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Effects of Protein Levels on the Growth Performance of Giant African Land Snails (*Achatina achatina*) in Captivity

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Abstract

In order to preserve and conserve the Giant African Land Snails, a study was carried out between September 2015 and January 2017 at the University of Buea (South-West Region, Cameroon), to assess the effect of protein level on the characteristics of growth of *Achatina achatina* in captivity. 90 young snails of one month old, weighing between 1 and 1.5 g, of shell length between 15.5-23.85 mm and shell diameter between 12.60-16.85 mm and free from wounds or shell defects were divided into 3 groups of 5 snails each and 6 replicates in cages equipped with feeders and drinking troughs. Each treatment was randomly assigned to one of the experimental feed with variable protein levels (20, 22 and 24%) in addition to pawpaw leaves as a staple feed. These were previously weighed as well as the remnants using a 0.5g precision balance. The cultured substrates were watered daily (0.50 liter/substrate). At the beginning of the test, and then every week, the snails were weighed, and shell measurements done using a digital caliper of 0.05 mm accuracy. The animals were monitored for fourteen months. The results show that feed intake (3.01±1.57), weight gain (24.50±5.72), daily weight gain (0.058±0.016), gain of shell length (30.26±4.19) were significantly higher ($P < 0.05$) in snails receiving 24% protein in the diet compared to snails from the other treatments. The highest consumption index was recorded in snails receiving 20% protein in the diet but the statistical analyses did not find any significant difference. In conclusion, the protein level of 24% can be retained in the diet of growing snails.

Keyswords: *Achatina achatina*, protein level, growth, protein

1. Introduction

African fauna is an important source of animal protein (Ajayi, 1997). Estimates of quantity of bushmeat consumed in some cities stand at: 1100 tons for Yaounde Cameroon (Ivoveva, 2000); 500 tons in Libreville, Gabon (Steel, 1994); 105 tons in Liberia (Ajayi, 1997; Sale, 1981); 373600 tons in Senegal and 1320000 tons in Nigeria (Adeola & Decker, 1987). In the Congo Basin, this meat represents 30 to 80% of the animal protein supplied in families living in forests (Koppert et al., 1996). The continued availability of this important food source is now threatened by over-exploitation coupled with ecosystem degradation. Increasing demand due to the population explosion and the popularity of bushmeat among the population is leading to the decline of African wildlife today, and is a serious threat to survival of species and therefore biodiversity (Aboua, 1990; Ajayi, 1997). There is a lucrative bushmeat trade, sometimes due to the lack of a viable economic alternative that can sustain the survival of village populations (Kenfack et al., 2007).

In order to preserve wildlife, the breeding of unconventional species has developed, because it allows to control local animal species and to safeguard species overexploited for various human uses with respect to environment (Fantodji & Soro, 2004). The giant African snail, which is one of the most endangered species in the world, is one of the most common species on the continent. Their tender, tasty flesh represents an alternative source of animal protein (Aboua, 1990; Adeyeye, 1996). Imevbore and Ademosun (1988) reported that snail meat has a protein content of 88.37% compared to meat of pigs (82.42%) and beef (92.75%), which is low in fat (1.64%), saturated fatty acids (28.71%) and cholesterol (20.28 mg/100 g). These same authors reported that its flesh is rich in calcium (185.70 mg/100 g), phosphorus (61.24 mg/100 g) and iron (45-50 mg/kg) (Ademola et al., 2004) as well as in amino acids such as lysine, leucine, isoleucine and phenylalanine (Imevbore, 1990; Stievenart, 1992; Ademola et al., 2004). The quantity of snails consumed each year is estimated at 15 000 tons, in France, 300 000 tons in Togo (Ekoué & Kuevi-Akue, 2002), 8 000 tons in Ivory Cost (CTA, 1999) and 42 000 tons in Benin (Fagbuaro et al., 2006). The high collection pressure of these animals due to the increasing demand for local and subregional consumption and the destruction of their biotope by humans are a threat to the survival and sustainability of these species. Faced with this situation, achatiniculture has been initiated not only to reduce collection pressure, the seasonal deficit, the fight against the exhaustion of natural stocks of purchases and the preservation of its resources, but it is also an important source of financial income for the population. However, although widely consumed, very little information is available on the zootechnic of the species (*Achatina achatina*). One of the important elements in breeding is nutrition because it ensures good growth of the individuals, optimal reproduction, low mortality (Adeyemo et al., 2007). Thus, Sika et al. (2015) studying the effect of dietary protein content on snail growth (Achatina fulica), showed that growth characteristics improve with the level of protein in the diet. Similarly, studies by Ani et al. (2013) on the determination of the level of proteins and energy at *Achatina achatina* revealed that a diet containing 24% protein and 3000 kcal/kg is needed in the diet of growing snails.

