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Interrelationships between Body Weight and Dimensional Shell Measurements of Giant African Land Snails (*Archachatina marginata*) in Calabar, Nigeria

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Abstract

Two hundred *Archachatina marginata* snails, one hundred each of *A. marginata var. saturalis* and *A. marginata var. ovum* with weights ranging from 33.10 – 349.00 g and 127.60 – 443.40 g, respectively sorted out of a base population were used for this study. Phenotypic traits measured on each of these snail varieties/strains included shell length, shell width, aperture length, aperture width, spiral length, spiral width, diagonal length, length between aperture and first spiral, number of whorls and body weight. Data collected were used to estimate phenotypic correlations between pairs of traits and to predict the relationship between body weight and other dimensional shell measurements (DSM). Results of phenotypic correlations between body weight and the DSM and between the DSM of the two *A. marginata* varieties showed that all the pairs of phenotypic traits investigated on *A. marginata var. ovum* expressed positive correlation values, while the pairs investigated on *A. marginata var. saturalis* showed both positive and negative correlation values. The regression estimates of parameters and coefficients of determination for the simple linear function of *A. marginata var. ovum* snails showed slightly high and very strong interrelationship between body weight and one phenotypic trait, while the multiple linear function for predicting body weight using four phenotypic traits showed highly significant and very strong interrelationship. In *A. maginata var. saturalis* snails, both the simple and multiple linear regression equations showed highly significant and very strong interrelationships between body weight and shell parameters. The range values of coefficient of determination showed that 78 to 100% of the variability in both snail strains body weights can be explained by changes in the considered dimensional shell parameters. Also, the linear functions with four and two parameters/traits best predicted the live weights of *A. marginata var. saturalis* and *A. marginata var. ovum* snails, respectively. Prediction results showed that explainable traits best predicted live weight when more than one phenotypic/shell trait were fitted into the regression functions.

Keywords: Snails; *A. marginata*; Body Weight; Dimensional Shell Measurements; Interrelationships

Introduction

Giant African land snails are unique cold-blooded invertebrate animals, possessing soft, un-segmented, slippery skinned asymmetrical body which is enclosed in segmented calcareous shells that are also asymmetry. Okon and Ibom stated that snails refer to a rather wide variety of soft, non-segmented-bodied, cold-blooded, shell-bearing invertebrate animals and it refers to them whether they are alive or dressed [1]. Tommaseo-Ponzetta and Paoletti reported that terrestrial invertebrates, including snails are presumed to have consistently contributed to the diets of our ancestors [2]. Similarly, opined that snail meat has traditionally been a major ingredient in the diets of West Africans living in the humid tropical zone [3]. The author further stated that the snails consumed by our ancestors were gathered from the wild by villagers. However, the decline in snail populations in the wild in recent years, coupled with the problem of animal protein intake deficiency in developing countries, including Nigeria has encouraged the domestication of snails. Besides, reported that the problem of animal protein intake in Nigeria has encouraged researchers to look for sources of protein from animals which can be reared with little or no capital [4].

Snail keeping (snailery, or heliciculture, or achatiniculture) has attracted the attention of Nigerian farmers, agriculturists and researchers in recent times, perhaps as an aftermath of the alarm raised by the Food and Agriculture Organization on animal protein intake deficiency among Nigerians [2,5]. Snails potentials in bridging the animal protein intake deficiency gap among Nigerians have been stressed [5-7]. The growth of an animal in terms of body weight gain is the most widely used growth index from birth to maturity [8]. Chapman and Shaffer defined growth as a systematic increase in the mass of body during definite intervals of time according to character of a species [9]. Body weight according to is the growth parameter used to measure growth in animals [10]. Barbato reported that growth trend defines changes that occur in an animal's size in terms of length and weight [11]. Ibom et al. opined that growth in terms of body weight gain and shell parameters increments are the most widely used growth indices for snails from hatch to maturity [12].

