Journal of Agricultural Science; Vol. 4, No. 11; 2012
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Reproductive and Growth Traits of Parents and F_1 Hatchlings of *Achatina achatina* (L) Snails under Mixed Feeding Regime with Graded Levels of Swamp Taro Cocoyam (*Cyrtosperma chamissonis*) and Paw paw leaves (*Carica papaya*)

Okon, B.[1], Ibom, L. A.[1], Nsa, E. E.[1] & Ubua, J. A.[1]

[1] Department of Animal Science, University of Calabar, Nigeria

Correspondence: Okon, B., Department of Animal Science, University of Calabar, Nigeria. Tel: 234-803-418-3263. E-mail: blessedbassey4destiny@yahoo.com.

Received: August 23, 2012 Accepted: September 8, 2012 Online Published: October 17, 2012

doi:10.5539/jas.v4n11p289 URL: http://dx.doi.org/10.5539/jas.v4n11p289

Abstract

Achatina achatina snails were raised on mixed feeding regime of forage and diets containing graded levels of sun-dried swamp taro cocoyam (*Cytosperma chamissonis*) meal to assess the parent snails' reproductive traits and the growth performance of their juveniles. Ninety parent snails, forty-five (45) each of the black-skinned (BS) and white-skinned (WS) ectotypes weighing 50.75 to 62.50 g and 48.40 to 60.75 g respectively constituted the 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)] studied. Snails in each mating group were randomly allocated to five diets containing different levels of the test ingredient. Results of the reproductive traits of the study showed that inclusion of cocoyam above 50% had negative effects. The results revealed that snails on the control diet (without cocoyam meal) consistently performed better than those on diets containing the test ingredient. Snails on the control diet had higher mean clutch size value while those on 100% inclusion level of test ingredient recorded the least mean clutch size value across the mating groups. The incubation period of eggs laid by snails on control diet was lower than those on diets containing test ingredient inclusion. Eggs hatchability and hatchlings weights decreased with increasing levels of test ingredient inclusion. Results of growth traits of hatchlings showed that there was decreasing growth rate with increasing levels of test inclusion. However, snails on diets containing between 25% and 50% test ingredient inclusion compared favourably with those on control diet in terms of weight gain, final body weight, feed intake, feed conversion ratio and percent mortality across the mating groups. Based on the results of this study, it is recommended that sun-dried taro cocoyam meal can replace maize up to 50% in the diet of *A. achatina* without detrimental effects on reproductive traits of parents and growth traits of the F_1. We however suggest that other methods of processing be applied to the cocoyam to allow for higher inclusion levels.

Keywords: hatchlings, cocoyam, reproductive traits, mixed feeding, growth traits

1. Introduction

Nigeria has been plagued for many decades with the problem of lack of sustainable policies and implementation on several programmes aimed at improving the recommended animal protein of the people (Hamilton-Amachree et al., 2009). This has rather contributed greatly to the problem of protein inadequacy among Nigerians, hence the need to shift research and production emphasis to the domestication of micro-livestock such as snail, rabbit, grasscutter (cane rat), quail, guinea pig and African giant rat (Ibom, 2009; Okon & Ibom, 2010).

Nigeria is greatly endowed with snail species. Ejidike (2002), Ibom (2009) and Okon et al. (2009a) noted that snails have been a major ingredient in the diets of many West Africans living in the humid tropical zone. It forms a very important part of the diets of many households in the rain forest belts (Hamzat et al., 2007). The four different breeds of snail found in Nigeria include *Archachatina marginata*, *Achatina achatina*, *Achatina fulica* and *Limicolaria* species (Omole et al., 2000; Omole, 2002). Amubode (1994) and Okon et al. (2010c) reported both *Archachatina marginata* and *Achatina achatina* as the two most abundantly distributed and popular breeds of snail in Nigeria.

Most snails are herbivores, feeding on green vegetation including fruits and vegetables on farms, although a few land species and many marine species may be omnivores or carnivores (Kehinde et al., 2004;

Hamilton-Amachree et al., 2009). Akinnusi (2004) and Okon and Ibom (2010) have listed the conventional feeds of snails which are mainly of plant origin to include paw-paw leaf and fruits, breadfruits, sweet potatoes, water leaves, leaf and ripe fruits of banana and plantain, orange, mango fruits, among others. These feeds according to Kehinde et al. (2004) and Odunaiya and Akinyemi (2008) are seasonal, perishable and cannot supply all the nutrients required for optimum performance of snails. Ibom (2009) and Okon et al. (2009b,c) observed that snails fed on either sole forage, sole concentrate feed or on mixed feeding regime of forage and formulated (concentrate) diets do well in terms of growth and reproductive performance. Such diets according to the authors contain varying combinations of ingredients for growth and reproduction.

