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SEASONAL AND DAILY ACTIVITY IN THE PALE-HEADED BLINDSNAKE *LIOTYPHLOPS BEUI* (SERPENTES: ANOMALEPIDAE) IN SOUTHEASTERN BRAZIL

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Abstract. The family Anomalepididae which includes four genera and around 15 species has been less studied than all other Scolecophidia. *Liotyphlops beui* is one of the most collected snake species in São Paulo city. We studied the seasonal and daily surface activity pattern of this fossorial snake. The snakes were collected mainly in rainy and warm periods, indicating a highly seasonal activity. The minimum temperatures explain this pattern more accurately. The decrease in activity of *L. beui* during the dry and cold season is more pronounced than in any other snake from southeastern Brazil. The morphological and ecological characteristics may explain why this species is collected in lower numbers in the dry season than other snakes from the same region. Activity in *L. beui* occurs predominantly during the early dark hours, usually between 19:00 and 21:00 h. This short activity period may be determined by light intensity and temperature, although prey and/or predator activity may also influence this activity pattern.

Keywords. Scolecophidia, Anomalepididae, *Liotyphlops beui,* seasonal activity, daily activity, ecology.

Introduction

Information on seasonal activity in snakes is concentrated mainly in temperate areas, but recent studies have begun to examine this parameter in several Neotropical species (Gibbons and Semlitsch, 1987; Marques *et al.,* 2001, 2006; Maciel *et al.,* 2003). Data obtained from museum specimens or from institutions that receive a great number of snakes throughout the year can be permitted inferences on seasonal activity. Such data has helped to establish seasonal activity pattern in many species of tropical snakes including boids, elapids, viperids and colubrids (e.g., Salomão *et al.,* 1995; Marques *et al.,* 2001, 2006). Starting from available information on seasonal activity in tropical snakes it has been possible to detect several factors that can affect their activity patterns (cf. Marques *et al.,* 2001, 2006).

On the other hand, daily activity is an aspect that is little known in tropical snakes. The characterization of daily activity in Neotropical snakes is generally difficult to assess, mainly because many snakes are seldomly found in nature (but see Maciel *et al.,* 2003). However captive specimens can supply data on activity rhythms (e.g., Thomas and Thomas, 1978).

The Instituto Butantan (IB) receives a great number of snakes from São Paulo city throughout the year. The Pale-headed Blindsnake *Liotyphlops beui* (Figure 1) is one the most collected snakes in this locality. This snake belongs to the Anomalepididae family that includes 17 species and four genera (Kley, 2003). Anomalepidade, together with another two families (Typhlopidae and Leptotyphlopidae), composes the infraorder Scolecophidia (Greene, 1997). All these snakes, collectively called blindsnakes, are fossorial, have reduced eyes, and polished, round, equal-sized scales throughout a slender cylindrical body (Greene, 1997). Some ecological information is available for Leptotyphlopidae and Typhlopidae (e.g., Punzo, 1974; Webb and Shine, 1992, 1993; Webb *et al.,* 2000, 2001; Avila *et al.,* 2006). However, Anomalepididae is less studied than all other Scolecophidia and almost nothing is known about their behavior and ecology, beyond their restriction to tropical habitats (Greene, 1997). In the present study we characterize the daily and seasonal surface activity pattern of this fossorial snake from a locality from southeastern Brazil.

Material and Methods

Study area

The studied specimens came from São Paulo city (23°32'51"S, 46°38'10"W), an urban area in southeastern Brazil. São Paulo has fragments of secondary Atlantic forest, gardens and empty grounds (Prefeitura do Município de São Paulo, 2002). The climate in this region is humid tropical (Nimer, 1989; Prefeitura do Município de São Paulo, 2002) and can be characterized by two marked seasons: a dry one from April to

FIGURE 1. *Liotyphlops beui.*

September, with less rainfall and lower temperatures; and a rainy one from October to March, with higher rainfall incidence and temperature (Figure 2).