In this study, we propose to determine the nutritional needs of the giant African snail. The general objective of the study is to contribute to the preservation and enhancement of African giant snails and more specifically to evaluate the effect of protein level on the growth parameters of animals (body weight, weight gain, morphometric characteristics of the shell).

2. Materials and Methods

2.1 Period and Study Area

This study was carried out between September 2015 and January 2017 at the University of Buea (South-West Region, Cameroon), located in a humid forest zone with monomodal rainfall (LN 4°12.77′-4°4.25′ and LE 9°19.43′-9°9.20′), at an average altitude of 400 m. The average annual temperature is 20 to 29 °C and the relative humidity is between 85 and 95%. The average annual rainfall is 2000 to 4000 mm with a rainy season (March-November) and a dry season (November-March). The photoperiod was 12 hours of light and 12 hours of darkness.

2.2 Animals

Snailets of one-month-old born from breeding animals derived from the snailery, weighing between 1 and 1.5 g, of length and shell diameter respectively between 15.5-23.85 mm and 12.60-16.85 mm, free of injury or breakage were used. These are Pulmonate gastropod molluscs. They belong to the order Stylommatophores, Super Family of the Achatinideae, the Family of the Achatinidae, Genus Achatina and the species *Achatina achatina*.

2.3 Housing

The animals were housed in plastic containers of 30 cm in diameter and 20 cm in height. The bottom of each was covered with 5 cm thick loose soil substrate previously disinfected with virunet (0.5 g/l/substrate) and then covered with wire mesh forming a leakage prevention device and placed in a building constructed in a block, covered with metal sheets.

2.4 Experimental Diets

Table 1 below shows the experimental diets used in this study.

Table 1. Bromatological compositions and characteristics of experimental diet

Compositions (kg)	**Proteins levels**		
	P_1	**P_2**	**P_3**
Corn flour	30.00	27.00	22.20
Cassava flour	24.00	22.50	20.00
Soybean cake	6.00	5.10	5.00
Groundnut cake	27.00	33.00	38.50
Palm kernel cake	3.00	2.00	3.00
Fish flour	2.00	2.10	2.00
Shell	1.42	1.42	1.42
Bone meal	2.83	2.83	2.83
Palm oil	3.50	3.80	4.80
Vitamin premix 2%	0.25	0.25	0.25
Total (kg)	**100.00**	**100.00**	**100.00**
Calculated bromatological characteristics (g/DM)			
Crude protein	20.09	22.04	24.00
Metabolizable energy (kcal/kg)	3000.50	3000.01	3000.85
Fat	8.49	9.34	10.75
Calcium	1.82	1.83	1.83
Phosphorus	0.81	0.84	0.86
Lysin	0.85	0.91	0.99
Methionine	0.27	0.29	0.31

Note. DM = Dry matter, kg = kilogramme, g = gramme.

2.5 Experimentation and Data Collection

Snailets (*Achatina achatina*) aged 1 month were divided into 3 groups of 5 snails and 6 replicates in cages equipped with feeding and drinking troughs. At each treatment, one of the randomly selected experimental diets was assigned in addition to the pawpaw leaves as a staple feed. These were previously weighed as well as the remnant using a 0.5 g precision scale. The same quantity of forage placed under the same experimental conditions without animals made it possible to make the corrections of weight due to the desiccation of the plant material. The cultured substrates were watered daily (0.50 liters/substrate) in order to maintain a constant relative humidity (85-95%). They were regularly cleared of dead animals and faeces to avoid the development of possible pathogens. The dead animals were inventoried by treatment and replaced by those of similar age and weight. At the beginning of the test, and then every week, the snails were weighed and shell measurements made using a 0.05 mm precision digital caliper. The animals were monitored for fourteen months.