There is need to feed snails with concentrate which according to Kehinde et al. (2004) is inevitable in sustainable snail production as it enhances performance. Akinnusi (2004) and Okon and Ibom (2010) added that for commercial production also, the growth rate of young snails can be improved upon by using compounded feed. According to Okonkwo et al. (2000), the growth of snail like that of other animals is affected by what they are fed. Growth tissues and shell marks and weight gain, are influenced by the Nutritive value of feeds (Okonkwo et al., 2000). Intensive approach to snail production would however, entail the use of alternative feed resources other than the already existing conventional ones. This could enhance productivity of meat at affordable cost by farmers. Such alternative non-conventional plant source is swamp taro cocoyam, readily available in Nigeria, especially Calabar, the capital of Cross River State. Okon et al. (2010b) feeding swamp taro cocoyam as energy source and soyabean meal as protein source through the concentrate and forage (paw-paw leaves) mixed feeding regime reported that up to 50% of maize can be replaced with sun-dried swamp taro cocoyam (*Cytosperma chamissonis*) in the diet of *Archachatina marginata* snail without any adverse effects on reproductive and egg quality traits.

There is a dearth of information on the use of swamp taro cocoyam in formulating feeds for snails. The objective of this study was to evaluate the effects of mixed feeding on reproductive and growth traits of *Achatina achatina* snails fed graded levels of swamp taro cocoyam meal as a replacement for maize.

2. Materials and Methods

The geographical position of Calabar is latitude 4°58' North and 8°17' East (Ojanuga, 2006). The relative humidity of Calabar is 51-98% (Ojanuga, 2006). Ninety (90) breeder snails, forty-five (45) each of the black-skinned ectotype weighing 50.75 to 62.50 g and white-skinned (Albino) ectotype weighing 48.40 to 60.75 g were used for the experiment.

The selection of the snails, experimental procedures and preparation of swamp taro cocoyam meal were as previously described in Okon et al. (2009a, b, c), Okon et al. (2010a, b) and Okon et al. (2011). A mating management of two snails per cell for the three groups/crosses, namely; 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) was adopted. Each of the three crosses were further replicated thrice with each replicate having two snails per cell measuring 40 by 30 sq. cm. Putting two snails per cell was to ensure that resulting eggs were products of mating between the two snails. The snails were allowed acclimatization period of four weeks during which time they would have shed the eggs they came with before the commencement of the study. They were marked and grouped/reared in pairs (two snails) of closely similar weights to a hutch compartment in a randomized complete block design (RCBD). The pairs were allowed together in one cell for one week and then separated for another one week before being returned in that cycle until they laid eggs.

Table 1. Proximate composition of sun-dried swamp taro cocoyam

Component	Composition
Dry matter	88.73±0.66
Crude protein	7.93±0.11
Ether extract	0.41±0.02
Crude fibre	1.36±0.05
Ash	4.71±0.20
Nitrogen-free extract (NFE)%	74.31±0.05

Each cross was randomly assigned five different experimental diets formulated using sun-dried swamp taro cocoyam meal to replace maize as an energy source in the diets at 0% or no sun-dried cocoyam meal as control diet (T_1); diets T_2, T_3, T_4 and T_5 were formulated to replace maize at 25%, 50%,75% and 100% levels respectively (Table 1). The experimental snails were fed weighed quantities of experimental diets in the morning at 0800 hours and forage (paw-paw leaves) in the evening at 1800 hours throughout the twelve weeks of the study. The reproductive traits evaluated included clutch size, incubation period (days), percent hatchability and hatchlings weight, while body weight, weight gain, feed intake and feed: gain were growth traits evaluated.

Juvenile snails obtained from the hatching of eggs laid by the parent snails' mating groups were selected at hatch and managed in wooden cells according to test diets. Selected juveniles were grouped into colonies of five snails of similar weights in three replicates per treatment and raised for four weeks. The mean weight of mating groups ranged from 0.52-0.56 g (BS X BS), 0.71-0.74 g (WS X WS) and 0.58-0.72 g (BS X WS).

The test ingredient (swamp taro cocoyam) was prepared by washing thoroughly to remove all forms of extraneous materials. It was chopped with the peels intact into chips for easy drying. The chips were sun-dried for 7 days to a constant weight and thereafter milled. The milled cocoyam was then screened with 1.00 mm sieve and used for the formulation of the test diets.

Proximate composition of sun-dried swamp taro cocoyam was determined using standard methods (AOAC, 1995). Data collected were analyzed using GENSTAT (2007) software package for individual crosses while factorial design was used to compare the different crosses. Significant means were separated using Duncan's Multiple Range Test (Duncan, 1955).

3. Results and Discussion

The proximate composition of sun-dried swamp taro cocoyam cormel is presented on Table 1. The percent crude protein (% CP) levels in the experimental diets (Table 2) ranged from 20.56% to 23.04% and that of the metabolizable energy (ME) levels ranged from 2727.94 to 2995.20 Kcal/Kg. The range in metabolizable energy levels in these diets fall within the energy requirements for breeder snails, whereas that of the crude protein levels in T_4 and T_5 were below the bench mark of 22-23% reported in Okon and Ibom (2010) and Okon et al. (2011).

