

Influence of breeds and number of whorls on phenotypic traits and correlations among giant African land snails in Nigeria

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Abstract

Six hundred adult mature black-skinned snails with four and five whorls on the shell comprising of 200 each of the breeds; *Archachatina marginata*, *Achatina achatina* and *Achatina fulica* were used for the study. Phenotypic traits measured from the snails included body weight (BDW), shell length (SHL), shell width (SHW), aperture length (APL), aperture width (APW), spiral length (SPL), spiral width (SPW), diagonal length (DAL), length between the aperture and first spiral (LAS). The data obtained were used to estimate simple statistics (mean, standard error and coefficient of variations) and correlation coefficients. The results showed high significant ($p < 0.01$) breed effects on phenotypic traits as *A. marginata* snails with four (288.700g) and 5(394.500g) whorls were phenotypically and genotypically heavier, larger and wider than *A. achatina* (127.0g and 182.000g) and *A. fulica* (48.850g and 65.050g) with four and five whorls respectively. There were also high significant ($p < 0.01$) disparity number of whorls effects on body weight and other phenotypic traits studied. There was only one strong, negative and significant ($p < 0.01$) phenotypic correlation (r_p) between SHL and LAS ($r = -0.650$) recorded for *A. achatina* snails with four whorls while *A. achatina* snails with five whorls recorded few strong, negative and significant ($P < 0.01$) phenotypic correlations between BDW and SHW ($r = -0.613$), SHL and LAS ($r = -0.641$), SHW and APW ($r = -0.602$). Similarly, *A. fulica* snails with four whorls recorded few strong, negative and significant ($p < 0.01$) phenotypic correlations between BDW and SHW ($r = -0.627$), SHL and APL ($r = -0.639$), SHW and APW ($r = -0.657$) and only one strong, negative and significant ($p < 0.01$) phenotypic correlation between SHL and LAS ($r = -0.605$) for *A. fulica* snails with five whorls. Again, *Am* snails with four whorls had only one strong, negative and significant ($p < 0.01$) phenotypic correlation between BDW and SHL ($r = -0.720$). The only two low, positive and significant ($p < 0.05$) phenotypic correlations recorded in this study were between APL and APW ($r = 0.544$) and between SPL and DAL ($r = 0.583$) for *A. marginata* snails with four and five whorls respectively. Thus, the breed type and number of whorls on snail shells strongly influenced estimates of phenotypic traits and correlation coefficients of giant African land snails in Nigeria. Also, that estimates of correlation coefficients of mature giant African land snails with higher whorls were (4 and 5) are scarcely strong, positive and significant. The study revealed and confirmed that *A. marginata* snails are phenotypically and genotypically heavier, larger and wider than *A. achatina* and *A. fulica* snails with 4 and 5 whorls. These estimates are recommended as strong and efficient tools for selection and up grading or improvement of giant African land snails genetic traits in Nigeria.

Keywords: Breed, Number of whorls, phenotypic traits and correlation, Black-skinned snail.

Introduction

Nigeria is one of the African countries with variable wet and dry seasons, most suitable and favourable for wildlife species. Thus,

the snail domestication and rearing become easy. In the earlier reports, Okon *et al.* (2012) established that giant African land snails have emerged as a notable

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experimental model for several fundamental and applied biological descriptions in the last few decades. Besides, snail production holds lots of potentials in the Nigerian livestock industry and can serve as a means to alleviate the acute protein shortage while Ebenebe (2017) noted that snails are such small creatures with deposit of many raw materials for the industries.

Yet, snail farming according to Ajayi *et al.* (1979) is an unexploited avenue suitable for economic development in Nigerian. It is one of the least recognized aspects of livestock production in Nigeria, even though snail species have lots of potentials in contributing to the nutritional and otherwise welfare of the populace. The associated risks and the capital investment is less compared to fishery, poultry or other animal husbandry, yet can provide the populace with a better animal protein source, thus making a healthier nation (Ejidike and Uzuseba, 2017).

Giant African land snail meat is tender, tasty

and highly nutritious with no cholesterol, compared to that of other animals; the meat is low in fat (0.05 – 0.08%), contains high levels of protein (12 – 16%), iron content (45 – 50mg/kg) and almost all the essential amino acids required by man (Dauda *et al.*, 2017) and hence serves numerous medicinal benefits. Several species exist and; Cobbinah *et al.* (2008) documented *Archachatina marginata*, *Achatina achatina*, *Achatina fulica* as the most predominant snails in Africa. *Achatina achatina* (Plate 1) is the largest gastropod among the giant African land snails, which can grow and reach shell length of up to 27cm (Venette and Larson, 2004). *Archachatina marginata* (Plate 2) is the second largest, while *Achatina fulica* (Plate 3) is the smallest (CAB, 2003; Venette and Larson, 2004). But in Nigeria, *Achatina achatina* is the second most popular breed of snail after *Archachatina marginata* which is the most accepted, highly cherished, commonly kept and reared (Okon *et al.*, 2012; Ejidike and Uzuseba, 2017).



Plate 1: *Achatina achatina*

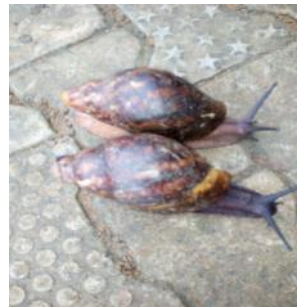


Plate 2: *Archachatina marginata*



Plate 3. *Achatina fulica*

To ensure the sustainability of the breeding of giant African land snails, there is need to improve on their productive capabilities through a phenotypic traits differentiation and correlations. According to Okon and Ibom (2011), the quantitative measure of the animals' conformation is desirable as this will enable reliable genetic parameters for a given trait to be estimated and therefore allow its inclusion in breeding programmes. Besides, measurement of body weight and some body size parameters provide a faster and easy means of determining the percentage growth rate of measurable traits in animals (Ganiyu *et al.*, 2016). It is also important to have knowledge of variations of phenotypic/morphometric traits in local genetic resources as such measurements have been discovered to be very useful in comparing body size and by implication shape of animals (Latshaw and Bishop, 2001). Hence, Ibom (2009) opined that body weight and body parameters such as shell length, shell width, shell thickness, shell 'mouth' length and shell 'mouth' width are quantitative traits mostly used to measure snail growth and growth rate.

