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Full Length Research

Growth and phenotypic traits of juvenile *Achatina fulica* snails in Mkpatak, Nigeria

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ABSTRACT: Juveniles of *Achatina fulica* snails were selected from a population produced by three (3) mating groups (Black-Skinned X Black-Skinned [BS X BS], White-Skinned X White-Skinned [WS X WS], and Black-Skinned X White-Skinned [BS X WS]). One hundred and fifty (150) snails, with each mating group consisting of fifty (50) juvenile snails were used in this study to evaluate growth progress and phenotypic traits of juvenile *Achatina fulica* snails. The snails were grouped into three (3) treatments based on the mating groups and monitored for six (6) weeks using growth and phenotypic traits. Results obtained from this study indicated that there were highly significant differences ($p<0.01$) between the juveniles of the three (3) treatments and within the age groups for both growth and phenotypic traits. The results also showed that White-Skinned juveniles performed best for the growth traits, whereas all the snail groups performed well in terms of phenotypic traits. The results obtained in this study will be used as baseline information for farmers, researchers and snail breeders in the management and development of breeding stocks, thus leading to greater management and productivity for effective snail meat and protein availability in Nigeria.

Keywords: Increment, juvenile, morphometric, snail, traits, young.

INTRODUCTION

Growth in living organisms especially animals, is the increment in size and weight of an organism (McDonald *et al*., 1995). Growth may be estimated as the increase and development in body weight with time, and it largely and solely relies on the quantity of food or the totality of nutrient consumption. Therefore, growth rate according to Fox (1980), is defined as the increase in size and weight gain per unit time in an individual.

The growth of giant African land snails especially the *Achatina fulica* under the tropical condition is generally low due to both climatic and environmental factors (Okon *et al*., 2014; Etukudo *et al*., 2024). The survival and growth of snails are affected by relative humidity, population density, diseases, light, and temperature (Thompson and Chenrey, 2004; Etukudo *et al*., 2017). The phenotypic traits are controlled by the genotype and environment of that snail, and the phenotypic traits and the size of the snail vary with the age of the snail (Okon and Ibom, 2012; Okon *et al*., 2014; Etukudo *et al*., 2017). The growth rate of young snails of *A. marginata* is rapid but varies for the first six (6) months after hatched (Hodasi, 1979; Etukudo *et al*., 2018). The weight of young snails at hatch is about 2.14 g and the average growth of *A. marginata* snail is 0.17 g per day according to Ajayi *et al*. (1978). Akpante (2008) reported

the following differences with the body components of *A. achatina* snails with respect to months of growth, the body weight and the shell length at two (2) months of age is 7.5 g and 27.5 mm, that at four (4) months, the body weight and the shell length of the same species increased to 20 g and 48 mm respectively, while at six (6) months of age, the same species increased to body weight of 33 g with a shell length of 57 mm.

The *A. fulica* snail is of African ecosystems naturally, but is currently distributed to Africa, the Americas, East and South Asia and Oceania (Silva *et al*., 2020), but *A. marginata* occurs mostly in Nigeria and Congo Basin (Hodasi, 1984). Snails are popular delicacies with a high proportion of nutrients in addition to their texture and favourable flavour (Eruvbentine, 2012).

Hatchling, juvenile, grower snails, grower fattening snails and breeder snails are the five developmental stages of snails, which are like other livestock species (Eruvbentine, 2012; Okon and Ibom, 2012). The second stage of snail's developmental stage which is juvenile snails, are those that are about a week to six weeks of age (Eruvbentine, 2012). The rapid growth of snails takes place during the juvenile stage of development and protein, energy and calcium are highly needed for the healthy growth and development of the snails. There is variation in the growth rate of snails between individuals in each population group, and snails show slow differences with respect to growth rate (Cobbinah, 1993).

More so, there are paucity of information on the growth rate for *A. marginata*, *A. achatina* and *A. fulica* according to Ebenebe *et al*. (2011). Therefore, the outcome of this research with *A. fulica* juveniles (from day old to six weeks of age) will be used as baseline information for other researchers to rely on. This study was therefore intended to provide meaningful information on the growth and phenotypic traits of juvenile *A. fulica* to snail farmers, breeders and researchers for snail management, improvement and production.

MATERIAL AND METHODS

Study site and experimental animals

The research was conducted behind the Biological Laboratory of Topfaith University, Mkpatak, Akwa Ibom State, Nigeria. The area is planted with succulent plants and trees that provide shade for the snails in constructed wooden cages to grow and survive, and the climatic condition of the place is just like the natural habitat of snails.

