

**COMPARATIVE STUDY OF SNAIL PRODUCTION
SYSTEMS USING CROPS AS COVER**

BY

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BENIN CITY, NIGERIA**

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**A THESIS WRITTEN IN THE DEPARTMENT OF ANIMAL
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OF THE REQUIREMENT FOR THE AWARD OF THE
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ANIMAL SCIENCE**

SEPTEMBER, 2023

CERTIFICATION

This is to certify that this research project was carried out by **Winifred Eno. AKINWALE** under the guidance of the project supervisors and approved by the Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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CERTIFICATION OF THESIS/DISSERTATION ON PLAGIARISM

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DEDICATION

This project is dedicated to my Heavenly Father, Saviour, Jesus Christ and the Holy Spirit through whom I obtained unmerited favour and grace to complete the programme.

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ABSTRACT

This study was carried out to comparatively study different snail production systems using crops as cover.

The systems evaluated were open and screened paddocks in comparison with the conventional paddock. In the open and screened paddocks, four different crops (*Pueraria phaseoloides*, *Centrosema mole*, *Calapogonium mucunoides* and *Manihot esculenta*) were cultivated to simulate the natural environment of the snails. The snails were allowed to live on the crops as applicable in the wild for the first 6 weeks after which concentrate was introduced for another six weeks while conventional feeding materials like pawpaw leaves, fruits and water leaf were utilized in the conventional paddock. A total number of three hundred and twenty (320) apparently healthy *Archachatina marginata* with liveweight between 50 to 60 g were used in the study which was laid out in a 2 X 4 factorial in Randomized Complete Block Design with four replicates. Data collected on growth, reproduction, environmental temperature and relative humidity were subjected to Analysis of Variance (ANOVA) using GenStat version 12.0 statistical software. Significant level was taken at $P < 0.05$.

There was a significant difference ($P < 0.05$) in the weight of the snails among the four cover treatments when compared on the basis of the production systems. The snails in the Mucuna, Centro, Puero and Cassava screened paddock recorded 10.75, 5.90, 5.63 and 4.43 g weight gain respectively while the snails reared under the open paddock in Mucuna, Puero, Centro and Cassava had weight gain of 4.28, 3.7, 2.9 and -2.8 g respectively. The snails in the conventional paddock had an average weight gain of 6.5 g. The snails reared under Cassava in the screened paddock laid the highest average number

of eggs (10). Snails from the *Mucuna* pen in the screened paddock had bigger average size of eggs (20 mm) while the Snails from the *Centro* pens in the screened paddock had the highest average egg weight (1.30 g). The incubation period ranged between 26.5 to 32 days. Eggs laid by snail in the *Centrosema* pen in the screened paddock recorded 100 % hatching. The average temperature recorded at 0, 6 and 12 weeks for Open paddock were 39.43, 37.98 and 45.05 °C; for screened paddock were 36.19, 36.67 and 42.76 °C and conventional paddock were; 39.75, 39.10 and 45.05 °C respectively. The relative humidity recorded in the open paddock at 0, 6 and 12 weeks were 77.31, 63 and 65.11 %; screened paddock were 77.31, 66.63 and 71.56 % and Conventional paddock were 78.75, 68.75 and 67.50 % respectively. It was concluded that rearing snails under a screened paddock did not only help to regulate the temperature and relative humidity of the snails immediate environment but also protected the snails from intruders, predators and escape which are the major factors responsible for successful snail farming.

CHAPTER ONE

2.0 INTRODUCTION

1.1 Background of Study

In snail taxonomy, the order Stylommatophora is the most successful group of terrestrial gastropods in terms of species diversity (Barker, 2001). This is of particular importance to this study as most species of Giant African Land Snails (GALS) are of this order. The GALS belong to the phylum *Mollusca*, of class Gastropod, subclass Pulmonata, order Stylommatophora and family Achatinidae. The word snail is a common name that is used for almost all members of the Mollusca class Gastropoda which have coiled shells in their adult stage (Cobbinah, 1992). Those snails which do not have shell or only a very small shell are usually called slugs.

Snails may be regarded as pest and vector in some countries of the world, but in others, particularly West African, snail meat popularly called ‘Congo meat’ is highly relished and indeed considered a delicacy. From historic times the Romans are known to have considered escargot, an elite food, as noted in the writings of Pliny, a Roman nobleman, scientist and historian (Chapman, 2009).

In Nigeria, the very well-known edible land snails belong to the genera *Archachatina*, *Achatina* and *Limicolaria*. The species of *Archachatina* and *Achatina* constitute the most conspicuous terrestrial mollusc in the southern part of Nigeria and are very important economically. It is known to be rich in protein (between 12-16%), iron (between 45-50 mg/kg) and contains almost all the amino acids such as lysine, leucine, arginine and tryptophan that are needed by humans but low in fat according to Ibom and Okon (2012).

The popularity and peculiarity of snail farming include ease of handling, availability of foundation stock, low cost of production and low incidence of diseases (Akinnusi, 1998).

In the past, snails were abundant in the wild and easily handpicked but these days, there is a noticeable decline in wild population as developments, industrialisation, deforestation and other activities of humans is on the increase and have become a threat to the existence of snail in the wild and its supply to markets (Kehinde, 2013). A recent study by Osabuohien and Omoyakhi (2018) showed that there is high risk associated with wild search for snails and that the availability of captive bred snails will augment the exploitation of the wild and prevent snails from going on extinction. However, major factors affecting snails in captivity were identified as housing types, feeding, breeds, environmental temperature, humidity, management practices and stocking density (Omoyakhi *et al.*, 2008). Series of researches have also shown that *A. marginata* has great potentials for growth and reproduction in captive rearing (Omoyakhi *et al.*, 2008; Omoyakhi and Osinowo, 2010; Omoyakhi *et al.*, 2017; Okhale *et al.*, 2018).

1.2 Justification

The livestock industry plays a vital role in the Nigerian economy as well as provides nutritious animal protein to the teeming population. According to Egunike *et al.* (1999) animal protein deficiency diseases are rampant in children in most developing countries especially Nigeria. The daily animal protein intake is between 6.8-12.8g/caput which is lower than 35g/caput recommendation by FAO (1986). Therefore the drive for a boost in protein availability has led to a shift of focus to alternative sources of protein like insects, rodents, birds, snails and other animals in the wild. The demand for low cholesterol containing meat had also made scientists to grow interest in the production of highly

nutritive, medicinally important and efficient by-product utilizer like snail (Egunike *et al.*, 1999).

However, the snail production systems used in Nigeria are far from the standard obtained in developed world as the developed production technologies currently being deployed have not been able to produce the expected results when compared with other conventional livestock. The deployment of these technologies such as the use of drench pens and tyres only advances small scale productions that struggle to survive rather than make profits (Omoyakhi and Osinowo, 2010). Also, snail farming is well known to be associated with the onset and during the raining season when the snails are usually at their best growth and reproductive performance. This season is characterized by glut in the market and less economic value, hence rearing snails during the dry season will ensure all year round availability and will command higher market value as farmers involved in snail production enterprise aim at getting good return on their investment within the shortest possible time and sustainability in the business all year round, therefore any production system that will combine adequate climatic control and low production cost is of great value to a commercial snail farmer.

Previous researches have centred on conventional snail production system which is capital intensive, expose snails to the effect of inclement weather and do not give opportunity for the snail to exhibit their characteristics for optimum performance. This research however focused on alternative housing system that is less expensive, simulate the wild and easy to adopt by snail farmers.

1.3 Main Objective

The main objective of this research was to evaluate snail production systems on semi free range using crops as cover.

1.3.1 Specific Objectives

The Specific Objectives were to determine the:

- i. optimum production system that supports snail rearing
- ii. most suitable crop as cover for snail production
- iii. cost of production under the different systems
- iv. constraints of snail production amongst the production systems

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Snails

Snails are bilaterally-symmetrical invertebrates with soft segmented exoskeleton in the form of calcareous shells which belong to the phylum *Mollusca* (Cobbinah *et al.*, 2008). In West Africa, snails dwell mostly in humid forest areas from where they are gathered by villagers for consumption and other uses. Snail foot (the fleshy part) is usually referred to as the meat. The meat has been a major ingredient or component in the traditional diet of people living in high forest zones (Agbogidi and Okonta, 2011). It has high protein content and medically valuable and based on this, the demand for snails has increased over the years in both domestic and foreign markets. Asheye *et al.* (2001) reported that snail could be used to reduce the problem of malnutrition because the meat is known to be high in iron, calcium and phosphorus but low in sodium, fat and cholesterol and contains all the amino acids needed by man (Ibom and Okon, 2012). The high iron content of the meat is considered important in the treatment of anaemia and also for combating ulcer and asthma (Efarmspro, 2008). It has very low cholesterol level which is useful in the treatment of Arteriosclerosis and other heart-related diseases (Abere and Lameed, 2008). The amino acid in the protein of snail meat would complement the cereal source of protein by augmenting the deficiency of lysine (Bender, 1992). In addition to the nutritional value of the meat, recent studies indicated that glandular substance (Mucin) from edible snails causes agglutination of certain bacteria, which could be of value against a variety of ailments including whooping cough (Cobbinah *et al.*, 2008). They are environmental-friendly, unlike other conventional livestock such as pigs, poultry and

goats. Their droppings do not have offensive smell which makes it easy to rear at the backyard. The amount of capital required for the establishment of snail farm is appreciably small and the practice requires little labour with no strenuous physical exertion (Goodman, 2008). They are noiseless and quite easy to handle and can be reared in urban environment without infringing on the peace of neighbors (Agbogidi *et al.*, 2008). The practice also has the need for small space requirement. Besides, snail have been shown to adapt to various environmental conditions hence can be raise in small towns, cities, villages, farms, at background or commercial level (Ejidike, 2002).

The most common GALS (*Archachatina marginata* and *Achatina achatina*) are considered as a delicacy in Nigeria and they command high demand in the market (Adeyeye, 1996). *Archachatina marginata* is the largest known snail in Africa (Olawoyin and Ogogo, 2006). They generally have high rate of productivity or fecundity. Though they are hermaphrodites, they do practice sexual reproduction (Akinnusi, 2004). They are selective in their mating partners and sometimes uninterested in mating with other snails of the same species originating from a considerable distance away (Omole and Kehinde, 2005). Their natural habitat are mostly found in the forest, farms and gardens where they have unlimited vegetation to feed on. According to Raut and Barker (2002) the most dominant types of vegetation in Africa are the tropical forest and the savannah where a wide variety of the African terrestrial Gastropods inhabit. Most land snails, especially, the giant African land snails (GALS) that are eaten and exported are usually picked from their natural habitat. However, with the large market for the meat, many concerns have been raised about the reduction in their natural population. With challenges such as depletion of the stock of wild snails, over population, high cost of conventional animal

protein, and also for health reasons, the demand for snails has increased such that commercial production is necessary.

The commercial farming of snails on a continuous basis trespassing the dry seasons through good management practices needs assurance of constant feed supply. Thus, there is the need for alternative cheap and available feedstuff sources, not in competition with other animal species. Limitation of rearing snails includes their very slow growth rate and seasonal breeding pattern, severely limiting their productivity (Eze *et al.*, 2010). This indicates the importance of intensive management and nutrition to induce profitability in snail farming. Concentrate feed or supplements is necessary to optimize the growth and productivity of the snail enterprise, as most of the plant food materials are seasonal and do not possess balanced nutrient. The high cost of concentrate ration occasioned by expensive conventional protein feedstuff could reduce the profit margin in snail enterprise. Ejidike and Afolayan (2010) pointed out that the availability of acceptable snail feed could contribute a lot in encouraging interest in snail farming, thereby mitigating the current acute animal protein shortage.

2.1.1 *Archachatina marginata*

This species according to Akinnusi (2002, 2004), Ogogo (2004), Omole *et al.* (2007) and Ibom (2009) is native to Nigeria but has spread to other African countries and beyond, Southern Asia and the Pacific Island through commerce (Payne and Wilson, 1999). It survives and spreads easily in other parts of the world such as Britain and several islands of Gulf of Guinea, proving its tolerance to temperature and tropical climate (Egonmwan, 1988; Gascogne, 1994). The ability for snails to aestivate is most likely an adaptation for

surviving in varying conditions associated with different parts of the world where they are found.

Archachatina marginata are highly fecund, prolific and can live as long as nine years (Adikwu, 2012). They are soft-bodied animals consisting of two main parts; the body and the shell. The body is divided into three parts; the head, the foot and the visceral mass which are all encapsulated by the shell. The wall of the shell is lined by the fleshy mantle. The head consists of the mouth and four tentacles of which the upper pair is longer. The head bears two tentacles that can be retracted. The upper pair is longer than the lower pair (Roberts, 2000). Each pair of the tentacles has a tiny eye at the tip. The eye is used to distinguish light and darkness. The two shorter tentacles are knobbed at the tips and are the organ of smell and touch. The mouth is located at the centre of the head. The mouth opens directly into the muscular cavity lined with a horny jaw and a radula flexible file-like rasping organ with numerous rows of muscular teeth for shredding food (Akinnusi, 1998). The foot, protruding from the shell, allows movement and sticking of the snail to the ground. The bottom part of the foot contains many glands that secrete slime thus creating visible silvery trace. Its movement are slow but strong. The lower part of the foot is made of strong muscles. The visceral mass, which is the softest part, is confined within the upper whorls of the shell. It is hump shaped and generally holds the bulk of the digestive, reproductive, excretory and respiratory system. The skin of the visceral hump secretes a large calcareous shell.

The typical snail has a calcareous shell coiled in a spiral pattern around a central axis or columella. The secretion of the shell is by outward additions to the shell lip and then by secretion of inner thickening layers. The outer layer of the shell is a mixture of protein

known as conchin. Inner layers of the shell are made up of calcium carbonate join with a network of conchin and are impregnably with variety of mineral salt. Cobbinah (1992) submitted that 98 % of the shell is in the form of calcium carbonate.

2.1.2 Nutritional values of snail meat

The nutritional value of snail meat can not be overemphasized. Outside the conventional sources of protein (which are mainly meat and fish), snails are excellent sources of protein and mineral elements for many families. The meat is a nutritious food that is high in protein, low in fat and a good source of iron (USDA, 2006). According to Akinnusi (2002) snail meat is high in protein, iron, calcium and phosphorus, but low in sodium, fat and cholesterol and contains almost all the amino acids needed by man. The meat is high in health benefiting essential fatty acids such as linoleic and linolenic acids. A study on a snail species in Brazil estimated that 75% of the fat in snail is unsaturated fatty acids. That is 57% polyunsaturated fatty acids, 15.5% of monounsaturated fatty acids and 23.25% of saturated fatty acids (Su *et al.*, 2004).

2.1.3 Other benefits of snail meat

The other benefits derived from the consumption of snail meat are numerous and there is a continuous increase due to the fact that people consume snail meat for different reasons (Ogogo *et al.*, 2011). While some consumers patronise the meat for health reasons, others harness its believed medicinal values. The low content of fat (1.3%) and low cholesterol level makes snail meat a good antidote for vascular diseases such as heart attack, cardiac arrest, hypertension, stroke, high blood pressure and other fat related ailments according to Akinnusi (2002). Ayodele and Ashimolowo (1999) reported that among the people of West Africa specifically the Yoruba speaking people of the South Western Nigeria, snail

is a requirement in several preparations in traditional medicine. At the household level, nursing mothers depend on the snail mucus for treating wounds from the umbilical cords. All these medicinal attributes are however yet to be proven.

The numerous benefits of GALS (*Archachatina marginata*) have been enumerated in the past (Orisawuyi, 1989; Akinnusi, 2002). The high nutritive value has made it to form part of diets for both urban and rural dwellers (Ademolu *et al.*, 2007). Its medical importance and ability to cure diseases was highlighted by Amusan and Omidiji (1999). The presence of vital ions and other metabolites in its haemolymph might be responsible for its medicinal use according to Ejidike (2002). Due to these and other benefits of snails, there has been an increase in its demand over the years and this has made its rearing and domestication inevitable.

2.1.4 Challenges with the consumption of snail meat

Even though ‘Congo meat’ is known to be highly nutritious, the several issues associated with it has prevented a number of persons from patronising it especially consumers who are engaged in sedentary work with little time at their disposal. The percentage of individuals who do not eat snails may be due to traditional, religious and cultural believe and it could also be as a result of health problems such as allergies among others (Ebenso, 2003). Outside the challenges identified by Ebenso (2003), the habitat and feeding habit of snails is another factor people consider. Due to their natural habitat and their feeding habits, there is a high possibility of the meat being contaminated with lots of microorganisms. Snails are usually picked from the soil were they live, feed and breed. However, the soil is a host of several microorganisms most of which are pathogenic but there is growing interests on the extent to which edible land snails may present a threat to

the health of humans (Ekundayo and Fagade, 2005). Other limiting factors could be the slime and shelling of snails, dirt, and price. Unlike meat or fish, snail preparation could be very complex and requires some skills in doing so, there are also problems associated with the slime found on them. One complication in commercial processing of snail to meat has been the mucus or “slime” secreted by the snails, used in their locomotion, defence, water retention and other physiological activities (Gallo, 2002). Snails are also dirty and covered with mud since they are mostly on the ground. All these, prevents consumers from patronising it. Therefore these limitations contradict the general beliefs that the meat has traditionally been a major ingredient in the diet of people living in high forest zone and the rural or semi urban communities (Agbogidi and Okonta, 2011; Ademolu *et al.*, 2007).

2.1.5 Snail parasites and pathogens

It is necessary to understand the parasites and pathogen that could have effect on humans upon consumption of Congo meat. According to ICMSF (2005), snails may contain some parasites and other pathogenic bacteria which cannot be gotten rid of even after purging. This could be due to the habitat in which they are found. A study conducted by Ekundayo and Fagade (2005) on different snail farms in Nigeria showed that microbial load of snail farm soil had a count of 5.35 to 5.85 (log₁₀ CFU/g) and a count of 5.43 and 5.08 (log₁₀ CFU/g) in the visceral mass of snails obtained from different snail farms. This indicates some relationship between the microbial load of snail and the soils they have contact with and the visceral fluid and excretion process of the snail can also result in cross contamination of the meat. Efuntoye *et al.* (2011) isolated several species of *Staphylococcus* from the intestines of snails of both *Achatina* and *Archachatina* species.

Total viable count is used to indicate the level of microbial contamination of a product (Maturin and Peeler, 1998). Although this may not directly relate to food safety hazard, it can be used to indicate the quality, shelf life and post-harvest contamination of these foods. According to Adagbada *et al.* (2011), there is a close association between snails and microorganisms because their habitat is made up of filth, sewage, manure, rotten materials and poor latrine system which could increase the microbial load of land snails. Another possible source of contamination among the breeding farm samples is the presence of other decomposed snails or their fecal material which had become part of the soil (Ekundayo and Fagade (2005). Their findings also indicated that, as a result of snails licking the slime of infected snails or dead rotten snail, the microbial flora of the meat could be high. Therefore, efficient processing methods should be done to eliminate the organism totally from the cooked meat (Parlapani *et al.*, 2014).

2.1.6 Snail feeding and management

The type of feed and management provided for snails will determine how well they will perform both in growth and reproduction. Thompson and Sheldon (2004) reported that poor nutrition affects snail growth and causes a drop in the reproductive performance. According to Amaefule and Onwudike (2000), Ani and Okeke (2003), Esonu *et al.* (2003) and Oyeagu *et al.* (2015; 2018), the most important factor influencing the performance of animals under captivity is the quality of diet offered to the animals. Nyameasem and Borketey-La (2014) reported that layer mash (a concentrate ration) supported reproduction in the snails better than pawpaw fruit diet which was attributed to the report that pawpaw fruit as a sole diet is not nutritionally balanced enough to meet snails'

requirements for reproduction while the available nutrients of the diets originating from different feedstuffs are more nutritionally balanced.

According to Olatunji *et al.* (2020) egg hatchability, the fertility of eggs, and average juvenile growth of snails fed on leaf meal-inclusive diets were superior to concentrate-fed snails without leaf meal inclusion. This is suggestive of the beneficial ability of the leaf meals to influence reproduction positively and his findings corroborated other reports in rabbit and poultry that leaf meals enhance reproduction and fertility (Ewuola *et al.*, 2012). The result of the study by Olatunji *et al.* (2020) is in agreement with the finding by Ejidike (2007) and Oyeagu *et al.* (2018) that snails fed with diets containing concentrate feed and herbs performed better than those that received only concentrate or herbs. The concentrate ration enhanced reproductive organ development and the inclusions of leaf meals also contributed to organ development compared to laying snails on natural plant feed/roughage. Moreso, the gonadosomatic index of snails on herbs and roughage treatment was better than snails on concentrate without leaf meal inclusion. The reproductive ability of snails is predicted by the gonadosomatic index; this explains the high gonadosomatic index of snails on leaf meal-based diet accompanied with better reproductive output in laying snails (Olatunji *et al.*, 2020). He therefore submitted that concentrate diet is essential for optimal reproductive output in snails and that the conventional belief that snails are herbivores and can survive on herbs and roughage is for maintenance requirement also, that the reproductive functions such as egg laying and snaillet production require concentrate-based feeding to improve growth and offspring production, especially for commercialization.

