TITLE PAGE

THE EFFECT OF FEEDING VARYING LEVELS OF RUMEN DIGESTA ON THE GROWTH OF AFRICAN LAND GIANT SNAIL (*ARCHACHATINA MARGINATA)*

APPROVAL PAGE

This Project has been approved for the Department of Vocational Teacher Education, Faculty of Education University of Nigeria, Nsukka.

By

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CERTIFICATION

Ifediba Christiana, a postgraduate student in the department of Vocational Teacher Education with Registration Number PG/M.Ed./07/42855 has satisfactorily completed the requirements for Master's Degree in Agricultural Education. The work embodied in this research project is original and has not been submitted in part or full for any other Diploma or degree of this or any other University.

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DEDICATION

This is dedicated to our Lord Jesus Christ to whom I owe all that I am and to Very Rev. Fr. Professor Christian Anieke and Monsignor Dr. Christopher Enem who laid the foundation of my academic greatness.

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The researcher's immense appreciation goes to Almighty God who made the completion of this programme possible. This project was done under the untiring supervision of Professor Nwabueze John. Ogbazi, a father, mentor and epitome of knowledge. I appreciate his effort in directing and criticizing the work constructively. Besides, I acknowledge Professor G.C. Okeke for accepting to supervise the practical section of the study. My profound gratitude goes to Dr. Ugwu and Dr. E.C. Osinem for stimulating my interest in practical snail rearing. I am indebted to the Head of department in Animal Science, Prof. A.G.Ezekwe for giving me the permission to use the facilities in their snailery and laboratory for the work. Special thanks to Professor Olaitan, Dr. Christian Nwachukwu and Dr. F.M. Onu for their wonderful assistance in editing and modifying this work.

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ABSTRACT

The study was designed to determine the effect of feeding varying levels of dried rumen digesta on the growth of African land giant snail (*Archachatina marginata).* Most snail feeds are seasonal and very expensive but rumen digesta is the waste product collected from the abattoir on daily basis at no cost. Three research questions and three null hypotheses guided the study. The study adopted an experimental research with completely randomized design. The growth rate was measured using sensitive digital weighing balance while Vennier Caliper was used to measure length and width. The feed intake was measured by a weigh-back technique. Proximate analysis of the feed was determined using Association of Official Analytical Chemists (1995) procedure. One way Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were used to analyze and test the null hypotheses. The findings depicted that treatment two (T_2) with 10% rumen digesta inclusion showed the highest weight gain and the increase in length and width was slightly higher than the snails in other treatments comparatively. Besides, the snails in treatment two indicated the highest feed consumption rate. The study inferred that rumen digesta could be fed to snails at 10% level of inclusion thus providing a cheaper source of feeding snails and help in utilizing the abattoir wastes to reduce associated environmental health hazard. It is recommended that extension agents should embark upon mass sensitization of snail rearing and how to compound snail feed using rumen digesta to reduce cost. Besides, rural and urban dwellers should be educated through government sponsored seminars and workshops on the nutritive value of snails and how to rear snails throughout the year using rumen digesta. Researchers on snail farming should be motivated and assisted through funds to publish their works for wider publicity on snail feeding and rearing which is still very new in the country.

CHAPTER I

INTRODUCTION

Background of the Study

The nutrients needed for life, growth and repair of body tissues are carbohydrates, protein, fats, minerals, water and fibre. The nutrient known to be usually in short supply is protein. Protein is of two origins: those from plants and those from animals. The FAO (Food and Agricultural Organization) in Nweze (2007) recommended 65-70g of protein per day per adult, out of which 35g must be of animal origin. The animal protein intake of many people is generally low leading to an acute malnutrition especially in developing countries. Oyenuga in Amusan and Omidiji (1998) stated that the essential amino acids in animal protein are more balanced and readily available to meet human dietary requirements than those of plant origin. In support of this, Akinnusi, Oso, Afolabi, Sogunle and Bamgbose (2007) stated that animal proteins are known to be preferable and better when compared with plant proteins based on their balanced amino acid profile.

The acute shortage of animal protein in the diets of many people demands that efforts should be directed to the rearing of animals that are highly prolific and highly desirable. A rich source of animal protein that has been silent for years in West Africa and is highly prolific is snail. Although man has eaten snail across the globe since pre-historic times when people gather them from the wild for food, the act of domesticating snail in most of the West African region is still a new venture (Chinwuko, 2007).

According to Akinyemi, Ojo and Akintomide (2007), the act of farming snails all started about 50 B.C. in the then Roman world where some species of snails were raised in special fattening units called “cochlear” gardens. Today, different structures are being designed to suit the species of snails being reared and the purpose of rearing. Bequaert in Chinwuko (2003) observed that snails are not only considered as a delicacy but also a medicinal and dietary therapy for hypertension, conjunctivitis, diabetes and iron-deficiency anemia. Mead in okafor (2009) also reported that Orthocalcium phosphate extract from snail could cure kidney diseases, tuberculosis, asthma, anemia, diabetes and certain circulatory disorders. However, Chinwuko (2003) stated that the nutritional value of snail is mainly attached to its high protein value.

Developing the snail industry/farm is the latest means of bridging the protein deficiency gap presently prevailing in many countries because snail is highly prolific and very nutritive. In order to make snail supply sufficient, its rearing is very vital to supplement the conventional method of picking snails from the wild.

Snail farming known as heliculture is a veritable means of increasing animal protein intake deficiency in the diet of average Nigerians because the demand exceeds supply. Heliculture could be practiced using various species of snails like*, Helix aspersa, Limicolaria Spp, Helix aperta* and African land giant snails like *Achatina achatina, Archachatina marginata, Achatina fulica* amongst others. African land giant snails (*Archachatina marginata)* are mostly preferred because they are highly economical and have high demand due to their size. At maturity, they are 11-19 cm long and weigh 150-800 gm The African land giant snails have the advantages of high adaptability and survivability. They are flesher, highly prolific in addition to their being abundant in Nigeria, Ghana and along the African continent. There is need to extend the supply of snail meat to all seasons of the year. This is because the seasonality of its supply limits largely its use as a regular meat.

In order to make snail meat available all year round, there is need to initiate some organized form of domesticating/rearing snails. This entails keeping the snails in an enclosure that is conducive as well as supplying them with acceptable feeds. For continuous production of snail, concise knowledge of snail nutrition is very important. Snail generally feed on both plant materials like leaves, fruits, tubers, compounded feed and kitchen wastes like peels etc. Purchasing compounded feed is very expensive while plant materials are seasonal. Therefore, effort should be directed towards feeding snails with cheap locally available but rich feed ingredients to minimize the effect of high cost of compounded feed and seasonality of plant materials to ensure continuity of snail production all year round. There is need for sourcing locally available and cheap sources of feed ingredients particularly those that do not attract competition in consumption between humans and livestock.

One of the possible sources of this is Dried Rumen Digesta (DRD). Rumen digesta is the solid matrix or ingested feed that is at different stages of degradation with saliva as the rumen liquor as well as microorganisms in the rumen of ruminant animals. It is animal waste product collected from the abattoir, dried and utilized in compounding snail feed. Rumen Digesta not only serves as a feed nutrient but when re-cycled will also reduce disposal and environmental pollution problems. Many researchers have worked on the use of rumen digesta in compounding livestock feed. For instance, Odunsi (2003) investigated on the blend of bovine blood and rumen digesta as a replacement for fishmeal and groundnut cake in layer diets. Dairo, Aina and Asafa (2005), demonstrated the performance evaluation of growing rabbits fed varying/graded levels of rumen digesta and blood rumen digesta mixture. Emenalom, Anyanwu, Ogbonna and Esonu (2006) carried out a study on evaluation of performance, organ characteristics and economic analysis of broiler finisher fed dried rumen digesta.

Dried Rumen Digesta contains high fibre that tends to increase the total fibre content of the snail diet. Snails require high fibre feeds to meet their energy requirement to sustain rapid growth and development. Rumen digesta also contains high protein component, undigested starchy and fibrous carbohydrates, short chain fatty acids and partially digested feed protein due to the influence of the microbial protein. The crude fibre content also activates the intestine, increases the occurrence of peristaltic movement and more enzyme production resulting to efficient absorption of nutrients in animals. (Kekeocha, 1984). This will enhance the growth of snails.

Plumer (1975) maintained that the average growth rate in snails generally is moderately low and depends largely on the type of feeding, type of management and environmental conditions. It is suspected that since rumen digesta performed very well in other animals like broiler (Emenalom et al., 2006), rabbit (Dairo et al., 2005) and layers (Odunsi, 2003) amongst others, using it to feed snail will enhance the growth rate.

This study is designed to find out the highest rumen digesta inclusion in formulating snail feed that will be most appropriate for rapid growth of snails. In order to achieve this, the experimental feed diets will be formulated using adjustable Pearson's Square method of feed formulation to contain dried rumen digesta at 0%, 5%, 10% and 15% levels respectively. The four experimental feeds will be compounded using maize, Soya bean, wheat bran, rumen digesta, fishmeal, bone meal and mineral premix. Due to high cost of wheat offal, it will be replaced with rumen digesta as a source of fibre in varying percentages. The control diet (0%) will not contain rumen digesta. Each of the four experimental feed will be fed with a particular diet daily to three replicates consisting of twelve snails simultaneously. The four treatments will be compared later to determine the growth response of these snails to the varying levels of rumen digesta in the feed.

Furthermore, conventional ingredients used in compounding snail feed such as maize, Soya beans, fishmeal, groundnut cake, wheat bran among others are very expensive, command higher priority and can pay higher than the compounded feed industry. Therefore, the seasonality of plant materials and high cost of conventional feed ingredients have necessitated the need for finding cheaper substitutes that are readily available and can be used in managing snail enterprise thereby making snail meat available on the table of every average Nigerian all year round.

Statement of the Problem

The increase in Population of the West African Nations and the rest of the developing world and decrease in food supply has put great pressure on the available food supply. Most staple foods are carbohydrates, thus food problems are more pronounced when there is inadequate consumption of protein especially animal protein because the protein from plant sources are usually insufficient to provide man with the necessary protein requirements (Akinnusi et al., 2007).

According to Olubanjo in Whyte and Wadak (2002), the intake of animal protein by Nigerians is generally poor resulting in acute malnutrition amongst the less privileged. There is acute competition between man and animals for the available plant proteins. The conventional sources of animal protein supply are cattle, sheep, goat, pig, poultry and fish. The increasing demands for animal protein coupled with more stringent economic conditions have necessitated greater interest in the production of cheap and very prolific micro-livestock like rabbit, grass cutter and snail amongst others to supplement other sources of animal protein.

Commercial snail production is one of the cheapest and simplest livestock productions within the reach of common person. This is because the cost benefit analysis of snail farming in Okafor (2009) showed that a farmer could commence snail enterprise with only one bucket of 400 snails costing twenty thousand naira. Since snails are highly prolific and a specie of African land giant snail lays up to 300-500 eggs per clutch, within a farming period of one year the profit margin will be very high. Besides, the management practices are very simple and within the reach of a common person when compared to other livestock production. Snails feed on a wide range of non-conventional feedstuffs that do not compete with man for the limited conventional feed resources. However, the success of snail farming as well as the availability of snail meat all through the year is largely dependent on the availability of feeds.

The availability of feeds is one of the major problems in many livestock productions including snail. Snails feed on leaves, vegetables, fruits as well as compounded feeds and kitchen wastes. Most conventional feedstuffs used in compounding the feed like maize, sorghum, soybeans and guinea corn are very costly and have high human preference and demand. Besides, plant materials are seasonal and very costly during dry season.

It is therefore very pertinent to seek for a possible solution to this problem by sourcing for alternative feed ingredients that would be locally available and affordable all year round for the farmers. One of the possible sources of this is dried rumen digesta. Rumen digesta is an unwanted material found in the recticulo-rumen of cattle and other ruminants. It could be collected from the abattoir almost on daily basis at no cost at all. Snails are known to perform well with feed rich in fibre which rumen digesta is highly rich in. Thus, instead of allowing such waste to cause environmental pollution and nuisance, there is the need to study its effect as feed ingredient on the growth performance of snails.

Purpose of the study

The major purpose of the study is to determine the effect of feeding varying levels of dried rumen digesta (DRD) on the growth of African land giant snails with a view to producing snails throughout the year. Specifically, the study will:

1. determine the weight gain (growth response) of African giant land snails to diets containing graded levels of sun dried rumen digesta.
2. find out the increase in the length and width of snails fed graded levels of rumen digesta.
3. determine feed intake of the snails as measured by the amount of feed consumed by African land giant snails on daily basis.

Research Questions

The following questions were formulated to guide the study:

1. What is the weight gain (growth response) of African land giant snails to diets containing graded levels of sun dried rumen digesta?
2. What is the increase in the length and width of snails fed graded levels of rumen digesta?
3. What is the feed intake of snails as measured by the amount of feed consumed by African land giant snails on daily basis?

Significance of the Study

This study focuses on all year availability of snail feed for the farmers using rumen digesta as an ingredient. The study will be of great significance to snail farmers, teachers, students, parents, Government, researchers and the public.

The knowledge of this non-conventional feed ingredient if utilized by snail farmers will enable them rear snails all year round at cheaper cost and with ease by compounding snail feed with dried rumen digesta collected relatively at no cost from the abattoir

The information about the nutritive value of dried rumen digesta obtained in the study will attract students, teachers and educators into snail farming, which is very new in the country; since production cost will be reduced when rumen digesta is used. It will spur students and teachers to research further on snail farming especially the feeding. The study will serve as reference material for other researchers.

The data contained in this study, if made available to parents will attract them into trying out the feeding technique and assist their children/wards offering agricultural science by financing their school and home projects in snail rearing. The findings of this study will hopefully encourage students to embark upon snail rearing to earn a living after graduation especially if they cannot go for further studies.

The findings of this study will be of utmost benefit to Ministries of Education and Agriculture, National Resources and Agricultural Research Institutes by providing them with useful data required for curriculum reform in secondary school agricultural science, policy making and implementation on snail rearing. Besides, the data therein will spur further research on the usefulness of rumen digesta as feed for other animal production.

Undoubtedly, the findings of this study will be of great benefit to the public and investors by encouraging them to embark upon snail farming thus increasing the quantity of snail available to consumers in the market thereby boosting the animal protein intake of many people. Snails will also be sold at cheaper rates since feeding becomes cheaper using non-conventional feed ingredient (rumen digesta).

It is expedient that this study will benefit job seekers, who will embark upon snail rearing as occupation thereby enforcing a shift from over dependency on the Government for job creation. Since snail farming is a great money-spinner both locally and internationally, many people will be encouraged to take it up as occupation and become self-reliant.

