ECOLOGY OF *MABUYA AGILIS* (SQUAMATA, SCINCIDAE) FROM A MONTANE ATLANTIC RAINFOREST AREA IN SOUTHEASTERN BRAZIL

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RESUMO. — Alguns aspectos da ecologia (principalmente reprodução e dieta) do lagarto scincídeo *Mabuya agilis* foram estudados com base em amostras mensais realizadas de dezembro de 1997 a abril de 1999 em uma área de floresta tropical serrana no estado do Espírito Santo, sudeste do Brasil. Dos 197 espécimes coletados, 82 eram machos, 110 eram fêmeas, e o resto não pôde ser corretamente sexado. Lagartos variaram em comprimento rostro-coacal de 30 a 96 mm e foram sexualmente dimórficos em tamanho, com fêmeas atingindo maiores tamanhos que machos. A menor fêmea grávida mediu 54.0 mm. O tamanho da ninhada para 49 fêmeas grávidas variou de 2 a 9 (média = 5.7) e esteve positiva e significativamente relacionado ao tamanho dos lagartos. As presas dominantes na dieta de *M. agilis* foram baratas, ortópteros e aranhas. A população de *M. agilis* aqui estudada diferiu de outras populações conspecíficas previamente estudadas em hábitats de «restinga» nos estados do Rio de Janeiro e Espírito Santo, sendo que os indivíduos crescem a tamanhos maiores e a fecundidade é mais alta, possivelmente devido a uma maior disponibilidade de alimento no hábitat de floresta tropical serrana.

Palavras-chave: lagarto, *Mabuya agilis,* reprodução, dieta, floresta Atlântica, Brasil.

ABSTRACT. — Some aspects of the ecology (mainly reproduction and diet) of the skink *Mabuya agilis* were studied based on monthly samples taken from December 1997 to April 1999 at a montane rainforest area in Espírito Santo state, southeastern Brazil. Of 197 collected specimens, 82 were males, 110 were females, and the rest could not be properly sexed. Lizards varied in snout-vent length (SVL) from 30 to 96 mm and were sexually dimorphic in size, with females growing larger than males. The smallest gravid female measured 54.0 mm in SVL. Litter size of 49 gravid females varied from 2 to 9 (mean= 5.7) and was positively and significantly related to lizard SVL. The dominant prey items in the diet of *M. agilis* were cockroaches, orthopterans and spiders. The population of *M. agilis* here studied differed from other conspecific populations previously studied in «restinga» habitats from Rio de Janeiro and Espírito Santo states in that individuals grow to larger sizes and fecundity is higher, possibly because of a higher food availability in the montane rainforest habitat.

Key-words: lizard, *Mabuya agilis,* reproduction, diet, Atlantic forest, Brazil.

INTRODUCTION

The ecology of neotropical skinks of the genus *Mabuya* was largely unknown until recently, and most of the ecological data on such animals was published after 1990 (Vitt, 1991; 1995; Vitt and Blackburn, 1991; Blackburn

and Vitt, 1992; Stevaux, 1993; Rocha and Vrcibradic, 1996; 1999; Vrcibradic and Rocha, 1995a,b; 1996; 1998a,b; 2002a,b; Vitt *et al.*, 1997; Dias and Lira-da-Silva, 1998; Vitt and Zani, 1998; Vrcibradic *et al.*, 1998; Mesquita *et al.*, 2000; Ramírez-Pinilla *et al.*, 2002; Rocha *et al.*, 2002a,b; in press). Most of the above studies have been carried out on a single locality. A comparison of the results of those studies among themselves evidence a few ecological aspects that are common among all species in general (such as active body temperatures), whereas other aspects may vary within species among different localities (such as food habits and brood size). For instance, the average body temperatures of *M. nigropunctata*, *M. frenata*, *M. agilis* and *M. macrorhyncha* are all similar, around 32-33ºC (Vitt and Blackburn, 1991; Rocha and Vrcibradic, 1996; Vitt *et al.*, 1997; Vrcibradic and Rocha, 1998a; 2002b), whereas different populations of *M. agilis* may show significant differences in brood size (Rocha *et al.*, 2002b). *Mabuya agilis* is a species found between latitudes 16º and 24º S in eastern Brazil (Vanzolini, 1988). It is common in montane Atlantic forest areas of Espírito Santo state, especially along forest edges and disturbed areas. Data on various ecological traits have been gathered from populations of *M. agilis* inhabiting «restinga» habitats in southeastern Brazil (Rocha and Vrcibradic, 1996; 1999; Vrcibradic and Rocha, 1995a; 1996; 2002a,b; Rocha *et al.*, in press). Restingas are open sand-dune habitats covered with scrubby vegetation, found along much of the Brazilian coast (Eiten, 1992), and represent a drier, more xeric environment compared to areas of Atlantic forest *sensu stricto*. We expect that populations of a given species inhabiting such different types of habitats would tend to show some differences in their ecology.