2.6 Data Presentation

The growth performance of snails in relation to the level of protein in the diet was estimated from the weight gain, daily average weight gain (g/j), length and shell diameter gains calculated according to the following formulae:

- Food consumption (FC):

FC = Amount of feed distributed – Remnant

- Weight Gain (WG):

WG = Final weight – Initial weight

- Average daily gain (ADG):

ADG = Weight gain/Duration of experiment

- Consumption index (CI):

CI = Food consumption/Body weight gain

- Shell length gain (SLG):

SLG = Final length – Initial length

- Shell diameter gain (SDG):

SDG = Final diameter – Initial diameter length

- Survival rate (SR):

SR (%) = (Ne – Nm) × 100/Ne

Where, Ne = Total number of snails; Nm = Number of dead snails.

3. Results

3.1 Effects of Protein Level on the Characteristics of Growth of Achatina achatina

The effects of the protein level on the growth characteristics are summarized in Table 2 and illustrated in Figures 1 to 5 below.

Weight gain, average daily weight gain, shell length and shell diameter gain (Table 2) in animals receiving 22 and 24% protein were not significantly different; but significantly higher ($P < 0.05$) than in snails that received 20% protein. Negative and strong correlations ($P < 0.01$) were found between weight gain and body weight ($r^2 = -0.246$), weight gain and shell length ($r^2 = -1.87$), body weight and shell diameter ($r^2 = -1.59$).

The lowest consumption index was obtained in animals receiving 22% protein; however, statistical analysis revealed no significant difference ($P > 0.05$).

The highest survival rate ($P < 0.05$) was recorded in snails receiving 20% protein in the diet compared to the other groups studied.

Table 2. Effects of protein level on the growth characteristics of snails (a.b): on the same line, the values assigned to the same letter do not differ significantly ($P > 0.05$); n = number of snails

Growth characteristics	**Protein level (%)**		
	20 (n = 30)	**22 (n = 30)**	**24 (n = 30)**
Weight gain (g)	15.53±2.94 [a]	23.34±6.3 [b]	24.50±5.72 [b]
Average daily weight gain (g/j)	0.037±0.00 [a]	0.055±0.00 [b]	0.058±0.016 [b]
Consumption index	8.80±23.88 [a]	7.07±15.47 [a]	7.24±25.22 [a]
Shell length gain (cm)	25.00±3.15 [a]	29.70±5.18 [b]	30.26±4.19 [b]
Shell diameter gain (cm)	17.26±2.79 [a]	20.09±2.55 [b]	19.06±2.622 [b]
Survival rate (%)	86.66±0.3 [b]	60.00±0.00 [a]	56.66±0.10 [a]

3.2 Effects of Protein Level on the Consumption of Pawpaw Leaves in Snails

Figure 1 shows the evolution of pawpaw leaves consumption with respect to the level of protein in the diet.

It can be noticed that the consumption of pawpaw leaves increased irregularly from the beginning to the end of the test regardless of the treatment. Negative and strong correlation ($P < 0.01$) was found between protein levels and pawpaw leaves consumption ($r^2 = -0.191$). At the end of the test, leaf consumption was significantly lower ($P < 0.05$) in animals receiving 20% protein in the diet compared to other treatments.

