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Reproductive performance of laying snails fed on roughages and different concentrate mix

Jimoh, A.O.

Department of Agricultural Technology. Federal Polytechnic Ado Ekiti. Nigeria.

Additional Keywords
Egg hatchability.
Fertile eggs.
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SUMMARY

This study aims to investigate the reproduction output of Archachatina marginata fed on roughage and concentrate feed with leaf meal inclusive diets. 150 point of lay snails weighing between 150-170g were randomly allotted to 5 treatment diets with ten (10) replicates, three (3) snails per replicate, designated as treatment 2 (GNCD) which has groundnut cake, Treatment 3 (GLLM) has *Gliricidia sepium*, Treatment 4 (MOLM) *Moringa oliefera* and Treatment 5 (LLLM) has *Leucaena leucocephala* leaf meals as protein source in snail diet and a control; treatment 1 (UPWP) fed roughage (unripe pawpaw and watermelon peel) in a 12 weeks feed trail. Feed intake, weight gain, egg lay, egg fertility, and hatchability and Gonado-somatic index were measured. The result revealed snails fed UPWP had least final weight and weight gain which was accompanied by the highest feed intake across the treatments. Average egg laid, hatchability, fertility, embryo mortality and average juvenile produced by snails on roughage-based diet were significantly least across the treatments. High gonado-somatic index of snails on leaf meal based diet accompanied with better reproductive output in laying snails were recorded. Snails fed Leucaena leucocephala inclusive diet had better egg production, fertility, hatchability and juvenile snails accompanied with gonado-somatic index across the treatments. In conclusion, concentrate ration is essential for optimal reproductive output in snails.

Rendimiento reproductivo de caracoles tendidos alimentados con forrajes y diferentes mezclas de concentrados

Palabras clave adicionales
Incubabilidad del huevo.
Huevos fértiles.
Comidas de hoja.
Caracol juvenil.
Supervivencia embrionaria.

RESUMEN

Este estudio tiene como objetivo investigar la producción reproductiva de Archachatina marginata alimentada con forraje y concentrado con dietas que incluyan harina de hojas. 150 puntos de caracoles laicos que pesaban entre 150-170 g se asignaron al azar a 5 dietas de tratamiento con diez (10) réplicas, tres (3) caracoles por réplica, designados como tratamiento 2 (GNCD) que tiene torta de maní, Tratamiento 3 (GLLM). *Gliricidia sepium*, Tratamiento 4 (MOLM), *Moringa oliefera* y Tratamiento 5 (LLLM) tiene harinas de hoja de *Leucaena leucocephala* como fuente de proteínas en la dieta de caracoles y un control; tratamiento 1 (UPWP) alimentado con forraje (papaya verde y cáscara de sandía) en una pista de alimentación de 12 semanas. Se midió el consumo de alimento, el aumento de peso, la postura de los huevos, la fertilidad de los huevos y la incubabilidad y el índice de Gonado-somático. El resultado reveló que los caracoles alimentados con UPWP tenían el menor peso final y el aumento de peso, que se acompañó de la mayor ingesta de alimento en todos los tratamientos. El promedio de huevos, la incubabilidad, la fertilidad, la mortalidad embrionaria y el promedio de juveniles producidos por caracoles en una dieta basada en forraje fueron significativamente menores en todos los tratamientos. Se registraron altos índices gonado-somáticos de caracoles en la dieta basada en harina de hojas acompañados de un mejor rendimiento reproductivo en los caracoles de postura. Los caracoles alimentados con dieta Leucaena leucocephala incluyeron una mejor producción de huevos, fertilidad, incubabilidad y caracoles juveniles acompañados con un índice gonado-somático en todos los tratamientos. En conclusión, la ración de concentrado es esencial para la producción reproductiva óptima en caracoles.

