Annual activity of the lizard *Liolaemus occipitalis* (Squamata, Liolaemidae) in the coastal sand dunes of southern Brazil[1]

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ABSTRACT. The activity pattern of the small sand lizard, *Liolaemus occipitalis* Boulenger, 1885, was investigated in the coastal sand dunes at Quintão beach (Palmares do Sul, southern, Brazil), between September 1998 and August 1999. The results showed that *L. occipitalis* is active all along the year, but with variations in its daily and seasonal activity patterns associated to climatic changes in the habitat. Lizard activity pattern was distributed as follows: under the sand, burrowed (73%), under vegetation (14%), dislocation (7%) and basking (6%). Mean habitat temperatures (air and substrate) were significantly different. The results indicate that *L. occipitalis* is a thigmothermic and heliothermic species that regulates its body temperature through behavioral mechanisms, and that thermoregulation is mainly associated with substrate.

KEYWORDS. *Liolaemus*, microhabitat use, sand dunes.

RESUMO. Atividade anual do lagarto *Liolaemus occipitalis* (Squamata, Liolaemidae) nas dunas costeiras do sul do Brasil. Este trabalho teve por objetivo o estudo da atividade anual do lagarto *Liolaemus occipitalis* Boulenger, 1885. O estudo se desenvolveu nas dunas costeiras da praia de Quintão (Palmares do Sul, sul do Brasil), no período de setembro de 1998 a agosto de 1999. Os resultados demonstraram que *L. occipitalis* é ativo ao longo de todo o ano com variações diárias e sazonais de acordo com as mudanças climáticas do habitat. A atividade do lagarto se distribuiu da seguinte forma: sob a areia (73%), sob a vegetação (14%), deslocando-se (7%) e exposto ao sol (6%). As temperaturas medias do hábitat (ar e substrato) diferiram significativamente. Os resultados indicaram que *L. occipitalis* é tigmotérmico e heliotérmico, regulando a sua temperatura corporal através de mecanismos comportamentais, estando a mesma relacionada principalmente com a temperatura do substrato.

PAVALVRAS-CHAVE. *Liolaemus*, uso do microhabitat, dunas costeiras.

To keep body temperature within tolerable limits to perform their metabolic functions, lizards behaviourally use the thermal variability of their habitats (i.e., they move alternately from sunny places to shadowy spots); they take stands or attitudes that increase either gain or loss of heat through radiation, conduction and/or by convection; and they either decrease or increase their period of activity in the microhabitat whenever thermal conditions are favorable (Heath, 1970; Grant & Dunham, 1988; Grant, 1990). Since this type of behavioral thermoregulation involves the use of thermal heterogeneity in the habitat, it mays strongly affect on the use of the microhabitat by the lizards (Grover, 1996).

Microhabitat use by lizards can also be influenced by biotic factors, such as interspecific competition (Schoener, 1977; Salzburg, 1984; Núñez *et al*., 1989), the avoidance of predators (Gibbons & Lillywhite, 1981), as well as size and morphology of the individual (Marcellini & Mackey, 1970; Scheibe, 1987). On account of such factors, use of the microhabitat can be determinant. It may have an indirect effect on thermoregulation and it may also have an influence on the evolution of thermal preferences. Therefore, differences in the pattern of temporal activity, in the use of the space, in the foraging pattern, in eating habits, and in the body-temperature relations for the lizards are not independent of each other; on the contrary, they are complex interactions between biotic and abiotic factors (Roughgarden *et al*., 1983).

Liolaemus occipitalis Boulenger, 1885, is a small lizard of the family Liolaemidae. Males and females have mean snout-vent lengths of 60.2 mm and 53.2 mm, respectively (Verrastro & Bujes, 1998). Its geographical distribution is restricted to the sand dunes of the South Atlantic coast of the states of Santa Catarina and Rio Grande do Sul, Brazil. It has a cryptic color pattern, which makes it inconspicuous in the environment background. The minimum reproductive size is 50mm for males, and 45mm for females (Verrastro & Krause, 1994). Reproduction takes place between September and March. The species is chiefly insectivorous and it is active during day time (Verrastro & Krause, 1994). Its main defense strategy against predators is burrowing superficially in the sand or escaping into refuges. The most commonly observed thermoregulating behavior of *L. occipitalis* is moving between sunlight exposed sites to shaded sites amidst dense vegetation (Verrastro & Bujes, 1998).

