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Research Article

Effects of Dietary Protein Levels on Growth Performances of African Giant Snail (*Archachatina marginata*)

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Abstract

This study was designed to evaluate the effect of dietary protein level on growth performances of African giant snail *Archachatina marginata*. The snails were fed on 4 diets with 4 diets containing graded protein content (20%, 23%, 26% and 29%) for thirty-two weeks. The main results revealed that, growth performances were higher ($p < 0.05$) with the highest protein content. The highest and comparable values were obtained with snails fed with diet containing the highest protein levels (26 and 29%) followed by those who fed on diet containing 20 and 23% crude protein. The feed conversion ratio was comparable in all the treatments fed on formulated diet. The snails fed on diet containing 26% and 29% crude protein presented comparable shell growth (0.25 - 0.26 mm/day in length and 0.087 - 0.088 mm/day in width) but higher than those of treatments 20% and 26%. It was concluded that, *A. marginata* performed better with 26% crude protein in the ration with respect to growth performances.

Keywords: *Archachatina marginata; Dietary; Growth; Protein; Shell*

Introduction

Despite a booming food production in sub-Saharan Africa, the nutritional status of populations in general and that of vulnerable groups in particular continues to be deteriorated. Among the main nutritional deficiencies observed, we have sources of protein, energy and an iron [1]. To solve this problem, exploiting the diversity of wild animals such as snail could be an effective solution. Indeed, numerous studies have shown that its flesh has excellent nutritional value [2]. It contains around 75% protein and is a good source of several minerals such as iron, calcium, magnesium and phosphorus [3,4]. Snail meat could therefore be used as an alternative source of nutrients for human consumption Otchoumou [5]. However, the main supply source of snails remains collection in forests during rainy season [6]. So, the massive exploitation of this forest resource by the populations raises questions about the continuous availability of these animals [7]. Similarly, the degradation of ecosystems, the expansion of cultivated land and the reduction of forest areas constitute a threat to the survival and sustainability of edible snails in their natural habitat [7]. To solve the problem, several studies have been carried out but not given good results due to a lack of information on the breeding techniques of snails in captivity. Among these constraints, we have a food formulation which does not cover the nutritional needs of the African Giant Snail. It is for this purpose that several studies have aimed to determine the dietary calcium content necessary to improve the growth and reproduction performance of *Archachatina marginata* in captivity [8,9] and the minimum dietary level protein [1]. No study has yet been carried out with the aim of determining the maximum

level of dietary protein to guarantee the best growth and reproductive performances in the snail *Archachatina marginata*. This study was designed to determine the growth and reproductive protein need of African giant snail *Archachatina marginata*.

Materials and Methods

Study area

This study took place at the Teaching and Research Farm of the University of Dschang between March 2019 and December 2019. The breeding took place in bins arranged along the walls inside a building. The average temperature and the relative humidity in the building were 19.7°C and 62.4% respectively, while the temperature of the rearing substrate and its humidity were 16°C and 84% respectively. The photoperiod was natural.

Animals

One hundred and eighty (180) young snails (*Archachatina marginata*) with average weight 10 ± 1g and 33.33 ± 1 mm in length and 24.25 ± 1 mm in width were used in this study. They were collected in cocoa plantations in the Moungo area (Njombé). The snails used in the study were selected based on their morphology and behavior: same live weight, well-formed shell, no breakage, individuals free from all visible and active traumas.

Substrate and breeding

The snails were raised in rectangular plastic tanks with 45 cm, 30 cm and 25 cm respectively for length, width and depth. An anti-leak device consisting of a fine mesh (2 mm mesh) was placed above each tank to prevent snails from escaping. Feeders and drinkers were made of small kitchen dishes.

Experimental diets

Four experimental diets (T1, T2, T3, and T4) were used. The 4 diets were obtained by varying the quantity of fishmeal (source of protein) and other ingredients, so as to obtain a protein level of 20%, 23%, 26%, 29% respectively for the T1, T2, T3 and T4. The calcium level in the diets was set at 16% [8]. The proportions of the various ingredients used for the composition of different diets are given in the table1 below.