Data collection

We used records of specimens of snake arrival at the reception of the Instituto Butantan (IB), São Paulo. The seasonal activity pattern of *Liotyphops beui* was inferred from the number of snakes brought each month to the Laboratório de Herpetologia of IB, São Paulo, Brazil, mostly by laymen (see Oliveira and Martins, 2001), collected throughout a ten-year period (1994-2003). In the records of the IB the snakes are classified as adults or juveniles; the latter category usually is used to define newborns (Marques *et al.,* 2001). Juveniles were not used in our study in order to avoid interference due to recruitment. To compare the number of snakes collected in each season, we used a chi-square test and for the influence of the minimum and maximum temperatures and total precipitation on

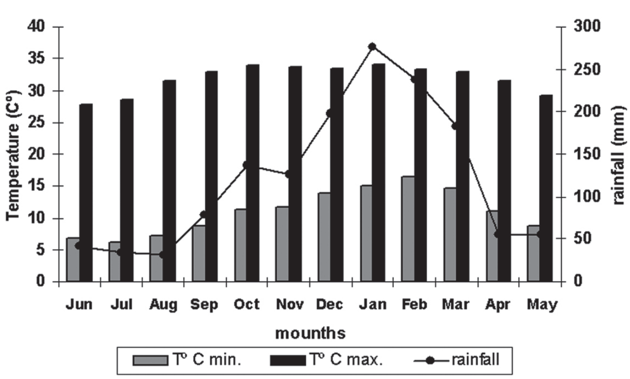

FIGURE 2. Average rainfall and temperature in São Paulo city (1994-2003). Data obtained in Instituto de Astronomia e Geociências da Universidade de São Paulo.

the activity throughout the year, we used a multiple regression test grouping data by month. Information and queries about the method used (e.g., influence of the collection effort throughout the year) can be found in Marques *et al.* (2001).

Data from captive snakes

We used 13 live snakes brought to the reception of the IB. Only three individuals (numbers 11, 12 and 13) were maintained in the dry season. Each specimen was placed in a terrarium measuring 50x15x50,5 cm containing soil substrate at 15 cm height. The air temperature in the terrarium is the same of the surroundings. We offered water and, three times a week, ant larvae and pupae as prey. When the food was not consumed, it was removed the following morning. Each captive snake was monitored 24 hours per day, during 10 days. The activity on the surface was records with and without food was analyzed in simple graphs. We used a closed-circuit television system for records of daily activity. The closed-circuit television systems include the program geo vision, a micro camera and night vision system.

RESULTS

During ten years (1994-2003), 309 adult specimens of *L. beui* were brought to IB, of which 81% ($X^2 = 87.50$; df = 1; $p < 0.0001$) were brought in the rainy season (October-March) (Figure 3) with peak observed in March. The number of specimens collected decreased in the beginning of the dry season, whereas a gradual increase occurred at the end of this season (Figure 3). The frequency of captures of adult females peaks in October and February, whereas adult males peak between January and March (Figure 4).

The *L. beui* activity was related with the minimum temperature but was not related with maximum temperature and the rainfall (Multiple Regression, $R^2 = -0.31$; $p < 0.05$; N = 120).

The daily surface activity of this snake was recorded from 17:40 to 00:40 h, peaking between 19:00 and 21:00 h (Figure 5A, B), decreasing considerably around 22:00 h. Activity after 23:00 h was recorded only in three of the 11 specimens maintained in the rainy season (number 1, 3 and 9). The activity on the surface usually started after 19:00 h, but one individual maintained in the dry season (number 13, see Figure 5A, B) frequently started its activity between

17:30 and 18:30 h and ceased always by 22:30 h and 23:00 h.

During the peak of activity, the temperature varied between 14.5 and 21ºC, with an average of 18.5ºC. The snakes were more active when food was available in the terrariums (with food, average = 2:27 h; without food, average = 1:35 h; Figures 5A, B). Activity on surface was not recorded during sunlight when the individuals remained underground. Some specimens remained stand still all time (see Figure 5). The activity usually started between 30 minutes to 2:30 h after sunset. The snakes were active for 69% (N = 39) of the days when food was offered, whereas they were active for only 50% (N = 86) of the days when food was not offered ($X^2 = 2.885$; df = 1; $p > 0.05$).

