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COMPETING FOR A PLACE IN THE SUN: A SHORT STUDY WITH *TROPIDURUS HISPIDUS* AND *TROPIDURUS SEMITAENIATUS* (SQUAMATA: TROPIDURIDAE)

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RESUMO

Competindo por um lugar ao Sol: um estudo de curta duração com Tropidurus hispidus* e *Tropidurus semitaeniatus (Squamata: Tropiduridae). A regulação da temperatura corporal em lagartos envolve o controle do período de atividade além de adaptações morfológicas e fisiológicas. Este trabalho testa a hipótese de que *Tropidurus hispidus* e *T. semitaeniatus*, espécies territoriais e simpátricas na Caatinga segregam seu nicho temporal para termorregulação em afloramentos rochosos no PARNA Catimbau (PE). Os lagartos foram observados a partir de sua exposição matinal ao sol e a sobreposição de nicho foi calculada utilizando o Índice de Pianka. *Tropidurus semitaeniatus* apresentou densidade aproximadamente quatro vezes maior que *T. hispidus*, o que é comum em afloramentos rochosos. A sobreposição de nicho foi baixa (Ojk = 0.38; p = 0.005) e essa segregação parece estar associada com diferenças na ecologia termal das espécies.
Palavras-chave: Competição, *Tropidurus hispidus, Tropidurus semitaeniatus*, termorregulação.

ABSTRACT

Competing for a place in the sun: a short study with Tropidurus hispidus and Tropidurus semitaeniatus (Squamata: Tropiduridae). The regulation of body temperature in lizards involves controlling the activity period as well as morphological and physiological adaptations. The sympatry of *Tropidurus hispidus* and *T. semitaeniatus* is well known and both are territorial, occupying rocky outcrops in Caatinga of northeastern Brazil. Therefore, this study tests the hypothesis that two *Tropidurus* species segregate temporal niche activity for thermoregulation in the rocky outcrops areas in the Caatinga at PARNA Catimbau, Pernambuco State, Brazil. The lizards were observed for time of sun exposure and niche overlap was calculated using Pianka Index. *Tropidurus semitaeniatus* presented a population about four times larger than *T. hispidus*, which is common in rocky outcrops. The niche overlap was low (Ojk = 0.38; p = 0.005) and this segregation seems to be associated with differences in thermal preferences.
Keywords: competition, *Tropidurus hispidus, Tropidurus semitaeniatus*, thermoregulation.

INTRODUCTION

Ectothermic organisms depend on the environment to regulate their body temperature (RICKLEFS, 2008). Reptiles use several regulation strategies which involve physiological and/or behavioral processes and maintain body temperatures close to those that optimize metabolic performance (ROCHA *et al.*, 2009). Among them, lizards exibit a greater diversity of behaviors to optimize efficiency and heat absorption (VITT and CALDWELL, 2009) and these strategies reflect on how these organisms respond to the environmental conditions. Temperature regulation control can involve the activity period, movement between microhabitats (shaded and sunny), and control of body shape or position before the heat source (ROCHA *et al.*, 2009).

Competition is an interaction in which one organism consumes a resource that could be consumed by another, which may occur basically for food, space and/or time (PIANKA, 1973). It can be intra or interspecific (BEGON *et al.*, 2006). Lizards show a gradient of foraging behavior to use space/time resources, ranging from foraging sit-and-wait type to active foraging (MAGNUSSON *et al.*, 1985), and representatives of these two behavioral extremes sharing resources in the same place are commonly found (SILVA and ARAÚJO, 2008). In a previously study, it was observed that *T. hispidus* and *T. semitaeniatus* of the Caatinga area showed a similar foraging mode (sit-and-wait), being affected by the marked seasonality of the biome (KOLODIUK *et al.*, 2009).

