would be interesting to study the effects of this and other substrates on ant lion capture efficiency. Ant lion larvae exhibit exploratory behavior prior to pit construction (McClure 1983). In a pilot study we conducted, ant lions in "foreign" soils took much longer to build traps than those placed in the soil type from which they were taken. Future study might address ant lion preference for different substrates.

LITERATURE CITED

McClure, M. S. 1976. Spatial distribution of pit-making ant lion larvae (Neuroptera: Myrmeleontidae) : Density effects. *Biotropica*. 8:179-83

McClure, M. S. 1983. *Myrmeleon* (Hormiga Leon, Ant Lions). Pages 742-743 in D. H. Janzen, editor, Costa Rican Natural History. University of Chicago Press, Chicago, USA.

DIURNAL BEHAVIOR PATTERNS OF DOMINANT MALE CTENOSAURS (*CTENOSAURA SIMILIS*)

CARTER D. WRAY

Abstract. Behaviors of heliothermic animals, such as the iguanid lizard *Ctenosaura similis*, are expected to change with ambient temperature during different times of day. I used territorial head bobbing, thermal regulation, and feeding to quantify the daily behavior patterns of dominant male ctenosaurs. In the morning they spent more time basking in the sun, and bobbed their heads less frequently than in the afternoon, indicating strong diurnal behavior patterns. The low morning activity evidenced by low head bobbing rates indicates that the ctenosaurs may be temperature limited and must spend the mornings warming themselves in the sun.

INTRODUCTION

Ctenosaurs depend on the sun for thermal regulation, so their activity should change from morning to afternoon. When temperatures are low in the morning, they should spend more time warming themselves in the sun than in the afternoon when the ambient temperature may be high enough to allow activity in the shade. If temperatures rise too high in the afternoon, ctenosaurs may have to remain in the shade to avoid heat stress.

Male ctenosaurs are highly territorial and bob their heads to assert their dominance and to keep rival males out of their territories (Fitch and Hackforth-Jones 1983). Higher activity later in the day should cause head bobbing by dominant males to be more frequent in the afternoon than in the morning.

The time of day during which ctenosaurs do the majority of their feeding should depend on their diet. They are insectivorous when young, but are almost entirely herbivorous when mature (K. Hanley, pers. comm.). During the dry season the adult ctenosaur's diet should consist primarily of low lying leaves of shrubs, the most prevalent form of accessible green plant tissue. At my study site this food source occurred almost exclusively in the shade. Unless ambient temperature is high enough to allow activity in the shade, access to the food there may be limited. Therefore adult ctenosaurs during the dry season should forage more in the afternoon when the air is warm enough for them to be able to spend time out of the sun.

METHODS

I observed large male ctenosaurs (snout-vent length >50 cm) in Palo Verde National Wildlife Refuge, Costa Rica, which occupied territories either around the administration buildings or the O.T.S. research station. These locations were chosen for their high densities of lizards which were accustomed to human presence. I observed the lizards through binoculars whenever possible to avoid approaching them. However the effect of having "enlarged eyes" may have elicited a stronger response than if had I observed them at a closer distance without binoculars (Burger et al. 1991).

On 11-13 January 1995, I observed individual ctenosaurs for half hour periods, noting number of head bobbing bouts and time spent in the sun versus in the shade. Bouts of head bobbing were defined as more than five consecutive vertical head motions. Pauses greater than two seconds between motions separated bouts. Time in the sun and time in the shade were calculated by noting motions to and from sunny areas. "Sunny areas" were defined as those within which the ctenosaur was >50% in direct sunlight, while "shady areas" were those in which ≤50% of the lizard was in the sun. All time was assigned to one of these two categories. Time spent foraging was also quantified.

Eight individuals were observed in the morning, but only four in the afternoon due to an unseasonal rainstorm. Some lizards were observed on more than one morning, in which case all morning data for each individual were averaged and considered as one data point. The same was done for one individual observed on two afternoons.

To determine the effect of the rain event on ctenosaur behavior, I walked around the study area 45 min. after the rainstorm began, and recorded the presence of all visible ctenosaurs.

