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Prediction of Body Weight on the Basis of Morphometric traits in Juvenile Tortoise (*Pelusios casteneus*) breeds in Rainforest Ecological Zone, Nigeria

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Abstract

Predicting a tortoise's body weight based on morphometric traits is possible through statistical analysis. The study was designed to provide information on body weight and morphometric traits relationships of juvenile tortoises in rainforest ecological zone of Nigeria. The research was conducted at the Department of Animal Production Research Farm (DAPRF), Southern Delta University (SDU), Ozoro. The interrelationships between morphometric traits of One hundred and twenty (120) tortoises of both sexes were studied using correlation and regression analyses of SPSS package. The result showed that body weight (BWT) was positively and significantly ($P<0.05$) correlated with all morphometric traits. Straight carapace length (SCL), straight plastron length (SPL) and Carapace circumference (CC) appeared to be the traits that could be used to predict BWT with high level of accuracy in male and female juvenile tortoises studied with R^2 value of 0.34 and 0.63, respectively. Comparatively, males showed higher values ($P<0.01$) than females in terms of body weight and all aspect of morphometric traits. The coefficient of variation (C.V) confirmed these results, with male juvenile being the most reliable (C.V. =7.18%) and female juvenile had the least stable (C.V.= 8.30%) for BWT. Highly significant ($P<0.01$) correlations were observed between BWT and SCL; BWT and SPL, and BWT and SPW in male and BWT and CC; BWT and SCW in female. In conclusion, it is therefore recommended to use linear regression techniques based on CC and SPL in both sexes.

Keywords: Juvenile, Carapace, Plastron, Morphometric traits, body weight, prediction

Introduction

Domesticated tortoises remained predominantly in the hand of few farmers; this is because of their inherent merits over their wild species in the forest. These include; ease of rearing, adaptability to the prevailing condition, disease resistance, better flavour of egg and meat (Petrozzi *et al.*, 2020; McKee *et al.*, 2021; Tiar-Saadi *et al.*, 2022 and Kperegbeyi *et al.*, 2024). Numerically, the meat is more health wise than beef, chevron, and mutton – red meat. Their outputs (egg and meat) are readily available to villagers and people in urban, semi urban areas thus serves as a good source of protein in their diet, in the same vein, they serve as good source of income.

Predicting a tortoise's body weight based on morphometric traits is possible through statistical analysis. Correlations between body weight and linear measurements like straight carapace length (SCL), straight carapace width (SCW), straight Plastron length (SPL), straight Plastron width (SPW) and Carapace circumference (CC) can be used to create predictive models. These models, often using regression analysis, allow for estimating body weight from the readily measurable linear dimensions. Researchers study the relationship between body weight and various linear measurements. They use statistical methods (like Pearson's product-moment correlation) to determine how closely these measurements are related. A strong positive correlation indicates that as one measurement increases, the other tends to increase as well (Gilliam *et al.,* 2020; Mazanaeva and Gichikhanova, 2021 and Mendoza *et al.*, 2022). Once correlations are established, regression analysis is used to develop equations that can predict body weight based on the linear measurements. These models can be simple (using a single measurement) or multiple (using several measurements).

Nevertheless, at commercial level tortoise have not been widely accepted because of religion taboo. Georgalis *et al*. (2021) and Gatto and Reina, (2022) suggested that animal needs to be improved and subjected to purposive selection or breeding programme and consequently to their low production and protein intake by an average Nigerian. Genetic information needed for their improvement is not available. Morphometric traits are useful in live weight determination (Gibbs *et al.*, 2020; Hromada *et al.*, 2020; Gaviria-Hernandez *et al.*, 2021 and Cordero *et al*., 2022) especially in villages where weighing machines are not available. This information are valuable raw materials for selection programme for improvement especially when selecting for body weight, as lower body weight has been widely reported for tortoise in the wild (Mandimbihasina *et al*., 2020; Luiselli *et al*., 2021 and Kperegbeyi *et al*., 2024). This study was therefore designed to provide information on body weight and morphometric traits relationships of juvenile tortoises in rainforest ecological zone of Nigeria.

MATERIALS AND METHODS

Experimental site

The research was conducted at the Department of Animal Production Research Farm (DAPRF), Southern Delta University (SDU), Ozoro. Latitude 5^0 32^I N and Longitude 6^0 15^I E of Greenwich meridian place the center in mid-western Nigeria's rainforest. Average rainfall ranges from 2500-3000 mm per year and 27.4^{0}C and 85 % are the mean temperature and relative humidity (SDU, 2025).

Experimental Animal and Management Practices

A total of one hundred and twenty (120) males (20) and females (100) juvenile tortoises were purchased from rural farmers in Isoko North and South Local Government Areas in Delta State. The female and male tortoises were housed and intensively reared, feed and water were given *ad libitum* throughout the duration of the research with commercial mash containing 16% CP and 2,700 kcal/kg ME. The study lasted for 52 weeks. The BWT was however measured on monthly basis using a 10kg measuring scale while the linear body measurements were taken on weekly basis using measuring tape.