With the awareness in snailery, there is obvious need for the genetic improvement of snails as is the case with conventional livestock. Continuous measurements of growth processes is nearly impossible, hence noted that model measurements by mathematical functions is preferred [13]. This is because such models allow interpolation of non-observed intervals with respect to age or body weight of animals. Wahua and stated that correlation and regression are the two most common techniques used to determine relationships between and/or among two or more variables [14,15].

Several models involving body linear measurements have been established on growth trends and used to predict live weight in conventional farm animal species; poultry, pigs, sheep and cattle [16-25]. There are limited reports on the correlation among phenotypic traits as well as body weights prediction from phenotypic traits of snail species. The two main varieties (strains) of *A. marginata* snails are *A. marginata var*. ovum and *A. marginata var. saturalis*. The objectives of this study were to estimate phenotypic correlations between body weight and various dimensional shell parameters/measurements and between the dimensional shell measurements themselves as well as to establish models for predicting body weight of *Archachatina marginata* snails using dimensional shell measurements.

Materials and Methods

Two hundred (200) adult snails sorted out of a base population purchased from a reputable snail farm in Calabar, Nigeria were used for the study. They included one hundred (100) *Archachatina marginata var. ovum* and one hundred (100) *Archachatina marginata var. saturalis*. Their weights ranged from 33.10 – 349.00 g for *A. marginata var. saturalis* and 127.60 – 443.40 g for *A. marginata var. ovum*. The snails were selected based on active appearance and lack of injury on the foot and on the shell. Each variety (strain) of the snail constituted a treatment and was replicated twenty (20) times with five (5) snails per replicate for ease of data collection.

Data collected on each snail included shell length, SL (cm), shell width, SW (cm), aperture length, AL (cm), aperture width, AW (cm), spiral length, LS (cm), spiral width, WS (cm), diagonal length, DL (cm), length between aperture and first spiral, LBAF (cm), number of whorls, NW and body weight, BW (g). BW was measured using a Metier® electronic scale, while the shell dimensional parameters were measured using vernier caliper. The data collected were analyzed to estimate phenotypic correlations between pairs of traits using Pearson's correlation test of statistical programme [26]. The stepwise variable selection procedure of the same software package was used to determine the most appropriate model for predicting body weight, using dimensional shell measurements. The general prediction model used is:

$$Y_i = a + \sum_{i=k}^{k} b_i X_i + e_i$$

where:
Y_i = Dependent variable (body weight)
a = Intercept on the Y – axis
b_i = Partial regression coefficients
X_i = Independent variables (i.e. the dimensional shell measurements)
e_i = Random error [identically, independently and normally distributed with zero mean and constant variance (iind ~ $0,\delta^2$)].

Results and Discussion

The results of phenotypic correlations between body weight and dimensional shell measurements (DSM) and between the DSM of two varieties (strains) of *Archachatina marginata snails (A. marginata var. saturalis* and *A. marginata var. ovum*) are presented in (Table 1). The upper part of the diagonal shows the correlation/association values between body weight and various dimensional shell parameters/measurements and between the DSM of *A. marginata var. saturalis*, while at the lower part of the diagonal are the correlation/association values between body weight and various dimensional shell parameters/measurements and between the DSM of *A. marginata var. ovum.*

The results showed that all the pairs of phenotypic traits investigated on *A. marginata var. ovum* expressed positive correlation values (Table 1). The correlations between most of the pairs of *A. marginata var. ovum* traits were highly significant. For instance, the pairs of BW vs SW and BW vs LS recorded the highest positive correlation value and was highly significant. Similarly, highly significant positive correlation values were recorded by other pairs of traits: SL vs LS, SL vs DL, SL vs AL, AL vs LS, AW vs NW, BW vs SL, BW vs AL, SW vs LS, AW vs LS, WS vs LBAF, SL vs AW, BW vs AW, LS vs DL, AL vs DL, SL vs LBAF, DL vs LBAF, SW vs AW, AW vs LBAF, LS vs NW, AL vs AW, WS vs NW, LS vs LBAF, LBAF vs NW and BW vs NW (Table 1).

