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**The Influence of Temperature
and Humidity on Activity
Patterns of the Lizards *Anolis
stratulus* and *Ameiva exsul* in the
British Virgin Islands**

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ABSTRACT.—Many organisms modify their behavior to reduce exposure to unfavorable abiotic conditions, but detailed information is available for only a few species. We studied the diurnal activity patterns of *Anolis stratulus* and *Ameiva exsul* on Guana Island, British Virgin Islands, in order to determine how they are affected by temperature and humidity. We surveyed transects on foot between 0730 and

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1700 h, scanned the ground and vegetation for visible lizards and recorded temperature and relative humidity. Lizard activity patterns were influenced by ambient conditions and body size. We found an inverse relationship between daily activity patterns and temperatures for juvenile *A. stratulus*; the cooler the temperature, the more juveniles were present. Adult *A. stratulus* did not show any significant correlations with temperature and time of day. Temperature and abundance were strongly positively correlated for *A. exsul*; the higher the temperature, the more abundant *A. exsul* became. Activity was strongly significantly correlated with humidity. Because temperature and relative humidity were significantly inversely correlated, we cannot identify which parameter most impacted lizard activity.

KEYWORDS.—body size, temperature, relative humidity, water loss, Guana Island

Thermoregulation is a primary activity of ectotherms. Many reptiles such as lizards act to reduce exposure to unfavorable abiotic conditions by simply moving out of direct sunlight or by increasing their water intake. Thus, understanding the relationship between abiotic conditions and activity patterns can be important in understanding the ecology of such animals. Here we report on the daily activity patterns of two lizard species in the British Virgin Islands (BVI), and the effects of temperature and humidity on those activity patterns. The two were chosen as representatives of the genera *Anolis* and *Ameiva* which constitute a large percentage of the diurnally active lizards in the West Indies.

Lizards have often served as model organisms in ecological studies (e.g., Milstead 1967; Vitt and Pianka 1994). Because of their abundance and visible nature, *Anolis* lizards have been especially extensively investigated (Roughgarden 1995; Reagan 1996). *Anolis stratulus* (adult mass approximately 1.7 g; Butler and Losos 2002) has received considerable attention, with studies ranging from habitat use (Dial et al. 1994) to molecular systematics (Jackman et al. 1999). *Ameiva exsul* (adult mass approximately 40 g; Lewis and Saliva 1987) is also a highly visible and well-studied species (Lewis and Saliva 1987). Both species are common on the islands of the Greater Puerto Rico Bank, including our study site,

Guana Island. Activity patterns and their correlates have not been previously reported for either species, although R. Powell and R.W. Henderson (unpublished data) observed that activity of *A. exsul* on Guana Island, BVI, primarily occurred between 0930 and 1400 hours.

Guana Island is a privately-owned wildlife sanctuary characterized by temperatures ranging from 27–33 °C, a relative humidity of 60–90% (Dmi'el et al. 1997), and an annual rainfall of about 900 mm (G. Perry, unpublished data). The island has an area of approximately 300 ha and a maximum elevation of 240 m (Lazell 1996, 2005). Additional details regarding the study island are in Lazell (1996, 2005).

To investigate the activity patterns of *A. stratulus* and *A. exsul*, we established twelve 50 m transects along existing trails during October 2003. A single observer repeatedly surveyed the entire length of each transect on foot between 0730 and 1700h. During each hourly pass, the observer would sample the same six stations, located 10 m apart. At each station, the observer examined the ground and vegetation for lizards, taking one minute to complete a 180° scan of the vegetation within a 2 m radius. The count was repeated five consecutive times at each station, for a total of 5 minutes at each location, and the number of lizards seen during the most productive one-minute count was recorded. Each transect required 30 min to complete, and a 30 min pause separated consecutive passes, resulting in 10 sampling cycles per day. Twelve daily samples were used in calculating the total numbers of animals observed.

