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Body Size and Timing of Reproduction in the Highly Endangered Stout Iguana, *Cyclura pinguis*, in the British Virgin Islands

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ABSTRACT.—**The stout iguana, *Cyclura pinguis* (also known as the Anegada iguana), survives only in the British Virgin Islands and the total population is believed to be about 250 individuals. The sole remaining natural population, on Anegada, is declining in both numbers and area inhabited. Several extra-limital populations have been established, and here we report on body size and timing of egg-laying in the Guana Island population, which is thriving. Egg laying occurs in June and July, and hatchlings emerge in September and October. For hatchlings, mean snout-vent length was 108 mm, mean undamaged tail length was 197 mm, and mean mass was 60 g. Growth of hatchlings is rapid. Overall, the relationship between log mass and log body length is statistically significant. Comparisons to data published for Anegada animals show that iguanas of similar length weigh more on Guana, suggesting possible food limitation in the Anegada population. Until progress is made towards establishing a national park on Anegada, reintroduced populations, such as the one on Guana, constitute a critically important precautionary measure for *Cyclura pinguis*. Moreover, we strongly recommend enhancing the Guana gene pool.**

KEYWORDS.—**Conservation, British Virgin Islands, lizard, Iguanidae, Guana Island**

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All iguanas of the genus *Cyclura* are considered threatened or endangered under the World Conservation Union (IUCN) Red List criteria. Still, most remain poorly studied (Alberts, 2000). The stout iguana, *C. pinguis* (also known as the Anegada iguana), is thought to have originally inhabited the entire Greater Puerto-Rico Bank (Pregill, 1981; Lazell, 2002, 2005). Today, however, the species survives only in the British Virgin Islands (BVI; Binns, 2003). Until recently, the only surviving population existed on the island of Anegada (approximately 38 km^2), where introduced herbivores, feral predators, and increasing development greatly degraded conditions for the species and caused a major population decline (Carey, 1975; Mitchell, 1999; Lazell, 2002). Because the species is so rare, our data are considerably less extensive than we would like. Unfortunately, similar problems plague many species of Caribbean iguanas (e.g., Mitchell et al., 2002, for *C. carinata* in the Turks and Caicos).

After reviewing the current situation in the wild, Lemm et al. (2005) concluded that conditions "justify an ex-situ conservation program as a safeguard against extinction" for this species. Over the last twenty years, *C. pinguis* has been translocated to a number of islands in the BVI (Lazell, 2002; J. Lazell, unpubl. data). Of the translocated populations, the one on Guana Island has been best studied (e.g., Goodyear and Lazell, 1994; Mitchell, 1999; Perry et al., 2003) and appears to be flourishing (Mitchell, 2000; Perry and Mitchell, 2003). The population on Necker Island is also expanding (Lazell, 2000; Binns, 2003). However, the other reintroductions are too recent for proper evaluation. Conservation efforts also include a headstarting facility on Anegada, which has lately released 24 individuals back into the wild (Binns, 2003; Bradley, 2004).

With only about 250 individuals thought to remain in all extant wild populations, *C. pinguis* is considered critically endangered (Alberts, 2000, 2004; Hudson and Alberts, 2004). The Anegada population appears to be shrinking both in numbers and in geographic scope on the island (Gerber, 2004). This severe threat to the species' survival demands that detailed information about its biology be obtained to implement successful conservation and restoration efforts. However, the small number of remaining animals makes obtaining such information difficult, especially on Anegada where only a few free-ranging individuals remain. The densest extant population, numbering about 100 individuals (Perry and Mitchell, 2003) and common enough such that it is both frequently observed and reintegrated into the food chain, is the one restored to Guana Island (LeVering and Perry, 2003; Perry et al., 2003). However, little is known about the life history of this critically endangered species anywhere, including Guana Island. We begin addressing this lack of data by reporting on timing of reproduction and body size, two important aspects of the biology of *C. pinguis* on Guana Island.

Data on timing of breeding activities were taken from a survey of the literature (see below) and interviews with BVI residents. Body size measurements were obtained from systematic collection efforts conducted in October of 2003 and 2004. We surveyed the island on foot and with a vehicle and, using nooses, attempted to capture every iguana sighted. Capture success was high for hatchlings (>75% of sighted animals) but much lower for adults (<25%). Captured animals were measured (snout vent length [SVL] and tail length [TL] to the nearest mm), weighed (for hatchlings, ±1 g, using a Pesola scale; for adults, ±100 g, using a Pesola scale or the change in weight reported by a bathroom scale when an individual picked up the animal), PIT tagged (AVID Identification Systems Inc., Norco, CA, USA), and released at the site of capture. Not all measurements were obtained for all individuals. Animal-related procedures were carried out under Texas Tech University ACUC permit 05006-01. Statistical analyses were conducted in SPSS using two-tailed probabilities. Whenever comparisons were conducted between measures representing different dimensionality (i.e., mass vs. length), a log transformation was used to linearize the data.

