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Phenotypic Correlations and Body Weight Prediction of Two Ectotypes of Giant African Land Snails (*Archachatina maginata,* Swain.) Based on Number of Whorls in Calabar, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author OME designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author EEE managed the analyses of the study. Author AJU managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: Giant African land snail (*Archachatina marginata*) is a micro livestock with potentials as a protein source especially among impoverished individuals. As such, it requires much research attention to fully unveil it genetic nature for possible improvements.

Materials and Methods: Two hundred (200) snails consisting of one hundred (100) each of black-skinned ectotype and white-skinned ectotype were selected based on number of whorls from a population gathered in the wild within Cross River State for the study. Data collected on number of whorls from the two ectotypes of snails were used for predicting body weights from phenotypic traits.

Results: The black-skinned ectotype body weight ranged from 0.70 g to 153.90 g, while the white-skinned ectotype body weight ranged from 0.60 g to 72.10 g. The results obtained from the study showed positive, strong and very high significant correlation coefficients (p<0.001) between body weights and all body components measured based on 2 and 3 whorls for the two ectotypes of

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A. marginata. A non-significant (p>0.05) phenotypic correlation was recorded for white-skinned ectotype with 4 whorls between mouth shell width and all the body components measured. Whereas a non-significant (p>0.05) phenotypic correlation was only recorded for mouth shell width and mouth shell length of 5 whorls for white-skinned snails. Prediction equations for the body weight of *A. marginata* with 2, 3, 4 and 5 whorls using body shell length, body shell width, mouth shell length and mouth shell width best predicted accurately body weight for the two ectotypes of snails with 2, 3, 4, and 5 whorls.

Conclusion: These phenotypic traits of the two ectotypes of snails studied could be chosen to characterize growing snails in Calabar, Nigeria.

Keywords: Archachatina marginata; correlation; ectotypes; phenotypic traits; prediction; snails; whorls.

1. INTRODUCTION

Giant African land snails (*Archachatina marginata*) are bilaterally symmetrical invertebrates with soft unsegmented body closed by an exoskeleton in the form of calcareous shell. In Nigeria, the species is distributed in many localities especially in the southern regions. The importance of this species as a reliable protein source especially to impoverish populations was earlier reported [1,2]. The shell is secreted by a body part known as the mantle [3]. The posterior end of the shell is lined with a ring-like structure known as whorls. The shell is an essential protector against the sun and against drying out [3].

The shell of the black-skinned and white-skinned ectotypes of giant African land snails (*Archachatina marginata*) often provides relevant phenotypic data used in taxonomy and phylogenic inference as well as in population biology. Shell morphology is the essential subject of theoretical morphology. This has led to studies on the formal and historical determinants of shell form, as well as functional interpretations of their observed distribution [4,5,6,7,8,9].

The black-skinned and white skinned ectotypes are frequently measured for differentiation of phenotypic traits. According to [10,11], body weight has been used by both local sellers/buyers and researchers as a parameter for selection. Body weight estimated as shell volume is a more reliable measurement of land snail size than live weight that depends on the state of hydration and is consequently variable [12]. Snail weight can be predicted using phenotypic traits. These traits include body weight, shell length, shell width, shell “mouth” length and shell “mouth” width. The authors [13], using multiple regression equations noted that shell length and shell width are better predictors of hatching body weights of *A. achtinata* than *A. marginata* juvenile snails.

These same authors obtained high, positive significant correlation values between body weights and these phenotypic traits in both *A. marginata and A. achatina* snails. Similarly, a number of earlier studies reported correlation between the body weight and phenotypic traits of snails [14,15]. Also, [16,18] reported highly significant positive correlations among the morphometric traits of F1 crossbred and albino (white-skinned) snail hatchlings (*A. marginata* var. *saturalis*). A correlation between body weight and shell measurements can serve as important factor in marketing, and breeders can use it as a guide to improve market value or the quality of breeding stocks [14]. Although these earlier studies tried to explore the relationships between body weights and phenotypic traits, however, there is scarce information on phenotypic correlations and body weights estimation of giant African land snail based on number of whorls. The current study is therefore aimed at evaluating the correlation of body traits of giant African land snail in order to provide information for stock selection in breeding improvement.

2. MATERIALS AND METHODS

The research was carried out at the Botanical Garden, University of Calabar, Calabar, Nigeria. The Botanical Garden is planted with trees like citrus, mango, almond, pawpaw, plantain and banana and crops like cassava, yam and maize [19,20]. These trees and crops provided a micro-environment similar to the natural habitat of snails as well as shade that protected the hutches used for the study from direct sunlight and heavy rainfall.

