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# SEXUAL DIMORPHISM IN A POPULATION OF *ANOLIS SAGREI* ON SAN SALVADOR, BAHAMAS

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## ABSTRACT

*Anolis sagrei,* the brown anole, is distributed throughout the Caribbean and the western Atlantic coast from Mexico to Belize. We examined sexual polymorphism in a population of *A. sagrei* near the plantation ruins on Kerr Mount. Individuals were captured with lizard nooses, measured, weighed, photographed, and tagged before being released. Enlarged post-anal scales were used to identify males from females. Female and juvenile lizards exhibited a dorsal brown chevron pattern while adult males were gray with occasional crests. An intermediate, brown-gray coloration seen in some males suggested that males may be chevron-patterned as juveniles and later develop gray coloration and post-anal scales as adults. Snout-vent length comparisons showed that these intermediate males bridge the size gap between adult female and male lizards, further supporting this proposal.

## INTRODUCTION

*Anolis sagrei* is an extremely widespread, abundant generalist species of anole. It is also a very successful invasive species and has been introduced in Florida, Jamaica, Hawaii, Grand Cayman, Taiwan, and Grenada (Kolbe et al., 2004). It is widespread and native in the Bahamas and has been studied on many islands in the Bahamas with several studies documenting intraspecific variability within this species (Calsbeek et al., 2010; Schoener, 1968; Schoener and Schoener, 1976).

*Anolis sagrei ordinatus* is one of several lizards to occur syntopically on the island of San Salvador. They coexist in the same habitat as *Anolis distichus* and *Leiocephalus loxogrammus*. In terms of anole ecomorphs, *A. sagrei* is considered a trunk-ground ecomorph and *Anolis distichus* is a trunk ecomorph (Losos, 2009). Elsewhere in the Bahamas *Leiocephalus* are saurophagous and will consume *A. sagrei* (Losos, 2009), but this does not seem to be the case with *Leiocephalus loxogrammus* on San Salvador (pers. obs.).

This species has been reported to exhibit a sexual size dimorphism (Schoener, 1968; Stamps, 1999). This was reported for several different years and sites by Stamps (1999). A female pattern polymorphism was first reported by Schoener and Schoener (1976). This three state polymorphism (Diamond, Diamond-bar and Bar) has been determined to have a genetic basis and to vary both temporally and geographically within the Bahamas (Calsbeek et al., 2010). There has been less discussion of the variability of patterning in males. The occasional presence of nuchal, dorsal and tail crests has been documented elsewhere. These crests are erected as a social signal coincident with dewlap extension (Losos, 2009).

Given the outlying locality of San Salvador in the southeastern Bahamas and that it is spatially separated from both the Little Bahama Bank and the Great Bahama Bank we decided to investigate the population structure and intraspecific variability within a population of *A. sagrei* on San Salvador, Bahamas. We conducted a study to document variability in size and patterning in this lizard.

## METHODS

The study site selected was the Kerr Mount Plantation ruins on the eastern shore of San Salvador (Figure 1). This area had been recently cleared for an archaeological study, which improved accessibility for capturing lizards. *A. sagrei* were captured on small trees and bushes, brushpiles and the masonry ruins (Figure 2).


*Figure 1. A map of the island of San Salvador, The Bahamas, showing the location of the Kerr Mount study site. Source: "SanSalvador." 24° 01' 42.13" N and 74° 29' 17.56" W.* ***Google Earth****. May 10, 2003-Jun 5, 2007.*

*Figure 2. The Kerr Mount Plantation site contained a variety of microhabitats including masonry, small trees and brush piles.*

This study was conducted from May 24-June 13, 2010. Both mornings and afternoons were spent on this site on alternating days with an afternoon break when lizard activity declined. *A. sagrei* were quite abundant. There were also numerous *Leiocephalus loxogrammus* on the ground and *A. distichus* higher off the ground on tree limbs or trunks. For each lizard, snout-vent length (SVL), tail length, weight, temperature, sex, date, time and site of capture were recorded. Capture sites were documented as GPS coordinates using MotionX-GPS HD on an iPad. Individual lizards were photographed as well.