RESULTS

The ctenosaurs spent significantly more time in the sun in the morning (21.5 ± 2.8 min. per 30 minute interval, mean ± 1 SE) than in the afternoon (5.0 ± 1.5 min., Student's T-test, t=3.99, df=10, P=0.003; Fig. 1). They also displayed less head bobbing behavior in the morning (8.3 ± 2.0 bouts per 30 minute interval) than in the afternoon (18.8 ± 1.4 bouts, Student's T-test, t=-3.484, df=10, P=0.006; Fig. 1).

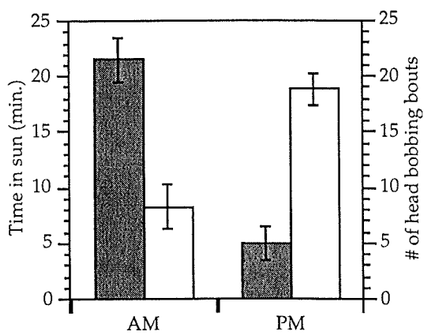

Fig. 1 Time in sun and head bobbing bouts of *Ctenosaura similis* in the morning (N=8) versus afternoon (N=4); gray bars represent time in sun, white bars represent number of head bobbing bouts (per 30 min. observation period).

During the rainstorm, I observed 13 lizards out of their burrows. This number is roughly equivalent to the number I saw on the same walk on a sunny day. I frightened two large males into their burrows, but they re-emerged after ten minutes.

DISCUSSION

There were strong diurnal patterns of increasing activity later in the day, as indicated by both increased head bobbing and decreased basking. The claim (Fitch and Hackforth-Jones 1983) that ctenosaurs spend the majority of their time basking in the sun held true only during the morning hours. The low morning activity evidenced by low head bobbing rates indicates that the ctenosaurs may be temperature limited and must spend the mornings warming themselves in the sun. In the afternoon the higher ambient temperature allows higher activity and may cause the ctenosaurs to spend some time in the shade to prevent overheating.

I observed too few foraging events to detect any diurnal trend. In their study of ctenosaur time allocation at the same study site, Shaffer and Rodrigues also found low foraging rates: only three instances in approximately nine hours of observation time (1988). At this site, garbage from nearby buildings was available to the ctenosaurs. This supplementation may cause the observed feeding behavior to be less frequent than that of a wild population. Females and small males were observed feeding at the feeding trough behind the administration buildings, but no large males This may indicate that large males may be unwilling to cross the territories of other males adjacent to the food source.

Location of food in the shade may limit the time spent foraging . Food in the shade may be less accessible to heliothermic ctenosaurs in the morning than in the afternoon. This may impose temporal restrictions on foraging and therefore on ctenosaur growth rates.

Due to the low digestibility of leaves, adult ctenosaurs may have to spend much of their basking time digesting (K. Hanley pers. comm.). If so, morning foraging would be more efficient in terms of nutrient uptake than afternoon foraging, because lizards could spend more time basking to further expedite their digestive process. The shorter time available to digest foods consumed in the afternoon could also compound the restrictions on nutrient

uptake caused by decreased potential foraging time in the morning.

Larger studies of ctenosaur populations without augmented diets are needed to elucidate the relationship between morning and afternoon foraging times. Other studies should also determine if time in the shade limits foraging time of adults during the dry season.

The finding that roughly the same number of ctenosaurs were observed before and during the rainstorm and especially the re-emergence of two males indicate the ctenosaurs' willingness to remain outside in spite of the weather conditions. This contradicts Fitch and Hackforth-Jones (1983), who said that ctenosaurs remain outside only briefly in cloudy weather conditions. Study of these animals during the wet season could shed more light on ctenosaurs' reactions to varying weather conditions.

LITERATURE CITED

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

Burger, J., M. Gochfield, and B. G. Murray, JR. 1991. Role of a predator's eye size in risk perception by black iguana, *Ctenosaura similis*. Animal Behavior, 42: 471-476

Shaffer, M., and J. Rodrigues, 1988. Time Allocation in *Ctenosaura similis*. Pages 162-165 *in* O.T.S. Tropical Biology.