Table 2. Gross Composition of the Experimental Diets containing sun-dried swamp taro cocoyam meal

Diet Ingredients	T_1 0%	T_2 25%	T_3 50%	T_4 75%	T_5 100%
Maize	57.60	43.20	28.80	12.40	0.00
Cocoyam meal	0.00	14.40	28.80	43.20	57.60
Soyabean meal	38.40	38.40	38.40	38.40	38.40
Bone meal	3.00	3.00	3.00	3.00	3.00
Min./Vit. Premix	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00
		Calculated Analysis			
Crude protein (%)	23.04	22.42	21.80	21.18	20.56
Metabolizable energy (Kcal/kg)	2995.20	2928.38	2838.08	2794.75	2727.94

Results of reproductive performance traits are presented on Table 3. Mean clutch size per snail ranged from 20 (T_5) to 28 (T_1) for the black-skinned purebred cross; 12 (T_5) to 18 (T_1) for the white-skinned purebred cross and 12 (T_5) to 20 (T_1) for the black-skinned x white-skinned crossbred cross. These results were quite higher than the mean clutch size value range of between 4 and 18 in Omole and Kehinde (2005) for *Achatina achatina*. The results were also higher than those in Okon et al. (2011) for *Archachatina marginata* on mixed feeding regime. The results confirmed that *A. achatina* is more prolific in clutch size than *A. marginata*. The results further revealed that snails on control diet (T_1) consistently recorded the highest mean clutch size per snail in the three mating groups/crosses but gradually decreased with increase in cocoyam meal levels in the diets. Snails on diet T_5 (100% inclusion of cocoyam meal) recorded the least mean clutch size for the three mating groups/crosses.

Table 3. Reproductive Traits of Snails (*Achatina achatina*) fed diets containing graded levels of sun-dried swamp taro cocoyam meal

Diets		T_1	T_2	T_3	T_4	T_5
Mating Groups/ Crosses	Reproductive Traits	0%	25%	50%	75%	100%
BS x BS	Mean clutch size/snail	28	27	25	20	20
	Incubation period (days)	11-30	12-30	14-30	15-30	18-30
	Mean No. of Hatchlings/snail	22	21	20	12	10
	Percent Hatchability	78.57	77.78	80	60	50
	Mean Weight of Hatchlings at day old (g)	0.56	0.54	0.54	0.54	0.52
WS x WS	Mean clutch size/snail	18	16	15	12	12
	Incubation period (days)	18-30	18-30	16-30	20-30	21-30
	Mean No. of Hatchlings/snail	15	12	10	8	6
	Percentage Hatchability	83.33	75	66.67	66.67	50
	Mean Weight of Hatchlings at day old (g)	0.74	0.72	0.71	0.71	0.71
BS x WS	Mean clutch size/snail	20	18	18	16	12
	Incubation period (days)	16-30	15-30	15-30	18-30	20-30
	Mean No. of Hatchlings/snail	18	15	14	12	7
	Percentage Hatchability	90	83.33	77.78	75	58.33
	Mean Weight of Hatchlings at day old (g)	0.72	0.70	0.62	0.62	0.58

BS = Black-skinned, WS = White skinned.

The variations in clutch size obtained may partly be due to the residual effects of anti-nutritional factors in cocoyam (Okon et al., 2011) and partly due to the snails' genetic composition, parity and environment. Anti-nutritional factors in test ingredient are suspected because the control diet (T_1) without cocoyam meal (0%) had the best performance in all the traits evaluated. Implication of genetic composition, parity and environment corroborates Akintomide (2004) and Okon et al. (2009b) who reported that clutch size is dependent on genetic composition, parity and environment.

The incubation period varied among the three crosses and the different diets (Table 3). The incubation periods were within the range of 11-30 days, 16-30 days and 15-30 days for black-skinned x black-skinned purebred cross, white-skinned x white-skinned purebred cross and black-skinned x white-skinned crossbred cross. The results were within the range of 10-31 days reported by Hodasi (1979). However, Okon et al. (2011) recorded higher incubation with *A. marginata* using the same diets. Unexpectedly, snails on diets (T_4 and T_5) recorded highest incubation periods. These again might be due to both the diets and the genetic composition of the snails.

The percent hatchability ranged between 50% and 90% in the three crosses and decreased as the levels of cocoyam meal increased, showing that higher levels of cocoyam meal had adverse effects on hatchability of snails' eggs. This was also reflected on mean number of hatchlings per snail (Table 3). The higher percent hatchability recorded between diets T_1 and T_3 fall within the range reported in Ogogo (2002) for *Achatina achatina*. Lower percent hatchability values for diets T_4 and T_5 confirmed the residual effects of anti-nutritional factors in the concentrate feed fed to the snails on hatchability of snails' eggs.

