



## Thermal ecology, activity pattern, habitat, and microhabitats used by the skink *Mabuya arajara* (Squamata: Scincidae) in the Araripe Plateau, northeastern Brazil

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### ABSTRACT

We evaluated the activity period, thermal ecology, habitats, and preference for microhabitats of the skink *Mabuya arajara* in a humid forest environment on the slope of the Araripe Plateau, Brazil. A total of 283 lizards were observed. The lizards were found to be diurnally active (unimodal type pattern), with peak activity during the hottest hours of the day (1100 to 1200). About habitat use, the majority of individuals (73.8% N = 209) were recorded in the narrow transitional area, in the edges of the forest; while 26.4% of individuals were observed in open areas and no observations were made in dense forest. Seven different types of microhabitats were used, with fallen palm leaves (Arecaceae) being the preferred (47.7% N = 135). Considering all lizards, microhabitat niche breadth was 3.27. Males and females presented a high overlap (0.95) in microhabitat use. The average  $T_c$  recorded for *M. arajara* was  $32.06 \pm 2.72^\circ\text{C}$ . Body size (SVL) did not influence body temperature ( $F = 0.51$ ,  $P = > 0.05$ ). Most of the animals were observed with their bodies completely exposed (67.84%,  $N = 192$ ), 18.37% ( $N = 52$ ) were semi-exposed and 13.79% ( $N = 39$ ) were in shelters. Among animals with some degree of sunlight exposure, 57.59% ( $N = 163$ ) were in shadows, 25.10% ( $N = 71$ ) were under sunlight filtered by vegetation, and 17.31% ( $N = 49$ ) were under direct sunlight. A review of the ecology of *Mabuya* spp. shows that several features appear to be conserved among members of the genus.

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## Introduction

Brazil harbours many species of skink in the genus *Mabuya* (now considered multiple genera by Hedges and Conn 2012; but see Methods section), and the number of studies focusing on aspects of the natural history and ecology of these lizards has increased

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considerably in recent years (e.g. Rebouças-Spieker 1974; Vitt 1991; Vrcibradic and Rocha 2002, 2011; Caicedo-Portilla et al. 2010; Ribeiro et al. 2015). These morphologically similar skinks inhabit areas of Caatinga (Vanzolini et al. 1980; Rodrigues 2000; Ribeiro et al. 2012a), Savanna (Vitt 1991), Atlantic forest (Teixeira et al. 2003), Amazon rainforest (Ávila-Pires 1995; Vitt et al. 1997; Vitt and Zani 1998), and Restingas (Araújo 1991). However, there is considerable variation in microhabitat preference (Vrcibradic and Rocha 1996, 1998), ranging from strictly terrestrial species (e.g. *M. heathi*, Vitt 1995), species with different degrees of arboreality (e.g. *M. nigropunctata*, Vanzolini and Rebouças-Spieker 1976 [= *M. bistriata*]; Vitt et al. 1997), and saxicolous/arboreal species (*M. frenata*, Vitt 1991; Vrcibradic and Rocha 1998), including primarily bromeliculous species such as *M. macrorhyncha* (Vanzolini and Rebouças-Spieker 1976; Vrcibradic and Rocha 1996) and *M. agmosticha* (Rodrigues 2000; Ribeiro 2012).

Despite the use of diverse habitats and microhabitats, the effect of phylogeny seems to act strongly on the ecological aspects and natural history, and members of the genus *Mabuya* demonstrate similarities in aspects such as reproduction, sexual dimorphism, and, on a smaller scale, diet (Vrcibradic and Rocha 1998, 2011; Ribeiro et al. 2015). Other aspects that are phylogenetically conservative in *Mabuya* lizards relate to activity patterns, which are predominantly unimodal (e.g. Vrcibradic and Rocha 1998), with a few exceptions (see Vrcibradic and Rocha 1998; Caicedo-Portilla et al. 2010). Another highly conservative aspect is the thermal ecology, being that corporal temperature was very similar among close related species (Vitt and Blackburn 1991; Ávila-Pires 1995; Vrcibradic and Rocha 1996, 2004, 2005), with a few exceptions usually related with high altitude populations, like *M. dorsivittata* in southeastern Brazil (Vrcibradic et al. 2004; Rocha et al. 2009b).

