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SEXUAL DIMORPHISM AND POPULATION STRUCTURE IN THE SAN SALVADOR CURLY-TAILED LIZARD (*LEIOCEPHALUS LOXOGRAMMUS PARNELLI*)

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ABSTRACT

The population structure of *Leiocephalus loxogrammus parnelli* is poorly characterized. To investigate the *L. loxogrammus* subspecies endemic to San Salvador, a study of lizard size, and population structure was undertaken. Snout-vent length differed significantly between males and females, indicating sexual dimorphism. Color differences in the ventral scales were also observed between males and females. Hence, substantial differences exist between male and female *L. loxogrammus parnelli*.

INTRODUCTION

There has been recent interest in the connection between global warming and the local extinction of lizard populations (Sinervo et al., 2010). As ectotherms there is an expectation that lizard populations might increase as a result of increasing temperatures, but Sinervo et al. (2010) hypothesize that instead lizards spend more time in refuges and less time foraging, eventually leading to lower egg production. Given these potential impacts on lizard populations it is important to establish baseline data on a wide range of lizard species from a wide range of geographic locations.

One lizard lacking baseline data is *Leiocephalus loxogrammus parnelli* found only in San Salvador, Bahamas. This study documents some of the population parameters of this species including the distribution of individual animals, sexual dimorphism and variability in lizard colors and pigmentary patterns.

The genus *Leiocephalus* has been described taxonomically by Pregill (1992) but little is known about the biology and behavior of individual species within the genus (Schoener et al., 1982). *Leiocephalus* are found on both Hispaniola and Cuba and throughout the Bahamian archipelago and are ground-dwelling sit-and-wait foragers (Pregill, 1992). Multiple species of *Leiocephalus* are found on both Hispaniola and Cuba, but no islands in the Bahamas contain more than a single species (Schoener et al., 1982). *Leiocephalus loxogrammus* is restricted to just San Salvador and Rum Cay, each with a separate subspecies; *Leiocephalus loxogrammus parnelli* on San Salvador and *Leiocephalus loxogrammus loxogrammus* on Rum Cay (Olson et al., 1990).

The diet of *Leiocephalus* is primarily composed of arthropods and plant material but instances of saurophagy have also been reported (Schoener et al., 1982). Jenssen et al. (1989) conducted a study in which tethered lizards were presented to *L. schreibersi* and their results showed that *L. schreibersi* is opportunistically saurophagous and even cannibalistic. Herbivory is extremely variable between taxa but can constitute up to about half of the diet for some species (Schoener et al., 1982). Herbivory has been well documented in *L. loxogrammus*, but not saurophagy (Schoener et al., 1982).

Sexual size dimorphism is widespread within the *Leiocephalus*. One measure of sexual size dimorphism is the sexual size dimorphism index (SSDI) which is calculated as the average male snout-vent length (SVL) divided by the average female SVL. The degree of sexual size dimorphism correlates with latitude within the Bahamian *Leiocephalus*. The more northern the population, the less sexual size dimorphism is present and the smaller the SSDI (Schoener et al., 1982). This latitudinal gradient, however, breaks down when Greater Antillean species from Cuba and Hispaniola are also considered. *Leiocephalus* in the Greater Antilles show as much variability in sexual size dimorphism as is found in the rest of the genus even though the Greater Antillean species have the southernmost distributions and would thus be expected to be the most dimorphic (Smith and Nickel, 2002).

Jenssen et al. (1989) has shown that *Leiocephalus schreibersi* is territorial with stable home ranges. These lizards live in xeric coastal regions in semi-open areas with scattered rocks that are used as perch sites. Males had home ranges larger than those of females. Female home ranges typically overlapped those of males. Juveniles' home ranges overlapped those of other adult lizards. It was reported that 9 of 25 adults attempted to feed on tethered juvenile *L. schreibersi*. These individuals did not have overlapping territories with juveniles.

We conducted a mark-recapture study of a population of *Leiocephalus loxogrammus parnelli* to collect data on population characteristics including sexual size dimorphism and information on the spatial distribution of individuals as well.

