

# Comparison of growth and heterosis of body parameters of two varieties of snail [*Archachatina marginata* (Swainson 1821)] and their crosses reared under tropical conditions

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**ABSTRACT:** The main objective of this paper was to compare growth traits and heterosis of body parameters of two varieties of *Archachatina marginata* (*var. ovum* and *var. saturalis*) and their crosses under experimental conditions. Three hundred (300) juvenile snails (*Archachatina marginata*), one hundred (100) each of *A. marginata var. ovum*, *A. marginata var. saturalis* and their crosses with mean body weights of  $12.40 \pm 0.58$  g were used for the study. The snails were randomly allotted using completely randomized design into three (3) treatment varieties. Results from the study showed significant variety effect ( $P < 0.05$ ) on final body weight and average weight gain. The crossbred variety recorded the highest average weight gain compared to the other two varieties. No significant ( $P > 0.05$ ) variety effect was observed on daily weight gain, total feed intake, daily feed intake and feed conversion ratio. The crossbred variety recorded the highest final body weight and final shell width, indicating heterotic effects on these two bodies and shell parameters. Significant variety effects ( $P < 0.05$ ) were observed on body weight, shell length and shell "mouth" length. The low heterotic values obtained for body weight and the shell parameters supported the assertion that growth traits have low heterotic values which may be due to their high heritability. Though, low and positive heterotic values were obtained for all parameters studied, the crossbred variety recorded the highest heterotic values, which indicated that it may have heterotic advantage over the purebred varieties.

**Keywords:** Growth, heterosis, snail, trait, variety.

## INTRODUCTION

Breed types, according to Okon et al. (2012a), have a marked effect on performance and production of snails than all other factors considered. Thus, these authors asserted that the performance of any animal is dependent upon the inherent genetic make-up and the environment in which it is raised. In Nigeria, there are different breeds of giant African land snails and they vary in size, colour, adaptability and performance (Amusan and Omidiji, 1998; Okon et al., 2012b). These breeds include *Archachatina marginata*, *Achatina achatina*, *Achatina fulica*, *Limicolaria* species and *Thapsia* species. Within a snail breed, there exist varietal differences in foot pigment, length of whorls,

aperture size (length and width) and egg clutch size (Okon and Ibom, 2012). *Archachatina marginata* is the largest known breed of snail in Africa (Omole, 1998; Olawoyin and Ogogo, 2006; Okon et al., 2012b) and has two varieties namely, *Archachatina marginata var. ovum* and *Archachatina marginata var. saturalis*. On *Archachatina marginata var. ovum*, both columella and parietal callus are white, while on *Archachatina marginata var. saturalis*, both columella and parietal callus are red. Most studies carried out combined these two varieties as one breed and these have not really given the true performance or production of these varieties.

Growth studies of *A. marginata var. ovum* and *A. marginata var. saturalis* have been extensively done by Ibom et al. (2011), Ibom and Okon (2012), Okon et al. (2008, 2012a, 2012b, 2014), Imran and Alarape (2012), Isah and Peter (2012), Jayeola et al. (2013), Onuoha (2014), Oyeagu et al. (2015), Fayenuwo et al. (2015), Egbu et al. (2015), and Ejidike and Oladipo (2015). Growth measured in terms of body weight gain (BWG) is the most widely used growth index from birth to maturity (Okon and Ibom, 2012). In snails, the weight at hatch is the first indicator of hatchling growth rate and is useful as a starting point for measuring subsequent growth. Okon and Ibom (2012) also pointed out that the growth rate of snails can be measured as the increase in shell size, this being the obvious phenotypic trait. Similarly, Akinnusi (2002, 2004) opined that snail growth is measured by shell size.

Growth rate values in snails under the tropical condition have been reported by many authors (Ayayi et al., 1978; Hodasi, 1984; Udedibie et al., 1986; Oyelade et al., 2013; Okon et al., 2013). The growth rate of snail varies considerably between individuals in each population group, thus Cobbinah (1993) opined that snails show differences in growth rates. Ibom (2009) stated that dimensional shell parameters (shell length, shell width and shell thickness) and aperture (shell "mouth") parameters are indices that can be taken at hatch and used to measure subsequent snail growth. Body weight and body components are the growth parameters used to measure growth in animals and are common measures of size and growth rate.

