Reproduction of the Invasive *Boa constrictor* in Puerto Rico

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Abstract

Invasive species play a significant role in negatively altering their newly found environment as well as the ecosystem they inhabit. A broad increase in their populations, has generated: extinction of wildlife species, habitat degradation, infrastructure damage, and impact on human health. The given rise in their population has led this study to retrospect and analyze the reproductive anatomy of both the female and male *Boa constrictor*. Where analyzing their reproductive mechanism, portrays a clearer vision into their accelerated expansion. This was observed by using the different parameters available to determine their reproductive maturity. In the case of a female, a thickened oviduct and / or follicles were identified. For males we checked the epididymis and measured the left testicle. We found a correlation between the SVL of both males and females and their reproductive maturity. An increase in body size meant an increase in reproductive maturity, thickened oviduct in females and convoluted epididymis in males. Furthermore, we found a directly proportional relationship between the number of follicles presented in females and their SVL. This study shows that the species is actively reproducing on the Island.

Introduction

For the larger part of snakes, reproductive success is attributed to both the female and male constitution. In *Boa constrictor*, mating tends to occur in dry seasons, between the months of April and August (Lindemann, 2009) by internal fertilization. Gestation can either begin from a week down to a year and concludes in a period of five to eight months. Female boa constrictors are able to give birth to a range of 10-64 neonates, with an average of 25 (Bertona, 2003).

Invasive species such as boa constrictors, compete with native wildlife for limited resources, reduce biodiversity, and lead to extirpation of native species (Pyšek and Richardson, 2010). These are usually introduced by human assistance in a habitat not previously occupied (Simberloff, 2010). The release of multiple *Boa constrictor* neonates in the island of Puerto Rico around 1992 (Bushar, 2014), climate change and land use are thoroughly credited for an increase in the invasive species population. This rapid growth, moreover, is commonly attributed to their successful reproduction. Understanding how invasive species reproduce and compare in different regions can help provide aid in halting their spread, avoiding mayor effects in the ecosystem. In order to achieve this, male and female reproductive parts of the *Boa Constrictors* were thoroughly examined.

Objectives

- The aim of this study was to evaluate the reproduction of invasive *Boa constrictor* in Puerto Rico.
- Determine the sizes of breeding males and females *Boa constrictor* in Puerto Rico.

Methodology

A total of 884 individuals (450 females and 434 males) of *Boa constrictor* were obtained from the Puerto Rico Department of Natural Resources throughout the years 2011, 2012, 2013, 2014, 2018, 2019 and 2020. For each snake, we documented:
date of capture, snout-vent length (SVL), tail length and mass. Each snake was dissected following the correct aseptic measures. For the females, the number of follicles with a diameter larger than 5 mm were documented and the largest was also measured. Also, we determined the state of the oviduct (thickened or non-thickened). On the other hand, for the males the width and length of the left testicle was measure and the epididymis was evaluated to determine whether it was convoluted or non-convoluted. For our study, we considered as mature females those with 120cm SVL and males with 90cm SVL.

Results

The data recorded shows a relationship between the reproductive maturity and SVL of each individual. Out of the 434 males studied, 143 has a convoluted epididymis while 291 presented a non-convoluted epididymis. Moreover, males with non-convoluted epididymis were associated with smaller in SVL, when compare with the convoluted ones (Figure 1). The average SVL of males with non-convoluted epididymis was 138.33±23.94 cm. Males with convoluted epididymis has an average SVL of 149.83± 27.47 cm of SVL (Figure 1). Nevertheless, the male with smaller SVL and convoluted epididymis had a length of 61.2 cm.

A similar pattern concerning the SVL and reproductive maturity was seen for the females. A total of 195 females did not present a thickened oviduct whereas 255 showed it to be thickened. Adult females with greater SVL presented a thickened oviduct while females with less SVL were associated with a non-thickened oviduct and less reproductive maturity (Figure 2). As the SVL increases the number of follicles in females increases (Figure 3). Therefore, a directly proportional relationship among SVL and the number of follicles in females of *B. constrictor* is noticeable (Figure 3). Females with thickened oviduct and larger SVL were associated with a higher number of follicles, presenting an average of 21.87 ±19.64 follicles. In the contrary, females with a non-thickened oviduct and smaller SVL presented the development of less follicles with an average of 9.80± 11.826 follicles.

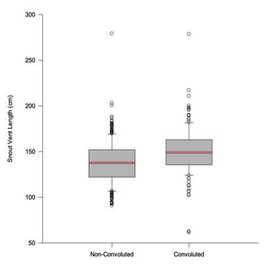

Figure 1. Box plot of Snout Vent Length (SVL) in males according to their reproductive state, non-convoluted epididymis and convoluted epididymis.