One population of *Liolaemus occipitalis* of the state of Rio Grande do Sul, was the object of investigation for the present study, which aims to determine the annual activity pattern of the species, as well as its seasonal rhythm of activity in its environment.

MATERIAL AND METHODS

This study took place in an area of approximately 40,000m^2 in the sand dunes of Quintão beach, in the

municipality of Palmares do Sul, southern Brazil (30º24'S; 50º17'W). This area was chosen because it had a high population density of lizards. It is situated 4km from Lagoa do Quintão and 3km from the Atlantic Ocean, in the coastal plain, being a flat landscape with walking sand dunes on holocenic geological substrate (DELANEY, 1965). The soil is formed by non-fixed sand-quartz deposits of eolic accumulation and quaternary origin (PORTO & CORTAZZI, 1982). The climate is of the type Cfa (Köppen classification) with mean annual rainfall around 1,323mm and no characteristic dry season. The mean annual air temperature is 20ºC. Northeastern winds predominate during the year (EIDT, 1968).

The coastal vegetation in the vicinity of the study site is described in PFADENHAUER & RAMOS (1979), PFADENHAUER (1980), and WAECHTER (1985, 1990). The vegetation in the study area is sparse, with plants covering less than 5%, and consists exclusively of herbaceous, psammophilous species, mainly Poaceae. The habitat includes small hummocks and dunes of sand 20 to 50cm high, many of which are situated next to clumps of herbaceous plants. In depressed areas among the dunes, temporary flooding may occur because of heavy rainfall. When these depressed areas accumulate organic matter for a long time, they become covered by dense, perennial plant species. The most abundant species is *Panicum racemosum* (Poaceae), which forms almost homogeneous clusters in wide extensions on top of small elevations. In the lower elevations, other Gramineae occur.

Observations were done monthly from September 1998 to August 1999, with whole area being visited within two days, between 08:00 and 18:00. Notes were taken for field records, and every activity of the lizard was described at the moment when it was first seen. After that, the lizard was manually captured, its snout-vent length (SVL) was measured (mm) and the lizard was weighed (g) (BM). With these two values, three age groups were established: young specimens (undetermined sex); immatures (SVL up to 45mm for females, and up to 50mm for males); and, adults (SVL higher than 45.1mm, for females, and higher than 50.1mm for males). Behavioral patterns were adapted from VERRASTRO & BUJES (1998), and these were: "under sand," "under vegetation," "basking," and "dislocation". Moreover, air temperatures (in ºC) were taken (at 10mm from ground surface), as well as temperatures of the substratum and at 50mm and 100mm below substratum using contact thermometers. Results were arranged according to frequency of sightings and divided in: (1) sightings per season of the year; (2) activities per season of the year; (3) age groups per season of the year; (4) age groups per activity per season of the year. Seasons of the year were established as follows: spring (from September to November, 1998), summer (from December, 1998 to February, 1999), fall (from March to May, 1999), and winter (from June to August, 1999). Temperature curves of the microhabitat were drawn from the averages of the monthly recorded temperatures.

RESULTS AND DISCUSSION

The specimens captured had a mean SVL of 50.31 SD ± 9.83 mm (N=301), with a mean BM of 4.92 SD ± 2.62g.

