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Effect of Calcium Source in Supplemental Diets on the Growth Performance and Carcass Characteristics of the Giant African Land Snails (*Archachatina marginata*) in the Western Highlands of Cameroon

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Abstract

To contribute to the diversification of protein sources, the conservation and preservation of the Giant African Land Snails (*Archachatina marginata*), a study was carried out between March and July 2019 at the Helvy Farms-WVED Cameroon located at Station Bamenda to investigate the effect of three calcium sources on their growth performance and carcass characteristics. 180 juvenile snails aged 4 months initially weighing between 24.2 and 28.5 g, shell length ranging between 40.25 - 48.35 mm, and shell diameter of between 14.08 - 18.44 mm were randomly allotted to 3 treatments containing each a different calcium source (crushed snail shell, eggshell and agricultural limestone) and a control treatment constituted of natural plant feeding materials of the snail. There were 45 snails per treatment, constituted of three replicates with 15 snails per replicate. Each replicate was housed in well-constructed surface trench pens equipped with drinking and feeding troughs. The basal diet made up of feedstuffs like pawpaw leaves and watermelons was provided *ad libitum*. The initial weights of the snails were recorded at the start of the experiment followed by weekly weight measurements, while the snail length and width were measured with a digital caliper of 0.05 mm accuracy. The snails were monitored for a period of 21 weeks and data was collected for 20 weeks after a 1 week adaptation period. The results showed that the weight gain (g) of snails for diets containing calcium sources in the supplemental diets were all significantly higher ($P < 0.05$) than the corresponding values recorded for the control diet with natural plant material. It was observed that the shell length (0.34 ± 0.02), shell width (0.16 ± 0.02), weight gain (13.13 ± 0.03) and feed conversion efficiency (1.977 ± 0.11) were highest in snails fed snail shell diet as calcium source compared with snails from other treatments. These values were however not significantly higher than corresponding values for the other two supplemental diets containing eggshell or agricultural limestone. It can be deduced that the snail shell is an important calcium source for growing snails and can be adopted and used in the diets of snails. This will amount to some good methods of recycling in snail production.

Keywords

Archachatina marginata, Shell Length, Shell Width, Growth Performance, Carcass Characteristics

1. Introduction

In Cameroon around the 1920s, snails were regarded as pests in most administrative divisions and were often considered unhealthy or as a taboo to eat [1]. The establishment of trade in most parts of English-speaking Cameroon by the Ibos from Nigeria initially paved the way for snail consumption. Just before the country's independence, snail consumption had become common though inconsistent in several forest-prone regions of the country, notably parts of the Centre/South, Littoral, and Southwest Regions. For instance, in the South West Region, snail consumption was common in the administrative divisions of Manyu, Ndian, and Meme, and to a lesser extent in the Fako division [1]. The regional differences in snail consumption were associated with specific cultural beliefs. Nowadays, snail meat has become an important food resource for almost all occasions, even beyond the traditional consumption areas of the country.

The meat often called "Congo meat" or "Nyama" is readily available alongside beef, pork, and chicken meat. Most travelers acquire it during their journey or in beer parlours and pubs. However, due to the low level of production, consumers have been unable to obtain the desired quantities [2] [3].

Generally, in Africa and Cameroon in particular, snail farming is practiced on a relatively low scale. Most snails are harvested from nature, especially during the rainy season, which is barely enough for local consumption [1] [3]. The advantages are that they are affordable and available all year round though with seasonal price fluctuations [4]. However, some studies show that the production of snails has not kept pace with demand [5]. The dearth of snail meat has also been aggravated by negative environmental and technical factors such as climate variability and change; complex human activities such as deforestation, pesticide usage, slash-and-burn agricultural practices, spontaneous bush fires, and the collection of immature snails. Since extremely high outdoor temperatures are not favourable to snail growth and development, wild snail populations have been declining considerably [6].

Despite the considerable potential for foreign and local demands, commercial snail farms similar to those found in Europe, South-East Asia and the Americas hardly exist in Africa in general [7] and Cameroon in particular [3]. Snail production in the wild has been on the decline due to the depletion of the rainforest, overharvesting of snails, bush burning, and the increased use of agricultural pesticides [8]. It is therefore important to encourage snail farming (heliculture) to optimize the contribution of this important food resource to humans [6].

Advantages associated with snail farming over most other livestock include a low capital requirement for its establishment and operation, less demand for professional knowledge, very high fecundity and low mortality, less labour requirement, the animal's noiselessness, and availability of ready domestic and international markets, amongst others [9] [10]. However, profitable snail farming is highly dependent on its growth and reproductive performance when in captivity.

