Daily activity and microhabitat use of sympatric lizards from Serra do Cipó, southeastern Brazil

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ABSTRACT. We studied the influence of seasonality on the daily activity pattern and microhabitat use of three sympatric lizard species, *Cnemidophorus ocellifer* Spix, 1825 (Teiidae), *Tropidurus montanus* Rodrigues, 1987 and *Eurolophosaurus nanuzae* (Rodrigues, 1981) (Tropiduridae), in an area of *campos rupestres* (rocky fields) habitat in state of Minas Gerais, Brazil. *Cnemidophorus ocellifer* exhibited low density and activity concentrated within the hottest hours of the day, and was observed mainly on shaded rocks. *Tropidurus montanus* and *E. nanuzae* had similar activity patterns that did not vary between seasons. Activity of *T. montanus* was related to environmental temperatures. However, we did not find such relationships for *E. nanuzae* during the dry season. Both *T. montanus* and *E. nanuzae* were sighted mainly on exposed rocks. Extension of activity varied between seasons, shorter for *C. ocellifer* and longer for *T. montanus* and *E. nanuzae* during the rainy season.

KEYWORDS. Activity patterns, seasonal variation, *Cnemidophorus ocellifer*, *Tropidurus montanus*, *Eurolophosaurus nanuzae*.

RESUMO. Atividade diária e uso de microhabitats de lagartos simpátricos da Serra do Cipó, sudeste do Brasil. Nós estudamos a influência da sazonalidade no padrão de atividade e uso de microhabitat ao longo do dia em três espécies simpátricas de lagartos *Cnemidophorus ocellifer* Spix, 1825 (Teiidae), *Tropidurus montanus* Rodrigues, 1987 e *Eurolophosaurus nanuzae* (Rodrigues, 1981) (Tropiduridae) em uma área de campos rupestres no estado de Minas Gerais, Brasil. *Cnemidophorus ocellifer* apresentou uma baixa densidade na área e sua atividade se concentrou nas horas mais quentes do dia, sendo visto principalmente em rochas sombreadas. *Tropidurus montanus* e *E. nanuzae* demonstraram padrão de atividade similar que não variou entre as estações. No entanto, a atividade em *T. montanus* esteve ligada às temperaturas do ambiente, enquanto esta condição não afetou o padrão de *E. nanuzae* durante a estação seca. Tanto *T. montanus* quanto *E. nanuzae* foram avistados principalmente em rochas expostas. A extensão da atividade variou entre as estações, sendo menor para *C. ocellifer* durante a estação chuvosa e maior para *T. montanus* e *E. nanuzae* durante o mesmo período.

PALAVRAS-CHAVE. Padrão de atividade, variação sasonal, *Cnemidophorus ocellifer*, *Tropidurus montanus*, *Eurolophosaurus nanuzae*.

Temperature plays a major role in many aspects of ectotherm physiology, behavior and ecology (Bogert, 1949; Huey & Stevenson, 1979; Bennett, 1980; Winne & Keck, 2004; Polo *et al.*, 2005). Thus, for these organisms, the temporal pattern of activity during the day may reflect changing environmental conditions, especially temperature (*e.g.* Vitt *et al.*, 1996; Pianka & Vitt, 2003). Indeed, lizard activity is generally strongly related to environmental temperatures (*e.g.* Hatano *et al.*, 2001; Nicholson *et al.*, 2005).

Nonetheless, individuals must avoid exposure to unfavorable thermal conditions, particularly during hours of unsuitably low or high temperatures (Kiefer *et al.*, 2007; Rocha *et al.*, 2009). In this sense, behavioral mechanisms of thermal regulation such as the orientation of the body relative to the sunlight incidence, change of basking posture, and avoidance of unfavorable thermal microhabitats may be used to control exposure to varying environmental temperatures (Van Damme *et al.*, 1987; Martín *et al.*, 1995; Grover, 1996; Vitt *et al.*, 1996).