Some other pairs of *A. marginata var. ovum* traits expressed significant positive correlation values. For instance, BW vs LBAF, AW vs DL, SL vs SW and SW vs AL, DL vs NW, BW vs DL, SL vs NW and WS vs DL.

Medium, positive and significant correlation values were recorded between the pairs of SW vs LBAF, AW vs WS and SL vs WS, AL vs LBAF (Table 1).

On the contrary, the positive correlation values obtained between the pairs of SW vs NW, LS vs WS, SW vs DL, BW vs WS, SW vs WS, AL vs WS and AL vs NW were not significant (Table 1).

The results of the pairs of phenotypic traits investigated on *A. marginata var. saturalis* (Table 1) showed that whereas some pairs expressed positive correlation values, other pairs expressed negative correlation values. The positive correlation values between some of these pairs of *A. marginata var. saturalis* snails' traits were highly significant. For instance, the pair of BW vs SL had highly significant positive correlation value which was the highest of the values obtained for this variety. Other pairs of traits with highly significant positive correlation values include BW vs SW, SW vs AL, SL vs AL, BW vs AL, SL vs SW, LS vs LBAF and LS vs NW.

Archachatina marginata var. saturalis snail										
	BW	**SL**	**SW**	**AL**	**AW**	**LS**	**WS**	**DL**	**LBAF**	**NW**
BW	1.00	0.97**	0.96**	0.92**	– 0.26	0.34	– 0.34	0.62*	0.45*	– 0.37
SL	0.86**	1.00	0.92**	0.93**	– 0.58	0.49*	– 0.35	0.56*	0.52*	0.12
SW	0.95**	0.70*	1.00	0.96**	– 0.59	0.33	– 0.33	0.54*	0.44	– 0.11
AL	0.85**	0.89**	0.70*	1.00	– 0.84	0.33	– 0.25	0.52	0.38	– 0.11
AW	0.82**	0.83**	0.76**	0.75**	1.00	0.23	0.53*	0.36	0.21	0.19
LS	0.95**	0.93**	0.84**	0.89**	0.84**	1.00	– 0.48	0.54	0.80**	0.79**
WS	0.40	0.50*	0.27	0.25	0.52*	0.51	1.00	0.70	– 0.41	– 0.29
DL	0.68*	0.91**	0.44	0.81**	0.71*	0.82**	0.65*	1.00	0.46*	– 0.27
LBAF	0.72*	0.78**	0.55*	0.50*	0.76**	0.74**	0.84**	0.78**	1.00	0.42
NW	0.66**	0.66*	0.61	0.04	0.87**	0.76**	0.75**	0.69*	0.74**	1.00
	BW	**SL**	**SW**	**AL**	**AW**	**LS**	**WS**	**DL**	**LBAF**	**NW**
Archachatina marginata var. ovum snail										

BW = Body weight, SL = Shell length, SW = Shell width, AL = Aperture length, AW = Aperture width, LS = Spiral length, WS = Spiral width, DL = Diagonal length, LBAF = Length between aperture and first spiral, NW = Number of whorls.
* = $p<0.05$, ** = $p<0.01$

Table 1: Correlations between body weight and dimensional shell measurements of *Archachatina marginata* snail varieties (*var. saturalis* and *var. ovum*)

Some other pairs of *A. marginata var. saturalis* snails traits expressed significant and positive correlation values. These were the pairs of BW vs DL, SL vs DL, SW vs DL, AW vs WS, SL vs LBAF, SL vs LS, DL vs LBAF and BW vs LBAF.

Other pairs of traits expressed non-significant positive correlation values. These include WS vs DL, SW vs LBAF, LBAF vs NW, AL vs LBAF, AW vs DL, BW vs LS, SW vs LS, AL vs LS, AW vs LS, AW vs LBAF, AW vs NW and SL vs NW (Table 1).