Nutrition accounts for a greater percentage in the survival and multiplication of animals under captive rearing. Since *Archachatina marginata* is a seasonal animal in the wild coupled with the fact that its natural food mostly plant materials are also seasonal, recent research interest within the country aimed at exploring different locally available feedstuffs in formulating and preparing the diet has been stimulated for these animals (e.g. [2] [3]). *Archachatina marginata* accepts and utilizes various plant food materials as well as formulated diets [11]. However, the rearing of this animal in the tropics is facing a lot of challenges due partly to the scarcity of its natural plant food during the dry season whereas its demand in both local and international markets is increasing rapidly [9] [10]. Supplemental diets that can improve the growth of *Archachatina marginata* are believed to have the potential in increasing the yield of the animal under large-scale farming when incorporated. Owning to the importance nutrition plays in the growth of these animals, there is an absolute need to source more information concerning the nutrition of these species. Whilst some work has been recently done on the protein nutrition of *Archachatina marginata* (e.g. [2]) [3], there is very little information on the mineral nutrition of this species in the western highlands of Cameroon. This is especially so for nutrition using locally available calcium sources that is a major component of the snail shell. This study was initiated to investigate the effect of feeding different calcium sources in the supplemental diets on the growth performance and carcass characteristics of the Giant African land snails in the Western Highlands of Cameroon

2. Materials and Methods

2.1. Study Site

The study was carried out at the Helvy Farms-WVED Cameroon located at Station Bamenda North West Region with a tropical transitional climate and a rainy season running from mid-March to mid-October and a dry season running from mid-October to mid-March. Latitude 5˚45"N and 9˚9"N and longitude 9˚13"E and 11˚13"E

2.2. Animal Management and Experimental Diets

180 juvenile Giant African land snails (*Archachatina marginata*) were used in the study. Snails were obtained from the farm for this experimental trial that lasted for a period of 21weeks and data was collected for a period of 20 weeks after an adaptation period of 1 week. Three supplemental diets were formulated and denoted as T1, T2 and T3 corresponding to the three sources of calcium in the diet and a control diet (T4) with only the basal diet composed of natural plant material. The supplemental diets were Iso-calorific and Iso-nitrogenous but varied in the source of Calcium (Table 1). Snails were housed in well-constructed surface trench pens equipped with drinking and feeding troughs. The basal diet made up of feedstuff like pawpaw leaves and watermelon provided ad libitum. Feeding and watering of the snails were done between 4 - 6 pm daily. The initial weights of the snails were recorded at the start of the experiment followed by weekly weight measurements using a KA8-AM digital LCD electronic balance sensitivity of 0.01 g, while the snail length and width were measured with a Focket-Carbon Steel Vernier Caliper of 0.02 mm accuracy.

For the chemical analysis, five (05) snails from each treatment were starved for 24 hours after which they were washed and later sacrificed. The edible portions of the snails were dried at 60˚C for 48 hrs in an oven. The dried samples were powdered in a Moulinex blender and sieved through a 450 μm sieve. The final powdered sample was stored in a desiccator and used for proximate analysis

Table 1. The Supplemental diets with different calcium sources fed to Giant African land snails (*Archachatina marginata*).

Ingredients	Proportion of ingredients (%)			
	T1 (Snail shell)	**T2 (Eggshell)**	**T3 (Agricultural limestone)**	**T4 (Control)**
Corn flour	58.5	58.5	58.5	
Soybean cake	14.5	14.5	14.5	
Palm kernel cake	2.9	2.9	2.9	
Fish meal	4.0	4.0	4.0	
Agricultural Limestone	-	-	20.0	*Natural Plant materials
Eggshell	-	20.0	-	
Snail shell	20.0	-	-	
Iodized salt	0.1	0.1	0.1	
Total	**100**	**100**	**100**	

*T4 which was the control treatment was made up of natural plant materials of pawpaw leaves and watermelons which was the natural diet fed to snails under captivity and in nature (basal diet).

of crude protein, crude fibre, ash, moisture, and fat content as described by AOAC (1990) (Table 4).

2.3. Trial Management

Snails were randomly allotted to treatments following a completely randomized design (CRD) with four (04) treatments containing 45snails each and three (03) replicates of 15 snails per treatment, to give an experimental model (1) as follows:

$$T_{ij} = \mu + t_i + e_{ij} \quad (1)$$

where,

T_{ij} = the effect of the j^{th} observation on the i^{th} treatment;

μ = general population mean;

t_i = the effect of the i^{th} treatment on the snails;

e_{ij} = random error associated with the j^{th} observation in the treatment.