METHODS

Field observations of *Leiocephalus loxogrammus parnelli* were conducted near Sandy Point on the southwestern tip of San Salvador, the Bahamas. The study site is also known as the Sandy Point Pits surrounding Owl's Hole (Figure 1). There were over 50 pits in this area that varied in size. The pits range greatly in size from .5 m in diameter and 2 to 3 m deep to 8m in diameter and 10 m deep and the site is approximately 18 m above sea level (Mylroie, 1988). This site can be described as rocky uneven terrain with scattered patches of vegetation in between the pits (Figure 2). Lizards seemed to prefer rocky areas at the edges of the vegetation patches.

The study was conducted from May 24-June 13, 2010. Both mornings and afternoons on alternating days were spent on the site with a break during midday when lizard activity declined. Even by 0900, rocks in the open could exceed 45°C.

Figure 1. A map of the island of San Salvador, The Bahamas showing the location of the Sandy Point Pits. Source: "San Salvador." 24°01'34.54" N and 74°30'18.42" W. ***Google Earth****. May 10, 2003-Jun 5, 2007.*

Figure 2. A view of the vegetated patches and open rock typical of the study site.

This site was selected because of the high abundance of *L. loxogrammus*. We caught 20 male and 18 female lizards, which were most of the lizards at this site. Lizards were captured with short nooses of braided fishing line on 12 foot collapsible fishing poles. For each lizard SVL, sex, date, time and site of capture were recorded. Capture sites were documented as GPS coordinates using MotionX-GPS HD on an iPad. Multiple photographs were taken of each lizard as well. Animals were also marked with unique combinations of thin colored stripes dorsally on the neck using model paint. The sex of individual lizards was determined by photographs of the post-anal scales, which are only enlarged in adult males (Figures 3 and 4) (Smith and Nickel, 2002).

RESULTS

Leiocephalus loxogrammus parnelli exhibits a distinct sexual size dimorphism. Males exhibit more variability in SVL than females and are also larger than females (Figure 5). This was determined using a restricted data set composed of the 10 largest lizards of each gender.

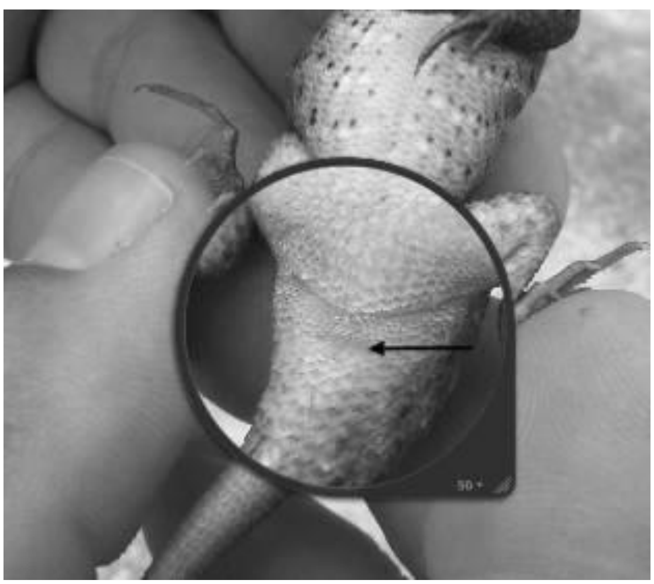

Figure 3. The post-anal scales of a female L. loxogrammus are located just below the vent and are small.

This restricted data set eliminates potential sampling bias and ensures that all of the individuals included are mature adults (Smith and Nickel, 2002).

The average adult male SVL was 80.6 mm, while the average adult female SVL was 64.5 using the restricted data sets and using a t-test were significantly different at $p<0.0001$. Males were also much more variable than females. The SSDI for this restricted data set is 1.25. This SSDI value is placed in the context of other members of the genus *Leiocephalus* in Table 1.

Figure 4. The post-anal scales of a male L. loxogrammus are triangular scales in a hemispherical arc just below the vent.

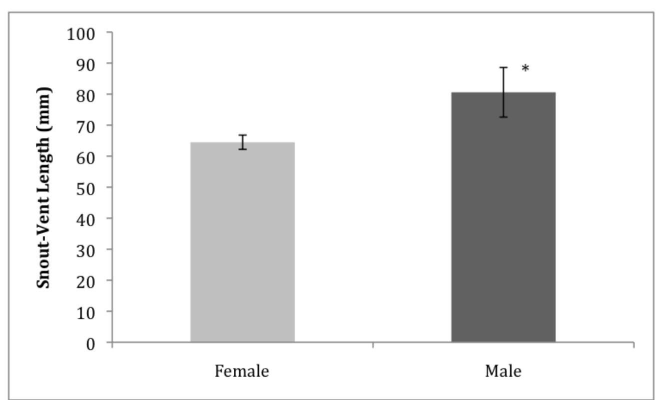

Figure 5. Average adult male and female SVL (± 1 SD), the asterisk denotes a statistically significant difference.

