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Assessment of Reproductive Performances and Feed Responses of African Giant Land Snail (*Archachatina marginata*) using Varied Percentages of Crude Protein

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ABSTRACT

This work aims at assessing the reproductive performances and feed responses of *Archachatina marginata* using varied percentages of crude protein. The research was carried out in four partitioned units of a rectangular cage of dimension 1.57m by 1.22m by 0.57m. The experiment was carried out in four units (treatments), ten snails were randomly selected for each treatment and stocked accordingly. The snails were fed for eight (8) weeks. Feed intake of the snails, eggs laid per week, the number that hatched, the time it took to hatch and the survived ones were recorded. Four compounded feed types were used with varied crude protein compositions which were 17%, 20%, 23% and 26% for treatments 1, 2, 3, and 4 respectively. The snails were fed two times daily. They were given fruits and vegetables in the morning (07:30am) and compounded feeds in the evening (05:30pm). The feed was made available to the animals within the range of 1 and 3% of their body weights. Left over collected was sun-dried and weighed. Weight of the snails, feed intake, egg diameter, egg length, egg weight and weight of the hatchlings were measured. Analysis of variance (ANOVA) and correlation analysis were carried out in a Complete Randomized Block Design (CRBD). Results showed that highest number of eggs was recorded in T3 (19), followed by T1 (8). The average incubation period for the eggs was 25.75 days. Percentage hatchability of the eggs was 57.1% and 44.4% for T1 and T3 respectively and the average weight of the hatchling at day old was 2.38g. The hatchlings began to take food after seven (7) days of hatching. One mortality was recorded throughout the period of the study and this was in T1. The highest feed-intake of the snails was found in T4 (3.336kg), while T2 recorded the least feed-intake. The mean for average feed intake for treatment 4 was the highest (T4= 8.3404±2.30857), followed by those of treatments 1 (T1= 2.1445±1.30551), 3 (T3= 1.9076±1.19973) and 2 (T2= 1.3528±0.75013). Analysis of variance of feed-intake is significant .000* (3 df, $P<0.05$). Duncan average feed intake per treatment per day indicated that treatments 1 and 3 have close values for average feed intake per

treatment per day (T1= 2.1445 and T3= 1.9076) and thus are homogenous. Treatment 4 recorded the highest body weight gain (247g) followed by T2 (95g) while treatments 1 and 3 had reduced body weight at the end of the experiment by -119g and -76g respectively. High crude-protein with finer particle size in the feed of snails will enhance high fecundity, bigger sized hatchlings and highly viable snailets. Thus, 23% crude protein level is advisable in large scale snail production. The weight gain of snails was not affected by the level of protein in the feed. This implies that protein in the feed of farm animals does not absolutely contribute to the weight of the animals but can influence and boost their level of fecundity.
Key Words: Feed particles, Snails, Responses, Crude proteins, Weight gain.

INTRODUCTION

The importance of protein in human diet cannot be over emphasized. Protein is required for growth and repair of body tissues. It is the principal constituent of the organs and structures of the body. While plant protein is deficient in one amino acid or the other, e.g. soybean is deficient in methionine and also contains anti-nutritive factor; animal protein is of high biological value and possesses all the amino acids in desirable quantities. According to FAO (1969), 70g of protein is recommended for consumption by an adult per day, 35 of which is required to be animal protein. However Odiabo, (1990) reported that out of an average of 58.8g of protein available to an average Nigerian, only 8.4g of it is from animal.

Animal protein is obtained as milk and beef from cattle, pork from pig, mutton from sheep, egg from poultry, etc. Game animal as well as edible land snails are also important sources of animal protein. The utilization of wildlife as source of food (meat) is not new; bush meat has been a source of meat before man domesticated a significant number of species used as flesh food. The management of wildlife in natural areas and in captivity therefore offers new prospect for contributing to the demanding requirements of animal protein (Ajayi, *et. al.,* 1985). Many species of edible land snails are recognized but the popular species of economic interest are; the West African giant land snails, *Archachatina marginata,* and *Achatina achatina* (Agbelusi and Ejidike, 1990).

