

Examining Sexual Dimorphism of the invasive *Boa constrictor* in Puerto Rico

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Abstract

The *Boa constrictor* exhibits a female-biased sexual size dimorphism in which the females have longer body lengths and are usually heavier than the males of the species. Descriptions of the *Boa constrictor* on islands have revealed a tendency for dwarfism when in comparison to the snakes that are observed on the mainland. Our objective is to determine if sexual dimorphism is changing in this invasive species on the island. Boas were collected from different locations from 2011 to 2014, 2018 to 2020, and early 2021. Sexual size dimorphism index was calculated. A total of 636 females and 572 males adult snakes were processed during the study period years of 2011-2014 and 2018-2021 the SSD for each resulted in 0.0519, 0.1561, 0.1446, 0.1388, 0.2156, 0.2407, 0.1925 and 0.1720 respectively. Statistical analysis exhibited a significant difference between sexes and their head lengths, tail lengths and stoutness, but showed no significant difference for the mass. Female snakes continue being larger than males, therefore, dimorphism is still present on the island. We can conclude that, in Puerto Rico, the conditions are still favorable for this species. Factors that may contribute to the increase in size may be due to a good source of food and energy, combined with a sustainable habitat.

Introduction

The Red tail boa (*Boa constrictor*) was introduced to Puerto Rico presumably by illegal pet trade. This species reaches a length of approximately 3.048m and a weight of 0.8 kilograms. The *B. constrictor* exhibits a female-biased sexual size dimorphism (SSD) in which females tend to have larger body lengths and are usually heavier than the males.

Body size is an important aspect of evolutionary biology and can be correlated with biotic and abiotic factors like prey availability, predation pressure and temperature, among others (Brown, et al., 2017). There are some descriptions of *Boa constrictor* on islands showing a tendency towards dwarfism in comparison to the ones observed in the mainland (Cyrus & Lee, 2012). A factor that may explain this phenomenon is the "diet alteration hypothesis", which suggests that the change of body size on snakes is influenced by the size and availability of prey in the island versus the mainland, meaning that body size correlates to prey type and size. Moreover, niche divergence and proximate ecological influences over SSD play a specific role over its patterns; this means that, for example, an increase in a prey type used by one sex exclusively can elevate the growth rate of given sex, but not for the other, hence, an alteration to the SSD levels. Consequently, food limitations also generate a longitudinal and chronological variation in SSD (Brown, et al., 2017).

The objective of this study is to determine the sexual dimorphism for the invasive *Boa constrictor* and also compare this dimorphism in different years.

Methodology

Our subject of study was *Boa constrictor*, which can be found naturally in regions of North, Central, and South America. The adult females have a minimum snout-to-vent length of 120 cm while the adult males have a minimum of 90 cm (Reed, et al., 2009). For this study, we only used the measurements from adult *Boa constrictors* that exhibited a complete tail. A total of 1,208 *Boas constrictors* (636 females and 572 males) were collected from different locations on the west side of Puerto Rico between 2011-2014, 2018-2020, and early 2021. Body length was recorded for each individual, divided into snout-to-vent length (SVL) and tail length (TL) which were measured to the closest centimeter. In addition, body mass was measured to the nearest gram. Using a caliper we measured the head length (HL) to the nearest centimeter.

After collecting the data, the averages and standard deviation of the acquired measurements, SVL, TL, body mass and HL were calculated. These averages were divided by the year of capture and its corresponding sex. We also calculated the stoutness (snake's weight divided by the total snake length) and relative tail length (SVL divided by the tail length). We made a comparison applying a t-test using the MiniTab software. The averages of the SVLs of both male and female boas, the sexual size dimorphism index (SSD) was determined by dividing the average of the SVL of female boas by the average SVL of the male boas and subtracting it to one (Lovich & Gibbons, 1992). With the SSD, we could identify the presence or absence of dimorphism in the *Boa constrictor* in Puerto Rico (Boback, 2006).