Discussion

The seasonal activity recorded in *L. beui* has been observed in other snakes from southeastern Brazil (Marques *et al.,* 2001). However, the decrease in activity of *L. beui* during the dry season is more pronounced than in any other species from southeastern Brazil (see Marques, 1996; Marques *et al.,* 2001, 2006). Only two specimens of *L. beui* were collected in June and July throughout 10 years; it was not observed in the other 11 species of Aletinophids snakes studied in southeastern Brazil in a same fashion (cf. Marques *et al.,* 2001). *Liotyphlops beui* belongs to the Scolecophidia, a group that is phylogenetically and ecologically very distinct to the Aletinophid snakes, thus this difference is not surprising.

Food availability throughout the year has been considered one of main factors explaining the activity of many Neotropical snakes (Henderson *et al.,* 1978, Marques *et al.,* 2001). Moreover, seasonal activity related to food availability was verified in several species of *Ramphotyphlops* sp. (Scolecophidia) from Australia. In the latter, specimens had prey in their gut mainly in the warm season (Webb and Shine, 1993). *Liotyphlops beui* is specialized in larvae and pupae on ants (Parpinelli, 2008). Generally the ants reproduce early in the rainy season, a period when many colonies appear (Tschinkel, 1998). Obviously, the increase of colonies in nature corresponds to the period of high food availability for *L. beui* which can explain the activity during the rainy season.

Rainfall and temperature seem to influence surface activity pattern of snakes (Gibbons and Semlitsch, 1987). Sometimes rainfalls can saturate soil with water, forcing subterranean snakes to go out to the surface. However, minimum temperature may be a more important factor in determining the surface activity of this snake. Temperature directly influences the metabolic rate of snakes (Lillywhite, 1987), limiting their movements.

Liotyphlops beui is a small and very slender snake which may result in low thermal inertia (Christian *et al.,* 2006). This snake is active on the surface of the ground only during nocturnal periods when air temperature is usually lower. These morphological and ecological traits probably stop individuals of *L. beui* from moving on the ground in cold days and can explain why this species is less collected in the dry season than other snakes from the same region.

However, if temperature is an important factor to determine the surface activity of *L. beui,* this is not true for the activity peak in March. The peak in March is not associated to elevate temperature, thus other factor can explain its higher activity in this month. Reproductive cycles usually affect the seasonal activity of snakes. In others Scolecophidia, the vitellogenic period in females occurs during spring and oviposition starts in summer (see Shine and Webb, 1990;

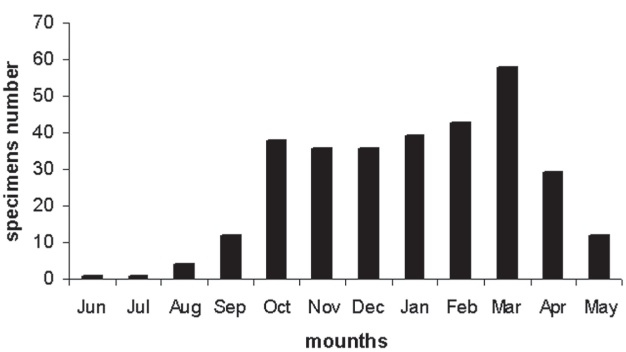

Figure 3. Number of adults (total length > 150 mm, n = 224) of *Liotyphlops beui* based on animals collected in São Paulo city and registered by Instituto Butantan between 1994-2003.

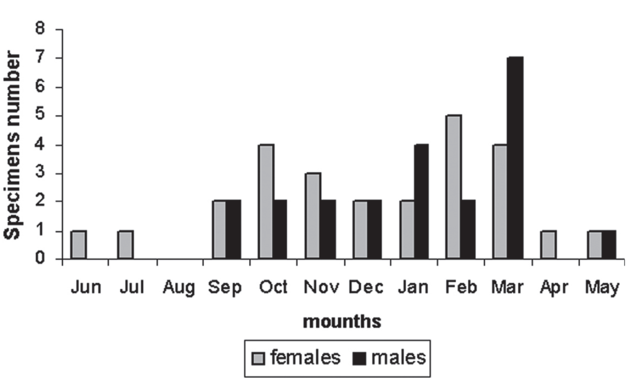

Figure 4. Number of adults (total length > 150 mm, n = 224) of *Liotyphlops beui* based on animals collected in São Paulo city and registered by Instituto Butantan between 2003-2007.