According to Olowofeso (2009), when several quantitative traits are measured in any species population, it is better to find out whether the characters measured correlated positively or negatively as knowledge about its magnitude and signs/direction help in judging how the improvement of one character will cause simultaneous change in the other character. Okon and Ibom (2011) opined that regression and correlation are the two most used techniques to determine the relationship between and/or among two or more variables. In addition, Ganiyu *et al.* (2016) noted that correlation and regression analyses of measureable traits in animals will also assist livestock breeders and

farmers in knowing at a glance the strength of relation between two or more traits correlation in live animals. Recently, Okon *et al.* (2017a) pointed out that breed type, age, size of snail, body weight ranges and numbers of whorls on snails' shell also have great and high effects on phenotypic traits differentiation and correlations. A lot of research studies have been carried out and reported on each of these breeds (*A. marginata*, *A. achatina* and *A. fulica*), but not much is documented on this combinations or comparison with different numbers of whorls on the shell. Therefore, this study was designed to evaluate and compare phenotypic traits and correlations of these three breeds of giant African land snails with different number of whorls on the shell.

Materials and methods

A total of six hundred adult mature black-skinned snails with four and five whorls on the shell comprising of two hundred each of *Archachatina marginata*, *Achatina achatina* and *Achatina fulica* were used for the study. The snails were selected from a base population of 1,000 snails sourced from a reputable snail farm in Ibadan, Oyo State, Nigeria. The selection was randomly done on the basis of breed, active appearance and no injury on the foot and shell of snails from the base population. The sorting was done using keys prescribed by Segun (1975) and Hodasi (1984). Identification of the snails into breeds (*A. marginata*, *A. achatina* and *A. fulica*) was done using the profile and template of Nisbert (1974) and Rushton (2012), respectively.

A. marginata, *A. achatina* and *A. fulica* snails with 4 whorls had body weight ranges from 108.05g to 394.50g (average 288.70g), from 83.00g to 180.05g (average 122.20g) and from 30.60g to 85.20g

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(average 48.85g) respectively. While *A. marginata*, *A. achatina* and *A. fulica* snails with five whorls had body weight ranges from 313.60g to 452.50g (average 394.50g), from 132.20g to 272.80g (average 183.00g) and from 50.60g to 119.30g (average 65.05g) respectively. The body weights (BDW) were measured using Scout Pro[®] electronic scale with sensitivity of 0.01g. Eight other phenotypic traits measurements taken were shell length (SHL), shell width (SHW), aperture length (APL), aperture width (APW), spiral length (SPL), spiral width (SPW), diagonal length (DAL) and length between aperture and first spiral (LAS) as described by Ibom (2009) and El-Zaffir *et al.* (2011) using Vernier Caliper Model (MITUTOTO 500-752-10, Spain).

The data collected on phenotypic traits were subjected to simple statistics (mean, standard error and coefficient of variation), variance analysis, multiple comparison and phenotypic correlations using GENSTAT (2011) software package. Significant differences were separated using Duncan Multiple Range Test (SAS, 2012). The data were analysed using the following model.

$$Y_{ijk} = \mu + B_i + N_j + (BN)_{ij} + E_{ijk}$$

Where:

Y_{ij} is any observation

μ is the overall mean

B_i is the effect of breed of snail

N_j is the effect of number of whorl

$(BN)_{ij}$ is the interaction between breed and number of whorl

E_{ijk} is the residual error

Results and discussion

The results of the description of sampled population were expressed as mean (\bar{x}) \pm standard error (SE), coefficient of variation (CV) for the three breeds of giant African land snails (Table 1). *Archachatina*

marginata snails with 4 and 5 whorls had higher, larger and wider values for all measured phenotypic traits, followed by *Achatina achatina* and the least *Achatina fulica* snails (Table 1). Mean body weights of 288.700g, 127.200g and 48.850g were obtained for *A. marginata*, *A. achatina* and *A. fulica* snails with 4 whorls respectively, while 394.500g, 182.00 g and 65.05g were recorded for *A. marginata*, *A. achatina* and *A. fulica* snails with 5 whorls, respectively (Table 1). Similarly, all other measured phenotypic traits (SHL, SHW, APL, SPL, SHW, DAL and LAS) of Am snails with 4 and 5 whorls were significantly ($P < 0.05$) longer and wider than those of *A. achatina* and *A. fulica* snails with 4 and 5 whorls (Table 1). The results showed high significant ($P < 0.01$) breed effects on phenotypic traits/characteristics as *A. marginata* snails with 4 and 5 whorls were phenotypically and genotypically heavier, larger and wider than *A. achatina* and *A. fulica* snails with 4 and 5 whorls. There were also high significant ($p < 0.01$) disparity in number of whorls effects on body weight and other phenotypic traits studied (Table 2). The results (Tables 1 and 2) contradicted the views of Nisbert (1974), Plummer (1975), CAB (2003), Akinnusi (2004) and Venetter and Larson (2004) that *A. achatina* snail is the largest snail among the giant African land snails (GALS); but rather agreed with that of *A. fulica* (Af) being the smallest. However, the results obtained here (Tables 1 and 2) are in line with the reports of Okon *et al.* (2012) and Etukudo (2013) that *A. marginata* is the largest snail followed by *A. achatina* and *A. fulica* the least among the giant African land snails (GALS) in Nigeria. Besides, the results supported and confirmed Okon *et al.* (2017b) recent view/submission that giant African land snails (GALS) with higher number of whorls (here five) weighed