Heterosis refers to the mean performance of hybrid progeny relative to the mid-parent value (Ibe, 1998). The author added that if the average performance of the hybrid is better than the mid-parent value, heterosis is positive, otherwise it is negative. Positive heterosis is referred to as hybrid vigour. Heterosis, according to Crow (2008) is predicted to be high in small population with gene flow and to increase with population structure, whereas it is reduced by inbreeding. Also, Asumoah (1999) reported that stressful environment may influence the expression of heterosis and hybrid performance may be reduced by out breeding depression. Although, heterosis in these snail varieties does not result from fixation load, its experimental estimation provides relevant information on the trends of heterosis on them, but heterosis is expected to be mainly contributed by mildly deleterious alleles (Clift, 2010) and maximized for moderate to intermediate selection coefficients (Crow, 2008).

Growth traits show moderate heterosis. However, heterosis is not very important for conformation (or body dimension) and composition traits which have high heritabilities and show little or no depression from inbreeding (Ibe, 1998). Integrating snails into target gene pool in an organized breeding project according to Clift (2010) will be beneficial as farmers had used hybrid vigour or heterosis to enhance growth and reproductive performance of farm animals (e.g., cattle, sheep, poultry

and pigs).

This paper compared growth traits and heterosis of body and shell parameters of two varieties of *Archachatina marginata* (*var. ovum* and *var. saturalis*) and their crosses under experimental conditions.

## MATERIALS AND METHODS

### Experimental site

The study was carried out at the Botanical Garden of University of Calabar, Calabar, Nigeria. Calabar (Longitude 8°17' and 10°43'E; Latitude 4°58' and 15°39'N) has annual rainfall and temperature ranges between 1260 to 1280 mm and 25 to 30°C respectively (CRADP, 1992). The botanical garden where the research was carried out provided a mini-environment similar to the natural habitat of snails - with trees (e.g., *Cola abure*, *Citrus* spp., *Carica papaya*, *Musa* spp., *Gmelina aborea*), crops (e.g., cassava and yams) and forages like *Centrosoma pubescence* and *Panicum maximum* which provided shades that protected the hutches and snails from direct sunlight and heavy rainfall.

### Experimental animals

Three hundred (300) juvenile snails, one hundred (100) each of the three varieties, *Archachatina marginata var. ovum* (AMO), *Archachatina marginata var. saturalis* (AMS) and their crosses (AMO x AMS) with mean body weights of 12.40 ± 0.58 g were obtained from an earlier study in the same location for this study. The snails were randomly allotted to the three (3) treatments of the varieties studied. The snails in the three (3) treatments were managed in wooden cells compartments kept under trees shades for the 5 months of study which lasted from May to September, 2015. The cells had dimensions of 40 cm (length), 40 cm (width) and 40 cm (depth). Each treatment was replicated ten (10) times in a completely randomized experimental design (CRD). The juvenile snails were housed in thirty (30) cells with ten (10) snails per cell containing sterilized loamy soil moistened with water for easy management. The snails were placed on mixed-diet of forages (fresh paw-paw leaves) and concentrates (containing 24% CP, 15% Ca and 2650 kcal/kgME). Fresh cool water was supplied *ad libitum* in shallow troughs during the study. The three (3) varieties of snails were kept under similar environmental and management conditions.

### Measurements of body and shell parameters of snails

The body weights (BDW) were taken using Scout Pro® electronic scale with sensitivity of 0.01 g, while dimensional shell parameters were measured using Vernier Caliper. The dimensional shell parameters were shell

**Table 1.** Growth Performance Traits of *Archachatina marginata* varieties (*var. ovum* and *var. saturalis*) and their crosses.