BWT: The BWT was taken on a digital scale every month.

SCL: Measured the SCL from the head region to the dorsal view.

SCW: The carapace width was taken between the bridges.

SPL: Measured the straight plastron length between the tips of the head end to either V-shape or

U-shape of the anus region.

SPW: It was taken between bridges of the ventral view.

CC: Measurement of the outer edge of the shell (carapace), taken along its widest point.

The analysis was replicated twice. The collected data were subjected to ANOVA using significant means to be separated by the DMRT. Correlation between dimensions was determined by Pearson's correlation coefficient separate models (linear and multiple).

Data Collection

The following measurements were taken from individual tortoise sampled with the aid of digital weighing scale and a measuring tape. These included body weight (BWT), SCL, SCW, SPL, SPW and CC. The LBM were taken according to the method described by Solomon (1996).

Statistical Analysis

Data obtained were subjected to analysis of variance, Pearson's correlation coefficients were estimated between body weight and all body measurements using general linear model of SPSS (2011).

The following statistical model was used.

$Y_{ij} = \mu + s_i + e_{ij}$

Where,

Y_{ij} = Estimated value for body weight or body measurement

μ = Population mean

e_{ij} = Residual Error
s_i = Fixed effect of the i^{th} female
The generalized prediction model adopted is as follows:

$$Y_i = a + \sum_{I=k}^{k} b_i x_i + e_i$$

Where,
Y_i = Dependent variable (body weight)
a = intercept in the y-axis
b_i = partial regression coefficients
x_i = Independent variable (i.e the linear body measurement)
e_i = Random error, identically and independently normally distributed with zero mean and constant variance $(0, \delta^2)$.

RESULTS

The descriptive statistics of body weight and morphometric traits of juvenile tortoise and sexes investigated are presented in Table 1. Comparatively, males showed higher values ($P<0.01$) than females in terms of body weight and all aspect of morphometric traits. The coefficient of variation (C.V) confirmed these results, with male juvenile being the most reliable (C.V. =7.18%) and female juvenile had the least stable (C.V.= 8.30%) for BWT.

Table 1: Means standard error, standard deviation, and coefficient of variation of measured body parameters of juvenile tortoise

Trait Significant	Sex	Mean	SE	SD	C.V (%)	Probability
BWT (kg)	M	77.67	0.47	5.58	7.18	**
	F	62.79	1.67	5.21	8.30	**
LBM (cm)						
SCL	M	7.72	0.04	0.47	6.09	**
	F	6.90	0.05	0.86	12.46	**
SCW	M	7.15	0.03	0.38	5.31	**
	F	5.51	0.04	0.52	9.44	**
SPL	M	7.43	0.58	0.48	6.46	**
	F	6.24	0.07	0.63	10.10	**
SPW	M	5.45	0.03	0.54	9.91	**
	F	4.20	0.02	0.89	21.19	**
CC	M	25.64	0.08	1.26	4.91	**
	F	21.25	0.04	1.35	6.35	**

**($P<0.01$), BWT = Body weight, LBM = Linear body measurement, SD = Standard deviation, C.V = Coefficient of variation, SCL = Straight carapace length, SCW =Straight

Carapace width, SPL =Straight Plastron length, SPW = Straight Plastron width, CC = Carapace circumference, SE = Standard Error

The Pearson correlation coefficient results from Table 2 shows that juvenile body weight of tortoise is high positive correlation with the various juvenile morphometric variables (SCL, SCW, SPL, SPW and CC) r = 0.926 and 0.794 and p-value = 0.000 for each. This indicates that increases in any of these body measurements are significantly associated with increases in body weight.

The correlation between body weight and body measurements in male and female ranged between 0.974 - 0.794 and 0.963 - 0.792 respectively, were positive and significant ($P<0.01$). Highly significant ($P<0.01$) correlations were observed between BWT and SCL; BWT and SPL, and BWT and SPW in male and BWT and CC; BWT and SCW in female.

Table 2: Correlation coefficients of juvenile between body weight and linear body measurements (value for males are above and those for females are below)

Traits	BWT	SCL	SCW	SPL	SPW	CC
BWT	1	0.928**	0.794**	0.931**	0.953**	0.796**
SCL	0.926**	1	0.935**	1.000**	1.000**	0.961**
SCW	0.794**	0.920**	1	0.920**	0.974**	1.000**
SPL	0.929**	1.000**	0.946**	1	0.864**	0.869**
SPW	0.938**	1.000**	0.927**	1.000**	1	0.928**
CC	0.792**	0.942**	1.000**	0.963**	0.946**	1

** correlations significant at ($P<0.05$)

Table 3 showed the linear regression and coefficient of determination R^2 for predicting body weight at different stages of growth in juvenile tortoise. Result indicates that all parameters measured were significant in the prediction of body weight ($P<0.001$). Result also showed that for both sexes, SCL, SPL, and CC will be more reliable for predicting body weight. The values for these parameters include 0.34, 0.19, 0.47, 0.63 and 0.39 for males and female respectively. Other parameters will not be reliable for predicting as they contributed little judging by their R^2 values.