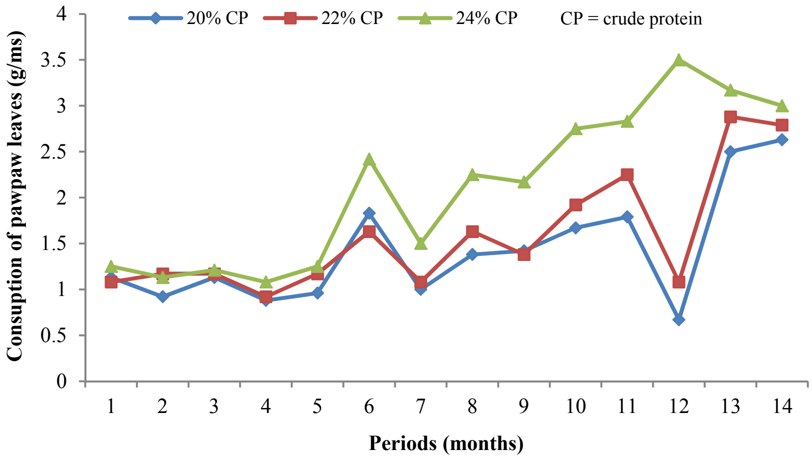

Figure 1. Evolution of papaw leaves consumption with respect of protein level in the diet

3.3 Effects of Protein Level on Food Consumption in Snails

The evolution of food consumption with respect to protein level is illustrated in Figure 2. It appears that, regardless of the period of the test, food consumption increased irregularly in all treatments. When the periods are considered, during the third and fourth periods of the test, food consumption decreased in animals receiving 24% protein but remained high during the other periods compared to other treatments. A negative and strong correlation was found between protein levels and food consumption (r^2 = -0.240), food consumption and pawpaw leaf consumption (r^2 = 0.597). At the end of the test, the highest food consumption was recorded in snails receiving 22 and 24% protein compared to other treatments.

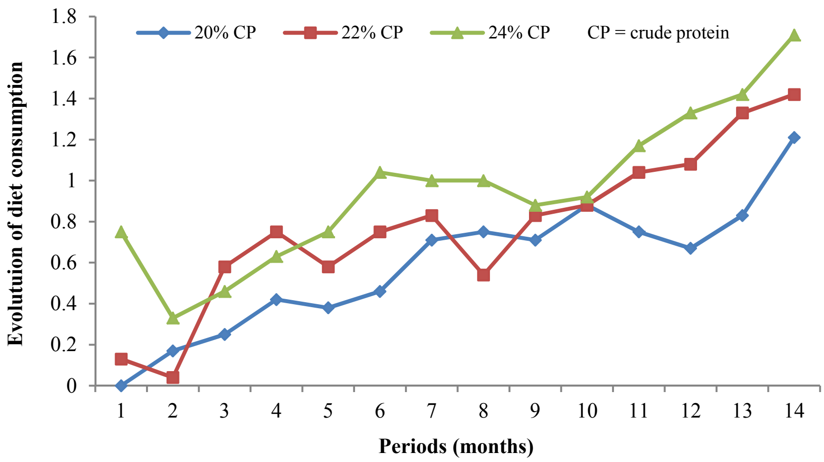

Figure 2. Effects of protein level on the monthly diet intake

3.4 Effects of Protein Level on the Evolution of Body Weight of Snails

Figure 3 illustrates the evolution of body weight with respect to protein level in the diet. It can be seen that body weight increased steadily from beginning to end of the test regardless of treatment. This increase was significant in snails that received 22 and 24% protein (Table 1) compared to those receiving 20%. A negative and strong correlation ($P < 0.01$) was found between protein level and body weight (r^2 = -0.269), food consumption and body weight (r^2 = 0.468).