One hundred and fifty (150) juvenile snails of *A. fulica*, fifty (50) each were selected at hatch from a pool produced from three (3) mating groups, which include; Black-Skinned (BS) X Black-Skinned (BS), White-Skinned (WS) X White-Skinned (WS), and Black-Skinned (BS) X White-Skinned (WS) were used for the study. The body weights of the parent snails (breeder snails) that were used for this study ranged between 45.70 and 50.60 g. Selection of the juvenile snails for the study was based on active appearance and absence of injury, lesion on the foot and/or shell. Thereafter, the selected juvenile snails were grouped into three (3) treatment groups on the basis of the mating groups. Each treatment was replicated five (5) times with ten (10) juveniles per treatment in a Completely Randomized Design (CRD).

Juvenile snail's management:

The juvenile snails were managed in constructed wooden cage compartments measuring 0.60 X 0.50 X 0.30 cm^3, embedded with sterilized loamy soil up to 10 cm deep. The soil in the cage was sprinkled with water on a daily basis to moisten the soil and to facilitate the burrowing activities of the snails. The experimental animals were fed on a mixed feeding regime of *Carica papya* leaves and fruits, supplemented with formulated diet. The formulated diet contained 23.04% CP, 2995 Kcal/kgME and 15% Ca. The ingredients used for the diet formulation include vitamin/mineral premix (1.00%), Bone meal/Oyster shell (3.00%), Soybean meal (38 - 40%), and sundried cocoyam (57 - 60%). Feed and water were administered *ad libitum* throughout six (6) weeks of the experiment.

Growth and phenotypic measurement of the juvenile snails

Growth traits measured include; body weight, weight gain, feed intake and feed efficiency or conversion ratio, while the phenotypic traits were body shell length, body shell width, mouth shell length, and mouth shell width. All the traits were measured at hatch and weekly for six (6) weeks with the aid of an electronic scale (Model- M411L England) with 0.01 g sensitivity for body weight, and Vernier calliper for body traits parameters, respectively. Body weight gain was calculated by subtracting the present week's weight from the previous week's weight. Feed intake was measured daily by subtracting between quantity of feed served and the quantity left over after 24 hours, while the feed conversion ratio or efficiency was calculated as the ratio of the feed intake to weight gain.

Statistical analysis

Data collected were subjected to analysis of variance using the GENSTAT (2007) software package. Least Significant Difference according to Steel and Torrie (1980) was used to separate the significant means.

Table 1. Mean weekly (g) of Juvenile *A. fulica* Snails (1day to 6weeks of Age).

Growth traits	Age (weeks)															
	BS X BS								WS X WS							
	0	1	2	3	4	5	6	p-value	0	1	2	3	4	5	6	p-value
BDW (g)	0.50	0.61	0.66	0.72	0.75	0.85	0.94	p<0.01	0.51	0.60	0.68	0.72	0.76	0.83	0.98	p<0.01
BDWG (g/wk)		0.11	0.05	0.06	0.03	0.07	0.12	p>0.05		0.10	0.08	0.04	0.04	0.07	0.15	p>0.05
FI (g/wk)		3.10	4.62	5.05	6.12	7.20	8.30	P<0.01		4.40	5.60	6.71	7.31	8.45	9.13	p<0.01

Growth traits	Age (weeks)							
	BS X WS							
	0	1	2	3	4	5	6	p-value
BDW (g)	0.48	0.50	0.66	0.68	0.72	0.86	0.96	p<0.01
BDWG (g/wk)		0.02	0.16	0.02	0.04	0.14	0.10	p>0.05
FI (g/wk)		3.00	4.15	5.20	6.60	7.65	8.21	p<0.01

BDW = Body weight, BDWG = Body weight gain, FI = Feed intake, BS = Black-Skinned, WS = White-Skinned, WKs = Weeks, P>0.05 = Non significant at 5% level, P<0.01 = High significant at 10% level.

RESULTS AND DISCUSSION

Growth traits of juvenile *A. fulica* snails

The results obtained in this study for growth traits of juvenile *A. fulica* snails are presented in Table 1. There were highly significant differences (p<0.01) between the three (3) mating groups and within the age groups (6 weeks). The white-skinned purebred juveniles recorded the highest body weights (0.51 to 0.98 g) from hatch to six (6) weeks of age, followed by the purebred black-skinned juveniles (0.50 to 0.94 g), while the crossbred black-skinned and white-skinned recorded the lowest values (0.48 to 0.96 g). There was a progressive increase in body weight across the three (3) mating groups at different stages of development among the juvenile phage (week 1 to week 6). This progressive increment in body weight is in tandem with the reports of Amubode (1994), Odunaiya and Akinyemi (2008), Ibom and Okon (2012), Okon and Ibom, (2012), and Okon *et al*. (2014).