Therefore, the benefit of combining herbs and concentrate to feed snails cannot be overemphasized as Oyeagu *et al.* (2018) also reported that inclusion of *C. pubescens* in concentrate ration for snails increased the number of eggs laid, hatchability, and fertility of eggs with a lesser mortality of the embryo.

2.2 Heliculture and its potentials

Heliculture is the practice of rearing and raising snails in captivity for human consumption and it involves the provision of physical conditions required for feeding, growth and reproduction. In captivity or intensive system, snails are reared in various housing units: basket, old tyres, drums, pots, pen and cages. However, conditions in captivity do not always mimic perfectly those in the wild which may result in slow growth rate, immortality and non-reproduction (Odaibo, 1997). Some factors that could affect snails in captivity are lack of suitable space and over crowding (Amusan and Omidiji, 1998). Over stocking snails in captivity results in over crowding which was reported by Orisawuyi (1989) to affect the growth, sexual development of snails and survival. Agbelusi and Adekugbe (1999) also highlighted that stocking ratio should be considered for snails to be able to perform optimally. However, Ademolu *et al.* (2006) observed that stocking density influences the growth performance and haemolymph biochemical value of *A. marginata*. Hence, as snail domestication is now gaining popularity in Nigeria there is need to assess how well the conditions in captivity mimic those in the wild where the snails were originally residing and consuming conventional feeds which comprise breadfruits, waterleaf, pawpaw leaf and fruit, sweet orange, mango fruit, ripe fruit of plantain and banana, and other feeds of plant origin (Isikwenu, 2015).

The natural habitat of African giant land snail is facing deforestation and degradation due to human activities. Hence, there is need for heliculture and deliberate effort to commercialize snail production to meet the required animal protein demand in Nigeria. Large-scale farming of GALS (*Archachatina marginata*) is paving way in the international market as well as meeting people's demand in the local market for protein intake (Ejidike and Afolayan, 2010).

Snail farming is a potentially lucrative business in Nigeria. The market price varies and depends on many factors such as location, season and whether its been sold live or processed for value addition (Ahaotu *et al.*, 2019). They are generally more expensive during the dry season because people picking from the wild will be short of supply, thereby increasing the demand for snails. It is advisable to sell snails during dry season if one understands the strategy (Ahaotu *et al.*, 2019). They sell generally high compared to other meat source hence their establishment can go a long way solving unemployment, nutritional and health problems (Fagbuaro *et al.*, 2006). According to Hamzat *et al.* (2002) *Archachatina marginata* is common in Nigeria and it is an excellent source of animal protein while Murphy (2001) reported that snails have been and are still much sought after food and come to the table as a gastronomic delight.

2.3 Snail production systems

The type of production system to be used in snail rearing is dependent on the quantity of snail that is intended to be reared. Snail farm could be extensive, semi-intensive, or intensive in increasing order of complexity, management and financial inputs. Irrespective of the type of production system to be adopted in rearing snails, some factors which include adequate spacing, escape-proof, accessibility and protection from

predators and poachers have to be considered (Cobbinah, 1992).

The Extensive system is known as the outdoor and free-range snail pens while the Intensive makes use of a closed system, for example plastic tunnel houses, greenhouses and buildings with controlled climate. The third type is called semi-intensive system which is a mixture of both intensive and extensive systems of production. In this type, egg laying and hatching occur in a controlled environment just like the intensive while the young snails are removed after 6-8 weeks to outside pens for growing or fattening or both. The choice of system to be employed should also consider the fact that Snails are extremely strong and can lift 10-50 times their own weight and could lift a lid that isn't clipped or weighted down. Also, snails suffer from overcrowding when the spacing is inadequate which can hinder their development and increase the risk of diseases. The most suitable rearing densities range from $> 100/m^2$ for hatchlings to $7-10/m^2$ for intensive snail farming (Cobbinah, 2002).

One major challenge of domestication especially in the intensive production system is the ability to mimic perfectly the conditions in the wild so as to maximize the growth and reproductive potentials of the animal. Ademolu *et al.* (2012) reported that much still have to be done to achieve this task as a great gap exists between snails in the wild and those reared in captivity. Another obstacle to efficient snail production in intensive and semi-intensive management system is high cost of feed materials. In livestock farming feed cost is responsible for 60-70% of the total cost of production (Omole *et al.*, 2013). They are fed with various food items in captivity ranging from compounded feed to plant materials (roughages) and the plant materials vary from annual to perennial plants. Similarly, non-compounded materials like poultry dropping, pineapple peel,

Centrosemae sp. and *Calapogonium sp.* have also been consumed by snails in captivity (Eruvbetine, 2012). Omole *et al.* (2013) used dry unpeeled sweet potato in the diet of snails as energy source. However, pawpaw leaves and fruits of any age (green and yellow) have been provided for the animals especially during dry season when there is shortage in vegetation and the feed provided consist of different biological properties (Osato *et al.*, 1993). Ayoola and Adeyeye (2010) earlier reported that different leaves of *Carica papaya* (pawpaw leaves) have different phytochemical and nutritive values when fed to snails. Results from the study on contribution of pawpaw to the performance of giant African land snail by Ademolu *et al.* (2007) also showed that snails fed on ripe pawpaw fruits laid highest number of egg while snails fed old pawpaw leaves did not lay any egg. A similar reported by Okonkwo *et al.* (2000) also stated that the inability of snails fed old pawpaw leaves to lay egg might be due to the dry nature of the leaves and lack of nutrients. Old and yellow pawpaw leaves had been reported to have low nutrients, minerals and vitamins composition which are necessary for egg formation (Ayoola and Adeyeye, 2010). Similarly, Shenx and Xianch (2003) earlier observed that photosynthetic properties of leaves decreased with age. Diets have been admitted to influence the reproductive performance of snails in captivity (Abiona *et al.*, 2012) and increased nutrients in the pawpaw fruits might have influence on the albumen gland composition which is transferable to the eggs during the process of egg coating as opined by Ademolu *et al.* (2013a). Various plant parts have different effects on animal tissues (Ademolu *et al.*, 2013b). His study agreed with the fact that snails fed fresh pawpaw leaves had highest shell length gain but had little influence on the weight gained suggesting that fresh pawpaw leaves contain high concentration of minerals like calcium and phosphorus

which are needed for shell development but, are not well utilized by the flesh or other tissues. The good performance recorded by snails fed with ripe fruits and fresh leaves of pawpaw will definitely reduce the cost of production in snail farming as nothing or less will be spent on feed formulation as earlier observed by Omole *et al.* (2013). Emphasis was laid on pawpaw as its various parts constitute the major diet of snails in captivity or in conventional snail production system.

2.4 Factors to Consider in Snail Production

2.4.1 Environmental factors

Environment constitute a major factor affecting growth, feed utilization, reproductive performance and health status of snail (*Archachatina marginata*). Environment could be defined as the physical and biological factors along with their chemical interaction that affect organism. According to NRC (1991), environment means the surrounding, the condition that surrounds us and it constitute abiotic element like air, water, soil, energy, humidity, temperature, etc. there are lots of environmental factors that affects snails productivities. Some of these factors according to Amusan and Omidiji (1999), Akegbejo-Samson and Akinnusi (2000) and Omole (2003) are predators, soil types, temperature, relative humidity, water, sunshine, housing type, feeding, rainfall, light and wind direction.

2.4.1.1 Temperature

High temperature causes dryness. Dryness inhibits or even stops growth and reproductive activities of livestock. It was reported by Amusan and Omidiji (1999) that when it becomes too hot and dry in summer that snails become inactive, seals up shell and aestivate until cooler, moist weather returns. Slow growth and poor laying of eggs are

associated with high temperature. If the soil temperature is high, it could lead to the death of hatchlings, growers and even the adult snails. Snail could tolerate temperature range between 25 and 28°C (Omole, 2003). If the soil temperature is below 20 °C, the snails will bury themselves inside the soil and this condition is referred to as hibernation. During this period, the growth rate will be reduced (Ayodele and Asimolowo 1999; Omole *et al.*, 2011).

2.4.1.2 Rainfall

During the rainy season, there are lots of fruits and vegetables that can be used to feed snails. Snails eat more feed during the rainy season. Rainy season is characterized with high relative humidity and low temperature. Improved growth rate and increased egg laying capacity are recorded during the rainy season. Moreover, cost of snails is always low during rainy season (Ayodele and Asimolowo, 1999; Omole *et al.*, 2011).

2.4.1.3 Relative humidity

It is vital to know the relative humidity of the environment where snails are reared because snails are cold blooded animals. Their body is sensitive and responds to environmental changes especially when the relative humidity is less than 65 %, they cover up their surface or the fleshy part with white substance called Epiphragm or Cyst; a process called aestivation (Bright, 1996). Activation is common during the dry season or during harmattan when the relative humidity is low. Sometimes when the weather condition is unfavourable, the snails will burry themselves inside the soil as it there are no snails in the pen. Aestivation and Hibernation can be prevented by provision of shade to cover the pens, mulching of the pens with dry leaves of cocoa, plantain and banana,

regular tilling of the soil, regular watering of the soil in the pens (Ayodele and Asimolowo, 1999; Omole *et al.* 2011).

2.4.1.4 Flooding

Flooding is common when there is heavy rainfall. If the pens where snails are kept are flooded, they may crawl out so that one can see them on the wall of the pen otherwise, flooding may cause difficulty in breathing and apparent death of snails. It may also cause damage to the eggs laid and make them infertile. The surviving snails may possess white patches or nodules on their fleshy part (Ayodele and Asimolowo, 1999; Omole *et al.*, 2011).

2.4.2 Feeds and feeding

Feeding is one of the major factors affecting snail growth, egg production and attainment of early maturity (Bright, 1996; Omole, 2003). Snails have been described as nocturnal animals. Omole *et al.* (2003) observed that snails feed mainly in the night, at dusk or by day when there is rain or if the sky is overcast. Snail eats little quantity of feed compared to other conventional livestock such as poultry and sheep (Bright, 1996). The conventional feeds of snails are mainly of plant origin. The young snails seem to prefer leaves of pawpaw to fruits when offered as a mixture (Omole, 2003). When feeding snails with fruits, it must be cut into pieces (Akinnusi, 1998). Bright (1996) reported that there was an increment in growth rate when snails feed was supplemented with broiler starter mash, which contained 23% crude protein while Omole (2003) reported increase in weight gain when snail diet was supplemented with compounded ration and also observed improvement in feed efficiency when feed was ground compared to coarse feed.

2.4.3 Stocking rate

Ayodele and Asimolowo (1999) and Akegbejo-Samson and Akinnusi (2000) reported that the amount of eggs laid and frequency of laying is reduced at higher stocking rate. Different authors have suggested different stocking rates (Akinnusi, 1998; Bright, 1996; Amusan and Omidiji, 1999). Higher stocking rate could result into competition for feed, water and space resulting in poor ventilation, disease spread, and cannibalism. Based on weight gain, low mortality and efficiency of feed utilization, 40 to 50 hatchlings were recommended for one meter square apartment in intensive system of production (Omole, 2010). For growing snails, it was recommended that 35 growing snails could be put inside a cage of one meter square (Omole, 2010). There was also findings that one meter square apartment could house up to 15 breeding snails without any adverse effect on growth, reproduction and state of health of the breeding snails by Ayodele and Asimolowo (1999) and Akegbejo-Samson and Akinnusi (2000).

2.4.4 Predators

Predators of African giant land snails according to NRC (1991), Amusan and Omidiji (1999) and Omole (2003) includes mice, rats, frogs, toads, ducks, turkeys, lizard, snakes, carabid beetles, millipede, centipedes, human beings. Predators like soldier ants could be prevented by dipping the cage inside containers containing water and used engine oil while water bath or gutter should be dug round the pen housing. Lizard, flies and rodents could be prevented by reinforcing the wire mesh with mosquito netting (Amusan and Omidiji, 1999; NRC, 1991; Omole, 2003). The snailery and the surrounding have to be cleared with the door to the snailery properly closed while left over feed or remnants

should also be removed daily (Amusan and Omidiji, 1999).

2.4.5 Pathogens

Pathogens are disease causing organisms. Examples include Bacteria, Virus and Fungi. The following signs may be recognized in infected snails according to Amusan and Omidiji (1999), Ayodele and Asimolowo (1999), Fajimi *et al.* (2001) and Omole and Amusan (2007).

1. Inactiveness: Sick snails will be inactive. The snails will stay in a place without movement. The fleshy part will withdraw into the shell
2. Dryness of the fleshy part: the flesh part under good condition of health is brownish but slimy. The fleshy part of sick snail will be dried with no ensilivation
3. Colour of the shell: The colour of the shell may turn whitish if the snail is sick.
4. Loss of weight: there will be reduction in the weight of the snail if snail is sick. Weight loss could be as a result of loss of appetite
5. Loss of appetite: Sick snails may fail to eat. The same quantity of feed given will still remain as left – over or the feed consumption could reduce.

2.4.6 Soil characteristics

Soil is a major part of a snail's habitat. Soil composition, water content and texture are important factors to consider in site selection. The snail's shell is made up mainly of calcium derived from the soil and from feed. Snails derive most of their water requirements from the soil. Snails dig in the soil to lay their eggs and to rest during the dry season. For all these reasons it is essential that the soil is loose and that its calcium and water content is high (Adikwu, 2012). Snails dig in soil and ingest it therefore good soil favour snail growth and provides some of their nutrition. Lack of access to good soil

may result in fragile shells even if the snails have well-balanced feed; the snails' growth may lag far behind the growth of other snails on good soil.

2.5 Ultra-Violet Radiation Screening

Ultraviolet (UV) radiation is a form of non-ionizing radiation that is emitted naturally by the sun. Artificial source of UV radiation is by tanning beds (Castellano and Russo, 2005). UV radiation is of benefit to life (plant and animals) as it is involved in the creation of vitamin D and photosynthesis. Its demerit is that it exposes humans and livestock to health risk therefore, prevention of direct UV ray is paramount. Some materials that could be used to shade off the direct penetration of UV radiation are shading nets for greenhouses. The nets moderately modifies the microenvironment around a crop or livestock and this is the most common case. The different types of net are characterized by different structural features like type of material, type and dimensions of threads, texture, mesh size, porosity/ solidity and weight. By radiometric properties; like color, transmissivity/ reflectivity/ shading factor. By physical properties; like air permeability and by several mechanical characteristics; such as tensile stress, strength, elongation at break and durability (Castellano and Russo, 2005). Normally, the available dimensions of nets vary a lot in both width and length. Widths usually vary from 1 to 6 m or from 12 to 20 m (depending on the type of net) and lengths from 25 to 300 m. Wider nets are constructed by attaching the required number of nets in width. A first classification of nets can be based on type of material, type of threads and texture, color and additives used (Castellano and Russo, 2005).

For agricultural nets, primarily high density polyethylene (γ HDPE = 940-960 kg/m³) is used (Castellano and Russo, 2005). It is a non-toxic material which could be used in

direct contact with plants. It is completely recyclable, easily convertible, waterproof and durable if stabilized to ultra violet (UV) radiation agents are added in the correct quantity. Starch-based biodegradable materials are also used in some innovative agricultural net productions. At the end of their life, biodegradable materials can be disposed directly in soil or can be incorporated in a composting plant with organic materials, such as food and vegetable residues and manure, in order to generate carbon-rich compost (Narayan, 2001). Biodegradable materials are not very common in the market due to their high costs compared with other plastic materials and because of the reduction of their physical and mechanical properties when exposed for prolonged periods to climatic agents and mainly to solar radiation (Scarascia *et al.*, 2004).

2.6 Paddock Establishment

The relevance of crops in paddock establishment cannot be overemphasized in Nigeria livestock production system. Felici *et al.* (2020) submitted that snails' traditional feed consists of fresh leaves and shoots (such as pawpaw, lettuce, cabbage, cassava, cocoyam, African spinach, and water leaf), ripe fresh fruits (such as pawpaw, mango, banana and plantain), kitchen and agricultural wastes. Snails also require calcium to construct and maintain their shell in addition to the nutrients required. However, they must consume enough calcium to prevent their shell from becoming thin and rough rather than thick, smooth and glossy. The leaves of some plants are rich in protein, and have several vitamins, minerals, amino acids and a significant number of phytochemicals such as alkaloids, flavonoids, triterpenes, and cardiac glycosides.

This study explored the nutritional qualities of some plant (*Centrosema molle*, *Calapogonium mucunoides*, *Pueraria phaseoloides* and *Manihot esculenta*) on the

growth and reproductive characteristics of *Archachatina marginata* reared in a semi free range paddock.

2.6.2 *Centrosema molle*

Centrosema molle is a vigorous twining, trailing and climbing perennial legume. It has a deep root-system with tap roots and lateral roots. The leaves are dark green and trifoliate (FAO, 2015). Leaflets are ovate with about 4 cm long x 3.5 cm broad. The flowers, borne in axillary racemes, are bright or pale lilac with violet stripes. The pods are linear, slightly twisted with about 7.5 cm to 15 cm long which becomes dark brown when ripe. *Centrosema* is a valuable legume forage for pasture, hay and silage. After four to eight months, *Centrosema* forms a dense cover of about 40 to 45 cm high and it is able to fix Nitrogen (ranging from 120 to 270 kg/ha). Like other N fixing legumes, *Centrosema* is a soil improver and its association with grass is beneficial to grass yields making N fertilizer unnecessary (FAO, 2015). *Centrosema* is also used as green manure crop in rubber, coconut and oil-palm plantations (Cook *et al.*, 2005).

2.6.2 *Pueraria phaseoloides*

Pueraria phaseoloides (Tropical kudzu) commonly called ‘puerara’ is a vigorous, dense-growing vine cultivated in tropical countries as a cover crop, green manure and fodder for livestock. It is a vigorous twining and climbing perennial legume. It is deeply rooted (down to a depth of 2 m) and its hairy, slender stems may be up to 6-10 m long (sometimes up to 15 m x 0.6 cm) in diameter. The stems may root from the nodes and then develop several branches (Halim, 1997; Cook *et al.*, 2005; FAO, 2015). The inflorescence is an axillary raceme of about 15-30 cm in length, bearing small scattered mauve to deep-purple flowers. Once pollinated, the flowers turn into pods (fruits) which

are linear, cylindrical, straight or slightly curved. The pods are about 4-11 cm in length and 3-5 mm in diameter. The pods are green when young but they turn black when matured. The pods split open easily after sun-drying (Halim, 1997; Acevedo-Rodriguez, 2005; Cook *et al.*, 2005; FAO, 2015). Pueraria is a valuable forage for livestock. It is highly palatable and can be grazed or cut for conservation as hay or silage (Cook *et al.*, 2005). It shows a high protein content in the seeds (12-20%), the nutrient (protein - 3.8%) and sugar (7.3%) content of the whole fresh plant (green part) is very high (Cook *et al.*, 2005).

2.6.4 *Calapogonium mucunoides*

Calapogonium mucunoides commonly known as ‘Calapogonium’ is a vigorous, hairy annual or short-lived perennial trailing legume. The leaves are trifoliolate and up to 16 cm long. The hairy leaflets are 4-10 cm long x 2-5 cm broad and ovate to elliptical in shape. The inflorescence is a slender hairy raceme that may be up to 20 cm long and bears 2 to 12 blue or purple small flowers. The fruits are 3-8 seeded hairy pods, 2-4 cm long (Cook *et al.*, 2005; FAO, 2011; Chen Chin Peng *et al.*, 1997). *Calapogonium* is mainly used as cover crops alone or in mixture with other legumes, especially in rubber, oil palm or in young forest plantations (Cook *et al.*, 2005; Chen Chin Peng *et al.*, 1997)). It can be grazed and made into hay or silage. Cattle graze on it during the latter part of the dry season (Cook *et al.* 2005). Its good persistence under grazing might be a way to improve overall pasture quality through enhanced soil fertility, subsequent higher pasture growth rate and weed control. *Calapogonium* establishes readily after seeding and can cover the soil after only about 3-6 months or even sooner in newly cleared fertile land (Chen Chin

Peng *et al.*, 1997). In some part of the world, it is considered a weed (US Forest Service, 2011).

2.6.4 *Manihot esculenta*

Manihot esculenta commonly called ‘cassava’ is a perennial woody shrub with an edible root which grows in tropical and subtropical areas of the world. It represents both an important human food resource and in many regions, it is an underutilized animal feed ingredient. It is cultivated in tropical/subtropical environments and can be grown on marginal lands. It is relatively drought-hardy, and all parts of the plant can be utilized and its roots comprise an energy staple in many regions. Kehinde *et al.* (2004) reported that various parts of cassava can be utilized in livestock feeding. In recent years, the African continent produced about 60% of the global cassava crop (256 million tonne) through targeted efforts to develop improved varieties yet, only a small fraction is being utilized for animal feeding programs throughout Africa (FAOStat, 2013). Potential for increased utilization is vast particularly of unused or underused fractions and residues such as peels. Cassava root and peel fractions represent primary energy sources in feeding programs whereas leaves provide protein, minerals, and antioxidant vitamins as well as polyphenols. Despite recognized nutritional shortcomings, all parts of cassava can be successfully used in livestock and aquaculture feeding programs (Kehinde *et al.*, 2004).