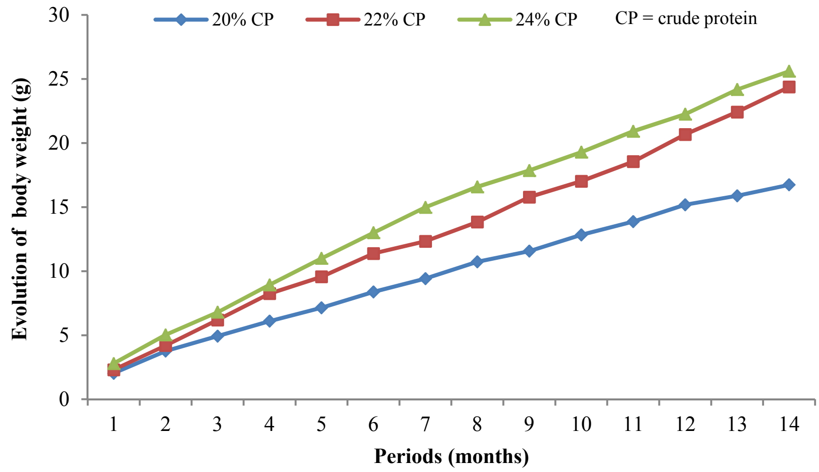

Figure 3. Effects of the protein level on the evolution of body weight of snails

3.5 Effects of Protein Level on the Evolution of Shell Length

It can be seen from Figure 4 illustrating the evolution of shell length with respect to the level of protein in snail feed that the length of the shell increased steadily regardless of the treatments. A negative and strong correlation ($P < 0.01$) was found between protein level and shell length ($r^2 = -0.288$), positive and strong correlation ($P < 0.01$) between body weight and shell length ($r^2 = 0.952$). At the end of the test, the significantly higher shell length ($P < 0.05$) were recorded in snails receiving 22% and 24% protein in the diet compared to those fed at 20%.

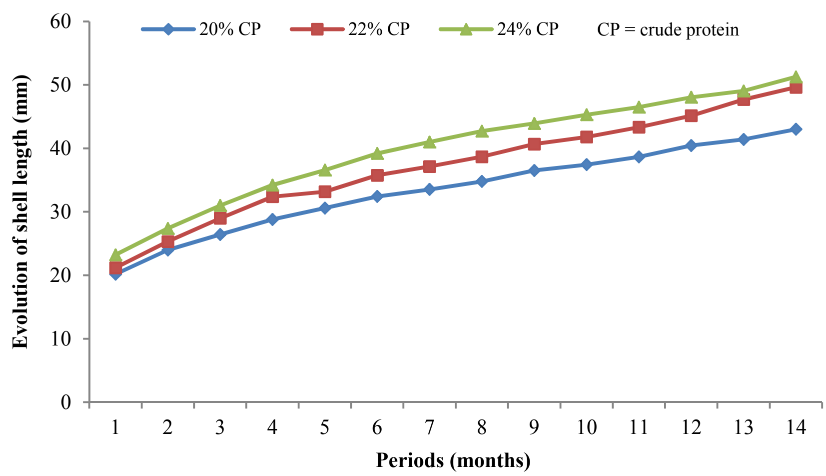

Figure 4. Evolution of shell length with respect of protein level in the diet

3.6 Effects of the Protein Level on the Evolution of the Shell Diameter

Figure 5 illustrates the evolution of the shell diameter with respect to the level of protein in the snail feed. It was revealed that the diameter of the shell increased steadily regardless of the treatment. At the end of the test, the significantly higher shell diameters ($P < 0.05$) were recorded in animals receiving 22% and 24% protein in the diet compared to those fed at 20%. A negative and strong correlation ($P < 0.01$) was found between shell diameter and protein level ($r^2 = -0.239$), positive and strong correlation ($P < 0.01$) was found between body weight and shell diameter ($r^2 = 0.924$).