In the neotropics, active forager lizards generally concentrate their activity during the hottest periods of the day (due to their higher body temperature requirements) and have a shorter total extent of daily activity (Rocha, 1994; Hatano *et al.*, 2001; Mesquita & Colli, 2003). On the other hand, diurnal sit-and-wait foragers tend to have a broader period of activity (Bergallo & Rocha, 1993; Colli & Paiva, 1997) and frequently avoid staying exposed during periods with high temperatures in the warmer months of the year; however, they may concentrate activity within the hottest hours of the day during the cooler months (Rocha, 1994).

Tropical lizards generally present differences in the activity patterns between seasons. Van Sluys (1992) have shown that the lizard *Tropidurus itambere* Rodrigues, 1987, altered its pattern of activity from unimodality during the dry season to bimodality during the rainy season. A seasonal shift in daily activity was also found for the skink *Mabuya frenata* (Cope, 1862), which was less variable during the wet season (Vrcibradic & Rocha, 1998). Although a shift from unimodality to bimodality was not demonstrated for *Ameiva ameiva* (Linnaeus, 1758) and this species had a peak of activity at the same period of the day both in the wet and dry seasons, its activity was more extended during the dry season (Zaluar & Rocha, 2000). Hence, we expect that activity patterns

of studied species of lizards will change from the dry to the wet season.

Here we provide data on activity and daily patterns of microhabitat use by three sympatric lizard species (one active forager and two sit-and-wait foragers) from a tropical seasonal habitat in southeastern Brazil. Specifically we addressed to the following questions: 1. to which extent do lizards of the community under study differ in activity period within and among seasons? 2. will the activity of individuals will be related to environmental temperatures?

MATERIAL AND METHODS

Fieldwork was conducted from 27 to 29 May 2005 and from 2 to 4 February 2006 at the Serra do Cipó (19º00'S, 43º39'W, 1,100 m above sea level), in the southern portion of the Espinhaço Mountain Range, Minas Gerais, Brazil. In the area the climate is highly seasonal with rainy periods occurring between October and April and drier periods between May and September. Monthly rainfall averages between 11.9 mm and 281.1 mm and temperatures vary between 17ºC and 24ºC. July is the coolest and driest month, and January the warmest and wettest month (Galdino *et al*., 2003). The Serra do Cipó varies in altitude from *ca*. 870 m to *ca*. 1,500 m, and above 1,000 m the local habitat is known as *campos rupestres* (rocky fields), presenting vegetation typically composed by species in the families Eriocaulaceae, Melastomataceae, Poaceae and Velloziaceae growing over rock outcrops (Giulietti *et al*., 1987).

We established three 500 m transects *ca*. 300 m apart along the studied area, marked with bright tapes tied to the vegetation. Each transect was surveyed by a pair of observers that systematically searched for lizards by walking through transects between 06:00h to 18:00h. All transects were sampled by walking in a regular slow cadence for up to *ca*. 40 minutes each, beginning consecutively with a one-hour time lag from each other on the same day. Thus, a given transect started within intervals of three hours. This method was used to increase the independence of observations. All lizards sighted along the transects were recorded.

For each sighted lizard we recorded the time of sighting, condition of the sky (sunny, partially clouded or cloudy), whether the lizard was in the sun, shade or filtered sun, and the type of substrate where it was first sighted. We also took hourly air, rock and soil temperatures with a bulb thermometer to the nearest 1°C, prior to the beginning of each transect.

Differences in daily activity patterns between species within a season and within species between seasons were evaluated by the Kolmogorov-Smirnov two-group test (Van Sluys *et al*., 2004). Multiple regression analysis was used to test for the relationships between number of lizards observed and air, rock and soil temperatures (one regression model per lizard species).