Archachatina marginata is the largest of *Archachatina* snails and is found in West Africa. It can be found aestivating underground during drier months. This species does not cause any appreciable damage to crops and is actually considered an economic asset among people who include it in their diet. In many parts of West Africa, it is considered the second best snail to eat after *Achatina achtina.* The shells of *A. marginata* are used for domestic purposes by locals as salt holders, cups, etc. The shell can also be grounded and used as a source of Calcium Carbonate in the formulation of animals feed. Also, the alkalinity of the crushed shell can be used to reduce soil acidity. The meat is tender, tasty and nutritious; all these make it a suitable meat for all ages (Ademosun and Imevbore, 1988).

Snail meat is socially well accepted in Nigeria. The meat is high in protein (37-51%), compared to that of poultry (18.3 %), fish (18.0%), cattle (17.5%), sheep (16.4 %) and swine (14.5 %). Its iron content is (45-59mg/kg), has low fat content (0.05-0.08 %) and contains almost all the amino acids needed for human nutrition. In fact, the amino acid profile compare favourably with those of broiler, fish and pork because snail meat contains 18% crude protein and it contains all essential amino acids (Omole, 1999).

In addition to the nutritional value of snail meat, recent studies indicated that the glandular substance from edible snails cause agglutination of certain bacteria, which could be of value in the treatment of various ailments including whooping cough. In folk medicine, the bluish liquid obtained when the meat has been removed from the shell is believed to be good for infant development. It is believed in some quarters that snail meat contains pharmacological properties of value in countering high blood pressure (FAO, 1986).

Snails are hermaphrodite in nature (having both the male and female organs in the same individual), with the exception of a group, the

Pomatidae, which have separate sexes. The age of sexual maturity varies depending on species, like *A. marginata* was reported by Plummer, (1975) to attain sexual maturity between 9 and 10 months. Adverse environmental condition may delay the onset of sexual maturity in snails.

The Giant African land snails feed on variety of feeds, these include;

- **Fruits:** apple, banana, mango, pawpaw, tomato, water melon and almond.
- **Vegetables:** cabbage, carrot, cucumber, lettuce, mushroom, pears, potato and common plantain.
- Compounded feed and kitchen remnants.

The main source of supply of snail to the market is from the forest. During raining season which is the breeding season for snails, there is an abundance of this animal, but the reverse is the case in the dry season. This creates a gap in the supply availability of snails as a source of protein. This work thus aimed at the assessment of the reproductive performances and feed responses of *Archachatina marginata* using varied percentages of crude protein so as to increase supply rate to the market.

MATERIALS AND METHODS

The Description of Experimental Site

The research was carried out at the Domestication unit of the Department of Wildlife and Ecotourism Management, Faculty of Agriculture and Forestry, University of Ibadan, Nigeria. The University of Ibadan is the oldest and one of the most prestigious Nigerian Universities, and is located five miles (8 km) from the center of the major city of Ibadan in western Nigeria. This research site lies on the following coordinates: 7°23′47″N and 3°55′00″E. It falls within the humid tropical climate zone which is next to the transitional forest of guinea savannah belt of Nigeria. Ibadan been a low land tropical rain

forest has an annual mean temperature of about 27°C. The dry season occurs between November and March while the rainy season is from April to October every year. Harmattan is usually experienced between the mid December and late January of each year due to hot, dry and dusty North-East trade wind which blows across the Sahara desert in the country.

The total space used for the research was 8.86 squared meter. This site was partly chosen because of the presence of constant water supply from a bore-hole located beside the mini zoo inside the domestication unit, which aided easy access to water and utility during the experiment. Also, the presence of the University security officers around the domestication centre 24 hours of the day prevented the invasion of poachers.

The Rearing Unit (i.e. the snail cage)

The research was carried out in four partitioned units of a rectangular cage of dimension 1.57m by 1.22m by 0.57m. The enclosure was made of wood with its openings reinforced with a 2mm diameter plastic netting material (mosquito net) and was doubled-up with 1cm diameter fine wire mesh to keep off the predators.