Perry et al. (unpublished MS) reported that smaller body size makes individual lizards more prone to water loss in *Anolis cristatellus* and *A. exsul*. Based on this work, the authors predicted that water conservation requirements will force smaller lizards to be active during cooler and more humid times of day. They suggested that adults may be able to retain water more efficiently than juveniles, who have a larger surface-area-to-body-size ratio. Juveniles should therefore decrease activity during the hottest part of the day to avoid water loss, es-

pecially in water-restricted locations such as Guana. To test this prediction, we categorized *A. stratulus* into two size classes, juvenile and adult, based on lack of dewlap development in juveniles (G. Perry and K. LeVering, unpublished). Size classes of *A. exsul*, which is less common on Guana, were combined to obtain an adequate sample size. To avoid artifacts caused by aberrant climatic conditions such as heavy rainfall, counts were conducted only during days with climatic conditions conducive to lizard activity. We recorded ambient temperatures ($^{\circ}\text{C}$) and relative humidities (%) at five minute intervals by placing a datalogger at the starting point of each transect. To avoid making assumptions about data distribution, we used Spearman's non-parametric test of correlation for all analyses of relationship between climatic conditions and lizard activity.

We recorded a total of 140 *A. stratulus* sightings during our surveys, of which 56 were adults and 84 juveniles. Both adult and juvenile *A. stratulus* showed variation in activity levels during the day. However, the activity levels of adults (Fig. 1A) were not significantly correlated with either temperature (Fig. 1D; $\rho = 0.534$, $N = 10$, $P = 0.112$) or relative humidity ($\rho = -0.222$, $N = 10$, $P = 0.537$). In contrast, juvenile ac-

tivity levels (Fig. 1B) were negatively related to temperature ($\rho = -0.684$, $N = 10$, $P = 0.029$) and positively related to relative humidity ($\rho = 0.720$, $N = 10$, $P = 0.019$). Temperature and relative humidity were also negatively correlated to one another ($\rho = 0.848$, $N = 10$, $P = 0.002$), making it difficult to distinguish which factor lizard activity patterns were responding.

We encountered 43 *A. exsul* of all sizes, and their activity pattern was different than that observed in *Anolis*. Number of sightings was positively correlated with temperature for *A. exsul* (Fig. 1C; $\rho = 0.800$; $N = 10$, $P = 0.005$), and negatively correlated with relative humidity ($\rho = -0.804$; $N = 10$, $P = 0.005$). Few individual *Ameiva* were active during the cooler parts of the day and most observations occurred during the warmer, drier surveys. Activity peaked between 1430h and 1500h. R. Powell and R.W. Henderson (unpublished) report similar activity times in *A. exsul* from Guana. Similarly, activity in *Ameiva erythrocephala* begins at 0930, peaks midday, and ceases by 1600 h (Kerr et al. 2005). Thus, the activity pattern we describe, although not previously documented in detail, is not surprising.

Although both species are diurnal, *A. exsul* and *A. stratulus* are most active at different times of the day. The physiological differences between the two species may partially explain this pattern: members of the genus *Anolis* are typically thermoconformers, whereas teiid genera such as *Ameiva* are normally heliothermic (Hertz 1992; Rivera-Vélez and Lewis 1994; Rogowitz 2003). However, this does not explain the intraspecific difference within *A. stratulus*. Juvenile *A. stratulus* are active during the coolest, most humid parts of the day, adult *A. stratulus* are active throughout the day, and the much larger *A. exsul* are preferentially active during the hottest part of the day. We believe that this difference is related to differences in body size and the effects they have on water loss rates (Perry et al. submitted). Our results thus support Perry's et al. (submitted) conclusion that smaller body size makes individual lizards more prone to water loss, and that this will affect their ecology, especially in water-

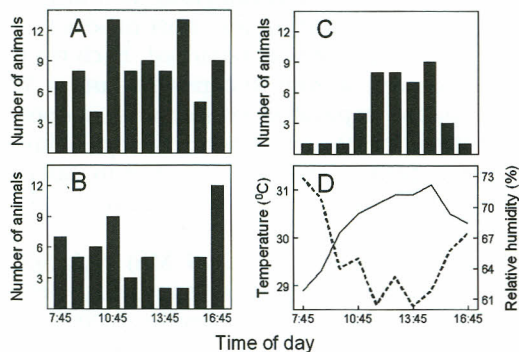


FIG. 1. Numbers of adult (A) and juvenile (B) *Anolis stratulus* and all *Ameiva exsul* (C) recorded between 0730-1700 h on Guana Island, British Virgin Islands. Bars represent the combined totals from twelve transects. Ambient conditions (relative humidity and temperature) measured during a typical study day are presented in D. Adult *A. stratulus* showed similar activity levels throughout the day, whereas juveniles were less active during the hot and dry midday. In contrast, *A. exsul* are primarily active during midday.