RESULTS

We recorded three lizard species in the studied site during surveys: *Cnemidophorus ocellifer* Spix, 1825 (Teiidae; n = 8 sightings), *Tropidurus montanus* Rodrigues, 1987 (Tropiduridae; n = 125 sightings) and *Eurolophosaurus nanuzae* (Rodrigues, 1981) (Tropiduridae; n = 107 sightings).

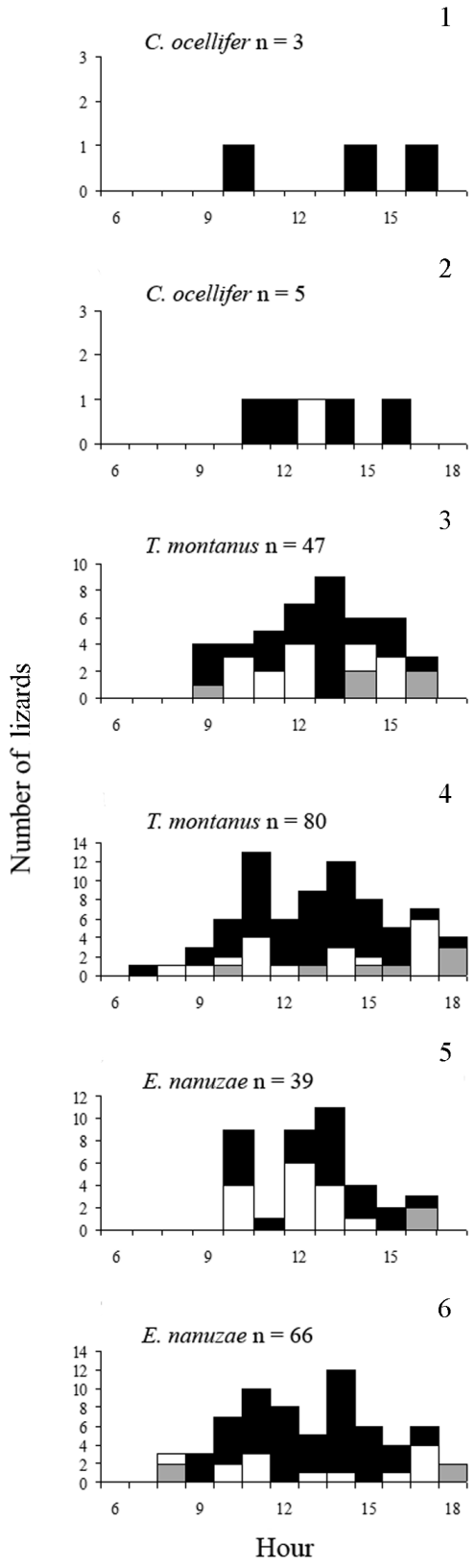
During the dry season *C. ocellifer* was observed at 10:00h-11:00h, 14:00h-15:00h and 16:00h-17:00h intervals (n = 3; Fig. 1); nonetheless, in the rainy season individuals were found active from 11:00h until after 16:00h (n = 5; Fig. 2). This species seems to occur at relatively low densities at the studied site (Conrado A. B. Galdino pers. obs.), thus the small sample size precluded the use of statistical tests. *Cnemidophorus ocellifer* was sighted mainly during sunny periods (Figs 1, 2) and was observed mainly on shaded rocks in both seasons, and once on an exposed rock and twice on the ground among vegetation.

Tropidurus montanus had the broadest activity among the surveyed species. During the dry season, activity of this species lasted for nine hours beginning at 09:00h and ceasing at *ca*. 17:00h, with a peak of activity at 13:00h (Fig. 3). We did not find any *T. montanus* individuals active before 09:00h or after 17:00h during the dry season. In the rainy season *T. montanus* was active for 12 h. The first few individuals were sighted at *ca*. 07:00h, with activity increasing through 11:00h when a peak of activity occurred (Fig. 4). At 12:00h the frequency of active individuals decreased suddenly, rising again at 14:00h then decreasing through 18:00h (Fig. 4). Nonetheless, we did not find differences in the activity pattern of *T. montanus* between the rainy and dry seasons (D_{max} = 0.12; p = 0.38). The frequency of active *T. montanus* was positively related to the overall effect of microhabitat temperatures both in the dry ($F_{3.44}$ = 11.71; R^2 = 0.75; p = 0.003) and rainy seasons ($F_{3.77}$ = 6.29; R^2 = 0.57; p = 0.014), but none of the partial regressions had a significant effect in lizards' activity.