The pairs of *A. marginata var. saturalis* snails traits that expressed negative correlation values (Table 1) were AL vs AW, SW vs AW, SL vs AW, WS vs LBAF, LS vs WS, BW vs NW, SL vs WS, BW vs WS, SW vs WS, WS vs NW, DL vs NW, BW vs AW, AL vs WS, SW vs NW and AL vs NW.

The positive correlation values recorded in this study for some of the pairs of *A. marginata var. saturalis* and *A. marginata var. ovum* snails' traits could mean that the traits are influenced by the same genes in the same direction. This corroborated the position of [27]. Besides, and opined that the positive correlation could also suggest that there are direct relationships between the traits, and that weight increment is as a result of increase in the size of corresponding traits [27,28].

The significant positive correlation values recorded by some pairs of traits in this study compare favourably with the reports of Okon *et al.* who reported $r_p = 0.98$ to $r_p = 1.00$ as the range of phenotypic correlation values for sexually mature *A. marginata var. saturalis*, Okon *et al.* who reported correlation values of $r_p = 0.89$ and $r_p = 0.774$, respectively for hatchlings of purebred white-skinned and crossbred of the same snail breed, who reported range values of $r_p = 0.134$ to $r_p = 0.722$ for the pairs of traits evaluated in *A. marginata* and *A. fulica* snail breeds. Ehiobu, Kyado earlier reported that positive significant correlations could indicate that the pairs of traits are controlled by the same genes in the same direction, thus selection and improvement for one trait will lead to improvement of the other [15,27,29-31].

The zero and negative significance recorded by some pairs of traits in this study agreed with the report of that *A. marginata* snails of different age groups expressed negative or no significant difference amongst some pairs of their traits [32].

Negative correlation values recorded by some pairs of phenotypic traits in this study signified that the genes controlling their expression are working in opposite direction, and improvement in one trait will lead to reduction in the other. This corroborated the position of Ehiobu, Kyado. Falconer, who stated that negative correlations denoted that such pairs of traits have indirect relationship and are at least controlled by the same genes in different direction [27,28]. Thus, selection for one trait will lead to the reduction of the other.

(Tables 2 and 3) show the results of regression equations, correlation coefficients and coefficients of determination relating the body weights and dimensional shell parameters of *A. marginata var. ovum* snails and *A. marginata var. saturalis* snails, respectively. The regression estimates of parameters and coefficients of determination for the simple linear function of *A. marginata var. ovum* snails showed slightly high and very strong interrelationship between BW and SL. The multiple linear function for predicting body weight using two to eight phenotypic traits evaluated in this study (Table 2) showed highly significant and very strong interrelationship between body weight and dimensional shell parameters. In *A. maginata var. saturalis* snails, both the simple and multiple linear regression equations showed highly significant and very strong interrelationships between body weight and shell parameters (Table 3). When eight and nine phenotypic parameters were fitted into the multiple linear regression functions for *A. marginata var. saturalis* snails and *A. marginata var. ovum* snails, respectively, a perfect relationship was obtained between body weight and the dimensional shell parameters (Tables 2 and 3).