Pre-rearing preparations carried out on the enclosure include: cleaning of the cage, repairing of the damaged parts, partitioning of the cage (into four) and blocking of some holes on the cage to prevent predators from entering the cage. The four legs were supported with a metal container each, which held liquid (i.e. spent engine oil) to prevent access of predators such as termite and soldier ants into the cage.

A tent of 2.5-2.25m height was made with iron sheet on the cage to prevent the snails and the cage from the direct effects of rain fall and sunlight. Empty cartons were also used as asbestos to reduce the radiation of the sun from the iron sheet during the hot day. A polythene

nylon of 2.6m wide and 2.1m long was used to cover the front side of the tent to further reduce the effect of direct rainfall on the snails since the experiment was done in captivity.

Finally, the removal of weeds, plant stumps, stones and litters were done within the surrounding of the study site so that fine humus soil could be collected in-situ. The cages were filled-up with the humus collected on the site at a depth of 10cm (4 inches) after which the wetting of the soil was done to prepare the cages for stocking.

Materials used for the Experiment

These include: 40 brood stocks, broom, spent engine oil, cotton wool, cutlass, digital weighing balance (Model: Scout Pro Spu 402, Max 400g d = 0.01g), empty cartons, feed (compounded feed, fruits and vegetables), feeding troughs, four metal containers, hand trowel, hatchery (a separate cage for eggs), polythene nylon, tent, transparent ruler, Vernier caliper, watering can and wooden cage.

Experimental Design and Methods

The study was designed to assess the reproductive performances of giant African land snails (*Archachatina marginata*) to the varying crude protein levels which include the egg laying, hatching and survival of the hatchlings and also to evaluate their responses to feed items of varying crude protein levels. The study commenced on 25th of August and ended on 23rd of October 2014. Forty matured snails (*Archachatina marginata*), that is the brood stocks, were purchased from a viable and reputable farm. The brood stocks were 18 months old and their average weight was 427g. The experiment was carried out in four units (treatments), ten snails were randomly selected for each treatment and stocked accordingly. The snails were allowed to acclimatize for several weeks before the commencement of the experiment. The snails were fed for eight (8) weeks. Feed intake of the snails, number of eggs laid per week,

the number that hatched, the time it took to hatch and the survived ones were recorded. The percentage hatchability of the eggs was also done.

The Food and Feed Items

The feed items used for the research were compounded feed, while the food items include the fruits and vegetables. Examples of fruits and vegetable includes; ugwu leaves (*Telfaria occidentalis*); pawpaw fruits and leaves (*Carica papaya*) and almond fruits (*Terminalia catapa*). Four compounded feed types were used. The four compounded feed types varied in their crude protein compositions which were 17%, 20%, 23% and 26% for treatments 1, 2, 3, and 4 respectively. Yellow maize and groundnut cake in the feed constitute the major crude protein and as such are vary in their percentage composition. Wheat offal and fish meal also play a part in the crude protein percentage of the feed. Wheat offal and other feed additives are fixed in percentage composition for the four treatments and are called 'Fixed Feed Additives (FFA)'. Table 1 below shows the formula for the four compounded feeds; the ingredients and their percentage compositions.

Table 1: Formula for the Compounded Feeds

Ingredients	Percentage compositions (g)			
	Treatments			
	1	2	3	4
Yellow maize	64.68	56.38	48.26	45.29
Groundnut cake	18.32	26.62	34.47	37.71
Wheat offal	10.0	10.0	10.0	10.0
Fish meal	1.5	1.5	1.5	1.5
Bone meal	2.5	2.5	2.5	2.5
Oyster shell	1.5	1.5	1.5	1.5
Premix	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Enzymes	0.5	0.5	0.5	0.5

Feeding Method

Cheney (1988) reported that snail may sometimes eat food equals to 10-20% of their body weight, within 24 hours and if deprived of food, may lose as one-third of their body weight before death results; a process that would take between 8 and 12 weeks. Consequently, series of pre-tests were done to determine what feeding standard will best suit the rearing purpose. This was done to establish the basis for feeding snails in commercial farming practices and also to minimize waste and reduce cost.