Ingredients (Kg)	Experimental formulated diets			
	T1 (20%CP)	T2 (23%CP)	T3 (26%CP)	T4 (29%CP)
Maize	30	26	21.50	15
Cotton cake	2	-	-	2.5
Fish meal	27.75	34.75	40.25	44.50
Sea shell	37.00	36	35	34.25
Palm oil	2.5	2.5	2.5	3
Salt	0.25	0.25	0.25	0.25
Prémix 0.5%	0.5	0.5	0.5	0.5
Total	100	100	100	100
Analysed chemical composition				
Crude protein (%)	20.01	22.87	25.98	28.95
Metabolisable Energy (Kcal/DM)	2213.20	2321.10	2315.82	2321.26
Fat (%)	3.12	3.23	3.20	3.28
Calcium (%)	15.95	16.07	16.01	15.96
Phosphorous (%)	1.15	1.2	1.22	1.23
Potassium (%)	0.09	0.10	0.11	0.12
Magnésium (%)	0.56	1.02	1.04	1.04
Natrium (%)	0.42	0.40	0.40	0.44
Iron (%)	0.12	0.11	0.12	0.14

Table1: *Chemical composition of experimental diets.*
T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein;
T3: Diet containing 26% of crude protein; T4: Diet containing 29% of crude protein.

Experimentation and data collection

One hundred and eighty (180) young *Archachatina marginata* with equal average weight (10 ± 1g) and length of shells (33.33 ± 1 mm) were randomly distributed in 20 breeding tanks with a density of 75 snails/m^2 with 9 snails/tank replicated 4 times. Inside each tank, 10 cm of sawdust was introduced as breeding substrate. The moisture content of the substrate was maintained above 85% by watering every day each tank with the same amount of water (120 ml).

Growth performances

The feed was weighed and fed to the snails, and every two days the leftover was weighed. Troughs and feeders were properly cleaned before being reused. Faeces were also removed after every two days and once a week the breeding substrate was stirred and mortalities of snails recorded. The snails were weighed every two weeks for a period of eight months using a 1g precision scale. Length of the shells was measured with electronic callipers to assess monthly shell growth. Feed intake, weight gain, shell growth, and mortality rate were calculated as proceeded by Otchoumou., *et al* [10].

Feed intake (FI)

The feed intake was calculated using the formula below:

Feed intake (FI) = Quantity of fed served - Refusal quantity.

Live weight

Live weight is used to assess changes in body mass, snails were weighed at the beginning of the trial and every 14 days thereafter using a 1g precision scale. The weight gain was calculated by making the difference in weight between two consecutive weighing. The length and diameter of the shells were measured with electronic callipers in order to evaluate shell growth.

Weight gain (Wg)

The daily gain in live weight was expressed using the following formula:

Wg (g/d) = (P2-P1)/(T2-T1)

With Wg = Weight gain, P1 (g) = Initial weight; P2 (g) = Final weight; T1 (d) = Day 1; T2 (d) = Final day.

Shell growth (Sg)

The shell growth expresses the growth in length and width of the shell:

Sg (mm/d) = (L2-L1)/(T2-T1)

With L1 (mm) = Initial length of the shell; L2 (mm) = Final length of the shell; T1 (d) = Day 1; T2 (d) = Final day.

Feed conversion ratio (FCR)

The feed conversion ratio was expressed by the following formula:

FCR = (Amount of feed consumed (g) / (Weight gain (g)

Cumulative mortality rate (CMr)

The mortality rate was calculated according to the following formula:

CMr (%) = Nm x 100/Ei

With Nm = Total number of dead snails; Ei = Initial number of snails.

Statistical analysis

The data collected on the different parameters were submitted to one way analysis of the variance test by General Linear Model procedure of statistical package for Social Science Software (SPSS 20.0). In case of significant difference between treatment groups, the means were separated by the Duncan Multiple Range test at 5% threshold.