Traits	Prediction equation	R	r^2
BW/SL	$Y = -244.63 + 37.14X_1$	0.89**	0.78
BW/SL,SW	$Y = 283.74 + 18.87X_1 + 47.43X_2$	0.98**	0.97
BW/SL,SW,AL	$Y = 275.828 + 24.672X_1 + 49.60X_2 - 13.099X_3$	0.99**	0.98
BW/SL,SW,AL,AW	$Y = -282.674 + 27.333X_1 + 52.514X_2 - 13.600X_3 - 8.422X_4$	0.99**	0.98
BW/SL,SW,AL,AW,LS	$Y = -287.879 + 21.159X_1 + 44.988X_2 - 17.651X_3 - 9.164X_4 + 26.205X_5$	0.99**	0.99
BW/SL,SW,AL,AW,LS,WS	$Y = -289.22 + 20.95X_1 + 38.575X_2 - 26.028X_3 - 5.406X_4 + 43.122X_5 - 10.926X_6$	0.99**	0.99
BW/SL,SW,AL,AW,LS,WS,DL	$Y = -306.069 + 12.008X_1 + 50.545X_2 - 37.820X_3 - 4.279X_4 + 40.060X_5 - 24.294X_6 + 35.967X_7$	0.99**	0.99
BW/SL, SW, AL, AW, LS, WS, DL, LBAF	$Y = -303.371 + 12.3032X_1 + 51.407X_2 - 39.363X_3 - 3.898X_4 + 39.850X_5 - 23.775X_6 + 37.909X_7 - 3.773X_8$	0.99**	0.99
BW/SL,SW,AL,AW,LS,WS,DL,LBAF,NW	$Y = -275.100 - 5.039X_1 + 54.531X_2 - 51.282X_3 + 29.175X_4 + 65.763X_5 - 6.919X_6 + 69.142X_7 - 36.307X_8 - 259X_9$	1.00	1.00

Y = BW = Body weight, X_1 = SL = shell length, X_2 = SW = shell width, X_3 = AL = Aperture length, X_4 = AW = Aperture width, X_5 = LS = spiral length, X_6 = WS = spiral width, X_7 = DL = diagonal length, X_8 = LBAF = length between aperture and first spiral, X_9 = NW = Number of whorls, r = correlation coefficient, r_2 = coefficient of determination, ** = significant (p<0.01)

Table 2: Regression analysis of body weight on other phenotypic traits of *Archachatina marginata var. ovum*

Traits	Prediction equation	R	r^2
BW/SL	$Y = -462.010 + 58.60X_1$	0.97**	0.94
BW/SL,SW	$Y = -441.171 + 34998X_1 + 43.959X_2$	0.98**	0.97
BW/SL,SW,AL	$Y = -4\ 29.38 + 41.208X_1 + 75.788X_2 - 39.893X_3$	0.99**	0.98
BW/SL,SW,AL,AW	$Y = -456.982 + 41.102X_1 + 75.123X_2 - 38.945X_3 + 5.705X_4$	0.99**	0.98
BW/SL,SW,AL,AW,LS	$Y = -421.144 + 55.181X_1 + 69.275X_2 - 48.523X_3 + 16.531X_4 - 24.441X_5$	0.99**	0.99
BW/SL,SW,AL,AW,LS,WS	$Y = -437.138 + 55.393X_1 + 55.120X_2 - 36.469X_3 + 35.376X_4 - 32.589X_5 - 8.417X_6$	0.99**	0.99
BW/SL,SW,AL,AW,LS,WS,DL	$Y = -423.074 + 58.348X_1 + 54.409X_2 - 37.280X_3 + 42.477X_4 - 36.381X_5 - 9.185X_6 - 9.491X_7$	0.99**	0.99
BW/SL,SW,AL,AW,LS,WS,DL,LBAF	$Y = -386.70 + 64.835X_1 + 42.947X_2 - 31.222X_3 + 56.655X_4 - 57.239X_5 - 10.163X_6 - 33.009X_7 + 30.754X_8$	1.00**	1.00
BW/SL,SW,AL,AW,LS,WS,DL,LBAF,NW	$Y = -392.465 + 65.403X_1 + 43.281X_2 - 33.477X_3 + 56.057X_4 - 1.859X_5 - 10.264X_6 - 31.609X_7 + 25.896X_8 - 2.402X_9$	1.00**	1.00

Y = BW = Body weight, X_1 = SL = shell length, X_2 = SW = shell width, X_3 = AL = Aperture length, X_4 = AW = Aperture width, X_5 = LS = spiral length, X_6 = WS = spiral width, X_7 = DL = diagonal length, X_8 = LBAF = length between aperture and first spiral, X_9 = NW = Number of whorls, r = correlation coefficient, r_2 = coefficient of determination, ** = significant (p<0.01).