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abubakarjimoh2011@gmail.com

INTRODUCTION

Snail production in Nigeria, like most mini-livestock, is largely rudimentary and its demand is met by hunting from their habitat in the wild. The natural habitat of African giant land snail is facing deforestation and degradation due to human activities. Hence growing efforts to commercialize snail production to meet the animal protein demand. Large-scale snail farming of African giant land snail (*Archachatina marginata*) has paved way for it in the international market as well as meeting people's demand for the snail in the local market to the protein intake of the populace (Ejidike and Afolayan, 2010). Conventional feeds of snail comprise of breadfruits, waterleaf, pawpaw leaf and fruit, sweet orange, mango fruit, ripe fruit of plantain and banana and other feeds of plant origin (Isikwenu, 2015). The commercial farming of snails on a continuous basis trespassing and dry seasons through good management practices need assurance of constant feed supply. Thus, there is the need to source alternative

cheap and available feedstuff, not in competition with other animal species. Limitation of rearing snails includes their very slow growth rate and seasonal breeding pattern, severely limiting their productivity (Eze *et al*., 2010). This indicates the importance of intensive management and nutrition to induce profitability in snail farming. Concentrate feed or supplements is necessary to optimize the growth and productivity of the snail enterprise, as most of the plant food materials are seasonal and do not possess balanced nutrient. The high cost of concentrate ration occasioned by expensive conventional protein feedstuff could reduce the profit margin in snail enterprise. Ejidike and Afolayan (2010) pointed out that the availability of acceptable snail feed could contribute a lot in encouraging interest in snail farming, thereby mitigating the current acute animal protein shortage. However, the use of concentrate ration supplemented with plant materials in feeding snails will arouse the establishment of commercial farming of African giant land snails for constant supply to the market (Oyeagu *et al*., 2018). It is imperative to investigate non -conventional protein feedstuff such as leaf protein which is abundant and can be processed as feed all year long. Multipurpose browse plants such as *Moringa oleifera, leucaena leucocephala, Gliricidia sepium* leaves are valuable resource high in protein and minerals. This research therefore aimed at comparing the effect of roughage and concentrate feed with *Moringa oleifera, Leucaena leucocephala, Gliricidia sepium* leaf meal inclusion in snail diet on reproductive attributes of *Archachatina marginata.*

MATERIALS AND METHODS

Experimental protocol

The study was conducted at the Snail Research unit of Teaching and Research Farm, Department of Agricultural Technology, Federal Polytechnic, Ado-Ekiti, Nigeria. The study area is located between latitude 7°3′7′′N and 7′12′′N and latitude 5°11′′E and 5° 31′′E.

A total of 150 points of lay snails (*Archachatina marginata*) age range 7-8 months were purchased from a farm in Ibadan, Oyo state Nigeria. Snails were kept in wooden cages with dimension 30cm by 40cm by 24cm. Feed and water were provided in feeding and water trough. *Moringa oleifera, Leucaena leucocephala, Gliricidia sepium* leaf meals were obtained from pasture and forage field within the teaching and research farm premises. The harvested leaves were shed dried until they were crispy to touch while retaining their greenish coloration. The leaves were then milled to obtain a product herein referred to as *Moringa oleifera* leaf meal (MLM), *Leucaena leucocephala* leaf meal (LLM), *Gliricidia sepium* leaf meal (GLM). And designated as treatment 2 has soybean meal, treatment 3 has *Gliricidia sepium*, treatment 4 *Moringa oliefera* and treatment 5 has *Leucaena leucocephala* leaf meals as the protein source in snail diet and a control (treatment 1) fed the roughage (unripe pawpaw and watermelon peel).

The meals were analyzed for its chemical composition as described by AOAC (1990). The gross composition and chemical composition of experimental diets are shown in **Table I**. One hundred and fifty snails used for this experiment were randomly assigned into five (5) different treatments with ten (10) replicates three (3) snails per replicate. The cages, drinkers, and feeders were cleaned before the arrival of the snails, the first two (2) weeks for acclimatization of the snails before the experiment will commence. The snails were weighed individually at the start of the experiment, thereafter at the end of each week to determine the weekly live weight gain for the animal. The snails were fed ad libitum, both feeders and drinkers were cleaned before the provision of feed and water. The experiment was conducted for twelve (12) weeks.

Table I. The gross composition of the experimental diet (g/100g) (Composición bruta de la dieta experimental (g/100g).