Parameters	Varieties		
	T <sub>1</sub> (AMO)	T <sub>2</sub> (AMS)	T <sub>3</sub> (AMO x AMS)
Initial body weight(g)	12.40 ± 0.59	12.40 ± 0.57	12.40 ± 0.58
Final body weight(g)	20.03 ± 0.94 <sup>a</sup>	17.08 ± 0.85 <sup>b</sup>	20.02 ± 1.01 <sup>a</sup>
Average weight gain(g)	7.63 ± 1.11 <sup>b</sup>	7.94 ± 1.56 <sup>b</sup>	8.86 ± 0.81 <sup>a</sup>
Daily weight gain(g)	0.05 ± 0.01	0.06 ± 0.01	0.06 ± 0.01
Total feed intake(g)	17.02 ± 1.68	17.03 ± 1.56	17.04 ± 1.76
Average Daily feed intake(g)	0.14 ± 0.01	0.14 ± 0.02	0.14 ± 0.02
Feed conversion ratio (FCR)	0.46 ± 0.07	0.42 ± 0.04	0.62 ± 0.04

<sup>ab</sup>Means with different superscripts along the row differ significantly at P<0.05. **AMO**, *Archachatina marginata* var. *ovum*, **AMS**, *Archachatina marginata* var. *saturalis*.

length (SL), shell width (SW), shell “mouth” length (SML) and shell “mouth” width (SMW). The measurements were as described in Ibom (2009) and El Zaffir et al. (2011).

### Data Analysis

The fixed model used in the experiment is show below as described by Ibom, 2009.

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

Where: Y<sub>ij</sub> = Single observation, μ = Common mean, S<sub>i</sub> = Fixed effect of snail varieties (i = 1 – 3) and e<sub>ij</sub> = Random error associated with the measurement of each observation

Heterosis was estimated using the formular below (Ibe, 1998):

$$\% \text{ Heterosis} = \frac{(H_1 - P)}{P} \times \frac{100}{1}$$

Where H<sub>1</sub> = Average performance of offspring and P = Average performance of parents

Data were subjected to analysis of variance (ANOVA) for Completely Randomised Design (CRD) experiment using Statistical Analysis System (SAS, 2006). Significantly different means were separated using Duncan’s New Multiple Range Test (Duncan, 1995) as outlined by Obi (2002).

## RESULTS AND DISCUSSION

Growth performance traits of the three *Archachatina marginata* varieties (AMO, AMS and AMO x AMS) are

presented in Table 1. The initial weight recorded no significant (P>0.05) variety effect, while significant variety effect (P<0.05) existed on final body weight (FBW) and average weight gain (AWG). The AMO recorded the highest FBW, followed by AMO x AMS, while AMS recorded the least value. The results of FBW obtained fell within the range mean final body weight values from 16.43 ± 0.6 to 24.57 ± 3.5 g reported by Ademolu et al. (2004) for giant African land snails (*Archachatina marginata*) fed different nitrogen sources, but higher than Egbu (2015) range from 12.87 to 14.89 g for hatchlings of *Archachatina marginata* (A. M.). Opara (2010) reported lower mean FBW values of 16.21 g, 14.07 g and 17.75 g for F<sub>1</sub>-hybrids of three (3) giant African land snail ectotypes. The differences in the mean FBW values reported by the different authors might be due to the body weight, age, variety and size of the parent stock used, the feed type as well as management system adopted. The better performance observed for final body weight could be due to the combination of forage and concentrate as reported that snail’s performance is better on mixed-feeding regime.

The AWG showed significant variety (P<0.05) effect, confirming heterosis or hybrid vigour for this growth trait. The AWG obtained for this study is quite higher than the range of 0.08 ± 0.02 to 0.11 ± 0.01 g reported by Egbu et al. (2015) for hatchlings of *Archachatina marginata* snails fed varying levels of palm kernel cake. The reason being that Egbu et al. (2015) worked with hatchlings of *Archachatina* species, while this study was on juveniles of the three varieties of *A. marginata*.

There were no significant (P>0.05) variety effects on DWG, TFI, DFI, and FCR. The TFI consumed in this study were similar to the mean total fed intake of 17.66 g, 17.98 g and 17.43 g reported by Omole et al. (2007) for *Archachatina marginata* snails raised on different stocking rates. The DFI obtained in Table 1 were similar to the mean DFI intake values of 0.14 ± 0.16 g, 0.13 ± 0.16 g, 0.15 ± 0.16 g and 0.18 ± 0.16 g reported by Oni et al.

**Table 2.** Shell Parameters of *Archachatina marginata* varieties (*var. ovum* and *var. saturalis*) and their crosses.