Two hundred (200) snails of different sizes consisting of one hundred (100) back-skinned ectotype and hundred (100) white-skinned ectotype of *Archachatiana marginata* were used for the study. These two ectotypes were selected based on 2, 3, 4 and 5 whorls for the study. The description of the management of the snails were prescribed by [19,20] and [16]. Data collected were body weight, body shell length, body shell width, mouth shell length and mouth shell width. An electronic balance, Scout™ pro electronic scale with 0.01 g sensitivity was used to measure the body weights, while Vernier caliper was used to measure length and width. Phenotypic correlation among body measurements were determined [21]. Multiple regression function was used for predicting body weights of the two ectotypes from phenotypic traits of the two ectotypes of snails studied.

3. RESULTS AND DISCUSSION

The results of phenotypic correlations among body traits based on number of whorls for the two ectotypes of giant African land snails (*Archachatina marginata*) evaluated are presented (Tables 1-4). The result showed highly significant (P<0.001) phenotypic correlation between all the body traits (Tables 1 and 2) studied for the two ectotypes based on 2 and 3 whorls respectively. The highest correlation coefficient (rp) obtained was between body shell length and mouth shell length (r= 0.962) for black skinned ectotype with 2 whorls (Table 1). Similarly, highly correlation coefficient (rp) of 0.975 was obtained between body shell width and body shell length for white-skinned with same whorls (Table 1) while the lowest positive correlation coefficients (rp) was between body weight and mouth shell width (r= 0.867 and 0.868) for black-skinned and white-skinned ectotypes based on 2 whorls respectively (Table 1).

Based on 3 whorls, the highest positive correlation coefficients (rp) was between pairs of body shell length and mouth shell length (r= 0.970 and 0.978) for black-skinned and white-skinned ectotypes respectively while the lowest positive phenotypic correlation coefficients (rp) was between pairs of body weight and mouth shell width (r= 0.878) for black-skinned ectotype and between body weight and mouth length (r= 0.937) for white-skinned ectotype (Table 2).

Based on 4 whorls (Table 3), there was positive, strong and very high significant (P<0.001) phenotypic correlation coefficients (rp) between body weight and all body components studied for black-skinned ectotype, with the highest correlation coefficients (rp) obtained between body weight and body shell width (r= 0.985) while the lowest positive significant value of 0.881 was obtained between mouth shell length and mouth shell width. On the other hand, the white-skinned ectotype with 4 whorls was highly significant (P<0.001) between pairs of body weight and body shell length, body weight and body shell width, body weight and mouth shell length, but no significant (P>0.05) phenotypic correlation coefficient (rp) between body weight and mouth shell width, between body shell length and mouth shell width, between body shell width and mouth shell width, and between mouth shell length and mouth shell width. The highest positive significant (P<0.001) value was obtained between body weight and body shell length (r=0.882), while the lowest positive non-significant value was obtained between body weight and mouth shell width (r= 0.263) for white-skinned ectotype with 4 whorls.

Based on 5 whorls (Table 4), there was positive, strong and very high significant (P<0.001) phenotypic correlation coefficient (rp) between body weight and all body components studied for black-skinned ectotype, except positive non-significant (P>0.05) phenotypic correlation coefficient (rp) between body weight and mouth shell width (r= 0.484). The highest positive significant correlation coefficient (rp) was recorded between body shell length and mouth shell length for the black-skinned ectotype. On the other hand, the white-skinned ectotype with 5 whorls was highly significant (P<0.001) between body weight and body shell length (r= 0.997), while low significant difference (P>0.05) was recorded between pairs of mouth shell width and mouth shell length. In fact, the highest positive significant phenotypic correlation coefficient (rp) was between body weight and body shell length (r=0.997), while the lowest positive but non-significant phenotypic correlation coefficient (rp) was between mouth shell width and mouth shell length (r=0.164) for white-skinned ectotype with 5 whorls (Table 4).

The positive significant correlation coefficient obtained in this study were noted by [22,16,17] and [23]. According to [22] and [23], this signifies that the pairs of quantitative traits used have direct relationship or at least are controlled by the same gene in the same direction, thus selection of one trait will lead to improvement of the other. Furthermore, these results confirmed [16,17] and [23] earlier views of high correlation responses of these phenotypic traits for selection and cross breeding for genetic improvement as well as being better predictors of the body weights in growing snails. On the other hand, the lowest positive but non-significant phenotypic correlation coefficient (rp) obtained in this study based on 4 and 5 whorls may be due to the differences in size, number of whorls and the body weights of snails used for the study.