In the present study, we evaluate some aspects of the reproductive ecology and diet of *M. agilis* in an altered environment within a montane Atlantic forest area of Espírito Santo state, southeastern Brazil. We also compare our results with data on other conspecific populations from restinga habitats.

METHODS

The lizards were collected monthly from December 1997 to April 1999, in the area of Alto Rio Saltinho (19º 55' S; 40º 32' W; altitude 700-800 m), municipality of Santa Teresa, in Espírito Santo state, Southeastern Brazil. Collections were made mainly along the banks of a small stream near a coffee plantation. Mean monthly temperature in the region of Santa Teresa varies from 16.4ºC in July to 22.2ºC in February and total annual rainfall averages 1450 mm.

The lizards were captured manually between 08:00 and 18:00 h, fixed in 10% formalin solution and placed in 70% alcohol. In the laboratory, the snout-vent length (SVL, in mm) of each animal was measured with a vernier caliper (to the nearest 0.1 mm). All lizards were then opened for examination of the gonads and excision of the stomachs. For each reproductive female (*i.e.* those with implanted ova/embryos in the oviducts), the number of ova/embryos was counted to determine litter size. The removed stomachs were opened and their contents placed in petri dishes and prey were identified to Order level. Each prey item (except for unidentified fragments of arthropods) was measured along its longer axis with a vernier caliper (to the nearest 0.1 mm) and its wet mass was taken with an eletronic balance (precision of 0.001 g).

The sex-ratio of the *M. agilis* sample was statistically compared to 1:1 using the Chi-Square test (χ^2). Sexual size differences were assessed by comparing the SVLs between males and females

using One-Way Analysis of Variance (ANOVA), considering only the upper (larger) 50% of the animal sample for each sex (see Ramírez-Bautista *et al.*, 2000). The effect of female SVL on brood size was evaluated by Regression Analysis. The length of the longest prey in each stomach, or maximum prey length (prey items whose original length could not be estimated with reasonable confidence were not considered), was related to lizard SVL (with both variables log-transformed) using a Regression Analysis. Average maximum prey length was compared between sexes using ANOVA. Basic statistics are given throughout the text as mean ± one standard deviation.