2.4. Data Collection and Statistical Analysis

Data were collected weekly to compute the different growth parameters of feed intake, weight gain, shell characteristics (shell length and width), and feed conversion ratio, meanwhile, data for carcass weight and carcass composition were collected at the end of the experimental trial after the snails were sacrificed and different parts (snail shell weight, edible portion, and visceral organs) weighed, samples of the edible portions were collected for analysis of the chemical composition of the snail meat.

The data collected were analysed using the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corp, 2011). The Analysis of variance (ANOVA) with SPSS 20.0 was used to test the significant differences in the measured variables of the snails. Duncan's New Multiple Range Test was used to separate significant means at a 5% level of significance [12]. Chemical analysis to determine the proximate composition (moisture, crude protein, crude fibre, fat, and ash content) of the carcass was carried out according to the methods described by the Association of Official Analytical Chemists (AOAC) [13].

3. Results

Effect of feeding different calcium sources on weight gain, feed intake (FI), and feed conversion ratio (FCR) of the Giant African Land Snails (*A. marginata*)

Data for the weight gain of the supplemental diets containing the three different calcium sources were comparable (P > 0.05). However, there was a significant difference (P < 0.05) between the supplemental calcium source included diets and the control diets. This mean weight gain of the snails varied among the different diets with the highest recorded in the snail shell diet (13.13 ± 0.03), followed by the agricultural limestone diet registering 12.56 ± 0.02, and the eggshell diet recorded 12.41 ± 0.12 with the least coming from the control diet with

8.11 ± 0.01 (Table 2). There was no significant difference (P > 0.05) between the snails in all four treatments in Feed intake and Feed conversion ratio.

Effect of feeding different Calcium sources on shell and carcass characteristics of the Giant African Land Snails (*A. marginata*)

Data on the effect of calcium source on the shell and carcass characteristics is shown in Table 3. There was no significant difference (P > 0.05) in shell length among the snails fed the different supplemental diets. Concerning the different calcium sources, the diet containing snail shells produced snails with the longest mean shell length (0.34 ± 0.02) while the control diet produced snails with the lowest mean shell length (0.24 ± 0.01).

Secondly, there was no significant difference (P > 0.05) in the mean shell width of snails across the different treatments. The highest mean shell width was recorded in the snails fed the diet containing snail shells (0.16 ± 0.02) and the lowest recorded in snails fed the control diet (0.12 ± 0.01).

Lastly, there were no significant differences (P > 0.05) in the parameters of shell weight, and visceral organs weight meanwhile, there was a significant difference (P < 0.05) in edible portion weight between the snails fed the supplemental diets and those fed the control diet. The highest shell weight (69.2 ± 0.02), highest visceral organs (49.2 ± 0.02), and highest edible carcass weight (141.82 ± 0.02) were recorded in snails fed supplemental diets containing calcium from snail

Table 2. Mean weekly weight gain, feed intake (FI), and feed conversion ratio (FCR) of the Giant African Land Snails (*A. marginata*).

Parameters	T1 Snail shell	T2 Eggshell	T3 Agricultural Limestone	T4 Control (C)
Weekly Weight gain (g)	13.13 ± 0.03[a]	12.41 ± 0.12[a]	12.56 ± 0.02[a]	8.11 ± 0.01[b]
Feed Intake (FI) (g)	86.7 ± 0.02[a]	78.6 ± 0.02[a]	80.3 ± 0.02[a]	81.4 ± 0.02[a]
Feed Conversion Ratio (FCR)	1.977 ± 0.11[a]	1.997 ± 0.22[a]	1.987 ± 0.11[a]	1.025 ± 0.11[b]

Means with the same letters in a row are not significantly different (P > 0.05).

Table 3. Mean shell and Carcass characteristics of the Giant African Land Snails (A. marginata).

Parameters	T1 Snail shell	T2 Eggshell	T3 Agricultural Limestone	T4 Control
Shell length	0.34[a] ± 0.02	0.30[a] ± 0.02	0.31[a] ± 0.02	0.24[a] ± 0.01
Shell width	0.16[a] ± 0.02	0.15[a] ± 0.02	0.14[a] ± 0.02	0.12[a] ± 0.01
Shell weight	69.2 ± 0.02[a]	58.81 ± 0.02[a]	54.73 ± 0.02[a]	45.6 ± 0.02[a]
Visceral organs weight	49.2 ± 0.02[a]	38.9 ± 0.01[a]	43.10 ± 0.02[a]	35.2 ± 0.01[a]
Edible portion weight	141.82 ± 0.02[a]	133.41 ± 0.02[a]	139.6 ± 0.02[a]	75.7 ± 0.01[b]

Means with the same letters in a row are not significantly different (P > 0.05).