Mean hatchling weights obtained at hatch (day old) (Table 3) varied from 0.52 g to 0.56 g, 0.71 g to 0.74 g and 0.58 g to 0.72 g for BS X BS, WS X WS and BS X WS mating groups/crosses respectively. *Achatina achatina* snails recorded lower mean hatchlings weights at day old when compared with that of *Archachatina marginata* fed the same cocoyam meal diets in Okon et al. (2011). This might be attributed to the small body size and higher mean number of hatchlings per snail of *Achatina achatina*. The BS X BS purebred cross had the lowest mean hatchling weights (Table 3). The weights were however much higher than the 0.10 g average weight reported in Hodasi (1979) for *Achatina achatina*. The difference between hatchling weights of this study and that in Hodasi (1979) could be attributed to differences in location, and thus snail types. Besides, it might partly be due to the effect of the egg size as BS X BS purebred cross had the least egg size among the three mating groups/crosses (Okon et al., 2010a). The mean hatchling weights obtained (Table 3) decreased with increased levels of cocoyam meal, further implicating the residual effects of the anti-nutritional factors of cocoyam in the compounded concentrate since the control diet (without cocoyam) performed better. Hatchlings from the control diet (T_1) with 0% cocoyam meal inclusion level had the highest mean weights across the three crosses studied; signifying that inclusion of cocoyam meal in the diets of *A. achatina* snails affected their reproductive traits negatively. This is because there was no significant difference in the reproductive traits with up to 50% inclusion of cocoyam meal in the diets.

Results of growth traits of hatchlings fed the test diets are presented in Table 4. The average initial body weights of the juvenile snails for the five different diets irrespective of levels of replacement were not significantly different (P>0.05) among the three mating groups/crosses. General growth performance of the hatchlings reduced with increasing levels of cocoyam meal in the diets. However, hatchlings fed diets T_2 and T_3 at 25% and 50% inclusion levels in the diet compared favourably with those in diet T_1 (0%) in terms of average final body weight, average weight gain, average feed intake, feed conversion ratio and percent mortality for these mating groups/crosses. Dietary inclusion level of cocoyam meal had no significant (P>0.05) influence on average final body weights of the black-skinned purebred (BS X BS) and the white-skinned purebred (WS X WS) crosses. However, significant influence (P<0.05) was observed on average final body weights among hatchlings of the crossbred (BS X WS) cross (T_5). Hatchlings fed diet T_5 (100% inclusion level of cocoyam meal) recorded the lowest average final body weight of 0.80 g, 1.01 g and 0.90 g for BS X BS, WS X WS and BS X WS mating groups/crosses respectively. Whereas hatchlings fed the control diet (T_1) at 0% inclusion level of cocoyam meal recorded the highest average final body weight of 0.97 g, 1.24 g and 1.20 g for BS X BS, WS X WS and BS X WS mating groups/crosses respectively. The average final body weight obtained for the test diets among the three mating groups were quite higher than the 0.10 g (range of 0.009-0.13 g) reported in Hoadsi (1979). Apart from the presence of residual effects of anti-nutritional factors in the test diets, location as well as strain of snail used could be implicated for the results. Agwunobi et al. (2002), Abudlrashid et al. (2007) and Okon et al. (2011) had reported that cocoyam meal contains anti-nutritional factors like calcium oxalate and phytate with other unidentified chemicals which account for reduced intake by animals. However, Tang and Sakai (1983) and Agwunobi et al. (2002) noted that processing cocoyam by either sun-drying, parboiling or cooking etc, reduced the anti-nutritional factor, oxalate; thereby making it suitable as feed resource.

There was no significant (P>0.05) influence of dietary inclusion level of cocoyam on average weight gain for the black-skinned purebred and the crossbred crosses, while it does significantly (P<0.05) influence that of the white-skinned purebred cross (Table 4). Average weight gains obtained varied from 0.38 g to 0.40 g, 0.30 g to 0.50 g and from 0.32 g to 0.48 g for the BS X BS, WS X WS and BS X WS crosses respectively (Table 4). The highest average weight gain was recorded by hatchlings on T_1 (0% inclusion level of cocoyam meal) of white-skinned purebred (WS X WS) cross. The values obtained for average weight gains in this study was quite higher than the 0.22 g/d recorded for *A. achatina* on concentrate in Amubode (1994) and 0.26 g/d recorded for *A. achatina* in Omole (2000) as well as 0.27 g/d recorded for *A. achatina* in Odunaiya and Akinyemi (2008). The variations in weight gains could be due to differences in feed types as well as composition for low nutrient concentration of feed mixtures by corresponding increases in feed intake. This signifies the acceptance of cocoyam diet by the juvenile of *A. achatina* snails. Besides feed, weather conditions (heat) could also be responsible for mortality of juveniles.

