Comparative morphometric traits differentiation and phenotypic correlations between *Achatina achatina* (Linne, 1758) and *Achatina fulica* (Bowdich, 1822) snails with four and five whorls

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ABSTRACT: Four hundred (400) adult black-skinned snails, two hundred (200) each of the *Achatina achatina* and *Achatina fulica* with 4 and 5 whors were used respectively for the study. Identification and sorting of the snails sourced from a reputable snail vendor in Ibadan into breeds was done using the appropriate profile and template. The body weights of *Achatina achatina* and *Achatina fulica* snails with 4 whors ranged from 83.00 to 180.50 g (average 156.90 g) and from 30.60 to 85.20 g (average 49.70 g) respectively. That for *Achatina achatina* and *Achatina fulica* snails with 5 whors ranged from 132.70 to 272.80 g (average 138.95 g) and from 50.60 to 119.30 g (average 59.58 g) respectively. Results obtained from the study showed that *Achatina achatina* snails with 4 and 5 whors were genetically heavier and larger than *Achatina fulica* with 4 and 5 whors. Results of phenotypic correlation coefficient among morphometric traits of the two breeds indicated negative, weak, low significant (P<0.05) and mostly non-significant (P>0.05) differences between body weight and most body components (morphometric traits) studied. The only positive, low non-significant (P>0.05) phenotypic correlation coefficient (r_p) obtained was r = 0.420 between body weight and aperture width for *Achatina fulica* snails with 4 whors. Whereas, for *Achatina achatina* snails with 5 whors, positive, low significant (P<0.05) phenotypic correlation coefficients obtained was r = 0.529 between body weight and aperture width and r = 0.660 between spiral width and aperture width respectively. *Achatina fulica* snails recorded the only positive highly significant (P<0.01) phenotypic correlation coefficient of r = 0.602 between aperture width and shell width for the snails with 5 whors. Breed type, age and size differences of snails used, body weight ranges, as well as number of whors on snail shell have high effects of morphometric traits differentiation and phenotypic correlation coefficient estimates. Thus, the morphometric traits of the two breeds (*Achatina achatina* and *Achatina fulica*) of snails studied could be chosen to differentiate as well as characterize snails.

Key words: Black-skinned snails, *Achatina achatina*, *Achatina fulica*, morphometric traits, phenotypic correlations.

INTRODUCTION

Snail farming is an interesting and profitable venture if large, mature breeding stocks of snails with high reproductive potentials are used and properly managed. Nigeria is richly endowed with many breeds of snails (*Archachatina marginata*, *Achatina achatina*, *Achatina fulica*) which has recently attracted the attention of consumers, producers/sellers and researchers (Okon and Ibom, 2012; Nwankwo and Onwarah, 2015).

Among these, *Achatina achatina* and *Achatina fulica* are snails with tremendous unexploited nutritional, health, economic and genetical potentials. According to Okon et al. (2012), *Achatina achatina* is the largest gastropod among the giant African land snails recorded in the Guinness Book of records, with a maximum of recorded shell length of 27cm; while *Achatina fulica* 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 kept and reared (Okon et al., 2012).

Achatina achatina (Plate 1) also called giant Ghana snail or giant tiger land snail is found in Nigeria, Ghana, Cameroon, Guinea, Togo, Cote d’Ivoire, Liberia, Benin Republic and Sierre Leone (Venette and Lason, 2004; Okon and Ibom, 2012). It is often sought after because of its large size, distinct markings and nutritive value. It has a pattern of black wavy streaks on a yellowish background and can grow up to 30 cm in shell length and 25 cm in shell width (Cobbinah et al., 2008). The shells are conical in shape and fairly pointed than other snail species. In captivity under intensive management, it attains sexual maturity between 10 and 12 months and can lay between 30 and 300 eggs/clutch with diameter from 4 to 10 cm per egg (King, 2008). It is the most prized snail after Archachatina marginata for eating as it may weigh up to 500 g at maturity.

Achatina fulica (Plate 2), also called giant East African snail found in Africa, specifically in South of the Sahara in East Africa (Kenya and Tanzania), Liberia and Cote d’Ivoire (Venette and Larson, 2004; Okon and Ibom, 2012). A. fulica is one of the smallest among the giant land snails of the world, growing with a long and greatly swollen body whorl (Jummai and Okoli, 2013). It has a narrow, conical shell being about twice as long as its width and contains 7 to 9 whorls when fully grown. The shell is generally reddish brown in colour with weak yellowish vertical markings but colouration varies with environmental conditions and diet. The adult A. fulica snail shell is about 7 cm in length and 20 cm or more in width. It produces large eggs that are 4.5 to 5.5 cm in diameter and only hatch at temperature of about 15°C.