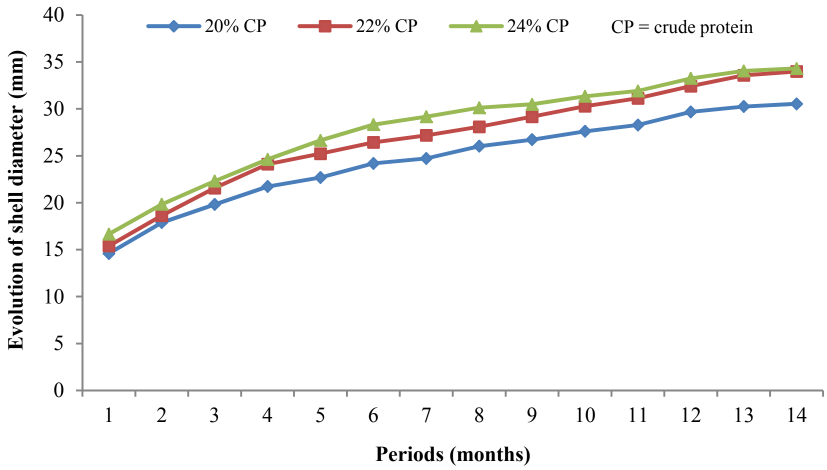

Figure 5. Evolution of shell diameter with respect of protein level in the diet

4. Discussion

The results of the study on the effect of protein level on snail growth performance showed that: pawpaw leaves consumption increased with the level of protein with the highest levels of consumption ($p < 0.05$) recorded in animals receiving 22 and 24% protein in the diet. This would be justified by the high consumption of food in these treatments. Indeed, concentrated feed based on flour concentrates are high in protein, dry matter, and low in water while pawpaw leaves are rich in water and low in protein (Sika et al., 2015). The high consumption by snails in these treatments to meet their needs would have stimulated the consumption of pawpaw leaves to meet water needs. In addition, in nature, snails in the growth phase consume more tender and water-rich plants (Adeola et al., 2010; Otchoumou et al., 2004). Quantitative protein intake appeared to have an effect on food consumption in snails receiving 22 and 24% protein in the diet. Our results differ from those of Ferrando (1969), who has shown in his studies that protein requirements decrease when food consumption increases, but corroborate those of Jensen et al. (1990); Calderon and Jensen (1990) who studied the effect of protein level on breeding and growth performance of hens and reported that food consumption increases with increasing protein levels in the diet. This could be explained by the fact that increasing the level of protein in the food would stimulate appetite in growing snails whose body weight, weight gain and average daily gain would be consequences. Similar results were obtained by Akinnusi (2002) who evaluated the effect of fruit, leaf and concentrated feed on the reproduction and growth of African giant snails (*Archachatina marginata*) and reported that the snail needs protein for its growth. These results are also in line with those of Sang-Min and Tae-Jun (2005); Omole et al. (2000) who respectively showed that a diet containing 22% protein and 3.3 kcal/kg of energy and 28% protein and 28 kcal/kg energy are needed to optimize the growth performance of juvenile snails (*Semisulcospira gottschei*). These results could be explained by the fact that the snails used the available proteins efficiently to produce energy essential for their growth. Indeed, proteins are the building blocks and maintenance of living cells whose contribution is essential to increase muscle mass and production. They have a structural role and participate in the renewal of muscle tissue, bone matrix and many physiological processes in the form of digestive enzymes, hemoglobin, hormones, receptors or immunoglobulins. Protein deficiency can cause fatigue in animals, permeability to larger infections, decreased muscle mass (Jurgens, 2002). However, proteins can not be the only ones responsible for the growth performances observed. It is essential to note the synergistic action of organic matter (proteins and lipids) and all the mineral elements in the growth metabolism (Cobbinah et al., 2008). Thus, magnesium is essential for the assimilation of vitamin B2 (Thianine) and the synthesis of proteins (Parigi, 1986).

Our results also revealed that significantly higher values in shell length and shell diameter were recorded in animals receiving 22 and 24% protein. The values of shell length and shell diameter obtained in this study are higher than those obtained by Ani et al. (2013), and Oluokun et al. (2005) who respectively worked on the effect of the level of protein and energy on growth performance of snails (*Achatina achatina*) and the effect of the level of calcium supplementation on growth characteristics (*Archachatina marginata*) and showed that a diet containing 24% protein and 3000 kcal/kg energy, and 8% of calcium is needed in young growing individuals. This could be attributed to the growth performance of snails in these treatments. Indeed, a significant food consumption in these treatments would have led to a high weight increase resulting in significant shell growth. The differences in results observed with the authors mentioned above may be related to the age difference of the animals used, species and environmental factors (temperature, hygrometry, etc.).

5. Conclusion

At the end of the study on the effect of protein level on the growth performance of Achatina achatina, we can conclude that the diet containing 24% of protein served for 56 weeks improves food consumption, body weight, length and shell diameter in snails. So, the protein level of 24% can be retained in the diet of growing snails.

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