The feed intake values recorded in the study varied from 4.00 g to 5.22 g for the BS X BS cross, 4.95 g to 5.16 g for the WS X WS cross and 4.00 g to 5.25 g for the BS X WS cross (Table 4). These values do not agree with the feed intake value of 1.96 g/d reported in Odunaiya and Akinyemi (2008) for *Achatina achatina*. But the 5.13 g/d feed intake reported in Amubode (1994) for *A. achatina* snails at four weeks of age falls within the range obtained in this study. Increase in feed intake will normally result in increased body weight gain (McDonald et al., 1995). The increased feed intake in this study without a corresponding increase in body weight gain may be ascribed to the lower crude protein and energy concentration per kilogramme of feed (Table 2). Thus the juvenile snails increased their feed intake at these levels to meet their energy requirements (McDonald et al., 1995).

Table 4. Growth Traits of Juvenile Snails (*Achatina achatina*) fed diets containing graded levels of sun-dried swamp taro cocoyam meal (0-28 days)

Diets Mating groups/crosses	Growth Traits	T_1 0%	T_2 25%	T_3 50%	T_4 75%	T_5 100%	±SEM
BS X BS	Av. Initial weight (g)	0.56^{a}	0.54^{a}	0.54^{a}	0.54^{a}	0.52^{a}	0.10
	Av. Final weight (g)	0.97^{a}	0.96^{ab}	0.94^{ab}	0.89^{ab}	0.80^{bc}	0.15
	Av. weight gain (g)	0.40^{a}	0.40^{a}	0.40^{a}	0.35^{a}	0.39^{a}	0.17
	Av. feed intake (g)	4.31^{b}	4.37^{b}	4.00^{bd}	4.66^{ab}	5.22^{a}	0.75
	Feed Conversion Ratio	10.78^{c}	10.93^{b}	10.00^{d}	13.31^{a}	13.74^{a}	0.45
	Mortality (%)	0	0	0	16.67(2)	20.00(2)	-
WS X WS	Av. Initial weight (g)	0.74^{a}	0.72^{a}	0.71^{a}	0.71^{a}	0.71^{a}	0.10
	Av. Final weight (g)	1.24^{a}	1.18^{a}	1.14^{a}	1.06^{a}	1.01^{a}	0.25
	Av. weight gain (g)	0.50^{a}	0.46^{ab}	0.43^{ab}	0.35^{bc}	0.30^{cd}	0.15
	Av. feed intake (g)	4.95^{ac}	5.16^{a}	4.53^{b}	5.08^{ab}	5.13^{ab}	0.42
	Feed Conversion Ratio	9.90^{d}	11.22^{c}	9.06^{e}	14.51^{b}	17.10^{a}	0.60
	Mortality (%)	6.67(1)	8.33(1)	0	37.50(3)	50.00(3)	-
BS X WS	Av. Initial weight (g)	0.72^{a}	0.72^{a}	0.62^{a}	0.62^{a}	0.58^{a}	0.15
	Av. Final weight (g)	1.20^{a}	1.07^{ab}	1.07^{ab}	0.97^{c}	0.90^{cd}	0.20
	Av. weight gain (g)	0.48^{a}	0.47^{a}	0.46^{a}	0.35^{a}	0.32^{a}	0.18
	Av. feed intake (g)	5.00^{a}	4.91^{ab}	4.00^{bc}	5.00^{a}	5.25^{a}	0.80
	Feed Conversion Ratio	10.42^{c}	10.45^{c}	10.00^{d}	14.29^{b}	16.41^{a}	0.50
	Mortality (%)	5.56(1)	6.67(1)	0	25.00(3)	28.57(2)	-

The feed conversion ratio (FCR) obtained in this study varied significantly (P<0.05) within the test diets and among the three mating groups/crosses. The FCR values were quite higher than the 7.23 and 7.26 values reported by Odunaiya and Akinyemi (2008) for *A. marginata* and *A. achatina* respectively. The values were also higher than the 5.38, 5.39 and 6.30 reported in Omole (2010) for growing *A. marginata* snails fed paw-paw leaves, *Pueraria phaseoloides* and *Calopogonium mucunoides* respectively. The differences here might be attributed to the feed types (sole or mixed), age, breed and the ectotype of the snails used. Although the juvenile snails accepted the cocoyam diets, the best (least) FCR was recorded on T_3 (50% inclusion level) for the three mating groups while the poorest (highest) FCR was recorded for diet T_5 (100% inclusion level).

The results of the percent mortality obtained (Table 4) revealed that juvenile snails on diets T_1-T_3 i.e. inclusion levels of 0%-50% cocoyam meal recorded very low percent mortality rates (0%-8.33%). Juvenile snails on diets T_4 (75%) and T_5 (100%) recorded higher mortality rates, between 16% and 50% among the three mating groups. The lower percent mortality rate recorded for juvenile snails on diets T_1 to T_3 agreed with the lower results range of 6-8% reported in Ojating and Ogar (2002). The higher mortality rates recorded for juvenile snails on diets T_4 and T_5 could be as a result of the residual effects of anti-nutritional factors of cocoyam meal since it does not apply in the control and lower inclusion levels. Dietary inclusion levels of cocoyam from 0% to 50% did not have any adverse effect on the growth traits of juvenile snails of *A. achatina* studied.

