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Relationships among Phenotypic Traits of Giant African Land Snails in Western region of 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

The relatedness among three populations (*A. achatina, A. fulica* and *A. marginata*) of giant African land snails, a highly relished source of protein in West Africa was studied. Three hundred (300) matured snails consisting of one hundred (100) each of *A. achatina, A. fulica* and *A. marginata* collected randomly from three locations in Western region of Nigeria were used to evaluate the relationships among phenotypic traits. The results of the mean body weight and shell traits (body weight, shell length, shell width, shell 'mouth' length and shell 'mouth' width) studied showed highly significant differences ($P< 0.05$). Phenotypic correlations among the pairs of traits showed positive, strong and highly significant ($P< 0.01$) correlation coefficients (r_p). Similarly, the clustering of the phenotypic traits also showed that the three populations were divided into two major groups with *A. marginata* being more closely related to *A. achatina* than *A. fulica.* The body traits studied was grouped into one principal component with a total variability of 98.75%. This study revealed phenotypic differences among the species of snails used.

Keywords: Phenotypic; relationship; snail; trait; African Land Snails.

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1. INTRODUCTION

The intake of animal protein in the diet of an average Nigerian has been reducing from year to year [1]. In Africa, Nigeria is still among the least consumer of animal protein, consuming on the average about 6 g to 8.4 g by an individual per day [2]. This may be attributed to non-availability and high cost of the product which has impoverished Nigerians [1]. Owing to these, a common man finds it difficult to buy animal products from conventional animals. Besides, the cost of production inputs of conventional animal protein sources like fish, chicken and beef have become highly expensive for most Nigerians [3]. Efforts are being made towards producing animal protein from unconventional animals like snails and grass-cutters by domesticating them because of the shortage of meat protein from conventional animal sources [4]. Nigeria is richly endowed with various species of snails and it is the cheapest animal protein source during the rainy season, especially for rural dwellers in the rainforest zone of Nigeria [5,6]. In the past, snails were cheap because of their enormous supply and small numbers of individuals were interested in their meat [7]. In the quest to meet daily protein intake, the consumption of snail meat has increased tremendously in Nigeria over the years [8]. Giant African land snails have unique traits and characteristics such as adaptation to extreme climatic conditions by aestivation process that could prove fundamental to the food security of future generations.

Upon all these great benefits derived from snails, they are still being gathered from the wild indiscriminately and excessively. This, together with deforestation and bush burning, has drastically reduced giant African land snails population, thus subjecting the species to the threat of extinction [8,9,10].

Giant African land snails consist of the following breeds; *Archachatina marginata, Achatina fulica, Achatina achatina, Limicolaria species* and *Thapsia species* in Nigeria and other African countries as stated in [6] and they belong to the family Achatinidae, consisting of about thirteen genera. These snail breeds could be black or white with respect to their skin colouration [11, 12]. This difference in the colour of the skin could be genetic in origin, and capable of causing remarkable differences in a population [13].

Authors [14,15] stated that *Achatina achatina* is the largest land gastropod. However, [16] reported that *Archachatina marginata* is the largest known land snails in Nigeria in the Guinness Book of records. Differences exist among the populations of snails in Nigeria which could be chromosomal, genetic and/ or phenotypic and animal breeders and geneticists can exploit it for the species improvement. The performances of animals including snails depend on the environment where they are found and their genetic make-up [17]. The Western states in Nigeria have different environmental conditions (relative humidity, vegetation, temperature and rainfall pattern). These differences in environmental conditions could give rise to diversity in gene pool of snails, which will eventually influence the body components and growth pattern of the organisms including the snail species that inhabit the area. The knowledge of phenotypic relationship among giant African land snails is so important for the understanding of economic traits of the snail species. This study therefore seeks to evaluate the relationships among phenotypic traits of giant African land snails in western region of Nigeria (Osun, Ondo and Oyo States).

2. MATERIALS AND METHODS

2.1 Sample Collection and Snail Management

A total of three hundred (300) matured giant African land snails consisting of 100 each of *Achatina fulica* (Plate 1), *Achatina achatina* (Plate 2) and *Archachatina marginata* (Plate 3) respectively, were procured from three different locations (Ile – Ife forest in Osun State, 7°.55 ^{1}N, 4°.43 ^{1}E, Oluwa forest reserve in Ondo State, 6°.82 ^{1}N, 4°.67 ^{1}E and Amusan's Snailery in Oyo State, 7°.38 ^{1}N, 3°.95 ^{1}E) of western region of Nigeria for phenotypic traits studies.

The experiment was conducted at the Botanical garden, University of Calabar, Calabar. The snails were kept alive and maintained under moist conditions to ensure their survival. They were fed daily with fresh paw-paw leaves and fruits, and succulent plant parts for two weeks before the commencement of the experiment. The snails were managed intensively in condemn drums kept under shade to provide suitable environment for the snails. Loamy soil was collected, made un-compacted by sun-drying, heated in an oven at a temperature of 65℃ to kill all inhabited organisms. The loamy soil had a pH range of 7.00 to 8.00 as measured by pH meter (p1367 SIGMA), as snails show preference for

neutral to slightly alkaline pH soils [12]. The soil in the drums was turned regularly with care to enhance burrowing activities of the snails. Proper sanitation was duly carried out daily.

