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Performance of Growing African Giant Snails (*Archachatina marginata)* Fed Forage Mixtures and Maize-based Concentrate Supplemented with Monkey Cola *(Cola rostrata)* Seed Meal

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Authors' contributions

This work was carried out in collaboration between all authors. Authors GIC and ECO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author UEU managed the analyses of the study. Author MJU managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: An experiment was conducted to assess the performance of growing snails fed maize-based concentrate and maize supplemented with C*ola rostrata* seed meal in addition to forage mixtures.
Methodology: A total of eighty eight (88) growing snails with weight ranging from 94.45g - 94.73g were randomly allotted to four treatment groups (T_1, T_2, T_3 and T_4), replicated two times with eleven (11) snails per replicate in a completely randomized design (CRD).The snails on T_1 were fed maize-based concentrate only, T_2 were fed with maize concentrate supplemented with 40% *cola rostrata* seed meal, T_3 were fed with forage mixture and maize-based concentrate while, T_4 consisted of snails fed forage mixtures and maize concentrate supplemented with 40% C*ola rostrata* seed meal. The feeding trial lasted for fifty six (56) days.
Results: The results showed that the mean final body weight and total weight gain were higher for

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T_4. More so, feed conversion ratio (FCR) of T_4 was equally as good as that of the control (T_1).
Conclusion: Diets comprising, maize-based concentrate with 40% C*ola rostrata* seed meal supplementation and leguminous forage mixtures gave better growth performance when compared with other treatment diets and therefore for optimum growth performance of A*rchachatina marginata it was* recommended.

Keywords: Archachatina marginata; Cola rostrata seed meal; forages; maize and performance.

1. INTRODUCTION

Snails are small to medium sized mollusks that have shells that are segmented which give them an appropriate design and beauty [1]. Okon and Ibom [2] classified snails into the group of micro-livestock resulting from their small body sizes. Omole, Sansi and Osayomi [3] reported that the total body of the snail constitutes the shell of about 22-24% body size, foot or edible portion of about 30-40%, viscera and liquid parts makes up to 20-23%. The snail meat is a good source of protein containing about 18% crude protein as well as essential amino acids like- Tryptophan, lysine, etc. [3].

In the tropics, snails are not only considered as a delicacy, but are used in the treatment of certain ailments like- iron-deficiency anaemia, diabetes, cardiovascular problems, kidney disease, conjunctivitis, asthma, hypertension, and other fat related body challenges, because it is rich in iron, calcium, and low in cholesterol content [1,4 and 5]. The shell which is made up of calcium, can be processed and used in livestock feed manufacturing [3].

Nigeria is greatly blessed with various snail species and among those that are pre-dominantly found in the Southern parts (especially Akwa Ibom State) is *Archachatina marginata* which is bigger in size than others.

Snails are slow growing animals, but their performance can be augmented through proper nutrition and management practices. Snail feeding is less expensive as compared to other livestock [6] because they mainly feed on leguminous forages and tree leaves, thereby making their feeding materials easily sourced for by the farmer.

Most snails are herbivores, feeding on green plants including fruits and vegetables [7,8]. These fruits and vegetables are seasonal, perishable, and cannot supply all nutrients needed for optimum performance of snails and therefore for sustainable production and enhanced growth, there is need to supplement snail feed with concentrates [9-8].

Intensive approach to animal production especially snails would however, entails the use of feed resources other than the already known conventional ones like- maize. The use of non conventional feed resources would enhance productivity of meat at affordable cost by farmers [10]. Such alternative non-conventional feed sources such as Monkey cola (*Cola rostrata*) are available in Nigeria, especially in the Southern part (Akwa Ibom and Cross River States).

Keay, Onochie, & Starfield [11] described Monkey cola (*Cola rostrata*) seed, as gotten from an evergreen plant that belongs to the Family: *Sterculliaceae*, Genus: *Cola*, and Specie: *rostrata* and could be a good alternative to maize as an energy source. According to Dosumu and Eka [12], Cola family is further classified into different species relative to the size and colour of the fruits.