*Mabuya arajara* is a skink distributed in northeastern Brazil, and for nearly three decades it was considered as endemic for the Araripe Plateau (Rebouças-Spieker 1981; Ribeiro et al. 2008). Recently, Roberto and Loebmann (2010) recorded the species in other mesic environments (Brejós-de-altitude) of the northern part of Ceará State and in Piauí State (Roberto et al. 2012), and Ribeiro et al. (2012a) recorded this species in savanna environments at the top of the Araripe Plateau (800–900 m elevation) and in Caatinga (semi-arid matrix) at elevations above 300 m, also in the Araripe region. *Mabuya arajara* is morphologically similar to *M. nigropunctata* and widely distributed in the forested regions of South America (Miralles and Carranza 2010). Both species are grouped within the *arajara/nigropunctata* complex, characterised by species with a large body size, paired frontoparietals, and no vertebral stripes (see Rodrigues 2000). *Mabuya nigropunctata* has been well studied concerning different aspects of its natural history and ecology (Vitt and Blackburn 1991; Ávila-Pires 1995; Vitt et al. 1997; Vitt and Zani 1998). In addition, there are a few recent ecological studies about *M. arajara* regarding aspects of reproduction, sexual dimorphism, diet (Roberto and Loebmann 2010; Ribeiro et al. 2015), defensive behaviour (Ribeiro et al. 2010), and pulmonary parasitism (Ribeiro et al. 2012b; Cabral et al. 2018).

Thus, we studied the thermal ecology and several aspects of the natural history of *M. arajara* and, when possible, we compare these aspects with other congeners. The main questions that guided our study were: 1) What are the body temperature ( $T_c$ ) averages in active male and female individuals of *M. arajara*, respectively? 2) To what extent does heat source (air temperature and substrate) affect the body temperature of the lizards? 3) Does the body size of lizards influence their body temperature? 4) What are

the habitat and microhabitat preferences of these lizards? 5) Are there differences/overlap between sexes regarding microhabitat use?

## Material and methods

This study was conducted between September 2009 and July 2010 twice a month, lasting 10 consecutive days for each sampling, on the slopes (north) of the Araripe Plateau in Crato (07°15'19" S, 39°28'13" W and 07°16'50" S, 39°26'18" W) and Barbalha Municipalities (07°21'49" S, 39°17'51" W and 07°58'19" S, 39°24'38" W), Ceará State, northeast Brazil. The study areas are located within the boundaries of the Environmental Protection Area of Araripe (APA Araripe). These forest enclaves, along with all forest enclaves in the Caatinga Biome related to the slope of hills, are known as 'Brejos-de-altitude'. Rainforest exists on the upper third of the north/northeast slopes (600 to 800 m of altitude). The region has a predominantly warm semi-arid tropical-type climate, with temperatures ranging between 24° and 26°C. The rainy season extends from January to May, and the average annual rainfall is 1100 mm<sup>3</sup> (IPECE 2010).

A total of 131 lizards were captured by hand or using an air gun (4 mm calibre). The collecting methodology was approved by the appropriate regulatory agency in Brazil (ICMBio/SISBio: 20,388–1 and 23,544–1). All collecting took into account the ethical guidelines provided by American Society of Ichthyologists and Herpetologists (ASIH), The Herpetologists' League (HL), the Society for the Study of Amphibians and Reptiles (SSAR) and Conselho Brasileiro de Biologia (CBO). The specific numbers of animals used in each section of the manuscript are described in the results section. Animals captured alive were killed by injection of lidocaine, packed in boxes with ice, and taken to the laboratory, where they were weighed using a digital scale (precision 0.01 g). We measured the following variables (digital caliper, to the nearest 0.01 mm): snout–vent length (SVL) and tail length (TL, measured from cloaca to the tip of the tail, considering only individuals with an intact tail). The specimens were preserved in alcohol (70%) and permanently deposited in the collection of the Universidade Regional do Cariri (URCA-H 2041-2067, 2082-2090, 2727-2819).

In order to provide a phylogenetic perspective on ecological evolution in Brazilian *Mabuya*, we adapted the recently proposed phylogenetic hypothesis (Pyron et al. 2013), and included *M. arajara* as a sister species of *M. nigropunctata*, based on morphological similarities (Rodrigues 2000). In addition, we considered that all species belong to the genus *Mabuya* and did not adopt the classification of multiple genera suggested by Hedges and Conn (2012), for the reasons proposed by Pyron et al. (2013) and Pinto-Sánchez et al. (2015). Only Brazilian species of *Mabuya* were included.