The rhythm of activity of *L. occipitalis* varied throughout the year (Fig. 1), usually showing a tendency

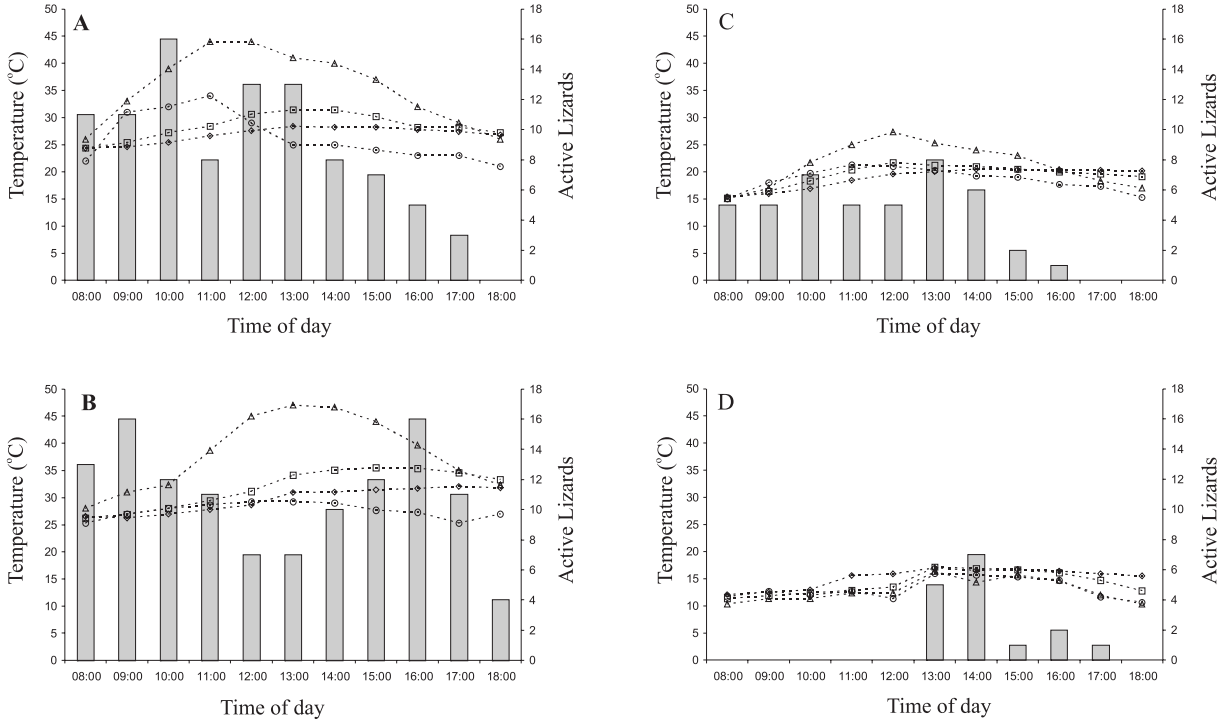

Fig. 1. Diel changes in mean microhabitat temperature: air temperature (circles), soil temperature at surface (triangles), 50 mm (square), and 100 mm of depth (lozenge); and daily activity cycle of *Liolaemus occipitalis* Boulenger, 1885 in the sand dunes of Quintão beach, Palmares do Sul, southern Brazil, recorded in Spring (A), Summer (B), Fall (C), and Winter (D) between September 1998 and August 1999.

toward a bimodal rhythm. The same behavior was found in several species from Chile, such as *L. curis* Núñez & Lobra, 1985 (NÚÑEZ, 1996), *L. fuscus* Boulenger, 1885 and *L. lemniscatus* Gravenhorst, 1837 (NÚÑEZ *et al*., 1989). NÚÑEZ (1996) argues that the predators pressure on lizards is a determining factor for the activity of the preyed-upon organisms, and mentions the example of *L. hermani* Sallaberry & Nunez, 1982, a lizard with a unimodal activity restricted to the morning period, whereas its predators prefer to be active in the afternoon. Thus, the species would be responding to the pressure of its predators with morning activities. It was also observed a unimodal activity pattern in *L. lutzae* (Mertens, 1938) from the restingas in Rio de Janeiro a pattern that was mainly concentrated in the morning (ROCHA, 1988). On the other hand, ROCHA (1991) asserts that the pattern of coloration of the *L. lutzae*, rather cryptic on the sands of the shore, added to the fact that open areas in general offer more opportunities to predation, suggests that the pressure of predators in the area must be high, and predators in general use vision to locate lizards. Given that *L. occipitalis* also presents cryptic coloration (VERRASTRO, 2004) as a response to the environment and that it is active throughout the day in spite of suffering the pressure of predators such as the bird *Guira guira* Gmelin, 1788 and the snake *Lystrophis dorbignyi* (Duméril, Bibron & Duméril, 1854) (C. S. Bujes pers. obs.), one can conclude that most probably the activities of *L. occipitalis* are directly related to the interaction of these factors with its thermoregulation, as well as to its sit-and-wait type of foraging (PIANKA, 1977).