Lizards of the genus *Tropidurus* (Wied-Neuwied 1820), are one of the most abundant groups of reptiles found in the Caatinga, having several morphological and physiological adaptations for this kind of environment. They have a wide geographical distribution: all over South America, from Venezuela to Argentina (RODRIGUES, 1987). *Tropidurus semitaeniatus* (Spix 1825) and *T. hispidus* (Spix 1825) are common Caatinga species, which occur sympatrically and syntopically in rocky outcrops throughout most of the area of influence of these dry forests (VANZOLINI *et al.*, 1980). *Tropidurus semitaeniatus* corresponds to a complex of species, along with *T. pinima* (ROBERTS, 1984), *T. helenae* (MANZANI and ABE, 1990), and *T. jaguaribanus* (PASSOS *et al.*, 2011), composing the *semitaeniatus* group (FROST *et al.*, 2001; PASSOS *et al.*, 2011). They are flattened dorsoventrally, which allows the use of rock crevices as a refuge from predators, as well as for thermoregulation (VANZOLINI *et al.*, 1980; VITT, 1995). *Tropidurus hispidus*, along with 11 other species, belongs to the *torquatus* group (FROST *et al.*, 2001). It has a more robust body and can be found in rocks, forest edges, tree trunks, sandy soils, as well as human constructions, being a more generalist species (RODRIGUES, 1987; VANZOLINI *et al.*, 1980; VITT, 1995). *Tropidurus hispidus* and *T. semitaeniatus* exhibit similar ecology in many aspects, like foraging mode and thermal ecology (KOLODIUK *et al.*, 2009; RIBEIRO and FREIRE, 2010), indicating the importance of phylogenetic origin in ecological traits (LOSOS, 1992). But the species also can be influenced by environmental conditions, as was noted that precipitation can affect the reproductive strategies

of *Tropidurus* in Caatinga (RIBEIRO *et al.*, 2012).
Time of exposure to the sun is an essential resource for thermoregulatory activity and it's plausible that competition may occur for this resource in sympatric species of the same genus. Thus, this study aims to test the hypothesis that *T. hispidus* and *T. semitaeniatus* show temporal segregation in thermoregulation activity in rocky outcrops in a Caatinga area.

MATERIAL AND METHODS

Study Site - The Caatinga is composed of a mosaic of different vegetation types, with forest or savanna physiognomies, consisting mainly of deciduous trees and shrubs that often have thorns, microfilia, and, in some species, xerofilia (RIZZINI, 1997). The Parque Nacional do Catimbau is located in Pernambuco State, Northeast Brazil, and it has four distinct types of vegetation: Caatinga scrubland, rocky fields, evergreen shrub, and forest vegetation. The topography is characterized by tabular elevations ranging from 600 to 800m (RODAL *et al.*, 1998). The highest rainfall rates occur between April and June and the annual average temperature is 26º C (SUDENE, 1990). The experiment was conducted on an area locally known as Chapadão (08º 31'S, 37º 15'W - 921m), which features a scrub physiognomy and has large rocky outcrops (*Tropidurus* preferential habitat). The outcrops where the observations were conducted comprises approximately 67m in length and 35m wide, with an estimated area of 2345m^2.

Sampling Design - The data were collected during the "V Curso de Campo de Ecologia e Conservação da Caatinga", conducted by Universidade Federal de Pernambuco and Universidade Federal do Vale do São Francisco. Observations were taken on three consecutive days (April16th-18th 2012). All three days showed sunny sky with scattered clouds. The days of observation were used as replica, but considering that there was only one sampled area, pseudorreplication could affect our conclusions. The observations occurred from 7:30h to 16:30h, with 1h30h min intervals to categorize the activity periods (7:30h to 9:00h, 9:00h to 10:30h, 10:30h to 12:00h, 12:00h to 13:30h, 13:30h to 15:00h, 15:00h to 16:30h). The observation site was the same during all the data gathering period. Lizards were observed at a distance of about three meters, to avoid observer's influence on lizard's activities. To assess if the species are competing for exposed sunny areas, only exposed individuals were observed and their exposure time was recorded (in minutes) from the moment the individual left a shaded to a sunny area until they moved again to a shaded spot. The amount of head movements (*head bobbing*), a way of territorial demarcation of species (KOHLSDORF *et al.*, 2006), was also recorded. Some important data (e.g. substrate and air temperatures) can't be assessed due to the nature of experiment, which occurred during a field course, over a short period of time.