We investigated the occurrence, density, and habitat use of *M. arajara* considering three distinct habitats: dense forest, characterised by low light incidence and higher humidity; transitional area (or edge), ecotone between dense forest and adjacent open areas, characterised by less canopy cover and a higher density of palms (*Arecaceae* spp.); and open area with remnant vegetation. During sampling, every hour we collected the temperature, humidity, and luminosity (accuracy 1.2°C, 4%, and 5%, respectively) in each environment using a thermo-hygro-luximeter digital (Instruterm® THAL-300).

To verify microhabitat preferences by lizards among the three habitats, we studied each environment for two non-consecutive days (six standard days). We searched for

lizards randomly in each environment for 30 minutes at each hour interval (from 0700–1700). In addition, to complement other studied parameters, we also performed random searches among the three environments during four days per excursion (10 days in total per excursion) totalling 60 sampling days (standardised and non-standardised data collection). The rates of encounter (RE) of lizards for each environment were calculated by dividing the total number of lizards sighted by the number of hours of sampling, multiplied by the number of persons in the search (man x hour). Additionally, 46 pitfall traps were installed in each environment (184 buckets total). The traps were open during ten consecutive days of sampling and were each checked at least once a day. We did not use guide fences, because the transition areas possess a high rate of falling palm leaves, with a very irregular and swampy ground.

We recorded the time of day of each visual encounter. The microhabitat was divided into leaves of fallen palm trees, leaf litter, open ground, logs or fallen branches, trunks, shrubs, and rocks. Further, we recorded the exposure of the animal to sunlight according to the following categories: under direct sunlight, in filtered light (sunny site cover by vegetation), or shaded area. The perch height and the depth of the substrate (leaf litter, palm trees) used by the animals were measured with a ruler (1 cm precision).

The niche breadth was calculated (numeric and volumetric) using the inverse of Simpson's diversity index ( $B$ ) (Simpson 1949):

$$B = \frac{1}{\sum_{i=1}^n p_i^2},$$

where  $i$  is the category of the resource,  $p$  is the proportion of the resource category  $i$ , and  $n$  is the total number of categories. The standardised niche breadth was calculated by dividing  $B$  by the number of categories of resources. This procedure produces values that range from 0 to 1. The standardised niche value could thus be compared with the values of other studies (see Pianka 1986).

The habitat use overlap ( $\emptyset_{jk}$ ) between sexes was calculated using the following equation (Pianka 1973):

$$\emptyset_{jk} = \frac{\sum_{i=1}^n p_{ij} p_{ik}}{\sqrt{\sum_{i=1}^n p_{ij}^2 \sum_{i=1}^n p_{ik}^2}},$$

where  $p$  is the proportion of resource use, as described before, and  $j$  and  $k$  represent the compared sexes. The overlap  $\emptyset_{jk}$  ranges from 0 (no overlap) to 1 (complete overlap).

The differences in microhabitat used between males and females were tested with a Kruskal–Wallis test. The differences between the months of study were tested by analysis of variance (ANOVA).

The body temperature ( $T_c$ ) of the lizards captured with the air gun (without handling) was always taken within 30 s after capture and was measured with a sensor (Instruterm® S-11 k) coupled to a digital quick-reading thermo-hygrometer (accuracy  $\pm 1.2^\circ\text{C}$ ; Instruterm® TH-1300). Temperatures of the substrate ( $T_s$ ) used by the lizards and of the air ( $T_a$ ) (2 cm above ground) were also collected.

The relationship between the body and environment temperatures was tested through multiple regressions. The effect of body size on temperature was tested

using a simple regression analysis. Differences in body temperatures between sexes were tested using a *t* test.

The degree of behavioural thermoregulation (passive or active thermoregulator) was estimated using the absolute values of the differences between  $T_c$  and  $T_a$  ( $\Delta T_a$ ) and between  $T_c$  and  $T_s$  ( $\Delta T_s$ ) in module (see Vrcibradic and Rocha 1998). The values of  $\Delta T_a$  and  $\Delta T_s$  were compared using a non-parametric Wilcoxon test (Zar 1999).