2.7 Snail Diet in Conventional System of Snail Production

In the conventional system of production, fruits and vegetables are fed to snails of all ages. Series of researches have been carried out on different feeding materials for snails such as plantain leaves, cocoyam and pawpaw. *Pueraria phaseoloids*, *Centrosema mole*

and *Calapogonium mucunoides* have been evaluate as alternative source of feed for snails (Omole, 2010; Omole *et al.*, 2011). Kehinde *et al.* (2004) stated that snail farmers should be encouraged to adopt cassava parts (leaves and peels) in snail feeding, because of their availability and affordability. Snail feeding is dependent on weather and they tend to be more active and feed better at night as nocturnal animals

2.8 Regulation of Growth and Reproduction

The developmental and reproductive biology of terrestrial gastropods is strongly influenced by the environment in which the live. Scientific research over the last few decades has led to markedly increased understanding of the environment cue and the endocrine and neuroendocrine response mechanisms that regulates the growth and reproduction in terrestrial gastropods. Albeit in a small number of species. This knowledge has been built up through laboratory experiments involving manipulation of environmental factors and microsurgical manipulation of the animals in conjunction with cytological and biochemical analysis. The improved understanding of regulation of growth and reproduction has been of particular benefit to heliculture, where the goal is to optimize the production of edible snail species by maintaining optimum environmental conditions (Barker, 2001). As the snail grows, so does its calcium carbonate shells. The shell grows additively, by the addition of new calcium carbonate, which is secreted by glands located in the snail's mantle. The new material is added to the edge of the shell aperture (the opening of the shell). When the snail reaches full adult size, it may build a thickened lip around the shell aperture. At this point the snail stops growing and begin reproduction (Cobbinah *et al.*, 2008)

2.9 Aestivation in Giant African Land Snails (Gals)

Animals exhibit morphological, behavioural, physiological and biochemical adaptations in stressful environment (Storey, 2002). During the dry spells free living snails withdraw into their shells and conserve water by sealing the shell aperture with a calcified mucous membrane called the “epiphragm”, to minimize water loss due to evaporation (Omoyakhi *et al.*, 2008 a, b; Storey, 2002). Epiphragm formation has been reported to vary from five (5) days from the day of incubation (Omoyakhi, 2007) to nine (9) days (Abdussamad *et al.*, 2010; Ajayi *et al.*, 2012). This variation is probably dependent on the prevailing climatic condition (Humidity and temperature) and is also species and age and/or size dependent. The calcereous compound dries on contact with the air and is impermeable; and can stay in this state for up to three years (Adikwu, 2012) as they aestivate, they reduce mobility, reproductive behaviour, activities and growth. Water loss is further retarded by the use of discontinuous breathing pattern; the pneumostome open intermittently to allow a rapid exchange of CO₂ and O₂ (Hermes-Lima *et al.*, 1998).

In ectotherms, fluctuating ambient temperatures may affect the body temperature (poikilothermy). In small aquatic creatures such as Rotifera, the poikilothermy is practically absolute (Davenport, 1991), but other GALS have wider physiological options at their disposal and they can avoid ambient temperature changes, or moderate their effects basically by aestivation.

Snail lack physiological thermal control as most of the heat of the body is derived from the environment rather than from metabolic source (Osunkeye *et al.*, 2011) but are said to

survive many months without food and water under aestivation (Akinnusi, 1998). Aestivation is invariably a homeostatic condition of the snail. The aestivated snail draw on their body reserves at much reduced rate which implies an imminent reduction in weight and loss of seemingly valuable growing time as growth during aestivation is said to reduce.

2.10 Biological Cycle in Giant African Land Snails

Biological Cycles are rhythmic repetition of biological phenomena in association with organisms which serves as an adaptation to cyclic changes in their conditions of existence. According to Cobbinah (1992), biological cycles may be daily, seasonal (annual), or at intervals of many years. At their base lie automatic mechanisms which are corrected by the effects of external factors such as variations in illumination, photoperiodism, temperature, humidity, moisture, and food reserves. The associated metabolic changes in animals are regulated by hormones. In various seasons the condition and behaviour of the animal change; accumulation or consumption of reserve substances may occur; shedding of outer layers (molting), reproduction, animal migration, hibernation, aestivation and other seasonal phenomena begin or end. To a considerable degree they are automatized.

Cobbinah (1992) divided the active period of *A. achatina* into three phases:

- a. Pre-spawning phase which begins immediately after aestivation. It lasts from March to April. The snails are fairly active during this phase and food consumption is quite high.
- b. Spawning phase: which lasts from April to July and characterized by egg laying; food consumption is reduced for egg laying snails

- c. Post spawning phase: from July to October. Food consumption is high. Snails start storing resources for the dormancy period (October to March) ahead.

The fourth phase in the life cycle of GALS is the dormancy phase characterized with aestivation in the tropics and hibernation in the temperate.

On a general note, snails in the wild grow actively and reproduce during the raining season (March to October in tropical Africa), they go into dormant state during the dry hot period, seal up their shell aperture and aestivate thus reducing mobility, reproductive behaviour, growth and retard several physiological activities. These snails are aroused from their lethargy and resumes activities at the onset of next rain. While heat, dryness and lack of food are among factors that induce aestivation, cold and famine induce hibernation. There is reason to believe that there is more to the practice than the mere existence of certain external factors (Barrows, 2001). In view of this, Kokori (1992) concluded that snails are governed not only by climatic conditions but by internal rhythms that are not fully understood. This course of action can be said to be invariable pursued by nature mostly- a natural phenomenon which has been adjusted over time to coincide with seasons of unfavourable weather conditions. Or rather the snails utilize the seasons in recognizing the beginning and end of each phase of certain biological cycle such as the circadian rhythm (the bodies' daily natural sleep – wake cycle)

However, this phenomenon has been completely eliminated in the captive propagations of snails and may constitute a long term major setback in the domestication (Omoyakhi and Osinowo, 2012). Aestivation is suggestive of an indispensable need (like any other

living thing) for rest, sleep and fasting. During sleep, the body has chances to replacing chemicals and repair muscles, other tissues and aging or dead cells.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Description of Experimental Site

The study was carried out in the Teaching and Research Farm, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. Benin City is within the tropical rain forest vegetation zone of Southern Nigeria lying between longitude 5°E and 6°42'E and latitude 5°45' and 7°34'N of the equator (FAAN, 2015). On the north, Edo State is bounded by Kogi State, to the east is Anambra State, south by Delta State and west by Ondo State. The climate of Edo is humid (Ikhile and Aifesehi, 2011).

3.2 Snail Production Systems

Three types of production systems were designed and comparatively evaluated. The three production systems involved first, the use of Trench pens raised above the ground with well-drained floor. The floors were filled with suitable soil to a depth of 10 cm. Each pen was covered with steel frame lids, wire mesh and padlocks fitted to the openings. The Snailry was roofed with thatches to prevent direct rain and sunlight. The second system involved a semi free range pen made of a fenced area. Different plants (*Centrosema molle*, *Puereria phaseoloides*, *Calapogonium mucunoides* and *Manihot esculenta*) were used to provide food, shelter from wind, sun and rain. The soil was prepared to provide suitable environment for the snails. A fence was constructed with fine chicken wire mesh

and chain link as escape-proof and to prevent intruders. The third system involved the construction of a screen house with galvanized pipes, wire mesh, snail net and anti UV ray net. The same crops cultivated in the open paddock were also cultivated in the screened paddock. Each system was equipped with irrigation facilities to provide water for the plants, the snails and to regulate the environmental humidity.

Environmental temperature, relative humidity and snail productive indices were evaluated. Physical properties of the snails from the three production systems were evaluated.

3.3 Physiological Season Classification of the Months of the Year in the Study Area

Table 3.1 shows the mean rainfall and temperature data in the study area as collated over a-15 year period. The least temperature (25.42°C) was obtained in the month of July and the hottest was February with mean temperature of 28.69 °C. Mean rainfall data was least in December (3.60 mm) and closely followed by January (16.48 mm). There was a sequential increase in rainfall with highest rainfall in August (468.98 mm) and eventual decline from September by 40.79 %. There was a further decline in October by 20.42 % and then a sharp drop thereafter (52.53 mm in November).

From Table 3.2, five (5) months of the year were classified as cold-wet season (June to October) with rainfall of above 200 mm and temperature below 27 °C. Three (3) of the months were hot dry (January to March) with rainfall below 200 mm and temperature above 27 °C. April to May were classified as hot-wet physiological season with temperature above 27 °C and rainfall above 100 mm but below 200 mm. November to

December were grouped as Cold-dry with temperature below 27 °C and rainfall below 100 mm.

The first phase of the experiment was to cultivate the crops for cover in the open and screened paddock to attain full ground cover. This phase spanned between January 2021 to September 2021. The second phase of the experiment was the introduction of snails into the respective pens within the paddocks. The first six weeks of this phase (Mid-October to ending of November 2021) fell under the Cold-wet and Cold-dry physiological classification while the second six weeks phase (first week of December 2021 to Mid January 2022) was characterized by the introduction of concentrate feeds and irrigation and this phase fell under the Cold-dry and Hot-dry physiological classification as shown in Tables 3.1 and 3.2.

Table 3.1: Mean Daily Rainfall and Temperature Over 15 Years (2001 – 2015)

MONTH	TEMPERATURE (°C)	RAINFALL (mm)	PHYSIOLOGICAL SEASON
January	27.40	16.48	Hot Dry
February	28.68	41.29	
March	28.51	88.25	
April	27.92	176.15	Hot Wet
May	27.35	199.01	
June	26.23	258.50	Cold Wet
July	25.42	287.96	
August	25.43	468.94	
September	26.22	277.67	
October	26.61	220.98	
November	26.97	52.53	Cold Dry
December	26.63	3.60	
Mean	27.03± 2.84	173.45±20.10	

Source: Nigeria Institute for Oil Palm Research (NIFOR)

Table 3.2: Physiological Season Classification of the Months of the Year in Study Area

Physiological Season	Month
Hot Dry	January*
	February
	March
Hot Wet	April
	May
Cold Wet	June
	July
	August
	September
	October*
Cold Dry	November*
	December*

***Sampling months**

3.4 Materials

A total of three hundred and twenty (320) apparently healthy grower *Archachatina marginata* with liveweight of between 50 and 60 g were purchased from an established snail farm in Benin City. Anti U.V Ray net was purchased in Lagos, Nigeria. Predator protective net (snails special net), galvanizes pipes, galvanized wire mesh, binding wire, chain links, 2 x 2 plank, shallow feeders and drinkers used in this experiment were purchased in Benin City. The seeds of *Centrosema molle* (Centrosema) and *Calapogonium mucunoides* (Calapogonium) were obtained from the International Institute for Tropical Agriculture (IITA) Ibadan. The seed of *Puereria phaseoloides* were obtained from the Department of Forest Resources and Wildlife Management, Faculty of Agriculture, University of Benin, Benin City. The stem of *Manihot esculenta* (Cassava) were obtained from Ministry of Agriculture, Benin City, Edo State. The ingredients for feed formulation were obtained from the open market in Benin City, Edo State, Nigeria. The calliper, measuring tape, digital weighing scale and thermo-hygrometer were purchased in Hospital and Biological Equipment Store in Benin City.

3.4.1 Concentrate composition

The composition of the snail feed (concentrate) introduced during the experiment is presented in Tables 3.3.

Table 3.3: Gross composition and proximate analysis of the snail feed (concentrate)

S/N	Ingredient	Percentage composition
1	Maize	44.00
2	Soyabean meal	17.00
3	Rice bran	13.30
4	Palm Kernel Cake	10.00
5	Limestone	11.55
6	Bone meal	3.90
7	Premix	0.25
	Total	100
Proximate Analysis (Calculated)		
	Crude protein (%)	16.06
	Crude Fibre (%)	5.79
	Ether Extract	3.91
	Ash (%)	3.67
	NFE (%)	49.05
	Metabolizable Energy (Kcal/kg)	2,469.40
	Lysine (%)	0.59
	Met+Cyst (%)	0.05
	Calcium (%)	5.31
	Total Phosphorus (%)	1.07

*Composition of vitamin – mineral premix per kg of diet: vit. A,5,000 IU; Vit. D, 800IU; Vit. E, 12 mg; Vit B, 1.5 m, Niacin, 12 mg; pantothenic acid, 5mg, Biotin, 0.02mg; Vit. B12, 0.01 mg; Folic acid, 0.3 mg; Chlorine chloride, 150 mg; Manganese, 60 mg; Iron, 10 mg, Zinc, 15 mg; copper, 0.8 mg; Iodine, 0.4 mg; Cobalt, 0.08 mg; Selenium, 0.04 mg. antioxidants, 40 mg.

3.5 Experimental Design

The experiment was laid out in 2 X 4 factorial in a Randomized Complete Block Design with the system of production as the factor and the crops (Centrosema, Calapogonium, Puereria and Cassava) as treatment. The experiment was replicated four times with 10 snails per replicate.

3.6 Experimental procedure

The site that was selected for paddock establishment was well drained (void of water logging) with sandy-loam soil and manually ploughed. A paddock measuring 32 m X 22 m was demarcated using chain link and partitioned into two equal parts. The first part was left under direct sunlight (open paddock) while the other part was protected against ultra violet rays of the sun with the use of galvanized pipes and anti U.V Ray of fifty five per cent radiation (screened paddock). The two parts were divided into sixteen plots each using galvanized wire mesh and escape proof net. The plot measurement was 2.25 m x 2 m each and 0.5 m between two plots.

The hard coated seed of Centrosema, Calapogonium and Puereria were subjected to treatment (scarification) and planted at the depth of 2-3 cm with 3 seeds per stand at spacing of 75 cm between rows and 10 cm between plant to plant within the row while cassava was planted at a depth of 5-6 cm with one stem per stand at a spacing of 75cm between the rows and 25 cm between the plant to plant within the row.

The crops were purposefully planted in the plots with routine management practices ensured. Weeding was done manually in the paddock between the plots and the peripheral while the weeds within the plots were hand-picked. Manure (poultry dropping) was also applied to the soil for performance enhancement during crop growth and

establishment phase. Continued crop maintenance practices were ensured till the crops attained full ground cover.

When the crops had attained full ground cover and were well established, snails were purchased from a reputable snail farm in Benin City. The snails were housed in the conventional snailry unit where they were provided with feed (pawpaw leaves, formulated diet and unripe pawpaw fruit) and water as obtainable in modern practices with optimum hygiene ensured by removing excreta and uneaten food materials from the pen on a daily basis and the soil moistened as required for the first two weeks of acclimatization to normalize all possible previous treatments and to attain stability prior to the experiment.

At the end of two weeks acclimatization period, the parameters of the snails such as the size, weight, shell thickness, shell length and width were taken. The weight of the snails were taken using electronic weighing scale, the shell thickness was measured using calliper and the length, width and aperture measured with measuring tape.

The snails were allocated to the various treatment groups and allowed to feed solely on the crops for a period of 6 weeks. The snails were monitored daily for tendency to escape, consumption of the crops, accessibility, suitability of the crops to provide cover and adaptation. Records were taken daily based on the observation while the record of growth indices were taken on a weekly basis.

The second phase of the experiment was to evaluate the impact of the immediate environment on snail production. Water and concentrate were provided for all the snails in the three production systems using drinkers and feeders. The snails were allowed to feed for a period of additional six (6) weeks while their performance characteristics were

recorded on a weekly basis. Thermo-hygrometer was used to take the environmental temperature and relative humidity within the systems of production.

3.7 Layout of the Experiment

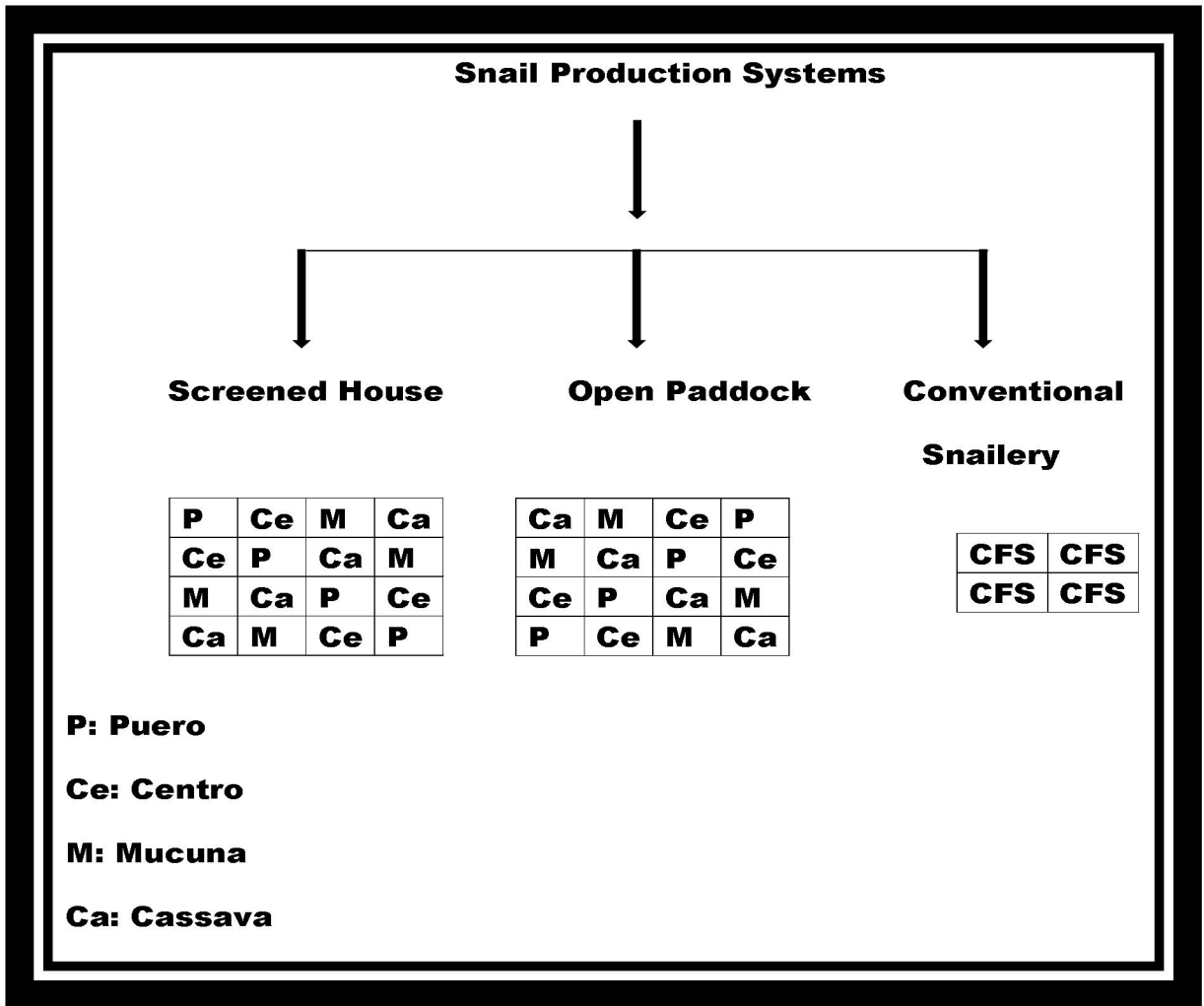


Figure 1: Experimental layout

CFS- Conventional Feed Stuff

3.8 Data Collection

Data were collected on the snails, the crops, the immediate environment and the interaction between them.

Crop parameters that were taken include:

1. Width of leaf
2. Length of leaf
3. Time of establishment

Snail Adaptation and performance

1. **The tendency of the snails to escape:** this was measured by the number of snails that were not found on the ground or found on the wire mesh at any given interval.
2. **Mortality:** The dead snails were removed and documented.

Growth performance: parameters taken were;

1. Snail body weight
2. Shell length
3. Shell width
4. Shell aperture
5. Shell thickness

Reproductive performance: parameters taken were;

1. The number of egg laid/clutch size
2. Number of clutches
3. Size of egg
4. Egg length

5. Egg width
6. Egg weight
7. Clutch weight
8. Incubation period
9. Hatching percentage.
10. Percentage survival

Hatchling performance: parameters taken were;

1. Body weight
2. Mortality

Environmental factors: parameters taken were;

1. Temperature
2. Relative humidity

Snail predators: physical assessment was done on-site.

1. Screened paddock assessment
2. Open paddock assessment
3. Conventional snailry unit assessment

Cost implication and cost benefit: Assessment was based on:

1. Start-up capital: cost of constructing the housing system (is it capital intensive or not)
2. Cost of Production: which system of production was more expensive
3. Cost of maintenance: how often does the system of production need maintenance and at what cost

4. Performance evaluation: Which system of production gave better result on snail performance and sustainability with minimum cost investment.

3.9 Data Analyses

Descriptive statistics was used to analyse data obtained from physical observations while data on snail growth parameters, reproduction, hatchling performance, environmental impact were subjected to Analysis of Variance (ANOVA). Significance comparison was done at $P < 0.05$. All analyses were done using GenStat version 12.0 statistical software.

CHAPTER FOUR

4.0 RESULTS

The results obtained from snail performance evaluation under crops established in the open and the screened paddocks are presented in comparison with the conventional paddock.

4.1 Establishment of paddock system of snail production

The paddocks that were established and evaluated in this experiment are presented in Plates 1 to 5.



Plate 1: Open Paddock system of production



Plate 2: Outside view of the screened paddock system of production.



Plate 3: Side view of the screened paddock system of snail production



Plate 4: Inside the screened paddock system of production

The Conventional paddock (Control) that served as means of comparing the Open and Screened paddock is presented in plate 5.