There are two varieties of *Cola rostrata* (yellow and white/colourless mesocarp types). The mesocarp of *Cola rostrata* is widely eaten in Southern Nigeria as fruits, while the seed are often thrown away [10]. Dosumu and Eka [12] reported that the starch component of the seed is about 83.42% (which is relatively higher than maize), is a good energy source in animal feed. Christopher and Okon [10] and [13] reported that *Cola rostrata* seed is a potential non-conventional alternative energy feedstuff for animals, when processed (particularly when boiled for 30 minutes) and fed at 40 percent replacement level for maize.

There is paucity of information on the use of *Cola rostrata* seed meal in livestock feed generally and specifically in snails, and it is for this reason that this study was done to evaluate the performance of growing African giant snails (*Archachatina marginata)* fed concentrates with *Cola rostrata* seed meal supplementation and mixed forages.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Department of Animal Science Teaching and Research Farm, Akwa Ibom State University, Obio-Akpa Campus, Oruk Anam Local Government Area of Akwa Ibom State, Nigeria. Obio Akpa is located within the southern zone of Nigeria at a Latitude of 4^{O}50N of the Equator and Longitude of 7^{O}45E and 7^{O} 55E of the Greenwich Meridian. The area is in the hot humid tropics with a climate that is characterized by two seasons (rainy and dry seasons). The rainy season spans between April and October while the dry season spans between November and March, Temperature are uniformly high throughout the year ranging between 26^{O}c and 28^{O}c. Solar radiation ranges from 4.11 to 4.95 mm, partly because of the high values of insulation and temperature [14].

2.2 Sources of Feed Ingredients

2.2.1 *Cola rostrata* seed and preparation of *Cola rostrata* Seed Meal (CRSM)

The seeds were washed in clean tap water in order to remove adhering dirt and were then boiled for 30 minutes in a pot of water that had been pre-heated to boiling point. The boiled seeds were spread on corrugated roofing sheets to cool-off, before cutting them into sizeable chips for easy drying in the sun. After drying, the seeds and other ingredients were milled using a Hammer mill (0.5 mm screen) and stored for diet formulation.

2.2.2 Forages and their preparation

The forages which were selected for this study were harvested from the vicinity of the campus included; *Carica papaya* (pawpaw) leaves, *Calopogonium mucunoides* (calopo) leaves and *Centrosema pubescens* (centrosema) leaves. The pawpaw leaves were harvested before they became dry, while *Calopo* and *centrosema* were harvested before flowering. The forages which were harvested daily in the morning hours were washed with clean water to remove dirt, drained, weighed (with Salter Electronic Scale) and chopped into smaller sizes before being fed to the animals.

2.3 Preparation of Diets

Two (2) concentrate diets were formulated for the snails (Table 1). One of the diets was maize blended with other ingredients to supply 24% crude protein required for growing snails. The second diet was formulated such that *Cola rostrata* replaced 40% maize in the first diet. The blended ingredients used for the formulation of the two diets were weighed with Salter Electronic Scale and mixed with a 500kg/cycle mixer connected to the Hammer mill.

2.4 Experimental Snail and Design

Four treatments (T_1, T_2, T_3, and T_4) were used in the experiment as follows;

> T_1 was maize-based concentrate only, T_2 was maize-based concentrate where maize was supplemented with 40% *Cola rostrata* seed meal, T_3 was forage and maize-based concentrate while, T_4 was forage and maize-based concentrate supplemented with 40% *Cola rostrata* seed meal.

Eighty eight (88) grower snails (*Archachatina marginata*) which were purchased from University of Ibadan, Oyo State, Nigeria were randomly assigned to the four (4) treatment groups comprising 22 snails each. Each treatment was replicated twice and each replicate having 11 snails. The snails were managed in a Completely Randomized Design (CRD).

