ESTIMATING SNOUT TO VENT LENGTH FROM DATA ACQUIRED FROM THE SHED SKINS OF THE NORTHERN BROWN SNAKE, *STORERIA DEKAYI DEKAYI*

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Abstract: Data (snout-vent length, SVL; frontal scale length, FL) from shed skins and actual specimens of Northern Brown Snakes, *Storeria dekayi dekayi,* were studied using correlation and linear regression analysis for the purpose of determining the best of three methods of estimating the SVL of a snake from a cast shed skin. The methods tested were: 1) using a regression equation to predict actual SVL from the shed skin SVL, 2) using a regression equation to predict actual SVL from the shed skin FL, and 3) using the average amount that an *S. d. dekayi* shed skin stretches to predict actual SVL. All three estimation methods were not significantly different from the actual SVL. Using a regression equation that predicts actual SVL from shed skin SVL proved to be the best method. However, an equation estimating actual SVL from the known average amount of shed skin stretch would be accessible by a greater number of people, including those without knowledge of statistical analysis.

Introduction

A shed snake skin found during a field survey can provide much useful information. For instance, when properly prepared and identified, a shed snake skin can be used as a voucher, documenting a species presence without sacrificing an individual. If the shed skin is complete, the gender of the snake that left it can be inferred by counting ventral scales and or subcaudal scales. Shed skins also provide high-quality DNA for use in molecular studies (Bricker et al. 1996; Clark 1998). The location where a shed skin is found can provide insight regarding species habitat preferences during ecdysis (i.e., shedding of skin).

During ecdysis, a snake's stratum corneum is stretched, resulting in a shed skin that is usually 10–20% longer than the actual snake (Bellairs 1970; Mattison 1995). It is likely that a great deal of variation in this character occurs within and among species. Knowing the average percentage that a species' shed skin stretches, may allow a researcher to estimate the "actual" snout-vent length (SVL_A) of the snake that left a shed skin. Regression analysis may also prove useful in attempts to estimate SVL_A from shed skin data. In this paper, I examine three methods for estimating SVL_A of Northern Brown Snakes, *Storeria dekayi dekayi,* from shed skin data.

Materials and Methods

Between 1998 and 2008, Northern Brown Snakes, *Storeria dekayi dekayi* (*n* = 53) in preecdysis were collected from a site in Erie County, Pennsylvania, for the purpose of examining the relationship between SVL_A and shed skin data, such as frontal scale length (FL), shed skin snout to vent length (SVL_S), and the degree that shed skins stretch. Individual snakes were maintained in plastic shoeboxes (32.2 x 18.7 x 10.8 cm), with shredded paper as a substrate, and a water bowl until they shed. As soon as a shed was observed in a shoebox, it was carefully removed, then placed on a paper towel and allowed to air-dry. Measurements for SVL to the nearest mm were obtained from each dried shed skin by placing the rostral scale at 0 mm, then gently pulling the shed taunt along the edge of a ruler and noting the location of the vent along the ruler. To measure FL, the cephalic portion of the shed was cut, spread and mounted as described in Gray (2005), then measured using a stereo microscope and a miniscale (Bioquip Products, Rancho Dominquez, California) accurate to 0.1 mm. Within a day of shedding, the actual SVL and FL measurements were also obtained from each individual snake using a ruler and calipers, respectively. Snakes were released at the site of capture after data collection.

Simple correlation and regression analysis were used to study the relationship between FL and SVL_A, and also the relationship between SVL_S and SVL_A. The regression equations derived from these analyses provide estimates of SVL_A from shed skin data.

For each individual, the amount that the shed skin had stretched *(P)* was calculated by subtracting SVL_A from SVL_S, then dividing by SVL_A. The equation is as follows:

$$P = [(SVL_S - SVL_A)/SVL_A]$$

Multiplying *P* by 100 gives the percentage that a shed skin has stretched.

Table 1. A summary of comparisons between actual snout-vent length (SVL_A) and three SVL estimation methods (est. SVL_F, est. SVL_P, and est. SVL_S). All three estimation methods were not significantly different from SVL_A. *n* = number; *sd* = standard deviation; *df* = degrees of freedom; *P* value = observed probability.