more, are heavier and larger than those with lower number of whorls (here four). In other words, breed type and number of whorls on the snail shell influenced the values of phenotypic traits/characteristics differentiation. The mean body weight of 394.50g obtained for some *A. marginata* snails with five whorls was higher than that of 248.20g obtained for *A. marginata* snails with five whorls from Edo State reported earlier by Okon *et al.* (2008); but closer to 323g recorded by Samuel *et al.* (2013). Whereas, Ibom *et al.* (2014) reported higher mean body weight of 120.90g for *A. achatina* and 93.70g for *A. fulica* snails from central Agro-ecological zone, 107.50g for *A. achatina* and 109.70g for *A. fulica* snails from northern Agro-ecological zone and 72.00g for *A. achatina* and 73.60g for *A. fulica* snails from Southern Agro-ecological zone of Delta State.

The disparity in higher phenotypic traits reported by Ibom *et al.* (2014) could be attributed to the non-classification or separation of the snails into their different number of whorls, sizes, age, body weight ranges, management system (feeding and housing) and high rate of acclimatization of the snails in Delta State. Worthy of note however, is that Delta State, one of the 9 states of the Niger Delta region in Nigeria is characterized by significant flora and fauna diversity and the region is reputed to be the world's third largest wetland (Emaziye *et al.* 2012); thus known to harbour larger species of giant African land snails. The results of phenotypic correlations among the three breeds namely *A. achatina*, *A. fulica* and *A. marginata* snails with 4 and 5 whorls are shown on Table 3, 4 and 5 respectively. There was only one strong, negative and significant ($P < 0.01$) phenotypic correlation (r_p) between SHL and LAS ($r = -0.658$) recorded for *A.*

achatina snails with 4 whorls (Table 3). All other phenotypic traits measured in this study for *A. achatina* snails with 4 whorls had low, negative and non-significant ($P > 0.05$) phenotypic correlations between body weight with/and among other phenotypic traits (Table 3). However, there were few, strong, negative and significant ($P < 0.01$) phenotypic correlations (r_p) obtained between BDW and SHW ($r = -0.613$), SHL and LAS ($r = -0.641$), SHW and APW ($r = -0.602$) as well as low, weak, negative and significant ($P < 0.05$) phenotypic correlations (r_p) between BDW and SHL ($r = -0.500$), SHL and SPL ($r = -0.549$), SPL and SPW ($r = -0.550$) for *A. achatina* snails with five whorls (Table 3). Similarly, few, strong, negative and significant ($p < 0.01$) phenotypic correlations (r_p) were obtained between BDW and SHW ($r = -0.627$), SHL and APL ($r = -0.639$), SHW and APW ($r = -0.657$) as well as low, weak, negative and significant ($p < 0.05$) correlations obtained between BDW and SHL ($r = -0.581$), BDW and LAS ($r = -0.547$) and SHL and DAL ($r = -0.578$) for *A. fulica* snails with 4 whorls (Table 4). Worthy of note again was the non-significant ($p > 0.05$) phenotypic correlation (r_p) between BDW with/and among all other phenotypic traits measured for *A. fulica* snails with 5 whorls, with the exception of only one strong, negative and significant ($P < 0.01$) correlation between SHL and LAS ($r = -0.605$) in Table 4.

Again, only one strong, negative and significant ($p < 0.01$) phenotypic correlation was recorded between BDW and SHL ($r = -0.702$) for Am snails with 4 whorls (Table 5). Whereas, there were two strong, negative and significant ($p < 0.01$) correlations between BDW and SHW ($r = -0.604$) and SHL and LAS ($r = -0.720$) recorded for *A. marginata* snails with 5 whorls (Table 5). The two low, positive and

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Table 1: Mean \pm SE and Coefficient of Variability (CV%) of Phenotypic Traits of *Achatina achatina* (Aa), *Achatina fulica* (Af) and *Archachatina maginata* (Am) snails