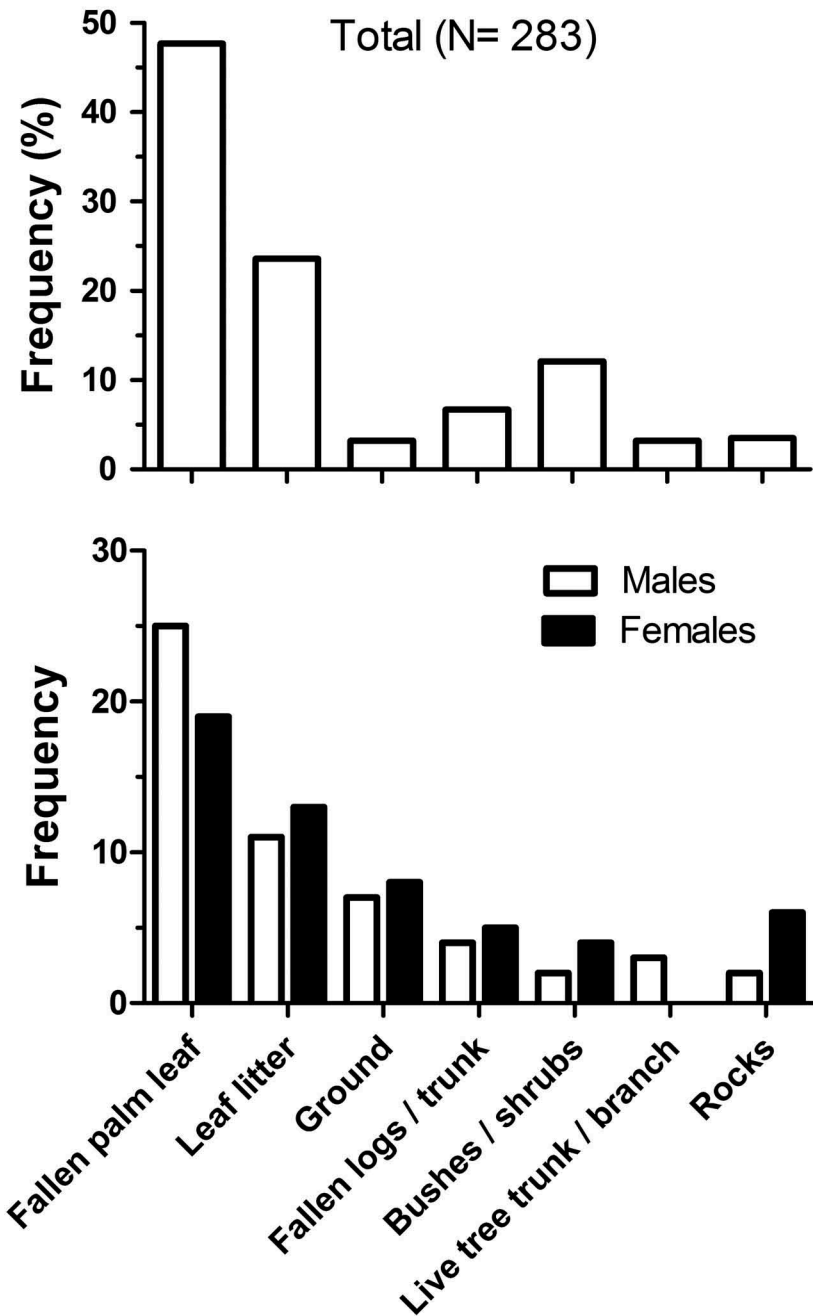
## Results

Regarding habitat use, the vast majority of individuals of *Mabuya arajara* (73.8%) were recorded in the narrow transitional area (RE = 1.74), mainly the edges of the forest; 26.4% of individuals were observed in open areas (RE = 0.61), and none was not found in dense forest (Table 1).

A total of 283 lizards (131 collected) were recorded in seven different microhabitats (Figure 1). The average height of the microhabitats used was  $29.92 \pm 37.23$  cm (range 3–250). The fallen palm leaves used by the lizards showed an average depth of  $21.38 \pm 19.42$  cm (3–100), greater than leaf litter with  $3.5 \pm 2.7$  cm (1–6). Most of the animals were observed with their bodies completely exposed (67.84%, N = 192), while 18.37% (N = 52) were semi-exposed and 13.79% (N = 39) were in shelters. Among animals with some degree of sunlight exposure, 57.59% (N = 163) were in shadows, 25.10% (N = 71) were under sunlight filtered by vegetation, and 17.31% (N = 49) were under direct sunlight. Active lizards were found mainly from 1000 to 1200 (N = 20). Significant differences were found regarding the use of microhabitats between males and females (Kruskal–Wallis,  $H = 30,5$  Gl 13,  $P = <0.003$ , Figure 1). There were no significant differences in the use of microhabitats throughout the year (ANOVA  $F = 12.38$ ,  $P = 0.85$ ). Considering all lizards, microhabitat niche breadth was 3.275 (standard = 0.0436). Males and females presented a high overlap (0.957) in microhabitat use.