According to Okon and Ibom (2011), the quantitative measure of animal conformation is important as this will enable reliable parameters for a given trait to be estimated and therefore allow its inclusion in breeding programmes. While, 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 (morphometric) traits mostly used to measure snail growth and growth rate. In addition, Okon and Ibom (2011) recommended morphometric (phenotypic) traits as good prediction tools of hatching weights in juvenile and F1 crossbred of A. marginata snails. Besides, these authors opined that genetic improvement of any breed of snail in order to increase their contribution to the much needed animal protein in Nigeria is inevitable and could be achieved by estimate of genetic correlations among performance traits in the breeding objective and development of selection program for effective planning. There is dearth of information on comparative morphometric (phenotypic) traits differentiation and phenotypic correlations between these two breeds of snails with 4 and 5 whorls.

MATERIALS AND METHODS

Experimental site

The research was carried out in Department of Animal Science, University of Calabar, Calabar, Nigeria.
Experimental Animals

Four hundred (400) adult mature black-skinned snails, two hundred (200) each of Achatina achatina (Aa) and Achatina fulica (Af) were sourced from a reputable snail farmer in Ibadan. The sorting was done using keys prescribed by Segun (1975) and Hodasi (1984). Identification of the snails into breeds (Achatina achatina and Achatina fulica) was done using the profile and template of Nisbert (1974) and Rushton (2012) respectively.

Achatina achatina and Achatina fulica snails with four (4) whors on the shell had body weight ranges from 83.00 to 180.50 g (average 156.90 g) and from 30.60 to 85.20 g (average 49.70 g) respectively. While Aa and Af snails with five (5) whors on the shell had body weight ranges from 132.70 to 272.80 g (average 139.95 g) and from 50.60 to 119.30 g (average 59.58 g) respectively.

Data collection

Data measured on morphometric (phenotypic) traits from both breeds were body weight (BDW), shell length (SHL), shell width (SHW), Aperture length (APL), Aperture width (APW), Spiral length (SPL), Spiral width (SPW), diagonal length (DAL) and length between the aperture and first spiral (LAS).

The morphometric (phenotypic) dimensional shell parameters were measured in millimeters (mm) using Venier caliper, while the body weights (BDW) were measured in grammes (g) using Scout Pro® electronic scale with a sensitivity of 0.01 g. The dimensional shell parameters were taken as described by Ibom (2009) and El. Zaffir et al. (2011).

Statistical analysis

The data obtained were analysed using GENSTAT (2011) software package for simple statistics (mean and standard error), t-test and phenotypic correlations, between body weights and other morphometric traits.

RESULTS AND DISCUSSION

The results of the description of sampled population were expressed as Mean ± standard error of mean and paired sampled test for each morphometric measurement (Table 1). Achatina achatina snails with 4 and 5 whors had higher values for all measured morphometric traits than Achatina fulica snails. There were large disparities which were significantly different (p<0.001) between the mean body weights with number of whors of these two breeds; 156.90 g for A. achatina, 49.70 g for A. fulica with 4 whors while 138.95 g for A. achatina, 59.58 g for A. fulica with 5 whors (Table 1). Similarly, all other measured morphometric traits of A. achatina snails 4 and 5 whors were bigger and longer than those of A. fulica with 4 and 5 whors. The results indicated that A. achatina with 4 and 5 whors are genetically heavier and larger than A. fulica with 4 and 5 whors, as this was confirmed by the test of significance of the difference (t-test) between the two breeds with 4 and 5 whors (Table 1). The results agreed with the views of CAB (2003) and Venette and Larson (2004) that A. achatina is the largest snail among the giant African land snails and A. fulica is the smallest. Besides, the results also agreed with Okon et al. (2012) and Etukudo (2013) that snails with higher number of whors weigh more and are heavier and larger than those with lower number of whors.

On the other hand, the results of mean body weights (Table 1) in this study did not agree with the higher mean body weight (BDW) value of 138.60 g for A. fulica snails with 4 whors by Okon et al. (2012). The BDW results were higher than the 127.20 g and 48.85 g for mean body weights for A. achatina and A. fulica snails with 4 whors respectively reported recently by Eitim (2017). The mean BDW of 182.00 g and 65.05 g for A. achatina and A. fulica snails with 5 whors also reported by Eitim (2017) were higher and heavier than the 138.95 g and 59.58 g for A. achatina and A. fulica snails with 5 whors obtained in this study. Whereas, Etta et al. (2015) reported a higher mean BDW of 137.50 g for A. fulica snails with 4 whors compared to very low mean BDW of 49.90 g for A. fulica snails with 4 whors in this study. While, Ibom et al. (2014) had earlier reported higher mean body weights of 93.70 g, 109.70 g and 73.00 g for A. fulica snails from central agro-ecological zone, northern agro-ecological zone and southern agro-ecological zone of Delta state respectively. But, further recorded low mean body weights of 120.90 g, 107.50 g and 72.00 g for A. achatina snails from central agro-ecological zone, northern agro-ecological zone and southern agro-ecological zone of Delta state compared to the higher and heavier results obtained for A. achatina snails here (Table 1). The difference in BDW here could be attributed to the age and size differences of snails used; body weight ranges as well as number of whors on the shell of the snails. Ibom et al. (2014) used snails that were not classified into their different number of whors, thus the variations in the mean BDW results.