L. occipitalis was active throughout the year. The lizards kept themselves active from 7:30-8:00a.m. to 6:00-6:30p.m., during the spring and summer. Two peaks of activities were observed during spring: the first, between 8:00 and 10:00a.m., and the second, between 12:00 and 3:00p.m. During summer, the peaks of higher activity were registered between 8:00 and 10:00a.m. and between 2:00 and 5:00p.m. During both seasons those peaks diminished during the hours of higher temperatures. Activity diminished perceptibly during fall and winter. During winter, active lizards could only be seen after 1:00p.m. The largest range in numbers of active lizards was observed during spring (a minimum of 3 and a maximum of 16 individuals) and during summer (a minimum of 7 and a maximum of 16). During the study, mean habitat temperatures (air and substrate) were significantly different among seasons (ANOVA, $F_{3.857}$=81.64; P<0.001).

The activity of *L. occipitalis* throughout the year seems to be associated to thermoregulation. Most of the lizards sighted (73%) were under sand. The main thermoregulating and evading behavior of the *L. occipitalis* is to dive into the sand (VERRASTRO & BUJES, 1998). This will allow the lizard, during most of its period of activity, to keep temperatures relatively lower than those registered when exposed directly to sunlight. In the study performed by BUJES & VERRASTRO (2006), an ecritic temperature of approximatelly 31ºC was observed for this species and was significantly differnt from the recorded mean annual air temperature (25.74ºC). It is also a strategy to avoid the risk of predation when it is in an open area. It also avoids the constant heat loss that would be expected with a prolonged exposure to colder air temperatures caused by a exposure to the constant wind which is characteristic of the coastal region. FUENTES & JAKSIC (1979) documented this fact in species of *Liolaemus* from Chile. All three species from the coastal region presented ecritic temperatures lower than continent species due to the heat loss by wind exposure. The burrowing behavior is observed in all species in the group *boulengeri*, to which *L. occipitalis* belongs, with exception of *L. ornatus* Koslowsky, 1898 (HALLOY *et al*. 1998). According to a study performed by HALLOY *et al*. (1998), this innate behavior would be the main sinapormorphy of the species in the group *boulengeri*, suggesting a phylogenetic component.

The activity of *L. occipitalis* throughout the year showed the following distribution: 73% of the lizards were found under sand, 14% were under vegetation, 7% were dislocating, and 6% were in basking (Fig. 2). The fact that 14% of the lizards sighted were under vegetation is also associated to thermoregulation. They look for milder temperatures during the warmer periods of the day, thus avoiding overheating. As was observed in a study carried out by BUJES & VERRASTRO (2006) the mean temperature of the substrate was 29.59ºC. The substrate corresponds to the place where the lizards were captured, close to the bushes. Moreover, this behavior leads to predator escape and capture of prey that live among the vegetation. ROCHA (1988) observed the same activity pattern for, *L. lutzae* where the activity concentration during the morning would be associated to the increase of substrate temperature late morning (11h). Moreover, this behavior helps them both to evade predators and to capture preys found under the vegetation. VERRASTRO & BUJES (1998), studying the same species during the months of January and February (when temperatures are the highest in the area of dunes), observed that the main activity for that period of the year was found under vegetation, *Liolaemus occipitalis* presents a omnivore diet (VERRASTRO, 2004), which according to ROCHA (1992), would represent an alternative to compensate the impossibility of the lizards to graze for a long period of time, when temperatures are critical. Substrate temperatures limit the activities of the lizards during the warmest hours of the day, when they are confined to shadows under the grassy vegetation. In