2.2 Phenotypic Measurement of Snails

Parameters that were measured as phenotypic traits included; Body weight (BDW), Shell length (SHL), Shell width (SHW), Shell 'mouth' length (SML) and Shell 'mouth' width (SMW). Shell length and width, and Shell 'mouth' length and width were measured using Vernier caliper (MITUTOYO 500-752-10, Spain), while body weight was measured using Pro-ScoutST electronic scale with sensitivity of 0.01 g.

2.3 Statistical Analysis

The mean phenotypic traits comparison among/within the three species of giant African land snails was carried out using 3 × 3 factorial under a Complete Randomized Design (CRD) in statistical package for Social Science (SPSS) software version 20.0. Data collected were transformed using the log transformation method in order to reduce possible biases in the measurements. Significant means were separated using Least Significant Difference (LSD) at 0.05 probability level. The data were further subjected to correlation, principal component analysis (PCA) and clustering analysis.

Plate 1. *A. fulica*

Plate 2. *A. achatina*

Plate 3. *A. marginata*

Plates 1-3. The three species of giant African land snails

3. RESULTS AND DISCUSSION

The weight of the snails used ranged from 128 g to 221 g (*Achatina achatina*), 36 g to 57 g (*Achatina fulica*) and 165 g to 390 g (*Archachatina marginata*). The results of mean phenotypic traits of giant African land snails obtained from different populations in this study are presented on Table 1. The results revealed that there were significant differences (P<0.05) in all the parameters investigated. It however, showed that the *A. marginata* obtained from Ondo State recorded the highest body weight (328.33 g), which was not significantly different from the ones from Oyo state (291.00 g). It was also observed that all other phenotypic traits were highest in *A. marginata* from all the locations (Table 1). Mean body weights reported in this study for the three species; *Achatina achatina* (181.67 g, 176.67 g and 169 g), *Achatina fulica* (45.67 g, 41 g, and 40.67 g), *Archachatina marginata* (328.33 g, 291 g and 258.33 g) are significantly higher than the mean body weights of 120.90 g for *A. marginata,* 93.70 g for *A. achatina* and 79.80g for *A. fulica* respectively reported by [17]. These differences in mean body weights may be due to differences in the locations, types of diets fed, size, physiological stage and age of the snails used. Snails used by [17] were growers and were gathered from central agro-ecological zone of Delta State, while the snails used in this study were adults and were gathered from three locations (Osun, Ondo and Oyo) States in the western part of Nigeria. Results of phenotypic traits for the three snail breeds in this study were not in line with the views of [14] and [15] that the largest land gastropod is *Achatina achatina*. The results, however, agreed with that of [18,19,20], who stated that *Archachatina marginata* is the largest known land snail in Nigeria.

The results of correlation analysis revealed that all the phenotypic traits (body weight, shell length, shell widths, shell 'mouth' lengths and shell 'mouth' widths) measured were significant ($p < 0.01$) and positively/highly correlated. The highest correlation value was recorded between shell length (SHL) and body shell width (SHW) ($r = 0.992$) (Table 2). The phenotypic correlations recorded in this study for all the pairs of traits were positively and closely correlated. The observed correlations and positive values among these pairs of traits could suggest that the traits are linked and that improvement in one trait might lead to improvement in the other [21]. The correlation results recorded in this study is in agreement with the works of [12] and [17] who reported positive and close correlations among snail traits. The results also agreed with the view of [22], that correlation could be high or low and positive or negative between traits.

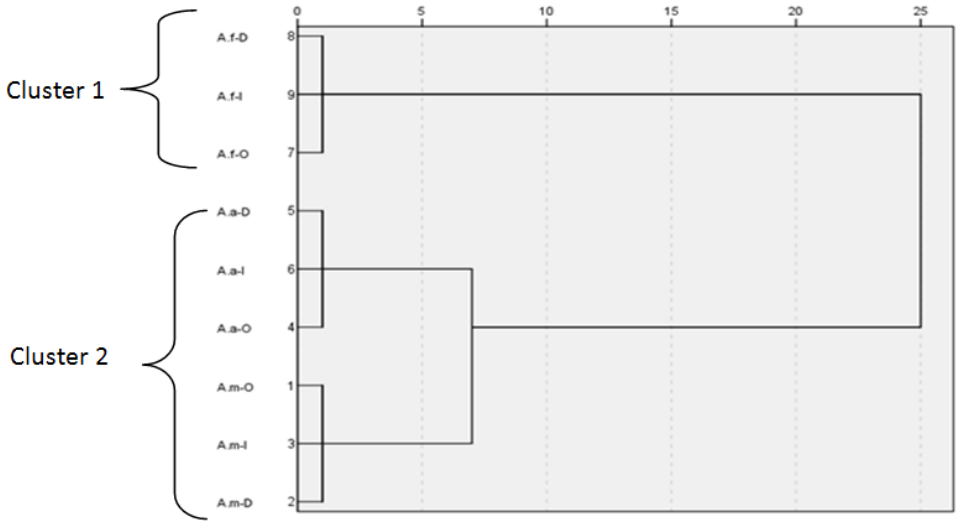

Fig. 1. The results of cluster analysis of the phenotypic traits evaluated for the three species of giant African land snails