Published data on timing of reproduction in *C. pinguis* are sparse but consistent in two respects: oviposition occurs in June and July and eggs are deposited in sandy areas. On Guana, Lazell (2005: 185) documents some nesting in late June and a gravid female in late July while Binns (2003) reported that some females were heavily gravid in late July of 2002. As part of the headstarting efforts on Anegada, nests are located every year in June and July (Gerber, 2004). Incubation on Guana Island appears to take about three months, with hatchlings appearing in late September or October and rapidly dispersing into the higher elevations in the center of the island. L. Jarecki and F. Kraus (pers. com.) found iguana eggs that had been accidentally dug up on the Guana Island beach in late September or October 1991. These hatched three days later. Roger Miller also reports a large number of hatchlings being seen in late September of 2004. Our own observations indicate that the prevalence of recently-hatched hatchlings on Guana occurs in late September and October of most years. Hatching on Anegada also occurs at that time (Gerber, 2004) and there have been no sightings of hatchling on Guana at any other time of the year.

In 2003 we obtained body size data for 29 hatchlings and four adults. Data collected in 2004 included 18 hatchlings and two adults, one of which was previously captured in 2003. In 2005 we captured 13 new hatchlings on Guana and recaptured an adult previously measured in 2003 and 2004. Mean hatchling SVL was 108 mm (SD = 10.8 mm, N = 59), mean undamaged tail length was 197 mm (SD = 12.9 mm, N = 21), and mean mass was 60 g (SD = 28.3 g, N = 52). For animals with complete tail, SVL and tail length were directly related (linear regression: tail length = 133.6 + 0.604*(SVL), $R^2 = 0.32$, N = 20, $p = 0.008$). Of the animals for which tail measurements exist, tail damage consisting of missing tips (Figure 1) was noted in three, a rate comparable to that seen on Anegada (Gerber 2000 in Iverson et al., 2004, Table 13.8).

The relationship between SVL and mass was positive and significant for Guana animals (Figure 2, squares and regression line; linear regression: log(mass) = −3.213 + 2.440*log(SVL), $R^2 = 0.65$, N = 51, $p < 0.001$).

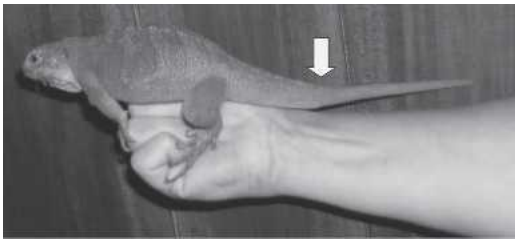

FIG. 1. A young *Cyclura pinguis* showing tail regeneration after unusually extensive damage of unknown origin. The arrow indicates where the original tail ends and the regenerated tail begins.

Comparing current Guana size data to those collected by Carey (1975) and Mitchell (1999) on Anegada (Figure 2) shows that the difference between the three studies in the size-mass relationship was statistically significant (ANCOVA of log-transformed adult mass as a function of sampling effort [present study for Guana; Carey, 1975 and Mitchell, 1999 from Anegada], with log[SVL] as the covariate; $F_{2,22} = 4.343$, $p = 0.026$). Guana animals

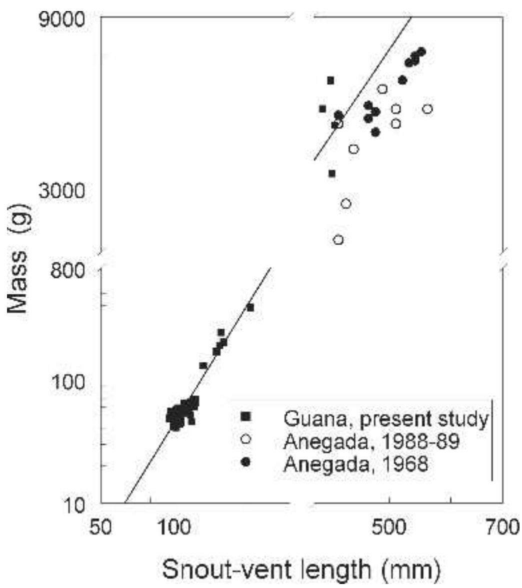

FIG. 2. The relationship between snout-vent length and mass in *Cyclura pinguis*. Guana data are from the present study, those for Anegada are from Carey (1975) for the 1968 values (full circles) and Mitchell (1999) for 1988-89 values (empty circles). The line represents the relationship for Guana animals. Previously measured Anegada animals had a lower mass at a given body size than seen on Guana today.