	GNCD	GLLM	MOLM	LLLM
Maize	50	50	50	50
Wheat offal	27.5	27.5	27.5	27.5
Groundnut cake	16.5	-	-	-
Gliricidia	-	16.5	-	-
Moringa	-	-	16.5	-
Leucaena	-	-	-	16. 5
Bone meal	3	3	3	3
Oyster shell	3	3	3	3
Total	100	100	100	100
Nutrient Composition of Experimental diet				
Dry Matter (%)	83.46	74.17	72.02	72.78
Crude Protein (%)	17.10	13.70	14.58	14.82
Metabolizable Energy (kcal/kg)	2666.85	2303.03	2298.74	2231.25
Ether Extract (%)	3.95	3.78	5.17	3.72
Crude Fibre (%)	4.16	7.15	4.17	7.01
Calcium (%)	2.23	2.35	2.40	2.51
Phosphorus (%)	0.61	0.63	0.75	0.62

Feed intake was determined by finding the difference between the amount of feed supplied and the leftover feed for each replicate. Body weight and body weight gain were measured to know the cumulative differences between the final and initial body weights. Feed conversion ratio (FCR) was calculated from the ratio of feed intake to body weight gain during the experimental period.

Reproductive performance

The total number of eggs laid by the snails was determined and recorded. All eggs that did not hatch after the 30th day were collected and opened to determine the ones with dead embryos and those that were not fertile ab initio. These were counted and recorded. From these, the following parameters were calculated:

Fertility (%) = $\frac{\text{No. of eggs that hatched + No. of dead-in-shell}}{\text{Total no. of eggs laid}} \times 100$

Hatchability (%) = $\frac{\text{No. of eggs that hatched}}{\text{Total no. of fertile eggs}} \times 100$

Embryo mortality (%) = $\frac{\text{No. of dead-in-shell}}{\text{Total no. of fertile eggs}} \times 100$

At the end of the feeding trial, 12 snails were randomly selected from each treatment for organ assessment. The snails were euthanized by fast-freezing them at -20 °C/30 min (Nica *et al*., 2015). The foot (edible portion), the shell and the visceral mass were weighed separately. Organs such as gastrointestinal tracts, kidney, salivary gland, vagina, oviduct, penis, and mouth were extracted and weighed. Specimens were measured with a Vernier caliper and weighed in the analytical balance with a sensitivity of 0.01 g. The gonado-somatic index was estimated as expressed by Barber and Blake (2006); GSI = Gonad Weight × 100 /Organ weight

Statistical analysis

Data obtained in this study were subjected to analysis of variance at α=0.05 using the general linear model procedure of statistical analysis software. Means were separated with New Duncan's multiple range test of statistical analysis software (2011).

RESULTS

The reproductive performance of laying snails fed different treatments is shown in **Table II**. The initial weight was similar across the treatments, indicating homogeneity in randomizing and allotting snails to treatment. The final weight, weight gain, feed intake, the average egg laid, hatchability, fertility, embryo mortality and average juvenile snails were significantly ($p<0.05$) affected by the diets offered to snails. The shell changes were not statistically ($p>0.05$) influenced by the treatments.

The final weight of snails on T2 to T5 were statistically ($p>0.05$) similar and significantly ($p<0.05$) higher than snails on T1. The weight gain of snails on T2 was significantly ($p<0.05$) highest and the least value was obtained in T1. Snails on leaf meal inclusive diets (T3-T5) had statistically ($p>0.05$) similar weight gain. The feed intake of snails on T2- T5 were statistically ($p>0.05$) similar and significantly ($p<0.05$) lower than snails on T1. Feed conversion ratio of snails fed roughage (T1) was highest apparently compared to snails on other treatments.

The average egg laid per snails reveal that snails on leaf meal inclusive diets (T3-T5) had statistically ($p<0.05$) higher value and the significantly ($p<0.05$) least values were obtained in snails fed T1. Egg hatchability of snails on T4 and T5 were significantly ($p<0.05$) highest than snails on treatment 2 and 3. Fertility of eggs was significantly ($p<0.05$) highest in snails on T5 and least in snails on T1. Embryo mortality was statistically ($p>0.05$) similar in snails on concentrate based diets (T2-T5) and were significantly ($p<0.05$) lower than snails on T1. The average juvenile snails were statistically ($p>0.05$) similar in snails on leaf meal inclusive diets (T3-T5) and significantly ($p<0.05$) higher than snails on GNC inclusive diets.

Table II. Reproductive performance of laying snails fed roughages and concentrate with different leaf protein (Rendimiento reproductivo de los caracoles ponedores alimentados con forrajes y concentrados con diferentes proteínas de la hoja).