The snails were fed two times daily. They were given fruits and vegetables in the morning (07: 30 am) while compounded feeds were served to them in the evening (05:30pm). It was observed in the first week that the snails responded less to the fruits and/or vegetable, because they mostly burrowed down and less active in the morning. While burrowing, a small hole is left through which they eat their food and sense their environment before they are completely immersed in the soil. The fruit was then placed at that point where it was accessible by the snail after which they were covered with fresh banana leaves. Fresh banana leaves were used because snails don't eat it and as such they will be able to eat the food giving to them. This was also used to simulate their natural environment, as they normally hide under shady area during the day.

The feed was made available to the animals within the range of 1 and 3% of their body weights. A small quantity of water was added and mixed with the feed for easy consumption. Left over collected the next day was sun-dried to obtain its dry weight. The feed was presented to the snails on flat pieces of asbestos central to them. Each experimental unit was fed 3% of their body weight in the first week, (127.2g, 131.61g, 126.48g and 128.19g for treatment 1, 2, 3 and 4 respectively). The feed was reduced to 2% in the third week due to large amount of waste recorded in the first and second week (for treatments 1, 2 and 3) while that of treatment 4

remained unchanged (i.e. 3%). The feed was also reduced to 1% for treatments 1, 2 and 3 because of waste recorded in the third week though less than that of the first and second week and this was used for the rest of the experiment. The leaves with which they were covered in the morning were reduced in the evening after giving them compounded feed so that the feed is not covered.

Parameters Measured

These include:

1. **Weight of the snails (initial and final):** This was taken with the use of sensitive weighing balance (Model: Scout Pro Spu 402, Max 400g d = 0.01g), the soil on the body and in the mouth of each snail was removed before taking its weight.
2. **Feed intake:** To obtain feed intake, left over was deducted from the quantity of feed given to the snail.
   Therefore,
   Feed intake = Feed given – Left over
   This shows the acceptability of the feed by the snail.
3. **Egg diameter:** This was measured with the aid of Vernier calliper. The diameter (mm) was taken at the broadest point of the egg, because of varying shapes of the eggs.
4. **Egg length:** This was measured in mm also with the aid of Vernier calliper. The Vernier calliper was placed at the two edges and the reading was taken.
5. **Egg weight:** This was measured using sensitive weighing balance (Model: Scout Pro Spu 402, Max 400g d = 0.01g). Cotton wool was used to wrap the egg before putting it on the balance so as to avoid having contact with the metal cover of the balance and not to be exposed to day light as this can lead to cracking and finally breaking of the egg.
6. **Weight of the hatchlings:** The hatchlings were weighed immediately after hatching. Cotton wool was used to clean the

soil and egg shell remnants on each hatchling before taking its weight.

Management Practices

It was established that snails perform best under humid condition (Mead, 1961; Awesu, 1980; and Eimslie, 1982). The experimental partitioned units were regularly watered to maintain high level of humidity most especially during dry and hot weather. Almost two litters of water were usually sprinkled on the each replicate every day to keep the soil moistened and the snails active. Fresh banana leaves were used as a protective cover to shield the snails from direct effect of sun and penetration of light into the cage; the leaves were usually changed after one week when it is becoming dry. Feed wastes and faecal droppings were never allowed to decay in the cage to avoid bacteria explosion and fungi introduction to the snails which can lead to epidemics and diseases. Eggs of the snails were checked on weekly basis and if found, were buried separately (out of the rearing cage) to ensure maximum protection of the eggs, proper care and monitoring and easy determination of percentage hatchability. Cleaning of the surrounding which involved cutting of grasses, dusting of the net cover of the cage, sweeping of the floor and other management practices were observed.