Data Analysis - To test differences on frequency of occurrence between *T. semitaeniatus* and *T. hispidus* we used the Kolmogorov-Smirnov test using a 1:30h interval as replica. To test if the two species differed in the length of sun exposure and the amount of head movements we used a factorial ANOVA using each day as replica. Those tests were conducted on BioStat 5.0 and Statistica 7, respectively. We used 0.05 as significance level and hereafter means are reported with 1 SD.

Temporal niche overlap was also calculated using the Pianka index (PIANKA, 1973), which can vary from 0 (no overlap) to 1 (complete overlap). The index is described by the equation below:

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

where p_{ij} is the proportion of resource *i* used by specie *j*, p_{ik} is the proportion of resource *i* used by species *k* and *n* is the total resources used. The level of niche overlap was calculated with the help of the program EcoSim (GOTELLI and ENTSMINGER, 2006).

RESULTS

In three days of observation, we recorded the behavior of 43 individuals of *T. semitaeniatus* and 12 individuals of *T. hispidus*, indicating that the population of *T. semitaeniatus* is approximately four times greater than that of *T. hispidus*. Juvenile animals were not sampled, only adult individuals were recorded. The individuals of both especies showed a small size difference *T. semitaeniatus* being slightly larger. The period of greatest activity of sun exposure in *T. semitaeniatus* was between 9:00h and 10:30h, with 13 individuals observed, and the period of lowest activity was between 12:00h and 13:30h, with two individuals observed. The period of greatest activity of sun exposure of *T. hispidus* was between 7:30h and 9:00h, with four individuals observed, and periods of lowest activity were between 10:30h to 12:00h and 13:30h to 15:00h, with only one individual observed on each (Fig. 1).

The time of exposure to the sun and the number of head movements of *T. semitaeniatus* and *T. hispidus* in different observation periods is shown in Figs. 2 and 3. Total exposure time in sunny areas was 17.11min - SD: 10.41min for *T. semitaeniatus* and 5.94min - SD: 9.47min for*. T. hispidus*. The amount of head movements was higher in *T. semitaeniatus,* 14.22 - SD: 10.62, and lower in *T. hispidus,* 5.88 - SD: 8.50.

Analysis of variance was used to compare the duration of sun exposure and the amount of head movements between species and showed no significant

differences (p> 0.05)

The Kolmogorov-Smirnov test showed no significant difference between the territorial activity (head bobbing) of *Tropidurus* (p = 0.49).

However, the Pianka Index showed a weak temporal niche overlap between species (Ojk = 0.38, p = 0.005), when the effect of population size was removed (the index is calculated with percentage data and not with absolute data). Therefore there is a temporal segregation in the thermoregulatory activity of the species (Fig. 4).

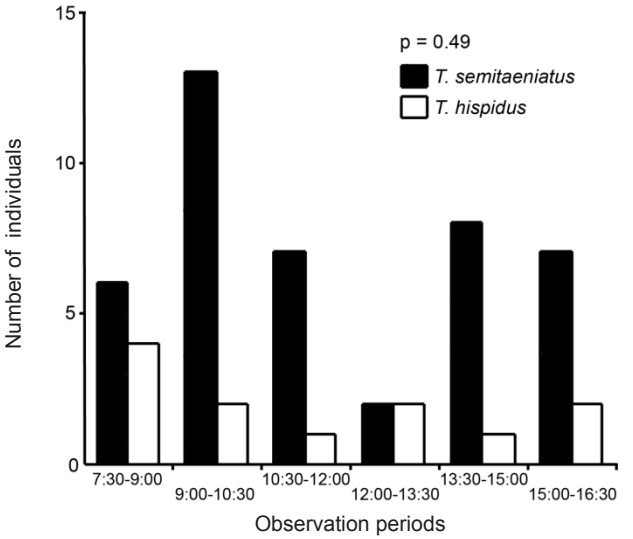

Figure 1 - Number of individuals of *T. hispidus* and *T. semitaeniatus* observed along the period of activity in PARNA do Catimbau, Buíque - PE, Brazil.