Animals were marked with a queen bee marking kit (Johnson, 2005). These kits contain cardboard dots in five different colors that are each individually numbered. A combination of dots are attached to the skin using phial glue and can be used to individually identify lizards from a distance (Figure 3). Dots are shed at the next molt and thus are temporary. The sex of individual lizards was determined by examining photographs of the post-anal scales; males have a characteristic "helicopter-blade" (Figure 4).

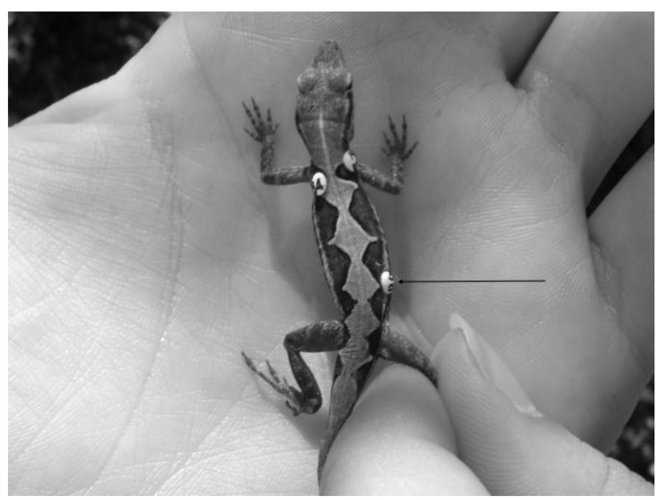

*Figure 3. This shows the numbered bee tags that were used to temporarily mark lizards in this study.*

## RESULTS

We captured and marked 40 adult male and 35 female and juvenile *A. sagrei*. As has been reported in other studies of *A. sagrei* in the Bahamas (Stamps, 1999), our results indicate that male lizards are larger than females (Figure 5). To calculate these body sizes we used a restricted data set of the ten largest lizards of each gender (Smith and Nickel, 2002). Given the low variability in SVL, this should approximate the asympototic sizes of Stamps (1999).

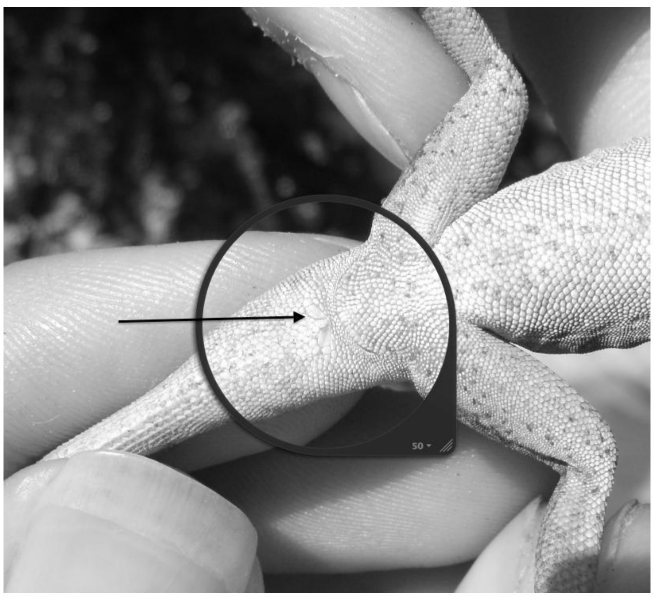

*Figure 4. The two large blade-like scales that are just below the vent are characteristic of males.*