Data Analysis

Tables and charts were drawn for various parameters measured. Analysis of variance (ANOVA) and correlation analysis were carried out in a Complete Randomized Block Design (CRBD) to test for significant variation between and within the four treatments considered. A correlation analysis was also carried out to establish some relationships among the parameters measured in the experiment.

RESULTS AND DISCUSSION

Reproductive Performances

Mating Process: During the study, two snails were observed mating which lasted for hours; sometimes it took place in the morning (07:00am), in the afternoon (during cold days) and also in the evening around 06:45pm.

Egg-laying Process: Snails about to lay eggs entered the soil with its left side of the shell adjacent to, and the head parallel to the wall of the cage. With the head retracted, the snail forced the lip of the shell into the soil, raising an arc-like mound of soil on its body as it penetrated more deeply, the shell thus behaving rather as plough-share. The depth of the burrow varied with the size of the snail, the range of between 6cm and 9cm (was recorded) below the surface of the shell lip, the soil at this stage normally covers the shell. The snail constructed a smooth-walled chamber of oval outline that is usually not more than 0.5 inch from the wall of the cage and deposited its eggs (through the reproductive pore) in a group only the peripheral members of which are in contact with the soil. The snail covered its eggs by parking soil (with its foot) from its surroundings until the eggs were well covered, the process of which took some minutes. The clutch size of the eggs laid ranged between 1 and 12. While pure white colour was observed in some eggs during the pre-tests, the colour of the eggs was normal light yellow, typical of *A. marginata* eggs. The brightness of the egg colour varied with the level of crude protein. Two different shapes were observed in the eggs; some were oblong while others were spherical in shape.

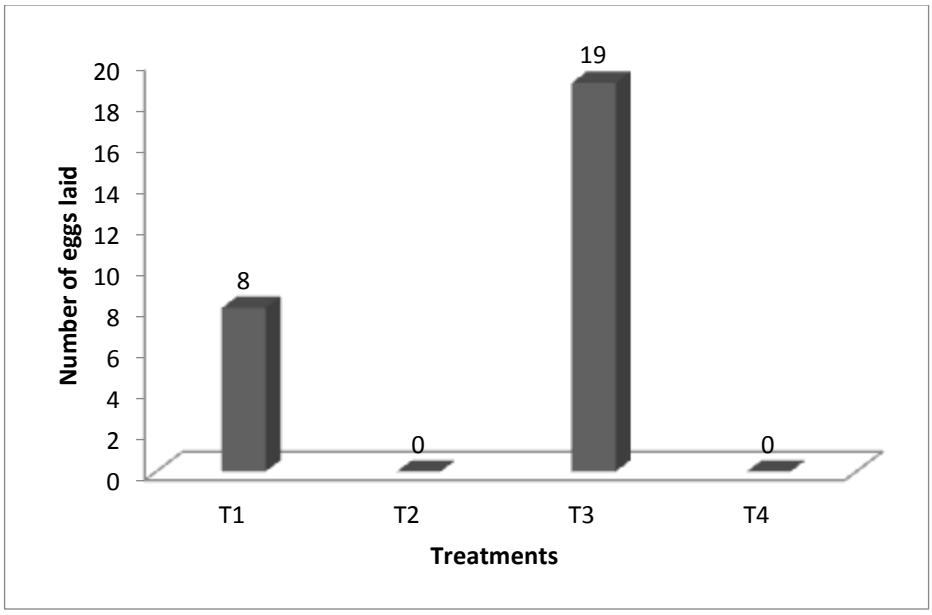

Figure 1: Number of eggs laid per treatments

The figure 1 above showed that nothing was recorded in terms of reproduction in treatments 2 and 4. Highest number of eggs was recorded in T3 (19), followed by T1 (8). The high level of crude protein as well as relatively small sizes of snails in T3 was responsible for the high productivity in T3.