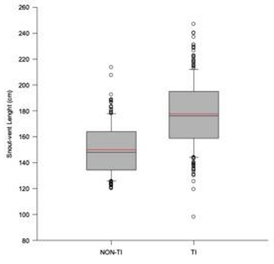

Figure 2. Box plot of Snout Vent Length (SVL), thickened (TI) and non-thickened (NON-TI) oviduct in females of *Boa constrictor*.

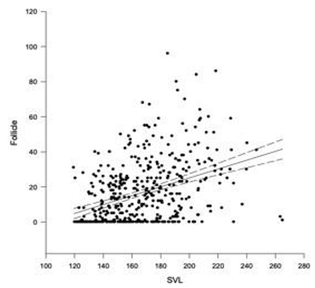

Figure 3. Linear regression with number of follicles in comparison with the Snout Vent Length (SVL) of females of *Boa constrictor* .

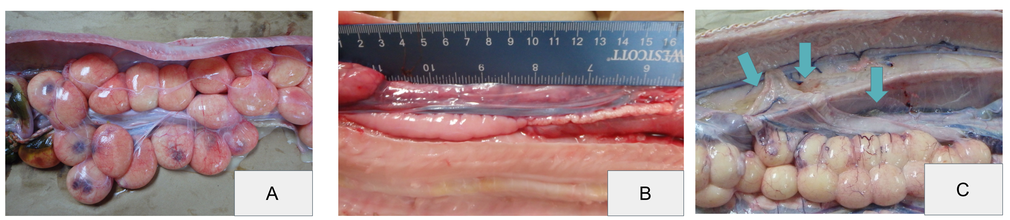

Figure 4. Documented photographs of dissection. (A) Eggs present in female during gestation period. (B) Testis with convoluted epididymis. (C) Immature eggs and thickened oviduct indicated by the arrows.

Discussion

The present study found that male boas were mature at smaller sizes than females, a pattern observed in multiple studies with species of *Boa constrictor* (Sironi *et. al.*, 2002; Bertona and Chiaraviglio, 2003; Pizzatto and Marques 2007). In a review done by Reed and Rodda (2009) the range of length in which male species of *Boa constrictor* become mature was from 90 cm to 160 cm. However, the data collected in this study demonstrated that the average size of males with epididymis convoluted was 149.835 ± 27.475 cm, indicating that maturity was commonly achieved at higher lengths. This can indicate that male *B. c. constrictor* individuals tend to achieve greater SVL before becoming reproductively mature. Similar to the findings of this study, Pizzatto and Marques (2007) reported the mean adult male sizes for *B. c. constrictor* ranged from 141.8 to 190.3 cm of SVL. While Reed and Rodda (2009) explain that maturity in males can be achieved at 90 cm, we found that at 90.7 cm males are still reproductively inactive. Furthermore, we found that the male with smaller SVL and convoluted epididymis had a length of 61.2 cm, which may indicate that this individual belonged to a different subspecies of *B. constrictor* that can achieve maturity at a lower SVL.

Similar to the males, we found that increasing SVL in females meant an increase in reproductive maturity. Reed and Rodda (2009) reported that females of *Boa constrictor* achieve maturity between 120 and 230 cm of SVL. This study found a similar pattern among the body size with relation to the state of the oviduct. Females with greater SVL presented a thickened oviduct while females with less SVL had a non-thickened oviduct, and therefore were reproductively immature. The data collected shows that the majority of the females of *B. c. constrictor* begin to achieve reproductive maturity at approximately higher values of SVL in comparison to the other species of boas (Reed and Rodda, 2009). As reported by Pizzatto and Marques (2007) *B. c. constrictor* females begin to achieve reproductive maturity once they reach 150 cm of SVL. This tendency for females to acquire greater SVL before reproducing is related to their body mass and energy investment in the production of offspring (Bertona and Chiaraviglio, 2003). A study done Bertona and Chiaraviglio (2003) considering the number of follicles in relation to the SVL of *Boa constrictor occidentalis* females, reported that an increase in litter size and number of follicles was associated with greater body size. The same direct and proportional tendency was found in the present study concerning a higher number of follicles in females with greater SVL and thickened oviduct.

Conclusion

In both male and female *Boa constrictors*, this research indicates as well as previous studies that sexual maturity is reached with a longer snout vent length. This is stated as snout vent length is analogous to age. In the contrary, in males, the described parameters exhibit a contrast in the average size of the convoluted epididymis. The difference lies as the male snakes found in the vast areas of the island, initially reach maturity above the norm. Females on the other hand, as the standard describes, display a thickened oviduct and a superior number of follicles after progression of the snout vent length. The increased quantity of follicles itself reveals a direct and proportional relationship with the mass and SVL of the boa. This connection demonstrates a positive response to gestation.

Acknowledgments

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