Tropidurus montanus was found exposed to sunlight during all day in both seasons. During the dry season, however, individuals used both sunny and filtered sun microhabitats during the hottest hours of the day (Figs 3, 4, 11). *Tropidurus montanus* was mostly found active on exposed rocks (77% during the dry season and 68% in the rainy season; Figs 7, 8, respectively).

During the dry season individuals of *E. nanuzae* were active for a total period of seven hours, beginning at 10:00h. Individuals were frequently sighted within the first hour of observation, but at 11:00h activity decreased (Fig. 5). At 12:00h the number of sighted individuals increased reaching a peak at 13:00h (Fig. 5). Thereafter, activity decreased steadily ceasing after 16:00h (Fig. 5).

In the rainy season activity of *E. nanuzae* lasted 11 hours, from 08:00h to 18:00h. Few individuals were sighted within the first hour of observation, but their number increased through 11:00h. Activity decreased from 12:00h to 13:00h, increased again at 14:00h, and then decreased from 15:00h onward, ceasing after 18:00h (Fig. 6). We did not find significant differences in the activity pattern of *E. nanuzae* between the rainy and dry periods (D_{max} = 0.24; p = 0.06). Activity of *E. nanuzae* was not related to the overall effect of environmental temperatures in the dry season ($F_{3.36}$ = 2.08; R^2 = 0.23; p = 0.18). However,



Figures 1-6. Frequency of individuals of *Cnemidophorus ocellifer* Spix, 1825, *Tropidurus montanus* Rodrigues, 1987, and *Eurolophosaurus nanuzae* Rodrigues, 1981, observed per hour during the dry (1, 3 and 5, respectively) and wet (2, 4 and 6, respectively) seasons at Serra do Cipó, state of Minas Gerais, Brazil. Divided bars represent the number of lizards observed during the different sky conditions (black = sunny; white = partially clouded; grey = cloudy).

in the rainy season the addictive effect of environmental temperatures positively affected *E. nanuzae* activity ($F_{3.63} = 4.72$; $R^2 = 0.48$; $p = 0.03$). None of the partial regressions had a significant effect on *E. nanuzae* activity. This species was sighted mainly exposed to the sun on rocks (62% in the dry season and 72% in the rainy season) during all day (Figs 5, 6, 9, 10). Activity during cloudy conditions was also noted, but restricted to the coolest hours of the day (*i.e.* early morning and late afternoon; Figs 5, 6, 11, 12).