On the other hand, morphometric traits measured as expressed large disparities which were significantly (p<0.001) different between the mean shell parameters with number of whors in these two breeds of snails (Table 1). The results obtained were higher and longer than the 10.440 mm, 5.087 mm, 5.291 mm, 2.990 mm for SHL, SHW, APL and APW for A. fulica with 4 whors respectively reported by Etta et al. (2015).

The results of phenotypic correlations among morphometric traits of the two breeds evaluated (Tables 2a and 2b) indicated negative, weak, low and non-significant (p>0.05) correlation coefficients (r_p) between

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body weights and most shell components studied for *A. achatina* and *A. fulica* snails with 4 and 5 whorls. There was only one negative, highly significant (p<0.01) phenotypic correlation coefficient (r = -0.658) between SHL and LAS for *A. achatina* snail with 4 whorls in this study (Table 2a). Also, there were very few negative, highly significant (p<0.01) phenotypic correlation coefficients (r_p) between BDW and SHW (r = -0.621), APL and SHL (r = -0.639), APW and SHW (r = -0.657) for *A. fulica* snails with 4 whorls. Most of the non-significant (p>0.05) phenotypic correlation coefficients obtained in this study (Table 2a and 2b) denoted that these pairs of traits have no direct relationship and are likely not controlled by the same genes in the same direction. The only positive, but low, non-significant (p>0.05) phenotypic correlation coefficient obtained for *Achatina fulica* snails with 4 whors was between BDW and APW (r = 0.420), whereas that for *A. achatina* with 5 whors was between BDW and APW (r = 0.529), and between SPW and APW (r = 0.550) respectively. The
only highly positive, significant phenotypic correlation coefficient of 0 = 0.602 was obtained between APW and SHW for the snails with 5 whorls. This, according to Ibom (2009) and Okon et al. (2011) signifies that the pairs of morphometric trait used have direct relationship or at least they are controlled by the same gene in the same direction, thus selection for one trait will lead to improvement of the others. The results corroborated Ehiobu and Kyado (2000) and Ibom (2009) views that correlations between morphometric traits could be high or low, positive or negative. On the other hand, these results of negative, low, non-significant phenotypic correlations between the body weights and most of the shell parameters studied disagreed with Okon et al. (2010a, b) and Okon et al. (2011) earlier views of high correlated responses of these morphometric traits for selection and cross breeding for genetic improvement. The differences in correlation coefficients could be attributed to breed effect, age and size differences of snails used; body weight ranges as well as number of whorls on the shell of snails. Most of the authors cited in literature had use A. marginata either at juvenile or growing phases without separating them into their ages and number of whorls. In other words, breed type and number of whorls on shell of the snails used have high effects on phenotypic correlation coefficient of 0 = 0.96 between hatchlings body weight (BDW) and shell length (SHL) for the purebred white-skinned (Albino) and F1, crossbred snails of A. marginata. Similarly, Sam et al. (2016) recently reported strong, positive and highly significant correlation coefficient of 0 = 0.717 between BDW and SHW for black-skinned A. marginata and 0 = 0.827 between BDW and SHW for white-skinned A. marginata. Whereas, Etta et al. (2015) noticed strong, positive, medium phenotypic correlation coefficients of 0 = 0.717 between BDW and BSL, 0 = 0.674 between BDW and BSW, 0 = 0.618 between BSL and SML for Achatina fulica snails. The differences in correlation coefficients could be attributed to earlier reasons of breed effect, age and sizes differences of snails used; body weight ranges as well as number of whorls on the shell of snails. Besides, it might also be due to the fact that A. marginata snails used by most of the authors cited is mainly a terrestrial snails, whereas A. achtina and A. fulica snails are mostly associated with tropical and sub-tropical moist broadleaf forest (Venette and Larson, 2004), typical of Ibadan where the snails were collected. Again, the size and wider spread of the body weight range of A. achtina than those of A. fulica snail. A. achtina and A. fulica snails with 4 whorls used for the study had higher and wider body weights ranges from 83.00 to 180.50 g (Averages 156.90 g) and from 30.60 to 85.20 g (Average 49.70 g) respectively. While A. achatina and A. fulica snails with 5 whorls had body weight ranges from 132.70 to 272.80 g (Average 138.95 g) and from 50.60 to 119.30 g (Average 59.58 g) respectively. Besides, the snails used here had 4 and 5 whorls as against other studies with or without varied number of whorls, age and size differences. But Venette and Larson (2004) opined that full-grown snails have between 7 and 9 whorls. Again, A. achatina is the largest gastropod among giant African land snails and A. fulica is known to be the smallest (CAB, 2003; Venette and Larson, 2004).