BWT predicted using carapace circumference (CC) gave the highest coefficient of determination (R^2) in both sexes followed by straight carapace length (SCL) and straight plastron length (SPL) while the least R^2 was observed for SPW. Further addition of body measurement in prediction equations did not make any reasonable improvement in R^2 values.

It is therefore recommended to use linear regression techniques based on CC and SPL in both sexes.

Table 3: Regression of body parameters on body weight in juvenile tortoise

	Male juvenile tortoise				Female juvenile tortoise			
Var.	**Regression Equation**	**R^2**	**SE**	**Prob**	**Regression Equation**	**R^2**	**SE**	**Prob**
SCL	Y=25.46+12.52X	0.08	6.41	***	Y=43.27+9.54X	0.18	3.51	***
SCW	Y=98.43+3.72X	0.16	0.74	***	Y=124.38+12.64X	0.03	2.75	***
SPL	Y=6.74+5.81X	0.34	1.06	***	Y= 23.65+8.93X	0.47	5.27	***
SPW	Y=21.5 +8.62X	0.07	3.62	***	Y=9.85+11.74X	0.63	3.84	***
CC	Y= 46.87+5.84X	0.19	6.48	***	Y=68.42+8.55X	0.39	1.32	***

*** =P<0.001, SCL = Straight carapace length, SCW =Straight Carapace width, SPL = Straight Plastron length, SPW = Straight Plastron width, CC = Carapace circumference, SE = Standard Error

DISCUSSION

Comparatively, males showed higher values (P<0.01) than females. This is line with reports of various researchers (Cozad *et al.*, 2020; Garcia *et al.*, 2020; Cordero and Vlachos, 2021; Conrad *et al.*, 2022; Kperegbeyi *et al.*, 2024). Highly significant (P<0.01) correlations were observed between BWT and CC; BWT and SCL, and BWT and SPL in male and BWT and CC; BWT and SCW in female which thus agrees with findings of Brezina *et al.* (2019); Burgess *et al.* (2021); Cilinir *et al*. (2022); Kperegbeyi *et al.* (2024). The strong relationship existing between BWT and LBM may be useful as selection criterion, since positive correlations of morphometric traits suggest that the traits are under the same gene action. Correlation coefficients of SCL and other parameters such as SCW, SPL, SPW and CC indicate that an improvement in SCL could lead to an improvement in the other parameter. High, positive and significant (P<0.001) correlations were observed for most of the variables tested. The high and positive correlations reported in this study implies that there exists a strong linear relationship between BWT and LBM. A similar result was reported by Radu *et al.* (2022). This result also corroborates the reports of Stanford, (2020); Rhodin *et al.* (2021) and Reinke *et al.* (2022) that high positive correlation exists between BWT and LBM in juvenile tortoise of Nigeria.

Highest R^2 was observed in SPL (0.34) for male juvenile while the highest in female juvenile tortoise was in SPW (0.63). It was observed that SPL, SPW and CC generally had high and significant R^2. The result of R^2 for SPW and SPL obtained from this work is higher than the R^2

(0.12 and 0.26) for juvenile tortoise at 6 months reported by Kperegbeyi *et al.* (2024). They also observed lower R^2 (0.02) for SCW at 6 months compared to what was observed in this work 0.03, 0.07 and 0.08 for both male and female juvenile respectively. The subsequent improvement of R^2 values indicates a better reliability in prediction of live weight using any one of the body parameters with R2 values above 60%. For R^2 values below 50% there is need for the use of two or more body indices for BWT estimation. The R^2 range obtained (0.34 – 0.07 and 0.63 – 0.03) for male juvenile and female juvenile tortoise were higher and closer compared with the wide range (0.02 – 0.19) obtained by Platt and Platt, (2020); Pike *et al.* (2021); Moore and Hunter, 2021 and Stemle *et al*., 2022).

CONCLUSION

The study showed that BWT in juvenile tortoise is linearly related to body measurements, especially with SCL, SPL and CC respectively. The prediction of BWT from these traits is possible. The high, positive and outstanding correlation between BWT and morphometric traits indicates that these easily measured parts can be used as criteria for assessment and selection of BWT. The study indicated that sexual dimorphism occurs in juvenile tortoises. The present information could aid their management, conservation and future selection and breeding programmes. When BWT is under consideration for improvement in tortoises, linear body parameters are useful for tools for selection most especially in remote areas where weighing scale are not available.

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