	UPWP	GNCD	GLLM	MOLM	LLLM	± SEM	P-Value
Initial weight (g/snail)	153.57	165.53	156.33	151.27	174.53	3.75	0.83
Final weight (g/snail)	211.36^{b}	259.45^{a}	241.16^{a}	246.00^{a}	259.26^{a}	7.70	0.04
Weight gain (g/d/snail)	0.69^{c}	1.24^{a}	1.13^{b}	1.13^{b}	1.01^{b}	0.03	0.03
Feed intake (g/snail/day)	36.87^{a}	26.29^{b}	26.22^{b}	26.07^{b}	26.01^{b}	3.08	0.03
Feed conversion ratio	57.61	21.20	23.20	23.07	25.75	4.67	0.76
Average egg laid per snail	2.26^{c}	5.07^{b}	8.13^{a}	6.07^{ab}	6.87^{ab}	2.07	0.04
Hatchability of eggs (%)	60.47^{c}	82.35^{b}	83.76^{b}	90.48^{a}	93.20^{a}	3.26	0.01
Fertility of eggs (%)	66.15^{d}	74.73^{c}	76.97^{c}	82.35^{b}	94.50^{a}	2.84	0.03
Embryo mortality	39.53^{a}	17.65^{b}	16.24^{b}	9.52^{bc}	6.80^{c}	5.05	0.03
No of Juveniles per snail	1.21^{c}	3.55^{b}	7.97^{a}	5.29^{ab}	6.88^{a}	0.86	0.02

abc: Means along the same row with different superscripts are significantly ($P<0.05$) different.

Table III. Reproductive organ weights of laying snails fed roughages and concentrate with different leaf protein (Pesos de **órganos** reproductivos de caracoles ponedores alimentados con forrajes y concentrados con diferentes proteínas de hojas).

	UPWP	GNCD	GLLM	MOLM	LLLM	±SEM	P- Value
Shell weight (g)	43.50^{b}	49.98^{a}	41.76^{b}	46.48^{a}	43.89^{b}	1.80	0.04
Carcass weight (g)	95.50^{c}	138.29^{a}	126.40^{ab}	118.75^{b}	139.54^{a}	4.73	0.03
Edible weight (g)	39.11^{c}	86.83^{a}	79.84^{ab}	94.23^{b}	82.61^{ab}	3.16	0.03
GIT weight (g)	28.56	30.12	31.42	28.69	31.90	0.59	0.24
Penis (g)	1.06^{b}	1.98^{a}	2.06^{a}	1.54^{ab}	1.57^{ab}	0.09	0.04
Oviduct (g)	4.36^{b}	2.63^{b}	4.24^{b}	4.42^{b}	10.21^{a}	0.92	0.04
Vagina (g)	0.16^{b}	0.37^{a}	0.35^{a}	0.25^{b}	0.41^{a}	0.04	0.03

abc: Means along the same row with different superscripts are significantly (P<0.05) different

Reproductive organ weights of laying snails fed different treatments are shown in **Table III**. All parameters assessed were significantly (p<0.05) affected by the treatments except GIT weight. The shell weight was significantly (p<0.05) higher in treatment 3 and 4 than the other treatments. The carcass weight was significantly (p<0.05) least in T1 followed by T4. The foot weight was significantly (p<0.05) least in snails on T1, followed by treatment 4 and significantly (p<0.05) highest value was obtained in snail on T1. The penis of snails on T2-T5were statistically (p<0.05) higher than snails on T1. Oviduct weight of snails on T5 was significantly (p<0.05) highest and other treatments share statistically (p>0.05) similar values. Vagina weight of treatments 1 and 4 are statistically similar (p<0.05) but are significantly (p<0.05) lower than snails on other treatments.

Gonado-somatic index of snails fed the different dietary treatments is shown in **Figure 1**. Snails on T5 had the significant (p<0.05) highest value and the significantly (p>0.05) least value is obtained in T2. Treatments 1,3 and 5 have statistically (p>0.05) similar values.