Results

Growth performances

The weight growth performances and the mortality rate of *Archachatina marginata* as affected by dietary level protein are summarized in table 2. It appears that all growth characteristics were significantly influenced ($p < 0.05$). The highest and comparable values were obtained with snails fed with diet containing the highest protein levels (26 and 29%) followed by those who fed on diet containing 20 and 23% crude protein. The cumulative mortality rate was higher in snails fed on 20% crude protein.

Growth characteristics	Experimental diets				p
	T1	T2	T3	T4	
Daily feed intake (g/d)	1,12 ± 0,08^{a}	1,18 ± 0,07^{a}	1,13 ± 0,01^{a}	1,18 ± 0,01^{a}	0,451
Final weight (g)	63,51 ± 2,74^{b}	64,17 ± 3,80^{b}	73,94 ± 2,87^{a}	73,96 ± 8,12^{a}	0,045
Total weight gain (g)	53,51 ± 2,74^{b}	54,17 ± 3,80^{b}	64,08 ± 2,82^{a}	63,96 ± 8,12^{a}	0,043
Daily weight gain (g/d)	0,22 ± 0,01^{b}	0,23 ± 0,01^{b}	0,26 ± 0,01^{a}	0,27 ± 0,03^{a}	0,041
Feed conversion ration	3,15 ± 0,80^{a}	2,53 ± 0,45^{a}	2,13 ± 0,15^{a}	2,38 ± 0,49^{a}	0,192
Mortality rate (%)	11.11 ± 0.00^{c}	13.88 ± 0.00^{b}	8.33 ± 0.00^{b}	5.55 ± 0.00^{a}	0,000

Table 2: *Effect of protein level in diet on growth and mortality rate of Archachatina marginata.*
a, b, c: Averages bearing the same letter on the same line are not significantly different (P > 0.05);
T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein; T3: Diet containing 26% of crude protein; T4: Diet containing 29% of crude protein.

Table 3 summarizes the linear and diametral shell growth of *Archachatina marginata* as affected by dietary level protein. It appears that the snails fed on diet containing 26% and 29% crude protein presented comparable shell growth but higher than those of treatments T1 and T2.

Shell growth Characteristics	Experimental diets				*p*
	T1	T2	T3	T4	
Final shell length (mm)	82,11 ± 0,99[b]	81,90 ± 1,21[b]	88,35 ± 1,74[a]	87,35 ± 3,01[a]	0,00
Shell growth in length (mm/d)	0,21 ± 0,01[b]	0,22 ± 0,01[b]	0,25 ± 0,01[a]	0,25 ± 0,020[a]	0,010
Final shell width (mm)	41,60 ± 1,88[b]	41,40 ± 0,15[b]	42,64 ± 2,41[a]	44,75 ± 1,22[a]	0,00
Shell growth in width (mm/j)	0,077 ± 0,05[a]	0,080 ± 0,05[a]	0,087 ± 0,06[a]	0,088 ± 0,05[a]	0,053

Table 3: *Effect of protein level in diet on shell growth of Archachatina marginata.*
a, b, c: Averages bearing the same letter on the same line are not significantly different (P > 0.05);
T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein; T3: Diet containing 26% of crude protein;
T4: Diet containing 29% of crude protein.

Shell growth evolution

The monthly shell growth in length of the snails as affected by dietary level protein is illustrated in figure 1. It appears that the curves have the same profile and the same trend from the beginning to the end of the experiment. However, from the 3rd month, the higher shell length was recorded with snails fed on diet containing the highest protein level.