DISCUSSION

The results support the hypothesis that there may be a temporal niche segregation between the *Tropidurus* species in the study area. This segregation agree with the results of RIBEIRO and FREIRE (2010) that studying the thermal ecology of *Tropidurus* in another Caatinga area showed that substrate temperature is more important to *T. hispidus*, while air temperature is more important to *T. semitaeniatus* this being a result of particular adaptations to rocky outcrops where the species live in sympatry. The differences in time exposure can be the result of these thermal preferences.

Among the three axes of niche (food, space, and time) suggested by PIANKA (1973), time seems to be the least important for the segregation

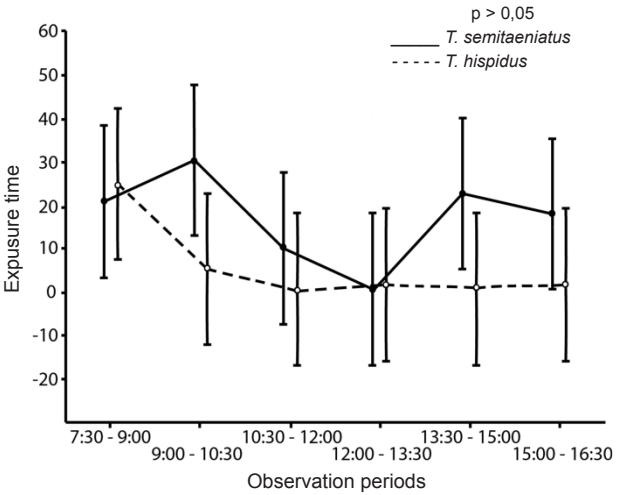

Figure 2 - Mean and SD of time of exposure to the sun (in minutes) in different observation periods for samples of *T. semitaeniatus* and *T. hispidus* in PARNA do Catimbau, Buíque - PE, Brazil.

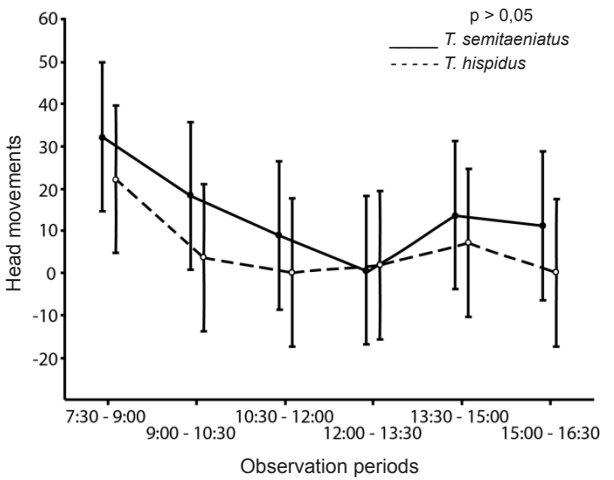

Figure 3 - Mean and SD of the number of head movements of *T. semitaeniatus* and *T. hispidus* during different observation periods in PARNA do Catimbau, Buíque - PE, Brazil.