Webb *et al.,* 2000, 2001; Avila *et al.,* 2006). Previous data for *L. beui* indicate a similar cycle for females (Parpinelli, 2008). For some snakes with similar female reproductive patterns, mating occurs in the fall (e.g., Almeida-Santos *et al.,* 2004, 2006) and an activity peak in autumn was recorded for many snakes

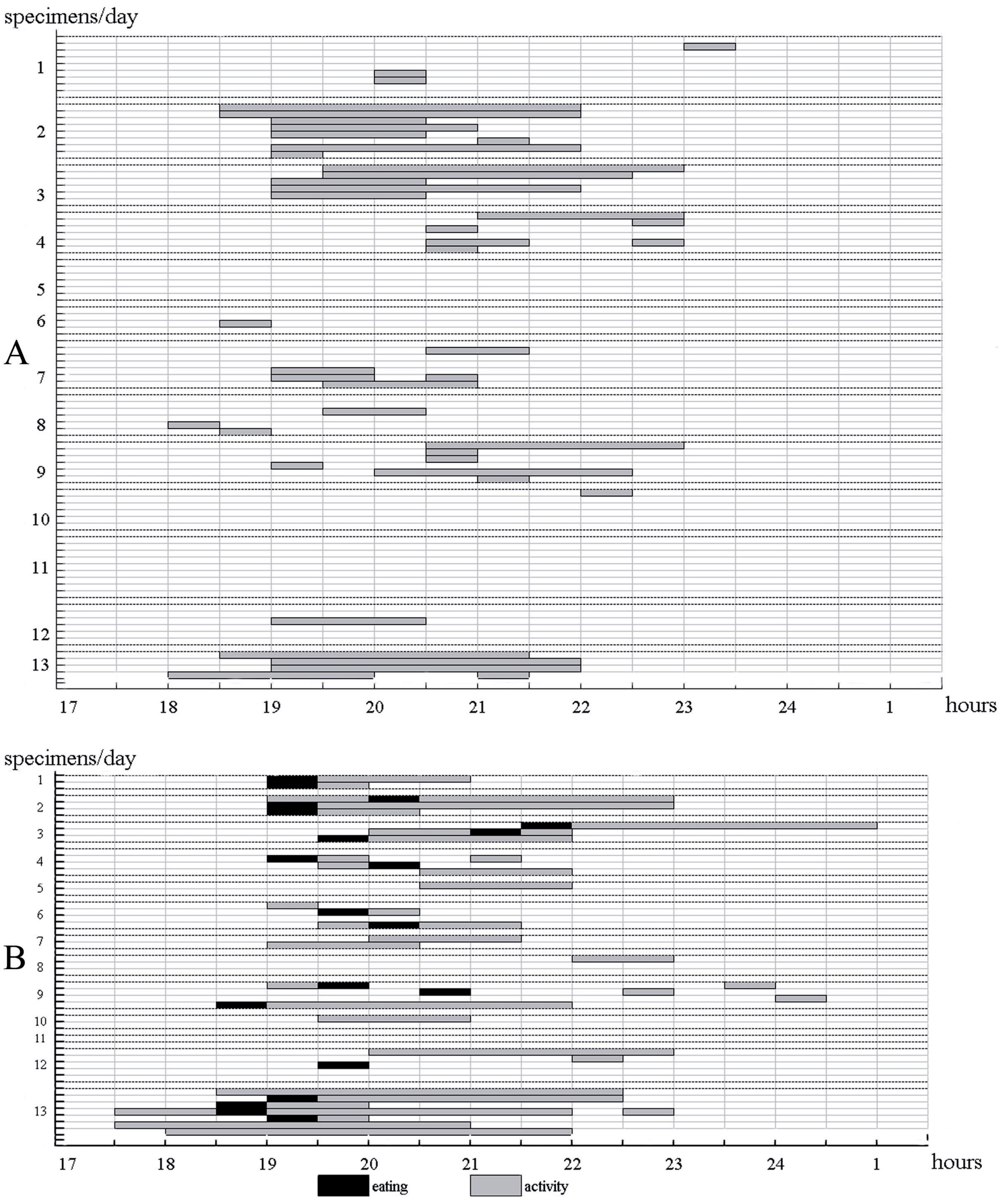

FIGURE 5. Daily surface activity of *Liotyphlops beui* based on captive snakes (n = 13). Each snake is represent between dotted lines. Lines without color correspond days without activity. A. Snakes that receive food. B. Snakes without food.