| Phenotypic Traits | No. of whorls | Aa | | | Af | | | Am | | |
|-------------------|---------------|----------------------------------|-------|---------------------------------|------------------|----------------------------------|-------|------------------|-----|-----|
| | | $\bar{x} \pm SE$ | CV% | SEM | $\bar{x} \pm SE$ | CV% | SEM | $\bar{x} \pm SE$ | CV% | SEM |
| BDW (g) | 04 | 127.200 \pm 5.165 ^b | 22.25 | 48.850 \pm 2.066 ^c | 23.16 | 288.700 \pm 11.47 ^a | 21.77 | 35.50 | | |
| | 05 | 182.000 \pm 6.071 ^b | 18.27 | 65.050 \pm 2.741 ^c | 23.08 | 394.500 \pm 6.043 ^a | 8.39 | 42.70 | | |
| SHL (cm) | 04 | 9.313 \pm 0.164 ^b | 9.66 | 5.973 \pm 0.137 ^c | 12.55 | 12.600 \pm 0.207 ^a | 9.00 | 2.10 | | |
| | 05 | 10.620 \pm 0.170 ^b | 8.77 | 7.063 \pm 0.156 ^c | 12.06 | 14.160 \pm 0.204 ^a | 7.88 | 2.30 | | |
| SHW (cm) | 04 | 3.983 \pm 0.070 ^b | 9.58 | 2.473 \pm 0.061 ^c | 13.59 | 6.330 \pm 0.137 ^a | 11.87 | 1.40 | | |
| | 05 | 4.613 \pm 0.080 ^b | 9.52 | 2.787 \pm 0.055 ^c | 10.86 | 7.013 \pm 0.098 ^a | 7.68 | 1.53 | | |
| APL (cm) | 04 | 4.743 \pm 0.078 ^b | 8.96 | 2.86 \pm 0.085 ^c | 16.21 | 7.280 \pm 0.139 ^a | 10.45 | 1.60 | | |
| | 05 | 5.330 \pm 0.072 ^c | 7.44 | 3.313 \pm 0.076 ^b | 12.60 | 8.083 \pm 0.093 ^a | 6.28 | 1.70 | | |
| APW (cm) | 04 | 1.637 \pm 0.043 ^b | 14.21 | 0.903 \pm 0.042 ^c | 25.26 | 3.910 \pm 0.150 ^a | 20.98 | 0.68 | | |
| | 05 | 2.017 \pm 0.057 ^b | 15.41 | 1.117 \pm 0.059 ^c | 28.71 | 4.360 \pm 0.156 ^a | 19.63 | 0.82 | | |
| SPL (cm) | 04 | 1.947 \pm 0.049 ^b | 13.81 | 0.863 \pm 0.044 ^c | 27.96 | 2.937 \pm 1.101 ^a | 18.79 | 0.60 | | |
| | 05 | 2.317 \pm 0.058 ^b | 13.65 | 1.190 \pm 0.055 ^c | 25.29 | 3.137 \pm 0.097 ^a | 17.00 | 0.80 | | |
| SPW (cm) | 04 | 0.903 \pm 0.086 ^b | 52.13 | 0.137 \pm 0.013 ^c | 52.57 | 1.777 \pm 0.112 ^a | 34.50 | 0.50 | | |
| | 05 | 1.007 \pm 0.063 ^b | 34.20 | 0.327 \pm 0.050 ^c | 83.52 | 1.697 \pm 0.075 ^a | 24.25 | 0.52 | | |
| DAL (cm) | 04 | 2.870 \pm 0.064 ^b | 12.11 | 1.623 \pm 0.055 ^c | 18.70 | 3.607 \pm 0.131 ^a | 19.95 | 0.30 | | |
| | 05 | 3.403 \pm 0.068 ^b | 10.95 | 1.870 \pm 0.054 ^c | 15.71 | 3.883 \pm 0.109 ^a | 15.41 | 0.35 | | |
| LAS (cm) | 04 | 6.520 \pm 0.115 ^b | 9.63 | 4.313 \pm 0.078 ^c | 9.906 | 9.51 \pm 0.224 ^c | 12.92 | 2.05 | | |
| | 05 | 7.580 \pm 0.133 ^b | 9.58 | 4.910 \pm 0.103 ^c | 11.53 | 11.17 \pm 0.099 ^a | 4.85 | 2.55 | | |

\bar{x} = Mean, SE = Standard Error, SEM = Standard error of mean, CV = Coefficient of variation

Table 2: Mean and ± Standard Error (SE) of Phenotypic Traits of *Achatina achatina*, *Achatina fulica* and *Archachatina marginata* snails

| Phenotypic traits | Breed | No. of Whorls | | ±SEM |
|-------------------|-------|---------------------|---------------------|-------|
| | | NW04 | NW05 | |
| BDW(g) | AA | 127.2 ^b | 182.0 ^a | 6.37 |
| | AF | 48.8 ^b | 65.1 ^a | 5.20 |
| | AM | 288.7 ^b | 394.5 ^a | 9.01 |
| SHL(cm) | AA | 9.313 ^b | 10.623 ^a | 0.175 |
| | AF | 5.973 ^b | 7.063 ^a | 0.143 |
| | AM | 12.597 ^b | 14.160 ^a | 0.247 |
| SHW(cm) | AA | 3.983 ^b | 4.613 ^a | 0.088 |
| | AF | 2.473 ^b | 2.787 ^a | 0.072 |
| | AM | 6.330 ^b | 7.013 ^a | 0.125 |
| APL(cm) | AA | 4.743 ^b | 5.330 ^a | 0.093 |
| | AF | 2.860 ^b | 3.313 ^a | 0.076 |
| | AM | 7.280 ^b | 8.083 ^a | 0.132 |
| APW(cm) | AA | 1.637 ^b | 2.017 ^a | 0.096 |
| | AF | 0.903 ^b | 1.117 ^a | 0.080 |
| | AM | 3.910 ^b | 4.360 ^a | 0.138 |
| SPL(cm) | AA | 1.947 ^b | 2.317 ^a | 0.071 |
| | AF | 0.863 ^b | 1.190 ^a | 0.058 |
| | AM | 2.937 ^b | 3.137 ^a | 0.101 |
| SPW(cm) | AA | 0.903 ^b | 1.007 ^a | 0.073 |
| | AF | 0.137 ^b | 0.327 ^a | 0.060 |
| | AM | 1.777 ^b | 1.697 ^a | 0.104 |
| DAL(cm) | AA | 2.870 ^b | 3.403 ^a | 0.086 |
| | AF | 1.623 ^b | 1.870 ^a | 0.070 |
| | AM | 3.607 ^b | 3.883 ^a | 0.121 |
| LAS(cm) | AA | 6.520 ^b | 2.580 ^a | 0.134 |
| | AF | 4.313 ^b | 4.910 ^a | 0.109 |
| | AM | 9.510 ^b | 11.167 ^a | 0.189 |

^{abc}Means with different superscripts along the row vary significantly at 5% level (P<0.05)

AA = *Achatina achatina*, AF = *Achatina fulica*, AM = *Archachatina marginata*

BDW = Body weight, SHL = Shell length, SHW = Shell width, APL = Aperture length,

APW = Aperture width, SPL = Spiral length, SPW = Spiral width, DAL = Diagonal length,

LAS = Length between the aperture and first spiral, NW = Number of whorls.

significant ($p < 0.05$) and two high, positive and significant ($p < 0.01$) phenotypic correlations recorded in this study were between APL and APW ($r = 0.544$), SPL and LAS ($r = 0.610$) for *A. marginata* snails with 4 whorls and between SPL and DAL ($r = 0.583$), SPL and LAS ($r = 0.615$) for *A. marginata* snails with 5 whorls (Table 5). This agreed with Okon *et al.* (2017b) earlier report of low, positive and significant

