Current Journal of Applied Science and Technology

23(3): 1-8, 2017; Article no.CJAST.35734
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Comparative Cost Effectiveness of Growth and Reproductive Performance of the *Archatina archatina* Fed Compounded Feed and Natural Feed Materials

Anold Tatah Kong[1*], Essia Uwem[1], Delvis Fru Ngang[1] and Brain Viyof Vegah[2]

[1]Pan African Institute for Development - West Africa (PAID-WA) Box 133, Buea, Cameroon.
[2]Centre for Development and Environmental Protection (CEDEP), Buea, Cameroon.

Authors' contributions

This work was carried out in collaboration between all authors. Author ATK designed the study, wrote the protocol, carried out the field experiment and co-wrote the draft. Author EU managed the literature searches. Author DFN performed the statistical analysis. Author BVV co- wrote the draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/35734
Editor(s):
(1) Xu Jianhua, Department of Geography, East China Normal University, China.
Reviewers:
(1) José Alfredo Villagómez-Cortés, Universidad Veracruzana Veracruz, Mexico.
(2) Iyiola, Adams Ovie (mfs), Osun State University, Osogbo, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/20861

Original Research Article

Received 27th July 2017
Accepted 19th August 2017
Published 8th September 2017

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. 180 snails were divided into three treatments and replicated thrice with 20 snails per replicate. 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 100 g 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=0.00) higher levels of feed intake than the replicates of Treatment I and Treatment II while no statistically significant difference in weight gain (P=0.37), feed conversion (P=0.11) and

**Corresponding author: E-mail: arnoldkong26@yahoo.com;*

shell length (*P*=0.17) were observed for the three different treatments. Though more expensive at commencement for poor farmers, Treatment III was found to have the best potentials for sustainability of snail farming.

Keywords: Growth performance; Achatina achatina; weight gain; compounded feed; natural feed; cost effectiveness.

1. INTRODUCTION

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 [2-4]. 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 12.2 mg/100 g and other mineral constituent is 60.5 mg/100 g.

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	12.2 mg/100 g
Water	74.06%
Other mineral constituents	60.5 mg/100 g

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.

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].

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]

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 [11-13]. 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 [16-18]. 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°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, the diets for each of the three treatments were 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 – 30 grammes.

Each replicate was stocked in wooden cages (1 m x 1 m x 0.5 m) that were enclosed with mesh that protected the nails from pests. 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 10 cm thickness was maintained for each replicate. Each cages was placed on four wooden legs that were raised 10 cm above the ground. Mulching was done using dried plantain leaves, which was constantly kept moist.

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

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

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 100 g 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 vernier 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. The study lasted for 3 months.

2.1 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:

$$Feed\ Conversion\ Ratio = \frac{Feed\ Intake\ (g)}{Weight\ gain\ (g)}$$

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.

3. RESULTS AND DISCUSSION

3.1 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 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)=17.23; P=0.00*).

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	56.56	18.33	2.73	51.05	62.06	20.00	95.00
Treatment II	45	63.11	13.56	2.02	59.04	67.19	40.00	93.00
Treatment III	45	74.18	10.10	1.51	71.14	77.21	55.00	95.00
Total	135	64.61	16.05	1.38	61.88	67.35	20.00	95.00

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*=0.00) by a mean difference of 17.62 (± 3.03).

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 [19,20] 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.

3.2 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 in weight gain 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.

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

3.3 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 5. Results of analysis of variance

	Sum of squares	df	Mean square	F	Sig.
Between Groups	7139.84	2	3569.92	17.23	0.00
Within Groups	27356.13	132	207.24		
Total	34495.97	134			

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
Treatment I	Treatment II	-6.54	3.04	0.08	-13.75	0.64
	Treatment III	-17.62*	3.04	0.00	-24.82	-10.43
Treatment II	Treatment I	6.56	3.04	0.08	-0.64	13.75
	Treatment III	-11.07*	3.04	0.00	-18.26	-3.87
Treatment III	Treatment I	17.62*	3.04	0.00	10.43	24.82
	Treatment II	11.07*	3.04	0.001	3.87	18.26

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

Table 7. Results of analysis of variance for weight gain

	Sum of squares	df	Mean square	F	Sig.
Between Groups	12155.44	2	6077.72	1.06	0.37
Within Groups	86004.17	15	5733.61		
Total	98159.61	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.

3.4 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*).

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.

3.5 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 = 225 frs/kg, pawpaw leaf = 150 frs/kg, sweet potato = 175 frs/kg, banana fruit = 250 frs/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.

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.

