Original Research Article

COMPARATIVE COST EFFECTIVENESS OF GROWTH AND REPRODUCTIVE PERFORMANCE OF THE *ARCHATINA ARCHATINA* FED COMPOUNDED FEED AND NATURAL FEED MATERIALS

ABSTRACT

This study evaluated the response of the giant African land *Archatina archatina* snails to three different diets, with regards feed intake, feed conversion, shell length and weight gain. A comparative cost analysis of growing snails with the different diets was also carried out. Sixty (60) snails were divided into three replicates of 20 snails each and placed on three different diets or treatments. Treatment I consisted of natural feed items only, Treatment II of compounded feed, while Treatment III was a mix of natural and compounded feeds. Each replicate was given 100g of feed every two days and water was given *ad libitum*. Feed leftovers and shell length were regularly measured and analyzed using descriptive and inferential statistics. Results showed that Treatment III snails had significantly ($P<0.05$) higher levels of feed intake than the replicates of Treatment I and Treatment II while no statistically significant difference ($p>0.05$) in feed conversion, weight gain and shell length were observed for the three different treatments. Though more expensive for poor farmers, Treatment III was found to have the best potentials for sustainability and economy of snail farming.

Key words: Growth performance, *Achatina achatina*, weight gain, compounded feed, natural feed

1. BACKGROUND OF THE STUDY

Snails are bilaterally symmetrical invertebrates with soft-segmented exoskeleton in the form of calcareous shells [1]. They belong to the phylum Mollusca and are hermaphrodites. They must mate with another snail of the same species before they lay eggs. Often, some act as males in one season and as females the next season. Other snails play both roles at once and fertilize each other simultaneously [2] [3] [4]. Typically in Africa, snails are gathered from nearby bushes and forests, usually from damp places under leaves, trees, stumps and stones and are more abundant during the raining season. They are reared in captivity either using the indoor or outdoor systems.

The indoor system generally involves raising snails in pens located in well-constructed or make-shift buildings. This system may utilizes little space as the snails could be raised even in trays placed on

shelves by the wall. Under advanced management, the system allows for temperature regulation, controlled lighting, regular cleaning, and health care. In these confined spaces, the farmer supplies the nutritional needs of the snails on a regular basis. These usually include a mixture of fresh vegetables, concentrates and other food materials. In the outdoor system, snails are raised out-doors on pastures. The snails may or may not be fed, but usually move about feeding on natural food materials. A modification of the out-door system confines the snails in enclosures and feeding is done using both synthetic and natural diets [5]. On maturity, the snails are harvested, processed and consumed or used as bi-products in cosmetics and medicines.

Africa is home to the largest species of land snail in the world. The Giant African land snail (*Achatina sp*), can grow up to 30 cm in length and are found mainly in the tropical rain forests of Guinea, Liberia, Sierra Leone, Ivory Coast, Ghana, Nigeria and Cameroon [6] [7]. Snail meat has been a major ingredient in the diet of many communities living in the high forest zone. Historical accounts indicate that in the Middle Ages, the Romans had specific gardens where snails were selectively reared for eating. According to [8], snail meat is very rich in proteins and is recommended by the Food and Agricultural Organization (FAO) as a healthy source of animal protein.

Table 1 summarizes the proximate nutritional composition of fresh snail meat. Chiefly, crude protein is 18.20 percent, iron 12.2mg/100g and other mineral constituent is 60.5mg/100g.

Table 1. Proximate composition of fresh snail meat

Nutrient	Value
Crude protein	18.20%
Carbohydrate	2.88%
Ether extract	1.36%
Fat	1.01%
Crude fibre	0.07%
Ash	1.37%
Nitrogen free extract	4.95%
Iron	12.2mg/100g
Water	74.06%
Other mineral constituents	60.5mg/100g

Adapted from [9].

Table 2 compares the nutritional values of snail with other food animals. Clearly, the level of protein in snail meat is only comparable to that of chicken. Moreover, snail meat has less fat compared to beef, chicken and whole milk. [10] note also that in addition to good quality protein, snail has potassium, phosphorus, essential amino acids and vitamins C and B complex.