Incubation: Regarding some observations made during the per-tests, incubation of the eggs was done artificially whereby eggs were parked out of the experimental cage and buried separately per clutch mimicking the natural arrangement. This method was used to reduce the damage done to the eggs by the snails in attempt to burrow down. The depth at which the eggs were laid was noted which was used for the artificial incubation. The snails laid their eggs close to one another and this was also used in the process of artificial incubation. The average incubation period for the eggs was 25.75 days.

Percentage Hatchability: Percentage hatchability of the eggs was 57.1% and 44.4% for T1 and T3 respectively. Percentage hatchability depends

on management practices and the environmental conditions. The eggs did not hatch uniformly, the first set (usually the uppermost members) to hatch were 3 to 5 days ahead of the main group. The newly hatched eggs (hatchlings) rasped on their egg shell and even predated on the eggs around them, at this stage the early hatched snails are danger to their siblings. In the light of this, it is important to start checking the eggs after three weeks so that the hatchlings are removed shortly after hatching to maximize hatchability. The average weight of the hatchling at day old was 2.38g.

Feeding the Hatchlings: The hatchlings began to take food after seven (7) days of hatching; they were fed with the following: ripe pawpaw fruit, fresh and dried pawpaw leaves and compounded feed. Out of these feed items, the hatchlings preferred pawpaw leaves to its fruit. They started taking compounded and other types of feed from the third week. There was rapid feed intake in the second and third week.

Mortality: One mortality was recorded throughout the period of the study and this was in T1. The snail was inactive and unable to take food for two days, it was then isolated on the third day (29th of September, 2014). It later became active and started taking leaves. The snail suddenly died on 4th of October, 2014.

Table 2: Weight, Length and Diameter of the Eggs

	T1			T3		
S/N	Weight (g)	Length (mm)	Diameter (mm)	Weight (g)	Length (mm)	Diameter (mm)
1	3.63	22.0	17.0	4.50	22.0	17.0
2	3.85	20.0	16.0	4.58	21.5	17.0
3	3.54	21.0	16.0	4.43	21.5	18.0
4	3.51	21.0	17.0	4.93	21.5	17.5

5	3.87	20.5	17.0	4.55	22.0	17.5
6	3.93	21.5	17.0	4.36	23.0	18.0
7	3.54	20.2	16.5	4.64	22.0	17.5
8	3.79	*	*	4.53	21.5	17.0
9				3.80	21.0	16.0
10				4.66	21.0	17.5
11				4.26	21.0	18.0
12				3.64	21.0	16.0
13				3.56	20.5	15.0
14				3.59	19.5	17.0
15				3.57	21.0	16.5
16				2.65	18.5	16.5
17				3.63	20.0	17.5
18				3.43	20.0	16.0
19				3.50	20.0	16.0

* = no value due to egg damage

During the study period, two snails were observed mating which last for some hours, this is supported by Akinnusi, (1997) who stated that snails are hermaphrodite but they practice sexual reproduction. While Mead (1961), reported that a virgin snail kept in isolation for two years did not lay eggs. Only treatments 1 and 3 recorded egg laying. The clutch size of the eggs laid ranged between 1 and 12. This is in line with the findings of Omole, (1998) who gave 4-10. Ajayi, *et. al.*, (1978) recorded 6-12 while Plummer, (1975) observed that the clutch size of *Archachatina marginata* ranged between 3 and 16. Also, Awesu (1980), found it to be between 8 and 16. However, average weight of the eggs was 3.94g (range: 3.43-

4.93g). This figure was bigger than those observed by Imevbore, (1990) and Omole, (1998) who recorded the average weight of *A. marginata* to be 2.2g and 1.72g respectively. This variation could be due to size of the snail. The weight of snail has positive correlation with the egg laid (Hodasi, 1979). Average length and diameter of the eggs were 20.95mm and 16.17mm respectively.

The average weight of the hatchling at day old was 2.38g (range: 1.48 – 2.96g). This observation was similar to 2.14g recorded by Ajayi, *et. al.,* (1978) and 2-2.5g recorded by Akinnusi (1998), while Omole (1998) recorded 1.6 - 2.3g. The incubation period was between 21 and 33 days. Akinnusi (1998) recorded 30.25 days (range; 29-32 days), while Ajayi, *et. al.,* (1978) observed 30-45 days for the incubation period of the eggs.