Parameters	Varieties		
	T <sub>1</sub> (AMO)	T <sub>2</sub> (AMS)	T <sub>3</sub> (AMO x AMS)
Initial shell length(cm)	3.85 ± 0.08 <sup>a</sup>	3.36 ± 0.09 <sup>b</sup>	3.82 ± 0.08 <sup>a</sup>
Final shell length(cm)	4.47 ± 0.16	4.48 ± 0.12	4.60 ± 1.11
Shell length increment(cm)	0.92 ± 1.14 <sup>b</sup>	1.12 ± 1.13 <sup>a</sup>	0.88 ± 0.09 <sup>b</sup>
Initial shell width(cm)	2.85 ± 0.07 <sup>ab</sup>	2.41 ± 0.06 <sup>b</sup>	2.61 ± 0.05 <sup>a</sup>
Final shell width(cm)	3.45 ± 0.08 <sup>a</sup>	3.22 ± 0.07 <sup>b</sup>	3.48 ± 0.07 <sup>a</sup>
Shell width increment(cm)	0.87 ± 0.11	0.81 ± 0.09	0.87 ± 0.06
Initial shell "mouth" length(cm)	2.62 ± 0.05 <sup>a</sup>	2.34 ± 0.05 <sup>b</sup>	2.59 ± 0.04 <sup>a</sup>
Final shell "mouth" length(cm)	3.34 ± 0.08	3.24 ± 0.08	3.27 ± 0.05
Shell "mouth" length increment(cm)	0.72 ± 0.07	0.07 ± 0.09	0.68 ± 0.05
Initial shell "mouth" width(cm)	1.56 ± 0.06 <sup>a</sup>	1.39 ± 0.03 <sup>b</sup>	1.49 ± 0.03 <sup>ab</sup>
Final shell "mouth" width (cm)	2.05 ± 0.03	2.06 ± 0.04	2.03 ± 0.05
Shell "mouth" width increment(cm)	0.49 ± 0.06	0.57 ± 0.04	0.55 ± 0.03

<sup>ab</sup>Means within the same row with different superscripts are significantly different (P<0.05). AMO, *Archachatina marginata* var. *ovum*, AMS, *Archachatina marginata* var. *saturalis*.

(2012) for A. M. snails fed vary protein and energy levels. Okonkwo et al. (2000) reported higher average DFI values of 1.41 ± 0.07 g, 1.52 ± 0.07 g, 1.97 ± 0.07 g, 1.61 ± 0.07 g, 1.87 ± 0.07 g and 1.50 ± 0.07g for A. M. snails fed dietary levels of *Moringa oleifera* leaf-meal. The differences in TFI and average DFI reported by these authors could be attributed to feed types, forage materials and breed or genotype effect of A. M. snails used as well as the age, size, variety and weight of parental A. M. snails used in their studies. The FCR which is an indication of efficiency of feed utilization in the snail varied significantly across the varieties (P>0.05). The results of FCR obtained in this study were quite higher than those of 0.23, 0.20, 0.19, 0.24, 0.32 and 0.07 reported by Okonkwo et al. (2000) for A. M. snails fed varying dietary levels of *Moringa oleifera* leaf-meal. The feed was better utilized in the purebred AMS with the least FCR value, than the AMO and the AMO x AMS.

Table 2 shows the shell parameters of *A. marginata* varieties (AMO, AMS, and AMO x AMS) studied. Significant difference (P<0.05) variety effects were observed in the initial shell length (SL), initial shell width (SW) and initial shell "mouth" length (SML). No significant (P>0.05) variety effects were observed in final shell length, final shell "mouth" length and final shell "mouth" width, except in final shell width (P<0.05). Similarly, no significant (P>0.05) variety effects were observed for increment in SW, SML and SMW, except in SL (P<0.05).