Hypotheses

The following hypotheses were formulated and tested at probability of 0.05 levels:

1. There is no significant difference in the mean weight gain of snails fed with rumen digesta and those fed with the control feed.
2. There is no significant difference in the mean length and width of snails fed graded levels of rumen digesta.
3. There is no significant difference in the mean feed intake of snails fed with graded levels rumen digesta

Assumptions

The following assumptions were made for the study:

1. Feeding snails with dried rumen digesta will provide adequate nutrients for the growing snails and will make for continuity of snail rearing all year round.
2. The specie of snails used for the study (*Archachatina marginata),* can be effectively managed by snail farmers.

3. If these snails are subjected to be fed with rumen digesta, they will still be very healthy and their mortality rate may be as low as those fed with the control group may.

Delimitation of the Study

The study focused on the non-conventional snail feed using rumen digesta as the locally available feed ingredient as well as determining its nutritional value in the diets and growth of African land giant growing snails (*Archachatina marginata)*. The parameters centered on the weight gain, length and width as well as the daily feed intake of snails. The experimental diets consisted of graded levels of feed formulated with dried rumen digesta

CHAPTER II

REVIEW OF LITERATURE

The literature for this study was reviewed under the following sub-headings:

- Theoretical Framework
- Establishment of Snails in the Farm
- The Nature of Snail Nutrition
- Rumen Digesta as a Source of Snail Feed
- Growth Pattern of African Land Giant Snails
- Anatomy of African Land Giant Snail (Archachatina marginata)
- Empirical Studies on Snail Feed Production and Use of Rumen Digesta as a Source of Animal Feed
- Summary of Literature Review

Theoretical Framework of the Study

Man is always trying to achieve the best that is humanly possible. He also tries to identify those factors that militate against his ability to attain his desired goals. In this study, some factors like the seasonality of snail feed as well as the high cost of conventional feed ingredient poses a great problem to snail production. Therefore, the theoretical framework of this study is based on the theories of production that studies the relationship between output and inputs that are responsible for its realization. The theory states that there is a functional relationship between output and its various inputs. Historically the well-known proponents of such theories are Adam Smith and Pierre Scraffa. Factors of production in snail farming are inputs which man manipulates like the use of rumen digesta in feeding snails as well as others to achieve economic outputs in snail production. Hansan (1996) corroborated that factors of production are inputs used to produce goods and services. The author listed the factors of production as land, labor, capital and entrepreneur.

Land according to Essang and Olayinde (1994) aids production in that it is on it that firms and industries are built. Land in the context of this study is a gift of nature consisting of water, forest and mineral resources that provide conducive environment for the growth of snails in order to ensure success in snail production. Besides, most snails need more calcium in the soil for good growth (Thompson, 2004). The pH value of the soil calcium must be available either from the soil or from another readily available source. Acidic soil should be neutralized with lime. A good medium soil that has neither a lot of sand nor too much clay could be used to rear snails. Soil that contain 20% to 40% organic matter is good. Besides, good soil favors snail growth and provides some of their nutrition. Lack of good soil may cause fragile shells even when the snails have well balanced feed. The snails' growth may lag far behind the growth of other snails on good soil. Alimi (2000) stated that in order to achieve optimum production level, resources must be available and the quantity of available resources must be used efficiently. Land is very essential since the skills needed for effective snail farming are carried out on land.

Labour is a factor that serves as input into all aspects of snail enterprise in order to obtain economic success in production. Harvey (1998) asserted that labour is the actual effort or activity, both physical and mental made by human beings in carrying out some work. In the context of this study, man makes use of labour to carry out activities in snail farming. These activities are the skills required by the farmers for the proper growth of snails in order to generate efficient labour for economic benefit in snail production. Production may not be very possible in the absence of labour. Therefore, labour is very essential in collecting and sun drying the rumen digesta. Labour can be referred here as a tool with which managerial skills and other factors of production are used to produce output and maximize profit.

Capital may be considered as a wealth set aside for the production of further wealth. In the view of Ehiametalor, Osu, Makeri and Oladunjoye (1986), capital is a man made factor of production consisting of physical cash, buildings, equipments and tools used in production. The success in snail production is based on efficient use of money, snail feeds and other inputs to perform tasks or activities needed to generate income in snail farming. This is because snail production is one of the areas in animal production that requires considerable low investment capital comparatively. Besides, the use of rumen digesta in snail production will reduce cost of production thereby boosting the farmer's income. Adam Smith's theory of cost of production of value is the theory that the price of an object or condition is determined by the sum of the cost of the resources that went into making it.

Entrepreneur or management describes the person who decides what goods to produce and brings the production resources to use. In the context of this study, the farmer is the sole manager who decides how best to feed the snails to boost efficiency and maximize output. The use of rumen digesta could be required in this decision. Etuk (1993), defined management as the process of making decisions so that efficient use of available resources in organization can be achieved. The author further stated that management involves planning, organization, directing, coordinating and controlling functions. It therefore involves the mental ability directed to production decisions, processing and distribution. Olayede and Heady (1982) also asserted that entrepreneurial functions include decision-making, setting objectives, organizing and controlling the production process in order to maximize profits in an enterprise. An entrepreneur controls other factors of production toward the achievement of goals of the enterprise.

The rationale for this study was extracted from Nwadukwe (2000) who stated that in spite of the considerable international and local demand for snail meat and its high nutritional value, commercial snail farms such as those in Europe, South-East Asia and other countries do not exit in Nigeria/West Africa. In Nigeria, Ghana and Co'te d'Ivore where snail meat is particularly popular, snails are still gathered from the forest especially during rainy season, but wild snail population have declined considerably, primarily because of the impact of such human activities as deforestation, bush burning and the collection of snails before they have reached maturity. Therefore, there is need to embark on commercial snail production and using rumen digesta as a non- conventional and locally available feed ingredient to boost snail production.

This theory of production implies that there is a functional relationship between output and the various inputs. In the context of this study, the use of rumen digesta as one of the inputs is being studied to determine its effect on the growth rate of snails in order to obtain maximum productivity, which is the output.

Establishment of Snails in the Farm

Farmers in under developed countries still practice bush burning. This is gradually leading to extinction of snails from bushes and forests because snails were previously gathered from the wild. In the view of Cobbinah (1998), wild snail production have declined considerably, primarily because of the impact of such human activities as deforestation, spontaneous bush burning, use of pesticides and the collection or hunting of snails before they have reached maturity. Bush burning destroys old, young and fertile eggs that could hatch and serve for perpetuation. Besides, Ugwu (2008) stated that the increasing encroachment of human activity into the forest through construction of roads, housing estates, farming etc. makes it necessary to develop homestead snail production else snails become endangered species. The author went further to state that it is very crucial to encourage snail farming as a means of conserving this important resource.

Snail farming in the view of Fasakin (2007) is the breeding and rearing of edible land snails in an enclosure called Snailery. Akintomide (2004) maintained that snail farming simply means the rearing of snails for production purpose. According to Etone, Nebafor and Ewang (2008), snail farming is the keeping of snails in a confined environment under human control and management. Special gardens in which ancient Romans reared snails were called cochlear, while in France they were called escargotieres. The act of farming snails all started about 50 B.C. in the then Roman world where some species of snails were raised in special fattening units for human consumption (Akintomide, 2004).

According to Akinnusi (2004), snail farming had existed in France as far back as 1911. By 1970, it was estimated that Paris alone consumed upwards of 100 million snails annually. Chiefly children who hunted for snails in the fields, vineyards and gardens sold the snails to dealers who placed them in “escargotieres” or “preserves” until required for market. These preserves were surrounded with a wall or fence to prevent the escape of the stock. The author further stated that Romans kept snails caught in the wild and raised them in farms by feeding them with special herbs to improve the taste of snail meat and to ensure constant availability.

However, snail farming is a relatively new area of animal production and research in Nigeria. For a very long time, the average Nigeria erroneously believed that snail population in the wild is inexhaustible. Nowadays, the situation at roadside and township markets in certain areas leaves no one in doubt that wild snail population has been greatly depleted. Snail farming then appears to hold the key to all year round availability of snail meat in sufficient quantities.

Snail farming is at subsistent level in Nigeria. Chinwuko (2003) noted that few households hunted for snails during rainy season and kept them in holes dug to accommodate them. The snails feed on garbage contained therein until they are required for sales or consumption. Farming of this nature is seasonal and evidenced by the fact that snails were abundant and relatively cheaper during rainy seasons and diminished in supply during dry season. Despite snail abundance during rainy seasons, it is still under supplied when compared to the number demanded. Ugwu (2008) noted that snails could be produced beyond the level of family consumption into commercial production through the provision of enabling environment for growth and development of snails. This necessitates commercial snail production that is gradually springing up in Nigeria.

Therefore, the use of rumen digesta in compounding feed for snails when found very effective will boost commercial snail production.

Management Practices adapted for snail farming

The systematic activities in snail rearing are not much different from those in conventional livestock rearing like poultry, pig, fish, cattle and goat amongst other. If differences exist at all; they are in the matter of details or particular treatments but not in the fundamentals. It involves:

Site Selection: The site selected for the snailery should be close to the farmer’s residence. If that is not possible, a farmer who already owns an organized farmland may select a site on the farm, not too far from the service center; that is where the security arrangement on the farm can be easily extended to cover the snailery. This is to prevent dangerous pests and predators as well as human pilferers. A flat surface with loamy soil is most preferred.

Housing: Snails are wanderers by nature and do not keep within bounds especially when the environment is friendly. According to Chinwuko (2003), subsistent farmers rear snails in pits, plastic containers, earthen pot, and enclosure made of palm fronds and bamboos, rectangular enclosure made of cement or clay blocks. The author also stated that piles of equal sizes of tyres with cover on top, hutch boxes and trench pens could be used to house snails. In the case of plastic containers and earthen pots, the farmers should simply excavate some amount of loamy soil to cover the bottom to about 12 cm high before introducing snails into them. Fasakin (2007) maintained that cane, palm frond strip basket and large size clay pot could be placed on a solid or concrete floor and kept under shade. Loamy soil should be filled to a depth of 15 cm. The author also noted that to aid ventilation and prevent snails from escaping and dangerous pests from gaining entrance, the housing should be covered with framed wire net lid. Akinnusi (2004) added that small perforations are put at the bottom of the cage or basket to allow excess water to drain out because snails do not thrive in waterlogged area.

However, for large scale or commercial snail production, chinwuko (2003) and Akintomide (2004) agreed that factors like wind speed and direction, soil characteristics, temperature and humidity should be considered before constructing a standard snail house. Various types of housing like cage pen, sandcrete pen and trench pen among others could be used to rear snails.

Stocking the Snailery: Akintomide (2004) stated that the selection of breeding stock should be based on fecundity, hatchability and growth of snails. It is more economical to use the giant land snails known as *Achatina achatina* and *Archachatina marginata.* These snails could be sourced from Research Institutes, other snail farmers/dealers and purchasing from local markets. Akinnusi (2004) is of the view that fully-grown, sexually mature and active snails weighing 150-250g, which can produce eggs soon after stocking, should be used. Akinyemi, Ojo and Akintomide (2007) stated that the idea behind the selection of good stock for production purpose is to have snails with superior or desired traits that is economically viable. This is why African giant land snail is mostly preferred in heliculture.

Other Management Practices: Fasakin (2007) noted that for optimal performance and safety of stocked snails, it is imperative that the farmer should adequately feed and supply water to the snails at intervals using high quality and salt-free feeding stuffs and water. Other management practices include cleaning of feeders and drinkers, daily attendance and inspection of the snailery for security breaches and outright presence of pests and predators. The farmer should remove dead snails, mulch stocked snails with suitable vegetable matter like leaves of plantain and banana, pawpaw, cocoyam etc. It is very vital to keep neat, accurate and readily accessible records.

The data obtained from using varying levels of rumen digesta in feeding snails should be recorded accurately so as to enable the farmer know the most appropriate level of inclusion for rapid growth of snails. Subsequent researchers can as well use these records.

The Nature of Snail Nutrition

For continuous production of snail, concise knowledge of snail nutrition is very important. Akintomide (2004) and Chiazor (2006) stated that snails are vegetarians and accept many types of food. In the view of Njoku (2002), snails are herbivores and scavengers and therefore eat anything edible including leafy vegetative growth, agro and industrial wastes. Chinwuko (2003) noted that since snails derive majority of its nutrients from plant materials, the nature of vegetation obviously affects the distribution of land snails. According to Akinyemi et al., (2007), snails feed on both plant and animal substrates by rasping on feed materials in bits, or simply sucking fluid feeds. Cobbinah (1988) noted that *Achatina achatina* is capable of utilizing a remarkably wide range of food items consisting of green leaves, fruits, tubers and flowers. The author went further to state that unlike other snails, it prefers leaves and fruits that are detached from the main plant. It also seems to prefer wet rather than dry leaves.

According to Fasakin (2007), snails feed on leafy vegetables that man safely consume like pumpkins, potatoes and amaranthus among others but waterleaf is suspected to induce diarrhea in snails. Carmela (2008) added that snails also chew young succulent plant barks with something called radula in its mouth for grinding up its food. This radula is like a rough tongue-like file with rows of tiny teeth that it uses to scrape off its food to eat. The author also stated that snails eat little bits of chalk in the rock, which they need for their shells (calcium). Akinnusi (2004) asserted that powdered chicken eggshell could also be fed separately or mixed in their feed as calcium source. Chinwuko (2003) added that sources of calcium to snails in the house are ground bone meal, oyster shell, limestone and grinded snail shells. The author stated that calcium source could be mixed with humus or powder sprinkled onto leafy vegetables. He went further to state that experience revealed that snails do not feed on humus that contains the calcium source but rather they rasp the wall of the house and derive their calcium need from the cement.

Classification of Snail Feed

Akinyemi, et al., (2007), Chinwuko (2003) and Amusan & Omidiji (1998) generally agreed that snail feed could be classified as:

Leaves: snails eat different kinds of leaves. The most common ones are pawpaw, okra, cassava leaves with low cyanide, cabbage, lettuce, plantain and banana leaves.

Fruits: These are rich in minerals and vitamins but are generally low in protein. There is need to supplement fruits with high proteinous feeds. Examples of common fruits that could be fed to snails are pawpaw, mango, banana, plantain, pineapple, avocado pear, cashew, orange etc.

Tubers: These are mainly sources of carbohydrates (energy) with little protein. Examples are cocoyam, potato, yam, cassava etc.

Flowers: These could also serve as feed for snails. Examples are sunflower, milk bush, pawpaw flower etc.

Household Wastes: some household wastes like left over food could be used as feed for snails. In using these, care must be taken to ensure that the food does not contain salt to prevent snail mortality. Examples are peels like banana, plantain, pawpaw, yam, cooked beans, rice, cowpea bran, fufu (fermented cassava product) pap etc.

Industrial by-Products: These by-products cannot be used as sole feed for snail because of their high fiber content rather they could be grinded and mixed with other feeds. Examples are wheat offal, rice bran, spent grains, maize bran, palm kernel cake (PKC), groundnut cake etc.