Table 4. Mean proximate chemical composition of the Giant African land Snail meat (*A. marginata*).

Treatments	% Moisture	% Crude Protein (CP)	% Crude Fibre (CF)	% Fat (F)	% Ash (A)
T1 Snail shell (SS)	72.61 ± 0.01[a]	20.02 ± 0.02[a]	0.95 ± 0.02[a]	1.64 ± 0.10[a]	1.57 ± 0.01[a]
T2 Eggshell (ES)	78.93 ± 0.02[a]	17.65 ± 0.01[a]	0.85 ± 0.02[a]	1.53 ± 0.02[a]	1.69 ± 0.02[a]
T3 Agricultural Limestone (ALS)	76.33 ± 0.02[a]	16.24 ± 0.02[a]	0.78 ± 0.01[a]	1.45 ± 0.02[a]	1.77 ± 0.02[a]
T4 Control (C)	87.24 ± 0.02[a]	12.54 ± 0.02[b]	1.12 ± 0.02[a]	1.36 ± 0.02[a]	1.39 ± 0.01[a]

Means with the same letters within the same column are not significantly different ($P > 0.05$).

shells while the lowest shell weight (45.6 ± 0.02), visceral organs (35.2 ± 0.01) and edible carcass weight (75.7 ± 0.01) were recorded in snails fed the control diet containing natural plant materials.

Effect of feeding different calcium sources on the chemical composition of snail meat

Table 4 shows the variation in the chemical composition of snail tissue with calcium sources in the supplemental diets. The moisture content varied from 72.61 ± 0.01 in the treatment with snail shells as a calcium source to 87.24 ± 0.02 in the control diet. The crude protein content of snail meat in the supplemental diets with calcium sources was significantly higher ($P < 0.05$) than the value recorded for the control diet fed natural plant material. The % crude fibre of the edible portion for the diet with Agriculture limestone was 0.78 ± 0.01 while the control diet recorded a higher value of 1.12 ± 0.02. For the % Fat and Ash, the control diet was observed to have lower values of 1.36 ± 0.02 and 1.39 ± 0.01 respectively. The highest values for these parameters were obtained with the snail shell calcium treatment for % fat (1.64 ± 0.10) and the agricultural limestone dietary treatment for % ash (1.77 ± 0.02). However, there were no significant differences between treatments for these parameters.

4. Discussion

From the results of this study, the importance and necessity of feeding snails with supplemental diets are seen in the different parameters measured in the study. The performance of snails fed supplemental diets involving the different calcium sources could be visibly appreciated as compared with snails fed with the natural diet of plant materials. The study revealed an appreciable increase in live body weight, width, and shell length of the snails fed supplemental diets with different calcium sources as such confirming that calcium plays a primordial role in the growth of the Giant African Land Snails. These results agree with the findings of several authors [11] [14] [15] [16] [17] who found out that snails grow faster when fed with formulated diets containing adequate quantities of calcium since calcium promotes shell growth which in turn promotes edible tissue growth in the snails. Furthermore, Akinnusi, [18] and Akintomide [19], revealed that proper nutrition and especially good quality calcium sources will enable a high growth rate, proper shell development, and faster sexual maturity at about 5 - 6 months of age in the snails. More recently, it has been reported that supplemental protein diets for snails improved growth [2] and reproduction [3].

In this study, snails fed snail shell diet expressed an increase in weight gain, shell length, and shell width compared with those fed with the other sources of calcium (**Table 2** and **Table 3**). The values for feed intake reported in this study are comparable with those of Ejidike, [20] and Emelue and Dododawa [17] who revealed that the high feed conversion ratio can be attributed to the availability and digestibility of the nutrients in the supplemental feed and also the ability of the Giant African land Snails to utilize the nutrients in the supplemental feed as compared with the natural feed. For the carcass weight, snails fed diets containing snail shells had the highest edible tissue weight, shell weight, and visceral organ weight as compared with the others. The quality of the snail meat is determined by its chemical composition and as such, the nutrient composition was higher in snails fed supplemental diets as compared with those fed the natural feed. It could be concluded that calcium source plays a vital role in the growth of Giant African Land Snails (GALS). However, due to the absence of statistical differences between the dietary treatments the diet with agricultural limestone could also be considered for effective use as a calcium source, in snail mineral nutrition as it is cheap, easy to handle, and readily available in the country.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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