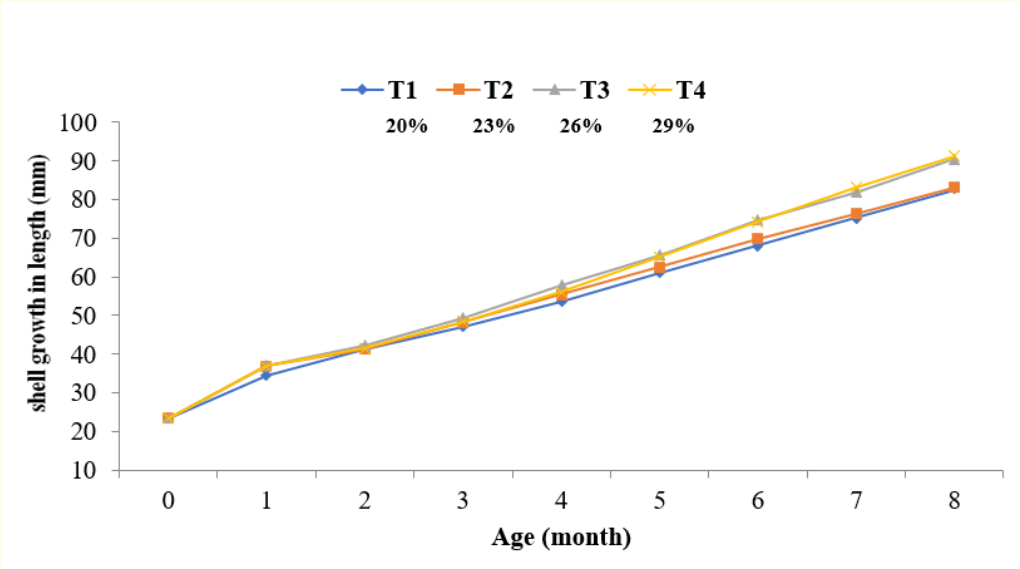

Figure 1: *Monthly shell growth in length evolution of Archachatina marginata as affected by the protein level of the diet. T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein; T3: Diet containing 26% of crude protein; T4: Diet containing 29% of crude protein.*

The shell growth evolution in width of the snails as affected by dietary level protein is illustrated in figure 2. It appears that the curves have the same profile and the same trend from the beginning until the end of the experiment.

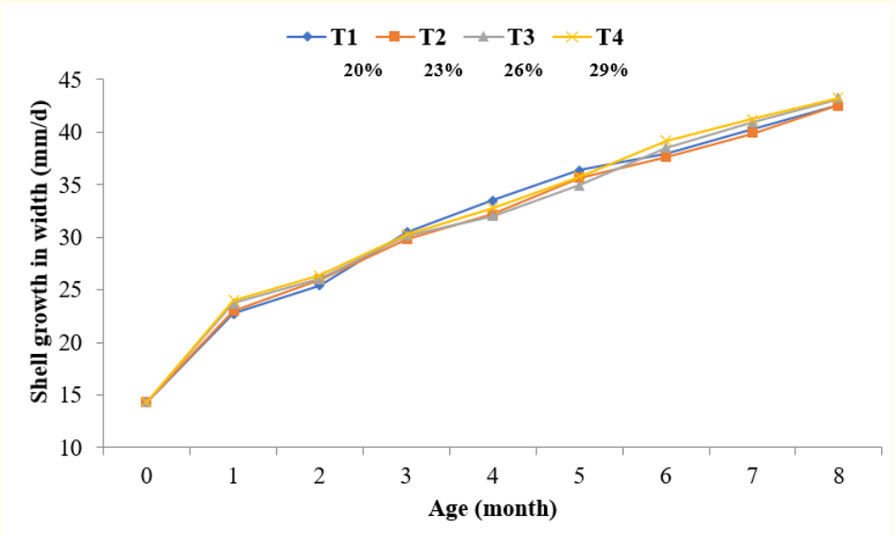

Figure 2: *Monthly shell growth in width evolution of Archachatina marginata as affected by the protein level of the diet. T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein; T3: Diet containing 26% of crude protein; T4: Diet containing 29% of crude protein.*

Feed intake evolution

The bi-weekly evolution of feed intake as affected by the protein level of the diet is shown in figure 3. It appears that, the curves have the same profile. However, from the 20th week until the end of the study, the feed intake of snails fed with ration containing 20% crude protein was higher than that of the other three treatments (T2, T3 and T4).