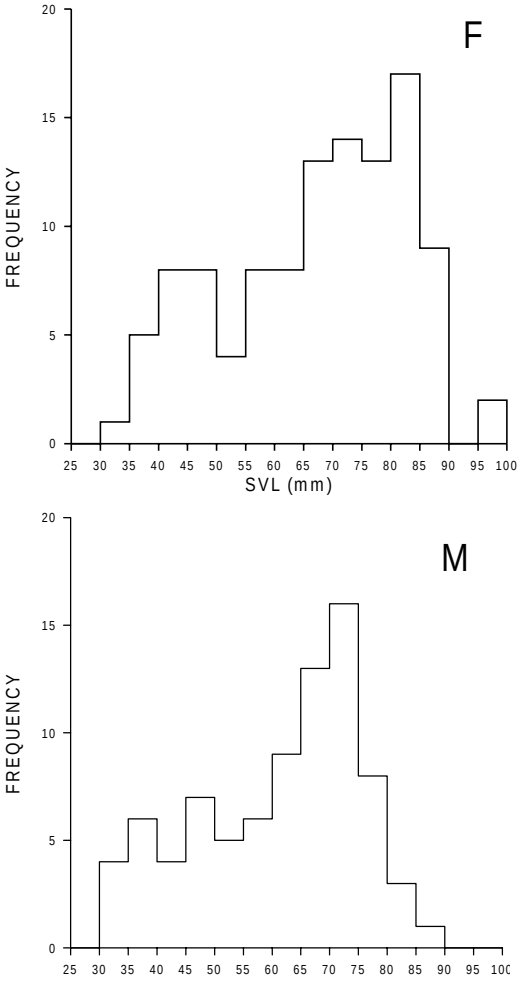

Fig. 1. Body size (SVL) distribution of males (M) and females (F) of *Mabuya agilis* from Santa Teresa, Espírito Santo, Brazil. Frequency is expressed as the number of lizards.

RESULTS

We collected 197 specimens of *M. agilis*, of which 82 were male, 110 were female and five whose sex could not be properly determined. The male:female ratio was 1:1.34, and differed statistically from equality (χ^2= 4.08; $p < 0.05$).

Lizard snout-vent length varied from 30 to 96 mm in the total sample (mean = 63.5 ± 16.0 mm) (Fig. 1). The 41 largest males averaged 72.7 ± 5.1 mm (range: 65-89 mm) in SVL and the 55 largest females 79.6 ± 6.2 mm (range: 70-96 mm). The sexes differed significantly in SVL, with females being larger (ANOVA; $F_{1,94}$ = 33.80; $p < 0.001$) (Fig. 1).

The smallest female with ova in the oviducts measured 54 mm in SVL. Litter size varied from two to nine (mean = 5.7 ± 1.6; N = 49) and was significantly related to female SVL (R^2 = 0.46; $p < 0.001$) (Fig. 2).

Only seven (3.6%) of the specimens had empty stomachs. The diet of *M. agilis* was dominated by arthropods, with no consumption of plant material (Table 1). The most important items in

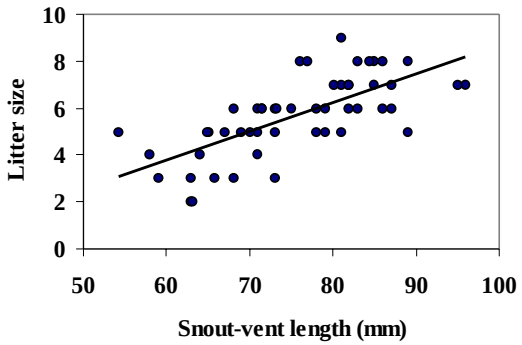

Fig. 2. Relationship between litter size and lizard SVL (y = 0.114x - 2.877; R^2 = 0.46, $p < 0.001$, N = 49) for female *Mabuya agilis* from Santa Teresa, Espírito Santo, Brazil.

PREY ITEMS	F. O.	%F.O.	N	%N	M (mg)	%M
INSECTA						
Collembola	1	0.5	1	0.2	27.6	0.1
Coleoptera (adults)	12	6.3	15	3.0	580.4	2.1
Coleoptera (larvae)	8	4.2	9	1.8	165.9	0.6
Diptera	3	1.6	5	1.0	27.6	0.1
Dyctioptera (=Blattodea)	107	56.3	152	30.5	10394.0	37.6
Hemiptera	2	1.0	3	0.6	82.9	0.3
Homoptera	2	1.0	2	0.4	55.3	0.2
Hymenoptera (Formicidae)	25	13.2	35	7.0	1078.1	3.9
Isoptera	12	6.3	50	10.0	387.0	1.4
Lepidoptera (adults)	1	0.5	1	0.2	248.8	0.9
Lepidoptera (larvae)	15	7.9	16	3.2	829.3	3.0
Odonata	1	0.5	1	0.2	55.3	0.2
Orthoptera	46	24.2	51	10.2	5501.1	19.9
Other larvae	1	0.5	1	0.2	11.6	0.04
Thysanoptera	2	1.0	2	0.4	304.1	1.1
ARACHNIDA						
Araneae	82	43.2	119	23.9	7187.3	26.0
Opilionida	1	0.5	1	0.2	12.4	0.05
MYRIAPODA						
Chilopoda	4	2.1	5	1.0	138.2	0.5
CRUSTACEA						
Isopoda	10	5.3	17	3.4	138.2	0.5
MOLLUSCA						
Gastropoda	1	0.5	1	0.2	8.3	0.03
OTHER ITEMS						
Mabuya shed skin	2	1	2	0.4	165.9	0.6
Snake skin	4	2.1	7	1.4	248.8	0.9
Squamatan scales	2	1	2	0.4	11.1	0.04
Miscellaneous					37.3	0.1
Total			**498**		**27643.6**	

