BEHAVORAL THERMOREGULATION IN *CTENOSAURA SIMILIS*

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Abstract. Heat regulation of *Ctenosaura similis* was examined to quantify behavior patterns as a function of time of day. We hypothesized that ctenosaurs alter their behavior to buffer their body temperatures from changing environmental conditions. During the morning, ctenosaurs spent relatively more time in the sun and less time active than during the midday and afternoon. Ctenosaurs fed only in the mid-day and late afternoon hours. Results support the hypothesis that ctenosaurs behaviorally thermoregulate.

Key words: Ctenosaura similis, *thermoregulation, poikilothermic behavior*

INTRODUCTION

Poikilotherms are dependent upon the environment for heat regulation. *Ctenosaura similis* is a large poikilothermic lizard found in the dry tropical forests of Costa Rica. They maintain a body temperature of 36 °C - 37 °C by modifying their behavior with changes in environmental conditions (Fitch and Hackworth-Jones 1983). Although behavioral thermoregulation has been observed (Fitch and Hackworth-Jones 1983), neither general activity levels nor time spent in various light environments have been analyzed quantitatively.

We hypothesized that ctenosaurs modify their behavior to buffer their body temperatures from diurnal fluctuations in environmental conditions. Specifically, we predicted that: (1) in the cool morning hours ctenosaurs will be inactive and will remain in the sun in order to retain body warmth; (2) in mid-day, when temperatures are highest, ctenosaurs will move to the shade to avoid overheating and will commence feeding and territorial defense; and (3) in late afternoon, when temperatures begin to drop, ctenosaurs will be less active and remain in the sun in order to maintain a warm body temperature.

METHODS

We studied ctenosaurs within Palo Verde National Park, Costa Rica on 11-12 January, 1996. Observations were conducted during two consecutive 30-minute blocks beginning at 0830, 1300 and 1600. At the beginning of each time block, we recorded air temperature (sun and shade) with a digital thermocouple thermometer. Ctenosaurs were then chosen opportunistically for each sample block without regard to size or sex. We observed ctenosaurs from an inconspicuous observation post 10 - 15 m from the lizard and classified their behavior into four categories: (1) stationary (ctenosaur did not move); (2) foraging (ctenosaur ate, or moved < 1 m to another food source); (3) head bobbing (> 4 consecutive head bobs); and (4) movement (ctenosaur moved to another location without feeding). The amount of time dedicated to each activity was recorded and classified as to whether it occurred in the sun or shade. If the ctenosaur was in mixed sun and shade, we determined whether the majority of its body was in the sun or the shade. We tested for diurnal changes in behavior patterns with one-way ANOVAs.

RESULTS

Temperatures in both direct sun and shade were relatively cool in the morning, warm during the mid-day, and cool in the late afternoon (Table 1). Ctenosaurs spent significantlymore time in the sun during the morning than during either the mid-day or afternoon ($F = 5.02$, $df = 2$, $P = 0.01$; Figure 1). Ctenosaurs maintained consistent activity levels throughout the day ($F = 0.35$, $df = 2$, $P = 0.71$; Figure 2), although feeding tended to be restricted to the mid-day and late afternoon hours.

Table 1: Average temperatures (n = 2 per average) in the sun and shade for 11-12 January, 1996 at Palo Verde National Park, Costa Rica.

	Air Temperature (°C)	
	Sun	Shade
0830	30.4	27.7
1300	39.1	33.3
1600	30.7	29.0

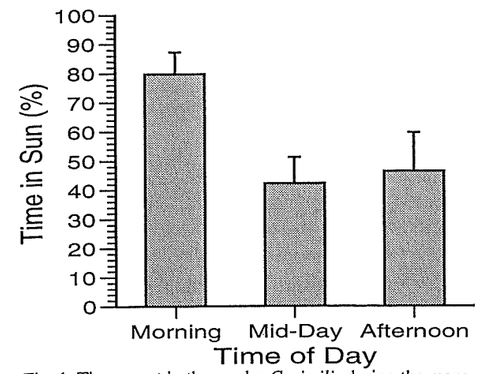

Fig. 1. Time spent in the sun by *C. similis* during the morning, mid-day and afternoon (n = 12, 12, and 8, respectively) at Palo Verde National Park, Costa Rica.

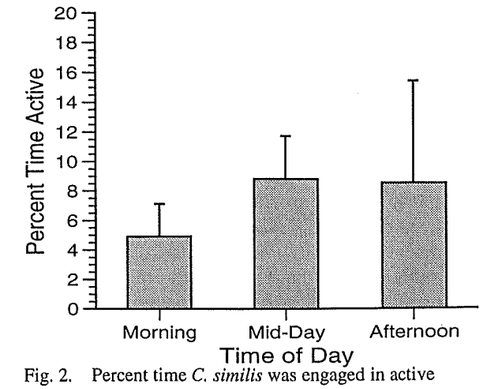

Fig. 2. Percent time *C. similis* was engaged in active behavior (aggression, feeding, moving) during hour-long observations as a function of time of day at Palo Verde National Park, Costa Rica.

DISCUSSION

Ctenosaurs change behavior with time of day. Ctenosaurs spent the majority of the morning in the sun, presumably to raise their body temperature to 36-37 °C. During the afternoon, ctenosaurs split their time between sun and shade, possibly fine-tuning their body temperature. Activity levels were generally higher in the mid-day and afternoon when temperatures were higher, suggesting that their behavior is temperature-dependent.

Ctenosaurs did most of their feeding during the midday and late afternoon. It could be that ctenosaurs require a body temperature of 36 - 37 °C to digest food efficiently. If so, basking behavior in the early morning might be a necessary prelude for feeding and other activities later in the day. While the lizard moves around in the morning without much thermoregulation, it may require higher temperatures to digest. Temperature dependent digestion may be an interesting topic for future research.

Ctenosaurs were difficult to find late in the afternoon. However, the lizards that were active during the late afternoon remained as active as those observed during mid-day, despite the cooling ambient temperatures. This could be partly a sampling artifact, because the lizards we could not observe may have had generally cooler body temperatures and lower activity levels than those we could observe. Further study could follow individual lizards throughout the day to test whether diurnal behavior patterns arerelated to the time when they retire to the burrow in the afternoon. Additional studies could (1) compare response times to stimuli at different times during the day to test for temperature affects; or (2) compare the diurnal activity patterns of lizards of different sizes, sexes, and colors.

LITERATURE CITED

Fitch, H. S. and J. Hackworth-Jones. 1983. *Ctenosaura similis*. Pages. 394-396 *in* D. H. Janzen, editor. Costa Rican Natural History. University of Chicago Press, Chicago, Illinois, USA.