Though the relationship was statistically insignificant, our data suggest that site may have had an effect on *J. pungens* abundance and height across the two forest types. These patterns may be related to variation in topography, soil, and moisture between the three study sites. In particular, the high saddle evergreen subsite has deep, moist soils, while the paired deciduous subsite, below the limestone cliffs, was rocky and dry. This may explain why the patterns at this site (Site 1) differ from those in the other two sites (Figs. 1 and 2).

Literature Cited

Janzen, D. H. 1983. *Jacquinia pungens*. Pp. 265-266 *in* D. H. Janzen, editor. Costa Rican Natural History. The University of Chicago Press, Chicago, IL, USA.

Behavioral response of *Ctenosaura similis* to perceived risk at different basking temperatures

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Abstract: Ctenosaura similis must bask in order to reach optimal body temperature, and therefore we hypothesized that ctenosaur risk tolerance would be affected by ambient temperature. We measured the distance between the approaching investigator and the ctenosaur at the time of retreat and the ambient temperature of the basking spot. Results differed between day one and two. The distance from the investigator to ctenosaur increased with the basking spot temperature on day 1. On day 2, ctenosaurs retreated at shorter approach distances and made more preliminary movements as the basking spot temperature increased. The results supported the hypothesis that ctenosaur response to a perceived risk changes with basking temperature.

Key Words: approach distance, conditional response, heliothermic, predator risk

Introduction

One source of variation in behavioral studies is conditional response, or behavior that varies according to the environmental and physiological state of an organism. The iguanid lizard *Ctenosaura similis* exhibits several documented conditional responses. Because ctenosaurs are heliothermic and bask in order to reach and maintain a body temperature, posture and basking behavior change through the day based on body and ambient temperatures (Fitch and Hackforth-Jones 1983). Ctenosaurs also react conditionally to percieved predators based on predator appearance (Burger et al. 1991), predator behavior (Burger and Gochfeld 1990), and the ctenosaur's habituation to predator presence (McLaren et al. 2000). We expected that tolerance of risk from predators is also conditional upon temperature. Risk tolerance, measured either as the distance at which an individual flees from a predator, or as the number of movements associated with the approach of a predator, should therefore be correlated with the temperature of a ctenosaur's basking location.

Methods

After locating a basking ctenosaur, a designated person (the Scare Unit) approached the ctenosaur at a steady rate (approximately one step per second) in a direct line. We took note of all lizard movements up to and including a final retreat, defined as a clear movement away from the Scare Unit. We measured the distance from the Scare Unit's position to the location of each ctenosaur movement, the "approach distance". Surface temperature at the ctenosaur's initial basking position was measured with a digital thermometer. For analysis, the basking spot temperature data was normalized by common-log transformation.

Results

The effect of basking spot temperature on the approach distance was significantly different between sampling days (multiple regression, $F = 3.39$, $df = 3,21$, $P = 0.037$). We found a significant difference in the basking spot temperatures between the days (t-test = 2.43, $df = 23$, $P = 0.023$). The average temperatures for day 1 and day 2 were 31.5 ± 0.44°C and 29.9 ± 0.49°C respectively. Because of this, we separated the days for analysis. The approach distance significantly increased with the basking spot temperature on day 1 ($r^2 = 0.42$, $df = 12$, $P = 0.009$, Fig. 1). On day 2, there

was an opposite, insignificant trend ($r^2 = 0.13$, df = 11, P = 0.14). On day 1, ctenosaurs made fewer preliminary movements as the basking spot temperature increased ($r^2 = 0.22$, df = 11, P = 0.072). On day 2, the ctenosaurs were significantly more likely to make preliminary movements as the basking spot temperature increased ($r^2 = 0.40$, df = 11, P = 0.017, Fig. 2). When data from both days are pooled, the approach distance decreases with increasing number of preliminary movements ($r^2 = 0.21$, df = 23, P = 0.015, Fig. 3). Pooled data also showed a suggestive but insignificant middle range of basking spot temperatures in which the approach distance was smallest ($r^2 = 0.11$, df = 2,22, P = 0.11).

Discussion

Ctenosaur behavior changes with variations in basking spot and ambient temperature. On day 1, when the mean ambient temperature was higher, the approach distance increased with increasing basking spot temperature. This trend might be explained by an increase in activity level due to temperature, resulting in earlier retreat. On day 2, when the mean ambient temperature was lower, preliminary ctenosaur movements increased with an increase in basking spot temperature, indicating that ctenosaurs may exhibit more risk tolerant behavior as a tradeoff for reaching their optimal body temperature. In warmer spots, which are presumably more efficient for thermoregulation, ctenosaurs accept greater risk by delaying full retreat. The overall increase in preliminary movements with decreasing approach distance suggests a continual assessment of risk.