Table 1. Representativity of prey categories in the diet of *Mabuya agilis* from Santa Teresa, Brazil. F.O.= frequency of ocurrence; N = prey number; M = prey mass.

the diet were cockroaches, spiders and orthopterans (Table 1).

Maximum prey length varied from 2.0 to 29.1 mm (mean = 13.2 ± 6.0 mm; N = 75) and did not differ between sexes (ANOVA; $F_{1,73} = 1.03$, $p = 0.31$). There was a positive and significant relationship between maximum prey length and lizard SVL ($R^2 = 0.13$; $p < 0.01$; N = 75).

DISCUSSION

We observed a female-biased sex ratio in our sample, though this may not necessarily mean that the population of *M. agilis* from our study area has a greater proportion of females than males. It is possible that, when gravid, female *M. agilis* may bask for longer periods and/or be physically encumbered by the extra mass of the litter (see Shine, 1980). Thus, they could be more easily found and/or captured than males during the pregnancy period, which would result in a greater representativity of females in the sample. In another population from a restinga habitat (Grumari) in Rio de Janeiro state the sex ratio was close to 1:1 (Vrcibradic and Rocha, 2002b). In the latter study, unlike the present one, the animals were collected with air rifles and not by hand, which further suggests that collecting methods may have an influenece on the sex ratio of samples. The population of *M. agilis* from Santa Teresa is sexually dimorphic, with females reaching larger sizes than males. This has been also reported for other species/populations of neotropical congeners (e.g. Vitt and Blackburn, 1983; 1991; Stevaux, 1993; Vrcibradic and Rocha, 1998b; Rocha and Vrcibradic, 1999), and is probably the rule for the New World *Mabuya*. It is also worth noting that the animals (both males and females) of the present population grow larger than those of other conspecific populations studied in restinga habitats (Van Sluys *et al.*, 1997; Rocha and Vrcibradic, 1999; Vrcibradic and Rocha, 2002b), though we cannot say if this is due to genetic or environmental factors, or to both (see Rocha *et al.*, 2002b).
Litter size was also relatively large among *M. agilis* from Santa Teresa, compared to those of conspecific populations studied at restinga habitats (Rocha and Vrcibradic, 1999; Rocha *et al.*, 2002b). This is not unexpected, due to the direct effect of female body size on clutch/litter size observed in many reptiles (see King, 2000). It is possible that differences in resource (i.e. food) availability between the more humid montane rainforest of Santa Teresa and the drier, more water-limited restinga environment may partially explain the greater body size and fecundity of *M. agilis* from the former area (see Rocha *et al.*, 2002b). However, this could only be evaluated through a comparison of relative arthropod availability between the two areas.

The *M. agilis* of Santa Teresa prey on a great variety of arthropods, though their diet is weighted towards cockroaches, spiders and orthoperans. Those are apparently common arthropods in the area, within the *M. agilis* microhabitat (numerous grasshoppers and spiders were usually seen among the grass during attempts to capture the lizards), and constitute relatively large and soft-bodied prey items. The combination of relatively large size, softness and abundance makes those arthropods highly energetically rewarding as preys, which may explain their dominance in the diet of the skinks. Studies on other *Mabuya* species/populations in various different habitats in Brazil also show that spiders, orthopterans and cockroaches tend to be among the most important items in their diets (Vanzolini and Rebouças-Spieker, 1973; Vitt and Blackburn, 1991; Vitt, 1995; Vrcibradic and Rocha, 1996; 1998a; 2002b; Vitt *et*