Compounded Feed: They are rich in all the nutrients but are very expensive to obtain. Compounded feed are indispensable for commercial snail producers (Fasakin, 2007). With a large number of snails to feed, it is practically not feasible for the farmer to grow or go in search of enough leaves, fruits and food remnants. Since the use of compounded mash is inevitable and very expensive, there is need to seek for alternative means of reducing the cost by using rumen digesta to compound the feed because it is collected from the abattoir at no cost on daily basis. Compounded feeds are formulated in the right proportions required by the snails. It should contain the under listed nutrients composition:

Carbohydrate	46%

Protein	41%
Fats	11%
Minerals (calcium)	
Carbonate	1.6%
Vitamins	0.4%

Source: Amusan and Omidiji (1998)

The authors further stated that all the above listed foods have been found to be well consumed by snails in their various studies and observations at their snailery. The ingredients that could be used in compounding the feed are maize, groundnut cake, Soya bean meal, fish meal, wheat offal, maize bran, palm kernel cake, bone meal, oyster shell and vitamin/mineral premix.

Combination of Snail Feed

According to Akintomide (2004), African land giant snails like other farm animals prefer to be fed on a combination of feeds rather than just feeding on a particular type of food. Amusan and Omidiji (1998) corroborated this fact by stating that the combination of foods in adequate proportions can give satisfactory results. Most of them are highly cherished and found to support rapid growth, regular laying, good shell formation, resulting in healthy, active snails.

Thus, a combination of at least three feed materials picked from the various feed groups or classes is desired. Ugwu (2008) observed that the best result in snail rearing is obtained through the mixture of fruits and leaves of common crops supplemented with minerals and vitamins. The author further stated that snails do well with either broilers or layers mash without salt. Thompson, R. and Cheney, S. (2007) supported this by stating that commercial chicken feeding mash is around 16% to 17% protein, from fishmeal, making it good for growing snails. The two feeds that snails like and that promote good growth are: (a) broiler finisher mash consisting of 7%, broiler concentrate, 58% corn, 16% Soya, 18% Sorghum, 7% limestone flour (40% Ca); and (b) chicken feed (pellets) for layers consisting of 5% layer concentrate, 10% corn, 15% Soya, 20% Sorghum, 44% barley, 6% limestone flour (40% Ca). Snails show a distinct preference for moist feed so the farmer should ensure easy access to enough water when dry mash is used to feed snails.

The combination should ensure the provision of high energy and protein needed for the snail to thrive well. It is desirable and advisable to establish some of them around the snailery for regular fresh supply especially the most highly cherished crops like pawpaw, cocoyam, sweet potato, banana, oranges, pumpkin and pineapple. For *Achatina achatina* specie, the attractiveness of these feed combinations is very important in its nutrition. If the food is appetizing or contains a feeding stimulant, the snails will eat a lot and grow fast. Pawpaw is a good example of snail stimulant. Akintomide (2004) and Chinwuko (2003) agreed that snails avoid hairy plants or plants such as physic nut (J*atropha curcas*) that produce defensive chemicals.

In addition to whatever feed material or combination desired, clean portable water should always be provided in a shallow tray as shown in appendix III (picture 5, pg. 84). Rebecca (2007) reported that the amount of feed a snail eats depends very much on air humidity and on the availability of drinking water.). In support of this, Chinwuko (2003) stated that water is very essential for the distribution and growth of snails.

Water should always be sprinkled on the environment to moisten it because when there is water stress (i.e. dry environment), snails instinctively assume a dormant state (aestivation) during which growth cease. Akintomide (2004) noted that periodic inclusion of vitamin electrolyte drug in their drinking water should be carried out to avoid bacterial growth over time. The drug may be applied via their choice feed rather than through water. However, salted water should be avoided strictly in the snailery as it can cause plasmolysis and degeneration of the snail flesh (Fasakin, 2007).

Feeding Pattern in Snails

The giant land African snail is a nocturnal animal. The feeding is normally at night when they are active, feeding as they crawl along. The mouth with which they feed is located on the lower part of their muscular head, just in front of the crawling sole of the foot. The upper and lower lip flaps protect this mouth. Within the mouth are positioned the "teeth" a tongue-like structure called odontophore (Akinyemi, et al.,).

The ideal time to give them food is in the evening between 5 p.m. and 7 p.m. The food for the day should be served in feed troughs such as flat plastic containers or trays. Water should also be provided in flat plates to avoid drowning especially for young snails. The adult and juvenile (young) snails come out form their burrows (hiding places or shell) between 6.30 p.m. and 7 p.m. The animal does not commence feeding as soon as it comes out of the burrow but rather spend sometime in exploring the environment. Snails do not feed continuously. They feed for a short period, followed by a break during which they move about or remain stationary. The juvenile snails commence feeding earlier than the adult ones (Hodasi, 1975). After feeding, snails move actively around the snailery, until they finally settle at a resting spot or burrow into the soil or hiding place where it stays through out the day. If well fed and healthy, the flesh should completely fill the shell (Amusan and Omidiji, 1998). The Achatina species burrow deep into the soil while the *Archachatina marginata* burrows slightly and mostly hide under decaying leaves. Both species burrow between 3.00 a.m. and 6.00 a.m. Amusan and Omidiji further stated that observing snails feeding or drinking water is very exciting to watch.

Brown (1994) stated that the availability of vegetation in a locality especially for wild snails play an important part in the distribution of snails because plants provide snails with shelter from solar radiation and some of these plants are also edible to snails. The author further stated that size plays an important part for feed consumed; with the bigger snails taking in more feed than the smaller ones. This is one major reason that housing of adult and juvenile snails should be discouraged. Experience has shown that few snails practice cannibalism, not on live and active snails but on moribund or freshly dead snails. Snails also feed on decaying matter such as dead plants and animal carcasses. Besides, sand, bricks and blocks may be taken to augment their mineral needs.

Hodasi (1986) showed that snails have a distinct preference for fruits of banana and pawpaw and leaves of fluted pumpkin and Africa spinach, over the fruits of cucumber and wild sweet potato. The younger snails prefer leaves while the older snails prefer fruits.

Rumen Digesta as a Source of Snail Feed

Rumen digesta is one of the abattoir by-products that could be environmentally unfriendly if not properly handled. The rumen being the vat where fermentation of roughages takes place contains microorganisms such as the phycomycetous fungi, protozoa, bacteria and others that are involved in this process (Preston, 1987). The availability of the rumen content in the Nigerian abattoir could be good source of protein in livestock if properly processed and harnessed. Adeniji (1996) estimated the rumen digesta of bouvine origin output in Nigeria abattoir to be 9,634 tonnes while 18,067 tonnes per annum could be obtained from caprine sources.

The rumen is a unique organ in all ruminant animals. The contents are rumen digesta, which is very heterogeneous and made up of ingested feed at different stages of degradation with saliva (which makes the rumen liquor), microorganisms and products of their metabolic activities such as proteins, peptides, amino acids, lipids, vitamins and volatile fatty acid (VFA).

Rumen Anatomy and Functions

The ruminant stomach is made up of four compartments called the reticulum, rumen, omasum and abomasum. The reticulum communicates with the omasum through the recticulo-omasal orifice. Running between the oesophagus and the omasal orifice, in the inner walls of the reticulum, there is the reticular groove. The rumen proper shows a multilobe structure. This consists of large dorsal sac separated from the ventral sac by a horizontal fold. There is the cranial blind sac that contains the rumen digesta.

Microorganisms in the rumen rapidly colonize feed eaten by the animal. Thus, the rumen forms a fermentation vat that aids the breakdown of ingested feed through mechanical and microbial action to produce fermentation and products of volatile fatty acids, methane gas, Carbon IV oxide and ammonia gas, which are either absorbed through the walls of the rumen or lost via eructation (Maynard and Loosli, 1969). The ammonia in the presence of available energy source (some from VFA and others from simple soluble sugars) is used in the synthesis of microbial proteins of high biological value of about 80% in the gastro-intestinal tract of ruminant animals (McDonald et al., 1988).

The author went further to state that rumen contains one of the most varied and dense microbial populations in nature. The microbial population of rumen is made up of bacterial and protozoa with more than 200 species of bacteria and 20 species of protozoa identified. Bauchop (1979) and others however have demonstrated with scanning electron microscope that there is also appreciable numbers of fungal zoospores and phages.

The strained rumen liquor consists of one billion bacteria and one million protozoa per milliliter but this is not uniform since considerable numbers of protozoa and bacteria are associated with the solid digesta (Mc Donald, 1988). The numbers of organisms in the strained rumen contents do not represent truly the microbial population of rumen. Czerkawski (1986) observed that the mean concentration of microorganisms in the solid matrix (i.e rumen digesta) is far greater than that found in the free suspension.

Hungate (1966) estimated the value of rumen bacteria as between 16.2 to 40.8 billion per milliliter of rumen content. This value may vary due to nature of diet, feeding regimen, time of sampling after feeding and individual animal differences. In general, however, the type of diet and feeding regimen determines the microbial population in the rumen but cases are known where animals on identical ration can spontaneously develop completely different fermentation patterns and therefore different microbial populations.

McDonald (1998) maintained that protozoa have the characteristics of being retained in the rumen, where they may “lock up” protein and prevent its use by the host animal. This is because some protozoa ingest and digest food particles, bacteria, even small protozoa, and in effect remolding bacteria protein into a better quality protein of about 80% biological value. This may however be a distinct advantage in the use of rumen digesta in compounding snail feed and other livestock feed. The bacterial and protozoa present in the rumen digesta die during intense drying with either oven or naturally by sun thereby increasing the nutrient value of the digesta.

Czerkawski (1986) citing the works of several authors gave the composition of microbial matter in the rumen as follows:

Table 1: Composition of Microbial Matter in Rumen (g/100g DM)

Component	A	B	C	D	E	F
Protein	55	48	29	40-35	32	29-60
Nucleic acid	9	10	6	6,5	8	5-10
Lipid	2	2	-	-	9	2-25
Cell Wall	-	2	-	-	9	6-15
Polysaccharides	29		10	6,5	17	2-23
Ash	5		2	16,9	13	5-25

Sources: A ...Baldwin (1970)

B ...Hendricks et al., (1972)

C ...Smith (1975)

D ...Merry and McAllen (1983), values for bacteria isolated from liquid and solid faction of digesta

E ...Czerkawski (1976)

F...Range of values found in Literature.

With a high protein level (55-60% of dry matter), microbial multiplication in the rumen corresponds to an efficient protein synthesis with an excellent equilibrium in essential amino acids which contain 8-10% lysine required in compounding snail feed.

Proximate Analysis of Feeds (Rumen Digesta)

Animals including snails require feed rations that are complete and balanced nutritionally. Each specie and category of animal has different nutritional requirement which must be calculated with care to ensure maximum productivity. In using rumen digesta to formulate snail feed, it is expedient to analyze the feed to ensure its efficiency in snail production.

The chemical components of feeds usually determined are water or moisture, crude protein, crude fibre, ether extract, ash and nitrogen free extract (Onazi, Ezedinma Youdeowei, 1986). After the determination of water, the other components are determined on dry milled samples of the feed.

Water: the water or moisture content is determined by calculating the loss in mass when a weighed quantity of fed is dried in an oven at 100 - 105 percentage to constant mass.

Crude protein: The nitrogen content of the feed is determined by the **kjeldahl method** in which the feed is diluted with concentrated sulphuric acid that converts the protein and most of the non-protein nitrogen into ammonium sulphate.The nitrogen in the ammonium sulphate may then be determined. Example is conversion into ammonia by boiling with sodium hydroxide and then neutralizing the ammonia using dilute hydrochloric or sulphuric acids. The value obtained for nitrogen is multiplied by a factor of 6.25 to convert it to protein.

Percent crude protein = percent nitrogen x 6.25 since protein contains an average of 16% nitrogen (100 divide by 16 =6.25).

Crude fibre: This is the insoluble residue of feed after boiling with dilute acid followed by alkali. The component is mainly cellulose, hemi cellulose and lignin.

Ether extract or crude fat: This is the percentage of the feed that can be extracted in ether. Part of this component is fat and the rest is pigments.

Ash or inorganic matter: This is the residue obtained by burning the feed in a furnace (usually above 400 centigrade) until all the organic matter is burnt off.

Nitrogen-free extract (NFE): This component is not directly determined but is obtained by difference after the other four components of the dry feed have been subtracted from 100% as follows:

Nitrogen-free extract =100 – (percentage crude protein + crude fibre + ether extract + ash). The nitrogen free extract consists mainly of sugars, starch and variable quantities of cellulose and hemi cellulose.

Proximate analysis is defective in that the components are not distinct chemical entities. Materials in a component may consist mainly of silica. However, the method serves to classify feedstuffs into concentrates that have low crude fibre and high nitrogen free extract and roughages that have high crude fibre and low nitrogen–free extract. It may also indicate for which group of animals a particular feed is suitable. For example, high fibre feeds are suitable for ruminants while low fibre feeds are suitable for non-ruminants. Rumen digesta has 15.30 crude fibre content therefore; it is moderate and suitable for snails.

Table 2: Proximate Composition of Dried Rumen Digesta

Nutrient (% DM)	Proximate composition
Moisture	18.20
Crude fibre	15.30
Crude protein	18.52
Ash	7.60
Ether extract	8.79
Nitrogen –free extract	38.39

Source: Emenalom, Anyanwu, Ogbonna and Esonu (2006).

Evaluation of Feedstuff

Feeds are evaluated based on their ability to supply the nutrient needs of the animals. There are several methods of evaluating feeds; three of the common methods are chemical analysis, digestibility and total digestible nutrients (TDN) (Onazi et al., 1986).

Chemical Analysis: The feeds are analyzed usually for the chemical nutrients components by proximate analysis. Some minerals and vitamins may also be determined. Results obtained by chemical analysis indicate the potential of the feed to meet the animals' needs but not the quantity of nutrient available to the animal since some of the feed taken is lost through the faeces.

Digestibility: This takes into account nutrient loss through the faeces. The percentage of feed taken which is not lost through the faeces is the digestibility coefficient of the feed. For example if a snail ate 1.0 kg of feed containing 0.40 kg, dry rumen digesta and excreted 0.50 kg of faeces containing 0.15 kg dry rumen digesta. The digestibility of dry rumen digesta is calculated as follows:

$$\text{Digestibility coefficient} = \frac{\text{DM (dry matter) eaten} - \text{DM excreted in faeces}}{\text{DM eaten}} \times 100$$

$$= \frac{40 - 0.15}{0.4} \times \frac{100}{1}$$

$$= 62.5\%.$$

Total Digestible Nutrient (TDN): The total digestible nutrient is obtained by summing up the digestible nutrients.