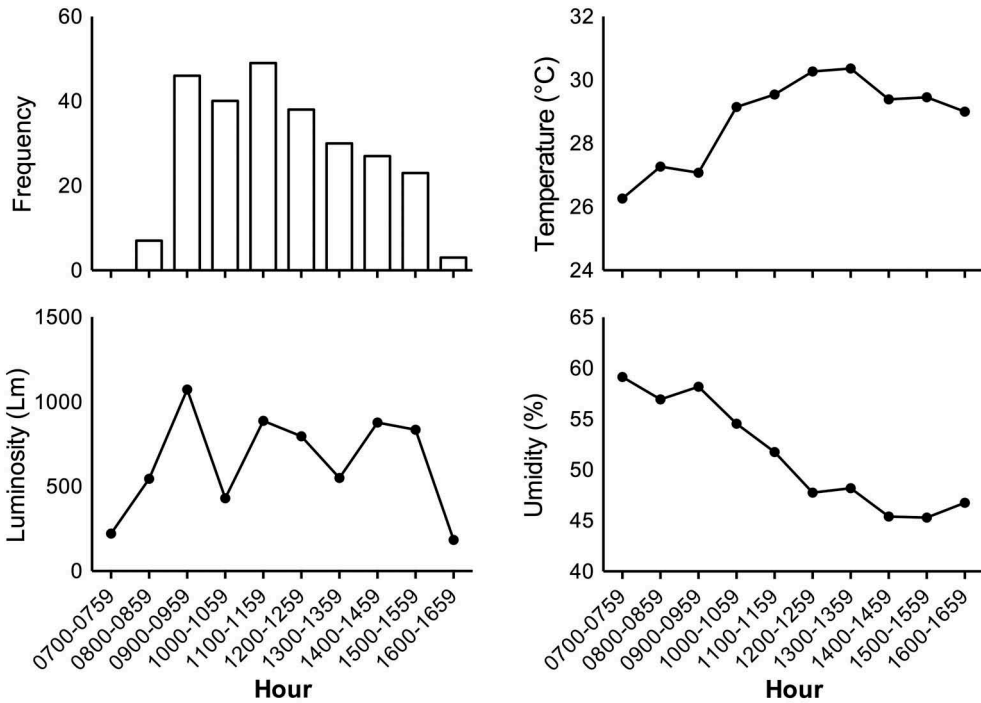
**Table 1.** Habitat and microhabitats used by *Mabuya arajara* along a gradient in the rainforest of the slope of the Araripe Plateau, northeastern Brazil. N = number; F = frequency (%); RE = rates of encounter.

Habitat	Microhabitat	N	F (%)
Dense forest	0	*	*
Transitional area	Fallen palm leaf	114	54.54
	Leaf litter	40	19.13
	Ground	5	2.39
	Fallen logs/trunk	18	8.61
	Bushes/Shrubs	16	7.65
	Live tree trunk/branch	9	4.30
	Rocks	7	3.34
	<b>Total</b>	209	
	<b>TE</b>	1.74	
Open area	Fallen palm leaf	21	28.37
	Leaf litter	27	36.48
	Ground	4	5.40
	Fallen logs/trunk	1	0.47
	Bushes/Shrubs	18	24.32
	Rocks	3	4.05
	<b>Total</b>	74	
	<b>TE</b>	0.61	



**Figure 1.** Frequency of occurrence of *Mabuya arajara* (males and females) in different microhabitats utilised on the slope of the Araripe plateau, northeast Brazil, from September 2009 to July 2010.

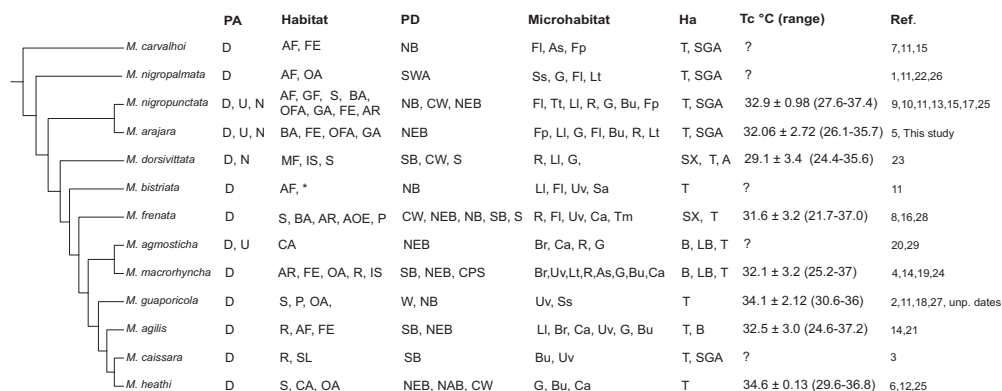
The lizards were active during the entire day, reaching maximum values around midday when ambient temperatures were high (Figure 2), thus reducing activity in the subsequent hours and ceasing around 1700. On cloudy days with low temperatures or rainy days, *M. arajara* began their activities later (between 1000 and 1100). We consider the