Key: A.f-D = Achatina fulica from Ondo State; A.f-I = Achatina fulica from Oyo State; A.f-O = Achatina fulica from Osun State; A.a-D = Achatina achatina from Ondo State; A.a-I = Achatina achatina from Oyo State; A.a-O = Achatina achatina from Osun State; A.m-D = Archachatina marginata from Ondo State; A.m-I = Archachatina marginata from Oyo State; A.m-O = Archachatina marginata from Osun State

Table 1. Mean phenotypic traits of giant African land snails obtained from different populations

Traits	Osun	State		Ondo	State		Oyo	State	
	Achatina Achatina	***Achatina Fulica***	***Archachatina marginata***	***Achatina achatina***	***Achatina fulica***	***Archachatina marginata***	***Achatina achatina***	***Achatina fulica***	***Archachatina Marginata***
Body weight (g)	169±18.02^{b}	45.67±5.55 ^{c}	258.33±38.69^{a}	176.67±23.14^{b}	40.67±0.88^{c}	328.33±35.96^{a}	181.67±14.80^{b}	41±3.51^{c}	291±66.34^{a}
Body shell length (cm)	12.77±0.67^{b}	8.17±0.22^{c}	14.43±0.99^{a}	12.70±0.80^{b}	7.93±0.69^{c}	16.07±0.84^{a}	13.13±0.59^{b}	7.83±0.24^{c}	15.97±0.74^{a}
Body shell width (cm)	6.67±0.24^{b}	4.40±0.15^{c}	8.07±0.58^{a}	6.87±0.69^{b}	4.30±0.12^{c}	8.63±0.45^{a}	6.93±0.16^{b}	4.73±0.23^{c}	8.83±0.48^{a}
Mouth shell length (cm)	6.90±0.21^{b}	4.93±0.07^{c}	8.97±0.29^{a}	7.13±0.18^{b}	4.97±0.09^{c}	9.0±0.43^{a}	6.93±0.05^{b}	4.83±0.39^{c}	8.87±0.34^{a}
Mouth shell width (cm)	4.70±0.25^{ab}	2.87±0.18^{c}	5.50±0.45^{a}	4.47±0.29^{b}	2.57±0.09^{c}	5.47±0.32^{a}	4.37±0.11^{b}	2.73±0.13^{c}	5.70±0.30^{a}

^{abc} *Means bearing different superscripts along the same row are significantly different ($p<0.05$)*

Table 2. The results of pooled correlation between body weight and other phenotypic traits of the snails' species evaluated

	BDW	SHL	SHW	SML	SMW
BDW	1.000	0.988**	0.989**	0.987**	0.973**
SHL		1.000	0.992**	0.975**	0.986**
SHW			1.000	0.985**	0.986**
SML				1.000	0.982**
SMW					1.000

*** = Highly significant level (P < 0.01)*
BDW = Body weight, SHL = Shell length, SHW = Shell width, SML = Shell 'mouth' length, MSW = Shell 'mouth' width

Table 3. The results of principal component analysis of evaluated traits

Phenotypic traits	Communality	PC_1
Eigen value	-	4.94
Proportion of variance	-	98.75
Cumulative variance	-	98.75
Body weight	0.987	0.994
Shell length	0.989	0.995
Shell width	0.994	0.997
Shell 'mouth' length	0.984	0.992
Shell' mouth' width	0.983	0.992

Results of the principal component analysis (PCA) showed that only one principal component was extracted where all the phenotypic traits contributed 98.75% to the total variability (Table 3). The highest component matrix was obtained from shell width (0.997), while the lowest was from shell 'mouth' length and width (0.992). The communality ranged from 0.983 to 0.989 (Table 3).The variability obtained for the snails was explained by the contribution of the body traits from PCA analysis. All the body traits contributed highly to the total variability of 98.75% recorded in this study. According to [23], communality values of principal component analysis indicate the fit of PCA in handling a morphometric dataset. It estimates the total amount of variance that an original variable shares with all other variables included in the analysis. The high communality values obtained in this study might suggest strong contribution of these traits to the variation observed in the three species.

The results of the cluster analysis for phenotypic data revealed two major clusters. Cluster 2 was divided into two sub-clusters consisting of *A. achatina* and *A. marginata*. The closeness of *A. marginata* to *A. achatina* phenotypically might be due to the closeness in sizes of the two species of snails as reported by [17] that *A. marginata* and *A. achatina* are closely related in terms of weight and their sizes.

4. CONCLUSION

This study indicated that there was a wide morphological variability among the species of snails investigated. The populations notwithstanding, showed that *A. marginata* and *A. achatina* were more closely related morphologically than *A. fulica.* Snails in other locations should also be used to assess the relationships among phenotypic traits of giant African land snails in Nigeria. Also, molecular markers should be employed to confirm these relationships.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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