Table 3: Regression analysis of body weight on other phenotypic traits of *Archachatina marginata var. saturalis*

The values of coefficient of determination (r^2) varied in both strains (*A. marginata var. ovum* and *A. marginata var. saturalis*) of snail. The range values of r^2 obtained in this study indicated that weight can be predicted using the dimensional shell parameters. Besides, the range values of r^2 showed that 78 to 100% and 94 to 100% of the variability in *A. marginata var. ovum* and *A. maginata var. saturalis* snails' body weights, respectively can be explained by changes in the considered dimensional shell parameters. The results also revealed that weight is more closely predicted when more than two dimensional shell parameters are used to explain the contribution of the independent variables to the prediction of the dependent variable (Tables 2 and 3).

The results of this study are in line with reports by Okon et al. and Fajemilehin, Fagbuaro that snails' weights can be predicted using shell parameters [29,33]. However, these results contrasted Okon, Ibom, who reported low coefficient of determination percentage (r^2 %) of 4.70 to 41.30% for *A. marginata* snails and concluded that variability in snails body weights cannot be explained by changes in body parameters alone.

The results of this study further revealed that the use of many (several) quantitative traits in the prediction equation would likely give a better and more reliable result. This corroborated the position of that the use of several parameters/traits as independent variables in multiple regression equations is likely to give more accurate and reliable results than the use of a single trait [34]. This tool can be relevant in rural communities where sensitive weighing scales are not readily available in the market or where the technical know-how in its usage might be lacking.

The results of predicted and actual body weights of *A. marginata var. ovum* and *A. marginata var. saturalis* snails are presented in (Tables 4 and 5) respectively. The actual body weights of snails measured with scale were 113.58 g and 341.71g for *A. marginata var. saturalis* and *A. marginata var. ovum* snails respectively (Tables 4 and 5). On the other hand, the predicted body weights of snails using the linear functions ranged from 113.28 g to 113.72 g in *A. marginata var. saturalis* snails, while it ranged from 340.85 g to 341.52 g in *A. marginata var. ovum* snails. A comparison between the actual body weight and the predicted body weights using the functions showed little or no difference. This might be as a result of the positive, strong and closely correlated responses of body weights with the phenotypic quantitative (dimensional shell) traits used in the predictions. The results of predicted body weights (Tables 4 and 5) showed that 113.55 g and 113.57 g (that is functions with six and four traits, respectively) were the closest body weights to the actual body weight in *A. marginata var. saturalis* snails, while in *A. marginata var. ovum* snails, 341.52 g and 341.51 g (that is the functions with two and three traits, respectively) were the closest predicted weights to the live or actual weight. The results in (Tables 4 and 5) showed that the linear function with four parameters best predicted the live or actual weight of *A. marginata var. saturalis* snails, while the function with two traits best predicted body weight in *A. marginata var. ovum* snails. The predicted weights derived from the regression equations evolved in this study showed that the explainable phenotypic traits best predicted live or actual weight when more than one dimensional shell traits were fitted into the regression functions. The results of this study also revealed that dimensional shell measurements were closely related to actual or live weights of snails. It could therefore be inferred that the use of more than one phenotypic dimensional shell traits in the regression functions gave better prediction of live or actual weight in snails. This corroborated the position of that more than one phenotypic trait predicted body weight better in animals [34].

Actual body weight (g)	Predicted body weight (g)
113.58	113.71
113.58	113.29
113.58	113.43
113.58	113.57*
113.58	113.50
113.58	113.55
113.58	113.72
113.58	113.34
113.58	113.28

* Value with asterisk best predicted live weight.