Results & Discussion

For this study, 1,208 *Boas constrictors* (636 females and 572 males) were considered. **Table 1** exhibits the means and standard deviations of the measurements studied. Females average SVL was 163.8 cm and for males was 138.3 cm. In **Figure 1**, we compare sizes of females from different countries. To confirm the presence of dimorphism of the invasive species in the island, several statistical analyses were performed (a t-test and ANCOVA) and the Sexual Size Dimorphism(SSD) index was calculated. The t-test analysis showed that there is a significant difference between sexes on their stoutness ($t=10.31$, $df=1204$, $p=0.00$) and relative tail length ($t=6.63$, $df=884$, $p=0.00$), where females exhibit a larger stoutness and relative tail lengths. Also, a single factor analysis of covariance, using sex as the factor and SVL as a covariant, showed that males and females *B. constrictors* are significantly different in head size ($F=20.14$, $n=1,211$, $p=0.0195$) but not significantly different in mass ($F=1.16$, $n=1,211$, $p=0.2816$), **Figures 3 and 4**. Lastly, **Figure 2** exhibits the SSD index in two time intervals for the years 2011-2014 and 2018-2021 the values of this index were 0.0519, 0.1561, 0.1446, 0.1388, 0.2156, 0.2407, 0.1925 and 0.1720, respectively. The median of the index for the species on the island was 0.16(± 0.05). The positive value confirms that the females are the bigger sex and thus, the sexual dimorphism is prevalent on the island.



Table 1. Averages and standard deviations of the snout to vent length, tail length, mass, head length divided by year and sex.

Year	males					females				
	N	SVL(cm)	TL(cm)	MASS(g)	HL(cm)	N	SVL(cm)	TL(cm)	MASS(g)	HL(cm)
2011	12	157.6±48	22.97±6.55	3464.5±2520	5.55±1.1	25	165.79±25	19.41±2.47	3707.69±2210	6.04±0.78
2012	49	140.49±31	20.13±5.61	2416.84±1521	5.15±0.75	48	162.44±22	19.27±2.9	4122.5±2088	5.86±0.65
2013	37	145.07±22	22.28±4.34	3106.26±2396	5.25±0.74	44	166.05±25	19.51±2.8	4839.3581	5.86±0.82
2014	35	141.50±24	19.74±4.59	2554.29±1488	5.01±0.63	28	162.4±18	19.43±2.8	3892.86±1795	5.62±0.62
2018	29	141.7±19	20.5±3.50	2538±1319	4.90±0.59	55	173.7±29	19.7±3.4	4369±2495	5.98±1.15
2019	114	133.4±21	19.68±4.38	2079.1±1654	8.35±8.82	139	165.59±27	19.63	4065±2542	5.82±0.92
2020	23	136.95±25	22.01±2.55	2398.28±1725	4.93±0.71	252	163.32±28	19.49±3.4	4004.07±2910	5.74±0.93
2021	63	139.24±23	20.89±4.19	2246.88±1300	4.92±0.79	45	163.19±28	19.70±4.1	4526.67±3115	5.69±0.89

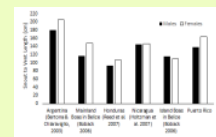


Figure 1. Comparison of snout-vent length (cm) of female and male *B. constrictor* in different areas where the species are within their natural distributions except for Puerto Rico.

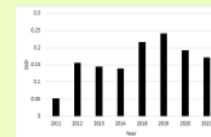


Figure 2. *Boa constrictor* SSD index throughout the years.

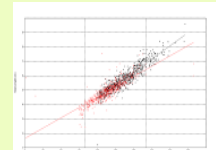


Figure 3. Single factor analysis of covariance, using sex as the factor and SVL as a covariant for the head length (cm).

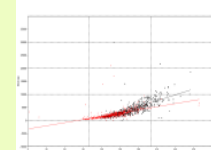


Figure 4. Single factor analysis of covariance, using sex as the factor and SVL as a covariant for the head length (cm).

Conclusions

After calculating the SSD, taking into consideration the parameters of this study (snout-vent length) it was observed that the tendency has remained steady over the years, hence, leading to the interpretation that sexual size dimorphism is still present in the *Boa constrictors* in Puerto Rico. Moreover, given that SSD and prey availability have a direct correlation with one another, the steady SSD patterns suggest that food and energy resources are still present and abundant on the island. With this in mind, *Boa constrictor's* SSD will be kept under surveillance.

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