Plate 5: The conventional paddock system of production

4.2 Treatment crops

The four crops cultivated in the open and screened paddocks are presented in plate 6, 7, 8 and 9 below.



Plate 6: *Manihot esculenta*



Plate 7: *Pueraria phaseoloides*



Plate 8: *Calapogonium mucunoides*



Plate 9: *Centrosema molle*.

4.2.1 Crop parameters

Table 4.1 shows the parameters that were taken in the four treatment crops (leaf length, leaf width and establishment time).

The different crops had distinctive characteristic features. The length and width of the leaves were measured after the crops attained maturity. It took the crops an average number of one hundred and twenty two (122) days to attain full ground cover/establishment. *Centrosema molle* had the smallest leaves with 7 cm length and 5 cm width.

Table 4.1: Characteristics of the crops evaluated

PARAMETERS	CENTROSEMA	CALAPOGONIUM	PUERARIA	CASSAVA
Leaf length (cm)	7	13	17	20
Leaf width (cm)	5	17	16.5	30
Establishment time (days)	156	105	96	131

4.3 Snail parameter

During the experiment, snails were monitored daily and data was collected. The results from the observations made are presented below.

4.3.1 Tendency to escape

The tendency of the snails to escape from the treatment pens in the open and screened paddock in comparison with the conventional paddocks is presented in Table 4.2. The snails in the Cassava pen in the open and screened paddock and the snails in Pueraria pen in the screened paddock recorded the highest number of snails (5 each) trying to escape. Some snails that were seen trying to escape are shown in Plates 10 and 11 while the snails that escaped from the pen but trapped within the screened paddock are shown in Plates 12 and 13.

Table 4.2: The tendency of the snails to escape

TENDENCY TO ESCAPE

Treatment	Open Paddock (number of snails)	Open Paddock (% of snails)	Screened Paddock (number of snails)	Screened Paddock (% of snails)
Centrosema	3	7.5	1	2.5
Cassava	5	12.5	5	12.5
Pueraria	4	10	5	12.5
Calapogonium	1	2.5	2	5
Conventional Paddock	3	7.5	3	7.5



Plate 10: Snail trying to escape through the wire mesh



Plate 11: Snail trying to escape through the wooden pole



Plate 12: An escaped snail from the pen trapped within the screened paddock



Plate 13: A trapped snail within the screened paddock found outside the pen.

4.3.2 Time to search

The range of time for snail search was between 1-10 minutes depending on the pen as presented in Table 4.3. The snails in the Calapogonium pens in the screened and open paddocks were not easily accessed during data collection. The snails in the cassava pens (open and screened paddocks) were very easy to locate (usually with 2 – 3 minutes). The snails in the cover crops were generally took more time before they could be seen. This was not the case of the snails in the conventional paddock as it took about one (1) minute to find them.

However, when concentrate feed was introduced to the snails in the different pens after the first six week of leaving them to live and feed on crop sole diet as obtainable in the wild, it was observed that the time taken to search for snails within the various pens reduced as most of the snails were found clustered around the feed spots. The figure showing snails clustered around feed source are presented in Plates 14 and 15.

Table 4.3: Time taken to locate snails in the pens (Minutes)
Search Time (Minutes)

Treatment	Open Paddock	Screened Paddock
Centrosema	7	7
Cassava	3	2
Pueraria	5	5
Calapogonium	10	10
Conventional Paddock	1	1



Plate 14: Cluster of snails around feed source within Calapogonium pens.



Plate 15: Snails clustered round feed source in Centresema pen.

4.3.3 Mortality

The number snails that died between the day of introducing the snails into the pen and the final day of the experiment were recorded and it was observed that snails in the *Centrosema* pen under open paddock recorded the highest mortality (3). There was no record of mortality among the snails housed in the *Calapogonium* and Cassava pens. The result is presented in Table 4.4.

The photograph of an apparently dead snail is shown in Plate 16.

Table 4.4: Snail mortality recorded in the open and screened paddocks in comparison with the Conventional paddock

Treatment	Number of Dead Snails		Dead Snails (%)	
	Open Paddock	Screened Paddock	Open Paddock	Screened Paddock
Centrosema	3	0	7.5	0
Calapogonium	0	0	0	0
Pueraria	1	1	2.5	2.5
Cassava	0	0	0	0
Conventional Paddock	2	2	5	5



Plate 16: A dead snail in the Centresema pen

4.4 Individual Treatment Evaluation

The growth parameters of *Archachatina marginata* subjected to the four treatment crops in the open and screened paddock system were taken across the 12 weeks of the experiment. The growth parameters that were considered are aperture, length, width, thickness and weight.

4.4.1 Centrosema treatment evaluation

Results of growth parameters of snails reared in open and screened Centrosema paddock in comparison with the conventional paddock are presented in Tables 4.5 - 4.10.

4.4.1.1 Change in Aperture (cm)

The mean aperture change in week 0, 6 and 12 showed that although there was increase in the aperture in the 6th and 12th week but it was not significant different in comparison with the conventional systems of production ($P > 0.05$) as presented in Table 4.5

Table 4.5: Mean Aperture change of *Archachatina marginata* reared in open and screened Centresema paddocks in comparison with the conventional paddock

Treatment	APERTURE (cm)		
	0 week	6 weeks	12 weeks
Centresema - Screened Paddock	4.90 ^a	5.00 ^a	5.10 ^a
Centresema - Open Paddock	4.90 ^a	5.15 ^a	5.05 ^a
Conventional Paddock	4.95 ^a	5.08 ^a	5.08 ^a
S.E.M	0.02	0.06	0.09

4.4.1.2 Change in shell length (cm)

The length (cm) of *Archachatina marginata* housed in the Centrosema open and screened paddock were not significantly different in statistical comparison ($P > 0.05$) with the conventional paddock as seen in Table 4.6.

4.4.1.3 Change in shell thickness (mm)

The thickness (mm) of the shell of *Archachatina marginata* subjected to Centrosema treatment in the open and screened paddock was not significantly difference in statistical comparison ($P > 0.05$) with the conventional paddock as presented in Table 4.7.

4.4.1.4 Change in Width (cm)

The width (cm) of *Archachatina marginata* subjected to Centrosema treatment in the open and screened paddock increased in the 6th and 12th week in comparison to the conventional paddock. But there was no significant difference in statistical comparison ($P > 0.05$) among the paddocks as presented in Table 4.8.

Table 4.6: Mean Length change of *Archachatina marginata* reared in open and screened Centrosema paddock in comparison with the conventional paddock

Treatment	LENGHT (cm)		
	0 week	6 weeks	12 weeks
Centrosema - Screened Paddock	9.00 ^a	9.70 ^a	9.75 ^a
Centrosema - Open Paddock	9.00 ^a	9.95 ^a	9.60 ^a
Conventional Paddock	9.08 ^a	9.83 ^a	9.70 ^a
S.E.M	0.08	0.12	0.14

Table 4.7: Mean Thickness change of *Archachatina marginata* reared in open and screened Centrosema paddock in comparison with the conventional paddock

	THICKNESS (mm)		
Treatment	0 week	6 weeks	12 weeks
Centrosema Screened Paddock	0.03 ^a	0.03 ^a	0.05 ^a
Centrosema - Open Paddock	0.03 ^a	0.03 ^a	0.07 ^a
Conventional Paddock	0.03 ^a	0.03 ^a	0.06 ^a
S.E.M	0.01	0.01	0.01

Table 4.8: Mean Width change of *Archachatina marginata* reared in open and screened Centrosema paddock in comparison with the conventional paddock

Treatment	WIDTH (cm)		
	0 week	6 weeks	12 weeks
Centrosema - Screened Paddock	5.98 ^a	9.65 ^a	10.80 ^a
Centrosema - Open Paddock	6.00 ^a	9.60 ^a	10.75 ^a
Conventional Paddock	6.23 ^a	9.63 ^a	10.78 ^a
S.E.M	0.16	0.21	0.14

4.4.1.5 Liveweight (g)

The liveweight (g) of *Archachatina marginata* subjected to Centrosema treatment in the open and screened paddock was significantly difference in statistical comparison ($P < 0.05$) to the liveweight recorded by snails in the conventional paddock. The liveweight of the snails increased in the 6th and 12th week in all the paddocks. The weight of snails in the open paddock was significantly different at 6 weeks into the experiment.

However, the weight at 12 weeks in the three paddocks differed significantly ($P < 0.05$) as presented in the Table 4.9.

4.4.1.6 Weight change (g)

There was an observed significant weight gain in the snails in the open, screened and conventional paddocks. Although, the initial weight of the snails were not significantly different from each other, but there was significant difference in their final weights ($P < 0.05$). The snails in the open paddock had the lowest weight gain of 2.9 g compared to the 5.6g and 6.5 g from the Screened and Conventional paddocks respectively.

Table 4.9: Mean Liveweight change of *Archachatina marginata* reared in open and screened Centrosema paddock in comparison with the conventional paddock

Treatment	LIVEWEIGHT (g)		
	0 week	6 weeks	12 weeks
Centrosema - Screened Paddock	56.60 ^a	59.75 ^a	62.50 ^{ab}
Centrosema - Open Paddock	56.10 ^a	57.00 ^b	59.00 ^b
Conventional Paddock	56.75 ^a	60.12 ^a	63.25 ^a
S.E.M	0.74	1.20	1.13

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

Table 4.10: Mean weight gain of *Archachatina marginata* reared in open and screened Centrosema paddock in comparison with the conventional paddock

		WEIGHT (g)		
Treatment		0 week	12 weeks	Weight Change
Centrosema	– Open paddock	56.10 ^a	59.00 ^b	2.90 ^b
Centrosema	– Screened paddock	56.60 ^a	62.50 ^{ab}	5.90 ^{ab}
Conventional Paddock		56.75 ^a	63.25 ^a	6.50 ^a
SEM		0.74	1.13	1.02

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

4.4.2 Evaluation of Calapogonium treatment

The results for the growth parameters of snails subjected to Calapogonium treatment in the open and screened paddock systems of production are presented in comparison to the conventional systems of production

4.4.2.1 Change in Aperture (cm)

The aperture increased in the 6th and 12th weeks of the experiment in the open and screened paddocks but the mean difference in aperture as presented in Table 4.11 showed that there was no significant differences impacted when compared with the conventional paddock ($P > 0.05$) statistically.

4.4.2.2 Change in Length (cm)

There was an observed increase in the length of *Archachatina marginata* subjected to Calapogonium treatment in the open and screened at 6th and 12th week of the experiment. There was no significant difference in statistical comparison ($P > 0.05$) with the conventional paddock as presented in Table 4.12.

Table 4.11: Mean Aperture change of *Archachatina marginata* subjected to Calapogonium treatment in open and screened paddocks in comparison with the conventional paddock

Treatment	APERTURE (cm)		
	0 week	6weeks	12 weeks
Calapogonium - Screened Paddock	4.83 ^a	5.15 ^a	5.30 ^a
Calapogonium - Open Paddock	4.88 ^a	5.20 ^a	5.25 ^a
Control - Conventional Paddock	4.95 ^a	5.08 ^a	5.08 ^a
S.E.M	0.05	0.05	0.09

^a Means with same superscripts within the same parametric column have no significant difference ($P > 0.05$).

Table 4.12: Mean Length change of *Archachatina marginata* subjected to Calapogonium treatment in open and screened paddocks in comparison with the conventional paddock

Treatment	LENGTH (cm)		
	0 week	6 weeks	12 weeks
Calapogonium - Screened Paddock	9.05 ^a	9.65 ^a	10.00 ^a
Calapogonium - Open Paddock	9.10 ^a	9.55 ^a	10.00 ^a
Control - Conventional Paddock	9.08 ^a	9.83 ^a	9.70 ^a
S.E.M	0.04	0.11	0.14

^a Means with same superscripts within the same parametric column have no significant difference ($P > 0.05$).

4.4.2.3 Change in Shell Thickness (mm)

The shell thickness of *Archachatina marginata* subjected to Calapogonium treatment in the open and screened was not significantly difference in statistical comparison ($P > 0.05$) to the conventional paddock as presented in Table 4.13.

4.4.2.4 Change in Width (cm)

The width of *Archachatina marginata* subjected to Calapogonium treatment in the open and screened paddock increased in the 6th and 12th weeks but there was no significant difference in statistical comparison ($P > 0.05$) among the three paddocks presented in Table 4.14.

Table 4.13: Mean shell thickness change of *Archachatina marginata* subjected to Calapogonium treatment in open and screened paddocks in comparison with the conventional paddock

Treatment	THICKNESS (mm)		
	0 week	6 weeks	12 weeks
Calapogonium - Screened Paddock	0.04 ^a	0.03 ^b	0.14 ^a
Calapogonium - Open Paddock	0.04 ^a	0.04 ^a	0.13 ^a
Conventional Paddock	0.03 ^a	0.03 ^{ab}	0.06 ^a
S.E.M	0.01	0.01	0.04

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

Table 4.14: Mean width change of *Archachatina marginata* subjected to Calapogonium treatment in open and screened paddocks in comparison with the conventional paddock

Treatment	WIDTH (cm)		
	0 week	6 weeks	12 weeks
Calapogonium - Screened Paddock	6.13 ^a	9.70 ^a	11.15 ^a
Calapogonium - Open Paddock	6.10 ^a	9.35 ^a	11.15 ^a
Conventional Paddock	6.23 ^a	9.63 ^a	10.78 ^a
S.E.M	0.07	0.12	0.19

^a Means with same superscripts within the same parametric column have no significant difference ($P > 0.05$).

4.4.2.5 Liveweight (g)

The weight of *Archachatina marginata* housed in the Calapogonium open and screened paddock was significantly ($P < 0.05$) different in statistical comparison with the conventional paddock as presented in Table 4.15. Calapogonium supported the mean weight at 6 and 12 weeks but the weight difference became significant at week 12 in the open and screened paddock in comparison with the conventional paddock. The weight of snails in the screened paddock was higher than the weight of snails in the open and conventional paddocks.

4.4.2.6 Weight change (g)

The Analysis of Variance presented in Table 4.16 showed significant ($P < 0.05$) difference in the weight gain of the snails subjected to Calapogonium treatment in the open and screened paddock against the conventional paddock. The highest weight gain (10.75 g) was observed in the screened paddock system of production. The conventional paddock had a weight gain of 6.5 g while the open paddock had a 4.28 g weight gain.

Table 4.15: Mean Liveweight of *Archachatina marginata* subjected to Calapogonium treatment in open and screened paddocks in comparison with the conventional paddock

Treatment	WEIGHT (g)		
	0 week	6 weeks	12 weeks
Calapogonium - Screened Paddock	55.75 ^a	60.00 ^a	66.50 ^a
Calapogonium - Open Paddock	54.73 ^a	57.50 ^a	59.00 ^b
Conventional Paddock	56.75 ^a	60.12 ^a	63.25 ^{ab}
S.E.M	1.15	1.08	1.35

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

Table 4.16: Mean weight gain of *Archachatina marginata* subjected to Calapogonium treatment in open and screened paddocks in comparison with the conventional paddock

Treatment	WEIGHT GAIN (g)		
	0 week	12 weeks	Weight Difference
Calapogonium-Open Paddock	54.73 ^a	59.00 ^b	4.28 ^b
Calapogonium-Screened Paddock	56.75 ^a	66.50 ^a	10.75 ^a
Conventional Paddock	55.75 ^a	63.25 ^{ab}	6.50 ^{ab}
SEM	1.15	1.35	1.78

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

4.4.3 Evaluation of Cassava treatment

Analysis of Variance for the growth parameters of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddock system of production are presented in comparison to the conventional system of production as seen in Table 4.17 - 4.22.

4.4.3.1 Change in Aperture (cm)

The mean difference in Aperture as presented in table 4.17 showed that there was no significant difference in the screened and open paddock in comparison with the conventional system of production ($P > 0.05$).

4.4.3.2 Change in Shell Length (cm)

The shell length of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddock increased in the 6th and 12 weeks in comparison with the shell length recorded by snails in the conventional system of production. At six weeks into the experiment, the increment in the length was significantly different from the initial week. The reverse was the case at the 12th week where the increment in shell length was not significantly different from the 6th week in the three paddocks.

Table 4.17: Mean Aperture change of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	APERTURE (cm)		
	0 week	6 weeks	12 weeks
Cassava - Screened Paddock	4.95 ^a	5.10 ^a	5.10 ^a
Cassava - Open Paddock	4.93 ^a	5.00 ^a	5.15 ^a
Conventional Paddock	4.95 ^a	5.08 ^a	5.08 ^a
S.E.M	0.05	0.04	0.09

Table 4.18: Mean shell length change of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	LENGTH (cm)		
	0 week	6 weeks	12 weeks
Cassava - Screened Paddock	8.98 ^a	9.95 ^a	10.00 ^a
Cassava - Open Paddock	8.95 ^a	9.55 ^b	9.40 ^b
Conventional Paddock	9.08 ^a	9.83 ^{ab}	9.70 ^{ab}
S.E.M	0.06	0.12	0.16

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

4.4.3.3 Change in Shell Thickness (mm)

The shell thickness of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddock was not significantly difference in statistical comparison ($P > 0.05$) with the conventional paddock as seen in Table 4.19.

4.4.3.4 Change in Width (cm)

The width of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks increased in progression with the weeks. At week six (6), there was a noticeable increase which was significantly different from the first week. The width at week twelve (12) was also significantly different from week six (6). The width of snails recorded at 6 weeks in the screened paddock was significantly different in statistical comparison ($P < 0.05$) with the open and conventional paddocks as seen in Table 4.20.

Table 4.19: Mean thickness change of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	THICKNESS (mm)		
	0 week	6 weeks	12 weeks
Cassava - Screened Paddock	0.03 ^a	0.04 ^a	0.09 ^a
Cassava - Open Paddock	0.03 ^a	0.14 ^b	0.10 ^b
Conventional Paddock	0.03 ^a	0.03 ^a	0.06 ^a
S.E.M	0.02	0.03	0.02

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

Table 4.20: Mean width change of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	WIDTH (cm)		
	0 week	6 weeks	12 weeks
Cassava - Screened Paddock	6.20 ^a	10.00 ^a	11.20 ^a
Cassava - Open Paddock	6.15 ^a	9.55 ^b	11.00 ^a
Control - Conventional Paddock	6.23 ^a	9.63 ^b	10.78 ^a
S.E.M	0.15	0.10	0.18

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

4.4.3.5 Liveweight (g)

The weight of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks was significantly different in statistical comparison ($P < 0.05$) with the conventional paddock at six (6) weeks into the experiment. But there was no significant difference in the weight of the snails in the screened and the conventional paddocks ($P > 0.05$) at twelve (12) weeks.

However, there was a reduction in the weight of the snails (57.3 g, to 56.5 g to 54.5 g) in the open paddock at initial, 6th and 12th weeks respectively as presented in Table 4.21.

4.4.3.6 Weight change (g)

The influence of housing systems on the mean weight gain of *Archachatina marginata* reared under Cassave pen is presented in table 4.22. There was no significant difference in the initial weight of the snails ($P < 0.05$). There was an observed weight loss in the open paddock with a negative weight gain of -2.8 g which was significantly different from the screened and conventional systems of production at 12th week of the experiment.

Although, there was no statistical difference between the weight gain recorded by the snails in the Screened and Conventional paddocks at 12 weeks but the snails in the conventional paddock gained a higher weight (2.08 g) than the snails in the screened paddock.

Table 4.21: Mean liveweight of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	WEIGHT (g)		
	0 week	6 weeks	12 weeks
Cassava - Screened Paddock	57.58 ^a	61.00 ^b	62.00 ^b
Cassava - Open Paddock	57.30 ^a	56.50 ^a	54.50 ^a
Conventional Paddock	56.75 ^a	60.12 ^{ab}	62.25 ^b
S.E.M	0.566	1.293	1.127

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

Table 4.22: Mean weight change of *Archachatina marginata* subjected to Cassava treatment in the open and screened paddocks in comparison with the conventional paddock

WEIGHT	WEIGHT CHANGE (g)		
	0 week	12 week	WEIGHT DIFFERENCE
Cassava -Open Paddock	57.30 ^a	54.50 ^b	-2.80 ^b
Cassava-Screened Paddock	57.58 ^a	62.00 ^a	4.43 ^a
Conventional Paddock	56.75 ^a	63.25 ^a	6.50 ^a
<u>±</u> SEM	0.57	1.13	1.07

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

4.4.4 Evaluation of Pueraria treatment

The mean difference for the growth parameters of snails subjected to Pueraria treatment in the open and screened paddock in comparison with the conventional paddock are presented below:

4.4.4.1 Change in Aperture (cm)

The result for Aperture presented in Table 4.23 showed that there was no significant difference in the aperture of the snails at 0 week in the open and screened paddock in comparison with the conventional paddock. At six (6) weeks into the experiment, the mean achieved a significant difference in the screened, open and the conventional paddocks. The snails in the screened paddock had the highest increase at 12th week of the experiment which was significantly different from the 6th week. The aperture at 6 weeks was significantly different from the first week but there was no significant difference at 12th week in the open paddock.