Table 1. Phenotypic correlation (rp) of body traits for the two ectotypes based on 2 whorls

	Black-skinned ectotype				
	BDW	**BDL**	**BDH**	**MSL**	**MSW**
BDW	1	0.958**	0.928**	0.933**	0.867**
BDL	0.960**	1	0.920**	0.962**	0.895**
BDH	0.934**	0.972**	1	0.952**	0.940**
MSL	0.926**	0.975**	0.971**	1	0.961**
MSW	0.868**	0.944**	0.922**	0.958**	1
	White-skinned ectotype				

*BDW= body weight, BDL= body shell length, BDH= body shell width, MSL= mouth shell length, MSW= mouth shell width, **= P< 0.001 (highly significant level)*

Table 2. Phenotypic correlation (rp) of body traits for the two ectotypes based on 3 whorls

	Black-skinned ectotype				
	BDW	**BDL**	**BDH**	**MSL**	**MSW**
BDW	1	0.965**	0.898**	0.959**	0.878**
BDL	0.975**	1	0.929**	0.970**	0.915**
BDH	0.974**	0.974**	1	0.945**	0.930**
MSL	0.937**	0.978**	0.949**	1	0.929**
MSW	0.961**	0.970**	0.972**	0.949**	1
	White-skinned ectotype				

***= P< 0.001 (highly significant level)*

Table 3. Phenotypic correlation (rp) of body traits for the two ectotypes based on 4 whorls

	Black-skinned ectotype				
	BDW	**BDL**	**BDH**	**MSL**	**MSW**
BDW	1	0.961**	0.985**	0.933**	0.960**
BDL	0.882**	1	0.976**	0.881**	0.943**
BDH	0.880**	0.873**	1	0.905**	0.967**
MSL	0.855**	0.856**	0.793**	1	0.881**
MSW	0.263^{NS}	0.296^{NS}	0.379*	0.291^{NS}	1
	White-skinned ectotype				

$^{NS=}$ P> 0.05 (Non significant level)
**= P< 0.05 (low significant level)*
***= P< 0.001 (highly significant level)*

Table 4. Phenotypic correlation (rp) of body traits for the two ectotypes based on 5 whorls

	Black-skinned ectotype				
	BDW	**BDL**	**BDH**	**MSL**	**MSW**
BDW	1	0.712**	0.718**	0.710**	0.484**
BDL	0.997**	1	0.638**	0.769**	0.685**
BDH	0.547**	0.588**	1	0.714**	0.745**
MSL	0.392*	0.443*	0.388*	1	0.713**
MSW	0.765**	0.743**	0.720**	0.164^{NS}	1
	White-skinned ectotype				

$^{NS=}$ P> 0.05 (Non significant level)
**= P< 0.05 (low significant level)*
***= P< 0.001 (highly significant level)*

Table 5. Prediction equations for body weight of black-skinned and white-skinned ectotypes

Snail ectotype	Number of whorls	Equation	R	R^1	SEE
Black-skinned	2	$Y= -2.063 + 1.053_{x1} + 1.493_{x2} + 0.408_{x3} – 1.64_{x4}$	0.969	0.938	0.174
	3	$Y= -8.427 + 2.728_{x1} - 0.871_{x2} + 4.538_{x3} – 2.345_{x4}$	0.972	0.944	0.620
	4	$Y= -109.607 + 0.021_{x1} – 27.411_{x2} + 9.418_{x3} – 5.577_{x4}$	0.990	0.980	3.686
	5	$Y= -155.806 + 12.211_{x1} – 33.566_{x2} + 11.519_{x3} – 25.864_{x4}$	0.839	0.704	7.046
White-skinned	2	$Y= -1.398 + 2.119_{x1} + 0.115_{x2} + 0.149_{x3} – 2.044_{x4}$	0.966	0.934	0.172
	3	$Y= -13.502 +5.080_{x1} + 5.554_{x2} – 3.646_{x3} – 0.055_{x4}$	0.984	0.968	1.234
	4	$Y= -61.893 + 3.810_{x1} + 11.388_{x2} + 8.5288_{x3} – 0.907_{x4}$	0.926	0.857	3.296
	5	$Y= -36.823 +18.812_{x1} – 8.371_{x2} - 2.637_{x3} – 0.713_{x4}$	1	1	0.00

Y= Body weight, $_{x1}$= body shell length, $_{x2}$ = body shell width, $_{x3}$= mouth shell length, $_{x4}$= mouth shell width
R= Multiple correlation coefficient, R^2= coefficient of multiple determination
SEE= Standard error estimate