**Table 2b. Phenotypic coefficient of correlation (rP) of Morphometric traits between Achatina achatina and Achatina fulica snails with 5 whorls.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BDW</th>
<th>SHL</th>
<th>SHW</th>
<th>APL</th>
<th>APW</th>
<th>SPL</th>
<th>SPW</th>
<th>DAL</th>
<th>LAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BDW</strong></td>
<td>1.000</td>
<td>-0.505</td>
<td>-0.163</td>
<td>-0.613**</td>
<td>0.529*</td>
<td>0.352NS</td>
<td>-0.001NS</td>
<td>0.439NS</td>
<td>0.271</td>
</tr>
<tr>
<td><strong>SHL</strong></td>
<td>-0.359**</td>
<td>1.000</td>
<td>-0.335</td>
<td>-0.314NS</td>
<td>0.090NS</td>
<td>-0.549*</td>
<td>0.003NS</td>
<td>-0.375NS</td>
<td>-0.641**</td>
</tr>
<tr>
<td><strong>SHW</strong></td>
<td>-0.252NS</td>
<td>0.226NS</td>
<td>1.000</td>
<td>-0.300NS</td>
<td>0.620**</td>
<td>-0.059NS</td>
<td>0.248NS</td>
<td>-0.142NS</td>
<td>0.089NS</td>
</tr>
<tr>
<td><strong>APW</strong></td>
<td>0.188NS</td>
<td>-0.243NS</td>
<td>-0.298</td>
<td>1.000</td>
<td>-0.264NS</td>
<td>-0.181NS</td>
<td>-0.027NS</td>
<td>-0.312NS</td>
<td>-0.325NS</td>
</tr>
<tr>
<td><strong>APW</strong></td>
<td>-0.068NS</td>
<td>0.067NS</td>
<td>0.113NS</td>
<td>0.136NS</td>
<td>1.000</td>
<td>0.146NS</td>
<td>0.550*</td>
<td>0.275NS</td>
<td>-0.133NS</td>
</tr>
<tr>
<td><strong>SPL</strong></td>
<td>0.467NS</td>
<td>-0.498NS</td>
<td>0.707NS</td>
<td>-0.271</td>
<td>0.088NS</td>
<td>1.000</td>
<td>-0.314NS</td>
<td>0.368NS</td>
<td>0.108NS</td>
</tr>
<tr>
<td><strong>SPW</strong></td>
<td>0.325NS</td>
<td>-0.070NS</td>
<td>0.088NS</td>
<td>-0.003NS</td>
<td>-0.095NS</td>
<td>0.343NS</td>
<td>1.000</td>
<td>-0.354NS</td>
<td>0.219NS</td>
</tr>
<tr>
<td><strong>DAL</strong></td>
<td>0.307NS</td>
<td>0.035NS</td>
<td>0.709NS</td>
<td>-0.401NS</td>
<td>-0.334</td>
<td>-0.346NS</td>
<td>0.046NS</td>
<td>1.000</td>
<td>-0.074NS</td>
</tr>
<tr>
<td><strong>LAS</strong></td>
<td>-0.141NS</td>
<td>-0.605**</td>
<td>-0.135NS</td>
<td>0.002NS</td>
<td>0.078NS</td>
<td>0.093NS</td>
<td>0.025NS</td>
<td>0.007</td>
<td>1.000</td>
</tr>
</tbody>
</table>

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, NS = N.S (Significant level), ** = P<0.01 (High significant level), * = P<0.05 (Lower significant level).
Conclusion

Achaitina achatina snails with 4 and 5 whorls had higher values than Achaitina fulica for all measured morphometric traits. There were high disparities which were significantly different (P<0.001) between BDW and all morphometric traits of snails with 4 and 5 whors. Achaitina achatina snails with 4 and 5 whors were genetically heavier and larger than Achaitina fulica with 4 and 5 whors as confirmed by the test of significance of the difference (t-test). The phenotypic correlations among morphometric traits of the two breeds were negative, weak and of low significant (P<0.05) correlation coefficient (r) between BDW and most shell components studied. These revealed that breed type, age and size differences of snails used, body weight ranges and numbers of whors on snail shells have high effects on morphometric traits differentiation and correlation coefficient estimates. Thus, the morphometric traits of the two breeds of snails studied could be chosen to differentiate as well as characterize snails.

REFERENCES