Table 2. Nutritional values of snail compared with other food animals

Food Items	Protein	Fat	Ash	Water
Snail meat	20.7	1.21	1.49	73.67
Beef	17.5	22	0.9	60
Chicken	20.2	12.6	1	81.8
Cow (whole milk)	3.5	3.8	0.7	87.3

Adapted from [9]

Furthermore, empirical evidence indicate that the glandular substances in edible snail meat cause agglutination of certain bacteria, which is of value in fighting a variety of ailments, including whooping cough. Edible snails also play an important role in folk medicine. The bluish liquid obtained from the shell when the meat has been removed is believed to be good for infant development. The high iron content of the meat is considered important in treating anemia and is also recommended for combating ulcers and asthma. In the Roman Empire, snail meat was believed to contain aphrodisiac properties and was often served to visiting dignitaries in the late evening [7]

Globally, culinary tastes of people have turned in favor of 'white meat' of which snail meat is one, and chefs in the increasing number of multicultural restaurants are creating exciting and different types of snail cuisines. Snail consumption has therefore increased in Africa due to more people avoiding red meat for health reasons [11]. Given a fast diminishing population of wild snails and a fast growing demand for snail meat, the opportunity to create wealth from snail farming is increasing in both the developed and the less developed countries. In countries where stringent health regulations for consumption of food are in place, controlled snail farming has protected the consumer against collected snails that may have ingested toxic plants and other harmful substance.

Snail farming or heliculture is a niche and money spinning enterprise business, requiring little startup and operating costs, less professional knowledge, and less labor requirement. Yet the market potential of snail is inexhaustible, both locally and internationally. Snail is an export commodity, which has value next to gold in many advanced countries [11] [12] [13]. With a startup capital of XAF 100,000, a small scale snail farmer can generate as much as XAF 1,000,000 within one year. The bulk of snails consumed in Cameroon are hand-picked from the wild, mostly in the night because their nocturnal character [14]. But with the fast growing demand for snail, snail farming can become an avenue for self-employment and job creation [4] [9] [15].

A handful of successful small-scale snail production schemes have been documented in Cameroon and Nigeria, but empirical evidence on the most appropriate feeding material is scanty. Experts agree however that inadequate fresh natural feeding materials can hinder large scale production [16] [17][18]. Therefore, to sustain small and large scale farming of *Archatina archatina* in Cameroon, alternative cheap and readily available feed source is necessary, although most plant food materials are seasonal [13]. Sound knowledge of the appropriate combination of snail feed material is essential for the growth of commercial snail farming. This study aimed to determine the comparative cost-effectiveness of growth performance of the giant African land snail *Archatina archatina* fed with two forms of composed feed on the one hand and the set feed with naturally occurring fruits and vegetables on the other hand. More specifically, the study evaluates how the three sets of snails fared in terms of consumption rate, weight gain, feed conversion and shell length. The study also compared the cost effectiveness of the different snail feeding options.

2. MATERIALS AND METHODS

The experiment was carried out at the research farm of Pan-African Institute for Development (PAID-WA), Buea, South-West Region, Cameroon. Buea has an annual rainfall of 2300 mm with average temperature 24 - 25^{o}C and relative humidity of 90 percent. Seven months old *Archatina archatina* snails were collected from the well-sectored production farm of PAID-WA for the trial. As summarized in Table 3 below, the treatment for each of the three replicates was formulated as earlier described, that is; Treatment I was of natural feed items, Treatment II of compounded feed, and Treatment III of 50 percent natural feed plus 50 percent compounded feed. Each replicate (experimental group) had twenty snails each weighing 25 - 30grammes.

Table 3: Composition of dietary items for snails grown in the Pan African Institute for Development West Africa (PAID-WA) Buea.

Treatment I Compounded feed Ingredient (100 %) Diet A	**Treatment II** Natural feed materials	**Treatment III** Mix of compounded and natural feed materials
Maize (56)	Okra leaves	50% of Compounded feed mixture and 50% of natural feed materials
Soya bean (16)	Sweet potatoes tubers	
Fish meal (4)	Banana fruit	
Bone meal (6)	*Wild Telferia occidentalis*	
Concentrate (2)	Paw-paw leaves	
Remoulage (15)	Paw-paw fruits	
Calaba chalk (1)		

Each replicate was stocked in wooden cages (1m x 1m x 0.5m) that were enclosed with mesh that protected the nails from insects and other parasites. The wooden box were constructed in a manner that prevented the snails from crawling out while also allowing for adequate ventilation. The wooden cages were filled with loamy soil prepared in the ratio of 3:1 of normal soil and sharp sand respectively. A soil content of 10cm thickness was maintained for each replicate. Each cages was placed on four wooden legs that were raised 10cm above the ground. Mulching was done using dried plantain leaves, which was constantly kept moist.