Table 4.23: Mean Aperture change of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	APERTURE (cm)		
	0 week	6 weeks	12 weeks
Puereria - Screened Paddock	4.95 ^a	4.90 ^b	5.40 ^a
Puereria - Open Paddock	4.98 ^a	5.05 ^{ab}	5.00 ^b
Conventional Paddock	4.95 ^a	5.08 ^a	5.06 ^b
S.E.M	0.06	0.05	0.10

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

4.4.4.2 Change in Shell Length (cm)

The shell length of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddock was not significantly difference in statistical comparison ($P > 0.05$) with the shell length recorded by snails in the conventional paddock as seen in Table 4.24.

The increase in length in the screened paddock was more obvious at 6th week (9.6 mm) and 12th week (9.8 mm). At six (6) weeks, the snails in all the paddocks experienced increase in shell length when compared with the initial week but there was an observed decline in the open and the conventional paddocks at 12th week respectively.

4.4.4.3 Change in shell thickness (mm)

The shell thickness of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddock was significantly different in statistical comparison ($P < 0.05$) with the shell thickness recorded by snails in the conventional paddock at 6th week of the experiment. But the shell thickness at 12th week was not significantly different from 6th week in the three paddocks as seen in Table 4.25.

Table 4.24: Mean Length change of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	LENGTH (cm)		
	0 week	6 weeks	12 weeks
Puereria - Screened Paddock	9.08 ^a	9.60 ^a	9.80 ^a
Puereria - Open Paddock	9.05 ^a	9.65 ^a	9.40 ^a
Conventional Paddock	9.05 ^a	9.83 ^a	9.70 ^a
S.E.M	0.08	0.12	0.15

^a Means with same superscripts within the same parametric column have no significant difference ($P > 0.05$).

Table 4.25: Mean shell thickness change of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	THICKNESS (mm)		
	0 week	6 weeks	12 weeks
Puereria - Screened Paddock	0.04 ^a	0.07 ^a	0.06 ^a
Puereria - Open Paddock	0.04 ^a	0.03 ^b	0.05 ^a
Conventional Paddock	0.03 ^a	0.03 ^{ab}	0.06 ^a
S.E.M	0.01	0.01	0.01

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

4.4.4.4 Change in width (cm)

The width of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddock was not significantly different in statistical comparison ($P > 0.05$) with the conventional paddock at the initial week as seen in table 4.26. At six (6) weeks into the experiment, there was an increase in width of the snails reared in the open, screened and the conventional paddocks but the increment recorded was not of significant difference statistically. The highest width was recorded in the screened paddock (11.15 cm) at 12th week and it was significantly different from the width recorded by snails in the open and conventional paddocks.

4.4.4.5 Liveweight (g)

The liveweight of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddock was not significantly different in statistical comparison ($P > 0.05$) with the conventional system of production as seen in Table 4.27. The snails in the three paddocks increased in weight in the 6th and 12th week of the experiment respectively.

Table 4.26: Mean width change of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	WIDTH (cm)		
	0 week	6 weeks	12 weeks
Puereria - Screened Paddock	6.18 ^a	9.93 ^a	11.15 ^a
Puereria - Open Paddock	6.13 ^a	9.35 ^a	10.50 ^b
Conventional Paddock	6.23 ^a	9.63 ^a	10.78 ^{ab}
S.E.M	0.09	0.19	0.16

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

Table 4.27: Mean liveweight of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	LIVEWEIGHT (g)		
	0 week	6 weeks	12 weeks
Puereria - Screened Paddock	57.38 ^a	62.00 ^a	63.00 ^a
Puereria - Open Paddock	56.30 ^a	59.50 ^a	60.00 ^a
Conventional Paddock	56.75 ^a	60.12 ^a	63.25 ^a
S.E.M	1.26	2.39	1.72

^a Means with same superscripts within the same parametric column have no significant difference ($P > 0.05$).

4.4.4.6 Weight Gain (g)

There was no statistical difference ($P > 0.05$) in the weight parameter of *Archachatina marginata* reared under Pueraria in the open and screened paddocks.

Although, there was an observed weight gain in the Open, Screened and Conventional paddock but it was not significant different from each other as seen in the initial weight and the final. The snails in the conventional paddock had the highest weight gain followed by the screened paddock as presented in Table 4.28:

Table 4.28: Mean weight difference of *Archachatina marginata* subjected to Pueraria treatment in the open and screened paddocks in comparison with the conventional paddock

Treatment	WEIGHT GAIN (g)		
	0 week	12 weeks	WEIGHT DIFFERENCE
Puereria-Open Paddock	56.30 ^a	60.00 ^a	3.70 ^a
Puereria-Screened Paddock	57.38 ^a	63.00 ^a	5.63 ^a
Conventional Paddock	56.75 ^a	63.25 ^a	6.50 ^a
SEM	1.26	1.72	1.91

^a Means with same superscripts within the same parametric column have no significant difference ($P > 0.05$).

4.5 Comparative Evaluation of the Individual Paddock systems on growth parameters at 0, 6 and 12 weeks.

4.5.1 Parameter: Aperture change (cm)

The mean aperture change at 0, 6, and 12 weeks showed that there was no significant differences observed in the screened, open and the conventional systems of production ($P > 0.05$) as presented in Table 4.29.

4.5.2 Parameter: Shell Length (cm)

The mean length change in 0, 6 and 12 weeks showed that there was no significant difference observed in the screened, open and the conventional systems of production ($P > 0.05$) as presented in Table 4.30.

4.5.3 Parameter: Shell Thickness (mm)

The mean thickness change in 0, 6 and 12 weeks showed that there was no significant difference observed in the screened, open and the conventional systems of production ($P > 0.05$) as presented in Table 4.31.

4.5.4 Parameter: Width change (cm)

There was an appreciable mean width change in all the snails in the various treatments at 6 and 12 weeks but there was no significant difference observed among the screened, open and the conventional systems of production ($P > 0.05$) as presented in Table 4.32.

Table 4.29: The mean changes in the aperture of *Archachatina marginata* at 0, 6 and 12 weeks

Treatment	Aperture (cm)		
	0 week	6 weeks	12 weeks
Open paddock			
Centrosema	4.90 ^a	5.15 ^a	5.05 ^a
Cassava	4.93 ^a	5.00 ^a	5.15 ^a
Calapogonium	5.25 ^a	5.88 ^b	5.20 ^a
Puraria	4.98 ^a	5.05 ^a	5.00 ^a
Screened paddock			
Centrosema	4.90 ^a	5.00 ^a	5.10 ^a
Cassava	4.95 ^a	5.10 ^a	5.10 ^a
Calapogonium	4.83 ^a	5.15 ^a	5.30 ^a
Puraria	4.95 ^a	5.90 ^b	5.40 ^a
Conventional Paddock	4.95	5.08	5.08

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

Table 4.30: The mean changes in the length of *Archachatina marginata* at 0, 6 and 12 weeks

Open paddock	Length (cm)			
	Treatment	0 week	6 weeks	12 weeks
Centrosema		9.10 ^a	9.55 ^a	10.00 ^b
Cassava		8.95 ^a	9.55 ^a	9.40 ^a
Calapogonium		9.10 ^a	9.55 ^a	10.00 ^b
Puraria		9.05 ^a	9.65 ^a	9.40 ^a
Screened paddock				
Centrosema		9.05 ^a	8.65 ^a	10.00 ^b
Cassava		8.98 ^a	9.95 ^a	10.00 ^b
Calapogonium		9.05 ^a	9.65 ^a	10.00 ^b
Puraria		9.08 ^a	9.60 ^a	9.80 ^b
Conventional Paddock		9.08 ^a	9.83 ^a	9.70 ^b

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05).

Table 4.31: The mean changes in the thickness of *Archachatina marginata* at 0, 6 and 12 weeks

Treatment	Thickness (mm)		
Open paddock	0 week	6 weeks	12 weeks
Centrosema	0.03 ^a	0.03 ^a	
	0.07 ^a		
Cassava	0.03 ^a	0.14 ^b	0.10 ^b
Calapogonium	0.04 ^a	0.04 ^a	0.13 ^b
Puraria	0.04 ^a	0.03 ^a	0.05 ^a
Screened paddock			
Centrosema	0.03 ^a	0.03 ^a	
	0.07 ^a		
Cassava	0.03 ^a	0.04 ^a	0.09 ^a
Calapogonium	0.04 ^a	0.03 ^a	
	0.14 ^b		
Puraria	0.04 ^a	0.03 ^a	0.05 ^a
Conventional Paddock	0.03^a	0.03^a	0.06^a

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

Table 4.32: The mean changes in the width of *Archachatina marginata* at 0 , 6 and 12 weeks

Treatment	Width (cm)		
	0 week	6 weeks	12 weeks
Open paddock			
Centrosema	6.00 ^a	9.60 ^a	
	10.75 ^a		
Cassava	6.15 ^a	9.55 ^a	11.00 ^a
Calapogonium	6.10 ^a	9.35 ^a	
	11.15 ^a		
Puraria	6.13 ^a	9.35 ^a	10.50 ^a
Screened paddock			
Centrosema	5.98 ^a	9.65 ^a	
	10.80 ^a		
Cassava	6.20 ^a	10.00 ^a	11.20 ^a
Calapogonium	6.13 ^a	9.70 ^a	
	11.15 ^a		
Puraria	6.13 ^a	9.35 ^a	10.50 ^a
Conventional Paddock	6.23 ^a	9.63 ^a	10.78 ^a

^a Means with same superscripts within the same parametric column have no significant difference (P > 0.05).

4.5.5 Parameter: Liveweight (g)

The mean liveweight change of *Archachatina marginata* in 0, 6 and 12 weeks showed that there was significant difference ($P < 0.05$) among the treatments in the screened and open paddock but the liveweight recorded in the conventional paddock was not significantly ($P > 0.05$) different from all the treatments in the screened paddock as seen in Table 4.33.

4.5.6 Parameter: Weight change (g)

The mean weight change of *Archachatina marginata* at 0, 6 and 12 weeks recorded a significant difference ($P < 0.05$) among the treatments in the screened and open paddock in comparison with the conventional systems of production as seen in Table 4.34. The highest weight gain (10.75 g) was recorded in Calapogonium treatment under the screened paddock while weight loss of -2.80 g was recorded in Cassava treatment under the open paddock.

Table 4.33: The mean changes in the liveweight of *Archachatina marginata* at 0, 6 and 12 weeks

Treatment	Liveweight (g)		
	0 week	6 weeks	12 weeks
Open paddock			
Centrosema	56.10 ^a	57.00 ^b	59.00 ^b
Cassava	57.30 ^a	56.50 ^b	54.50 ^b
Calapogonium	54.73 ^a	57.50 ^b	59.00 ^b
Pueraria	56.30 ^a	59.50 ^b	60.00 ^b
Screened paddock			
Centrosema	56.60 ^a	59.75 ^a	62.50 ^a
Cassava	57.58 ^a	61.00 ^a	62.00 ^a
Calapogonium	55.75 ^a	60.00 ^a	66.50 ^a
Pueraria	57.38 ^a	62.00 ^a	63.00 ^a
Conventional Paddock	56.75^a	60.12^{ab}	63.25^a

^{ab} Means with different superscripts within the same parametric column differ significantly (P<0.05)

Table 4.34: The mean changes in the weight change of *Archachatina marginata* at 0, 6 and 12 weeks

Treatment	Weigth Change (g)		
	0 week	12 weeks	Weight Change
Open paddock			
Centrosema	56.10 ^a	59.00 ^b	2.90 ^b
Cassava	57.30 ^a	54.50 ^b	-2.80 ^b
Calapogonium	54.73 ^a	59.00 ^b	4.28 ^b
Pueraria	56.30 ^a	60.00 ^a	3.70 ^b
Screened Paddock			
Centrosema	56.60 ^a	62.50 ^a	5.90 ^a
Cassava	57.58 ^a	62.00 ^a	4.43 ^a
Calapogonium	56.75 ^a	66.50 ^a	10.75 ^a
Puraria	57.38 ^a	63.00 ^a	5.63 ^a
Conventional Paddock	56.75^a	63.25^a	6.50^{ab}

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

4.6 Weight change analysis in the three paddocks

The relevance of the different housing systems was subjected to Analysis of Variance and the results from the weight parameters are presented below.

4.6.1 Initial Weight (g)

Table 4.35 showed the initial mean weight of *Archachatina marginata* as introduced to the four treatments (Centrosema, Puereria, Calapogonium and Cassava) and the conventional paddock which was the control.

4.6.2 Final Weight (g)

The differences in the final mean weight of *Archachatina marginata* after subjection to Analysis of Variance is presented in Table 4.36. Significant differences were observed in the final weights of the snails across the four treatment groups in the open and screened paddocks ($P < 0.05$).

Table 4.35: Means Initial weight of *Archachatina marginata* introduced to the four treatment groups in the three paddocks

Housing System	Cover Crop/ Feed					P value	SEM
	Centros ema	Puere ria	Calapog onium	Cassava	Conventional		
Open Paddock	56.10	56.30	54.73	57.30	56.75	0.39	0.92
Screened Paddock	56.60	57.38	55.75	57.58	56.75	0.78	1.10
Conventional	56.75	56.75	56.75	56.75	56.75		
P-value	0.81	0.84	0.49	0.60			
SEM	0.74	1.26	1.15	0.57			

Table 4.36: Mean Final weight of *Archachatina marginata* at the end of experiment in the four treatment groups within the two systems of production

Housing System	Cover Crop/ Feed					P value	SE M
	Centrosema	Puereria	Calapogoni	Cassava	Conventional		
Open Paddock	59.00 ^b	60.00 ^b	59.00 ^b	54.50 ^b	63.25 ^a	<.001	1.05
Screened	62.50 ^{ab}	63.00 ^a	66.50 ^a	62.00 ^a	63.25 ^a	0.24	1.42
Conventional	63.25 ^a	63.25 ^a	63.25 ^{ab}	63.25 ^a	63.25 ^a		
P-value	0.06	0.37	0.01	<.001			
SEM	1.13	1.72	1.35	1.13			

^{ab} Means with different superscripts within the same parametric row differ significantly (P < 0.05).

4.7 Individual paddock evaluation

The Screened and Open paddock were individually analysed in comparison with the conventional paddock on the bases of support provided for the treatment crops and snail growth in key performance indicator (weight) as seen below.

4.7.1 Screened Paddock

Table 4.37 showed the mean weight difference of *Archachatina marginata* as influenced by screening on the different treatments in the paddock.

The initial weight and final weights of the snails in the four treatment groups (Cassava, Pueraria, Calapogonium and Centrosema) were not significantly different from the conventional group ($P > 0.05$).

There was significant weight gain in all the treatments. Calapogonium has the highest weight gain of 10.75 g which is significantly higher than the conventional paddock (6.5 g). Although the conventional paddock was higher than the Pueraria and Centrosema, but there was no statistical difference ($P < 0.05$) among them.

However, Cassava had the least weight gain (4.43 g) which was significantly lower than all other treatments ($P < 0.05$).

Table 4.37: Mean weight comparison of *Archachatina marginata* in the screened paddock production systems

Treatment	INITIAL WEIGHT	FINAL WEIGHT	WEIGHT GAIN
Cassava	57.58 ^a	62.00 ^a	4.43 ^b
Puereria	57.38 ^a	63.00 ^a	5.63 ^{ab}
Calapogonium	55.75 ^a	66.50 ^a	10.75 ^a
Centrosema	56.60 ^a	62.50 ^a	5.90 ^{ab}
Conventional	56.75 ^a	63.25 ^a	6.50 ^a
SEM	1.10	1.42	1.58

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

4.7.2 Open paddock

The effect of direct ultra violet rays on the mean weight change of *Archachatina marginata* housed in the open paddock is presented in Table 4.38. No significant difference was observed in the initial weight. However there was significant difference at the final weight ($P < 0.05$).

The final weight for Cassava treatment was least (54.50 g) and significantly different from all other treatments. Although, there were no significant difference among the other three treatments (Puereria, Calapogonium and Centrosema) in their final weight but these weights were significantly different from that of the conventional paddock ($P < 0.05$).

The highest weight gain was observed in Calapogonium treatment (4.28 g) followed by Puereria (3.7 g). These weight gain were not as high as the Conventional paddock (6.5 g), but there were no observed significant differences among the treatments except for Cassava treatment that had a negative weight gain (-2.8 g).

Table 4.38: Mean weight comparison of *Archachatina marginata* in the open paddock production systems

Treatment	Initial weight	Final Weight	Weight Gain
Cassava	57.30 ^a	54.50 ^c	-2.80 ^b
Puereria	56.30 ^a	60.00 ^b	3.70 ^a
Calapogonium	54.73 ^a	59.00 ^b	4.28 ^a
Centrosema	56.10 ^a	59.00 ^b	2.90 ^a
Conventional	56.75 ^a	63.25 ^a	6.50 ^a
SEM	0.92	1.05	1.50

^{abc} Means with different superscripts within the same parametric column differ significantly (P<0.05)

4.8 Weight Change

As presented in Table 4.39, the mean weight gain of *Archachatina marginata* showed significant differences between the open and screened production systems ($P < 0.05$). The snails reared under the four treatment crops (Cassava, Pueraria, Calapogonium and Centrosema) in the screened paddock had significantly higher weight gains than those reared in the open paddock.

The conventional paddock had the highest weight gain when compared to all the treatments in the two paddocks except for Calapogonium treatment in Screened paddock which had 10.75 g weight gain.

Screened paddock competed favourably with the conventional paddock in all the treatment groups as seen in the Table 4.39 below.

Table 4.39: Mean Weight gain of *Archachatina marginata* at the end of experiment in the four treatment groups within the two systems of production

Housing System	Cover Crop/ Feed					P value	SE M
	Centrosema	Puereri	Calapogonium	Cassava	Conventional		
Open	2.90 ^{ab}	3.70 ^a	4.28 ^{ab}	-2.80 ^b	6.50 ^a	0.00	1.49
Paddock						7	
Screened	5.90 ^{ab}	5.63 ^{ab}	10.75 ^a	4.43 ^c	6.50 ^{ab}	0.10	1.58
Conventional	6.50 ^a	6.50 ^a	6.50 ^a	6.50 ^a	6.50 ^a		
P-value	0.07	0.59	0.08	<.001			
SEM	1.02	1.91	1.78	1.07			

^{abc} Means with different superscripts within the same parametric row differ significantly (P<0.05)

4.9 Evaluation of the Individual Paddock on Reproductive Parameters

The result showing the reproductive parameters of the snails subjected to the four treatments (Calapogonium, Cento, Puereria and Cassava) within the open and screened paddock system of production are presented below.

4.9.1 Average number of eggs

Snails reared in Cassava pen under the screened paddock laid the highest average number of eggs (10) while the snails reared in the Centrosema under the open paddock laid the lowest average number of eggs (3) as seen in Table 4.40.

4.9.2 Average weight of egg (g)

The average weight of eggs laid by the snails in the Centrosema pen in the screened paddock was the highest (1.3 g) while the eggs laid by the snails in the Pueraria (open and screened) recorded the least average weights of 0.97 g each as seen in Table 4.41.

4.9.3 Length of incubation (days)

The incubation period ranged between 26.5 days to 32 days and the eggs laid by the snails in Calapogonium under the screened paddock recorded the 26.5 days period while the eggs laid by the snails reared under cassava in open paddock recorded 32 days incubation period. This is presented in Table 4.42.

Table 4.40: Average (Mean) number of eggs laid by *Archachatina marginata* under various treatment groups in the open and screened paddocks in comparison with the conventional paddock

Average Number of Eggs Laid				
Treatment	Open Paddock	Screened Paddock	Conventional Paddock	SEM
Centrosema	3.00 ^a	7.00 ^{ab}	6.25 ^a	0.76
Calapogonium	6.00 ^{ab}	6.75 ^a	6.25 ^a	1.24
Puereria	7.00 ^b	6.75 ^a	6.25 ^a	1.10
Cassava	7.00 ^b	10.00 ^b	6.25 ^a	0.92

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$).

Table 4.41: Mean average weight of eggs laid by *Archachatina marginata* under various treatment groups in the open and screened paddocks in comparison with the conventional paddock

Average Weight of Egg (g)				
Treatment	Open Paddock	Screened Paddock	Conventional Paddock	SEM
Centrosema	1.00 ^b	1.30 ^a	1.06 ^a	0.04
Calapogonium	1.03 ^b	1.21 ^a	1.06 ^a	0.04
Puereria	0.97 ^a	0.97 ^b	1.06 ^a	0.04
Cassava	1.17 ^b	1.20 ^a	1.06 ^a	0.05

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

Table 4.42: Mean length of incubation of the eggs laid by *Archachatina marginata* under the various treatments in the open and screened paddock systems of production

Treatment	Length Of Incubation (Days)			SEM
	Open Paddock	Screened Paddock	Conventional Paddock	
Centrosema	28.00 ^a	28.00 ^a	27.25 ^a	0.55
Calapogonium	31.25 ^a	26.50 ^b	27.25 ^b	0.72
Puereria	29.25 ^a	29.00 ^a	27.25 ^b	0.31
Cassava	32.00 ^a	28.50 ^b	27.25 ^b	0.40

^{ab} Means with different superscripts within the same parametric row differ significantly (P<0.05)

4.9.4 Hatching percentage (%)

The eggs laid by snails in Centrosema and Cassava under the screened paddock recorded 100 % (highest) and 30 % (lowest) hatchability respectively.