2.5 Management of the Snails

The snails were raised and managed intensively in a wooden hutch which was covered and partitioned with wire mesh reinforced with mosquito nets. Loamy soil was used to cover the bottom of the cage to a depth of about 15cm. The soil was sprinkled with water daily to keep the internal environment moist. The hutch was placed in an arboretum (an area with trees forming a micro-climate effect) and shaded using palm fronds to prevent direct sunlight from entering into the wooden hutch with a temperature range of 26.50°C -29.03°C

On arrival, the animals were fed both forage and concentrates, and given water. They were left to stabilize for one (1) week, in order to recover from transportation stress, after which they were randomly assigned into the four (4) treatment groups.

At the start of the experiment, 20grams of feed was given to each replicate and was gradually increased as the need arose. Feeding was done twice daily (in the morning and evening). The

feed was presented to the animal using flat plastic trays and water was also provided using flat plastic plates to enable the snails crawl in easily to feed; drink and cool-off without any risk of getting drown. Watering was carried out at least twice daily to keep the snails moist and to prevent dehydration and hibernation.

The concentrates were moistened and weighed with a Salter Electronic Scale before being given to the snails to ease digestion, while forage was also weighed (on wet basis) with the same scale and fed fresh daily. Same amount of feed (concentrate and forage) fed, were daily kept separately to allow for the ease of accounting for moisture loss in the feed. The portions of feed kept aside were reweighed each morning and the differences in weights were recorded as moisture loss. The moisture loss was then subtracted from the left-over feed to have the actual amount of feed consumed by the snails (i.e. feed consumed = feed given less left-over minus moisture loss). Left-over feed was weighed after removing their feaces. The feaces were removed daily from the pens to prevent build up of pathogens which could have resulted to disease outbreak.

2.6 Data Collection

The following parameters were measured during the course of this study. Initial body weight (IBW) and Final Body Weights (FBW) were measured using an electronic sensitive scale (Salter Electronic Scale) at the start and end of the experiment. Total weight gain (TWG) was calculated by working the difference between the final and initial weights in the experiment, while daily weight gain was deduced by dividing total weight gain over the number of days the experiment lasted. Feed intake (FI) was determined by measuring the initial weight of the feed for each replicate before serving the snails and weighing the feed left over every morning to determine feed intake by the difference. A summation of all the daily feed intakes per treatment, gave total feed intake per treatment. Total feed intake per snail was determined by dividing total feed intake by the number of snails per treatment. The daily feed intake per snail per treatment was deduced by dividing the daily feed intake per snail by the number of days the experiment lasted. Feed conversion ratio (FCR) was calculated using the formula:

$$FCR=\frac{Daily\ Weight\ gain}{Daily\ Feed\ intake}$$

2.7 Proximate and Statistical Analyses

At the end of the experiment, the two diets as well as the mixtures of forages were subjected to proximate analysis (to determine their nutrients' composition using the method proposed by Analytical Chemist [15] in the laboratory of the Department of Animal Science in Obio Akpa campus of the Akwa Ibom State University. The data collected were subjected to Analysis of Variance (ANOVA), using Completely Randomized Design and significant means were separated using Duncan's New Multiple Range Test (1955). The statistical analysis was done with the use of SAS [16] statistical software.

Table 1. Composition of experimental concentrate diets fed to the growing snails

Feed Ingredients (%)	Diet 1 (T_1)	Diet 2 (T_2)
Maize	43.29	25.97
Soybean meal	27.91	27.91
Cola rostrata seed meal	0.00	17.32
Wheat offal	9.00	9.00
Bone meal	2.00	2.00
Oyster shell	8.00	8.00
Fish meal	9.30	9.30
Premix	0.50	0.50
Salt	0.00	0.00
Total	100	1 00
Calculated Analysis:		
Crude Protein (%)	23.97	23.82
Metabolizable Energy (Kcal/Kg)	2597.00	2615.19

3. RESULTS AND DISCUSSION

3.1 Proximate Analysis of Concentrate Diets and the Forage Mixtures

The proximate composition of the experimental concentrate feeds and mixed forages is presented in Table 2. The result indicates that the 40% supplementation of *Cola rostrata seed meal* in T_2 (diet 2) resulted in a decrease in crude protein and a relative increase in ether extract and energy. The finding agrees with the report of [10], that *Cola rostrata* is a poor protein supplier when compared with maize. However, the value of NFE confirms the report of [12,10,13], that *Cola rostrata* seed meal has higher energy content than maize. On the other hand, the forages mixture supplied more crude protein in T_3 and T_4 than in the two formulated concentrate diets (T_1 and T_2). The result supports the findings of (17) that legumes have higher protein content than grasses.