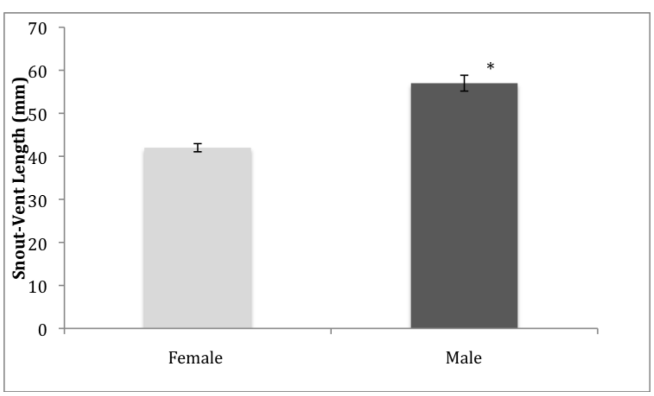


*Figure 5. The SVL of male and female lizards, the asterisk denotes that using a t-test this is a statistically significant difference (p<0.0001). Error bars indicate ± 1 SD.*

Using these averages a sexual size dimorphism index (SSDI) of 1.35 was calculated for this population. This is calculated as the average male SVL divided by the average female SVL and is a measure of the degree of sexual dimorphism.

Female lizards exhibited the dorsal pattern polymorphisms described by Calsbeek et al. (2010). We could readily distinguish the diamond (Figure 6), diamond-bar (Figure 7) and bar (Figure 8) dorsal patterns.

*Figure 6. The diamond pattern female.*

*Figure 7. The diamond-bar pattern female.*

Calsbeek et al. (2010) documented the frequency of the various female dorsal pattern polymorphisms in several populations on Eleuthera and Great Exuma (Figure 9). The frequencies of dorsal pattern polymorphisms are quite similar to the frequency distributions reported for Great Exuma and different from those reported from Eleuthera (Figure 10).

*Figure 8. The bar pattern female.*

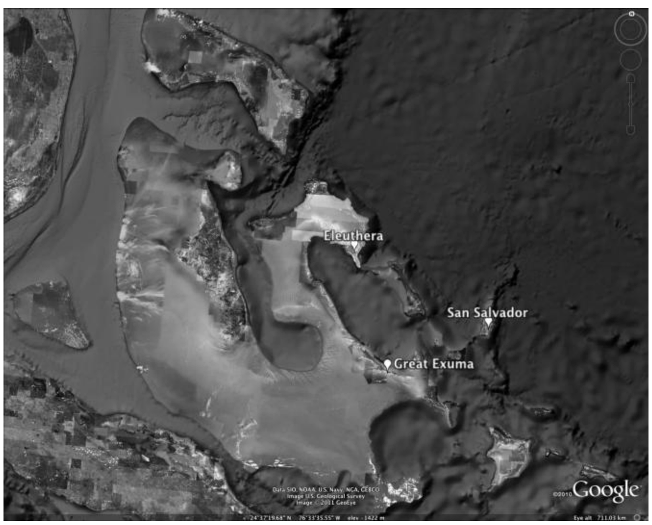


*Figure 9. A map of the Bahamas showing the relative positions of Eleuthera, Great Exuma and San Salvador. Source:"Bahamas." 24° 37' 19.68" N and 76° 33' 35.55" W. Google Earth.*

Males also exhibited some interesting color variations as well. All of the smallest lizards (presumably including males) captured exhibited the diamond pattern (Figure 6). In males this pattern would begin to disappear as the lizards begin to mature. It was quite common to see male lizards with some degree of patterning (Figure 11). The most pronounced aspect of this pattern and the last to disappear are the dark patches found just behind the forelimbs dorsally. These lizards can be clearly diagnosed as males because of the presence of enlarged post-anal scales (Figure 4).

Another interesting difference in males had to do with the absence or presence of cresting. In some males nuchal, dorsal and caudal crests are quite pronounced (Figure 12). The darker pattern elements are lost and light vertical patches are instead apparent. In other males the crests are much less apparent and the light patches are much reduced as well (Figure 13). Given the ontogenetic character of the disappearance of the diamond dorsal pattern it is interesting to note that degree of cresting is not necessarily correlated with size. Some males with a small SVL still have quite pronounced crests.