Results of shell length increment of the juvenile snails fed test diets are presented on Table 5. The average initial shell lengths for the five diets were not significantly different (P>0.05) for the black-skinned purebred (BS X BS) and the crossbred (BS X WS) mating groups. Discuss with the other hand, there was significant difference (P<0.05) in initial average shell length for the five test diets of the white-skinned purebred (WS X WS) cross. The average final shell length obtained were significantly (P<0.05) influenced by the diets among the three mating groups. The highest average final shell length was recorded in diet T_3 (50% inclusion level) for the three mating groups. Interestingly, there was significant (P<0.05) increment in the shell length on the 75% and 100% inclusion levels among the mating groups from commencement to termination of study. Though juvenile snails on diets T_4 (75%) and T_5 (100%) had the highest feed intake (Table 4), but lower utilization of feeds, thus lower average final shell length. This might be due to the residual effects of the anti-nutritional factors in cocoyam meal. Again juvenile snails on diet T_3 (50%) recorded the highest percent shell length increment of 16.21%, 19.25% and 18.97% for the S X BS, WS X WS and BS X WS crosses respectively. These results agreed with that of Okon et al. (2011), confirming the acceptance and utilization of diets containing cocoyam by juvenile snails for shell growth.

Table 5. Shell Length Increment of Juvenile Snails (*Achatina achatina*) fed diets containing graded levels of sun-dried swamp taro cocoyam meal

Diets Mating groups/crosses	Growth Traits	T_1 0%	T_2 25%	T_3 50%	T_4 75%	T_5 100%	±SEM
BS X BS	Av. Initial Shell length (g)	11.97^{a}	12.39^{a}	12.35^{a}	12.33^{a}	11.74^{a}	0.83
	Av. Final Shell length (g)	14.00^{b}	14.67^{ab}	14.74^{a}	14.17^{ab}	13.30^{c}	0.70
	Shell length Increment (g)	2.03^{ab}	2.28^{a}	2.39^{a}	1.84^{ac}	1.56^{cd}	0.71
	Percent Shell length increment(g)	14.50	15.54	16.21	12.99	11.73	-
WS X WS	Av. Initial Shell length (g)	13.56^{a}	14.00^{a}	13.84^{a}	14.77^{a}	13.96^{a}	0.95
	Av. Final Shell length (g)	16.07^{b}	16.59^{ab}	17.32^{a}	17.14^{a}	15.79^{bc}	1.25
	Shell length Increment (g)	2.51^{b}	2.59^{ab}	3.30^{a}	2.56^{b}	2.08^{bc}	0.79
	Percent Shell length increment(g)	15.61	19.25	16.21	14.78	13.21	-
BS X WS	Av. Initial Shell length (g)	12.02^{a}	12.26^{a}	12.22^{a}	12.19^{a}	12.27^{a}	0.30
	Av. Final Shell length (g)	14.15^{b}	15.00^{a}	15.08^{bc}	14.02^{bc}	14.15^{b}	0.85
	Shell length Increment (g)	2.13^{ab}	2.51^{ab}	2.86^{b}	1.92^{b}	1.88^{bc}	0.76
	Percent Shell length increment(g)	15.05	18.27	13.69	13.29	11.73	-

^{abcde} Mean within a row with different letter superscripts are significantly different (P<0.05).

The results of shell width growth of juvenile snails fed cocoyam diets in Table 6 indicated that significantly different (P<0.05) influence on average final shell width of 12.08 mm and 12.98 mm were recorded for juveniles on diet T_3 (50% inclusion) for the purebred black-skinned and white-skinned purebred mating groups. These values were quite lower than the mean shell width of 14.10 mm reported in Amubode (1994). The reason here might be due to higher initial juveniles body weight (1.9 g), higher percent crude protein (% CP) and energy concentrate fed. The average final shell width results obtained here were higher than that reported in Omole (2010). Again, beyond the 50% inclusion level (diet 3), both the average final shell width and shell increment significantly (P<0.05) decreased with increases of cocoyam meal inclusion.

The results obtained for average final shell width and shell width increment of juveniles for the purebred (BS X BS and WS X WS) mating groups were significantly (P<0.05) influenced by the effects of the diets. The results for average final shell width obtained were lower than the 14.1 mm mean shell width reported in Amubode (1994). And the range of 11.09-11.15 cm recorded in Omole (2010). The difference here might be due to the size (74.73±3.59) and age of the parent snails used by the authors. The juveniles of purebred mating groups on diet T_3 (50% inclusion) recorded the highest shell width increment of 2.17 mm and 2.88 mm for BS X BS and WS X WS respectively. Again there was a significant (P<0.05) increase in shell width of juveniles up to 50% inclusion level (diet T_3) but a significant decrease (P>0.05) in shell width among juveniles on diet T_4 (75%) and diet T_5

(100%). This might be attributed to the residual effects of the anti-nutritional factors in the test diets on shell width after 50% inclusion level.

