THE TERRESTRIAL REPTILE FAUNA OF THE ABROLHOS ARCHIPELAGO: SPECIES LIST AND ECOLOGICAL ASPECTS

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ABSTRACT

We have studied the terrestrial reptile fauna of the Abrolhos Archipelago (a group of five islands located ca. 70 km off the southern coast of the State of Bahia, Brazil) and analyze here some of its ecological aspects such as diet, thermal ecology, activity, and some reproductive parameters. Three lizards comprise the archipelago's terrestrial reptile fauna: *Tropidurus torquatus* (Tropiduridae), *Mabuya agilis* (Scincidae), and *Hemidactylus mabouia* (Gekkonidae). The first two are diurnal and the latter is crepuscular/nocturnal (initiating activity at ca. 17:30). The activity period of *T. torquatus* extended from 5:30 to 18:30 h. Mean field body temperatures of active *T. torquatus*, *M. agilis*, and *H. mabouia* were, respectively, 34.0 ± 3.7°C (range 23.8-38.0°C; N = 75), 34.5 ± 2.2°C (range 30.8-37.0°C; N = 6), and 26.3 ± 1.1°C (range 24.8-28.0°C; N = 8). The predominant prey items in the diet of *T. torquatus* were ants, coleopterans, and hemipterans. In the diet of *M. agilis*, coleopterans were the most frequent prey items. For *H. mabouia*, the most important dietary items were orthopterans. Clutch size of *T. torquatus* averaged 4.1 ± 1.1 (range 2-6; N = 15) and was significantly related to female size (R^2 = 0.618; p = 0.001; N = 15). Clutch size for *H. mabouia* was fixed (two) and mean litter size of the viviparous *M. agilis* was 3.3 ± 0.6 (range 3-4; N = 3). *Tropidurus torquatus* and *H. mabouia* deposit their eggs under rocks in the study area, with the former burying them but not the latter; in both species, more than one female often oviposit under the same rock.

Key words: Abrolhos Archipelago, Lacertilia, *Tropidurus torquatus*, *Mabuya agilis*, *Hemidactylus mabouia*, ecological aspects.

RESUMO

A fauna de répteis terrestres do Arquipélago de Abrolhos: lista de espécies e aspectos ecológicos

Estudamos a fauna de répteis terrestre do Arquipélago de Abrolhos (um conjunto de cinco ilhas localizadas a 70 km da costa sul do Estado da Bahia, Brasil) e analisamos alguns aspectos da ecologia das espécies, como a dieta, ecologia termal, atividade e alguns parâmetros reprodutivos. A fauna de répteis do arquipélago compreende três lagartos: *Tropidurus torquatus* (Tropiduridae), *Mabuya agilis* (Scincidae) e *Hemidactylus mabouia* (Gekkonidae). Os dois primeiros são diurnos e o último é crepuscular/noturno (iniciando atividade às 17h30). O período de atividade de *T. torquatus* se estendeu de 5h30 a 18h30. As temperaturas corpóreas médias em atividade de *T. torquatus*, *M. agilis* e *H. mabouia* foram, respectivamente, de 34,0 ± 3.7°C (amplitude 23,8-38,0°C; N = 75), 34,5 ± 2,2°C (amplitude 30,8-37,0°C; N = 6) e 26,3 ± 1,1°C (amplitude 24,8-28,0°C; N = 8). Os itens alimentares predominantes na dieta de *T. torquatus* foram formigas, coleópteros e hemípteros. Na dieta de *M. agilis*, coleópteros foram os itens mais freqüentes. Para *H. mabouia*, os itens alimentares mais importantes na dieta foram

ortópteros. O tamanho médio da ninhada de *T. torquatus* foi de 4,1 ± 1,1 (amplitude 2-6; N = 15) e estava significativamente relacionado com o tamanho da fêmea (R^2 = 0,618; p = 0,001; N = 15). O número de ovos para *H. mabouia* foi fixo (dois) e o tamanho médio da ninhada para a espécie vivípara *M. agilis* foi de 3,3 ± 0,6 (amplitude 3-4; N = 3). *Tropidurus torquatus* e *H. mabouia* depositam seus ovos sob rochas na área estudada, sendo que o primeiro enterra seus ovos e o segundo não; em ambas as espécies, mais de uma fêmea freqüentemente utiliza a mesma rocha para oviposição.