**Figure 2.** Period of activity of *Mabuya arajara* throughout the day (above left), temperature environment (above right), luminosity (below left), relative humidity (%) (below right). Slopes of the Araripe Plateau, northeast Brazil. Period September 2009 to July 2010.

activity of *M. arajara* unimodal, despite having two frequency peaks (Figure 2), since they are slightly separated by a short time interval during the morning, and may not represent two maximal activity events, but a continuum with slight difference between two periods of time culminating in a peak, followed by a decrease. The average cloacal temperature recorded for *M. arajara* was  $32.06 \pm 2.72^\circ\text{C}$  ( $N = 23$ , range  $26.1\text{--}35.7^\circ\text{C}$ ), while the substrate temperature was  $29.13 \pm 3.1^\circ\text{C}$  ( $24.6\text{--}36^\circ\text{C}$ ) and the air temperature (5 cm above ground) reached  $29.56 \pm 3.8^\circ\text{C}$  ( $24.5\text{--}29.5^\circ\text{C}$ ). The average body temperatures of lizards rose throughout the day:  $30.64 \pm 2.26^\circ\text{C}$  ( $N = 5$ ) between 0800 and 1000;  $31.65 \pm 2.87^\circ\text{C}$  ( $N = 12$ ) between 1000 and 1200;  $33.7 \pm 0.28^\circ\text{C}$  ( $N = 2$ ) between 1200 and 1400; and  $34.3 \pm 1.69^\circ\text{C}$  ( $N = 2$ ) between 1400 and 1600. The average temperature values differed slightly when we only considered specimens collected in the dry season ( $33.9 \pm 1.72^\circ\text{C}$ ;  $31.3\text{--}35.5^\circ\text{C}$ ;  $N = 6$ ) and wet season ( $31.6 \pm 2.8^\circ\text{C}$ ;  $26.1\text{--}35.7^\circ\text{C}$ ,  $N = 13$ ), but differences in the body temperature of lizards in relation to ambient temperatures were more pronounced in the wet season (substrate =  $4.28^\circ\text{C}$ , air =  $6.1^\circ\text{C}$ ) compared to the dry season (substrate =  $4.45^\circ\text{C}$ , air =  $1.84^\circ\text{C}$ ). The body temperatures of males and females did not differ ( $t = -0.3181$ ,  $Gl = 21$ ,  $P = 0.75$ ). There was no significant correlation among body, air, and substrate temperatures ( $F_{2,20} = 1.68$ ,  $Gl = 22$ ,  $P = 0.2$ ). The body size of lizards (SVL) did not influence the body temperature ( $F = 0.51$ ,  $Gl = 22$ ,  $P = 0.209$ ). Regarding the degree of behavioural thermoregulation, the average value of  $\Delta T_a$  ( $2.87 \pm 3.45^\circ\text{C}$ ,  $0\text{--}8.2^\circ\text{C}$ ,  $N = 25$ ) was similar to the average value of  $\Delta T_s$  ( $2.49 \pm 3.76^\circ\text{C}$ ;  $0\text{--}8.1^\circ\text{C}$ ,  $N = 25$ ), with no significant