Method	mean	*n*	*sd*	range	t-value	*df*	*P* value
SVL_A	209.3	25	54.3	135.0-343.0	N/A	N/A	N/A
est SVL_S	210.5	25	52.0	138.2-329.3	-0.079	48	0.9370
est SVL_P	205.7	25	55.9	128.0-333.4	0.230	48	0.8191
est SVL_F	222.4	25	33.7	181.4-301.5	-1.0261	40	0.3110

A mean was calculated by summing the individual measurements for *P* and dividing the total by the number of individuals. This mean was then used to estimate SVL_A from SVL_S with the following equation:

$$\text{Est. } SVL_P = SVL_S - (SVL_S \cdot P)$$

Comparisons between methods: During May and June 2009, a second sample of twenty-five *Storeria d. dekayi* in preecdysis were collected from the Erie County site, for the purpose of testing the reliability of the regression equations obtained from the first sample. Snakes were housed as described above. Once the specimens molted, the shed skin exuviate was removed and allowed to air-dry on a paper towel, and measurements (FL, SVL_S, and SVL_A), made as described above. From each shed skin I measured SVL_A, and calculated estimates from SVL_F, SVL_S, and SVL_P. I used Student's *t*–tests to determine whether there was a statistically significant difference between SVL_A and each of the three methods for estimating SVL. Prior to performing a *t*-test, I tested for homogeneity of variance by calculating an F ratio as described in Runyon et al (1996). When compared variances were heterogeneous, a corrected *t*-test was employed. For all statistical tests, $\alpha = 0.05$.

Figure 1. Relationship of actual snout-vent length and shed skin snout-vent length in the Northern Brown Snake, *Storeria d. dekayi.*

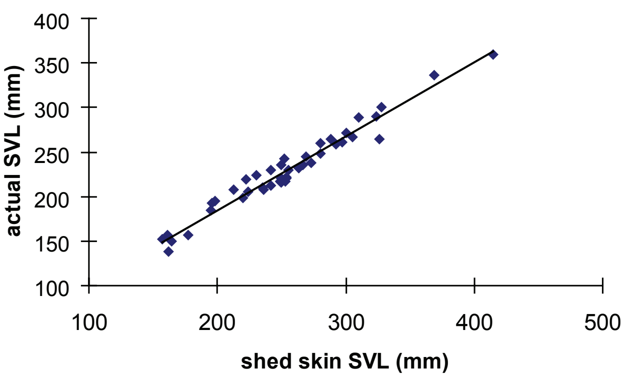
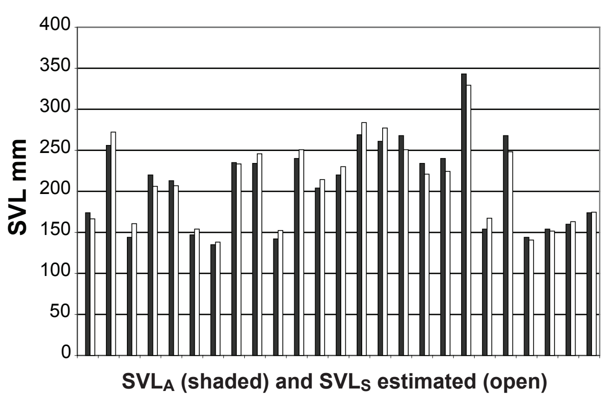


Figure 2. Graphic representation of paired measurements for actual snout-vent length (SVL_A) and estimate of snout-vent length from shed skin (est. SVL_S) for each of twenty-five Northern Brown Snakes, *Storeria dekayi dekayi.* SVL_A is depicted with shaded columns; est. SVL_S is depicted with open columns.



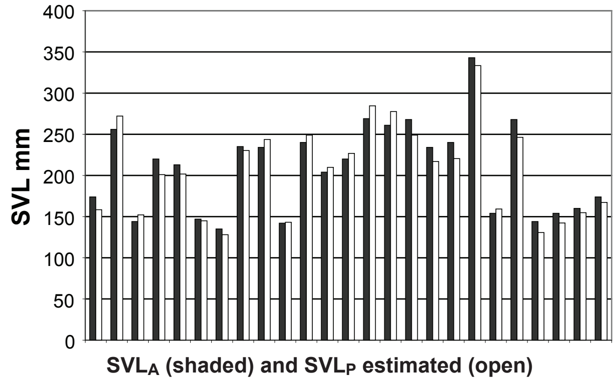


Figure 3. Graphic representation of paired measurements for actual snout-vent length (SVL_A) and estimate of snout-vent length from amount of shed skin stretch (est. SVL_P) for each of twenty-five Northern Brown Snakes, *Storeria dekayi dekayi.* SVL_A is depicted with shaded columns; est. SVL_P is depicted with open columns.

Results and Discussion

There was a significant positive correlation between SVL_A and SVL_S (r = 0.98, *df* = 46, *P* = < 0.01) (Figure 1). The regression equation used to estimate SVL_A from SVL_S was

$$Y = 0.8273x + 19.101$$

where Y is the estimated SVL and SVL_S is x. Estimated SVL using the above equation is designated as est. SVL_S.

The variances of SVL_A and est. SVL_S were homogenous (F = 1.0895, *df* = 48, *P* = 0.4177), and there was no significant difference between SVL_A and est. SVL_S (*t* = -0.0790, *df* = 48, *P* = 0.937) (Figure 2 and Table 1).