The AMO x AMS recorded the highest final SL and final SW than the other varieties, indicating heterotic effects on these two parameters. The final SL value of AMO x AMS

in this study was similar to mean shell length of 4.62 ± 0.08 cm reported by Badmos et al. (2011) for *A. marginata* fed a mixed-diet of concentrate and forages. Ejidike (2004) reported similar shell length values of 4.70 ± 0.30 cm and 5.70 ± 0.30 cm for grower *A. marginata* fed different dietary protein levels, whereas Okon et al. (2012b) reported higher mean shell length values of 9.76 cm and 10.44 cm for mature *A. marginata* and *A. fulica* respectively. The differences in mean shell length values reported by these authors could be attributed to the feeding regime used, breed, ecotypes and variety of the snail, their different ages and the prevailing environmental conditions. The final shell width value of the AMO x AMS in this study (Table 2) was similar to the mean shell width values of 3.50 ± 0.20 cm and 3.70 ± 0.30 cm reported by Ejidike (2002) for *A. marginata* snails fed different dietary levels.

The values of heterosis for body and shell parameters of *A. marginata* obtained in this study are shown in Table 3 which showed that all the varieties expressed positive heterotic values for body and shell parameters studied. Significant difference (P<0.05) variety effects were observed on body weight (BDW), shell length (SL) and shell "mouth" length (SML). No significant (P>0.05) variety effects were observed on the shell width (SW) and shell "mouth" width (SMW). The positive heterotic values expressed by body and shell parameters were in line with Nwakpu and Omeje (2005) and Ibom et al. (2014) who reported that the effects of heterosis are most often but not always positive, and depend mainly on choice of parents and selection pressure applied on parental lines (breeds).

The AMO x AMS recorded the highest heterotic values

**Table 3.** Heterosis (%) values of Body Weight, SL, SW, SML, SMW of *Archachatina marginata* varieties and their crosses.

Traits	Age in months	Varieties		
		T <sub>1</sub> (AMO)	T <sub>2</sub> (AMS)	T <sub>3</sub> (AMO x AMS)
Body weight	5	56.36 <sup>b</sup>	58.89 <sup>b</sup>	63.59 <sup>a</sup>
Shell Length	5	20.98 <sup>b</sup>	22.97 <sup>b</sup>	34.11 <sup>a</sup>
Shell Width	5	29.21	27.97	30.22
Shell "Mouth" Length	5	26.90 <sup>b</sup>	27.37 <sup>b</sup>	39.74 <sup>a</sup>
Shell "Mouth" Width	5	33.99	34.67	35.28

<sup>ab</sup>Means with different superscripts along the same row are significantly different (P<0.05). **AMO**, *Archachatina marginata* var. *ovum*, **AMS**, *Archachatina marginata* var. *saturalis*.

than AMO and AMS varieties for all the traits and parameters studied (Table 3), showing that the crossbred variety has advantage over the two purebred varieties. The results of heterosis of body weight in this study was similar to heterosis of body weight of 53.73% and 57.75% reported by Ibom et al. (2011) for purebred black skinned and purebred white skinned *A. marginata* ectotypes respectively, but lower than the heterosis of body weight of 71.71% for the crossbred *A. marginata* variety. However, the heterosis values in this study for body weight were in contrast with Ibom et al. (2014) who reported lower heterosis values of 38.89% (purebred black) and 37.01% (purebred white) and 53.59% (crossbred) *A. marginata* for body weight at hatch. The heterotic values of shell parameters (SL, SW, SML and SMW) at five (5) months of this study were low (Table 3), as these shell parameters are known to have high heritability; supporting earlier findings of Cliff (2010) and Ibom et al. (2014) that heterosis tends to be greater for traits that have low heritability (e.g., reproductive traits), and small for traits that are highly heritable (e.g., growth traits).

## CONCLUSION

This study revealed that there were significant variety effects (P<0.05) on FBW and AWG, confirming heterotic effects for these growth traits. The crossbred (AMO x AMS) variety recorded the highest AWG, followed by the AMS variety, while AMO variety recorded the least value. There were no significant (P>0.05) variety effect on DWG, TFI, DFI and FCR. The AMO x AMS recorded the highest final SL and final SW than the other two varieties, indicating heterotic effects again on the two shell parameters. Results for all body and shell parameters studied showed low, and positive heterotic values. There were significant variety effects (P<0.05) observed on BDW, SL and SML. The heterotic values obtained for body and shell parameters, though low, tend to support the assertion that growth traits have low heterotic values which may be because they are highly heritable. The crossbred variety recorded the highest heterotic values than the two purebred varieties for all the body and shell parameters

studied, indicating that the crossbred variety has heterotic advantage over the purebred white variety and purebred black variety.

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