Growth Pattern of African Land Giant Snails

In the wild (i.e in their natural habitat), snails go through a cyclical growth pattern that is determined by the occurrence of the seasons. During the dry and hot periods of the year, when there is little moisture and few succulent food materials available, snails hide under rocks, decayed plant debris where they withdraw into their shells and secret a membrane of mucus across the shell. This membrane called epiphragm hardens and closes off thus, protecting the snails against desiccation.

During this period (aestivation), the snail is in a quiescent state of reduced metabolism and processes essential for growth. Sustenance of life is dependent on stored energy and moisture reserves that are used up slowly (Hyman, 1967). However, if dry season becomes too severe or extended the snail tends to die. This means that snail depending on the length and severity of the dry season, will have a smaller body weight by the time it emerges again after the first rain. In view of this, Akinnusi (2004) asserted that active growth of snails generally occur during the rainy season. In spite of this, with proper management and feeding, snails can grow well all over the year.

Moreover, for a snail farmer, the aestivation of snails depicts poor management practices. If adequate feed and water is supplied and sprinkled on the soil or leaves in the snailery, snails stay active while growth continues throughout the year. In the submission of Ugwu (2008), snails multiply more under humid environment, especially during the rainy season but good management practices during the dry season promotes the growth of snails. According to Plummer (1975), the growth rate of young snails is high but variable. The body weight at hatching for *Archachatina marginata* specie is 2.14g while the average weekly growth rate is 0.85g with average increase in shell length being 0.33 mm/day during the first eight months. The rate can fall to 0.10 mm/day and rise to 0.55 mm/day between the ages of eight to fifteen months. The average growth rate shows 0.2 mm/day and thereafter, the snail will remain at about this figure for a long time. Rebecca (2007) stated that within the same population and under the same conditions, some snails would grow faster than others would. Some will take twice as long to mature. A hatchling's shell size depends on the egg size since the shell develops from the eggs surface membrane. As the snail grows, the shell is added onto in increments. Eventually, the shell will develop a flare or reinforcing lip at its opening. This shows that the snail is now mature; there will be no further shell growth. The author further stated that growth is measured by weight and shell size, since a snail's body weight varies and fluctuates even in 100% humidity. The growth rate varies considerably between individuals in each population group. Adult size, which is related to the growth rate, also varies, thus the fastest growers are usually the largest snails. Eggs from larger, healthier snails also tend to grow faster and thus larger. However, a snail farmer should obviously select and keep the largest and fastest maturing snails for breeding stock. As the animal increases in size, total weight and shell weight increases in proportion. The snail shell stops growing after four years. The lip tends to broaden and grow thicker although the snail's body may grow larger (Plummer, 1975). Brown (1994) corroborated by noting that growth of snails may be determinate, ceasing when the shell reaches a distinct mature form. The author further observed that some specie of snails like *Lanistes nyassanus* adds an annual increment to the shell throughout an adult life that may approach ten years. According to the author, growth in the shell of African snail is indeterminate and continues long after the beginning of sexual maturity. Although there is no distinct form of shell, changes in appearance due to growth may be obvious. The body weight and shell height or width is convenient measures of size and age. The construction of growth curves plays an important role in the study as it displays varied growth rate of individual snails under particular sets of conditions. Growth rate is one of the snail attributes monitored in laboratory using sensitive digital weighing balance or electric weighing machine to assess the effects of environmental factors in the ecology of snails. Temperature is generally an important influence on growth rate but other factors seem to be dominant in some localities (Brown, 1994).

Akinnusi (2004) and Fasakin (2007) agreed that although snails are generally believed to be most active at night under cover of darkness, research has indicated that when exposed to continuous lighting, they tend to increase their activity, consume more food and thus gain weight and size rapidly. Hodasi (1982) observed that though snails are nocturnal animals, they do not feed continuously throughout the night. Feeding is sporadic, interspersed with exploratory movements or rest periods; thus, less food would be consumed at normal darkness hours, which made snails reared under perpetual darkness to grow lesser than those reared under perpetual light would. Akinnusi (2004) also noted that newly hatched snails look very much like the adults except for the size and the shell that is delicate with characteristics color and shape of the particular breed of snail. As the snail grows, the transparent shell thickens and becomes darker.

The author further stated that snails would grow at acceptance rate on dry feed diets with high ash and relatively low protein content provided they have access to water and soil; which greatly improves growth performance and feed conversion. Snails grow well with diets of 15-25% crude protein with added calcium carbonate (limestone flour) necessary for shell growth. To achieve maximum size, snails could be reared in continuous light, while for maximum egg output; they must be cultured in natural photoperiods (Hodasi, 1982). In the view of Brown (1994), growth and reproduction are inhibited during hot periods. This, added to poor feeding conditions, result in population increase being possible in only a few months of the year. Reproduction is also deterred when snails are crowded and negative effects exerted by crowding (i.e over stocking) have been deduced from observations on natural populations as well as experiment in the laboratory. Omole, Taiwo, and Amusan (2007) is of the view that the slow growth of snails could be as a result of genetic make up, poor feeding and over crowding that could result to competition for feeding and space and has adverse effect on general performance.

Moreover, Plummer (1975) showed that there is a directly proportional relationship between increase in body weight and increase in shell parameters. The average growth rate in snails generally is moderate to low and depends largely on the type of feeding, type of management and environmental conditions. The author further stated that the giant African snails in particular, show a decrease in growth once they reach sexual maturity at 9-10 months of age for *Archachatina marginata*. Esobe (1986) estimated a growth rate of about 0.28g/day for the giant African snails under the most favorable conditions. Ajayi et. al., (1978) while investigating the growth pattern of Archachatina *marginata* from day old to 40 weeks of age obtained an average daily growth rate of 0.121g/day. Nevertheless, in the same investigation (using 22 week old snails), he obtained an average daily growth rate of 0.115g/day after feeding them for a test period of 13 weeks on pawpaw leaves. On the other hand, Elmlie (1982), working with *Helix pomatia* obtained a highest growth rate of 0.048g/day with experimental feeding on *Brassica oleracea* and *Helianthus anus*.

Besides, Plummer (1975) reported a high initial growth rate of .33 mm/day of shell length within the first 8 months of life in *Archachatina marginata* but this decreased to 0.2 mm/day between 8 and 15 months and finally leveled out to 0.2 mm/month by the 18^{tth} month. This is fairy comparable with Esobe's (1986) result of 0.2m/day on approximately 3.5 months old *Achatina achatina* fed a combination of waterleaf and pawpaw leaves. He stated that this result agreed with results obtained using *Archachatina marginata*, which may ingest and egest a food material without or with very little digestion. Hence, observations on feed intake may be lacking since the food is neither being digested nor utilized.

Anatomy of African Land Giant Snail (*Archachatina Marginata)*

The African land giant snails have the advantages of high adaptability and survivability. They are flesher, highly prolific in addition to their being abundant in Nigeria, Ghana and along the African continent. These giant snails are about the largest known land snails, reaching a documented shell length of 326 mm (1 foot) (Akinyemi et al.,).

These edible snails are of the family Achatinidae. The genera are Achatina and Archachatina. The three popular and commonly reared giant land snails are *Achatina achatina, Achatina fulica and Archachatina marginata.*The *Achatina achatina* is the most preferred in Ghana, and it is the tropical specie most acceptable in the world market (Amusan and Omidiji, 1998). However, the authors stated that this specie has been found to be more difficult to breed in Nigeria because they do not eat well and do not readily produce eggs. It lays 100-500 eggs per clutch once or twice a year and weighs 100-350gm. It is normally 10-14 cm long at maturity. The *Achatina fulica* is indigenous to East Africa particularly Kenya and Tanzania (Akinnusi, 2004). Many people do not eat it in Nigeria because of the taboos associated with it (Amusan and Omidiji, 1998). It lays 6-8 eggs per clutch, 4-8 times a year and weighs 15-25gm.

Archachatina marginata

This is commonly called the big black snail found in the forests along the coasts of West Africa. The shell is wider at the posterior end when compared to other breeds. The shell is thick and has a molted color of black, brown and white. At maturity, they are 11-19 cm long and weigh 150-800gm. They grow to full size in 18-24 months. Omole et al., (2007) noted that it lays 4-18 eggs per clutch, 4-8 times per year. Akintomide (2004) observed that the eggs are similar in shape to lizard eggs but yellowish in color and measure 1.6 to 2.3 cm. The author further stated that it lays on quarterly basis and the rate at which egg clusters are laid by healthy snails may slightly increase or decrease based on the quantity and quality of feed consumed. A cluster size of 2, 3 or at times 4 eggs should be picked along with their buried counterparts within a close range of about 10 cm radius. Once the eggs have been gathered, they should be buried in an incubating box that is filled with soil or substrate to a depth of not less than four cm (see picture 11 page 90). The soil should always be kept moist and the temperature preferably maintained above 30 degree centigrade to enhance good hatchability. This is easily achieved by placing the box in a warm location (e.g. in a garage). The box may be of any desired shape or measurement and the picked clusters of eggs are buried in it in straight lines. The box (0.5m by 1m) can accommodate four egg clusters (sideways) by eight egg clusters (lengthwise). They should be constructed with nets at the base to ensure proper drainage of excess water. A loose soil is advisable to enable the hatched hatchlings to surface from beneath the soil (see picture 12, page 91). Eggs hatch between 28 to 40 days and hatchlings should be carefully handpicked and reared in a separate nursery. The feed should consist of powdered formulated ration, very soft leaves, ripe fruits, mashed feeds and pasty feeds. The shell of hatchlings is generally thin walled, thus being transparent. As they grow, the shells continue to increase in length, breadth and thickness spirally, until their maximum sizes are attained which could be less than two years if well fed.

Table 3: Growth Pattern in *Archachatina Marginata*

Age (months)	0	1	2	4	5 months& 2 weeks	9-10	….18
Number of turns	2 & 1/4	3 & ¼	4	5	5 & 1/2	6	…..6 & 1/2
comment	1st Day				Point of maturity		Maximum size

Source: Akinyemi et al., (2007)

The above described growth pattern may serve as a yardstick in determining the performances of each Snailery unit. For example, if *Archachatina marginata* snails produced within a confinement were on the average having about four and half turns at five months, it means that their nutrition/management should be improved (Akinyemi et al., 2007)

Table 4: Similarities and Differences in the Three Common African Land Giant Snails

PARAMETERS	***A. marginata***	***A. achatina***	***A. fulica***
Meat softness	Soft	Softer	Softest
Body color	Dark brown	Brown	Brown
Body backline	Dark	Dark	Brown
Tentacles	Dark	Dark brown	Light brown
"Eye" color	Dark	Dark	Brown
Shell apex	Blunt	Pointed	Pointed
Shell strength	Very strong	Strong	Weak
Adaptability to new environment	More adapted	Less adapted	Most adapted

Source: Akintomide (2004).

Economic Importance of African Land Giant Snail

Snail meat may be served as a well-balanced and medicinal food for those recuperating from various ailments or are malnourished. Akinnusi (2004) asserted that the fresh flesh of the land snails contain at least 70% water while its dry matter consists of high quality protein with high contents of lysine, leucine, arginine and tryptophan. These compare well with values obtained from other conventional animal protein sources like beef, chicken, mutton, pork and fish. In addition to the high levels of calcium and phosphorus, snail meat is low in sodium, fat and cholesterol. Chinwuko (2003) corroborated by stating that the nutritional value of snail is mainly attached to its high protein (12-16%) and iron (45-50 mg/kg) value. The author further stated that it contains all the amino acids needed by man.

Akinyemi et al., (2007) noted that land snails when eaten provide some preventive/curative medicinal values that may be associated with the high content level of protein/essential amino acids, vitamins and minerals (including ortho-calcium phosphate). The authors further stated that it acts as complete haematinic, anti-inflammatory agent and haemostatic agent to effect its numerous healing actions. The therapeutic values of snails are anemia, some circulatory disorders like hypertension, hemorrhoid, epistaxis, migraine, stroke and heart failure due to cardiac angiostenosis. Besides, glaucoma, otitis media, asthma, urticaria, diabetes, constipation, fever, infertility, some kidney and liver diseases are medicinal values of snails. The slime is used to cure insect bite, burns, skin rashes and eczema. Whiteney and D'Amo (1996) asserted that those with a family history of breast cancer should introduce snails into their diet. The authors further stated that edible snails especially *Helix pomatia* contains a powerful lectin that specifically agglutinates muted A-like cells for two of the most common forms of breast cancer. This is a positive kind of agglutination and snail lectin gets rid of sick cells.

Akintomide (2007) added that other medicinal values of snails such as; it improves conception/fertility, promotes fetal development and maternal health, the fluid may be used as haemostatic agent to stop bleeding e.g. when performing circumcision. It is also used in the management of aural haematoma. Chinwuko (2003) reported that glandular substances from edible snails cause agglutination of certain bacteria that could be of value against a variety of ailments including whooping cough. The author further stated that the Orthocalcium phosphate extract from snail could cure kidney disease, tuberculosis, anemia and certain circulatory disorders among others. Adikwu (2007) noted that it has been clearly demonstrated that snail produce mucin which possesses wound healing property. Besides, a number of factors determine the rate of healing of wound onto which mucin preparation has been applied, it is determined by the depth and the level of microbial infection. It is also affected by the type of mucin formulation.

Akinnusi (2004) asserted that snail shells are used for the manufacture of buttons, earrings, rings, ornamentals and jewellery, artistic decorations and designs of walls and lawns. The shells are equally good sources of calcium for livestock feed formulation. Besides, it can be added to soil to reduce its acidity (i.e as liming agent) (Omole, 1997). According to Wosu (2003), the ash from burnt shells is very rich in minerals like iron, potassium and other trace elements like magnesium, manganese, zinc, copper but there is no phosphorus. Fasakin (2007) noted that the whole shell after it has been polished or painted is used for wall decoration, as drinking cup and flower vase.

Furthermore, snail farming provides employment opportunity and some farm workers reported that working in snail farm is more relaxing, interesting, entertaining and less strenuous than working in any other animal farm. Snails are huge export materials to earn foreign exchange and it has potential for very huge returns on investments with low level of inputs. The rearing operations can be accommodated within a backyard. Snails are hermaphrodites and highly prolific. Snails can also be reared as pet and laboratory animal.

On the other hand, Wosu (2003) reported that snails could serve as secondary or intermediate hosts to many worm parasites or mites of man and animals example is schistosomiasis. According to Souza, Barbosa and Resende (2008), schistosomiasis is an endemic disease that affects tens of millions of people throughout the world. One way to fight the disease is to avoid contamination through intermediate hosts, which are primarily certain **planorbid** as well as fresh water snails like *Bulinus truncates* (okafor, 2009). The authors further stated that one of the preventive strategies is to control the population of these transmitting molluscs. Moreover, Akintomide (2004) observed that snail considerably limit the probability of serving as intermediate hosts of some zoonotic diseases like eosinophilic, encephalomyelitis, colibacillosis, salmanellosis and balantidiosis. In the submission of Akinnusi (2004), those snails that harbor the larval stages of trematode parasites such as fasciola, schistosoma are not the land snails.