Feed Responses

Feed-intake: The feed-intake of the snails is shown in table 3 below with T4 having the highest (3.336kg), while T2 recorded the least feed-intake. This was observed to be caused by the varied crude protein percentages, particle size of the feed and size (weight) of snails per treatment. Duncan average feed intake per treatment per day presented in Appendix 1c explains the homogeneity of the subset which indicated that treatments 1 and 3 having close values for average feed intake per treatment per day (T1= 2.1445 and T3= 1.9076) are homogenous. Harmonic mean sample used was 8 which equal the number of weeks used for the study. The mean for average feed intake for treatment 4 is the highest (T4= 8.3404±2.30857), followed by those of treatments 1 (T1= 2.1445±1.30551), 3 (T3= 1.9076±1.19973) and 2 (T2= 1.3528±0.75013) as shown in Appendix 1a. Analysis of variance which mirrored the variations in feed intake between and within different levels of crude-protein used in all the treatments to be significant .000* (3 df, $P<0.05$) as indicated in Appendix 1b.

Table 3: *Weekly Feed-intake of the Experimented Snails*

Weeks	Feed-intake (g)			
	T1	T2	T3	T4
1	238.8	82.88	197.83	273.69
2	160.31	144.61	174.84	548.57
3	88.23	79.03	110.04	500.22
4	63.72	53.43	48.40	352.92
5	119.01	57.00	61.11	384.55
6	84.27	33.02	56.69	507.9
7	34.16	22.41	43.87	255.87
8	69.3	68.75	70.24	512.43
Total	857.8	541.13	763.02	3,336.09

Weight Gain: Treatment 4 recorded the highest body weight gain (247g) followed by T2 (95g), while treatments 1 and 3 had reduction in their body weight at the end of the experiment by -119g and -76g respectively. Thus, it can be inferred that the weight gain of snails was not affected by the level of protein in the feed. Table 4 below gives the weight gain of the snails.

Table 4: *Weight-gain of the Snails*

Treatments	Initial weight (g)	Final weight (g)	Weight-gain (g)
T1	4,240	4,121	-119
T2	4,387	4,482	95
T3	4,216	4,140	-76
T4	4,273	4,520	247

Preference of the Snails on Fruits and Vegetable used: Fruits and vegetable used during the experiment include ripe and unripe pawpaw fruit, fresh and dried pawpaw leaves and water melon. In this experiment, it was observed that snails preferred ripe pawpaw fruit to other fruits and vegetables, this was followed by dried or rotten leaves of pawpaw (as it was soft and easy for them to rasp), and others down to *Amaranthus spp* .The order of preference of the feeds by the snails is shown below:

- Ripe pawpaw fruit xxxx
- Dried pawpaw leaves xxxx
- Water melon xxxx
- Unripe pawpaw fruit xxx
- Almond fruit xxx
- Squeezed, fresh pawpaw leaves xxx
- Banana peel xx
- Squeezed, fresh Ugu leaves xx
- Fresh leaves of *Amaranthus spp* x

Key:

xxxx Totally consumed
xxx Highly consumed
xx Moderately consumed
x Just a little bit eaten

It can be deduced from Appendix 1c below that there was variation in the feed intake per treatment per week between and within the four treatments. Treatment 4 was the highest (T4 = 3336.09g), followed by those of treatments 1 (T1= 857.8g); 3 (T3 = 763.02g) and 2 (T2 = 541.13g). This was observed to be caused by the varying crude protein levels, particle size of the feed and size (weight) of snails per treatment. Treatment 4 that had the highest feed intake had weight gain of 247g and had the finest particle size of feed. Treatment 1, though had the least crude protein percentage (17%) and the biggest particle size of feed,

had very small weight gain of -119g when compared to that of T4 (247g). Treatment 3 also had very small weight gain of -76g which was smaller when compared to those of T2 (95g) and T4 (247g). Treatment 2 had a bigger particle size of feed, 20% crude protein percentage and had the weight gain of 95g which explains the lowest feed intake recorded in T2. This was supported by Lameed, (2005) and Amusan, *et. al.* (1999) who recorded reduction in feed intake of snailets as they grow old and consequently gain more weight. The result of the weight gain of snails presented in Table 4 gives the weight gain of the snails in the following order; T4>T2>T3>T1. This therefore showed that the weight gain of snails is not really affected by the level of protein in the feed consumed.