Table 6. Shell Width Increment of Juvenile Snails (*Achatina achatina*) fed diets containing graded levels of sun-dried swamp taro cocoyam meal

Diets Mating groups/crosses	Growth Traits	T_1 0%	T_2 25%	T_3 50%	T_4 75%	T_5 100%	±SEM
BS X BS	Av. Initial Shell Width (g)	9.50^{a}	9.72^{a}	9.91^{a}	9.92^{a}	9.96^{a}	0.50
	Av. Final Shell Width (g)	11.37^{b}	11.69^{ab}	12.08^{a}	11.88^{ab}	11.88^{ab}	0.60
	Shell Width Increment (g)	2.03^{bc}	2.28^{ab}	2.39^{a}	1.84^{c}	1.56^{cd}	0.30
	Percent Shell Width increment(g)	16.45	16.85	17.76	16.50	16.16	-
WS X WS	Av. Initial Shell Width (g)	9.86^{a}	9.90^{a}	10.10^{a}	10.32^{a}	10.38^{a}	0.55
	Av. Final Shell Width (g)	12.66^{a}	12.36^{ab}	12.98^{a}	11.79^{cd}	12.15^{ac}	0.85
	Shell Width Increment (g)	2.80^{a}	2.46^{ab}	2.88^{a}	1.47^{bd}	1.77^{c}	0.40
	Percent Shell Width increment(g)	22.12	19.90	22.19	12.92	14.57	-
BS X WS	Av. Initial Shell Width (g)	10.16^{a}	10.13^{a}	10.00^{a}	10.00^{a}	10.00^{a}	0.20
	Av. Final Shell Width (g)	12.12^{a}	12.12^{a}	11.60^{ab}	11.44^{b}	11.30^{bc}	0.65
	Shell Width Increment (g)	1.96^{bc}	1.99^{b}	2.60^{a}	1.44^{d}	1.30^{de}	0.50
	Percent Shell Width increment(g)	16.17	16.43	12.59	13.29	11.50	-

^{abcde} Mean within a row with different letter superscripts are significantly different (P<0.05).

4. Conclusion

The study revealed that *Achatina achatina* parents and juveniles fed up to 50% sun-dried taro cocoyam meal diets performed very well in confinement without any adverse effects on reproductive traits.

References

Abdulrashid, M., Agwunobi, L. N., Jokthan G. E., & Abdul, S. B. (2007). Carcass quality characteristics of broiler finishers fed, taro (*Colocasia esculenta*) cocoyam meal. *Proceedings of conference of Nigerian society for Animal production* (NSAP) (pp. 457-560), Calabar 18th-21st March.

Agwunobi, L. N., Angwukan, P. O., Cora, O. O., & Isika, M. A. (2002). Studies on the use of *Colocasia esculenta* (*Taro cocoyam*) in the diets of weaned pigs*, Tropical Animal Health and Production, 34*, 241-243. http://dx.doi.org/10.1023/A:1015234709538

Akinnusi, O. (2004). *Introduction to snails and snails farming* (2nd ed.). Abeokuta, Nigeria. Triolas Exquisite Ventures.

Akintomide, T. O. (1997). *The African giant snails*: *Its rearing and production*. Ijebu-Ode: Alasset Press Ltd.

Amubode, F. A. (1994). Growth and Reproductive performance of two species of African Giant snail *(Achatina achatina* and *Archachatina marginata). Journal of Tropical Forestry Resources, 9 and 10*, 68-74.

AOAC. (1995). *Official methods of analysis* (16th ed.). (Association of Official Analytical Chemists, Washington, D.C.).

Cobbinah, J. R. (1993). *Snail farming in West Africa. A Practical Guide*. U. K. Sayee Publishing, CTA Publication.

Duncan, O. B. (1955). Multiple range and multiple t-tests. *Biometrics, 11*, 1-42. http://dx.doi.org/10.2307/3001478

Ejidike, B. N., Afolayan, T. A., & Agbelusi, E. A. (2000). Growth response of African giant land snail (*A. marginata*) on supplemented diet of 25% crude protein level (pp. 327-329). *Proc. 25th Annual NSAP Conference*, Umudike.

GENSTAT. (2007). *GENSTAT release 7.2DE* (*PC/Window XP*). Lawes Agricultural trust (Rothamsted experimental station).

Hamilton-Amochree, A., Mepha, H. D., & Ogunk Nnoka, C. U. (2009). Mineral content of tissues and body fluids and heavy metal contaminants of four predominant snail species in the Niger Delta. *Journal of Food, Agriculture and Environment, 7*(2), 163-168.

Hamzat, R. A., Omole, A. J., Babatunde, B. B., Adejumo, M. O., & Longe, O. G. (2007). Comparative value of kola testa, corn-bran and rice-bran with maize for mature African Giant Land snail (*Archachatina marginata*). *Nigerian Journal of Animal Production, 34*(2), 265-276.

Hodasi, J. K. M. (1979). Some observations on the edible giant land snails of West Africa. *World Animal Review, 52*, 24-28.

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.