4.9.5 Percentage Hatchling Mortality (%)

The highest percentage mortality (54 %) was recorded by the hatchlings from Cassava pen in the open paddock while the hatchling from Centrosema and Calapogonium in the screened paddock recorded the lowest (25 %) each.

4.10 Unhatched Eggs

Breaking the unhatched eggs revealed two snaillets had aestivated within the egg shell as shown in the Plates 17 and 18 below. One of the snaillets shielded itself with a coat of epiphragm while the other had its operculum/aperture or aperture covered with white calcareous substance.

Table 4.43: Hatching percentage of eggs from *Archachatina marginata* under the various treatment groups in the open and screened paddock system of production

HATCHING PERCENTAGE (%)				
Treatment	Open	Screened	Conventional Paddock	SEM
	Paddock	Paddock		
Centrosema	85.08 ^b	100.00 ^a	82.50 ^b	3.60
Calapogoniu	67.22 ^b	95.00 ^a	82.50 ^{ab}	6.13
m				
Puereria	84.38 ^a	90.62 ^b	82.50 ^a	4.28
Cassava	36.11 ^b	30.00 ^a	82.50 ^a	6.23

^{ab} Means with different superscripts within the same parametric row differ significantly (P<0.05)

Table 4.44: Percentage mortality of the hatchling of *Archachatina marginata* under the four treatments in the open and screened paddocks in comparison with the conventional paddock.

Percentage Hatchling Mortality (%)				
Treatment	Open Paddock	Screened Paddock	Conventional Paddock	SEM
Centrosema	33.33 ^a	25.00 ^b	29.17 ^{ab}	2.41
Calapogonium	28.12 ^a	25.00 ^a	29.17 ^a	3.31
Puereria	29.76 ^a	29.76 ^a	29.17 ^a	1.70
Cassava	54.17 ^a	35.42 ^b	29.17 ^b	4.11

^{ab} Means with different superscripts within the same parametric row differ significantly

($P < 0.05$)



Plate 17: Un-hatched snaillet covered with epiphragm



Plate 18: Un-hatched snaillet with aperture covered with epiphragm inside the egg.

4.11 Snail Predators

Different enemies of snails were discovered during the course of this experiment. Most of them were lizards, birds, frogs, moth, centipedes, millipedes and soldier ants.

Photograph of some predators captured during the experiment are shown in Plates 19 – 24.



Plate 19: Frog inside the incubator



Plate 20: Frog inside Centrosema pen



Plate 21: Centipedes feeding on snail



Plate 22: Soldier ants in the hatchling unit



Plate 23: Soldier ants in the Pueraria pen



Plate 24: Moth feeding on a snail

4.12 Environmental Factors

The environmental factors considered in this experiment were temperature and relative humidity.

4.12.1 Temperature (°C)

The average temperature recorded at 0, 6 and 12 weeks were; Open paddock (39.43, 37.98 and 45.05 °C); Screened paddock (36.19, 36.67 and 42.76 °C) and Conventional paddock (39.75, 39.10 and 45.05 °C) respectively.

Table 4.45 shows the mean value in the temperature within the pens of the four treatment groups inside the open and screened paddocks.

There was no significant ($P < 0.05$) difference in temperature of the three treatment pens (Centrosema, Calapogonium and Pueraria) at the initial week. The temperature of Cassava pen in the open paddock was significantly lower (35 °C) than the other three treatment pens. At six (6) and twelve (12) weeks, there was no statistically observed difference among the treatment pens.

In the screened paddock, there were variations in the temperature of some treatment pens in comparism with the open paddock. The temperature in Centrosema and Cassava pens in the open and screened paddocks was not significantly different ($P > 0.05$). Calapogonium and Pueraria pens in the open paddock were significantly different from the screened paddock.

However, there were no significant differences in the temperature of the four treatment pens in the open and screened paddock at six weeks with the exception of Cassava pen in the screened paddock. The temperature at week six (6) weeks were lower than the initial

week except for Cassava in open paddock, Calapogonium and Pueraria in the screened paddock.

At twelve week, the temperature in all the treatment pens was high and was not significantly different in comparison. Although the temperature in the Pueraria and Cassava screened paddock was high, but it was significantly lower than the open paddock. However, the temperature in the conventional paddock was not significantly different between the initial and six weeks. The twelve week temperature was also high and not significantly different from the open paddock.

Table 4.45: Changes in the temperature (°C) in the treatment pens under the open and screened paddocks in comparison with the conventional paddock

	TEMPERATURE (°C)		
	0 week	6 weeks	12 weeks
OPEN Paddock			
CENTROSEMA	39.50 ^a	35.27 ^a	44.33 ^a
CALAPOGONIUM	40.23 ^a	37.50 ^a	45.00 ^a
PUERERIA	43.00 ^a	40.30 ^a	46.62 ^a
CASSAVA	35.00 ^b	38.85 ^a	44.25 ^a
SCREENED Paddock			
CENTROSEMA	38.00 ^a	34.67 ^a	43.25 ^a
CALAPOGONIUM	35.50 ^b	38.75 ^a	43.25 ^a
PUERERIA	35.50 ^b	37.77 ^a	43.30 ^b
CASSAVA	35.75 ^b	35.50 ^b	41.25 ^b
CONVENTIONAL Paddock			
CENTROSEMA	39.75 ^a	39.10 ^a	45.05 ^a
CALAPOGONIUM	39.75 ^a	39.1 ^a	45.05 ^a
PUERERIA	39.75 ^a	39.10 ^a	45.05 ^a
CASSAVA	39.75 ^a	39.10 ^a	45.05 ^a

^{ab} Means with different superscripts within the same parametric column differ significantly (P < 0.05)

4.12.2 Relative Humidity (%)

The average relative humidity recorded at 0, 6 and 12 weeks were; Open paddock (77.31, 63 and 65.11 %); Screened paddock (77.31, 66.63 and 71.56 %) and Conventional paddock (78.75, 68.75 and 67.50 %) respectively.

It was observed that the relative humidity varied with time and location. At the initial week (23rd October, 2021), the relative humidity was observed to be high under the various treatment pens in the open, screened and conventional paddocks. The relative humidity of *Centrosema* and *Calapogonium* in the open paddock were not significantly different from the *Calapogonium* and *Centrosema* in the screened paddock which was also not significantly different from the conventional paddock. The relative humidity of *Cassava* and *Pueraria* pens in the open paddock was also not significantly different from the *Pueraria* and *Cassava* pens in the screened paddock. Therefore, the screening of the paddock did not have a significant influence on relative humidity. However, this was not the case in *Calapogonium* pen in the open paddock and *Calapogonium* pen in the screened paddock where a significant difference was observed six weeks into the experiment. At twelve weeks the relative humidity varied significantly among some of the treatment pens (*Calapogonium* and *Pueraria*) in the open and screened paddock, although the relative humidity in the open paddock was not significantly different from the conventional paddock. However, there was a higher relative humidity in the screened paddock when compared to the open and conventional paddock at twelve weeks.

Table 4.46: Changes in relative humidity of the treatment pens in the open and screened paddocks and comparison with the conventional paddock.

RELATIVE HUMIDITY (%)			
OPEN Paddock	0 week	6 weeks	12 weeks
CENTROSEMA	79.50 ^a	70.50 ^a	68.50 ^a
CALAPOGONIUM	79.75 ^a	57.75 ^b	63.00 ^b
PUERERIA	74.50 ^b	62.00 ^b	62.50 ^b
CASSAVA	75.50 ^b	64.75 ^a	66.25 ^a
SCREENED Paddock			
CENTROSEMA	80.00 ^a	71.00 ^a	72.25 ^a
CALAPOGONIUM	79.50 ^a	67.75 ^a	75.00 ^a
PUERERIA	75.00 ^b	61.75 ^b	71.75 ^a
CASSAVA	74.75 ^b	66.00 ^a	67.25
CONVENTIONAL Paddock			
CENTROSEMA	78.75 ^a	68.75 ^a	67.50 ^a
CALAPOGONIUM	78.75 ^a	68.75 ^a	67.50 ^b
PUERERIA	78.75 ^a	68.75 ^a	67.50 ^{ab}
CASSAVA	78.75 ^a	68.75 ^a	67.50 ^a

^{ab} Means with different superscripts within the same parametric column differ significantly ($P < 0.05$)

4.13 Cost Analysis (₦)

The cost incurred during the experiment was analyzed and the summary is presented in Table 4.47. The cost of establishing the open and screened paddocks were 22 and 78 % respectively of the total cost of six hundred and eighty eight thousand, one hundred naira only (₦688,100.00).

However, the cost of running the operations in the open and screened paddocks was not different. After the experiment, the total cost incurred (cost of establishing the paddocks and running cost) amounted to eight hundred and thirty one thousand, six hundred naira only (₦831, 600) of which the screened paddock had the highest contribution of 73.53 %.

Table 4.47: Evaluation of paddock establishment and operational cost

SUMMARY	COST ANALYSIS				
	TOTAL COST	SCREENED PADDOCK	% COST (S.P)	OPEN PADDOCK	% COST (O.P)
Total Cost of materials	517,600.00	430,950.00	83.26	86,650.00	16.74
Total labour cost	170,500.00	108,750.00	63.78	61,750.00	36.22
Cost of Paddock Establishment	688,100.00	539,700.00	78.43	148,400.00	21.57
Running cost					
Total production cost	76,000.00	38,000.00	50.00	38,000.00	50.00
Total Other Cost	67,500.00	33,750.00	50.00	33,750.00	50.00
Total running cost	143,500.00	71,750.00	50.00	71,750.00	50.00
TOTAL COST	831,600	611,450	73.53	220,150	26.47

Detailed analysis of the cost presented in this table is presented in the appendix

CHAPTER FIVE

5.0 DISCUSSION

The introduction of the snails into the paddocks by (Mid. October 2021) referred to as the 0 week fell under the Cold wet physiological classification which was characterized by moderate average temperature of 39.43, 36.19 and 39.75 °C in the open, screened and conventional paddocks respectively between the hours of 8 am to 12 noon. The average relative humidity at 0 week was relatively high; 77.31, 77.31 and 78.75 % in the open, screened and conventional paddocks respectively.

The 6 weeks phase (November ending) fell under the Cold dry physiological classification with average temperature of 37.98, 36.67 and 39.19 °C in the open, screened and conventional paddocks respectively while the average relative humidity recorded was 63.00, 66.63 and 68.75 % in the open, screened and conventional paddocks respectively.

The 12 weeks of the experiment ran through December to Mid January 2022. December month is classified under the Cold dry physiological season while January month is classified under the Hot dry physiological season. The average temperature recorded was 45.05, 42.76 and 45.05 °C in the open, screened and conventional paddocks respectively. The average relative humidity recorded as 65.11, 71.56 and 67.50 % in the open, screened and conventional paddocks respectively.

Cold dry and hot dry physiological seasons are characterized by inclement weather as seen in the high temperature and low relative humidity. This is the period the snails are supposed to naturally observe physiological rest and rejuvenate their organs for the next

cycle of production but deliberate distortion to natural phenomenon occurred in this experiment as irrigation and concentrate were provided ad libitum to prevent the snails from going on aestivation. This was done to see the possibility of rearing snails in adverse weather condition for all year round production.

The experiment was also to comparatively study different systems of snail production using crops as cover. Ejidike (2004) reported growth response of giant African land snail under the control of man as being dependent on the dietary protein levels of its feed and nutrient availability of the feed materials to the animal. Therefore, the crops that were used in this experiment (*Pueraria phaseoloides*, *Centrosema mole*, *Calapogonium mucunoides* and *Manihot esculenta*) have earlier been identified to have the nutritional values required for feeding snails and other livestock. *Pueraria phaseoloides*, *Centrosema mole* and *Calapogonium mucunoides* were evaluated as alternative source of feed for snails (Omole, 2010; Omole *et al.*, 2011) while Kehinde *et al.* (2004) stated that snail farmers should be encouraged to adopt cassava parts (leaves and peels) in snail feeding. These crops (treatment) were able to provide adequate feed and housing for the snails. From observation, it was very easy for the snails to hide under the cover crops and remain under the debris within the pens than the cassava that did not have much debris (fallen leaves) to sufficiently cover the snails. Hence, mulching materials such as the plantain leaves were introduced into the cassava pens (Screened and Open paddock) to enable the snails find sufficient hide-out materials and ground cover. There are some unique features that characterize *Archachatina marginata* in confinement such as the tendency to escape, feeding, hide-out, etc, the choice of crops was therefore to provide these basic requirements for the snails to ensure optimum performance.

These crops were cultivated under the screened and open paddock systems of production, the growth and reproductive performance of the snails introduced to the crops in these two paddocks were compared to the performance of the snails that were reared in the conventional paddock. In the conventional system of snail production, fruits, vegetables and concentrates were the major source of feed.

There was introduction of concentrate and irrigation to the snails in the open and screened paddocks at six weeks of the experiment. The irrigation was not only to regulate the snails' immediate environment to ameliorate the effect of the inclement weather on the growth and reproductive activities, it was also to sustain the crops.

5.1 Paddock Establishment

Two paddocks were established in the course of this experiment to compare with the existing conventional paddock. One of the paddocks was protected from direct solar radiations by the use of anti-Ultra violet ray net for screening while the other was left exposed to the effect of direct sun rays. The existing conventional paddock was roofed with raffia to prevent direct penetration of the sunrays. The anti U.V ray net was not to totally prevent the sun ray penetration into the paddock but it was to reduce the rays to about 55 % penetration which was totally different from the conventional paddock. The screened and open paddocks were divided into 16 pens each and the treatment crops were planted in four replicates.

5.1.1 Crop establishment

The unique features of the crops determined the time it took the crops in the paddocks to attain full establishment. These features include the leaf size, width, length, shape, etc. The rate at which the crops were growing was another factor that determined the time of establishment. Puereria and Calapogonium were more vigorous and attained full ground cover before Cassava and Centrosema. The time it took the crops; Puereria, Calapogonium, cassava and Centrosema to attain full establishment were 96 days, 105 days, 131 days and 156 days respectively.

5.1.2 The Size of leaf

The size of the leaves determined when the crops attained full ground cover. Centrosema had the smallest leaf size (5 cm X 7cm) as compared to the other three crops; Calapogonium (17 cm X 13 cm), Pueraria (16.5 X 17 cm) and Cassava (30 cm X 29 cm). The size of the leaves was one of the factors that determined the time and degree (density) of crop establishment.

5.1.3 Description of the crops

The leaves of Centrosema are trifoliate with a petiole of about 2 cm and the leaflets are ovate. Pueraria leaves are alternate and trifoliate with long hairy petiole of about 15 cm long having an apical leaflet that is triangular to ovate at its base. Calapogonium leaves are trifoliate with petiole of about 5 cm and the leaflets are broad, ovate to elliptical. Cassava leaves are palmate with a petiole of about 30 cm and each leaflet is cylindrical with apical ending. Cassava has an erect stem and had to develop canopy to provide adequate shade as against the other three that are creeping crops. The spacing between

the cassava crops was a factor to consider achieving ground cover; 75cm X 25 cm (75cm between the rows and 25cm between the plants to plant within the row).

5.2 Observations

During the course of the experiment, it was observed that snails were not easily found in their pens during search for data collection. The time it took to search for the snails differed in comparison to the density of the crops. It was more difficult to collect snails in the *Centrosema* and *Calapogonium* pens as it took an average of 10 minutes and 19 minutes respectively. This was not the case with Cassava and *Pueraria* as the snails were found within an average time of 4 minutes and 7.5 minutes respectively. This could have been due to the nature of the crops most especially the rooting system. The roots of *Calapogonium* and *Centrosema* were very dense as they establish adventitious roots at any point the stem got in contact with the soil. *Pueraria* had an obvious tap root with very little adventitious roots at any contact with the ground while it was creeping. Cassava being an erect crop did not pose significant challenge while looking the snails for data collection. The snails were mostly found under the mulch materials (debris) provided in the pen to be a medium of hide-out for the snails.

However, there was a noticeable change in the time of snail search when formulated feed was introduced to all the pens. It was discovered that snails fed more when the feed was placed directly on the ground than when they were placed in a feeder. Feed placed in the feeder were always discarded at the point of monitoring while it was observed that snails clustered round the spot where feed was sprinkled on the ground. This is evident in Figure 1 showing the pictures of snails gathered in one spot around the feed in *Calapogonium* and *Centrosema* pen within the screened and open paddock respectively. This was

observed in the pens of all the four treatment crops within the open and screened paddocks.

5.3 Growth Parameters

The growth parameters of snails in the four treatment groups were taken and subjected to Analysis of Variance. Each of the treatment was analyzed to be able to ascertain which of the crop was more suitable for snail production. The paddocks were also analyzed individually to evaluate the most suitable to be adopted by the farmers for all year round snail production.

5.4 Snails Subjected to *Centrosema* Treatment

Centrosema molle was able to provide adequate support for snail survival during the inclement weather. There were variations in the growth parameters of snails that were housed in *Centrosema* pen.

5.4.1 Aperture

There was no significant difference ($P > 0.05$) in the aperture of the snails reared under *Centrosema* pens at 0, 6 and 12 weeks in the open and screened paddock in comparison with the conventional paddock. This could be attributed to the physiological response of the snails to the inclement weather. Although irrigation and concentrates were made available to the snails from six weeks but the impact was not appreciable in the aperture growth due to the natural cyclic seasonal response mechanism. This is in line with the findings that snails are very responsive to their external environment (Osunkeye *et al.*, 2011).

5.4.2 Shell length

There was no significant difference in the the mean length of *Archachatina marginata* at 0, 6 and 12 weeks in the open and screened paddocks in comparison with the conventional paddock. Although, there was increase in length at 6 weeks (average of 1 cm) but the became retarded at twelve weeks of the experiment. This could be that they were undergoing induced physiological stress. This corroborates with the findings that there is reason to believe that there is more to aestivation than the mere existence of certain external factors (Barrows, 2001) in view of which Kokori (1992) stated that snails are governed not only by climatic conditions but by the internal rhythms that are not fully understood.

5.4.3 Shell thickness

The thickness of the snails' shell increased at twelve weeks than what it was at six weeks in all the snails within the open, screened and conventional paddock. This could be as a result of higher secretion of Calcium that should have been used for epiphragm formation if the snails were allowed to aestivate. This corroborates with the findings that higher secretion of Calcium during aestivation is responsible for the formation of the calcereous compound which is dried on contact with air and becomes impermeable "epiphragm"; and can stay in this state for up to three years during aestivation (Adikwu, 2012). The outer layer of the shell is a mixture of protein known as conchin. Inner layers of the shell are made up of calcium carbonate join with a network of conchin and are impregnably with variety of mineral salt. Cobbinah (1992) submitted that 98 % of the shell is in the form of calcium carbonate.

5.4.4 Shell width

The width of the snail increased in the six and twelve weeks respectively. The increment was more appreciable at six weeks (58.71 %) than at twelve weeks (11.96 %). At six weeks into the experiment, the snails were able to consume *Centrosema* to have attained an appreciation increase in width. At twelve weeks when the dry spell had deepened, the snails were unable to achieve much increase in width despite the constant provision of formulated feed/concentrates and water to argument the nutrient intake from *Centrosema* and irrigation to regulate the immediate environment of the snails. This could be as a result of hormonal regulation. The associated metabolic changes in animals are regulated by hormones and in various seasons, the condition and behavior of the animal change; accumulation or consumption of reserve substance may occur (Cobbinah, 1992). Therefore the increase at six weeks is an indication of accumulation of reserve to be used during aestivation but due to the fact that they were prevented from observing their physiological rest at twelve weeks, there was a drop in width increment performance.

5.4.5 Liveweight

There was increment in the liveweight of snails subjected to *Centrosema* treatment at six weeks and twelve weeks of the experiment in the open, screened and conventional paddocks. The percentage increase in liveweight were 5.57 %, 1.69 % and 5.94 % at six weeks and 4.60 %, 3.51 % and 5.21 % at twelve weeks in screened, open and conventional paddocks respectively. This liveweight increment can be attributed to food consumption. It has been reported that there was an increment in growth rate when snails feed was supplemented with broiler starter mash, which contained 23% crude protein

(Bright, 1996). Therefore this is true as the crude protein for *Centrosema* as estimated by AJOEA (2013) is 23.24 % hence the growth that was observed.

5.4.6 Weight gain

There was a significant weight gain ($P < 0.05$) in the snails within the open, screened and conventional paddocks. The snails in the open paddock had the lowest weight gain of 2.9 g compared to the 5.6g and 6.5 g from the Screened and Conventional paddocks respectively. This could be as a result of direct impact of sun rays on the crops which provided housing, shade, feed and other basic requirements by the snails. The highest weight gain was recorded in the conventional paddock 6.5 g followed by the screened paddock of 5.6 g. There was no significant difference in the weight gain by the snails in the screened paddock when compared to the conventional paddock.

5.5 Change in Growth Parameters of *Archachatina marginata* subjected to Calapogonium Treatment in the Open and Screened paddock in comparison with the Conventional Paddock

5.5.1 Aperture

The snails experienced change in their aperture (6.74 %, 8.73 % and 2.53 %) at six weeks into the experiment in the screened, open and conventional paddocks respectively. There was an obvious increase at twelve weeks in the screened paddock with 4.85 % from the sixth week and this was contrary to the negative growth of -0.94 % and 0 % observed in the open and conventional paddocks respectively. This findings show that snails had negative aperture growth response to high temperature that was prevalent at twelve weeks. According to Omoyakhi and Osinowo (2012), if snails are not allowed to observed rest, the body will have no chance to replace chemicals and repair muscles, other tissues and

aging or dead cells and this phenomenon may constitute a long term major setback in the domestication of GALS.