**Figure 3.** Phylogeny of *Mabuya* species showing the mapping of ecological characteristics. Abbreviations: PA = Activity Pattern: D = Diurnal, N = Some activity nocturnal, U = Unimodal; H = Habitats: R = Restinga, AF = Amazonian Forest, GF = Galery forests in Savannahs, OA = Open areas, S = Savannah, CA = Caatinga, OFA = Open and forested areas, MF = Montane fields, BA = Brejos-de-altitude (Relictual forests) in Northeastern of the Brazil, AR = Atlantic rainforest, IS = Islands from Costa southeastern Brazil, FE = Forest edges, GA = Grassland area, P = Pantanal, \*Restricted to the courses of the main rivers of the Amazon basin; PD = Patterns distribution: CW = Central West of the Brazil, NEB = Northeastern Brazil, NAB = Northwest of the North of Brazil, CPS = Coastal plains of southeastern Brazil, SB = Southeastern Brazil, W = Western Brazil, NB = Northern Brazil, S = Southern Brazil; M = microhabitat: Fl = fallen logs, trunk, or limb, Lt = live tree trunk or branch, Ll = leaf litter, R = rocks, Ca = cacti, Uv = about undergrowth vegetation, G = ground, Bu = bushes/shrubs, Br = bromeliculous, As = Artificial substrate, Ss = sandy soils, Fp = Fallen palm leaf, Fp = Fallen palm leaf; H = Habit: T = Terrestrial, SGA = Some grau of arboreality, SX = Saxicolous, B = Bromeliculous; Reference: 1 = Andersson (1918), 2 = Dunn (1935), 3 = Vanzolini and Reboucas-Spieker (1976), 4 = Rebouças-Spieker (1974), 5 = Rebouças-Spieker (1981), 6 = Vitt and Blackburn (1983), 7 = Rebouças-Spieker and Vanzolini (1990), 8 = Vitt (1991), 9 = Vitt and Blackburn (1991), 10 = Blackburn and Vitt (1992), 11 = Ávila-Pires (1995), 12 = Vitt (1995), 13 = Vitt et al. (1997), 14 = Rocha and Vrcibradic (1996), 15 = Vitt and Zani (1998), 16 = Vrcibradic and Rocha (1998), 17 = Vitt et al. (1999), 18 = Mesquita et al. (2000), 19 = Hatano et al., (2001), 20 = Rodrigues (2002), 21 = Vrcibradic and Rocha (2002), 22 = Moravec and Aparicio (2004), 23 = Vrcibradic et al. (2004), 24 = Vrcibradic and Rocha (2005), 25 = Mesquita et al. (2006), 26 = Miralles et al. (2009), 27 = Mesquita and Colli (2010), 28 = Ribeiro et al. (2012a), 29 = Ribeiro (2012).

differences (paired Wilcoxon;  $t = 104$ ,  $P = 0.3011$ ). Both  $\Delta T_a$  and  $\Delta T_s$  presented 24% of negative values.

An analysis of published data with other skinks and present study indicates that several characteristics of this group are phylogenetic conservative, especially regarding activity patterns, and body temperatures, with a few minor differences in microhabitat use (Figure 3).

## Discussion

The preferred habitat used by *M. arajara* in the Araripe Plateau was the transition (ecotone) located between the more open areas and dense forest, whereas Roberto and Loebmann (2010) suggested that only the edges of rainforests are used by this species. *Mabuya arajara* was not observed inhabiting dense and dark forest habitat, instead it was sometimes observed in open areas near the forest, like the Cerrados from the Plateau of



Araripe and we know that the species occurs in Caatinga environment, at least marginally (Ribeiro et al. 2012a), in areas above 300 m altitude (Roberto and Loebmann 2010).

In Amazonia, *M. nigropunctata* (a close relative of *M. arajara*, Rodrigues 2000) was also reported as typical species edge species (Vitt et al. 1997), and like *M. arajara*, it inhabits the adjacent open areas. *Mabuya nigropunctata* primarily uses trunks and branches of fallen trees (Vitt and Blackburn 1991; Ávila-Pires 1995; Vitt et al. 1997; Vitt and Zani 1998), whereas *M. arajara* uses mainly fallen leaves of palms (Arecaceae spp.). The leaves of fallen palm trees, when aggregated, provide structurally complex microhabitats with large surfaces for thermoregulation and foraging, while they have a complex and deep labyrinth of leaves that provide shelter, usually deeper than leaf litter.

Studies with other *Mabuya* lizards indicate that there is interspecific variation in microhabitat use (e.g. Vrcibradic and Rocha 1995, 1996, 1998; Caicedo-Portilla et al. 2010) (Figure 3). *Mabuya nigropunctata* was recorded on canopies and fallen palm leaves (Vitt et al. 1999).

Regarding the how our microhabitat results compare to other congeners, *M. macrorhyncha* exhibits an association with bromeliads (Rocha and Vrcibradic 1996, 1999), similarly to *M. agnosticha* (Rodrigues 2002; Ribeiro 2012). Further studies with *M. arajara* in other localities will be needed to confirm a preference of the species for leaf litter.