($p < 0.05$) phenotypic correlations for *A. achatina* and *A. fulica* snails with 5 whorls. The phenotypic correlation results obtained here indicated that BDW correlated negatively with almost all phenotypic traits measured for the 3 breeds (*A. achatina*, *A. fulica* and *A. marginata*) of snails with 4 and 5 whorls (Tables 3, 4, 5). This therefore denoted that the pairs of phenotypic traits have direct negative relationships between

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Table 3: Phenotypic coefficient of correlation (rp) of Phenotypic Traits between *Achatina achatina* snails with 4 and 5 whorls

| | BDW | SHL | SHW | APL | APW | SPL | SPW | DAL | LAS |
|-----|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| BDW | 1 | -0.362 ^{NS} | -0.041 ^{NS} | -0.434 ^{NS} | 0.259 ^{NS} | 0.151 ^{NS} | 0.226 ^{NS} | 0.026 ^{NS} | 0.223 ^{NS} |
| SHL | -0.500* | 1 | -0.124 ^{NS} | -0.011 ^{NS} | 0.094 ^{NS} | -0.030 ^{NS} | 0.0350 ^{NS} | -0.182 ^{NS} | -0.658** |
| SHW | -0.163 ^{NS} | -0.335 ^{NS} | 1 | -0.355 ^{NS} | -0.479 ^{NS} | -0.066 ^{NS} | 0.254 ^{NS} | -0.227 ^{NS} | 0.090 ^{NS} |
| APL | -0.613** | -0.314 ^{NS} | -0.300 ^{NS} | 1 | -0.210 ^{NS} | -0.125 ^{NS} | -0.013 ^{NS} | -0.034 ^{NS} | -0.480 ^{NS} |
| APW | 0.529* | -0.090 ^{NS} | -0.602** | 0.264 ^{NS} | 1 | 0.338 ^{NS} | -0.001 ^{NS} | 0.012 ^{NS} | -0.430 ^{NS} |
| SPL | 0.352 ^{NS} | -0.549* | -0.059 ^{NS} | 0.181 ^{NS} | 0.146 ^{NS} | 1 | -0.303 ^{NS} | -0.205 ^{NS} | -0.222 ^{NS} |
| SPW | 0.001 ^{NS} | -0.003 ^{NS} | 0.248 ^{NS} | -0.027 ^{NS} | -0.550* | -0.318 ^{NS} | 1 | 0.066 ^{NS} | -0.063 ^{NS} |
| DAL | 0.439 ^{NS} | -0.375 ^{NS} | -0.142 ^{NS} | -0.312 ^{NS} | 0.275 ^{NS} | -0.368 ^{NS} | 0.354 ^{NS} | 1 | -0.020 ^{NS} |
| LAS | 0.271 ^{NS} | -0.641** | 0.089 ^{NS} | -0.325 ^{NS} | -0.133 ^{NS} | -0.108 ^{NS} | 0.219 ^{NS} | -0.074 ^{NS} | 1 |

BDW = Body weight, SHL = Shell length, SHW = Shell width, APL = Aperture length, APW = Aperture width, SPL = Spiral length, SPW = Spiral width, DAL = Diagonal length, LAS = Length between the aperture and first spiral, Upper Diagonal (Aa snails with 4 whorls)/ Lower diagonal (Aa snails with 5 whorls)

** P<0.01 (High significant level), * = P<0.05 (Lower significant level), NS = P>0.05 (Non Significant)

Table 4: Phenotypic coefficient of correlation (rp) of phenotypic traits between *Achatina fulica* snails with 4 and 5 whorls

| | BDW | SHL | SHW | APL | APW | SPL | SPW | DAL | LAS |
|-----|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| BDW | 1 | -0.581* | -0.627** | -0.060 ^{NS} | 0.420 ^{NS} | 0.187 ^{NS} | -0.239 ^{NS} | -0.339 ^{NS} | -0.547* |
| SHL | -0.359 ^{NS} | 1 | -0.273 ^{NS} | -0.639** | 0.091 ^{NS} | -0.195 ^{NS} | -0.248 ^{NS} | -0.013 ^{NS} | -0.084 ^{NS} |
| SHW | -0.252 ^{NS} | -0.266 ^{NS} | 1 | -0.163 ^{NS} | -0.657** | -0.141 ^{NS} | 0.183 ^{NS} | -0.578* | 0.020 ^{NS} |
| APL | -0.188 ^{NS} | -0.243 ^{NS} | -0.298 ^{NS} | 1 | 0.190 ^{NS} | 0.024 ^{NS} | -0.002 ^{NS} | -0.090 ^{NS} | -0.016 ^{NS} |
| APW | -0.068 ^{NS} | -0.067 ^{NS} | 0.113 ^{NS} | 0.136 ^{NS} | 1 | 0.191 ^{NS} | -0.370 ^{NS} | 0.193 ^{NS} | -0.165 ^{NS} |
| SPL | 0.467 ^{NS} | -0.489 ^{NS} | -0.076 ^{NS} | 0.271 ^{NS} | 0.088 ^{NS} | 1 | -0.368 ^{NS} | -0.213 ^{NS} | -0.165 ^{NS} |
| SPW | 0.001 ^{NS} | -0.003 ^{NS} | 0.088 ^{NS} | -0.003 ^{NS} | -0.095 ^{NS} | -0.343 ^{NS} | 1 | 0.222 ^{NS} | 0.003 ^{NS} |
| DAL | 0.439 ^{NS} | -0.375 ^{NS} | -0.079 ^{NS} | -0.401 ^{NS} | -0.334 ^{NS} | -0.346 ^{NS} | 0.046 ^{NS} | 1 | -0.300 ^{NS} |
| LAS | -0.141 ^{NS} | -0.605** | -0.135 ^{NS} | 0.002 ^{NS} | 0.078 ^{NS} | 0.093 ^{NS} | 0.025 ^{NS} | 0.007 ^{NS} | 1 |

BDW = Body weight, SHL = Shell length, SHW = Shell width, APL = Aperture length, APW = Aperture width, SPL = Spiral length, SPW = Spiral width, DAL = Diagonal length, LAS = Length between the aperture and first spiral.