CONCLUSION

It is evident from the study that the level of crude protein, feed particle size as well as different sizes of the snail affected the feed intake of the snails. This then necessitated the use of snails of uniform size and the same particle size of feed to indicate differences in the reaction of snails to different levels of crude protein.

High fecundity rate was recorded in T3 and higher values were obtained for the weight, length and diameter of eggs in T3 compared with those laid in T1. Therefore, high crude-protein (23%) with finer particle size in the feed of snails will enhance high fecundity, bigger sized hatchlings and highly viable snailets. Thus, 23% crude protein level is advisable in large scale production of snail.

The weight gain of snails was not affected by the level of protein in the feed. This implies that protein in the feed of farm animals does not absolutely contribute to the weight of the animals but can influence and boost their level of fecundity.

RECOMMENDATIONS

Based on our findings in the course of this work, we recommend that:

- Snails like eating their food in bits from each cut until they are satisfied. Therefore, fruits and vegetables should be cut into smaller pieces to minimize food wastage and reduce cost of feeding;
- Compounded feed should be moistened before giving to snails, for easy consumption;
- Snail eggs should be kept as much as possible away from the heat of sun. The eggs should not be exposed to day light at the early stage between (1st -7th day). Therefore, any measurement on the eggs should be taken after seven days;
- Artificial incubation allowed proper monitoring, cares and management of the eggs. It also ensures higher hatchability. It is therefore recommended for large scale production of snails in captivity;
- Finally, high crude-protein of (23%) with finer particle size in the feed of snails enhanced high fecundity, bigger size hatchlings and highly viable snailets. Thus, 23% crude protein level is recommended in large scale production of snail

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APPENDIX 1

(1a) Average Feed-intake per Treatment per day

	N	Mean	Std. Deviation	Std. Error
T1	8	2.1445	1.30551	.46157
T2	8	1.3528	.75013	.26521
T3	8	1.9076	1.19973	.42417
T4	8	8.3404	2.30857	.81620
Total	32	3.4363	3.22502	.57011

The mean for average feed intake for treatment 4 is the highest (T4= 8.3404), followed by those of treatments 1 (T1= 2.1445), 3 (T3 =1.9076) and 2 (T2 =1.3528).

(1b) Average feed intake per treatment per day

(ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	259.173	3	86.391	38.244	.000
Within Groups	63.251	28	2.259		
Total	322.424	31			

Table above shows the variations in feed intake within and between different levels of crude-protein used in all the treatments.

(1c) Duncan average feed intake per treatment per day.

Treatments	N	Subset for alpha = 0.05	
		1	2
T2	8	1.3528	
T3	8	1.9076	
T1	8	2.1445	
T4	8		8.3404
Sig.		.329	1.000

The table beside shows the means for treatments in homogeneous subsets. Harmonic Mean Sample Size used is 8.

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

Plate 6

Plate 7

Plate 8

Plate 9

APPENDIX 2 (List of Plates)

- **Plate 1:** The wooden cage used for the experiment
- **Plate 2:** Interior Partition of the cage
- **Plate 3:** Ripe pawpaw fruit
- **Plate 4:** Compouded feed of four types
- **Plate 5:** Compounded feed served to the snails
- **Plate 6:** Sensitive weighing balance used to weigh snails before and after the experiment
- **Plate 7:** Cracked egg due to its exposure to day light
- **Plate 8:** Two giant African land snails during mating activities
- **Plate 9:** Mimicking natural arrangement of the snail eggs during artificial incubation