Table 6. Comparison between actual and predicted body weights of black-skinned and white-skinned ectotypes of *A. marginata* based on number of whorls using regression equations

Number of whorls	Black-skinned ectotype		White-skinned ectotype	
	Actual weight (g)	Predicted weight (g)	Actual weight (g)	Predicted weight (g)
2	1.113	1.114*	1.300	1.300*
3	4.147	4.146*	9.620	9.620*
4	97.364	97.372*	31.987	31.922*
5	123.117	123.128*	61.262	61.262*

The prediction equations evolved for the body weights of the two ectotypes of snails with 2, 3, 4, and 5 whorls using phenotypic traits from black-skinned and white-skinned ectotypes are shown in Table 5. The equations indicated that these phenotypic traits, namely; body shell length, body shell width, mouth shell length, mouth shell width best predicted body weights for black-skinned and white-skinned with 2, 3, 4 and 5 whorls, as there were little or no differences between the actual and predicted live weights (Table 6) of these two snail ectotypes using multiple regression. This may be due to the positive, strong and closely correlated responses of body weight with the phenotypic traits used in the predictions. However, these results of prediction equations agreed with that of [24] for *A. marginata* and *A. fulica* with 4 whorls, but do not agree with [23] and [25] for *A. marginata* snails because of age differences and number of phenotypic traits used in the equation. Authors [23] could not closely predict hatching (juvenile) body weight of *A. marginata* snails using shell length and shell width. Also, [25] reported shell length as a better predictor of body weight for growing snails. Thus, using more than two phenotypic traits in the prediction equation may likely give a better and more reliable result. This might be attributed to the effects of age and size of snails, number of whorls on the snail shells and number of traits involved in the prediction as [23] used juvenile snails with 2 to 3 whorls and two traits (shell length and width) in their study, while [25] used growing snails with 3 to 5 whorls but only on trait (shell length) in their prediction.

High percent coefficient of determination (R^2) of 94, 94, 98 and 70% (Table 5) were obtained in this study for black-skinned ectotype with 2, 3, 4 and 5 whorls respectively, while that of white-skinned ectotype was 93, 97, 86, and 100% (Table 5) for 2, 3, 4, and five whorls respectively. These high percent of coefficients of determination (R^2) obtained in this study for the two ectotypes indicated that variations in the body weights of the two ectotypes of *A. marginata* with 2, 3, 4, and 5 whorls on the shell use can be explained by changes in the number of phenotypic traits and methods of statistical analysis used in the prediction. Hence, [23] further noted that methods of statistical analysis could also affect the results obtained. The authors [16,17] using simple correlation analysis for a single trait obtained very high coefficient of determination (R^2) whereas [23] results that involved multiple correlation analysis and two traits (shell length and shell width) in the equations obtained low R^2 values, but for this study, using multiple regression analysis, and four phenotypic traits (body shell length, body shell width, mouth shell length and mouth shell width) from snails with 2, 3, 4 and 5 whorls, the coefficients of determination obtained were very high.

4. CONCLUSION

Prediction analysis of body weights using multiple regression analysis on phenotypic traits (body shell length, body shell width, mouth shell length and mouth shell width) of black and white-skinned ectotypes of *Archachatina marginata* predicted the body weights of both ectotypes with 2, 3, 4 and 5 whorls very accurately. Thus, these phenotypic traits for the two ectotypes of snails studied could be chosen to characterize growing snails and also, the phenotypic traits should be considered for selection of individual snail for the purpose of improving the performance of these snails.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Etukudo OM, BIna-ibor O, Ekerette EE. Comparative study of egg quality traits of black-skinned and white-skinned ectotypes of snails (*Archachatina marginata*) based

on four whorls in Calabar, Nigeria. Journal of Biological Sciences. 2015;15(2):98-101.