DISCUSSION

The trend reveals that snails fed UPWP had the least final weight and weight gain which was accompanied by the highest feed intake across the treatments. This indicates nutritional inadequacy, despite the high feed intake it could not meet its requirement for growth. This summarises the call for the balanced nutrient formulation to meet the production requirement of snails. This is important to enhance growth rate and reproduction in snails. Similarly, the average egg laid, hatchability, fertility, embryo mortality and average juvenile produced by snails on roughage-based diet were significantly least across the treatments. Thompson and Sheldon (2004) also reported that poor nutrition affects snail growth and causes a drop in the reproductive performance, this is evident in the result of laying snails fed roughage/natural plant material (UPWP) which had the least reproductive performance as compared to concentrate GNCD-LLLM fed snails. According to Amaefule and Onwudike (2000), Ani and Okeke (2003), Esonu et al (2003), Oyeagu et al (2015) and Oyeagu et al (2018), the most important factor influencing the performance of animals under captivity is the quality of diet offered to the animals. This study corroborates the claim of Nyameasem and Borketey-La (2014) that layer mash (a concentrate ration) supported reproduction in the snails better than Pawpaw fruit diet which gave the poorest result. This is attributed to the report that pawpaw fruit as a sole diet is not nutritionally balanced enough to meet snails' requirements for reproduction.

The reproductive traits of laying snails fed concentrate based feeds (GNCD-LLLM) was superior to plant/roughage fed snails. Nyameasem and Borketey-La (2014) reported that snails on compounded diets showed remarkable performance in terms of growth and reproduction over snails fed pawpaw fruit diet. This might be due to the fact that available nutrients of the diets originate from different feedstuffs thereby making them more balanced.

Egg hatchability, the fertility of eggs and average juvenile snails of snails on leaf mal inclusive diets were superior to concentrate fed snails without leaf meal inclusion this suggest the beneficial ability of the leaf meals to influence reproduction positively. This corroborates other reports in rabbits, poultry that leaf meals enhance reproduction and fertility (Ewuola et al

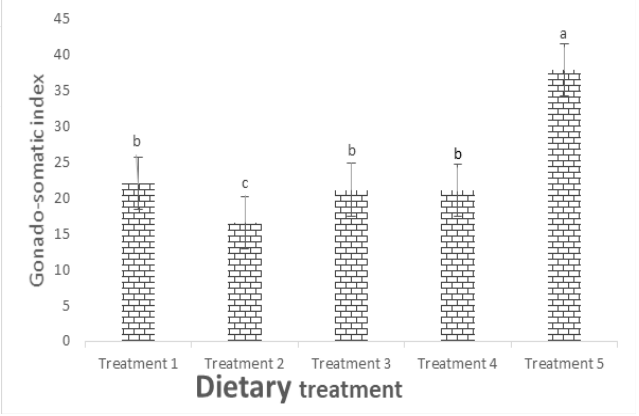

Figure 1. Gonado-somatic Index of laying snails fed roughages and concentrate with different leaf protein (Índice gonado-somático de caracoles ponedores alimentados con forrajes y concentrados con diferentes proteínas foliares). abc: Means with different superscripts are significantly (P<0.05) different

Similarly, Oyeagu et al (2018) reported that inclusion of C. *pubescens* in concentrate ration for snails increased the number of eggs laid, hatchability and fertility of eggs with a lesser mortality of the embryo.

The result of this study is in agreement with Ejidike et al (2002) that both growth and reproductive performance of African giant land snails (A. *marginata*) were better when their diets are supplemented with natural plant food materials than the snails that were placed on pure concentrate diets.

The concentrate ration enhanced reproductive organ development and the inclusions of leaf meals also contributed to organ development compared to laying snails on natural plant feed/roughage. However, gonado-somatic index of snails on herbs and roughage treatment was better than snails on concentrate without leaf meal inclusion. The reproductive ability of snails is predicted by the gonado-somatic index; this explains the high gonado-somatic index of snails on leaf meal based diet accompanied with better reproductive output in laying snails. However, the standout performer is snails fed *Leucaena leucocephala* inclusive treatment, judging by their egg production, fertility, hatchability and juvenile snails accompanied with gonado-somatic index.

CONCLUSION

Concentrate diet is essential for optimal reproductive output in snails. The conventional belief that snails are herbivores and can survive on herbs and roughage is for maintenance requirement. Productive functions as egg laying and snailet production require concentrate based feeding to improve growth and offspring production, especially for commercialization. The importance of leaf meals to snails as herbivores is demonstrated in this study; laying snails fed leaf meal inclusive diets have the higher reproductive ability.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research outcome presented in this article

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