could get benefits from being less exposed to predators. Studies in laboratory with Australian scincids (SHINE, 1980) demonstrated that the escape capability of gravid females is reduced from 20% to 30% in comparison to conspecific males.

ACOSTA *et al.* (1991) mention as basic elements of the diet of *T. oculatus* in Argentina: Isoptera, Orthoptera (grasshoppers), Coleoptera and larvae (coleopteran, lepidopteran and dipteran). We did not find dipteran larvae in this study, however, coleopteran larvae were present in the stomachs of juveniles and adults of both sexes, and lepidopteran larvae were recorded in the stomachs of adult females. D'AGOSTINI *et al.* (1997) analyzed stomach contents of *T. oculatus* from some areas in Rio Grande do Sul and mentioned Coleoptera as the most frequent item in the diet, followed by Hymenoptera and Orthoptera.

The lower diversity of prey found in juvenile lizards in comparison to adult lizards may be partially explained by the difference in the mouth size of juveniles and adults (the smaller mouth size of juveniles establishes a feasible limit of prey size that could be consumed among the available assortment of prey, thus, limiting the prey types that could be ingested) and, possibly also by the comparatively high amount of termites that juveniles consume (76.9% of the total number of prey), which tends to restrict the generalization of their diet comparing to

adults. Furthermore, the data indicated a tendency to the increase of prey size consumed corresponding to the increase in the lizard size. That happens because juvenile lizards are limited to capture comparatively smaller prey (smaller volume) probably due to their size, whereas adult lizards may feed on a larger range of available prey size. Since each lizard size has an upper limit of prey size that could be consumed, and since this limit increases as the lizard size increases, the result is the observed tendency to consumption of larger prey as the SVL increases in *T. oculatus*.

The analysis of the importance value of each food item indicated Orthoptera as the most important category in the diet of *T. oculatus*. Even though it is not the most important in number of items, this prey category corresponded to the larger volume of prey ingested as well as it was the most frequently found. This record indicates that orthopteran insects are base elements in the diet of *T. oculatus* in Dom Feliciano.

The highest trophic similarity both numerical and volumetric was verified between adult males and juveniles. This higher similarity was probably due to their tendency to consume larger amount of isopterans and spiders than females did. Considering that *T. oculatus* hibernates and also that females are generally reproductive during the annual activity period of the species, it is possible that differences between the diet of females and that of adult males and juveniles partially reflect a possible decrease of movements, which generally happens with gravid females.

We concluded that the diet of *Teius oculatus* in Dom Feliciano region is essentially composed of arthropods, with predominance of orthopteran, isopteran and coleopteran species and that there is no difference between the diet of adult males and females. Prey size tends to increase as the size of *T. oculatus* increases, being the mean volume of prey ingested by adult lizards significantly higher than that ingested by juveniles.

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