Table 5: Nutritional Value of Snail Compared to Other Animal Meats

Food Items	Carbohydrates %	Protein %	Fat %	Ash %	Water %
Snail meat	2.93	20.7	1.21	1.49	73.67
Beef	-	17.50	22.00	0.90	60.00
pork	-	11.90	45.00	0.60	42.00
Lamb	-	15.70	37.70	0.80	56.00
Chicken	-	20.20	12.60	1.00	52.00
Whole milk	5.00	3.80	3.50	0.70	87.00

Source: Chinwuko (2003) in Ajayi et al., (1978)

Table 6: Essential Amino Acids, Minerals, Cholesterol, and Proximate Composition of Snail Meat Compared to Other Animal Meats

	% of dry matter		Minerals mg/100g dry samples				Mg/100g fresh Sample	Amino acids,/g/16gN			
	Crude protein	Fat	Ca	P	K	Fe	Cholesterol	Lysine	Leucine	Arginine	Tryptophan
Snail meat	88.37	1.64	185.70	61.24	63.30	1.40	0.42	9.21	9.36	8.31	1.29
Beef	92.75	4.59	53.00	24.05	81.44	1.25	1.06	9.30	8.39	6.98	1.00
Chicken	92.21	4.34	55.60	28.29	74.14	0.90	0.84	9.22	7.75	8.90	0.80
Goat meat	86.63	3.01	65.30	28.08	97.21	0.19	0.76	10.06	8.28	7.01	0.90
Mutton	86.34	4.20	55.20	22.45	82.83	0.85	0.62	10.28	8.85	6.40	1.32
Pork	82.42	13.7	64.00	34.42	83.45	0.90	1.02	9.96	7.90	7.22	0.07
Fish Clarias	91.99	3.18	69.12	26.13	61.48	0.55	0.92	11.44	9.45	5.78	1.40
Fish Tilapia	90.81	3.35	103.38	30.81	75.69	0.52	0.39	11.49	9.33	7.27	1.24

Source: Fasakin (2007) in Akinnusi (2004).

Principles of Experimental Design

Experimental design refers to the totality of all preliminary steps taken to ensure that appropriate data are obtained to facilitate correct analysis and thereby lead to valid inferences. It begins as soon as experiment has been formulated and ends when all data have been collected for analysis (Akindele, 2004). It refers to the various patterns of arranging the experimental materials. The experimental materials include the experimental units, the sampling units and the treatments. The experimental unit is the material to which a single treatment is applied in one replication of the basic experiment. The term treatment refers to any particular set of experimental conditions or factors that will be imposed on an experimental unit for evaluation.

There are three basic principles of experimental design, namely: **randomization, replication and local control.** Randomization is a process by which the allocation of treatments to experimental units is done by means of some chance device in order to ensure that no particular treatment is consistently favored or handicapped. By this, all treatments are given equal chances of being allocated to any particular experimental unit.

Replication refers to a situation where a treatment is applied to more than one experimental unit. It could be referred to as the repetition of the basic experiment, either over space or over time. It may also be used to increase the scope of inference of an experiment. Jeffers (1960) noted that the only practical method of reducing experimental error is therefore by replication of the treatments.

Local control refers to the amount of grouping or blocking of the experimental units that is employed in the adopted experimental design. It entails grouping the experimental units into blocks such that the samples within are of the same type while the units between the blocks are heterogeneous. All the treatments are then randomly applied within each block. Local control is also termed 'error control' since it reduces the error variance and thereby makes the experimental design more efficient (Akindele, 2004).

The aforementioned principles are strictly applied in this study to minimize error and make the inference more efficient.

Types of Experimental Designs

Good experimental design is very essential in eliminating uncontrollable factors wherever possible. Some of the experimental designs are as follows:

Completely Randomized Design (CRD): The completely randomized design according to Jeffers (1960) is the simplest and most useful of experimental designs. In support of this, Akindele (2004) asserted that it is the simplest type of experimental design used in agriculture. It involves the random allocation of the treatments to the experimental units without any particular restriction. Thus, the probability of receiving any particular treatment is the same for all the experimental units. The CRD is used only in experiments where the experimental units are homogenous. This is the most suitable design for this study since all the experimental units are the same. Jeffers (1960) stated that each unit is made as uniform as possible, and each treatment is repeated in each unit. The author further stated that this design in addition to its simplicity and adaptability is very efficient in reducing the size of the experimental error. CRD has the advantage of being flexible in that any number of treatments and replicates may be used. This type of design is restricted mainly to experiments where there is only one 'independent variable' and that fits in this study, which has rumen digesta as the independent variable.

Factorial Design: In this type of experimental design, two or more factors are introduced in all their combinations, and each factor has two or more levels of application. This means that it involves the interaction of two or more factors. Factorial design usually has more than one independent variable. The simplest factorial experiments are those comparing two levels of two factors, giving four combinations. This type of design is not suitable in this study because it requires the interaction of two or more factors while in this study only one factor (rumen digesta) is being tested in each experimental diet.

Latin Square Design: This design is arranged in a square, the number of rows and columns being equal to the number of replications. In this design, the treatments are assigned to random subject to the restriction that each treatment appears but once in each row and once in each column. The Latin square model assumes that there are no interactions between rows and columns, rows and treatments and columns and treatments. Thus the effects of all three factors (rows, columns and treatments) are assumed to be additive. The major limitation of this design is that it requires at least as many replications as there are treatments. Akindele (2004) noted that in agricultural experimentation, Latin Square design is recommended only for experiments having four to eight treatments. This study is not arranged in square, row or column therefore this design is not suitable for it.

Other experimental designs are:

True Experimental Design: True experimental designs are so called because they endeavor to control against all sources of invalidity. The two different designs that may be considered as true experimental designs are post-test only group and pretest posttest control group design. Post-test only group is that in which there are two groups, one experience the treatment while one does not. The group that does not receive the treatment is used as a control group. The two groups are chosen by random assignment, which ensures that no group is favored in the selection process. This is the design most appropriate for this study.

Quasi – Experimental Design: This design is partly not fully experimental design. It is recommended in those situations in which true experimental designs cannot be used. This applies to most life situations in education where random selection of subjects into treatment and control groups cannot be carried without extensive disruption of the school programme. This type of design is not suitable for this study.

Ex – Post Factor Design: In this type of design, the researcher examines the effect of a naturally occurring treatment on a group of subjects rather than applying the treatment himself. The researcher does not manipulate any variable; rather the selection of subjects is made to reflect the groups in the researcher's mind. The typical examples of this design are co-relational study and the criterion group design. This type of design is not suitable for the study because the selection of subject is randomized and not made to reflect the groups in the researcher's mind.

Empirical Studies on Snail Feed and Use of Rumen Digesta in Compounding Livestock Feed

Various researchers have conducted feeding trials to enhance the growth of snails (*Archachatina marginata).* Recommendations of proper levels of inclusion based on their findings have been made.

Okpako (1988) reported that the use of pawpaw leaves and brewers dried grains are acceptable to edible African giant land snails (*Archachatina marginata)* and therefore enhance the growth performance. The author obtained a growth rate of 0.16g/day in the study and recommended that further researchers should use juvenile snails since he used snails already close to maturity. Besides, Ajayi et al., (1978) using 22-week-old Archachatina *marginata* obtained a growth rate of 0.27g/day with pawpaw fruit and 0.115g/day with pawpaw leaves. Plummer (1975) observed that various significant factors like type of feed ingredient used, physiological maturity and age of snails will directly affect the growth of snails.

Investigations have been carried out on the effect of supplementing the snail natural feed (plant leaves) with formulated diets in order to increase growth, nutrient and immensely increase protein intake of the populace. Ejidike, Afolayan and Agbelusi (2000) investigated the growth response of Africa giant land snail (*Archachatina marginata)* on supplemental diet of 25% crude protein level. The authors recorded positive results with fresh pawpaw leaves, and fresh sweet potato leaves diets but the best result was obtained with the fresh pawpaw leaves plus 25% supplemental diet.

Nwokeji (1989) investigated the growth response of edible giant land snails (*Archachatina marginata)* on formulated diets and reported that cheap and locally sourced materials can be used to rear snails effectively. The author obtained 0.21g and 0.19g growth rate respectively for the diets used and recommended that further investigation should be done using other locally available sources to boost snail rearing and reduce cost of production.

Ekwunife (1998) studied the use of rumen digesta as a source of animal feed using cattle (White Fulani). He found out that rumen digesta has nutritive value and that the crude protein value can be used effectively in the formulation of animal feed. The author added that the crude protein values were not affected by the feeding regimen, though it helped maintain the rumen vome.

Dairo, Aina and Asafa (2005), demonstrated the performance evaluation of growing rabbits fed varying/graded levels of rumen digesta and blood rumen digesta mixture. The authors found out that rumen content (digesta) could be included optimally at 30% in growing rabbit rations for success in rabbit production. However, they recommended that further investigation should be carried out on the effect on the physiology of rabbits. They further stated that rabbits are pseudo-ruminants with capacity to handle high fibre feedstuffs. This they asserted was responsible for the observed result as the crude fibre levels in the formulated diets were still within limits for rabbits.

Odunsi (2003) investigated on the blend of bovine blood and rumen digesta as a replacement for fishmeal and groundnut cake in layer diets. The author observed that the protein content of bovine blood rumen digesta meal (BBRDM) is lower than that of fishmeal but higher than that of groundnut cake. The BBRDM could replace part of what was lost through the removal of fishmeal whereas it appears this was not so in the groundnut cake (GNC) based diets. Using the economic analysis of table egg production, the author noted that the cost differential per kg egg and relative cost benefit per kg recorded improved savings with the use of BBRDM to replace fishmeal at 50 and 100% levels, which however was not feasible when BBRDM replaces groundnut cake. In addition, layers on diets where fishmeal was replaced by BBRDM gave better performance response than those in which groundnut cake replaced it. The author recommended that further studies should focus attention on nutrient imbalance in the utilization of bovine blood and rumen digesta mixture and possibly masking of the odor to enhance intake in the diet of layer birds (poultry).

Emenalom, Anyanwu, Ogbonna and Esonu (2006) carried out a study on evaluation of performance, organ characteristics and economic analysis of broiler finisher fed dried rumen digesta. The authors noted that birds on diets containing dried rumen digesta reduced cost of broiler finisher diet. Besides, recommendation was that further research should focus on investigating the biosafety of dried rumen digesta.

However, there is no available literature on the use of rumen digesta in compounding snail feed and that is what prompted this present study. Nevertheless, Amusan and Omidiji (1998) reported the chemical composition of some foods used in snail feeding thus:

Table 7: Proximate Analysis of Various Snail Feed

S/N		Percentage of Dry Matter			Mg Per 100g of Food			
A	LEAVES	Dry matter	Crude protein	True protein	Ca	P	Vit. A	Vit. B
	Cocoyam (Taro)	8.2	25	22.5	409.1	51.4	14.2	161
	Pawpaw	24.6	32.6	-	-	-	-	-
	Cassava(sweet)	25.6	14.7	13.8	-	-	-	-
	Sweet potatoes	12.5	24.7	22.6	98.1	27.6	3.3	38.2
	Amaranthus(G)	11.4	26.3	-	190	39.0	4.6	68.0
	Amaranthus(P)	19.4	31.9	-	5.9	79.0	-	81.0
B	TUBERS							
	sweet potatoes	28.1	5.4	4.1	16.6	31.0	0.0	26.2
	Sweet cassava	31.9	2.4	1.3	10.0	35.0	7.8	35.0
	Cocoyam (Taro)	26.5	8.7	6.9	24.0	53.6	1.2	14.0
C	FRUITS							
	Pawpaw(Green)	7.2	11.4	-	58.6	26.3	0.3	22.0
	Pawpaw (ripe)	15.0	4.1	-	15.8	7.4	0.3	112.0
	Sweet orange	-	-	-	33.0	23.0	190	49.0
	Mango (green)	17.7	35.0	-	14.0	9.0	0.8	25.0
	Mango (ripe)	17.3	5.6	-	-	-	-	-
	Water melon	-	-	-	7.0	12.0	590	6.0
	Pineapple	-	-	-	16.0	11.0	130	24
	Guava	-	-	-	16.0	33	200	300
	Coconut	89.8	11.0	9.8	25.0	75.0	nil	2.0
	Tangerine	-	-	-	33.0	23.0	240.0	31.0
D	GRAINS							
	Maize (yellow)	90.0	10.7	10.2	6.0	300	0.8	11.4
	Rice (Brown)	94.4	12.5	11.9	12.0	290	5900	0.0
	Guinea corn	-	-	-	23.0	71.0	100	29.1
	Millet, Bulrush	88.8	9.0	8.0	50.0	358	240.0	0.0
E	Grain Legumes							
	Soya bean grain	93.3	44.1	40.8	220.0	586	110.0	47.0
	Cowpea seed	91.3	24.7	22.8	90.0	451	50.0	0.0

Sources: Adapted from V.A. Oyenuga (1968). Nigeria's foods and feeding-stuffs.

It is very expedient to note that the above feed items that can be used in feeding snails are seasonal which necessitates the use of rumen digesta with a view to rearing snails all year round.

Summary of Literature Review

The rapid expansion of snail farm in Nigeria is a sign that the society is accepting and realizing the immense benefit of snail farming. The importance attached to Agriculture by the federal government as noted in the president's seven-point agenda as well as the emphasis on the Millennium Development Goals (MDGs) particularly the alleviation of abject poverty has necessitated the massive sensitization to boost agro-production. It is also a well-known fact that animal protein deficiency in the diets of most Nigerians has become a chronic problem. In order to raise the level of animal protein intake of many Nigerians from its present level of 5.5g per head per day (Idufueke, 1984) to the FAO (1988) recommended level of 35g/adult per head per day there is need to widen the scope of animal production through snail farming. Snail farming is a veritable and economic means of boosting animal protein intake deficiency in the diets of average Nigerians due to the nutritional and medicinal values of snail.

Snails feed on leaves, grains, tubers, fruits, vegetables as well as compounded feeds. The seasonality of the aforementioned plant materials and the high cost of purchasing the ingredients used in formulating snail feed are the factors that deter the rearing of snails throughout the year.

This necessitates the use of Rumen Digesta, which is an animal by-product, collected from the abattoir at no cost and on daily basis. In the submission of Scott, Neshemme and Young (1976), Rumen Digesta when dried could be used in formulating rations for livestock. The percentage crude protein and fibre content obtained in rumen digesta indicates that it could be dried and used in formulating snail feed to reduce cost of production and foster all year rearing of snails.