A 14 days adaptability period was allowed before the start of the experiment. As snails are nocturnal, feeding was done the evening after every two days. Each replicate received 100g of feed. The left-over feed of each cage was removed and weighed periodically to determine and record feed intake. Care was taken to separate leftover feed from the soil. Before replacement, the feeding plates were thoroughly washed to ensure that the snails were not exposed to potential diseases. Shell length and weight gain were measured after every two weeks. The shell length was taken with a meter venier caliper while weight was taken using an electronic balance. Other parameters measured were mortality and feed conversion ratio. An equal amount of water was provided *ad libitum* in water trough. Water was also used to moisten the soil by sprinkling. This was done each time the snails were fed. The area was constantly swept and disinfected to keep away predators like ants. The three cages were kept in the house to protect the snails from excessive sunlight and rain.

3. STATISTICAL ANALYSIS

The data was analyzed using descriptive and inferential statistics. The descriptive statistics included means and standard deviation while the inferential statistics included a one-way Analysis of Variance (ANOVA) and a Tukey post hoc test. The analysis was done using Statistical Package for the Social Science (SPSS) 20. The Feed Conversion Ratio (FCR) was calculated using the formula: *feed intake÷ weight gain*. In other words, the FCR is the mathematical relationship between the input of the feed that has been fed and the weight gain of a population. The lower FCR, the higher the weight gain obtained from the feed.

4. RESULTS AND DISCUSSION

4.1. Effect of feed type on feed intake

Table 4 summarizes the analysis of feed intake by replicate. The mean feed intake stood at 56.5 (± 18.32) gram for Treatment I, 63.11 (±13.5) gram for Treatment II, and 74.1 (± 10.10) gram for Treatment III. Feed intake was highest for Treatment III

Table 4: Descriptive statistics of feed intake by snails for various treatments

Treatments	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Treatment I	45	56.5556	18.32603	2.73188	51.0498	62.0613	20.00	95.00
Treatment II	45	63.1111	13.56001	2.02141	59.0372	67.1850	40.00	93.00
Treatment III	45	74.1778	10.10016	1.50564	71.1434	77.2122	55.00	95.00
Total	135	64.6148	16.04471	1.38091	61.8836	67.3460	20.00	95.00

Table 5 presents the results of a one-way ANOVA used to determine whether there are statistically significant differences in the feed intake for the various treatments. It was observed that there was a statistically significant difference in mean feed intake by the snails for the different feed types (*F(2,132)=17.226; p=0.00*).

Table 5. Results of Analysis of Variance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7139.837	2	3569.919	17.226	0.000
Within Groups	27356.133	132	207.243		
Total	34495.970	134			

Table 6 shows the result of a Tukey post hoc test used to differentiate means. The test reveals that feed intake for Treatment III was significantly higher than feed intake for Treatment II (p=0.001) with a mean difference of 11.06 (± 3.03) grams. Also, feed intake for Treatment III was statistically significantly different from feed intake for Treatment I (p=0.000) by a mean difference of 17.62 (± 3.03).

Table 6: Multiple Comparisons of feed type

Treatment Group (I)	Treatment Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Organic	Compounded	6.55556	3.03493	0.082	-0.6386	13.7497
	Mixed	-11.06667*	3.03493	0.001	-18.2608	-3.8725
Compounded	Organic	-6.55556	3.03493	0.082	-13.7497	0.6386
	Mixed	-17.62222*	3.03493	0.000	-24.8164	-10.4281

Mixed	Organic	11.06667*	3.03493	0.001	3.8725	18.2608
	Compounded	17.62222*	3.03493	0.000	10.4281	24.8164

*. The mean difference is significant at the 0.05 level.

On the other hand, feed intake for Treatment I was not statistically significantly different from feed intake for Treatment II (p=0.08). This results contrast reports by [19] and [20] which reported significant (P>0.05) differences in feed intake as a result of the different diets fed. Snails on herbage diet had a feed intake value significantly (P<0.05) higher than those on standard poultry diet.

4.2.Effect of feed type on weight gain

The results as provided in Table 7 shows increases in the body weight of the snail for all the three treatments. However, the one-way ANOVA test did not indicate any statistically significant difference due to the different feed types (*F(2,15)=1.060; p=0.371*). From the body weight gains of the *A. archatina*, it could be stated that compounded diets from locally available feedstuffs compares favorably with farm plant leaves. These implies that in difficult moments, farmers can cost effectively replace compounded feed with farm materials without any lost in production.