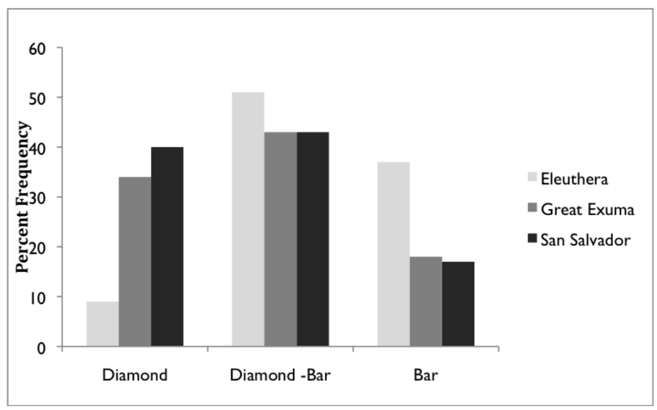


*Figure 10. Percent relative frequencies of female pattern polymorphisms from three islands in the Bahamas. The San Salvador data is from this study, and the Eleuthera and Great Exuma data is from Calsbeek et al. (2010).*

Adult male lizards are also capable of rapid and dramatic color change, changing from a light gray appearance to solid black and then back to a light gray color in well under a minute. This seems to be involved in signaling between males (pers. obs.). Typically dewlap extension accompanies this change.

*Figure 11. The transition pattern male.*

*Figure 12. A large male exhibiting nuchal, dorsal and caudal crests.*

*Figure 13. A large male lacking crests and vertical light patches.*

DISCUSSION

This population of *A. sagrei* exhibited a pronounced sexual size dimorphism. There was low variability within genders, suggesting the sizes reported are near the maximum size for these lizards (Stamps, 1999). Using the top ten SVL values to calculate restricted values helps to address an inability to accurately determine whether juveniles captured were male or female.

The calculated SSDI for this population was 1.35. Stamps (1999) reported SSDI values for *A. sagrei* on Abaco ranging from 1.24-1.32, on Bimini from 1.11-1.40 and on Andros from 1.17-1.21 depending on the population being measured. The SSDI value calculated here is certainly consistent with these values, albeit towards the high end of the scale.

We observed the female dorsal pattern polymorphism that was first reported from Bimini by Schoener and Schoener (1976) and then substantially expanded on by Calsbeek et al. (2010). Calsbeek et al. (2010) conducted a breeding study and determined that this polymorphism is genetically determined and addressed potential selection pressures. In addition, Calsbeek et al. (2010) reported polymorphism frequencies from multiple sites on or near both Eleuthera and Great Exuma. They determined that there was substantial intra-island variability as well as temporal variability in frequency. They did, however, clearly note that there were island specific differences in frequency between Eleuthera and Great Exuma (data reproduced in Figure 10).

The frequencies of polymorphisms on San Salvador largely mirror the frequencies seen on Great Exuma (Figure 10). Calsbeek and Smith (2003) hypothesize that the genetic structure of populations of *A. sagrei,* as determined using microsatellite analysis, strongly suggests that gene flow from island to island is determined by ocean currents and periodic hurricanes rather than by human transportation or connection between islands at times of lower sea level. Ocean currents in the Bahamas proceed from east to west and Great Exuma is west of San Salvador (Figure 9). It is interesting to note that both Eleuthera and Great Exuma are both on the Great Bahama Bank, while San Salvador exists on its own Bank that is separated by a deep-water channel, yet the polymorphism frequencies are most similar between Great Exuma and San Salvador. Future work will need to address intra-island and temporal variation in female polymorphism frequency on San Salvador.

Ontogenetic change in male dorsal color patterns was interesting as well. The diamond pattern is lost in a stereotypical way as males mature resulting in a light gray background that may or may not exhibit lighter vertical patches. Male lizards also exhibit a striking ability to change their dorsal color from light gray to a very dark brown and then back again when signaling. Crests are variable within males and their presence does not seem to correlate with SVL. When present they very much alter the appearance of males (Figure 12). There are both nuchal, dorsal and caudal crests observed on individuals in this population. Crests may be enhanced when males are displaying but are quite apparent on individuals that are not displaying as well. The use of crests and color change in this lizard will be considered in future studies.

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