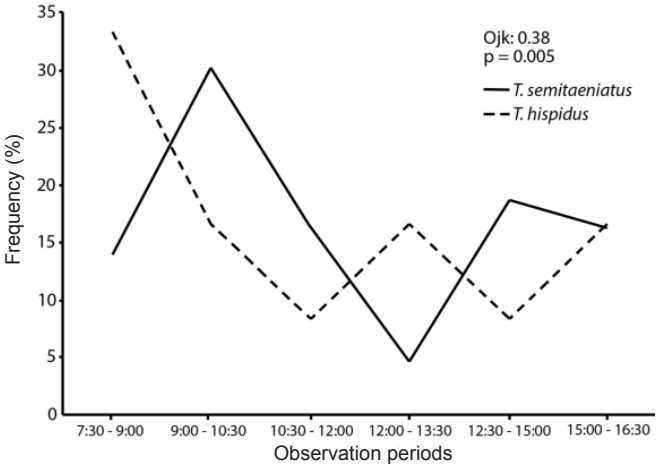

Figure 4 - *T. semitaeniatus* and *T. hispidus.* Frequency of time spent in the sun in percentage of the total time spent by all animals calculated for each observation period in PARNA do Catimbau, Buíque - PE, Brazil. Values used to calculate the Pianka Index.

between lizard species, although there is a clear segregation between diurnal and nocturnal lizards (SILVA and ARAÚJO, 2008). The diet of these species in the Caatinga region, especially in the dry season, is composed mainly of ants and termites (VITT, 1995) but it is not due to specialization, since these species are generalists (COLLI *et al.*, 1992; VITT and CARVALHO, 1995). However, RIBEIRO and FREIRE (2011) suggest that the scarcity of resources can promote a considerable niche overlap. In the dry season, when all other resources are scarce, ants and termites are still abundant and present in the form of groups, facilitating their capture (RIBEIRO and FREIRE, 2011). Evidence of temporal segregation in lizards are rare, the best known spatial segregation, between two species of Tropiduridae, being the case of Amazonian species *Plica plica* (Linnaeus 1758) and *Plica umbra* (Linnaeus 1758), where the first is the largest species and occupies vertical tree trunks while the second occupies the horizontal branches (VITT, 1991).

Lizards show a range of behavioral patterns based on body movements, linked to the activity of territorial defense and copulation (CARPENTER, 1962). The majority of these behaviors are displayed by males, both in relation to territory defense and to the defense of his harem (KOHLSDORF *et al.*, 2006). However, the behavior of moving the head quickly is the most commonly found in *Tropidurus* of both sexes (CARPENTER, 1977), so this behavior was recorded in order to show any kind of territorial defense for the activity of thermoregulation. No significant difference was found in the amount of head movement between the two *Tropidurus* species, which may indicate that this behavior may be related to some kind of intraspecific communication (between the sexes, for example)

and not directed to different species, removing any possibility of dominance of one species over the other.

It is known that the body surface increases the square, while the volume increases with the cube. Thus, as the size of the organisms increases, a longer exposure to sun is necessary to reach the optimum body temperature (RICKLEFS, 2008). Thus, the heavier the body, the longer it takes to heat or waste heat. In theory, *T. semitaeniatus* could reach its ideal temperature faster. However, we found here that *T. hispidus*, the larger species, remained less time exposed. The reason of this fact would be that these species uses different sources of energy. *T. semitaeniatus* uses direct sun radiation to thermoregulate, while *T. hispidus* prefer to use the substrate temperature (RIBEIRO and FREIRE, 2010).

The physiological pattern observed is that *T. hispidus* has an smaller optimal temperature than *T. semitaeniatus* (RIBEIRO and FREIRE, 2010), and this aspect may be a reflex of a competition that occurred in the past (CONNELL, 1980), resulting in all these behavioral and physiological changes. Another factor to be noted is the influence of the predatory pressure throughout evolutionary time. In a study with *T. hispidus*, VITT *et al.* (1996) suggested that predation in open areas, in comparison to rock crevices, can be minimized by reducing the time of exposure to the sun. This pattern which was corroborated in a Cerrado area (FARIA and ARAUJO, 2004), may indicate that selective pressure is greater in *T. hispidus* (larger species and perhaps more attractive to predators) than in *T. semitaeniatus*. This intense pressure may determine the coloration pattern of these organisms, which are extremely cryptic (VANZOLINI *et al.*, 1980) and have good camouflage on the substrate.

The results of this small contribution agree with earlier studies conducted in another Caatinga area (RIBEIRO and FREIRE, 2010).

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