Palavras-chave: Arquipélago de Abrolhos, Lacertilia, *Tropidurus torquatus*, *Mabuya agilis*, *Hemidactylus mabouia*, aspectos ecológicos.

INTRODUCTION

The fauna and flora of oceanic islands are generally unique because for most species gene flow is severely restricted or non-existent. As a result, community equilibria of such islands are relatively fragile and local environmental conservation depends on considerable knowledge of species composition and the range of the several ecological aspects on which they depend. The mere presence of humans may cause negative effects, especially when introduction of exotic species occurs, in which case the consequences may be grave for the insular community, possibly affecting population densities and sometimes resulting in extinction (Case & Bolger, 1991; North *et al*., 1993). For instance, on some islands, such as Round Island in Mauritius, the introduction of rabbits *(Oryctolagus cuniculus*) and goats (*Capra hircus*) brought about severe degradation of the soil and vegetation due to browsing and grazing, and ultimately population reductions and extinctions of plants and reptiles (North *et al*., 1993).

The Abrolhos Archipelago is a set of five oceanic islands located approximately 70 km off the southern coast of Bahia. On account of the high marine biodiversity of the coral reefs around the archipelago, the area has been converted into a National Marine Park. The largest of the islands (Santa Barbara) is inhabited by settlers, who introduced goats, rats (*Rattus rattus*) and, recently (1996), cats (*Felis domestica*). Although until now no study has evaluated the impact of these introduced species, their presence has presumably affected the indigenous terrestrial species negatively in some ways. Although continuous efforts are being made by local authorities to the archipelago, knowledge of the indigenous community composition and of the ecology of the respective species potentially benefits management and conservation of the insular community.

In this study we present data on the terrestrial reptiles of Abrolhos Archipelago and analyze some aspects of their ecology, such as food habits, thermal ecology, distribution, and some reproductive parameters.

MATERIAL AND METHODS

Study area

The Abrolhos Archipelago (17°58'S, 38°42'W) is situated off the coast of southern Bahia, northeastern Brazil, approximately 70 km from the continent. It is composed of five islands: Santa Bárbara, Redonda, Siriba, Sueste, and Guarita. Annual mean temperature varies from 25 to 27°C and annual rainfall averages 1030 mm (Estação Climatológica Rádio Farol de Abrolhos, Marinha do Brasil). Area rainfall is seasonal, with most occurring in October, December, and May; the other months are comparatively dry (Dutra, 2000). Santa Bárbara is the largest island (approximately 1.5 km long and 300 m wide) and the only inhabited one (about 20 people, mostly Navy personnel, and their families). The island is characterized by two major landscapes: i) a rocky area dominated by Cyperaceae with mean height above ground of ca. 1 m, and ii) an area covered with sparse herbaceous vegetation and/or exposed rock. Except for Guarita Island, the smallest in the archipelago and composed only of rocks with no vegetation, all the others are formed of boulders with sparse herbaceous vegetation or even, in some cases (i.e., Sueste, Redonda, and Siriba Islands), covered by dense herbaceous vegetation (Plano de Manejo, 1991; Dutra, 2000).

Collecting methods and analyses

We made reptile surveys of the archipelago islands on seven occasions (August 1994, March 1995, June 1995, October 1995, April 1996, March 1997, and April 1997), totalling 18 days of field work. On each occasion, diurnal and nocturnal searches were made for reptiles. Collections of individuals for analysis of diet, thermal ecology, and clutch size were made on Santa Bárbara for *T. torquatus* and *H. mabouia*, and on Sueste for *M. agilis*.

Lizards were collected with rubber bands, noose, or by hand. No later than 30 sec after collection body temperatures were taken, as well as microhabitat temperatures (substrate and air 1 cm above substrate) on the exact capture site, using a cloacal Schultheis thermometer (to the nearest 0.2°C). We performed regression analysis (Zar, 1999) of lizard body temperature on the temperatures recorded in the microhabitat (substrate and air) in order to evaluate the effect of these variables on lizard body temperature. We used multiple regression to analyze the additive effect of each environmental variable after factoring out the effect of the other. These analyses were performed only for those species whose sample sizes were sufficient. Each lizard was weighed in the field (to the nearest 0.2 g) using a Pesola® dynamometer and measured snout-vent length (SVL) with calipers (to the nearest 0.1 mm) prior to fixation in 10% formalin. Lizards were dissected and their stomach contents analyzed qualitatively and quantitatively. Animal prey (mostly arthropods) were identified according to Order. Unidentified arthropod remains (i.e., fragments of exoskeleton, legs, and wings) were grouped in a separate category: miscellaneous. Plant items were categorized as leaves, flowers, fruits (or seeds), and unidentified parts.