Table 4: Comparison between actual and predicted weights of *Archachatina marginata var. saturalis* as derived from regression equations

Actual body weight (g)	Predicted body weight (g)
341.71	341.32
341.71	341.52*
341.71	341.51*
341.71	341.47
341.71	341.49
341.71	341.11
341.71	341.08
341.71	340.85
341.71	341.00

* Value with asterisks best predicted live weight

Table 5: Comparison between actual and predicted weights (g) of *Archachatina marginata var. ovum* using regression equations

Conclusion

It could be concluded from this study that multiple linear regression model gave a more accurate and reliable results, thus best predicted body weights. Of the two varieties of *Archachatina marginata* snails studied, shell length and shell width best predicted live weight in *A. marginata var. saturalis* snails, while shell length, shell width, aperture length and aperture width best predicted live weight in *A. marginata var. ovum* snails. The two varieties of *A. marginata* snails' body weights and dimensional shell parameters were positively correlated. Besides, variability in their live weights can be explained by changes in phenotypic dimensional shell parameters.

It could therefore be recommended that in the prediction of snails live weight, breeders should consider the use of multiple phenotypic dimensional shell traits. Besides, genetic improvement by selection using dimensional shell parameters should be considered as basis for producing hybrid snails with high growth rates.

References

1. Okon B, Ibom LA (2012) Snail breeding and Snailery Management. Freshdew Productions, Nigeria 2012: 1-70.

2. Tommaseo-Ponzetta M, Paoletti MG (2006) Ecological Implications of Minilivestock. Potentialrole of rodents, frogs, snails 2006: 441-57.

3. Ejidike BN (2002) Snail Rearing Practices in Southern Nigeria. Proceedings, 27th Annual Conference of Nigerian Society for Animal Production (NSAP). Akure, Nigeria 2002: 307-8.

4. Omole AJ, Ayodeji IO, Raji MA (2004) The potential of peels of mango, plantain, cocoyam and pawpaw as diets for growing snails (Archachatina marginata). Livestock Res Rural Dev 16.

5. Akinnusi O (2000) Snail rearing- case study of Abeokuta, Ogun State, Nigeria. Proceedings 5th Annual Conference of Animal Science Association of Nigeria (ASAN). Port Harcourt, Nigeria.

6. Okon B, Ibom LA (2010) Commercialization of snail production in Nigeria: Potentials, Viabilities and Challenges. J Appl Sci 13: 9139-58.

7. Ibom LA, Okon B, Isaac LJ (2010) Effects of body weight ranges on variations in morphological traits of parent snails and eggs obtained from their matings in Obubra, Nigeria. Articlesbase.com – Free Articles Directory 11: 1-11.

8. Ensminger ME, Olentine CGJr (1978) Feeds and Nutrition (Complete). Ensminger Publishing, USA.

9. Chapman PW, Shaffer IM (1996) Livestock farming. Atlanta.

10. Ibom LA, Okon B (2012) Evaluation of growth correlations between body weight and shell measurements of the Juveniles of two ectotypes of Archachatina marginata var. saturalis (P) snails. Int J Agric For 2: 145-9.

11. Barbato GF (1991) Genetic architecture of growth curves structures of chickens. Theor Appl Genet 83: 24-32.

12. Ibom LA, Okon B, Adinya IB (2011) Evaluation of growth and body traits of snailets obtained from the crossbreeding of black skinned x white skinned snails [Archachatina marginata (S)] in the Niger Delta area of Nigeria. Afr J Agric Res 6: 4968-72.

13. Oengol T, Kiraz S (2005) Non-linear models for growth curves in large white turkeys. Turk J Vet Anim Sci 29: 331-7.

14. Wahua TAT (2010) Applied Statistics for Scientific Studies. Port Hacourt, Transparent Earth Nigeria Limited 360.

15. Okon B, Ibom LA (2011) Phenotypic correlation and body weight prediction using morphometric traits of snails in Calabar, Nigeria. Ethiopian J Environ Stud Manage 4: 7-11.