In lizards, differences in temporal patterns of activity, use of space, and body temperature are not mutually exclusive, so they can directly affect each other in different ways (Pianka and Vitt 2003). To perform daily activities lizards need to attend to their thermoregulatory requirements, which depend on the amount of heat available in the environment. The period of activity of the *M. arajara* included almost all hours of the diurnal period. This pattern of extensive daily activities is well recorded in Scincidae lizards (Huey and Pianka 1977), including the genus *Mabuya* (Vitt 1991; Caicedo-Portilla et al. 2010), and therefore an apparent characteristic of this group of lizards (Vrcibradic and Rocha 1998) (Figure 3). Like congeners, *M. arajara* has a unimodal pattern of activity (e.g. *M. frenata*, Vitt 1991; *M. agilis* and *M. macrorhyncha*; Vitt and Blackburn 1991) differing only the bimodal pattern shown in *M. frenata* in southeastern Brazil (Vrcibradic and Rocha 1998) and *M. sp.* in the cordilleras of the Andes, Colombia (Caicedo-Portilla et al. 2010). Because *M. arajara* is a diurnal lizard, radiation availability is essential for the development of its activities. However, the variations in ambient temperature and humidity should exert greater influence on the intensity of activity, which explains the absence of lizards early in the morning (before 0800) and late afternoon (after 1700), as well as its pattern, with peak activity in the hottest hours of the day or even the late start of activities on cloudy and rainy days.

In some surveys carried out during the night in our study area (unp. dates), some specimens of *M. arajara* (N = 3) were observed engaging in nocturnal activity, similar to what has been reported for *M. nigropunctata* (Vitt and Blackburn 1991) and *M. dorsivittata* (Vanzolini 1948). However, how common this behaviour is should be better investigated further.

Body temperatures of *M. arajara* were very similar to congeners in the Amazon rainforest (*M. nigropunctata* [= *M. bistriata*], Vitt and Blackburn 1991; Ávila-Pires 1995), in the 'restingas' of the southeast coast of Brazil (*M. agilis* and *M. macrorhyncha*, Vrcibradic and Rocha 1995, 2004, 2005; Rocha and Vrcibradic 1996), and also in the southeastern outcrops of Brazil (*M. frenata*, Vrcibradic and Rocha 1998), including the endemic skink *Trachylepis atlantica* of

the Fernando de Noronha Island, Brazil (Rocha et al. 2009a). Optimal cloacal temperature of *Mabuya* lizards seem to be similar, even when living in different habitats and microhabitats (Vrcibradic and Rocha 1998), suggesting that preferred active body temperatures are similar across species (Figure 3). Thus, related species that exist in different environments tend to have more similar temperature values than non-related species living sympatrically (Bogert 1949; Vitt 1995).

Although phylogeny is an important component in determining body temperature, some exceptions can be found, such as *M. dorsivittata* inhabiting high elevations in southeastern Brazil (Vrcibradic et al. 2004), where low temperatures constrain their thermoregulatory capacity. The relatively high altitude of the Araripe Plateau (600–900 m) could influence *M. arajara* body temperature, however, likely not to the extent of *M. dorsivittata* which was studied at much higher elevations in Itatiaia National Park (2460 m), Rio de Janeiro, Brazil (Vrcibradic et al. 2004).

*Mabuya arajara* is a heliophytic lizard that maintains high body temperatures in activity in relation to environmental temperatures, similar to *M. frenata* (Vrcibradic and Rocha 1998). In addition, *M. arajara* did not show a significant correlation between body temperature and the temperature of the substrate and air, similar to *M. nigropunctata* (= *M. bistriata*; Vitt and Blackburn 1991), but contrary to most studies of congeners in Brazil (Rocha and Vrcibradic 1996; Vitt et al. 1997; Vrcibradic and Rocha 1998; Vrcibradic et al. 2004), which do not have significant relationships between body and environmental temperatures. The low temperature of the substrate and the air in the habitat that *M. arajara* prefers, may explain the preferred activity during the hottest hours of the day in direct exposure to sunlight. *Mabuya arajara* prefer microhabitats with filtered light, unlike the high exposure to the sun recorded for *M. nigropunctata* living on the Amazon edges or clearings (Vitt et al. 1997). Males and females did not differ in their body temperatures. This finding is consistent with what has been observed in congeners (Rocha and Vrcibradic 1996; Vrcibradic and Rocha 1998). Vrcibradic and Rocha (2004) indicated that even gravid females do not have different body temperatures than non-gravid females and males. Our data support the idea that there is no influence of sex on body temperature, and that compared to other species of the group, little interspecific variation exists (Figure 3).

A review of the ecology of *Mabuya* spp. shows that several features are phylogenetically conserved. However, we also note that there are similarities in body temperature, activity pattern, habit, and preference for microhabitats among closely related species (Figure 3).

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