Differences in the color of ventral scales were also noted between males and females. Males had scales that were more yellow/orange in color, while females had scales that were more very light tan in color. In addition, adult males showed black striping on the face that was not commonly observed in females (Figures 6 and 7).

Table 1. SSDI (mean male SVL/mean female SVL) variability in Leiocephalus

Species	Location	SSI	Reference
L. carinatus	Bahamas (widespread)	1.02-1.18	Schoener et al. (1982)
L. macropus	Cuba	1.11	Smith and Nickel (2002)
L.loxogrammus loxogrammus	Rum Cay - Bahamas	1.12	Schoener et al. (1982)
L.psammodromus	Caicos Islands	1.20	Smith (1992)
L.loxogrammus parnelli	**San Salvador - Bahamas**	**1.25**	**This study**
L. inaguae	Inagua - Bahamas	1.30	Schoener et al. (1982)
L. raviceps	Cuba	1.30	Smith and Nickel (2002)
L. stictigaster	Cuba	1.33	Smith and Nickel (2002)

Figure 6. The typical profile of a large adult male showing the characteristic black striping.

DISCUSSION

There was strong sexual size dimorphism observed in *Leiocephalus loxogrammus parnelli*. Males varied in size in a much more significant way than females, no females exceeding 69 mm SVL were captured but nine males exceeded this size.

Figure 7. A large adult female that does not exhibit the dark facial striping of the males.

Schoener et al. (1982) documented size distributions *of Leiocephalus loxogrammus loxogrammus* from Rum Cay. They reported an average female SVL of 64.3 ± 2.8 mm, and an average male SVL of 71.8 ± 22.0 mm. The primary difference would seem to be in male size. In *L. loxogrammus parnelli* we are reporting an average male SVL of 80.6 ± 8.0 mm and female SVL of 64.5 ± 2.3 mm. The female sizes are very similar and the range of variability for males is higher in both populations, but *L. loxogrammus parnelli* are substantially larger. This of course leads to a larger SSDI of 1.25 for *L. loxogrammus parnelli* as compared to the SSDI of 1.12 *for L. loxogrammus loxogrammus*.

An interesting hypothesis was proposed by Schoener et al. (1982) to explain differences in SSDI within the *Leiocephalus*. There is a correlation between SSDI and latitude within the Bahamas (Schoener et al., 1982). The more southern the population the more dimorphism was exhibited, with males being larger than females. They suggested this would be a result of selection for increased clutch size in females in northern populations, so females would increase in size relative to males.

Smith and Nickel (2002) collected data from several species of *Leiocephalus* from the Greater Antilles. If these populations were consistent with the latitudinal gradient hypothesis, they should have larger SSDI values as these populations are south of the Bahamas and Turks and Caicos. They instead found as much variability in SSDI within Greater Antillean species as was found in the rest of the genus. It would appear that differences in SSDI are likely more complicated than a latitudinal gradient.

Several hypotheses have been proposed to explain sexual dimorphism ranging from sexual selection to a variety of distinguishable ecological causes (Gifford and Powell, 2007; Schoener et al., 1982; Shine, 1989; Smith and Nickel, 2002; Stamps et al., 1997). Further research will be required to determine the cause of sexual size dimorphism in *Leiocephalus*.

Some lizard interactions were observed during the study, but mainly involved larger lizards forcing smaller lizards to retreat under rocks. We saw no direct aggressive interactions. Typical behaviors included basking on rock perches, foraging and head bobbing. Occasionally lizards were observed eating insects, but no saurophagous behavior was observed. *Anolis sagrei* were quite common on the study site as well and were often quite near *L. loxogrammus parnelli*, but we never saw any interaction between these species. Birds were occasionally seen trying to capture lizards, and given the large number of regenerated tails, likely have an impact on this population.

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