The clutch or litter size of each lizard species was estimated by averaging the number of mature follicles, eggs, or embryos of gravid females. We also checked for the presence of lizard eggs under rocks, digging in the soil to uncover buried eggs.

Sexual differences in body size (SVL and mass) were tested for *T. torquatus* (the only species whose sample size allowed this analysis) by One-way Variance Analysis (ANOVA; Zar, 1999). Descriptive statistics are presented in the text as mean ± 1 standard deviation (SD).

RESULTS AND DISCUSSION

Species composition and occurrence on islands

We found only three reptile species living on the islands of the Abrolhos Archipelago, all of them lizards: the tropidurid *Tropidurus torquatus*, the scincid *Mabuya agilis*, and the gekkonid *Hemidactylus mabouia*. The *Mabuya* species occurring on the archipelago had been previously referred to as *M. heathi* (Dutra & Vrcibradic, 1998), but preliminary results of molecular analyses indicate that those populations may be conspecific with mainland *M. agilis* (P. Mausfeld, unpubl. data); thus, we provisionally refer the Abrolhos species to *M. agilis*, pending a more comprehensive molecular analysis of Brazilian *Mabuya*. Two of the lizard species were diurnal (*T. torquatus* and *M. agilis*) and one was crepuscular/nocturnal (*H. mabouia*). These lizard species were distributed differently on the islands of the archipelago. *Tropidurus torquatus* was the most widely distributed, being found on all islands but Guarita. *Mabuya agilis* occurs on Siriba, Sueste, and Redonda, and *H. mabouia* was found on Santa Barbara, Siriba, and Sueste. None of the species found is endemic to the archipelago: *T. torquatus* and *M. agilis* are widely distributed along the coasts of Rio de Janeiro, Espírito Santo, and southern Bahia (Rocha, 2000), and *H. mabouia*, a species of African origin, occurs throughout much of Africa, Madagascar, tropical America, and the Caribbean (Kluge, 1969; Ávila-Pires, 1995). The occurrence of these continental species on the archipelago suggests that they may have arrived in a relatively recent past. However, at this point, we are not able to suggest whether they were introduced or arrived as a result of dispersal (though we believe *H. mabouia* must have been accidentally introduced by man).

Mean SVL and mass of each lizard species from Abrolhos are presented in Table 1. Except for two immature individuals of *T. torquatus* (SVLs of 42 and 62 mm and masses of 3.5 and 8.5 g, respectively), all others were adult-sized. Adult male *T. torquatus* averaged larger SVL and mass (92.0 ± 8.5 mm and 28.6 ± 7.0 g, respectively; N = 35) than adult females (79.5 ± 4.6 mm and 18.0 ± 3.4 g, respectively; N = 42) (ANOVA SVL: $F_{1,75} = 67.85$; $p < 0.001$; ANOVA mass: $F_{1,75} = 75.84$; $p < 0.001$). *Tropidurus torquatus* from the Abrolhos

Archipelago apparently grow larger than their conspecifics from mainland coastal populations (Rocha & Bergallo, 1994; Dutra, 2000; Fialho *et al*., 2000), and it would be interesting to test to what degree genetic and ecological factors are responsible for this difference.

TABLE 1

Snout-vent length (in mm) and mass (in g) of the three lizard species occurring in the Archipelago of Abrolhos, BA. For each variable, we give sample size (N), range, mean plus one standard deviation and coeficient of variation (CV).

Species	N	Range	Mean ± SD	CV
T. torquatus				
SVL	82	70-103	84.8 ± 9.3	0.109
Mass	82	11.0-42.0	22.5 ± 7.7	0.343
M. agilis				
SVL	11	56-82	68.9 ± 9.0	0.131
Mass	6	7.5-12.0	8.9 ± 1.7	0.191
H. mabouia				
SVL	10	44-64	57.1 ± 5.7	0.100
Mass	6	3.5-5.5	4.3 ± 0.7	0.163

Activity and thermal ecology

The activity period of *T. torquatus* extended from sunrise to sunset (5:30-18:30 h), when individuals retreated to shelters. Field observations showed that, when inactive, *T. torquatus* usually remain hidden under stones, partially buried in the earth. *Tropidurus torquatus* initiate activity approximately at 5:30 h when the first individuals emerge from their shelter and begin to sunbathe on rocks (the first sun rays hits the rocks at approximately 5:40 h). Most individuals bask until 7:15-7:30 h, when their body temperatures reach up to 33-34°C, and then descend to the ground and initiate foraging among the herbaceous vegetation. At 8:00-9:00 h, body temperatures of individuals are approximately 35-37°C and social interactions such as territorial defence and copulation attempts occur. In this same period many agonistic interactions between males were observed. After 10:00 h, individuals begin to retreat to shelter and by mid-day most remain under rocks, due to the high temperatures in the microhabitat (ground temperatures reach 48-50°C). Social interactions were no longer observed during this period.