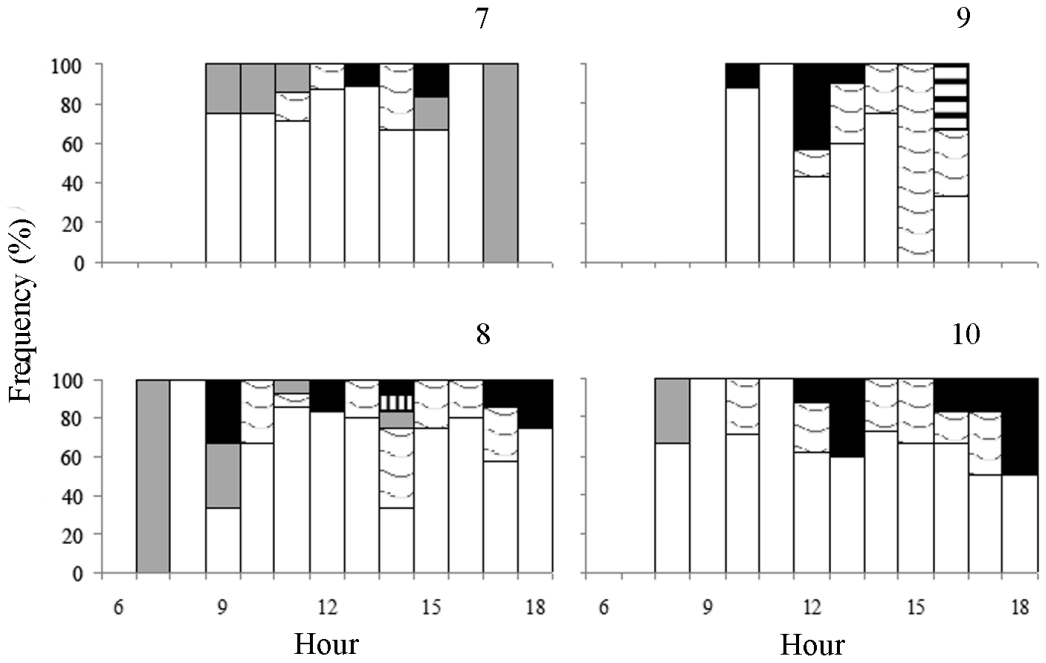
Activity patterns between *T. montanus* and *E. nanuzae* did not differ neither in the rainy ($D_{max} = 0.05$; $p = 0.81$) nor in the dry season ($D_{max} = 0.13$; $p = 0.48$).

DISCUSSION

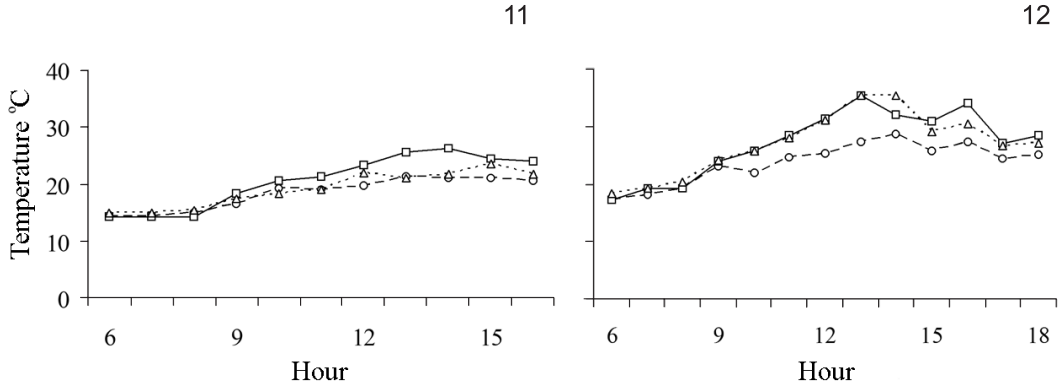
The teiid lizard *C. ocellifer* seemed to have a narrower period of activity compared to *T. montanus* and *E. nanuzae*. However, the small sample size of *C. ocellifer* precluded us to deal in detail with its activity pattern.