The results of the mean weight of juveniles at day old presented in Table 2, showed no significant genotypic effect (p>0.05), although the white-skinned purebred genotype recorded the highest initial weight of 0.51 g, followed by 0.50 g for black-skinned purebred genotype and the lowest value of 0.48 g was recorded for crossbred genotype respectively. The mean initial weights at hatch recorded for this study (Tables 1 and 2) are slightly lower than the mean hatchling weight of 0.60 g reported by Okon *et al*. (2012) and Okon *et al*. (2014) for *A. achatina* juveniles fed with pawpaw leaves and formulated diet containing 20.56% CP and 2727.94 Kcal/kgME, also lower than the value of 0.69±0.03 g and 1.08±0.08 g obtained by Ibom and Okon (2012) for purebreds white-skinned and black-skinned respectively, that were fed with pawpaw leaves and formulated diet containing 24% CP, 2650 Kcal/kgME and 15% Ca. A day-old hatchling weight is used as an indicator of the growth and development of juvenile snails (Okon *et al*., 2012).

A high significant difference (p<0.01) was recorded for the mean final body weight between the three (3) mating groups with purebred white-skinned juveniles recording the highest value of 5.08 g, followed by black-skinned purebred with 5.00 and 4.86 g recorded as the lowest value for crossbred. The differences recorded among the body weights in this study may be due to breed and strain effects, age and size of the parental breeder snails used, size and weight of eggs laid, diet type (sole or mixed), climatic and environmental factors as well as stocking density (Okon *et al*., 2014). Abiona *et al*. (2012) noted that the weight of hatchlings at hatch relied solely on the yolk sac residual and was directly affected by the size of the egg. The same authors reported a significant correlation between egg weight and hatchling weight, and also parental breeder snails and hatchling weight. They concluded that egg weight

Table 2. Growth traits of juvenile *A. fulica* snails.

Growth traits	Mating groups		
	BS X BS	WS X WS	BS X WS
Mean initial weight (g)	0.50[a]	0.51[a]	0.48[a]
Mean final weight (g)	5.01[a]	5.08[a]	4.86[b]
Mean weight gain (g/wk)	0.42[b]	0.48[a]	0.48[a]
Daily weight gain (g/d)	0.010[b]	0.011[a]	0.012[a]
Total feed intake (g)	34.39[b]	41.60[a]	34.81[b]
Daily feed intake (g/d)	0.819[b]	0.990[a]	0.829[b]
Feed efficiency (FE)	0.012[b]	0.011[c]	0.013[a]

[ab]Means along the same row with different superscripts are significantly different (p<0.05).

affected weight at the hatch of juveniles.

No significant difference (p>0.05) was recorded in body weight gain within the three (3) mating groups (Table 1). However, the purebred white-skinned and crossbred juveniles recorded the same and the highest mean weight gain of 0.48 g/w and daily weight gain of 0.011 g/d as indicated in Table 2. The results recorded in this study for mean weight gain and daily weight gain were higher than the values of 0.063±0.002 g/d and 0.066±0.001 g/d recorded by Ibom and Okon (2012) for black-skinned and white-skinned juveniles of *A. marginata*. This result was also higher than the value of 0.26 g/w body weight gain for *A. marginata* that was fed with plant food by Ogogo (2004). On the other hand, this result was lower than the values of 0.50 g/w and 0.012 g/d mean weight gain and daily weight gain respectively for *A. achatina* as reported by Okon *et al*. (2014). The disparity observed between these growth trait values might be attributed to variations in the age range of the juveniles and the total number of juveniles used for the study. Okon *et al*. (2014) classified the juvenile phase to be from one day to six weeks of age and used one hundred (100) juveniles against the fifty (50) juveniles used with the same six weeks of age in this research.

Significant daily feed intake was observed among the three (3) mating groups with white-skinned snails recording the highest value of 0.990 g/d, while the daily feed intake value of 0.819 g/d was recorded for black-skinned snails (Table 2). The results obtained in this study for daily feed intake were similar to the values of 0.965, 0.130 and 0.974 g/d recorded by Okon *et al*. (2014) for black-skinned, white-skinned and crossbred juveniles of *A. achatina* snails respectively. On the other hand, the result of daily feed was higher than the values of 0.0153±0.0001 g/d for black-skinned and 0.00141±0.0001 g/d for white-skinned juveniles of *A. marginata* as reported by Ibom and Okon (2012).

There was a significant difference (p<0.05) in feed efficiency among the three (3) mating groups in this study, with the purebred white-skinned juvenile showing the best feed utilization. These results were lower than the values of 0.89, 0.78 and 0.70 feed efficiencies reported by Okon *et al*. (2012) for black-skinned, white-skinned and crossbred juvenile *A. achatina* respectively. On the other hand, the results were slightly higher than the values 0.010, 0.011 and 0.009 feed efficiency values for black-skinned, white-skinned and crossbred respectively as reported by Okon *et al*. (2014) for juvenile *A. achatina* snails. According to Okon *et al*. (2012), the variation in growth traits studied may be due to the genotypic effect, protein and energy levels of the diets and the age range of the juveniles as the growth traits results obtained in this study, are based on age range from one to six weeks, while other authors worked with either grower or mature snails.