Mean body temperature of active *T. torquatus* was 34.0 ± 3.7°C (N = 75) with a range of 23.8-38.0°C. The body temperature was significantly related to air ($F = 95.55$; $R^2 = 0.75$; $p < 0.001$; N = 75) and substrate temperatures ($F = 82.19$; $R^2 = 0.74$; $p < 0.001$; N = 71) (Fig. 2); it was also significantly correlated with the interaction of air and substrate temperatures ($F = 55.89$; $R^2 = 0.62$; $p < 0.001$; N = 71). Body temperatures of *T. torquatus* were not significantly related to SVL ($F = 0.921$; $R^2 = 0.112$; $p = 0.340$; N = 75).

Like *T. torquatus*, *Mabuya agilis* is only active diurnally, with no individuals sighted after 16:00 h. Mean body temperature of active *M. agilis* was 34.5 ± 2.2°C (range 30.8-37.0°C; N = 6). *Hemidactylus mabouia* showed exclusively crepuscular/nocturnal activity, which began just after sunset and the start of the dark period (after 17:30 h). At that moment, individuals usually leave shelter and go to the side or top of rocks, where they remain ambushing potential prey. The mean body temperature of active *H. mabouia* was 26.3 ± 1.1°C. (N = 8) with a range of 24.8-28.0 °C, approaching the values found for a continental population of this gekkonid in northeast Brazil (e.g., Vitt, 1995).

Existing data on thermal ecology for coastal restinga populations of *T. torquatus* indicate that the mean body temperature in activity observed for the population of Abrolhos is comparatively lower (at least 1.3°C on average) than for those found in the other areas (e.g., Barra de Maricá restinga in Rio de Janeiro State, x = 35.3 ± 2.6°C –

Teixeira-Filho *et al*., 1996; Restinga of Linhares in Espírito Santo State, x = 35.6 ± 1.9°C – Bergallo & Rocha, 1993; Gandolfi & Rocha, 1998). Further study is required to determine whether or not the observed differences in mean body temperature in activity result from the continuous high rate of wind in the insular environment. On the other hand, mean body temperature of active *M. agilis* was relatively high compared to other populations of the same species in the restingas of Linhares (x = 31.4 ± 3.1°C – Vrcibradic & Rocha, 1995) and Barra de Maricá (x = 32.5 ± 3.0°C – Rocha & Vrcibradic, 1996) and probably reflects our small sample size for Abrolhos.

Diet

The diets of *T. torquatus*, *M. agilis*, and *H. mabouia* at the Archipelago of Abrolhos are summarized in Table 2. For *T. torquatus*, items from 10 different food categories were consumed and the numerically predominant prey was hymenopterans (particularly Formicidae – 60%), coleopterans (20%), and hemipterans (8%) (Table 2). Together, these three categories comprised most (88.5%) of the diet of *T. torquatus*. Ants, the most frequent item, were present in all *T. torquatus* stomachs analyzed. In the diet of the scincid *M. agilis*, Acarina (38%), homopterans (27%), and coleopterans (13%) predominated numerically, with coleopterans being the most frequent prey items (found in 82% of the stomachs; Table 2). For *H. mabouia* the most important items numerically were orthopterans (29%), followed by coleopterans, homopterans, lepidopteran larvae, and Aranae (12% each), whereas the most frequently consumed items were orthopterans and spiders (Table 2).

TABLE 2

Diet of the three reptile species which occur at the Abrolhos Archipelago (*Tropidurus torquatus, Mabuya agilis,* and *Hemidactylus mabouia*). Values are presented in terms of number of prey (N) and frequency of occurrence in the stomachs (F). Numbers in parenthesis are percentages.