al., 1997; Dias and Lira-da-Silva, 1998; Rocha *et al*., in press). Those studies also show that, as in the *M. agilis* population from Santa Teresa, plant material is seldom if ever consumed by those lizards. Thus, the dietary trends above seem to apply to Neotropical *Mabuya* in general, with geographic region and/or type of habitat notwithstanding. Unfortunately, there is a lack of data on the diets of other lizards occurring sympatrically with *M. agilis* in Santa Teresa to compare with those of the present work. The only informations available are from a study of Teixeira and Fonseca (2003) on some ecological aspects of the gymnophthalmid *Leposoma scincoides*. This lizard´s diet at Santa Teresa is composed of a variety of small arthropods, with isopods and spiders being the most important items. However, *L. scincoides* is a much smaller lizard than *M. agilis* and probably occupies a fairly different ecological niche, which makes comparisons between these two species less meaningful.

Mean length of prey consumed by *M. agilis* of Santa Teresa was similar to that reported for congeners studied in other Brazilian regions (Vitt, 1991; Vitt *et al.*, 1997; Vitt and Zani, 1998). The significant positive correlation between prey size and lizard SVL found in *M. agilis* is not surprising, since lizards are usually gape-limited generalist predators and will prey on practically any palatable organism that can fit in their jaws (*e.g.* Toft, 1985). Moreover, as lizards grow larger, they will tend to prey less often on relatively small items, since they provide a low net energy gain, which does not compensate for the costs of their searching and capture (*e.g.* Simon, 1976; Dickman, 1988). An exception to the latter case is when small items (such as colonial insects) are numerous and spatially concentrated, which translates into low search and ingestion costs (e.g. Simbotwe and Garber, 1979), and lizards which specialize in such items usually do not show ontogenetic variations in mean prey size (*e.g.* Teixeira-Filho and Rocha, 2003). Even though species of *Mabuya* are normally generalist feeders, they may take advantage of spatially concentrated prey such as termites when those are locally abundant (Simbotwe and Garber, 1979; Vrcibradic and Rocha, 1995; 1998a; Wymann and Whiting, 2002). Termites were not as frequent and important in the diet of *M. agilis* from Santa Teresa as they were in the diets of other conspecific populations inhabiting restinga habitats (Vrcibradic and Rocha, 1995; 1996; 2002b). This probably reflects a lower abundance of those insects in the forest edge habitat of Santa Teresa, compared to the restingas and/or that other more energetically rewarding preys were available in greater quantities in the former habitat.

The low frequency of empty stomachs (3.6%) indicate that *M. agilis* from Santa Teresa are generally in «positive energy balance» (see Huey *et al*., 2001). Thus, food does not seem to be limited for the skinks at the study area. The apparent abundance of prey may account for this species occurring at high densities there, as well as growing to large sizes and producing large litters compared to conspecific populations in restinga areas. On the other hand, a similarly low frequency of empty stomachs (3.5%) was reported for a conspecific population in a restinga habitat (Vrcibradic and Rocha, 2002b), which suggests that food limitation may not actually be a problem for those skinks in restingas. There is, thus, the possibility that the interpopulational differences mentioned above may be more a matter of food quality than of food quantity. It is also worth pointing out that in restinga habitats *M. agilis* is frequently found in sympatry with a congener, *M. macrorhyncha*, whereas at Santa Teresa it is apparently the only *Mabuya* species present. The fact that *M. agilis* is free from

competition with a closely related species in our study area could partially explain its attaining greater sizes and greater fecundity compared to restinga populations. Nevertheless, Pianka (1986) observed the opposite trend for the African species *M. spilogaster*: broods of this species were smaller in allopatry than they were in sympatry with the congener *M. striata*. Thus, the causes for the differences in body size and fecundity between the Santa Teresa population of *M. agilis* and conspecific populations from restinga habitats may be more complex than they appear.

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