Snout-vent length of shed skins was on average 11.08% (*n* = 36, *sd* = 0.860, range 1.5–23.5%) longer than SVL_A. To estimate SVL from the amount of stretch (est. SVL_P), I used the following equation:

$$\text{est. } SVL_P = SVL_S - (SVL_S \cdot 0.1108)$$

The variances of SVL_A and est. SVL_P were homogenous (F = 0.9425, *df* = 48, *P* = 0.4429). There was no significant difference between SVL_A and est. SVL_P (*t* = 0.2300, *df* = 48, *P* = 0.8191) (Figure 3 and Table 1).

A significant positive correlation was also observed between FL and SVL_A (r = 0.84, *df* = 52, *P* = < 0.01) (Figure 4). The equation used to predict SVL using FL data was

$$Y = 109.24x - 91.747$$

where Y is the estimated SVL (est. SVL_F) and x is FL.

The variances between SVL_A and est. SVL_F were heterogeneous (F = 2.5953, *df* = 48, *P* = 0.0116), thus requiring an adjusted *t*- test. There was no significant difference between SVL_A and est. SVL_F (*t* = -1.0261, *df* = 40, *P* = 0.3110) (Figure 5 and Table 1). However, the estimates of SVL obtained from the regression equation for predicting SVL from FL measurements ranged widely, with twelve out of twenty-five (48%) of the estimates being greater than

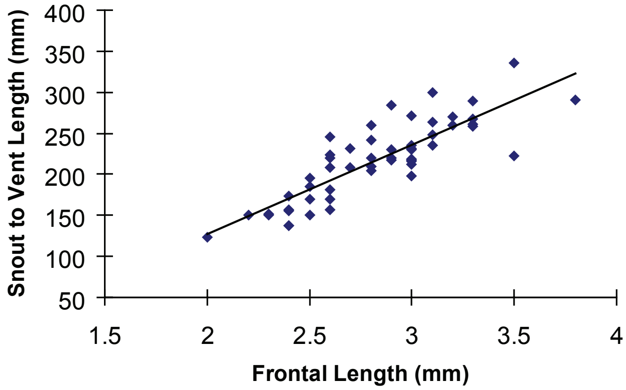


Figure 4. Relationship of frontal scale length and actual snout-vent length in the Northern Brown Snake, *Storeria dekayi dekayi*.

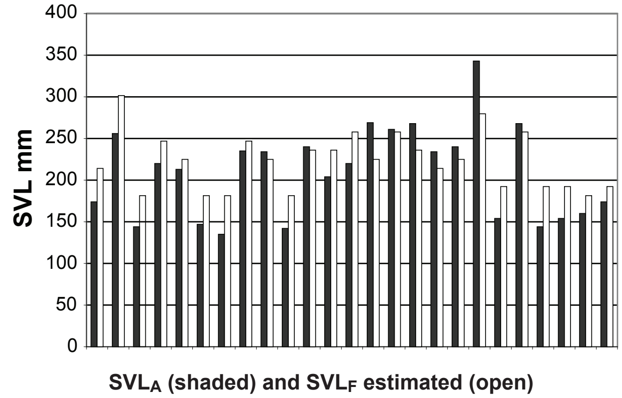


Figure 5. Graphic representation of paired measurements for actual snout-vent length (SVL_A), and estimate of snout-vent length from frontal scale length (SVL_F) for each of twenty-five Northern Brown Snakes, *Storeria dekayi dekayi.* SVL_A is depicted with shaded columns; est. SVL_F is depicted with open columns.

the shed skin SVL. Furthermore, SVL_F were underestimated by as much as 63.3 mm, and overestimated by as much as 48.3 mm. Thus making est. SVL_F the least favorable of the three estimation methods considered in this study.

Although predicted mean values for all three SVL estimation methods were not significantly different from SVL_A, the method that best estimated SVL_A was the regression equation derived from SVL_S data. It is therefore recommended that this method (est. SVL_S) be used whenever a SVL measurement can be obtained from a shed skin. However, for individuals lacking an understanding of linear regression analysis, the use of the est. SVL_P method has the advantage of requiring only elementary mathematics. Most anyone can calculate the average amount of shed skin stretch, in this study 0.1108, and utilize the equation given above for est. SVL_P. To illustrate, suppose a *Storeria d. dekayi* shed skin is found that is 200 mm SVL; using the average amount of stretch method, we multiply 200 by 0.1108, which is 22.16, and subtract this value from 200, resulting in an estimate of 177.84 mm SVL. Due to the much greater range of estimated SVL values, the est. SVL_F should only be used when one cannot obtain a SVL measurement from a shed skin. If the relationship between SVL and mass is studied, it may also be possible to estimate the mass of a snake from shed skin data.

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