Items	*T. torquatus* (n = 20)		*M. agilis* (n = 11)		*H. mabouia* (n = 9)	
	N (%)	F (%)	N (%)	F (%)	N (%)	F (%)
Insecta						
Blattaria	–	–	01 (0.6)	9.0	–	–
Coleoptera	309 (20.2)	95.0	21 (13.0)	81.8	02 (11.8)	11.0
Diptera	18 (1.2)	25.0	01 (0.6)	9.0	–	–
Hemiptera	127 (8.3)	90.0	–	–	–	–
Homoptera	96 (6.3)	75.0	43 (26.7)	63.6	02 (11.8)	11.0
Hymenoptera (Formicidae)	924 (60.3)	100.0	01 (0.6)	9.0	–	–
Lepidoptera	49 (3.2)	90.0	–	–	02 (11.8)	11.0
Lv. coleoptera	–	–	–	–	01 (5.9)	11.0
Lv. lepidoptera	–	–	12 (7.4)	54.5	02 (11.8)	11.0
Odonata	01 (0.1)	5.0	–	–	–	–
Orthoptera	–	–	07 (4.3)	45.5	05 (29.4)	33.0
Pupa	–	–	01 (0.6)	9.0	–	–
Arachnida						
Acarina	01 (0.1)	5.0	62 (38.3)	18.2	–	–
Aranae	06 (0.4)	30.0	12 (7.4)	63.6	02 (11.8)	22.0
Chilopoda	–	–	01 (0.6)	9.0	–	–
Plant matter	–	100.0	–	18.2	–	–
Shed skin remains	–	–	–	9.0	–	–
Total	1,532 (100.0)	–	162 (100.0)	–	17 (100.0)	–

Plant material consumed by *T. torquatus* included mostly flowers and leaves, whereas for *M. agilis* it consisted only of fruits and seeds. The categories of food items consumed by *T. torquatus* in Abrolhos include most of those consumed also by some continental populations of coastal restingas (Linhares – Rocha & Bergallo, 1994; Barra de Maricá – Fialho *et al.*, 2000).

In the diet of *M. agilis*, the number of mites (Acarina) ingested was remarkable, but this prey type was found in only two stomachs. It is probable that mites were eaten accidentally by the skinks as they preyed on other arthropods, since the small size of mites presumably would not make them an energetically advantageous prey. In general, the scincid consumed a larger spectrum of food item categories (13) compared to the other lizard species of the archipelago, with no marked dominance of any food item. The consumption of a large spectrum of prey types including both relatively sedentary and highly mobile preys has also been found in continental populations of *M. agilis*, which has been argued to reflect a mixed (active-ambush) foraging strategy of this lizard (Vrcibradic & Rocha, 1995, 1996). The diet of the gekkonid *H. mabouia* included much nocturnal prey like lepidopterans and orthopterans, as expected for a nocturnal lizard.

Reproductive traits

Mean clutch size for *T. torquatus* was 4.1 ± 1.1 (range 2-6; N = 15) and was significantly related to female SVL ($R^2 = 0.618$; $p = 0.001$; N = 15). Clutch size for *H. mabouia* was two in all cases (it is, in general, a fixed number in the species; e.g., Vitt, 1986). Litter size of the viviparous *M. agilis* was 3.3 ± 0.6 (range 3-4; N = 3). The three reproductive *M. agilis* (collected in April 1997) all contained oviductal ova in stage 3 of Rocha & Vrcibradic (1999). Of 619 cavities examined by us under individual stones, 23 (3.7%) contained evidence of having been used by *T. torquatus* as oviposition sites (a total of 21 intact eggs and 262 empty shells were found). Of the 21 eggs, 15 (plus 25 empty shells) were under the same rock. These data indicate that sites beneath rocks are used for oviposition by several different females, since a maximum of about six eggs are deposited at a time.

On one occasion we found three eggs (dimensions: 9.6 × 8.3, 9.8 × 8.9, and 9.9 × 9.1 mm) of *Hemidactylus mabouia* under a rock 30 cm in diameter. Under another rock (42 cm in diameter) there were four eggs of *H. mabouia*. The gekkonid's eggs, unlike those of *T. torquatus*, were not buried. These observations indicate that the microhabitat under the rocks is also used by *H. mabouia* as an oviposition site. Since *H. mabouia* produces a clutch of only two eggs at a time, these observations also suggest that more than one female may use the same site for oviposition. Evidences of communal nesting have been previously reported for *H. mabouia* in both Africa (FitzSimons, 1943) and South America (Bock, 1996).

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