Table 8. Results of analysis of variance for feed conversion

	Sum of squares	df	Mean square	F	Sig.
Between Groups	0.002	2	.001	2.52	0.11
Within Groups	0.005	15	.000		
Total	0.006	17			

Table 9. Results of analysis of variance for shell length

	Sum of squares	df	Mean square	F	Sig.
Between Groups	63.75	2	31.88	1.79	0.17
Within Groups	6346.82	357	17.78		
Total	6410.57	359			

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	43.39

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

4. 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 organic materials (okra leaves, sweet potatoes tubers, banana peeling, paw-paw leaves and fruits, and *Wild Telferia occidentalis*) 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Agbogidi OM, Okonta BC, Dolor DE. Participation of rural women in sustainable forestry management and development. In Okoko, E., Adekunle, V. and Adeduntan, S, editors, Environmental Sustainability and Conservation in Nigeria. Akure: Jubee -Niyi Publishers; 2005.
2. Akinnusi O. Introduction to snail farming. Lagos: Omega Publishers; 1997.
3. Okafor F. Edible land snails: A manual of biological management and farming of snails. Lagos: Splendid Publishers; 2001.
4. Agbogidi OM, Okonta BC. Reducing poverty through snail farming in Nigeria. Agriculture and Biology Journal of North America. 2011;2(1):169-172.
5. Ahmadu Bello University. Snail Production Techniques in Nigeria. Extension Bulletin No. 108 Forestry Series No.12 National Agricultural Extension and Research Liaison Services, Zaria; 1995
6. Begg S. Farming Edible Snails - Lessons from Italy. Rural Industries Research and Development Corporation. Publication No 03/137. Project No SFI-1A; 2003.
7. Cobbinah JR, Vink A, Onwuka B. Snail farming: Production, processing and marketing (1st Ed.). Wageningen: Agromisia Foundation; 2008.
8. Akinnusi O. Snail rearing – case study Abeokuta, Ogun State, Nigeria. Proceeding of 5th Annual Conference of Animal Science Association of Nigeria, Port Harcourt Nigeria, Sept. 19-22; 2000.
9. Agbogidi OM, Okonta BC. Growth Response of *Achatina Achatina* (Linn.) and *Archachatina marginata I Swainson* as influenced by three vegetable feeds. ARPN Journal of Agricultural and Biological Science. 2011;6(9):72 -75.
10. Ngenwi A, Mafeni J, Etchu K, Oben F. Characteristics of snail farmers and constraints to increased production in West and Central Africa. African Journal of Environmental Science and Technology. 2010;4(5):274-278.
11. Olaleye DA. Consumers' preferences for snail meat in the Africa Community of Pittsburgh, Pennsylvania. A Research Paper Presented for the Master of Science in Agriculture and Natural Resources, the University of Tennessee at Martin; 2013.
12. Imevbore EA. Management techniques in rearing African giant land snail *Archachatina marginata* P.H.D Thesis, University of Ibadan, Nigeria; 1990.
13. Ejidike BN, Afolayan T. A effects of natural and compounded rations on the growth performance of african giant land snail (*Archachatina marginata*). Journal of Research In Forestry, Wildlife and Environment. 2010;2(1):107-111.
14. Etchu K, Mafeni M, Ngenwi A. Comparative performance of three edible snail species using intensive cage housing system in Cameroon. Bulletin of Animal Health Prodoction in Africa. 2008;56:345-352
15. Elimsile LJ. Snail and snail farming. World Animal Review. 1982;4:20 – 26.
16. Ajayi SS. Observation on the biological and nutritive value of the African Giant Snail (*Archachatina marginata*).East African Wildlife Journal. 1987;4:85 - 95.
17. Omole AJ, Oluokun JA, Oredein AO, Tiamiyu AK, Afolab AO, Adetoro FOand Adejuyigbe AP. Snails`production potential for increasing animal protein intake in West Africa. A paper presented at 26th Annual

NSAP Conference, March 21 – 25, Ilorin, Nigeria. 1999;393-401.
18. Wosu I. Commercial Snail Farming in West Africa: A guide. Nsukka: AP Express Publishers Ltd.; 2003.
19. Eze, J.N., Eruvbetine, D., Akpodiete, O. and Okonkwo, J. Feeding pattern, carcass and shell qualities of snails (*Archachatina marginata*) fed different material, Journal of Innovative Research in Engineering and Science. 2010;1:111–121.
20. Odo BI, Orji A. Evaluation of the growth performance of snails fed different forages under intensive management. Pakistan Journal of Nutrition. 2010;9:543-546.
21. Okonta B. Performance of giant African land snail *Archachatina marginata* (swainson) fed with selected diets. Global Journal of Bioscience and Biotechnology. 2012;1(2):182-185.
22. Okonkwo AG, Issac LJ, Nkanga I and Usoro OO. Effect of various feeding regimes on the performance of snails *A. marginata*. A paper presented at 25th annual NSAP conference, March 19-23, Umudike, Nigeria; 2000.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20861