It can be inferred from the review of literature above, that there is need for determining the effect of using varying levels of rumen digesta on the growth of African Land Giant Snail (*Archachatina marginata*). Other researchers studied the feed preferences of snails. The authors reported that vegetables, leaves, fruits, tubers, kitchen wastes as well as compounded feeds could be used to feed snails. The fact remains that the aforementioned are mostly seasonal and not easily affordable during dry season. The related empirical studies showed that some researchers studied the varying levels of rumen using rumen digesta in compounding feed for rabbit, broilers and layers.

However, there is no available literature on the use of rumen digesta in compounding snail feed as to confirm that the same results above could be applied to snail. This study is focusing on identifying the level of rumen digesta inclusion that will be most appropriate in rearing and making snail meat available throughout the year because rumen digesta can be obtained on daily basis from the abattoir at no cost. This is to ensure continuous supply of snail throughout the year and in large numbers in order to meet up with ever-increasing market demand and to attain maximum animal protein intake of many people especially in developing countries.

CHAPTER III

METHODOLOGY

This chapter described the procedure that was used in this study. It focused on the design of the study, area of study, population, sample, materials and methods for the experiment, experimental procedures, data collection and analysis.

Design of the Study

This study adopted a true experimental research, which investigated possible causes and effects relationship by exposing three experimental groups to three treatment conditions and comparing the results to one control group not receiving the treatment. It also required rigorous management of experimental variables and conditions by direct control and manipulation (Isaac and Michael, 1982).

The experiment was a Completely Randomized Design (CRD) with equal replication as described by Steel and Torrie in Akindele (2004). It involved random assignment of snails to four treatments with three replications each thus having twelve experimental units. Each replicate contained four snails that were equally assigned to a pen (see picture 5, page 84).

Table 8: Showing Treatments and Replicates

A	$\mathbf{T_0}$	$\mathbf{T_1}$	$\mathbf{T_2}$	$\mathbf{T_3}$
B	$\mathbf{T_0}$	$\mathbf{T_1}$	$\mathbf{T_2}$	$\mathbf{T_3}$
C	$\mathbf{T_0}$	$\mathbf{T_1}$	$\mathbf{T_2}$	$\mathbf{T_3}$

T_0 = Treatment Zero (Control experiment)

T_1 = Treatment One (Experimental group, 5% rumen digesta)

T_2 =Treatment Two (Experimental group, 10% rumen digesta)

T_3 =Treatment Three (Experimental group, 15% rumen digesta)

Best and Kahn (1986) described this type of experimental design (CRD) as the strongest type of design and one of the most effective in minimizing the threats to experimental validity. This design also permits that at the time of assignment all the groups are equal.

Area of the Study

The study was carried out at the Department of Animal Science Snailery of University of Nigeria Nsukka. It focused on the specie of African Land Giant Snail called *Archachatina marginata.*

Population of the Study

The population for this study consisted of one hundred and fifty African land giant snails (*Archachatina marginata)* which were purchased from a snail dealer at New Benin Market, Edo State. The reason is that the study commenced in dry season and the researcher could not locate any snail dealer in Nsukka. Snail is still seasonal within the vicinity and can only be purchased from the market during rainy season. The juvenile snails were three months old. One hundred and fifty snails were purchased to make up for losses in mortality due to transportation stress, acclimatization and disease incidence. The snails were allowed to acclimatize for two weeks during which fruits, vegetables and compounded rations were used to feed them prior to the commencement of experiment.

Sample and Sampling Procedure

Simple random sampling technique was used to obtain sample for the study through the following steps:

- Assigning numbers to all the snails on the shell with paint.
- Transferring these numbers to pieces of papers.
- Rolling each paper and putting them in a basket.

- Getting two students to select forty-eight pieces of papers.
- The numbers selected on each paper taken was used to select the appropriate snail.

Materials and Preparation of Diets for the Experiment

Materials: The materials used in formulating the various diets are:

(i) **Carbohydrate feed ingredient:** Maize

(ii) **Protein feed ingredients:** Soya bean meal, Fish meal and Rumen digesta

(iii) **Vitamins and mineral feed ingredients:** Bone meal and Oyster shells.

(iv) **Fats and oil feed ingredient**: Fish meal

(v) **Fibre**: Wheat offal and Rumen digesta

(vi) **Additive**: Mineral premix

Preparation: The rumen digesta was collected from Nsukka abattoir immediately after the animals were slaughtered between 6.30 – 7.00 am. The rumen digesta was sun-dried on a clean nylon spread on a concrete floor to moisture content below 15%. With the use of rubber hand gloves, the researcher properly shredded and removed the foreign objects like stone to allow for proper milling and mixing with other feed ingredients (see picture 1, page 80). The sun drying lasted for three days. The rumen digesta was then milled, bagged and stored in a cool dry place prior to using it to formulate feed at different percentages.

The other feed ingredients (feedstuffs) used for the study were purchased and milled at a feed mill in Nsukka. The various feed samples were taken to university of Nigeria Nsukka; animal science laboratory for proximate (chemical) analysis according to AOAC (Association of Official Analytical Chemists) (1995). The experimental diets were formulated using adjustable Pearson's Square method of feed formulation to contain dried rumen digesta at 0%, 5%, 10% and 15% inclusion levels respectively. The control diet (0%) did not contain rumen digesta.

Table 9: Experimental Feed Table

Ingredients	T_0 (0%)	T_1 (5%)	T_2 (10%)	T_3 (15%)
Maize	52	52	52	52
Soya bean	25	25	25	25
Wheat bran	15	10	5	0
Rumen digesta	0	5	10	15
Fish meal	2	2	2	2
Bone meal	5.75	5.75	5.75	5.75
Mineral premix	.25	.25	.25	.25

Certification of Snails for Safety

The snails that were used for the experiment was certified and tested for disease infection by a specialist in Animal Science Department, University of Nigeria Nsukka.

Experimental Procedure and Data Collection

The forty-eight snails were randomly assigned to four treatment groups with three replicates each in a completely randomized design (**CRD**). Twelve pens were used and each pen consisted of four snails. Each pen constituted an experimental unit.

A week before the assignment of the snails, the pens were thoroughly washed, disinfected and dried under the sun. The floor of the pens was covered with loamy soil to about 6cm high from the bottom. The feeders and drinkers were thoroughly washed and dried. Seven days trial feeding was done before the commencement of the experiment to allow for physiological adjustments.

The snails were weighed at the onset of the experiment and subsequently on a weekly basis. Water was provided ad libitum and each treatment group was fed with a particular diet daily for twelve weeks. The parameters measured were **weight gain (growth response), feed intake, length and width.** The weight was determined by using digital sensitive weighing balance (see picture 6, page 85) while the length and width was measured on weekly basis using Vennier Caliper (see picture 7 & 8, page 86 and 87). The feed intake was determined daily by a weigh-back technique (see picture 9, page 88). This means that a known quantity of fresh feed given to each experimental unit was weighed and recorded. In the morning of the next day, the left over in the feeder as well as feed wasted on the floor was collected, weighed and recorded. In this way, the quantity of feed consumed was calculated as (quantity given – quantity left over). This was the routine for feeding the snails throughout the experimental period, which lasted for twelve weeks.

The drinkers and feeders were emptied and washed on daily basis before new feed and water was served. Water was also sprinkled on the floor (soil) on daily basis to maintain adequate humidity and temperature in the pen. At the end of every three weeks, the soil was removed and replaced to prevent any pathogenic manifestation in the pen.

The proximate analysis of the Experimental Diets

The experimental diets used for the study was subjected to proximate analysis according to Association of Official Analytical Chemists (**AOAC) (1995)** method. The proximate analysis of the experimental diets is as follows:

Table 10: Proximate Analysis of the Experimental Diets (percentage)

Treatments	Crude Protein	Crude Fibre	Fat	Moisture	Ash
T_0 (0%)	25.4	15.8	0.9	9.9	9.7
T_1 (5%)	23.21	19.95	1.3	8.6	9.97
T_2 (10%)	24.96	19.6	2.3	8.85	10.85
T_3 15%)	20.15	17.3	0.95	9.15	10.2

Procedure for Data Analysis

Data collected was subjected to **One-Way Analysis of Variance (ANOVA)** for a completely randomized design (CRD) as described by Steel and Torrie (1980). The statistical model for this design is as given below:

Xij = μ + Tj + ∑ij

Where;

Xij =Individual observation (i.e observation of jth treatment in jth observation).

μ = the population mean

Tj = the effect of the Tj treatment

∑ij = the random error present in the i-th on the j-th treatment.

The difference between the treatment means was separated using Duncan's New Multiple Range Test (DMRT). The researcher employed the use of tables and percentages in reporting data on the nutrient composition of the feedstuffs.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

In this chapter, data collected for answering three research questions and testing three hypotheses posed in the study were presented and analyzed.

Research Question 1:

What is the weight gain (growth response) of African land giant snails to diets containing graded levels of sun dried rumen digesta?

Table 11: The Weight Gain of Snails Fed Graded Levels of Rumen Digesta

Treatment	Mean	Standard Deviation	Standard Error Mean	Degree of Freedom	F- Ratio	Sig.
T_0 (0%)	7.87	27.82	12.97	11	4.032	.051
T_1 (5%)	8.39	6.90				
T_2 (10%)	8.59	56.44				
T_3 15%)	7.80	20.38				

The performance on the weight gain of snails as presented in table 11 above indicated that the snails in treatment two (T_2) which contains 10% rumen digesta performed better than others and had the highest mean weight gain of 8.59. This was followed by the snails in treatment one (T_1) containing 5% rumen digesta with the mean value of 8.39. The snails in treatment zero (T_0) and treatment three (T_3) showed the mean value of 7.87 and 7.80 respectively.

Research Question 2:

What is the increase in the length and width of snails fed graded levels of rumen digesta?

Table 12: The Increase in Length of Snails Fed Graded Levels of Rumen Digesta

Treatment	Mean	Standard Deviation	Standard Error Mean	Degree of Freedom	F- Ratio	Sig.
T_0 (0%)	80.23	2.04	0.73	11	1.134	0.392
T_1 (5%)	80.73	0.21				
T_2 (10%)	82.50	4.50				
T_3 15%)	78.80	0.44				

The result in table 12 above showed that there are slight differences in the increase of the mean length of various treatments with treatment two (T_2) having the highest increase of 82.50. This was followed by the snails in treatment one (T_1) containing 5% rumen digesta with the mean value of 80.73. The snails in treatment zero T_0 and treatment one (T_1) indicated 80.23 and 78.80 mean value respectively.

Table 13: The Increase in width of Snails Fed Graded Levels of Rumen Digesta

Treatment	Mean	Standard Deviation	Standard Error Mean	Degree of Freedom	F- Ratio	Sig.
T_0 (0%)	39.33	0.85	0.82	11	0.716	0.57
T_1 (5%)	40.03	1.17				
T_2 (10%)	42.50	4.25				
T_3 15%)	39.63	3.86				

The result in table 13 above indicated slight differences in the increase of the mean width of various treatments with treatment two (T_2) having the highest increase with mean value of 42.50. This was followed by the snails in treatment one (T_1) with the mean value of 40.03. The snails in treatment three (T_3) indicated 39.63 mean value while the snails in the control group (0%) showed mean value of 39.33 while.

Research Question 3:

What is the feed intake of snails as measured by the amount of feed consumed by African land giant snails on daily basis?

Table 14: The Feed Intake of Snails Fed Graded Levels of Rumen Digesta

Treatment	Mean	Standard Deviation	Standard Error Mean	Degree of Freedom	F- Ratio	Sig.
T_0 (0%)	93.03	9.16	3.50	11	1.41	0.309
T_1 (5%)	99.37	6.12				
T_2 (10%)	111.03	18.42				
T_3 15%)	95.97	8.30				

The result in table 14 above indicated that the feed intake of snails in treatment two (T_2) showed the highest mean value of 111.03 Treatment one (T_1) showed 99.37 mean value. This is followed by treatment three (T_3) with 95.97 mean value and lastly treatment zero (T_0) which is the control group with the mean value of 93.03.

Hypothesis 1:

There is no significant difference in the mean weight gain of snails fed with rumen digesta and those fed with the control feed.

Using the result in table 11 above, a significant (P < 0.05) difference occurred between groups of snails. The use of Post Hoc Test called Duncan's New Multiple Rang Test (DMRT) was used to separate the means to determine where the significant difference was related. It indicated that there were significant differences in the total weight gain of snails among the treatments. The total weight gain of snails in T_2 significantly differed from values obtained for snails in T_0 and T_3. The total weight gains of snails in T_0, T_1 and T_3 were similar. Besides, total weight gain of T_1 and T_2 were similar as shown in appendix II (page 77). The F-ratio is greater than the F-tabulated at 0.05 level of significance. Therefore, the null hypothesis was rejected in favor of the alternative hypothesis.

Hypothesis 2:

There is no significant difference in the mean length and width of snails fed graded levels of rumen digesta.

The result in table 12 and 13 above indicated that no significant (P > 0.05) difference occurred in the length and width of snails fed graded levels of rumen digesta. Therefore, the null hypothesis was accepted because the F- ratio is lesser than the F tabulated at 0.05 level of significance.

Hypothesis 3:

There is no significant difference in the mean feed intake of snails fed with graded levels rumen digesta.

The result in table 14 above showed that there was no significant (P > 0.05) difference in the mean feed intake of snails fed graded levels rumen digesta. The null hypothesis was therefore accepted because the F- ratio is lesser than the F-tabulated at 0.05 level of significance.

Findings:

The following are the findings based on the data analyzed and presented:

1. Treatment two (T_2) with 10% rumen digesta content showed the highest weight gain as shown in table 11.
2. The length of snails in Treatment two (T_2) was slightly higher than the snails in $T_{1,}$ T_2 and T_3 respectively as shown in table 12.
3. The width of snails in T_2 was also slightly higher than the snails in $T_{1,}$ T_2 and T_3 as shown in table 13.
4. At twelve weeks, the snails in diet three (T_2) indicated the highest feed consumption rate as shown in table 14.

Discussion of Findings:

The findings of this study have been organized and discussed according to the research questions and hypotheses.

The result as summarized in table 11 generally showed the performance data. The use of rumen digesta as a replacement of wheat offal resulted in a significant difference occurring between groups of snails in the analysis of the final weight gain. The highest weight gain of 8.59g was recorded for snails in T_2 (10% rumen content). This showed the superiority and palatability of diet T_2 (10%) to other diets ($T_{0,,}T_1$ and T_3). Although 10% rumen content was recorded as the highest based on the findings, this might be because of chemical or nutrient composition of the type of pasture consumed by the ruminant animal because the researcher while compounding the first three diets ($T_{0,}$ T_1 and T_2) exhausted the rumen digesta collected. Another trip was made to the abattoir and the rumen digesta collected was used in formulating the last diet (T_3 that is 15% rumen content). Besides, this could be influenced by the stage of digesta degradation in the rumen. It is also expedient to note that two snails died and were replaced in treatment three (T_3) during the fourth week of the experiment.