Table 7. Results of Analysis of Variance for weight gain

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12155.444	2	6077.722	1.060	0.371
Within Groups	86004.167	15	5733.611		
Total	98159.611	17			

These results are similar to those of [13] [21]. However, the present results differs from those obtained by [12] who noted significant differences (P<0.05) between young African giant land snail fed on plant leaves (green papaw leaves) and broiler grower's mash

4.3. Effect of feed type on feed conversion

Feed conversion is an important indicator of snail growth as feed intake alone does not indicate conversion. Table 8 shows the result of a one-way ANOVA test indicating no statistically significant difference in feed conversion by snails of the three replicates (*F(2,15)=2.523; p=0.114*).

Table 8. Results of Analysis of Variance for feed conversion

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.002	2	.001	2.523	0.114
Within Groups	0.005	15	.000		
Total	0.006	17			

The result summarized in Table 8 is comparable to those of [13] [20]. A study [22] however reported significant difference in feed conversion ratios due to differences in the diet composed for different group of snails. Equally, [13] reported that supplementing plant leaves with compounded diets produced high snail yield.

4.4. Effect of feed type on shell length

The results of the effect of diet on the shell length of the snails are presented in Table 9. A one-way ANOVA test showed that there was no statistically significant difference in shell length of the snails for the different feed types (*F(2,357)=1.793; p=0.168*).

Table 9. Results of Analysis of Variance for shell length

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	63.754	2	31.877	1.793	0.168
Within Groups	6346.815	357	17.778		
Total	6410.569	359			

These result is similar to that obtained by [13] but contrast with [12] who reported significant differences ($P<0.05$) between young African giant land snail fed on plant leaves (green papaw leaves) and broiler grower's mash. Increase in the shell length of the snails in all the treatments indicate that the plant leaves as well as the diets aid the entire body growth of the snails. The morphological parameters of the snails in all the treatments were observed to increase proportional to their body weight, proving that the plant food materials and the diets have competing effects on snail growth.

4.5.Cost - benefit assessment of the feed types

Table 10 presents the cost analysis of Treatment I, II and III, based on the market prices of the feed materials. Organic feeds comprised the natural feed resources, which include pawpaw fruit = 225frs/kg, pawpaw leaf = 150frs/kg, sweet potato = 175frs/kg, banana fruit = 250frs/kg, okra leaves =

200 frs/kg and compounded feed based diets 320frs/kg. The total cost of feed intake was 509 FCFA for Treatment I, 908.8 FCFA Treatment II, and 867.88 FCFA for Treatment III. Cost of feed per gram body weight is as follows: 25.45 FCFA, 45.44 FCFA and 43.394 FCFA for Treatment I, II and III respectively.

Table 10: Cost-benefit analysis of snails feed types

PARAMETERS	Treatment I	Treatment II	Treatment III
Cost/kg feed (FCFA)	200	320	260
Total feed intake (g)	2545	2545	3338
Total cost of feed Intake (FCFA)	509	908.8	867.88
Average weight gain (g)	37.5	37	39
Cost of feed/g body weight (FCFA)	25.45	45.44	43.394

Whereas at May, 2016:
1kg Compounded feed for snails = 320frs
1kg pawpaw fruit = 225frs
1kg pawpaw leaf = 150frs
1kg sweet potato = 175frs
1kg Banana fruit = 250frs
1kg okra leaves = 200frs

The result indicates that compounded feed was the most expensive feed. This is in contrast to the reports of [19] that it was more profitable to feed snails with concentrate diets. The mixed diet gave the highest weight gain followed by organic feed stuffs diet, and the least being compounded.

5. CONCLUSION

The indifference in feed intake, weight gain, feed conversion and shell length revealed that organic diets and compounded diets have good potentials of sustaining snail farming, though compounded diets are a little expensive and may be unaffordable in some areas. This is beneficial to farmers given that there is high availability of these materials for free collection in nature especially during the rainy season. Though the availability of these materials is a drawback in the dry season, small scale farmers can easily produce these organic feeds in gardens behind their houses or resolved to compounded feeds without affecting the output. The indifference in the results also show that using either compounded diets or organic diets of right proportions will not affect the predicted yields.

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