** P<0.01 (High significant level), * = P<0.05 (Lower significant level), NS = P>0.05 (Non Significant)
Upper Diagonal (Af snails with 4 whorls)/Lower diagonal (Af snails with 5 whorls)

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and among the traits as increased or improvement in one trait will automatically lead to decrease on the other trait. Also, the phenotypic correlation results agreed with Okon *et al.* (2017b) recent report of few, weak, negative and low significant ($p < 0.05$) and most non-significant ($p > 0.05$) correlation coefficients between body weight with/and among most shell components studied; but contradicted Ibom (2009), Okon *et al.* (2009a and b), Okon *et al.* (2010a,b), Okon and Ibom (2011), Sam *et al.* (2016) and recently Okon *et al.* (2017a) earlier views of high positive correlated responses of these morphometric/phenotypic traits for selection and crossbreeding for genetic improvement. Okon *et al.* (2010a, b) had earlier recorded strong, positive and highly significant ($p < 0.001$) correlation values of $r = 0.96$ between body weight and body shell length for purebred white-skinned (Albino) and F_1 crossbred *A. marginata* snails.

Besides, Sam *et al.* (2016) reported high, positive, significant ($p < 0.001$) correlation coefficients of $r = 0.711$ and $r = 0.827$ between BDW and SHW for black-skinned and white-skinned Am snails respectively. These authors used snails that were neither classified nor separated into neither their ages, sizes and phases of growth nor number of whorls. But Okon *et al.* (2017a) recently reported very high, positive and strong significant ($p < 0.001$) correlation values of $r = 0.958$ between BDW and SHW, $r = 0.934$ between SML and SHW, $r = 0.923$ between BDW and SML and $r = 0.936$ between SMW and SHW for juvenile crossbred *A. marginata* snails with 2 whorls, as well as very high, positive and strong significant ($p < 0.001$) correlation values of $r = 0.962$ between BDW and SML, $r = 0.977$ between BDW and SMW and $r = 0.976$ between SMW and SML for purebred juvenile black-skinned *A. marginata* snails with 3 whorls.

Surprisingly, Okon *et al.* (2017b) had also earlier reported strong negative and significant ($p < 0.01$) phenotypic correlations between BDW and SHW ($r = -0.621$), SHL and APL ($r = -0.639$) and between SHW and APW ($r = -0.657$) for *A. fulica* snails with four whorls as well as phenotypic correlations between BDW and APL ($r = -0.613$), SHL and LAS ($r = -0.605$) for *A. achatina* and *A. fulica* snails with 5 whorls, respectively. Again, coincidentally Okon *et al.* (2017b) had also earlier reported only two low, positive and significant ($P < 0.05$) phenotypic correlations between BDW and APW ($r = 0.529$) and APW and SPW ($r = 0.550$) for *A. achatina* snails with 5 whorls. In addition, these results revealed and confirmed that there is a strong, negative and significant influence of breed type and number of whorls on snail shell traits and correlation coefficients of mature giant African land snails with higher whorls (here 4 and 5) as Okon *et al.* (2017b) who used grower snails with lower whorls (two and three) obtained and reported strong, positive and significant correlation coefficients. Besides, the results obtained here further corroborated Ehiobu and Kyado (2000) and Ibom (2009) views that phenotypic correlations between morphometric traits could be high/strong or low/weak and positive or negative. These strong, negative and significant correlation coefficients obtained indicated the strength of linear associations between two traits and this will give useful information on the traits involved for the purpose of breeding and improvement. Also correlation procedure describes the interrelationships that exist among body traits. Thus, Ige (2013) noted that estimates of correlation coefficient are very useful in animal breeding as a means of producing potential response to, or progress from selection. Therefore, breed type, number of whorls and

Table 5: Phenotypic coefficient of correlation (rp) of phenotypic traits between *Archachatina marginata* snails with 4 and 5 whorls

| | BDW | SHL | SHW | APL | APW | SPL | SPW | DAL | LAS |
|-----|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| BDW | 1 | -0.702** | -0.007 ^{NS} | 0.223 ^{NS} | 0.095 ^{NS} | -0.178 ^{NS} | 0.449 ^{NS} | 0.154 ^{NS} | 0.149 ^{NS} |
| SHL | -0.002 ^{NS} | 1 | -0.113 ^{NS} | -0.321 ^{NS} | 0.006 ^{NS} | 0.337 ^{NS} | -0.480 ^{NS} | -0.017 ^{NS} | -0.482 ^{NS} |
| SHW | -0.604** | 0.045 ^{NS} | 1 | -0.382 ^{NS} | 0.077 ^{NS} | -0.320 ^{NS} | -0.097 ^{NS} | 0.041 ^{NS} | -0.346 ^{NS} |
| APL | -0.184 ^{NS} | -0.044 ^{NS} | -0.182 ^{NS} | 1 | 0.544* | 0.095 ^{NS} | -0.212 ^{NS} | -0.256 ^{NS} | -0.092 ^{NS} |
| APW | 0.265 ^{NS} | -0.036 ^{NS} | 0.430 ^{NS} | 0.012 ^{NS} | 1 | -0.128 ^{NS} | -0.054 ^{NS} | 0.074 ^{NS} | 0.142 ^{NS} |
| SPL | -0.097 ^{NS} | -0.298 ^{NS} | -0.341 ^{NS} | 0.174 ^{NS} | -0.443 ^{NS} | 1 | 0.137 ^{NS} | -0.249 ^{NS} | 0.610** |
| SPW | -0.199 ^{NS} | -0.456 ^{NS} | 0.034 ^{NS} | -0.328 ^{NS} | 0.269 ^{NS} | -0.294 ^{NS} | 1 | 0.203 ^{NS} | 0.120 ^{NS} |
| DAL | -0.252 ^{NS} | -0.580* | -0.174 ^{NS} | -0.140 ^{NS} | 0.116 ^{NS} | -0.271 ^{NS} | 0.583* | 1 | -0.120 ^{NS} |
| LAS | -0.414 ^{NS} | -0.720** | -0.306 ^{NS} | 0.084 ^{NS} | 0.251 ^{NS} | 0.615** | -0.006 ^{NS} | 0.078 ^{NS} | 1 |