However, the result obtained indicated clearly that incorporating dried rumen digesta up to the level of 10% in the snail diet is acceptable to snails and will meet the growth requirement thereby eliminating the need for costly energy supplements. Thus, rumen digesta, which is a non-competing and non-conventional feedstuff for human beings, was found useful as an economic replacement for energy feed ingredients as cereals. The use of dried rumen digesta in formulating snail feed is thereby advocated.

The improved performance could also probably be due to adequate dietary crude fiber level of rumen digesta. This is because crude fiber activates the intestine and results in more occurrence of peristaltic movement, more enzyme production leading to efficient digestion of nutrients (Kekeocha, 1984). This result conforms to the result of Dairo (2005) who reported that rumen digesta could be incorporated optimally at 30% in growing rabbit rations for success in rabbit production. This also agrees with the report of Abubakar (1995), who stated that the use of rumen digesta in livestock feeding has no harmful effect on growth performance. Besides, Emenalom (2006) reported that birds on diets containing dried rumen digesta recorded higher body weight gain than the control (0%) group.

The average weight gain of snails fed with rumen digesta statistically indicated that a significant ($P < 0.05$) difference occurred between the groups of snails in various levels of the treatment. This confirms that rumen digesta which is a locally sourced feed is very nutritive, palatable, acceptable and safe for feeding snails since no metabolic disorder was observed or recorded.

The result as summarized in table 12 and 13 clearly indicated that there was highest increase in the mean length (82.50) and mean width (42.50) of snails in treatment two (T_2). In comparing this result with other treatments (T_0, T_1 and T_3), one can infer that the snails in treatment two (T_2) performed better. Using the data in table 12 and 13, there was no significant ($P>0.05$) difference in the length and width of snails fed graded levels of rumen digesta.

The data in table 14 above showed that the snails in treatment two (T_2) recorded the highest mean feed intake of 1.11 at the end of the experiment and had the highest feed consumption rate. This is in line with Oyenuga in Kanu (1997) who reported that increased feed consumption rate has relationship with increased feed composition and palatability. This corroborated the result in table 14 which shows that snails in all the diets containing rumen digesta had higher feed intake values with the control feed (0%) having the least feed intake value. It can be inferred that rumen digesta was palatable, safe and free from toxins.

The data in table 14 statistically shows that there was no significant difference in the feed intake of snails fed with graded levels of rumen digesta. This is not in conformity with the result of Whyte and Wadak (2002) who reported a significant ($P<0.05$) difference in the feed intake for rabbits fed 30% rumen digesta inclusion.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Restatement of the Problem

The Food and Agricultural Organization in Nweze (2007) recommended 65-70g of protein per day for every adult, out of which 35g should be of animal origin. Regrettably, animal productions contribute only about 15-20% of the total protein intake in the nation. Omole (2007) asserted that the supply of protein of animal source in Nigeria is inadequate because the demand exceeds supply.

The economic distress mostly prevalent in Nigeria and most developing countries has affected the family consumption of protein, as emphasis has shifted from the conventional high quality animal protein like chicken, beef, pork to less qualitative alternative sources of cereals and pulses (i.e. plant protein). The need for consumption of quality and well-balanced food cannot be over-emphasized as this can help to reduce the level of malnutrition among the growing populace. There is inadequate supply of animal protein to meet up with the increase in population and hence the high cost of it.

Effort should be directed towards bridging the gap in animal protein production and making this easily available for consumption by all and sundry. The increasing demand for animal protein supply coupled with more stringent economic conditions have necessitated greater interest in the production of cheap and very prolific micro-livestock like rabbit, grasscutter and snail to supplement other sources of animal protein. Snail farming known as heliculture is a relatively new area of animal production and research in Nigeria. It involves the keeping of snails in a confined environment under human control and management. However, the success of snail farming as well as the availability of snail meat all through the year is largely dependent on the availability of feeds.

Snails feed on vegetables, fruits, tubers, leaves, kitchen wastes as well as compounded feed. Due to the seasonal nature of plant feed materials as well as the high cost of compounding snail feed; there is need for alternative cheap and locally available feed in order to sustain a continuous production of snails in rainy and dry seasons. Commercial snail farming should be encouraged to meet the demand for snail meat both locally and internationally.

Investigations are being carried out by many researchers on the effect of supplementing the natural feed (plant leaves) with formulated diets in order to increase growth, nutrient utilization and immensely increase protein intake of the populace.

Therefore, this study was designed to determine the effect of feeding varying levels of rumen digesta as a locally available feed ingredient on the growth of African land giant snail for maximum productivity. Specifically, the study was designed to:

1. determine the effect of three levels of feed containing rumen digesta with one control on the weight gain of African giant land snails fed with each level of feed.
2. find out the increase in the length and width of snails fed graded levels of rumen digesta.
3. determine the feed in-take of the snails as measured by the amount of feed consumed by them on daily basis.

Following the above purposes, three research questions and three null hypotheses were postulated.

Description of Method Used

This study is a true experimental research and the design adopted was the completely randomized design (CRD). The population for the study consisted of one hundred and fifty juvenile snails. Simple random sampling technique using balloting was used for the study. Forty-eighty juvenile snails were sampled for the experiment and assigned to four treatments with three replicates each thus consisting of twelve experimental units. Each treatment had four juvenile snails.

The data collected from the experiment was analyzed using one-way analysis of variance (ANOVA). The difference between the treatment means was separated using Duncan's New Multiple Range Test (DMRT).

Major Findings of the Study

The following are the major findings of this study:

1. T_2 (10% rumen digesta inclusion) showed the highest weight gain.
2. The length of snails in T_2 (10% rumen digesta inclusion) was slightly higher than the snails in other treatments ($T_{0,}$ T_1 and T_3).
3. The width of snails in treatment two (T_2) was slightly higher than the snails in other treatments. ($T_{0,}$ T_1 and T_3).
4. At the end of twelve weeks, the snails in diet three T_2 (10% rumen digesta content) showed the highest feed consumption rate.

Conclusion

Based on the findings of the study, the following conclusions were made:

1. Rumen digesta could be fed to snails at 10% level of supplementation thus providing a cheaper source of feeding and helps in clearing the abattoir wastes to reduce associated environmental health hazards.

2. Rumen digesta diets performed generally better than the control group. This improved performance could be attributed to higher protein component of the undigested and partially digested feed protein material due to the influence of microbial protein.
3. It can be inferred from the results of the experiment that rumen digesta could be supplemented with snail feed to ensure all year round availability and reduction in cost and competition from man and industries for conventional feed ingredients.
4. The experiment reveals that rumen digesta require further processing into more palatable, storable, acceptable and safe forms.
5. Rumen digesta was found nutritive enough to be incorporated as unconventional and locally sourced feedstuff in feeding snails.

Implications of the Study

The findings of this study have immense implications at both subsistence and commercial basis for the snail farmers, researchers, Ministries of Education and Agriculture, teachers, students, job seekers as well as the public.

Adoption of the findings of this study by snail farmers will enable them rear snails all year round at cheaper cost and with ease by supplementing snail feed with rumen digesta collected at no cost from the abattoir.

Ministries of Agriculture and Education need to revisit the curriculum in secondary school agricultural science because presently, snail husbandry is still new in the country and has not been included in the school curriculum.

Teachers as well as students in higher institutions will be spurred to research further on other ways of supplementing or improvising snail feed to ensure all year availability of snail in the market and at cheaper rates.

Limitations

The following difficulty was encountered during the study:

The snails suffered from a microbial disease infection at the fourth week of the experiment. This affected and reduced the feed intake of snails for that week for both the control and experimental groups. However, some samples of the snails were taken to the Veterinary Laboratory of University of Nigeria Nsukka for diagnosis. This resulted in a new discovery of snail disease but recommendation of drug (Gentamycin) was made. The drug was purchased and administered (see picture 10, page 89). Consequently, only two snails died while other snails became healthy until the end of the experiment.

Recommendations

From the findings of this study, the following recommendations were made:

1. Snail farmers should use2 rumen digesta as a locally available feed ingredient to compound and supplement snail feed at cheaper rate.
2. The government should sponsor seminars and workshops for snail farmers and the public who are interested in snail farming because of the nutritional and medicinal value of snail and train them on how to process and use rumen digesta to compound feed for snails to ensure commercial snail farming and all year availability of snail at cheaper rate.
3. The extension agents and some agricultural agencies should embark upon massive sensitization of snail rearing especially in rural areas where poverty is prevalent and train the illiterate ones on how to compound snail feed using rumen digesta. This will also boost the animal protein intake of the rural dwellers.

4. Successful snail farmers should organize exhibitions of these African land giant snails, probably attend agricultural shows, and trade fair to display and disseminate the skills required in snail husbandry for the public and for patronage.
5. Researchers on snail farming should be motivated and assisted financially to publish their works for wider publicity on snail rearing which is still very new in the country.

Suggestions for Further Research

The following suggestions are made for further research:

1. Similar study should be conducted to increase the percentage inclusion of rumen digesta but care should be taken to collect enough rumen digesta that will be used to compound all the experimental diets.
2. Similar study should also be conducted to verify whether dried rumen digesta could store for a long period (i.e one year) without further deterioration.
3. A study on other locally available feedstuffs that can be used in supplementing and compounding snail feed should be carried out such as Soya bean and breadfruit husks to identify and select potential feedstuffs available in the locality.
4. A study should be carried out on ways to actively involve students and youths in practical snail husbandry and feed formulation to enhance their interest in snail farming and enable them become self reliant by establishing their own snailery.
5. Periodic seminars should be carried out to keep snail farmers and the public abreast of innovations, methods and changes in snail feeding and animal nutrition.

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Appendix I

One Way ANOVA Result of the weight gain, Length, width and feed intake of snails fed varying levels of Rumen Digesta

		Sum of Squares	d f	Mean Squares	F	Sig.
Initial body weight	B/W Groups	76.487	3	25.496	3.63	.064
	W. Groups	56.260	8	7.033		
	Total	132.747	11			
Total weight gain	B/W Groups	13374.42	3	4458.138	4.03	.051
	W. Groups	8845.98	8	1105.748		
	Total	22220.396	11			
Initial Length	B/W Groups	.087	3	.029	1.28	.344
	W. Groups	.180	8	.023		
	Total	.267	11			
Final Length	B/W Groups	20.993	3	6.998	1.13	.392
	W. Groups	49.353	8	6.169		
	Total	70.347	11			
Initial Width	B/W Groups	.243	3	.081	2.86	.104
	W. Groups	.227	8	.028		
	Total	.470	11			
Final Width	B/W Groups	18.802	3	6.267	.716	.570
	W. Groups	70.040	8	8.755		
	Total	88.843	11			
Total feed intake	B/W Groups	560.543	3	186.848	1.41	.309
	W. Groups	1059.667	8	132.458		
	Total	1620.210	11			
Av. daily feed intake	B/W Groups	.005	3	.002	1.54	.279
	W. Groups	.009	8	.001		
	Total	.014	11			

Appendix II

Comparison of treatment means of Weight gain, Length, Width and Feed intake of snails fed varying levels of rumen digesta using Duncan's Multiple Range Test (DMRT) as Post Hoc Test.

Initial Body Weight

	Subset for alpha = 0.05		
Treatment	N	1	2
3	3	61.6667 b	
0	3	63.83333	63.83333 ab
2	3	66.4667	66.4667 ab
1	3		68.3000 a
Sig.		.066	.083

Total Weight Gain

	Subset for alpha = 0.05		
Treatment	N	1	2
3	3	780.6333 b	
0	3	786.9600 b	
1	3	838.7667	838.7667 ab
2	3		858.9667 a
Sig.		.074	.478

** **key:** The means not followed by the same letter in a cell are significantly different at 0.05 level of significance as determined by the DMRT. Means for groups in homogenous subsets are displayed.

Average daily weight Gain

	Subset for alpha = 0.05		
Treatment	N	1	2
3	3	b 2.3333	
0	3	b 2.3333	
1	3	2.5000	2.5000
2	3		a 2.5333
Sig.		.054	.650

* Means for groups in homogenous subsets are displayed.

Initial Length

	Subset for alpha = 0.05	
Treatment	N	1
3	3	6.6333
2	3	6.7000
0	3	6.7333
1	3	6.8667
Sig.		.111

* Means for groups in homogenous subsets are displayed.

Final length

	Subset for alpha = 0.05	
Treatment	N	1
3	3	78.8000
0	3	80.2333
1	3	80.7333
2	3	82.5000
Sig.		.125

* Means for groups in homogenous subsets are displayed.

Initial Width

	Subset for alpha = 0.05		
Treatment	N	1	2
0	3	3.1667	
1	3	3.3333	3.3333
3	3	3.3333	3.3333
2	3		3.5667
Sig.		.278	.142

* Means for groups in homogenous subsets are displayed.

Final Width

	Subset for alpha = 0.05	
Treatment	N	1
0	3	39.3333
3	3	39.6333
1	3	40.0333
2	3	42.5000
Sig.		.252

* Means for groups in homogenous subsets are displayed.