from southeastern Brazil (see Marques *et al.,* 2001). Thus, the peak in the fall can be result of mating in this period. A detailed study of reproductive cycles of *L. beui* in both sexes will be able to confirm this hypothesis (see Almeida-Santos *et al.,* 2006).

Nocturnal activity in *L. beui* was also recorded in other Scolecophidia, such as the North American *Typhlops biminiensis* and *T. pusilla* (Thomas and Thomas, 1978) and some Australian species of the genus *Ramphotyphlops* sp. (Shine and Webb, 1990) both members of Typhlopidae family. When placed in continuous light *T. biminiensis* was completely inactive for one week, indicating that light can influence its activity (Thomas and Thomas, 1978).

On the other hand, diurnal activity was recorded in *Leptotyphops diaplocius* (Leptotyphlopidae), a small Amazonian Leptotyphlopidae (ca. 200mm length) (Martins and Oliveira, 1998). However, preliminary data obtained by closed-circuit television on *Leptotyphlops koppesi* (Leptotyphlopidae) indicate a nocturnal activity too (pers. obs.). In the cryptozoic colubrid *Tantilla melanocephala* diurnal activity was recorded in the Amazon region, whereas this snake is nocturnal in southeastern Brazil (see Marques and Puorto, 1998; Martins and Oliveira, 1998). In the cryptozoic colubrid *Tantilla melanocephala* diurnal activity was recorded in the Amazon region, whereas this snake is nocturnal in southeastern Brazil (see Marques and Puorto, 1998; Martins and Oliveira, 1998). Thus, beside sunlight, other factors can influence the surface activity in fossorial or cryptozoic snakes.

Activity in *L. beui* occurs predominantly during the early dark hours. Temperature in the ground is lower at night and the snake probably does not keep an optimal body temperature for extended periods, limiting its activity to a short period. Moreover, the temperature value usually decreases between 1 and 2ºC after 12:00 h in São Paulo city (data obtained from Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo) being more difficult to be active after 12:00 h. The data obtained for one individual maintained in captivity during the dry season suggests that *L. beui* starts its activity earlier during the dry season. Additional observation including more individuals can confirm that hypotheses. Some snakes adjust their diel activity pattern in response to temperature (e.g., Heckrotte, 1962; Landreth, 1973) and such strategy may be occurring in *L. beui.* Additionally the diel activity may reflect the prey activity. *Solenopsis* ants are predominantly diurnal (Torres, 1984), thus during the nocturnal period the ants may be non-aggressive. Information on predator pressure is unknown, which is why, as in other animals, we cannot discount that predators may also be influencing the daily and seasonal activity of *L. beui.*

Resumo

A família Anomalepididae que inclui quatro gêneros e cerca de 17 espécies é a família menos estudada dentre os Scolecophidia. *Liotyphlops beui* é uma das espécies mais coletadas na cidade de São Paulo. No presente trabalho, estudamos a atividade sazonal e diária desta serpente fossorial. As serpentes são coletadas principalmente na estação quente e chuvosa, indicando uma atividade sazonal pronunciada. A temperatura mínima é o fator que melhor explica este padrão de atividade. A diminuição da atividade durante a estação seca e fria é mais pronunciada do que em qualquer outra serpente estudada do sudeste do Brasil. A morfologia e ecologia desta espécie podem explicar porque elas são menos coletadas na estação seca do que outras serpentes da mesma região. A atividade de *L. beui* ocorre durante as primeiras horas da noite, usualmente entre 19:00 e 21:00 h. Este curto período de atividade parece ser determinado pela intensidade luminosa e temperatura, embora a atividade da presa e/ou predador possam influenciar nesse padrão.

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