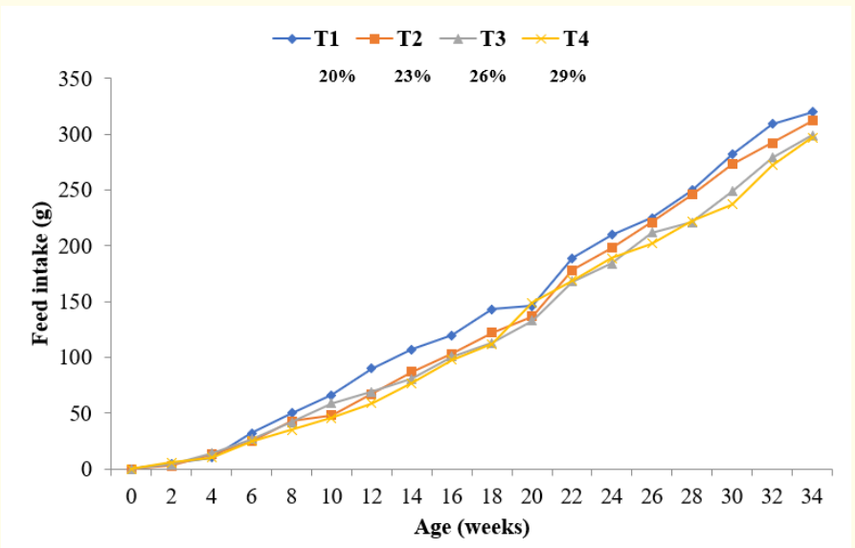

Figure 3: *Bi-weekly evolution of feed intake of Archachatina marginata as affected by the protein level of the diet. T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein; T3: Diet containing 26% of crude protein; T4: Diet containing 29% of crude protein.*

Live weight evolution

The bi-weekly evolution of the live weight of the snails according to the protein level of diet is illustrated by the figure 4. But, from the 12th week until the end of the study, the live weight of snails fed on 26 and 29% protein was higher than that of snails fed on diet containing 20 and 23% protein level. We also note that, from the 12th to the 28th week of the study, the live weight of the snails fed on 26% crude protein is below that of the snails of the T4 treatment before being confused from the 30th week, and this until at the end of the study.

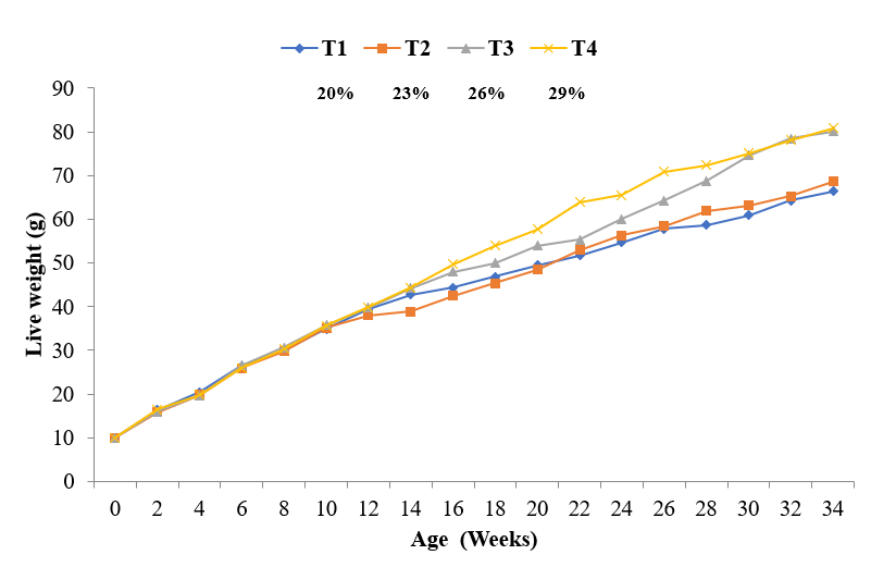

Figure 4: *Bi-weekly evolution of live body weight of Archachatina marginata as affected by the protein level of the diet. T1: Diet containing 20% of crude protein; T2: Diet containing 23% of crude protein; T3: Diet containing 26% of crude protein; T4: Diet containing 29% of crude protein.*