2. Etukudo OM, Okon B, Ekerette EE. Differentiation in growth of body components between two ectotypes of giant african land snails (*Archachatina marginata* S.) Based on Number of Whorls in Calabar, Nigeria. Asian Journal of Animal Science. 2016;10(3):196-201.
3. Banjoko OA, Oguntusi I, Osinowo OA. Estimation of shell surface area, shell weight and internal shell volume from linear measurements in the giant African land snail, *Archachatina marginata Swainson* 1821. Proceedings of 1st International Conference on Giant African Snails (GALS). February 12th-15th, 2012. University of Agriculture, Abeokuta, Ogun State. 2012;135-139.
4. Raup DM. Geometric analysis of cell coiling; general problems. Journal of Palentology. 1996;40:1178-1190.
5. Stone JR. Computer-stimulated shell size and shape variation in the Caribbean land snail genus *Cerion:* A test of geometrical constraints. Evolution. 1996;50:341-347.
6. Stone JR. Using a mathematical model to test the null hypothesis of optimal shell construction by four marine gastropods. Marine Biology. 1999;134:397-403.
7. Mc Ghee Jr GR. Theoretical morphology: The concept and its applications. Columbia University Press. New York; 1999.
8. Samadi S, David P, Jane P. Variation of shell shape in the clonal snail *Melanoides tuberculata,* and its consequences for the interpretation of fossil series. Evolution. 2000;54:449-502.
9. Mogbo T, Nwankwo O, Nwuzor I. Growth performance of snails (*Achatina fulica*) fed with three different leaf materials. American Journal of Biology and Life Sciences. 2014;2:96–99.
10. Fitzhurgh HA. Analysis of growth curves and strategies for altering their shapes. Journal of Animal science. 1976;42:1036-1040.
11. Ibom LA, Okon B, Asuquo LE. Heterosis of body weights and egg weights of F1 snails (*Archachatina marginata* var. *saturalis*) in Obubra, Nigeria. Journal of Biology, Agriculture and Healthcare. 2014;4(17): 120-123.
12. Baur A, Baur B. Attitudinal variation in size and composition of eggs in the land snails *Arianta arbustorum.* Canadian Journal of Zoology. 1998;96:2067-2074.
13. Okon B, Ibom LA. Phenotypic correlation and body weights prediction using morphometric traits of snails in Calabar, Nigeria. Ethiopian Journal of Environmental Studies and Management. 2011;4(3):7-11.
14. Ibom LA, Okon B. Evaluation of growth and correlations between body weight and shell measurements of the juveniles of two ectotypes of *Archachatina marginata var. saturalis* (P) snail. International Journal of Agriculture and Forestry. 2012;202(4):145-149.
15. Ibom LA, Okon B, Adinya BI, Okon FI. Reproductive performance and correlations among egg traits of two ectotypes of adult snail (*Archachatina marginata* var. *saturalis*) in the humid tropics. World Journal of Zoology. 2012;7(2):113-117.
16. Okon B, Ibom LA, Williams ME, Akwa NT. Parity effects on breeding and morphometric traits of egg and hatchings of purebred. Albino snails (*Archachatina marginata* (Swainson). Journal of Agriculture, Biotechnology and Ecology. 2010a;3(1):44-54.
17. Okon B, Ibom LA, Williams ME, Etukudo OM. Effects of parity on breeding and morphometric traits of eggs and hatchlings of F_1 crossbred of snails (*Archachatina marginata* var *saturalis*). Journal of Agriculture, Biotechnology and Ecology. 2010b;3(1):36-43.
18. José M, Avendaño Y, Edgar LL. Morfometría del caracol gigante africano *Achatina fulica.* (Gastropoda: Achatinidae) en Colombia. Research Journal of the Costa Rican Distance Education University. 2015;7(2):287-293.
19. Okon B, Ibom LA, Ekpo IA, Ewa EC. Evaluation of reproductive performance and some quality parameter of Albino snails (*Archachatina marginata saturalis*) (Swainson). Journal of Applied Science. 2009a;12(1):8234-4240.
20. Okon B, Ibom LA, Williams ME, Akpakpan IE. Comparative evaluation of reproductive performance and some egg quality parameters of black and white-skinned snails. Global Journal of Agricultural Sciences. 2009b;8(17):77-80.
21. Ibe SN. An introduction to genetics and animal breeding. Ikeja, Nigeria. Longman Nigeria Plc; 1998.
22. Ibom LA. Variations in reproductive and growth performance traits of white-skinned x black-skinned African giant snail

hatchlings [*Archachatina marginata* (*Swainson*)] in Obubra, Nigeria. Ph. D. Thesis. Department of Animal Science, University of Calabar, Calabar, Nigeria; 2009.

23. Okon B, Ibom LA, Odido EE. Reproductive performance and egg quality traits of crossbreeding between two strains of snails. Archives de Zootecnia. 2011; 60(229):153–156.
24. Okon B, Ibom LA, Ettah HE, Udoh UH. Comparative differentiation of morpho-metric traits and body weight prediction of giant African land snails with four whorls in Niger Delta Region of Nigeria. Journal of Agricultural Science. 2012;4(2):205-211.
25. Olawoyin OO, Ogogo AU. Predicting of optimum stocking density in growing African giant land snails. Tropical Journal of Science. 2006;9(2):72-84.

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