Kehinde, A. S., Omole, A. J., Odidi, S. E., Muraina, G. T., Ayoola, O. A., Adeyinka, A., … Oriowo, B. F. (2004). Effect of different protein levels on the performance of growing snails. *Journal of Agriculture, Forestry and the Social Sciences (JOAFSS), 2*(2), 78-83.

McDonald, P., Edwards, R. A., & Greenhalgh, J. F. D. (1995). *Animal Nutrition* (5th ed.). Singapore: Longman Publishers Press.

Odunaiya, O. & Akinyemi, A. A. (2008). Performance of two snail species-*Archachatina marginata* (*S*) and *Achatina achatina* (*I*) reared under the same management practices. *Nigerian Journal of Animal Production, 35(*2), 224-229.

Ogogo, A. U. (2002). Optimal Stocking Density and Utilization of Two Selected Snails (*Archachatina marginata saturalis*) and (*Archachatina marginata ovum*). *Ph. D. Thesis*, University of Ibadan, Ibadan, Nigeria.

Ojanuga, A. G. (2006). *Agroecological zones of Nigeria Manual* (pp. 73-76). FAO/Federal Ministry of Agriculture and Rural Development, Abuja.

Ojating, I., & Ogar, G. E. (2002). Effect of Feed Types on the Growth Performance of African Giant Snails Fattened at Room Temperature. *Journal Sustainable Agriculture and Environment, 4*(2), 303-308.

Okon, B., & Ibom, L. A. (2010). Commercialization of snail production in Nigeria: Potentials, Viabilities and Challenges. *Journal of Applied Sciences (JAS), 12*(2), 9139-9158.

Okon, B., Ibom, L. A., & Odido, E. E. (2009a). Reproductive Performance and Egg Quality traits of crossbreeding between black and white skinned *Archachatina marginata saturalis*. *Archivos de Zootecnia* (In Press).

Okon, B., Ibom, L. A., Ekpo, I. A., & Ewa, E. C. (2009b). Evaluation of Reproductive and some Egg Quality Parameters of Albino snails [*Archachatina marginata saturalis* (*swainson*)]. *Journal of Applied Science (JAS), 12*(1), 8234-8240.

Okon, B., Ibom, L. A., Williams, M. E., & Akpakpan. (2009c). Comparative Evaluation of Reproductive Performance and some Egg Quality Parameters of Black and White skinned snails. *Global Journal of Agricultural Sciences, 8*(1), 77-80.

Okon, B., Ibom, L. A., Williams, M. E., & Akwa, N. T. (2010b). Parity Effects on Breeding and Morphometric Traits of Eggs and Hatchlings of Purebred Albino Snails [*Archachatina marginata* (*Swainson*)]. *Journal of Agriculture, Biotechnology and Ecology, 3*(1), 44-54.

Okon, B., Ibom, L. A., Williams, M. E., & Etukudo, O. M. (2010a). Effects of Parity on Breeding and Morphometric Traits of Eggs and Hatchlings of F_1 crossbreed of snails (*Archachatina marginata var. saturalis*). *Journal of Agriculture, Biotechnology and Ecology, 3*(1), 36-43.

Okon, B., Ibom, L. A., Williams, M. E., Eyoh, G. D., & Afangideh, U. P. (2011). Reproductive and Egg Quality

Traits of African Giant Snails *(Archachatina marginata var. saturalis)* Under Mixed Feeding with Graded Levels of Swamp Taro Cocoyam *(Cytosperma Chamissonis)* and Forages. *Journal of Agriculture, Biotechnology and Ecology, 4*(1), 29-40.

Okonwo, A. C., Isaac, L. J., Nkanga, I., & Usoro, O. O. (2000). Effect of various feeding regime on performance of snails (*A. marginata*). *Proceedings of the 25th Annual Conference of Nigerian Society for Animal Production* (NSAP) (pp. 314-315). March 19-23, 2000. Umudike, Nigeria.

Omole, A. J. (2002). Snail Production Management. A Paper Presented at Lagos State Agricultural Development Project, S. M. S Monthly Review Meeting at Agege, Lagos State on 13-14, April, 2002.

Omole, A. J., & Kehinde, A. S. (2005). Backyard snail farming at a glance. *Back to Agricultural series* (1). Ibadan: Technovisor Agricultural Publications.

Omole, A. J., Tewe, O. O., Ogundola, F. I., Oluokun, J. A., Adebowale, E. A., Adetoro, F. O., Olupona, J. A., & Fapohunda, J. B. (2000). Performance and carcass analysis of four popular breeds of snail commonly reared in South West Nigeria. *Proceedings of the 25th Annual Conference of Nigerian Society for Animal Production* (NSAP) (pp. 316-318). March 19-23, 2000. Umudike, Nigeria.

Tang, C. S., & Sokai, W. W. (1983). Acidity of Taro Review Plants in Araceae. In J. K. wang, (ed.), *Taro Review of Colocasia esculenta and its potential* (pp. 48-164). Honolulu University of Hawali Press.