Discussion

The results of this study confirmed those of many authors [11-15] who have shown that by feeding snails with a formulated diet, the results were better because of their good nutritional value especially in calcium, protein, energy and vitamins. According to these authors, a diet based on plants such as green fodder, fruits and even tubers gives poor results in growth because of their low nutrient content. In addition to their physiological role, these nutrients are involved in the growth of the shell and therefore of the whole snail. Formulated diets are therefore suitable for feeding snails and are easier to use than plants. They provide energy, protein, minerals and vitamins that animals need. All these observations made it possible to envisage a formulated diet for snails as is the case in conventional species.

From our results based on effects of dietary protein level on growth performance of *Archachatina marginata*, it appeared that food intake was comparable (1.12 - 1.18g/d) in all the treatments receiving the diet composes with the increasing level of protein, but the values obtained in this study are slightly higher than 1 g/d obtained by Sika., *et al* [13]. However, the average daily weight gain (0.22 - 0.27g/d) was significantly influenced by the increasing level of dietary protein. These observations corroborate those of Ogbolo *et al.* [16] who reported that the weight of snails improves with increasing protein levels in the diet. Thus, the increase in protein content in rations has

a remarkable effect on the weight gain of snails *Archachatina marginata*. Likewise, Sika., *et al.* [12] and Sika., *et al.* [13] also noted that the snails *Archachatina marginata* and *Achatina fulica* experienced an improvement in their growth performance with the increase of dietary protein level. Feed conversion ratio showed no significant difference but the values obtained in the present study are higher than those reported by Ogbolo., *et al.* [16] (1.29 - 1.39) and close to those obtained by Tchakounte., *et al.* [8] (2.12 - 2.33) for the same species. These differences could be explained by the potentially different genetic characteristics of the species used by the authors due to the existence of several subspecies not yet identified [17] and another hand to the experimental techniques conditions. The snails fed on formulated diet recorded the highest survival rate (94.45%). This survival rate is close to that recorded by Ojebiyi., *et al.* [18] in *Archachatina marginata* receiving a formulated diet containing soybean and cassava residues as a source of protein (18.28% protein). While Otchoumou., *et al.* [6] obtained values ranging from 30 to 63% mortality rate in *Archachatina ventricosa* fed on two diets composed of leaves of *Lactuca sativa* and *Brassica oleracea* for the first diet and leaves of *Laportea aestuans* and *Phaulopsis falcisepala* for the second diet. Furthermore, Babalola., *et al.* [19] obtained 40% mortality rate in *Archachatina marginata* fed on leaf of *Euphorbia heterophylla* supplemented with bone meal as a source of calcium. This observation suggest that, increasing mortality rate is correlated with the low nutritional value of the ration. Indeed, formulated diets are rich in dry matter, proteins, minerals and vitamins and less water than leaves and fruits.

The results also showed that a daily shell growth of snails fed on 26 and 29% crude protein presented comparable performances (0.25 and 0.26 mm/d) but higher than those of T1 and T2 diets (0.22 mm/d). These values are slightly higher than those reported by Aman., *et al.* [20] which vary between 0.28 and 0.39 mm/d for *Archachatina marginata* fed on diet containing 12% calcium and 17.48% crude protein. While Ojebiyi *et al.* [18] obtained lower values (0.126 - 0.146 mm/d in length and 0.081 - 0.064 mm/d in width) for the same species with a diet containing 17.68% crude protein. The gains in shell lengths obtained by Ogbolo., *et al.* [16] (0.019 - 0.23 cm/d in length and 0.01 cm/d in width) depending on dietary protein level are much higher than the values obtained in the present study. These observations could be explained by the fact that the shell growth of snails is much more influenced by the dietary calcium level than by the dietary protein level. But it is essential to note the synergistic action of all mineral elements and organic matter as proteins, lipids and carbohydrates in the metabolism of growth and even of reproduction [21].

Conclusion

The present results showed that *A. marginata* performed better with 26% crude protein in the diet with regard to growth rates.

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