5.5.2 Shell length

There was no significant difference in the length of *Archachatina marginata* within the three paddocks. The growth in terms of length was not appreciable and cannot be recommended for commercial production as there was no clear evidence of the effect of the feed that was been consumed during the experimental phase.

5.5.3 Shell thickness

The thickness of *Archachatina marginata* was seen to have appreciated at twelve weeks when compared to the growth achieved at six weeks. Although there was no significant difference in the thickness of snail shells in the open, screened and conventional paddocks, but it was seen that the snails in the screened and open paddock gained more shell thickness than those in the conventional paddock at twelve weeks. According to Adikwu (2012), there is higher Calcium carbonate concentration during aestivation. Snail exhibit morphological, behavioural, physiological and biochemical adaptations in stressful environment (Storey, 2002). During the dry spells free living snails withdraw into their shells and conserve water by sealing the shell aperture with a calcified mucous membrane called the “epiphragm”, to minimize water loss due to evaporation (Storey, 2002; Omoyakhi *et al.*, 2008 a, b). Therefore, the calcium that was intended for epiphragm formation is concentrated in the shell and the stress imposed on the snails by preventing them from aestivating had a negative correlation with the growth in the shell thickness.

5.5.4 Width of the shell

The width of *Archachatina marginata* increased in the three paddocks at six and twelve weeks. The highest increase was recorded in the screened paddock at six weeks (58.37%) followed by the snails in the conventional paddock which had 54.63 % at six weeks. The snails in the open paddock had a closer percentage increase in their width (53.28%) when compared with the conventional paddock at 6 weeks each. However, it is worthy of note that the width of the snails increased at 12 weeks but with a significantly lower percentages in comparison to the increment obtained at 6 weeks. The highest increment was observed in the open paddock (19.25 %) followed by the 14.95 % and 12 % growth in the snails in screened and conventional paddocks respectively. The increase in width observed at six weeks correlate with the accumulation of feed reserve which is a natural phenomenon in preparation for dormancy. At twelve weeks, the environment became unfavourable and trying to prevent them from aestivation by providing them with feed and water through irrigation of the pens posed stress on the snail as seen in the growth in width at twelve weeks which is negatively correlated to the growth at six weeks. Although, this corroborated the findings by Storey (2002), that snails exhibit morphological, behavioural, physiological and biochemical adaptations in a stressful environment.

5.5.5 Liveweight

There was increase in the weight of *Archachatina marginata* in the open, screened and conventional paddock. The highest growth in weight was observed in snails under screened paddock at 12 weeks (10.83 %) from the weight at six weeks which was 4.25 %

higher than the initial weight. Although, there was increment in the weight across the three paddocks, but the snails in the open paddock had the lowest weight 2.77 % and 2.16 % at six and twelve weeks respectively. The snails increased in weight because they were prevented from undergoing aestivation which according to Akinnusi (1998) is characterized by imminent reduction in weight and loss of seemingly valuable growing time as growth during aestivation is said to reduce. This reduction is evident in other growth parameters such as length, width and aperture. While the increment in weight is as a result of continuous provision of feed for the snails to ameliorate the negative impact imposed on them by the environment.

5.5.6 Weight gain

The weight gained by *Archachatina marginata* in the open, screened and conventional paddocks was significantly different. The highest weight gain (10.75 g) was observed in the snails the conventional paddock. The snails in the screened paddock recorded 6.5 g weight gain while the snails in the open paddock had 4.28 g weight gain. The weight gained by the snails in the open and screened paddocks were lower than the conventional paddock as a result of the different varieties of conventional feeding materials that were made available to the snails in the conventional paddocks. Feeding is one of the major factors affecting snail growth, egg production and attainment of early maturity (Bright, 1996; Omole, 2003).

5.6 Change in Growth Parameters of *Archachatina Marginata* Subjected to Calapogonium Treatment in the Open and Screened in comparison with the Conventional Paddock

5.6.1 Aperture

The change in aperture of *Archachatina marginata* was not significantly different in the open, screened and conventional paddocks. However, the growth achieved at six weeks was higher than twelve weeks. The percentage aperture increment recorded at six (6) weeks was 6.74 %, 6.67 % and 2.53 % in the screened, open and conventional paddocks respectively. The increment at twelve weeks was significantly lower than six weeks. 2.91 %, 0.96 % and 0 % were recorded in the screened, open and conventional paddocks respectively. As temperature increased, the growth in aperture was retarded which corroborates the finding that growth is negatively correlated to high temperature (Akinnusi, 1998).

5.6.2 Length

The growth in length of the snails was not significant in the open, screened and conventional paddocks. The length increased at twelve weeks more than the increment observed at six (6) weeks in the open and screened paddock unlike the conventional paddock where reduction was observed at twelve weeks. This reduction could have been as a result of Calcium withdrawal from the shell when the temperature became too high.

5.6.3 Thickness

There was significant difference in the shell thickness of *Archachatina marginata* at six (6) weeks in the open, screened and conventional paddocks. The snails in the screened and open paddock had a negative thickness increment of -21.13 % and -89.09 % respectively at six weeks. At twelve weeks, the thickness of the snails increased

tremendously in the three paddocks. 382.14 %, 234.10 and 40.47 % in the screened, open and conventional paddocks respectively. The Calcium that was supposed to be used for epiphragm formation could have been deposited in the shell thereby increasing the shell thickness.

5.6.4 Width

There was increment in the width of *Archachatina marginata* at six weeks and 12 weeks. The percentage width increment was higher in the sixth week against twelve week. The percentage width increments were 58.37 %, 53.28 % and 54.62 % at six weeks, 14.95 %, 19.25 % and 12.00 % at twelve weeks in screened, open and conventional paddocks respectively. At six weeks, the highest increment was observed in the screened paddock immediately followed by conventional paddock before the open paddock while at twelve weeks the highest increment was observed in the open paddock immediately followed by screened paddock before conventional paddock. The increment in the width of all the snails in the three paddocks at six and twelve weeks is an indication of continuous feed consumption during the experiment.

5.6.5 Liveweight

There was an observed increment in the weight of *Archachatina marginata* in the open, screened and conventional paddocks at six and twelve weeks. At six weeks the weights were not significantly different among the three paddocks as seen in their percentage increase of 7.62 %, 5.06 % and 5.94 % in the screened, open and conventional paddocks respectively. This was quite different from the result obtained at twelve weeks where there was a significant difference in the weight of the snails among the three paddocks presented in percentage increase as 10.83 %, 2.61 % and 5.21 % in the screened, open

and conventional paddocks respectively. The snails in the screened paddock had the highest increase in weight at twelfth week (10.83 %) and highest increase in weight at sixth week (7.62 %). Although, there was increase in weight of the snails at six weeks in the open paddock (5.06 %) this was not sustained at the twelfth week as the rate of weight increment declined significantly to record an increment percentage of 2.61 %. However, the snails in the conventional paddock had a stable increment rate at six and twelve weeks as seen in the percentage increment of 5.94 % at six weeks and 5.21 % at twelve weeks. This could have resulted from the continuous supply of conventional feed materials and improved feed consumption by snails in the conventional paddocks. Calapogonium as a treatment under direct sunlight in the open paddock could have been affected by high temperature as such could not provide much nutrient for the snails in addition to the formulated diet that was provided which could have resulted in the decline in the rate of weight increment at twelfth week.

5.6.6 Weight Gain

There was a significant difference in the weight gain by *Archachatina marginata* among the three paddocks. The snails in the conventional paddock had the highest weight gain (10.75 g) followed by the snails in the screened paddock (6.5 g) before the snails in the open paddock which had weight gain of 4.28 g.

5.7 Change in growth parameters of *Archachatina marginata* subjected to Cassava Treatment in the Open and Screened paddocks in comparison with the conventional paddock

5.7.1 Aperture

The change in aperture of *Archachatina marginata* was insignificant when compared among the treatment groups at six and twelve weeks. The growth rate recorded at six

weeks for the snails in the screened, open and conventional paddock was 0.15, 0.08 and 0.13 % respectively. These rates at which the aperture increased were not economically and statistically significant. However, there was no growth in the aperture of the snails in the screened and conventional paddocks at twelve week. The snails in the open paddock recorded 3 % aperture growth at twelfth week in comparison to the 0.08 % growth that was recorded at sixth week. It could therefore be said that aperture did not increase significantly in all the snails in the three paddocks during the phase of this experiment.

5.7.2 Length

The change in length of *Archachatina marginata* recorded a significant difference among the open, screened and conventional paddocks at sixth and twelfth week phase of the experiment. The growth in length recorded in the screened, open and conventional paddocks were 0.98 %, 0.60 % and 0.75 % respectively at six weeks while 0.50 %, -1.57 % and -1.27 % were recorded at twelfth week in the screened, open and conventional paddocks respectively. It could therefore be said that the snails had a positive growth in length in the first phase of the experiment with the highest length recorded among the snails in the screened paddock followed by the conventional paddock. However, this was not so at the second phase when formulated diet was included in their ration and irrigation was provided in all the paddocks. Despite the deliberate effort to ameliorate the impact of the environmental factors on the snails, a negative growth in length was observed in the open and conventional paddocks. This corroborates the findings of the reason to believe that there is more to the practices of snails than the mere existence of certain external factors (Barrows, 2001). In view of which Kokori (1992) concluded that snails are governed not only by climatic conditions but by internal

rhythms that are not fully understood as this course of action can be said to be invariable pursued by nature mostly- a natural phenomenon which has been adjusted over time to coincide with seasons of unfavourable weather conditions.

5.7.3 Shell thickness

There were no statistical differences in *Archachatina marginata* in the open, screened and conventional paddocks at six and twelve weeks of the experiment. It was observed that only the snails in the open paddock at six weeks recorded an increase in their shell thickness likewise the snails in the screened and conventional paddocks at twelve weeks. The snails in the open paddock that had an increase in their shell thickness at sixth week were seen to have had a retarded growth leading to a negative growth rate of -30.15 % at twelve weeks. It could therefore be said that the thickness of snail shell is a function of the amount of Calcium that is being secreted by the snail at a particular point in time.

5.7.4 Width

The changes in the width of *Archachatina marginata* were significantly different between the snails in the screened paddock and the open paddock at six and twelve weeks of this experiment. It was observed that the growth in width recorded by the snails in the screened paddock at six weeks (61.29 %) was the highest followed by the 55.28 % recorded by the snails in the open paddock which was not significantly different from the 54.62 % growth in width recorded by snails in the conventional paddock at six weeks. However, the width of the snails at twelve weeks had a positive increment in the three paddocks with the highest (15.18 %) recorded in the open paddock. There was no difference in the width increment in the snails under the screened and conventional paddocks at twelve weeks as seen in the 12 % growth in width recorded by snails in each

of the paddock. It could be said that the continuous provision of adequate feed resulted in the width increment of the snails in the three paddocks although, the conversion and utilization of the feed was different as seen in the rate of growth presented above. This corroborates the findings that Feeding is one of the major factors affecting snail growth, egg production and attainment of early maturity Bright (1996).

5.7.5 Liveweight

The change in liveweight of *Archachatina marginata* under the screened and the open paddocks were significantly different from each other. There was an observed increase in the liveweight of 5.94 % each in the snails within the screened and conventional paddocks which was against the weight reduction -1.4 % recorded by the snails in the open paddock at six weeks. The weight of the snails in the open paddock further reduced (-3.54 %) at twelve weeks whereas the other snails in the screened and conventional paddocks increased in their liveweight with 1.64 % and 3.54 % respectively. This reduction in liveweight experienced by snails in the open paddock could have been as a result of the stress imposed on the snails when the cassava leaves were shed due to the inclement weather thereby exposing their immediate environment to direct sunlight penetration. This corroborates the finding that growth is negatively correlated with high temperature (Akinnusi, 1998).

5.7.6 Weight gain

Archachatina marginata under the open, screened and conventional paddocks had a significantly different weight gain. The highest weight gain was observed by snails in the conventional paddock (6.5 g) followed by the snails in the screened paddock (4.43 g). Unfortunately, the snails in the open paddock recorded a decline in their weight gain (-2.8

g). Although, it has been reported that there was an increment in growth rate when snails feed was supplemented with broiler starter mash, which contained 23% crude protein (Bright, 1996; Omole, 2003) also reported increase in weight gain when snail diet was supplemented with compounded ration and also observed improvement in feed efficiency when feed was ground compared to coarse feed. This is true for the snails as observed in the screened and conventional paddock especially as seen at six weeks when the environment was still slightly friendly. The reduction in weight of the snails in the open paddock could be as a result of the external stress factor associated with the treatment which also served as a housing medium for the snails. The retardation corroborates the finding that growth is negatively correlated to high temperature (Akinnusi, 1998) as the cassava leaves were shed exposing the pen to higher sunlight intensity. The reduction in weight could also be attributed to the poor nutritive value of dried cassava leaves. This corroborates the findings by Okonkwo *et al.* (2000) that the inability of snails fed old pawpaw leaves to lay egg might be due to their dry nature and lack of nutrients. Old and yellow pawpaw leaves had also been reported to have low nutrients, minerals and vitamins composition which are necessary for growth and reproductive performance (Ayoola and Adeyeye, 2010).

5.8 Change in Growth Parameters of *Archachatina marginata* Subjected to Pueraria Treatment in the Open and Screened paddocks in comparison with the Conventional Paddock.

5.8.1 Aperture

There was a significant change difference in aperture of *Archachatina marginata* at six and twelve weeks in the open, screened and conventional paddocks. The highest

increment observation was made in the screened paddock (10.2 %) at twelve weeks followed by 2.53 % aperture growth by snails in the conventional paddock at six weeks.

However, the growth in aperture declined (-1.01 % and 0.99 %) in the screened paddock at six weeks and open paddock at twelve weeks respectively. There was no change statistically in the aperture of the snails in the conventional paddock between six weeks and twelve weeks. This is suggestive of the fact that the snails were supposed to be allowed to undergo their natural rest cycle which is referred to as aestivation. However, this natural phenomenon has been completely eliminated in the captive propagations of snails and may constitute a long term major setback in the domestication (Omoyakhi and Osinowo, 2012). Aestivation is suggestive of an indispensable need (like any other living thing) for rest, sleep and fasting. During sleep, the body has chances to replacing chemicals and repair muscles, other tissues and aging or dead cells.

5.8.2 Length

The length of *Archachatina marginata* increased significantly in the open, screened and conventional paddock at six weeks unlike the result at twelve weeks. The snails in the conventional paddock at six weeks recorded the highest increase in length (8.56 %) followed by the snails in the open paddock (6.63 %) before those in the screened paddock (5.79 %). At twelve weeks, the snails in the screened paddock only increased their length with 2.08 % which was the best performance in comparison with the snails in the open and conventional paddocks which had a reduction in their length of -2.59 % and -1.27 % respectively.

5.8.3 Thickness

At six weeks, only the snails in the screened paddock increased in their shell thickness (1.07 %) while the other snails in the open and conventional paddock had a slight reduction of 0.19 % and 0.90 % respectively. At twelve weeks, the snails that initially increased in their thickness at six weeks experienced a reduction of (13.98 %) whereas the other snails in the open and conventional paddocks that experienced reduction in their shell thickness increased with 71.93 % and 74.45 % respectively. These variations could have been contributed by the quantity of calcium carbonate that was available in the snails' diet.

5.8.4 Width

Archachatina marginata recorded a significantly width increase in the open, screened and conventional paddocks. The changes in the width of *Archachatina marginata* was significantly higher at six weeks compared to twelve weeks. The snails in the screened paddock had the highest width increment of 60.73 % followed by the snails in the conventional paddock which had 54.62 % before the snails in the open paddock that recorded 52.65 %. Although, there were increments in the width of the snails at twelve weeks in the three paddocks, these increments were not significantly different from one another: 12.34, 12.3 and 12 % in screened, open and conventional paddocks respectively.

5.8.5 Liveweight

There was an observed increase in the liveweight of *Archachatina marginata* in the open, screened and conventional paddocks at six and twelve weeks. The rate at which the liveweight increased was greater in the sixth week compared to the twelfth week. The snails in the screened paddock had the highest liveweight (8.05 %). There was no

significant difference between the liveweight increment in the open (5.68 %) and conventional (5.94 %) paddocks at six weeks. The increase in the liveweight of snails in the conventional paddock at twelve weeks (5.21 %) can be compared to the liveweight increment observed in the open and conventional paddock at six weeks. Although, there was a positive change in the liveweight of snails in the screened (1.61 %) and open (0.84 %) paddock at twelve weeks, these could not be compared to the changes observed at six weeks.

5.8.6 Weight change

The weight gained by *Archachatina marginata* in the conventional paddock (6.5 g) was higher than the weight gained by the snails in the screened paddock (5.63 g). The snails in the open paddock had the least weight gain of 3.7 g during the twelve weeks period of the experiment. Omole (2003) reported increase in weight gain when snail diet was supplemented with compounded ration and also observed improvement in feed efficiency when feed was ground compared to coarse feed. However, it could therefore be said that weight gain is a function of the type or nature of feed being consumed by the snail and other external factors (e.g. relative humidity, temperature, etc) prevalent in the immediate environment of the snails.

5.9 Impact on the Weight of *Archachatina marginata* by the Treatments in the screened and open paddocks

5.9.1 Screened Paddock

The snails in Calapogonium treatment within the screened paddock had the highest weight gain (10.75 g), the weight gain by snails in the Centrosema treatment (5.9 g) was not significantly different from the weight gain by snails in the Pueraria treatment (5.63

g). The snails in the Cassava treatment had the lowest weight gain (4.43 g). However, in comparison with the weight gain obtained by the snails in the conventional paddock (6.5 g), the snails in the Calapogonium treatment did better. While the snails in the Pueraria and Centrosema treatment could compete favourably with the control as there was no statistical differences in their weight gain.

5.9.2 Open paddock

The snails in Calapogonium treatment did better than other snails in Pueraria, Centrosema and Cassava treatments in their respective weight gain. Unfortunately, the snails in Cassava treatment record weight loss (-2.8 g) from the initial weight. Although the snails in Centrosema, Pueraria and Calapogonium recorded an obvious weight gain (2.9 g, 3.7 g and 4.23 g), these were significantly lower than the conventional weight gain of 6.5 g. The observed performance of the snails in the four treatments (Cassava, Pueraria, Centrosema and Calapogonium) which were poorer than the performance by their counterparts in the screened and conventional paddocks could have been as a result of the direct penetration of sunlight negatively affecting the crops in which the snails were housed. These findings negates the report by Omole (2010) that snails fed with Pueraria had a higher weight gain than the snails feed on Calapogonium after twelve weeks. These results corroborate the finding that growth is negatively correlated to high temperature by Akinnusi (1998).

5.10 The mean change in the growth parameters of *Archachatina marginata* at 0, 6 and 12 weeks under various treatments within the open and screened paddocks in comparison with the conventional paddock.

5.10.1 Weight Change

The mean weight change of *Archachatina marginata* in 0, 6 and 12 weeks recorded a significant difference among the treatments in the screened and open paddocks in comparison with the conventional system of production.

The snails in Centrosema and Pueraria under the screened paddock recorded a significant weight gain (5.9 g and 5.63 g) respectively and this was statistically different from the weight gained (6.5 g) by the snails in the conventional paddock. The weight gained by snails in Calapogonium treatment in the open paddock (4.28 g) was not also significantly different from the weight gained (4.43 g) by the snails in Cassava screened paddock. However, the snails in Calapogonium screened paddock had the highest weight gain of 10.75 g. Lower weight gain were recorded in Centrosema and Pueraria in the open paddock (2.9 g and 3.7 g) compared to other snails with exception to the snails in Cassava open paddock which recorded weight loss (-2.8 g). It could therefore be said that the snails in Calapogonium screened paddock did better than the snails in the conventional paddock and that snails in Centrosema and Pueraria under the screened paddock favourably competed with the snails in the conventional paddock. From this result, the cover crops can replace conventional feeding to reduce cost of feeding the snails in corroboration with the Omole *et al.* (2013). The nutritional composition of the cover crops could have imparted on the the performance recorded and this is in line with the report by Ademolu *et al.* (2012) and Okonkwo *et al.* (2000). The poor performance of

the snails reared in the cassava pen under the open paddock could be as a result of the poor nutrient composition of the cassava leaves in comparison to the cover crops which corroborates the findings by Ayoola and Adeyeye (2010) and the high temperature that was recorded in the pen as a result of the the leaves that were shed in the adverse weather. This is also in line with the the findings by Akinnusi (1998) that snail performance is negatively correlated to high temperature.

5.10.2 Aperture

The mean aperture change at 0, 6 and 12 weeks showed that there was no significant difference observed in the open and screened paddock in comparison to the conventional paddock. The four crops supported the growth in aperture at 6 weeks more than at 12 weeks. This could be as a result of the physiological season at 12 weeks that concided with harsh environmental condition thereby posing stress on the snails.