BDW = Body weight, SHL = Shell length, SHW = Shell width, APL = Aperture length, APW = Aperture width, SPL = Spiral length, SPW = Spiral width, DAL = Diagonal length, LAS = Length between the aperture and first spiral,

** P<0.01 (High significant level), * = P<0.05 (Lower significant level), NS = P>0.05 (Non Significant)
Upper Diagonal (Am snails with 4 whorls)/Lower diagonal (Am snails with 5 whorls)

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Phase of growth of a snail have strong influence on phenotypic correlations of giant African land snails. This high disparity in phenotypic correlation values here might be attributed to effects of breed type, age, size, phase of growth and number of whorls on the snails' shells. Thus corroborating the position of Samuel *et al.* (2013) that the non-significant ($p>0.05$) phenotypic correlations for most of the pairs of morphometric/phenotypic traits studied might be due to the separation of the snails into different whorls, age, size, as well as growth phases.

Conclusion

The results of the study revealed and confirmed that *A. marginata* snails are phenotypically and genotypically heavier, larger and wider than *A. achatina* and *A. fulica* snails with 4 and 5 whorls. Also, there were very high significant ($P<0.001$) disparity in breed, number of whorls and all measured phenotypic traits studied. The result further revealed few, strong, negative and outstanding correlation coefficients between body weight with/and among all other phenotypic traits of *A. achatina*, *A. fulica* and *A. marginata* snails with four and five whorls studied. Thus, the breed type and number of whorls on the shell of the snails strongly, influenced estimates of phenotypic traits and correlation coefficients of giant African land snails in Nigeria. Also that estimates of correlation coefficients of mature giant African land snails with higher whorls (4 and 5) are scarcely strong, positive and significant. These estimates however are recommended as strong and efficient tools for selection and breeding for genetic improvement of giant African land snails in Nigeria.

References

- Akinnusi, O. 2004. Introduction to snails and snail farming. 2nd edition. Triolas Exquisite Ventures, Abeokuta, Nigeria, Pg. 60
- Ajayi, S. S., Tewe, O. O. and Awesu, M. O. 1979. Observation on biology and nutritive value of the African giant snail (*Archachatina marginata*). *East African Wildlife Journal*. 16(85-95)
- CAB 2003. Crop protection compendium: Global module. Commonwealth Agricultural Bureau International, Wallingford, UK
- Dauda, A., Ibom, L. A. and Okon, B. 2017. Protein sequence evaluation of *Achatina fulica* using an insilico approach. *Proceedings of 6th International Conference/Workshop on Giant African Land Snails (NetGALS), Akure, Nigeria, 4th – 7th June, 2017, Pg. 17–19.*
- Ebenebe, C. I. 2017. Uses of Giant Land Snails in Research and Industries. *Proceedings of 6th Annual International Conference/Workshop of giant African land snails (NETGALS), 4 – 7th June, 2017. Pp. 6-11*
- Ehiobu, J. R. and Kyado, J. A. 2000. Heritability, Repeatability and Genetic correlation of swine. *Proceedings of the 25th Annual Conference of Nigerian Society for Animal Production (NSAP), March 19 – 22, 2000, Umudike, Nigeria. Pp. 260-261.*
- Ejidike, B. N. and Uzuseba, E. D. 2017. Use of feather meal in diet of African giant land snail. *Proceedings of 6th Annual International Conference/Workshop on Network on giant African land snails (NETGALS), 4 – 7th June, 2017. Pp.*

32–35.

- El-Zaffir, B., El sheik, E. O. and Zuhier, N. M. 2011.** Some Linear Measurements of *Bulimustruncates* Snails collected from Water Bodies of Two Agricultural Schemes in Khantoun State, Sudan, *University of African Journal of Science* (UAJS). Vol. 1 (1): 35–43.
- Emaziye, P. O., Okoh, R. N. and Ike, P. C. 2012.** A critical analysis of climatic change factors and its projected future values in Delta State, Nigeria. *Asian Journal of Agriculture and Rural Development*, 2(2): 206–212
- Etukudo, O. M. 2013.** Developmental stages of eggs, phenotypic and genetic characterization of two Ectotypes of giant African land snails (*Archachatina marginata* var. *Saturali*). M.Sc. Thesis. Department of Genetics and Biotechnology, University of Calabar, Nigeria, Pp. 1–97.
- Ganiya, S. O., Olowofeso, O. O., Adeyemi, Y. V. and Sanda, A. J. 2016.** Strength and Nature of relationship between body weight and linear body measurement in Anak white broiler chicken in Abeokuta, Nigeria. *Proceedings of 41st Conference of Nigerian Society for Animal Production*. 20th – 25th March, 2016. Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Pp 23–26
- Genstat 2011.** Genstat Release 10.3 DE (PC/Windows 7), VSN International Ltd (Rothamsted Experimental Station).
- Hodasi, J. K. M. 1984.** Some Aspects of the Biology of *Achatina achatina* (Linne). *Journal of Molluscan Studies*, 48: 105–113.
- Ibom, L. A. 2009.** 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, Pp. 166.
- Ibom, L. A., Okon, B., Okon, F. I. and Nwambam, I. U. 2014.** Morphological characterization of Giant African Land Snails from three Agro-ecological zones of Delta States. *Proceedings of 3rd International Conference/Workshop on Giant African Land Snail (NetGALS)*, 1st – 4th June, 2014, Abeokuta, Nigeria, Pp. 38–44.
- Ige, A. O. 2013.** Relationship between body weight and weight and growth traits in crossbred Fulani ectotype chicken in Derived Savana Zone of Nigeria. *International Journal of Agriculture and Agricultural Research*. 9:157-166)
- Latshaw, J. D. and Bishop, L. 2001.** Estimating body weight and body composition of chickens by using non-invasive measurement. *Poultry Science*, 80(7): 868–873.
- Nisbert, R. N. 1974.** The Life of Archatinidae in London. *Proceedings of the Malacological Society of London*, 41:1171.
- Olowofeso, O. 2009.** Phenotypic correlation and prediction of body weight and body size parameters in broiler chicken. *Journal of Applied Agriculture Research*, 1:71–76.
- Okon, B., Ibom, L. A., Etuk, N. E. and Akpan, E. W. 2008.** Variations in