Phenotypic traits of juvenile *A. fulica* snails

The results recorded for phenotypic traits were significantly different (p<0.01) among the three (3) mating groups studied (Table 3). A non-significant difference (p>0.05) mean for the body shell length was observed among the three mating groups, though the purebred black-skinned recorded the highest mean final body shell length value of 10.99 mm (Table 4). There was a significant difference (p<0.05) in the mean for final body shell width, final shell mouth length and final shell mouth width among the three mating groups, the highest mean for final body shell width, with the value of 8.00 mm was recorded for both purebred black-skinned and crossbred, 9.00 mm mean value for final shell mouth length was recorded for purebred white-skinned snails and 4.00 mm mean value for final shell mouth width was recorded for crossbred snails.

The phenotypic trait values for juveniles recorded in this study are lower than the values reported by Okon *et al*. (2014) for juvenile *A. achatina* snails of six weeks old. These differences may be due to the species of the snails used in each study. Juvenile *A. fulica* snails were used in this study while Okon *et al*. (2014) used juvenile *A.*

Table 3. Mean weekly phenotypic traits (mm) of juvenile *A. fulica* snails (1day to 6 weeks of age).

Phenotypic traits	Age (weeks)													
	BS X BS							WS X WS						
	1	2	3	4	5	6	p-value	1	2	3	4	5	6	p-value
BSL (mm)	10.14	10.56	10.87	11.10	11.42	11.83	p<0.01	10.00	10.20	10.72	10.92	11.12	11.30	p<0.01
BSW (mm)	7.10	7.52	7.81	8.20	8.49	8.84	p<0.01	6.12	6.30	7.00	7.42	8.10	8.42	p<0.01
SML (mm)	7.41	7.60	8.10	8.72	8.93	9.21	p<0.01	7.10	7.60	8.71	8.94	9.23	9.68	p<0.01
SMW (mm)	2.42	2.61	3.12	3.76	3.92	4.10	P<0.01	2.12	2.51	3.18	3.26	4.30	4.58	p<0.01

Phenotypic traits	Age (weeks)						
	BS X WS						
	1	2	3	4	5	6	p-value
BSL (mm)	10.12	10.50	10.81	10.90	11.12	11.20	p<0.01
BSW (mm)	7.00	7.26	7.61	7.92	8.30	8.56	p<0.01
SML (mm)	7.32	7.81	8.20	8.60	8.96	9.20	p<0.01
SMW (mm)	2.35	3.00	3.45	4.01	4.20	4.52	p<0.01

p<0.01 = High significant at 10% level, BS = Black-Skinned, WS = White-Skinned, WKs = Weeks, BSL = Body shell length, BSW = Body shell width, SML = Shell mouth length, SMW = Shell mouth width.

Table 4. Phenotypic traits of juvenile *A. fulica* snails.

Phenotypic traits	Mating groups		
	BS X BS	WS X WS	BS X WS
Mean Initial BSL (mm)	10.14	10.00	10.12
Mean Final BSL (mm)	10.99[a]	10.71[a]	10.78[a]
Mean Initial BSW (mm)	7.10	6.12	7.00
Mean Final BSW (mm)	8.00[a]	7.23[b]	8.00[a]
Mean Initial SML (mm)	7.41	7.10	7.32
Mean Final SML (mm)	8.33[b]	9.00[a]	8.35[b]
Mean Initial SMW (mm)	2.42	2.12	2.35
Mean Final SMW (mm)	3.32[b]	3.33[b]	4.00[a]

[ab]Means along the same row with different superscripts are significantly different (p<0.05). BSL = Body shell length, BSW = Body shell width, SML = Shell mouth length, SMW = Shell mouth width, BS = Black-Skinned, WS = White-Skinned.

achatina snails of the same age. The disparity may also be attributed to the genotypic effect, age and size of the parent and juvenile snails used, period of study, diet (sole or mixed) as well as dietary protein and energy levels used in feeding the experimental snails.

Conclusion

The results obtained in this study indicated that during the growth phase of juvenile snails, there was a progressive body weight increment with a significant difference ($p<0.05$) in the mean final body weight among the three mating groups from week one to the sixth week of age. There was also a significant difference ($p<0.05$) in daily weight gain and feed efficiency among the mating groups. Notwithstanding, daily feed intake had a significant effect on the growth performance of the three mating groups. This was passed judiciously into the significant difference ($up<0.01$) recorded for the mean final measurement for all the phenotypic traits recorded among the three mating groups of juvenile *A. fulica* snails studied. These results would be useful to farmers, researchers and snail breeders in the development of their breeding stocks, thereby enhancing greater management and production of snail and food security in Akwa Ibom State in particular and Nigeria at large.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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