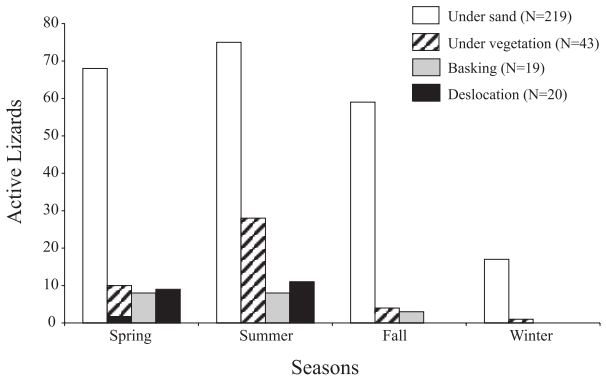

Fig. 2. Distribution of *Liolaemus occipitalis* Boulenger, 1885 in the sand dunes of Quintão beach, Palmares do Sul, southern Brazil, recorded by activity on each season (N=270) between September 1998 and August 1999.

these periods of the day, the access to vegetal material would be a way to ingest food without the exposure to high temperatures of the hot substrate. Lizards were seen changing places from one tuft to another (7%), that could be associated to the presence of the observer. Only 6% of the sighted lizards were in the sun, a thermoregulatory behavior that puts the lizard under solar radiation and its body in direct contact with the heated substratum (Fig. 2). As documented for other lizards from open areas, this behavior is not well observed for *L. lutzae* (ROCHA, 1995). According to the author, this fact would be associated to predation risk and exposure to high substrate temperatures that occur far from the vegetation. This behavior was occasionaly observed in *L. lutzae*, especially early in the morning (ROCHA, 1995).

There was always one age group absent for every season (Fig. 3): juvenile lizards during spring, immature females during summer, and adult females during fall and winter, once a time this species reaches sexual maturity in their first reproductive season after birth (VERRASTRO & KRAUSE, 1994). Adult males were the only group found active throughout the year, maybe due to the matter of the species territoriality. The frequency of these groups in their different activities per season varied along the year. The most frequent activity during Spring was under sand (digging), representing 81.2% of the activity of immature females, 93.3% of immature males, 70.3% of adult females, and 55.5% of adult males. Other activities were also registered for both adult males and females during Spring, consisting of dislocation (16.2% females and 11.1% males); under vegetation (5.4% females and 22.2% males); and basking (8.2% females and 11.1% males). During the summer, the number of observed young specimens was very low, with the population represented mainly by adults. The most frequent activity was under sand, representing 56.7% of females activity and 65.2% of males. The activities under vegetation represented 25.4% and 23.9% for females and males, respectively; dislocation was less frequent, 10.4% and 8.7% for females and males, respectively; and basking, 7.5% and 2.8% for females and males, respectively. During fall and winter, the observations consisted almost only of young specimens, being under sand the most frequent activity (89.1%).

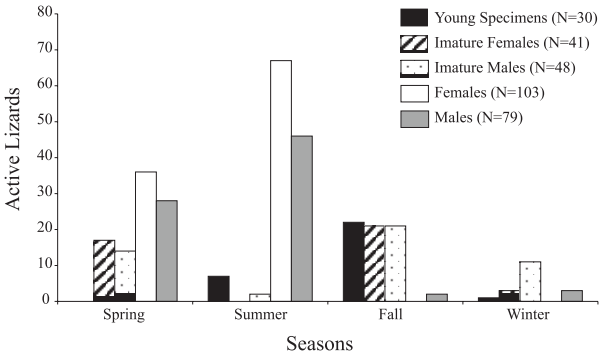

Fig. 3. Distribution of *Liolaemus occipitalis* Boulenger, 1885 in the sand dunes of Quintão beach, Palmares do Sul, southern Brazil, recorded by age classes on four seasons (N=270) between September 1998 and August 1999.

We concluded that *Liolaemus occipitalis* is a thigmothermic and heliothermic species; its major activity, as registered through the observations made for the present study, was superficial diving into the sand. The lizard is active all throughout the year, and its activity is directly related to thermal changes in the environment. It uses its microhabitat mainly as a means for thermoregulating, evading predators, and ambushing preys.

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