The two sit-and-wait forager lizards had similar patterns of activity and microhabitat use. This corroborates VAN SLUYS *et al.* (2004), who studied a *T. montanus* population in sympatry with *Tropidurus hispidus* Spix, 1825 in a similar habitat, and other studies where high temporal and spatial niche overlap between tropidurid lizards have been shown (*e.g.* VITT, 1991; 1995; COLLI *et al.*, 1992; FARIA & ARAÚJO, 2004). Both tropidurid species had a broad activity period and *T. montanus* exhibited the longest daily activity in the studied assemblage. In fact, extended periods of activity have been reported for a number of *Tropidurus* Wied-Neuwied, 1824 species (*e.g. T. itambere* - VAN SLUYS, 1992; *Tropidurus torquatus* (Wied, 1820) - BERGALLO & ROCHA, 1993; HATANO *et al.*, 2001; ROCHA *et al.*, 2002; *Tropidurus oreadicus* Rodrigues, 1987 - ROCHA & BERGALLO, 1990; MEIRA *et al.*, 2007; *T. hispidus* - VITT, 1995; VITT *et al.*, 1996; VAN SLUYS *et al.*, 2004; *Tropidurus hygomi* Reinhardt & Lütken, 1861 - VARGENS *et al.*, 2008). Hence, it seems that time is not a niche dimension that constrains the sympatric occurrence of tropidurid lizards. As an example, VAN SLUYS *et al.* (2004) found that *T. montanus* seemed to have a shorter period of activity than sympatric *T. hispidus* - despite the absence of statistical difference - during the beginning of the dry season. Nonetheless, the activity pattern of *T. montanus* in an assemblage with no *T. hispidus* (present study) was similar to that found in the aforementioned study.

Despite the statistical non-significance for differences between seasons in the proportion of individuals found during the hour intervals, both *T. montanus* and *E. nanuzae* had broader activities during the rainy season. In this period, conditions experienced by the lizards at Serra do Cipó at the first hours of the morning and at the late hours of the afternoon were thermally stable and favorable, enabling lizards to extend their activities. On the other hand, during the dry season, cold temperatures in association with winds and clouding resulted in low temperatures at such periods (Conrado A. B. Galdino pers. obs.). Thus, lizards may avoid unfavorable conditions by being inactive at the first hours of the morning and the latest hours in the afternoon. Changes in the duration of activity between



Figures 7-10. Frequency of microhabitat use by individuals of *Tropidurus montanus* Rodrigues, 1987 and *Eurolophosaurus nanuzae* Rodrigues, 1981, throughout the day during the dry and rainy seasons at Serra do Cipó, state of Minas Gerais, Brazil. *Tropidurus montanus*: 7, 8, dry and rainy seasons, respectively; *E. nanuzae*: 9, 10, dry and rainy seasons, respectively (white bars = exposed rocks; curved lines = shaded rocks; grey bars = crevices; black bars = soil among vegetation; vertical lines = shaded soil; horizontal lines = exposed soil).



Figures 11, 12. Microhabitat temperature variation (in °C) during the day in the dry season (11) and in the rainy season (12) at Serra do Cipó, state of Minas Gerais, Brazil (circles and spaced lines = air temperature; squares and solid lines = rock temperature; triangles and broken lines = soil temperature).

seasons were found for other tropical lizards. For a population of the species *Liolaemus occipitalis* Boulenger, 1885, individuals were seen from 08:00h to 18:00h during the summer. However during the winter, individuals were not seen before 13:00h because temperatures dropped significantly and lizards avoided such conditions (Bujes & Verrastro, 2008). The lizard *Mabuya frenata* Cope, 1862 also presents variation in activity between seasons and unfavorable thermal conditions (*i.e.* cold temperatures) at the onset of the morning and at the late hours of the day might restrict lizards' activity (Vrcibradic & Rocha, 1998). A similar pattern was also found for *Tropidurus itambere* (Van Sluys, 1992) from southeastern Brazil. Hence, for tropical lizard species inhabiting seasonal habitats, adjustments in the duration of daily activity in response to different conditions should constitute a common trend.

Activity of *T. montanus* was positively related to microhabitat temperatures (overall effects of rock, soil and air temperatures) in both seasons. On the other hand, activity of *E. nanuzae* was related to environmental temperatures only during the wet season. This may result from the concentration of active individuals during the warmest period of the day in the dry/cold season as a means of avoiding low temperatures in the early morning and late afternoon. Low temperatures experienced in the dry season in association with winds may indeed have a stronger effect in activity of the small-bodied *E. nanuzae*, due to physiological limitations on thermoregulation imposed by a high surface-to-volume ratio. Thus, the influence of temperature upon activity of *E. nanuzae* during the dry season might not be disregarded.

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