Phenotypic traits and correlations among giant African land snails in Nigeria

- Growth Pattern and Conformation of Snails: Influence of strain and location on Isometry of Growth in Cross River State of Nigeria. *Journal of Agriculture, Forestry and the Social Sciences*. Volume 6: No. 2, Pg. 218-226.
- Okon, B., Ibom, L. A., Ekpo, I. A. and Ewa, E. C. 2009a.** Evaluation of Reproductive Performance and some Egg Quality Parameters of Albino Snails [*Archachatina marginata* saturalis (Swainson)]. *Journal of Applied Sciences*. Volume 12: No. 2, Pg 8234-8240.
- Okon, B., Ibom, L. A., William, M. E. and Akpakpan, I. E. 2009b.** Comparative Evaluation of Reproductive Performance and Some Egg Quality Parameters of Black and White Skinned Snails. *Global Journal of Agricultural Sciences*. Volume 8: No. 1 Pg. 77-80.
- Okon, B., Ibom, L. A., Williams, M. E. and Akwa, N. T. 2010a.** Parity Effects on Breeding and Morphometric Traits of Eggs and Hatchlings on Purebred Albino snail [*Archachatina marginata* (Swainson)]. *Journal of Agriculture, Biotechnology & Ecology*, Vol. 3(1): Pg. 44-54.
- Okon, B., Ibom, L. A., Williams, M. E. and Etukudo, O. M. 2010b.** Effects of Parity on Breeding and Morphometric Traits of Eggs and Hatchlings of F₁ crossbred of snails (*Archachatina marginata* var. *saturalis*). *Journal of Agriculture, Biotechnology & Ecology*, Vol. 3 (1): Pg. 36-43.
- Okon, B. and Ibom, L. A. 2011.** Phenotypic Correlation and Body Weights Prediction using Morphometric Traits of Snails in Calabar, Nigeria. *Ethiopian Journal of Environment Studies and Management*, Volume 4 No 3Pg 7–11.
- Okon, B., Ibom, L. A., Ettah, H. E. and Udoh, U. H. 2012.** Comparative Differentiation of Morphometric Traits and Body Weight Prediction of Giant African Land Snails with four whorls in Niger Delta Region of Nigeria. *Journal of Agricultural Science*, Vol. 4: No. 10, Pg. 205-211.
- Okon, B., Ibom, L. A., Udo, U. H. and Sam, I. M. 2017a.** Phenotypic correlations and body weights prediction of *Archachatina marginata* (Swainson, 1821) snails using morphometric traits and number of whorls on the shell. *Journal of Molluscan Research*. Vol. 3, Pg. 42-48.
- Okon, B., Ibom, L. A., Halilu, A. and Onwuka, P. O. 2017b.** Comparative morphometric traits differentiation and phenotypic correlations between *Achatina achatina* (Linne, 1758) and *Achatina Fulica* (Bodwich, 1822) snails with four and five whorls. *Journal of Animal Science and Veterinary Medicine*. Vol. 2: 102 - 108
- Plumer, J. M. 1975.** Observation on the reproductive growth and longevity of laboratory colony of *Achatina achatina* and *Archachatina marginata* snails. *Proceedings, Malacological Society on land snail*. Volume 41 Pg 395–426.
- Rushton, J. 2012.** Species General Information. <http://www.petsnail.co.uk>.

- Accessed 2nd January, 2017.
- SAS. Institute Incorporation 2002.** SAS/STAT. User's Guide. SAS Institute Incorporated Cary, NC.
- Sam, I. M., Okon, B., Ukpanah, U. A. and Edem, W. M. 2016.** Body weight prediction of Black and White Skinned *Archachatina marginata* snails from Quantitative Traits measurements. *European Journal of Advanced Research in Biological and Life Sciences*. Vol. 5 No 1 Pg 29-35.
- Samuel, O. K., Maria, K. A., Sok, S. and Fagburo, S. S. 2013.** Relationships among body traits of African giant land snails (*Archachatina marginata*) at different age groups. *Global Journal of Science Frontier Research*. Vol 8 Pg1-4
- Segun, A. O. 1975.** The giant land snail, (*Archachatina [Calachatina] marginata* (swainson). Benin City. Ethiope Publishing House, Pp. 68.
- Venette, R. C. and Larson, M. 2014.** Mini risk assessment, giant African snail, *Achatina fulica* (Bowdich) (Gastrops: Achatinidae), Department of Entomology, University of Minnesota, St. Paw, MN55108, Pp. 1 – 30.

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