16. Monsi A (1992) Appraisal of Interrelationships among live measurements at different ages in meat type chickens. Niger J Anim Prod 19: 15-24.

17. Okon B, Ogar IB, Mgbere OO (1997) Interrelationship of live body measurements of broiler chicken in a humid tropical environment. Nigeria Anim Prod 2: 7-12.

18. Gueye EF, Ndilaye A, Branckaert RDS (1998) Prediction of mature body weight on the basis of body measurement in mature indigenous chickens in Senegal. Livestock for Res Rural Dev 10.

19. Mignon-Grasteau S, Piles M, Vasona L, deRochambeam H, Poivey JP, et al. (2000) Genetic analysis of growth curve parameters for male and female chickens resulting from selection on shape of growth curve. J Anim Sci 78: 2515-24.

20. Hassan A, Ciroma A (1990) Body weight measurements relationships in Nigerian Red Sokoto goats. Proceedings of the 1st Biannual Conference of the Small Ruminants Research Network 1990: 491-7.

21. Ozoje MO, Herbert U (1997) Linear measurements in West African Dwarf (WAD) and WAD* Red Sokoto goats. Nigerian J Anim Prod 24: 13-9.

22. Blaxter KL, Fowler VR, Gill JC (1980) A study of the growth of sheep to maturity. J Agr Sci 98: 405-20.

23. Kandasamy N, Gupta DC (1983) Studies on physical measurements, live weights and fleece weights in mature and crossbred sheep in a semi-arid zone of India. Trop Agric 60: 92-4.

24. Orheruata AM, Olutogun O (1994) Pre- and post- weaning phenotypic relationships between some N'dama cattle linear measurements in the tropics. Niger J Anim Prod 22: 76-82.

25. Williams CB, Jenkins TG (2003) A dynamic model of metabolizeable energy utilization for maintenance and support metabolites. J Anim Sci 81: 1371-81.

26. Makalah ODSPSS (2014) Scientific Package for Social Sciences, Indonesia.

27. Ehiobu NG, Kyado JA (2000) Heritability, Repeatability and Genetic correlation of Swine. Proceedings of the 25th Annual Conference of Nigerian Society for Animal Production (NSAP). Umudike, Nigeria 2000: 260-1.

28. Falconer DS (1989) Introduction to Quantitative Genetics (3rd Edn) Burat Mill, England. Longman Group Limited, USA 1989: 162-9.

29. Okon B, Ibom LA, Williams ME, Etukudo OM (2010) Effects of Parity on Breeding and Morphometric traits of eggs and hatchlings of F1 crossbred of snails (Archachatina marginata var. saturalis). J Agric Biotechnol Ecol 3: 36-43.

30. Okon B, Ibom LA, Etta HE, Udoh UH (2012) Comparative differentiation of morphometric traits and body weight prediction of Giant African land snails with 4 whorls in Niger Delta Region of Nigeria. J Agric Sci 4: 205-11.

31. Etta HE, Okon EA, Ekpe PA (2015) Comparative phenotypic Assessment of two snail Breeds – Archachatina marginata (S) and Achatina fulica (L) in Calabar, Cross River State. Proceeding of the 4th International Conference/Workshop on Giant African Land Snails 2015: 40-8.

32. Samuel OK, Maria KA, Sok S, Fagbuaro SS (2013) Relationships among body Traits of African Giant Land Snails (Archachatina marginata) at different age groups. Global J Sci Front Res 13: 1-4.

33. Fajemilehin SOK, Fagbuaro SS (2012) Relationship among shell dimensions and live weight of Giant African snail (Archachatina marginata). Proceedings 17th Annual Conference of Animal Science Association of Nigeria 2012: 89-92.

34. Groesbeck CN (2003) Use of heart girth to estimate the weight of finishing pigs. Kansas State University Cooperative Extension Service-Swine Update Newsletter, Spring.