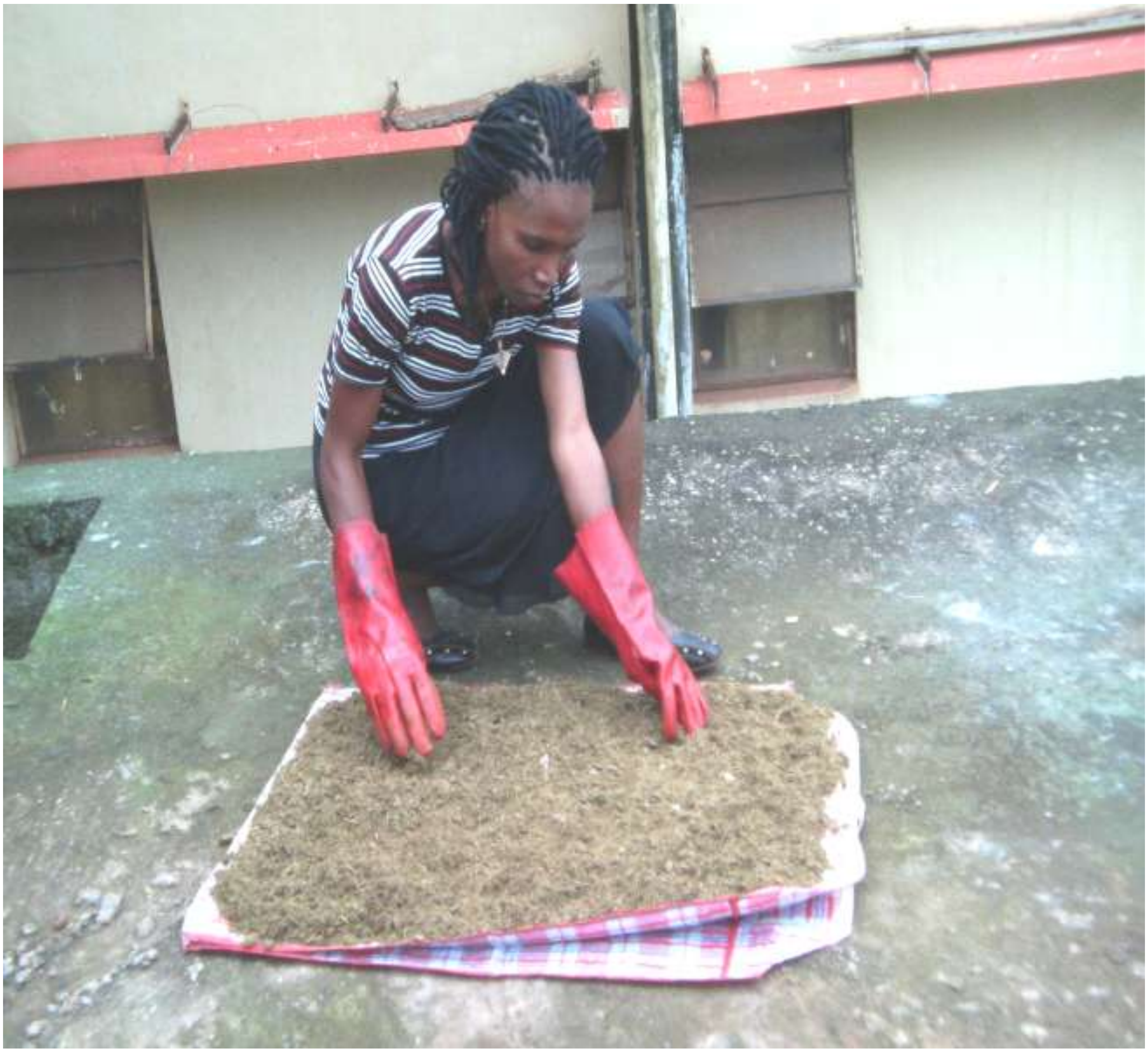
Total Feed Intake

	Subset for alpha = 0.05	
Treatment	N	1
0	3	93.0333
3	3	95.9667
1	3	99.3667
2	3	111.0333
Sig.		.110

* Means for groups in homogenous subsets are displayed.

Appendix III

Picture 1



Researcher sun drying rumen digesta collected from the abattoir

Picture 2

Researcher carrying various species of Snails with African giant land snail as the biggest

Picture 3

Front view of Animal Science Snailery

Picture 4

Researcher assigning the snails to the pens

Picture 5

Snails in the pen with feed and water

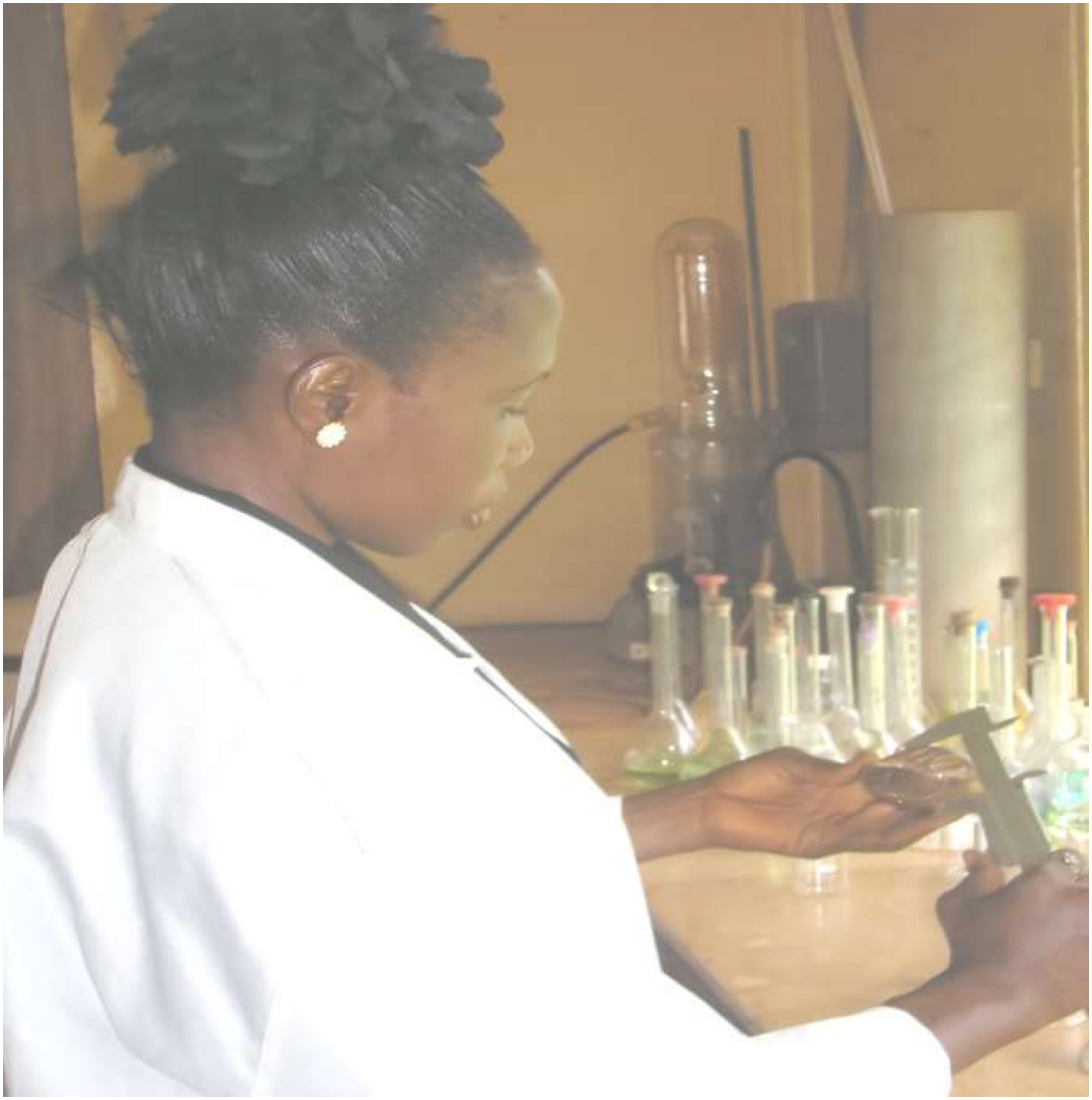
Picture 6

Measurement of the weight gain of snails using sensitive digital weighing balance

Picture 7

Measurement of the length of snails using Vennier Caliper

Picture 8

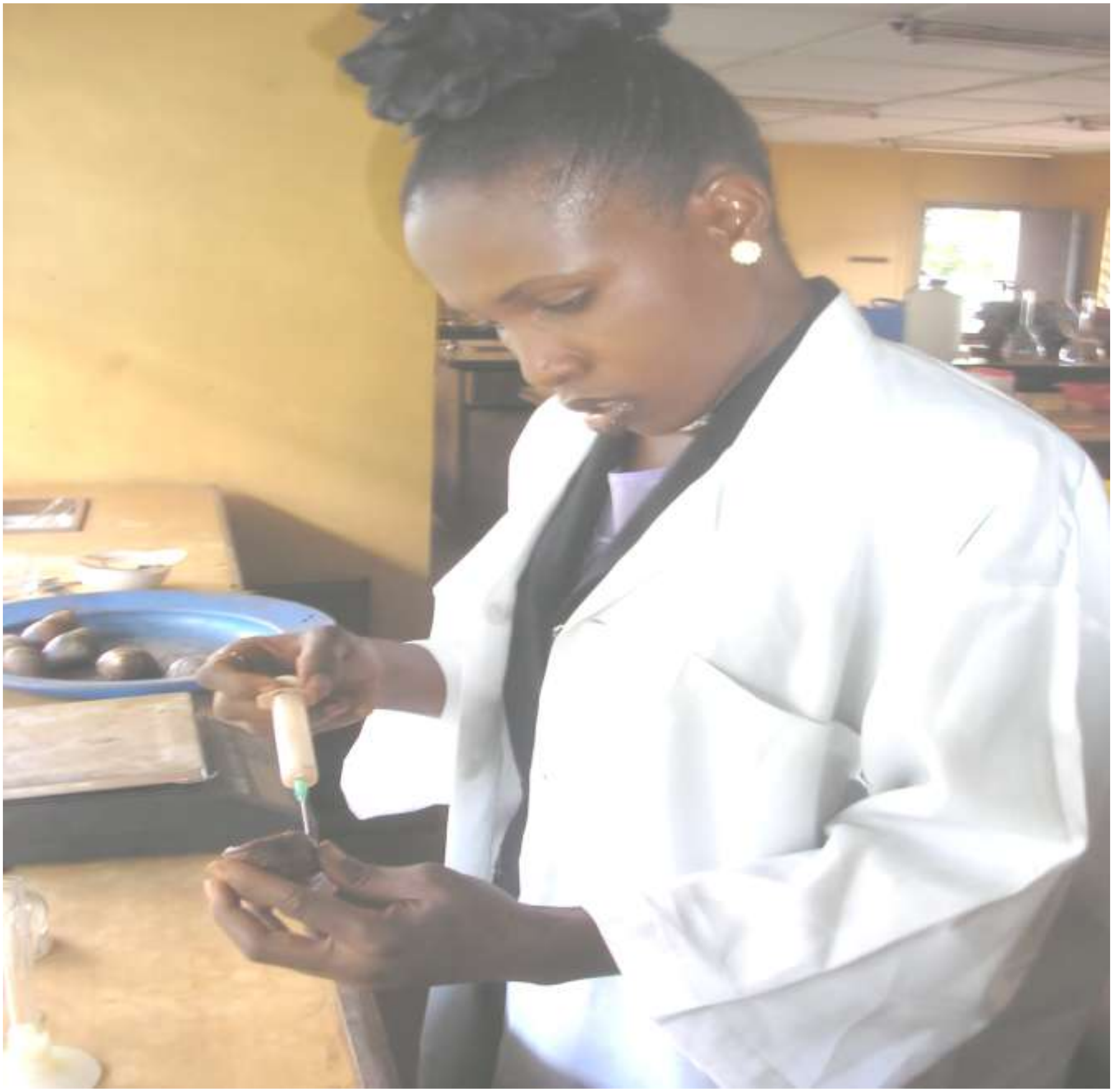


Measurement of the width of snails using Vennier Caliper

Picture 9

Measurement of the Feed intake of snails using weigh back technique

Picture 10



Researcher injecting the snails at the 4th week of the experiment during disease outbreak

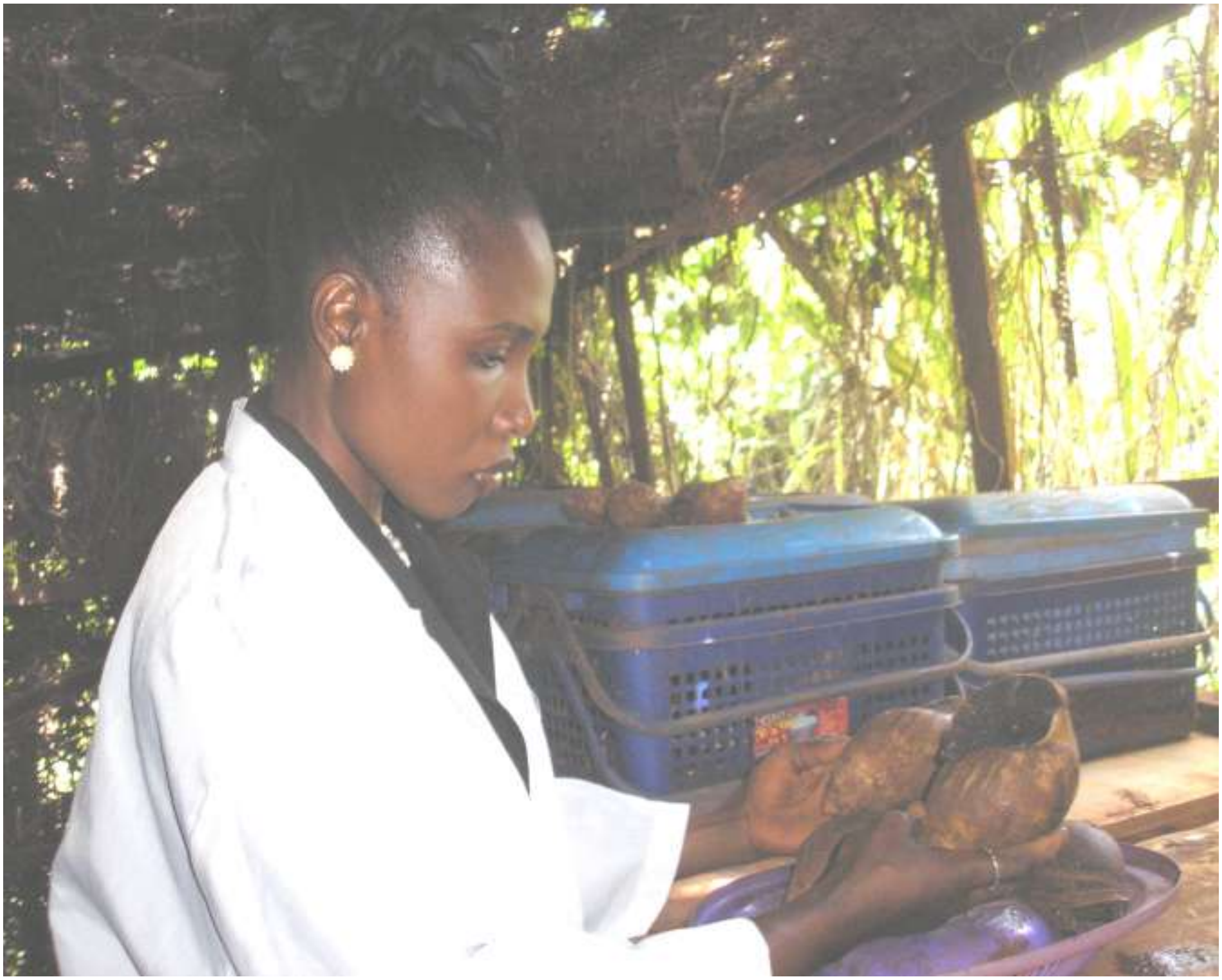
Picture 11

Researcher incubating the eggs laid by snails toward the end of the experiment

Picture 12

Researcher with the hatchlings (newly hatched snails)

Picture 13



Researcher with mature African giant land snail (*Archarchatina marginata)*