The fact that sampling days produced different responses was an unanticipated result. The difference in mean temperature between days suggests that risk tolerance depends not only on basking spot temperatures, but also on ambient temperatures. The decrease of approach distance in the middle range of temperatures covered over both days suggests that this range may favor risk tolerance over the loss of a chosen basking spot.

The tendency of ctenosaurs to adjust their response to perceived risk based on temperature illustrates the complexity of behaviors affecting animal interactions.

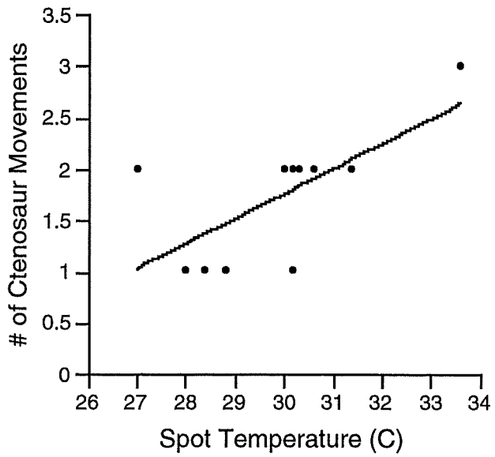

Fig. 2. Total ctenosaur movements as a function of basking spot temperature on day 2. Ctenosaurs made more movements before retreat as spot temperature increased.

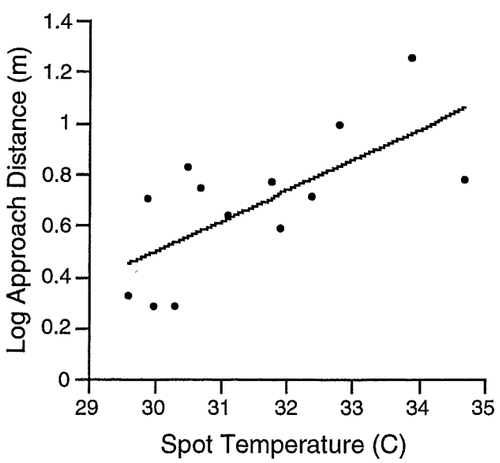

Fig. 1. Approach distance as a function of the basking spot temperature on day 1. As the basking spot temperature increases, ctenosaurs retreat at a greater distance from the Scare Unit.

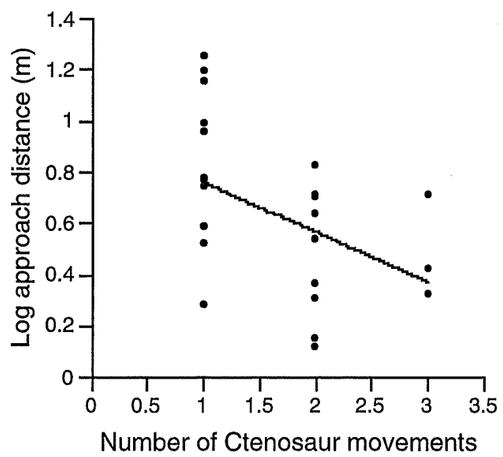

Fig. 3. Appraoch distance as a function of the number of Ctenosaur movements. More anticipatory movements before lizard retreat signficantly corresponds to a closer approach of our Scare Unit.

Literature Cited

Burger, J. and Gochfeld, M. 1990. Risk discrimination of direct versus tangential approach by basking black iguana (*Ctenosaura similis*): variation as a function of human behaviour. *Journal of Comparative Psychology* 104: 388-394.

Burger, J., M. Gochfeld, and B. G. Murray, Jr. 1990. Role of a predator's eye size in risk perception by basking black iguana, *Ctenosaura similis*. *Animal Behavior*. 42: 471-476.

McLaren, Z. M., C. B. Shannon, K. W. Manaras, J. S. Veysey, and J. A. Macintosh. 2000. Effects of human habituation on anti-predator behavior of *Ctenosaura similis*. Pp. 18-21 *in* L. E. Aucoin, M. N. Conte, and J. A. Macintosh, editors. Dartmouth Studies in Tropical Ecology 2000. Dartmouth College, Hanover, New Hampshire, USA.

Fitch, H. S. and J. Hackforth-Jones. 1983. *Ctenosaura similis*. Pp. 394-6 *in* D. H. Janzen, editor. Costa Rican Natural History. The University of Chicago Press, Chicago, IL, USA.