3.2 Growth Performance of Growing Snail Fed Experimental Diets

Table 3 shows the results of the performance of snails under the four treatments. The mean final body weights of the snails among the treatments at the end of the experiment (eighth-week) were significantly ($P<0.05$) different The snails fed maize supplemented with 40% *Cola rostrata* seed meal and forages (T_4) had the highest (118.36g) body weight amongst the four treatments. Asuquo [17] observed that leguminous forages supplied more protein to animals, while [12] and [10] had reported that *Cola rostrata* had a higher energy value than maize and therefore would have supported the higher weights of the snails.

There was no significant difference ($P>0.05$) in feed intake among the treatment groups. In terms of mean daily weight gain, T_1 and T_4 had significantly ($P<0.05$) higher values (0.39g and 0.42g) compared to other treatments. The significant higher weight gains in T_4 is attributed to the higher energy and protein content of *Cola rostrata* and mixed forages respectively. This result corroborates the findings of [18] and [19] who stated that good growth and physiological performance in snails and other livestock is dependent on good quality and well balanced ration.

Table 2. Proximate composition of feed (g/100g)

Nutrients	T_1 (Diet 1)	T_2 (Diet 2)	T_3	T_4
Crude Protein (CP)	23.62	21.00	53.37	46.38
Ether Extract	3.00	4.50	8.25	9.75
Crude Fibre	7.50	7.50	15.50	15.50
Ash	6.00	6.50	16.50	17.00
Moisture	10.57	9.66	21.52	20.61
Metabolizabe Energy ME (Kcal/Kg)	3203.97	3250.25	5,797.47	5,843.75

Note:* T_1 *(Diet 1) = Maize-based concentrate only.* T_2 *(Diet 2) = Maize-based concentrate supplemented with 40% Cola rostrata seed meal only.* T_3 *= Maize-based concentrate in addition to mixed forages.* T_4 *=Maize-based concentrate supplemented with 40% Cola rostrata seed meal in addition to mixed forages.

Table 3. Performance of growing snails fed experimental diets

Parameters	Treatments				
	T_1	T_2	T_3	T_4	SEM
Mean Initial Body Weight g)	94.50^{a}	94.45^{a}	94.73^{a}	94.59^{a}	4.61
Mean Final Body Weight (g)	116.46^{ab}	109.09^{c}	112.05^{b}	118.36^{a}	8.02
Mean Daily Feed Intake (g)	1.30^{a}	1.29^{a}	1.85^{a}	1.79^{a}	0.44
Mean Daily Weight Gain (g)	0.39^{a}	0.26^{c}	0.31^{b}	0.42^{a}	1.48
Feed Conversion Ratio (FCR)	3.32^{a}	4.94^{c}	5.99^{d}	4.21^{b}	5.60
Mortality (%)	1	0	0	0	
Survivability (%)	99	100	100	100	

Note: ^{abcd} = means along same row with different superscripts are significantly different ($P<0.05$).

The result further indicates that there was a significant difference in the FCR among the treatments. T_1 and T_4 had the best FCR of 3.32 and 4.21 respectively. The mortality was quite minimal and was not attributed to treatment effect but due to stress during weighing. About 99% survivability was obtained from the experiment and indicates that the treatments were not deleterious to the animals.

4. CONCLUSION

The snails fed with maize-based concentrate supplemented with 40% *Cola rostrata* seed meal and forages (T_4) performed better when compared with the control with respect to all the parameters (except FCR) considered in this experiment. Therefore for optimum performance of *Archachatina marginata* it is recommended that the animals be fed with a combination of maize-based concentrate supplemented with 40% *Cola rostrata* seed meal and leguminous forage mixtures.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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