restricted locations such as Guana Island. Unfortunately, the need to lump data for *A. exsul* of different sizes may obscure size-related differences in activity patterns within that species as well. We predict that a larger sample size would show that adult *A. exsul* are active at warmer parts of the day than are juveniles. In fact, Kerr et al. (2005) cite studies in which bimodal activity patterns were seen in other *Ameiva*.

It has long been known that different species are active at different times of day, and that this has profound consequences for their ecology at both the autecological and community ecology level. The effects of body size at multiple levels are also well known (e.g., Perry and Garland 2002 for home range size). Our study demonstrates that the two factors interact in ecologically important ways. Further, it indicates that further research needs to consider this interaction when studying variability in activity patterns.

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LITERATURE CITED

- Butler, M. A., and J. B. Losos. 2002. Multivariate sexual dimorphism, sexual selection, and adaptation in Greater Antillean *Anolis* lizards. *Ecol. Monog.* 72(4): 541-559.
- Dial, R., J. Roughgarden, and S. C. Tobin. 1994. Notes on the absolute abundance of canopy anoles, *Anolis cuvieri*, *A. stratulus*, and *A. evermanni* (Lacertilia: Polychridae) in the Luquillo forest, Puerto Rico. *Caribb. J. Sci* 30(3-4):278-279.
- Dmi'el, R., G. Perry, and J. Lazell. 1997. Evaporative water loss in nine insular populations of the *Anolis cristatellus* group in the British Virgin Islands. *Biotropica* 29(1):111-116.
- Hertz, P. E. 1992. Temperature regulation in Puerto Rican *Anolis* lizards: a field test using null hypotheses. *Ecology* 73(4):1405-1417.
- Jackman, T. R., A. Larson, K. de Quiroz, and J. B. Losos. 1999. Phylogenetic relationships and tempo of early diversification in *Anolis* lizards. *Syst. Biol.* 48(2):254-285.
- Kerr, A. M., R. Powell, and J. S. Parmerlee. 2005. *Ameiva erythrocephala* (Teiidae) on Sint Eustatius, Netherlands Antilles: Baseline data on a small population in a severely altered habitat. *Caribb. J. Sci* 41(1): 162-169.
- Lazell, J. 1996. *Guana Island. A Natural History Guide*. Jamestown, Rhode Island: The Conservation Agency.
- Lazell, J. 2005. *Island: Fact and Theory in Nature*. Berkeley, California: University of California Press. 416 pp.
- Lewis, A. R., and J. E. Saliva. 1987. Effects of sex and size on home range dominance, and activity budgets in *Ameiva exsul* (Lacertilia: Teiidae). *Herpetologica* 43(3):374-383.
- Milstead, W. W., ed. 1967. *Lizard Ecology: A Symposium*. Columbia, Missouri: University of Missouri Press.
- Perry, G., and T. Garland, Jr. 2002. Lizard home ranges revisited: effects of sex, body size, diet, habitat, and phylogeny. *Ecology* 83(7):1870-1885.
- Reagan, D. P. 1996. Anoline lizards. In *The Food Web of a Tropical Rain-Forest*, eds. D. P. Reagan and R. B. Wade, 321-345. Chicago, Illinois and London: University of Chicago Press.
- Rivera-Vélez, N., and A. R. Lewis. 1994. Threshold temperatures and the thermal cycle of a heliothermic lizard. *J. Herpetol.* 28(1):1-6.
- Rogowitz, G. L. 2003. Analysis of energy expenditure of *Anolis* lizards in relation to thermal and structural niches: phylogenetically independent comparisons. *J. Herpetol.* 37(1):82-91.
- Roughgarden, J. 1995. *Anolis lizards of the Caribbean: Ecology, Evolution, and Plate Tectonics*. New York, New York: Oxford University Press.
- Vitt, L. J., and E. R. Pianka, eds. 1994. *Lizard Ecology: Historical and Experimental Perspectives*. Princeton, New Jersey: Princeton University Press.