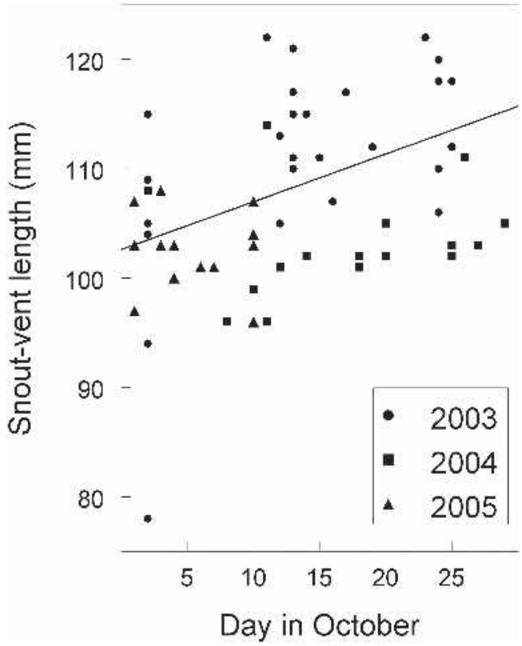

FIG. 3. Snout-vent length of juvenile *Cyclura pinguis* upon first capture. The increase over time is statistically significant, whereas the difference between years is not. The line represents the linear regression of the combined data.

reach similar masses at shorter SVLs, and Anegada animals fared less favorably in the late 1980s than they did two decades earlier. This supports the view of Carey (1975) and Mitchell (1999) that Anegada iguanas suffered from food limitation for a long period and that the condition of Anegada animals deteriorated between the 1960s (Carey, 1975) and the late 1980s (Mitchell, 1999).

Little is known about growth rates in the genus *Cyclura* (Iverson et al., 2004). On Guana, hatchling SVL was significantly and positively correlated with capture date. The difference between years (Figure 3) was not statistically significant (ANCOVA of SVL with year as random factor and day since work began that year as covariate; day: $F_{1,56} = 5.396$, $p = 0.024$; year: $F_{2,56} = 2.010$, $p = 0.144$). These data suggest that growth occurred even within the relatively brief sampling period available to us. However, the data do not make it possible to estimate growth rate for individuals as each animal was only measured once. A linear regression of SVL on day measured produced a highly significant but weakly predictive relationship (R^2 = 0.12, N = 59, p = 0.007). Both this and the regression equation (SVL = 102.6 + 0.438*day) suggest that hatchlings grow by almost 0.5 mm each day. Young *C. pinguis* are known to face predation from feral cats (Mitchell, 2000), snakes, and birds (LeVering and Perry, 2003) and may therefore have low survivorship (Mitchell 1999). Rapid growth thus has clear benefits and is to be expected at this early stage. Data for captive animals held in a headstarting facility on Little Thatch Island provide some additional insight. Between October 2003 and 2004, one animal grew from 122 mm SVL and 70 g to 156 mm and 240 g. By October 2005 it measured 206 mm SVL and 385 g. From 2004 to 2005, one female (hatched in 2004 on Guana) grew from 102 mm and 48 g to 150 mm and 169 g, another (hatched in 2003 on Necker) grew from 132 mm and 129 g to 154 mm and 190 g, and one male (hatched in 2004 on Guana) grew from 101 mm and 50 g to 160 mm and 201 g. The only adult for which we have repeated measurements is a free-ranging adult female, measured at 370 mm SVL in 2003 (unfortunately with no data on weight), 380 mm and 3000 g in 2004, and 422 mm and 3300 g in 2005. This suggests that females of that size range are approaching the growth asymptote (Stamps et al., 1994), perhaps as a result of most energy being invested in egg production.

Ex-situ captive husbandry of *C. pinguis* is finally enjoying modest success (R. Hudson, pers. com.; Lemm et al., 2005) and the headstarting program on Anegada has become successful in raising releasable animals (Gerber, 2004) with high survival rates (K. Bradley, pers. com.). At the same time, there has been little progress in establishing protected habitat for *C. pinguis* on Anegada (Mitchell et al., 2002) and iguana habitat appears to be shrinking from ongoing degradation by feral livestock (Gerber, 2004). Until progress is made in establishing a national park on Anegada, reintroduced populations, such as the one on Guana, function as critically important safety nets for this species. However, all Guana Island iguanas are descended from only eight individuals (Lazell, 2002) and other reintroduced populations form a subset of that already-limited genetic stock. Despite the findings of Knapp and Malone (2003), who found that a translocated population of *C. cychlura inornata* is doing well despite having originated from eight founders, we strongly recommend enhancing the gene pool.

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