5.10.3 Length

The mean length change at 0, 6 and 12 weeks showed that there was no significant differences observed in the screened and open paddocks in comparison with the conventional paddocks ($P > 0.5$). Although there was increase in the length of all the snails subjected to the various treatments but the increase in length was more appreciable at 6 weeks than at 12 weeks.

5.10.4 Thickness

The shell thickness of snails in Cassava pen under the open paddock (0.14 mm) was significantly higher than the thickness recorded by other snails in the cover crops at 6 weeks. However, the snails in the four treatments under the open and screened paddocks

recorded a higher shell thickness at 12 weeks than the snails in the conventional paddock (0.06 mm). This could be as a result of accumulation of Calcium in the snails occasioned by the physiological season corroborating the findings that higher Calcium secretion is associated with aestivation for the formation of cyst to ameliorate water loss (Cobbinah, 1993). It could also be that the feed consumed by snails in open and screened paddock were higher in Calcium content than the conventional paddock.

5.10.5 Width

There was an appreciable width change in all the snails in the four treatments under the open and screened paddock at 6 weeks and 12 weeks in comparison with the conventional paddock.

The width increment was not significantly different among the paddock. The rate at which the width increased was higher in 6 weeks than 12 weeks in all the treatments. The highest width increment (3.6) was recorded in the snails in the *Centrosema* pen among the treatments in the open paddock while the highest increment (3.8 cm) was recorded by the snails in the cassava pen under the screened paddock. This could mean that snails were consuming the feed in preparation for physiological rest while the reduction rate observed at 12 weeks could have been posed by external factors (Davenport, 1991).

5.11 Reproductive Parameters of *Archachatina marginata* reared under the four treatments in the open and screened paddock in comparison with the conventional paddock

The first set of eggs was harnessed at four weeks into the experiment in the *Calopogonium* treatment pen under the screened paddock. The snails in other treatments

also started egg lay later in the same week and this phase of egg-laying continued until first week of December 2021.

5.11.1 Average number of eggs laid

The snails that were housed in Cassava treatment under the screened paddock laid the highest average number of eggs which was significantly higher than the average number of eggs laid by others snails in the other treatment groups and the conventional paddock. The snails in the Centrosema screened paddock laid the same number of eggs as the snails in the Pueraria and Cassava screened paddock and these were not statistically different from the average number of eggs laid by Calapogonium open paddock, Pueraria and Calapogonium screened paddock and the conventional paddock. The snails in the Centrosema treatment in the open paddock were observed to have laid the lowest number of eggs in comparism to other snails under various treatments in the open, screened and conventional paddocks. Thompson and Sheldon (2004) reported that poor nutrition affects snail growth and causes a drop in the reproductive performance. According to Amaefule and Onwudike (2000), Ani and Okeke (2003), Esonu *et al.* (2003) and Oyeagu *et al.* (2018), the most important factor influencing the performance of animals under captivity is the quality of diet offered to the animals. Oyeagu *et al.* (2015) reported that layer mash (a concentrate ration) supported reproduction in the snails better than pawpaw fruit diet which was attributed to the report that pawpaw fruit as a sole diet is not nutritionally balanced enough to meet snails' requirements for reproduction while the available nutrients of the diets originating from different feedstuffs are more nutritionally balanced.

5.11.2 Average size of egg

The sizes of the eggs harnessed from the snails in the four treatments groups under the open, screened and conventional paddocks ranged between 16 mm – 20 mm. The biggest eggs were laid by the snails in Calapogonium treatment under the screened (20 mm) and open (18 mm) paddocks. These were followed by the eggs laid by snails in the Pueraria open and screened paddock (17.25 mm each) before the eggs that were laid by snails in the conventional paddock (17 mm) Although, the snails in Cassava treatment under the screened paddock laid the highest number of eggs but the size of the eggs were small (16 mm) likewise the eggs laid by snails in the Centrosema open and screened (16 mm each) paddocks.

5.11.3 Egg weight

The average weight of snail egg harnessed during this experiment ranged between 0.97 g – 1.21g. It was discovered that the weight of the eggs was not directly a function of the size of eggs as seen in the eggs laid by snails in the Cassava open and screened (1.2 g) which was not different from the weight of the eggs laid by snails in the Calapogonium screened paddock which were bigger in size. The weight of the eggs from the Cassava, Calapogonium and Centrosema in both the open and screened paddocks were not significantly different from the weight of the eggs laid by the snails in the conventional paddock. Meanwhile, the eggs laid by snails in Pueraria treatment under the open and screened paddock had the lowest average weight of 0.97 g each.

5.11.4 Egg incubation

The average length of incubation period ranged between 26.5 days to 32 days in this experiment. The first set of eggs to hatch was from the Calapogonium treatment in the

screened paddock (26.5 days) followed by the eggs from the conventional paddock (27.25 days). The average number of days it took the eggs in Centrosema treatment open and screened paddock (28 days each), Pueraria treatment open and screened (29.25 days and 29 days) and Cassava screened paddock (28.5 days) were lower than the days it took the eggs in Calapogonium open paddock (31.25 days) and eggs from Cassava open paddock (32 days) to hatch.

The average incubation period of the eggs was 29.25 days which corroborates with the findings of Okon *et al.* (2012) while the range of days in incubation was between 26.5 to 32 days in this experiment which was slightly different from the 28 -30 days Okon *et al.* (2012) reported. These values are higher than Cobbinah (1993) who reported values of between 14 -21 days. Ogogo (2004) reported that incubation period ranged between 29 and 32 days

However, Omole and Kehinde (2005) gave an incubation period ranging from 25 – 32 days. The disparity in incubation period between different researchers may be attributed to variation in genetic factors like breed, strain, age, size of the snail, egg size and environmental factors like temperature and relative humidity.

Nevertheless, Ibom *et al.* (2012) opined that exposure of eggs to fluctuating environmental conditions which differed from their near constant uterine environment may influence (increase/decrease) incubation period. In addition, Ibom *et al.* (2012) noted that incubation conditions such as uptake and loss of moisture and increased transpirational water loss resulting from increased heat produced by the developing embryo can also cause this variation.

5.11.5 Hatching/ Hatching percentage

The eggs harnessed from the treatment groups hatched successfully but at different rates. The eggs with the highest hatching percentage were from Centrosema treatment in the screened paddock (100 %) followed by the eggs from Calapogonium and Pueraria screened paddock (95 % and 90.62 %) respectively. The eggs from the snails reared under the conventional paddock recorded 82.50 % which was close to the 84.38 % and 85.08 % recorded by the eggs from Pueraria and Centrosema open paddocks respectively. The lowest percentage hatchability was recorded in eggs from Cassava treatment under open and screened paddock with 36.11 % and 30 % respectively. It could therefore be said that the quality of eggs from the Cassava treatment group in the open and screened paddock were affected probably because of the leaves that were shed which exposed the snails to adverse environmental condition. Hatchability could also be said to be a function of proper management of viable eggs during incubation. Several factors were responsible for the non-hatchability of some eggs. Some of these factors were due to infertility and non-viability of the eggs. Therefore, for the egg that hatched, they were viable, slightly covered to avoid desiccation and properly managed to ensure adequate soil moisture and density in the hatching unit. According to Olatunji *et al.* (2020) egg hatchability, the fertility of eggs, and average juvenile growth of snails fed on leaf meal-inclusive diets were superior to concentrate-fed snails without leaf meal inclusion suggestive of the beneficial ability of the leaf meals to influence reproduction positively. His findings corroborated other reports in rabbit and poultry that leaf meals enhance reproduction and

fertility (Ewuola *et al.* 2012). The result of his study is in agreement with Ejidike (2007) and Oyeagu *et al.* (2018) that snails fed with diets containing concentrate feed and herbs performed better than those that received only concentrate or herbs. Similarly, Oyeagu *et al.* (2018) reported that inclusion of *C. pubescens* in concentrate ration for snails increased the number of eggs laid, hatchability, and fertility of eggs with a lesser mortality of the embryo.

5.11.6 Hatchling mortality

The hatchling from Cassava treatment in the open and screened paddock recorded the highest mortality of 54.17 % and 35.42 % respectively. Above 70 % of the hatchling from the other treatment groups survived and grew to maturity after the experimental phase elapsed. The result of the study carried out by Olatunji *et al.* (2020) is also in agreement with Ejidike *et al.* (2002) that both growth and reproductive performance of African giant land snails (*A. marginata*) were better when their diets are supplemented with natural plant food materials than the snails that were placed on pure concentrate diets. The concentrate ration enhanced reproductive organ development and the inclusions of leaf meals also contributed to organ development compared to laying snails on natural plant feed/roughage. Moreso, the gonadosomatic index of snails on herbs and roughage treatment was better than snails on concentrate without leaf meal inclusion. The reproductive ability of snails is predicted by the gonadosomatic index; this explains the high gonadosomatic index of snails on leaf meal-based diet accompanied with better reproductive output in laying snails (Olatunji *et al.*, 2020). He therefore submitted that Concentrate diet is essential for optimal reproductive output in snails. The conventional belief that snails are herbivores and can survive on herbs and roughage is for maintenance

requirement. Reproductive functions such as egg laying and snaillet production require concentrate-based feeding to improve growth and offspring production, especially for commercialization. The importance of leaf meals to snails as herbivores was demonstrated in the study; laying snails fed with leaf meal-inclusive diets had the higher reproductive ability

5.11.7 Unhatched eggs

Some of the eggs from the Centrosema, Calapogonium, Cassava and Pueraria treatment in the open paddocks and some from Cassava treatment in the screened paddock were seen not to have hatched after 32 days of incubation. At the 34th days, the eggs were cracked and it was observed that some of the eggs were empty, some had gotten spoilt while some interesting had formed but were covered with white calciferous substance suspected to be epiphragm within the egg shell. These snaillets were harvested from their dormant stages and provided with feed and water and fortunately they survived. Plates 17 and 18 represents the snaillet in a stage that could be termed aestivation within the egg shell. A total number of three snails were mechanically harvested from their shells and the three snaillets survived and lived till maturity.

5.11.8 Predators

Different enemies of snails were discovered during the course of this experiment. Most of them were lizards, birds, frogs, moth, centipedes, millipedes and soldier ants. Worthy of note was the fact that the sealing of the aperture with epiphragm was not only a means of coping with the stress imposed on the snails by the environment, it also protected the snails from predators. The major predator with devastating effect on snailry was observed to be the migrating soldier ants. The soldier ants in search for a favourable environment

amidst the dry spell invaded the paddock and destroyed some of the snails. I want to believe that the snails could be protected against predators if they are allowed to undergo aestivation as the calcified epiphragm would seal off the aperture and render it difficult to be penetrated by the predators or reduce the direct impact on the fleshy part of the snails. For successful snail farming in Nigeria, attention must be paid to the prevention of predators in the snairy unit (Amusan and Omidiji, 1999).

5.12 Temperature

The temperature of the treatment pens were taken individually under the open and screened paddock in comparison to the temperature in the conventional paddock. It was observed that the temperature in Centrosema, Calapogonium and Pueraria treatment pens in the open paddock reduced at 6 weeks against the temperature of Cassava treatment pen in the open paddock that recorded an increment. The average initial temperature of the open paddock reduced from 39.43 °C to 37.98 °C at six weeks and at twelve weeks, the average temperature had increased to 45.05 °C with corresponding increase in the four treatment pens. The average initial temperature (36.19 °C) of the treatment pens within the screened paddock was not significantly different from the temperature at six weeks (36.67 °C). Rather, the average temperature at twelve weeks in the conventional paddock rose to 42.76 °C. The temperature in the conventional paddock was not significantly different from the open paddock at twelve weeks 45.05 °C. These temperature ranges are significantly higher than the temperature ranges in which snails can thrive (25 °C - 28 °C) as reported by Omole (2003). High temperature causes dryness and dryness inhibits growth and even stops activities. It was reported that when it becomes too hot and dry in summer that snails become inactive, seals up shell and aestivate. (Become dormant) until

cooler, moist weather returns (Amusan and Omidiji, 1999). Slow growth and poor laying of eggs are associated with high temperature. If the soil temperature is high, it could lead to the death of hatchlings, growers and even the adult snails and during this period, the growth rate will be reduced (Ayodele and Asimolowo, 1999; Omole *et al.*, 2011).

5.13 Relative Humidity

The relative humidity of the treatment pens in the open paddock recorded highest values at the initial week of the experiment with an average relative humidity of 77.31 %. There was a significant reduction at six weeks (63.75 %). The relative humidity at twelve weeks (66.25 %) was higher than the sixth week average value in the open paddock. However, there was no significant difference in the initial average relative humidity in the open, screened and conventional paddocks. At six weeks, it was observed that the relative humidity reduced in all the treatment pens in the screened paddock likewise the conventional paddock. There was an obvious increase in the average relative humidity in the screened paddock at twelve weeks (71.56 %) from six weeks (66.63 %) whereas; the relative humidity at twelve weeks (67.5 %) in the conventional paddock was not significantly different from the value (68.75 %) at six weeks. Snails are cold blooded animals because their bodies are sensitive to environmental changes (Bright, 1996). Snails respond to environmental changes when the relative humidity is less than 65 % by covering their surface or the fleshy part with white substance called Epiphragm or Cyst. The snails were prevented from undergoing aestivation following the finding by Ayodele and Asimolowo (1999) and Omole *et al.* (2011) that Aestivation and Hibernation can be prevented by provision of shade to cover the pens, mulching of the pens with dry leaves of cocoa, plantain and banana, regular tilling of the soil and regular watering of the soil in

the pens. One more major challenge of domestication is the ability to mimic perfectly the conditions in the wild so as to maximize the growth and reproductive potentials of the snails. Ademolu *et al.* (2012) reported that much still have to be done to achieve this task as a great gap exists between snails in the wild and those reared in captivity

5.14 Cost Analysis

The total cost incurred during the experiment was eight hundred and thirty one thousands, six hundred naira (₦831,600.00) with 26.47 and 73.53 % incurred on open and screened paddocks respectively. The bulk of the cost; five hundreds and seventeen thousand, six hundred naira (₦517,600.00) was incurred on the purchase of materials and 83.26 % of the material cost was for the construction of the screened paddock. The cost of running the experiment was equal. The conventional paddock was estimated to cost one million, three hundred and fifty thousand naira (₦1,350,000.00) only.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Snails have been included to a livestock group ‘mini-livestock’ and are increasingly playing important role in human nutrition across the income classes. The availability of snail meat is dependent on all year round production. To this effect, snails were reared under cultivated crops (*Pueraria phaseoloides*, *Centrosema mole*, *Calapogonium mucunoides* and *Manihot esculenta*) in an open and screened paddock to simulate the natural environment. The experiment on snail was carried out between the months of October 2021 to January 2022 which falls under the cold dry season in physiological classification known to be associated with dormancy phase (aestivation).

A total number of three hundred and twenty (320) apparently healthy *Archachatina marginata* with liveweight of 50 to 60g were used. The experiment was laid out in a 2 X 4 factorial with the system of production as the factor Centrosema, Calapogonium, Pueraria and Cassava as treatment and replicated four times with 10 snails per replicate. Data collection on growth and reproductive parameter was done on a weekly bases while routine monitoring, feeding and other management practices were carried out on a daily bases.

At the end of the experiment, it was obvious that the cover crops were able to support the rearing of snails in adverse weather condition with the provision of irrigation (to support the crops, snails and regulate the immediate environmental temperature and relative humidity) and concentrates to argument feed intake from crops. Cassava could not

provide adequate shading till the end of the experiment as the leaves were shed despite irrigation thereby depleting the shade that was initially provided.

The snails were able to live and attain a significant growth in all the parameters (aperture, length, thickness, width and weight) for the first six weeks when they were on sole crop diet without irrigation or concentrates. The growth rate at twelve weeks was significantly lower than the rate at six weeks for the cover crops while the snails in Cassava treatment recorded a significant weight loss at twelve weeks. Snails were found to have clustered round the spots where concentrates were placed and this was evidence to the feed intake as shown in Plate 1.

The temperature at six weeks was not significantly different from the initial temperature but was relatively high between six and twelve weeks which is believed to have posed physiological stress on the snails. At such high temperature, the snails were supposed to go into dormancy or rest phase in preparation for the next season of activities. It was therefore obvious that the snails could not perform optimally in growth and reproduction at twelve weeks characterized with high temperature.

However, from the reproductive parameters that were analysed (number of eggs, weight, clutch size, incubation length, hatchability, etc), there was no direct correlation of the size of egg to the weight of the eggs as seen that some smaller eggs had a higher weight than some of the bigger eggs. The average length of incubation in this experiment ranged between 26.5 days to 32 days. The eggs from the snails housed in Cassava treatment (open and screened paddock) had the poorest percentage hatchability while the eggs from

the snails in Pueraria and Calapogonium treatment under the screened paddock had the highest percentage hatchability.

The interesting observation was that some snaillets within the shell had undergone aestivation during incubation which was why they did not hatch within the incubation time frame while some eggs were seen to have been spoilt.

The snaillets/hatchlings that were hatched from the snails reared under the cover crops in the screened paddock survived to maturity post experimental phase. This was not so for the snails from Cassava treatment (open and screened) which recorded a mortality of 54 % and 35 % respectively.

The relative humidity recorded throughout the experiment was relatively above 60 % in the open, screened and conventional paddocks while the temperature at six weeks was not significantly different from the initial temperature but at twelve weeks, the temperature was seen to be relatively high in all the treatment groups under the open and screened paddocks and even the conventional paddock.

Among the predators that were observed during the experiment (frogs, lizards, millipedes, centipede, soldier ants, birds, etc), the predators that were seen to have had massive impact on snailery were the centipedes and the soldier ants.

The screened paddock apart from recording the highest relative humidity at twelve weeks was also seen to have prevented the snails from escaping to the surrounding bush as the snails that strayed out of their pens were found within the screened paddock. The screening also helps to limit the number of predators that gained access to the snails in their respective pens.

6.2 Conclusion

The snails reared in Calapogonium treatment under the screened paddock was seen to have attained a higher weight gain than the snails in other treatments and even the conventional paddock. The snails under the cover crops within the screened paddock were able to measure up to the snails in the conventional paddock unlike the snails that were reared under Cassava treatment in the open and screened paddock. Due to the high temperature that was associated with the periods of between six and twelve weeks of the experiment, the leaves of Cassava were shed despite irrigation. The inclement weather posed physiological stress on the snails that were reared especially in the open paddock. Screening did not only regulate the degree of sun penetration to the paddock but also provided some level of security for the snails from external predators and escape proof.

The screened paddock with the cultivation of cover crops to simulate the natural environment can replace the conventional paddock if snails are to be reared all year round. However, it was seen that even when concentrates were provided to supplement the feed intake by snails and irrigation was provided to ameliorate the effect of the inclement weather on the snails, crops and the environment, the performance of the snails at twelve weeks was not as good as the performance at six weeks when the snails were left to feed on the crops and live freely as obtainable in the wild. Therefore, not allowing the snails to rest may cause physiological breakdown and negatively affect their performance. This is in line with the thought that complete elimination of aestivation phase in the captive propagations of snails may constitute a long term major setback in their domestication (Omoyakhi and Osinowo, 2012) as aestivation is suggestive of an indispensable need

(like any other living thing) for rest, sleep and fasting. During sleep, the body has chances of replacing chemicals and repair muscles, other tissues and aging or dead cells.

6.3 Recommendation

Although, it is cheaper to rear snails in an open paddock compared to the screened and conventional paddocks but the merit of environmental factors control measures cannot be overemphasized.

Looking at the screened paddock in comparison to the conventional paddock, it was cheaper to construct the screened paddock which proved to better support the growth and reproductive performance of the snails. The attention to the snails in the natural environment is minimal compared to the conventional paddock where routine feeding, cleaning and other management practices are carried out for optimum performance.

Among the treatment crops, the snails reared in Calapogonium treatment (open and screened paddocks) had the highest weight gain and the eggs recorded 95 % percentage hatchability followed by the snails reared in Pueraria treatment (open and screened paddocks) with 90 % percentage hatchability. Although, eggs from snails reared in Centrosema treatment recorded 100 % hatchability but the average weight gain of the snails under the open and screened paddock was low. The snails under the Cassava in the screened and open paddocks recorded 30 % and 36 % percentage hatchability respectively.

I will therefore recommend Calapogonium crop to be adopted in the establishment of snailery as it was seen to support snail growth and reproductive performance in both the

open and the screened paddock. In the absence of Calapogonium, Pueraria can be a substitute.

6.4 Findings

- Screened paddock did not only control the temperature and relative humidity of the snails' environment for optimum growth and reproductive performance, it also prevented the snails from intruders, predators and escape.
- Snails reared under the cover crops (Calapogonium, Centrosema and Pueraria) had better growth and reproductive performance than those reared under Cassava pen and Conventional paddock
- Although it was cheaper to establish the open paddock, the adverse weather condition had a negative effect on the growth and reproductive performance of the snails.
- The challenges observed in the screened, open and conventional paddocks were high cost and availability of anti UV ray net; direct exposure to inclement weather, predators and escape; high capital and deliberate routine management requirement respectively
- Snails were found in clusters around feed spot: therefore, when snails are to be harvested during the day, feed should be used as bait otherwise, harvesting of snails will be difficult during the day as they would hide themselves requiring a desperate search.
- There was evidence of snails feeding on concentrates placed directly on the ground than when they were placed in the feeding troughs.
- Clutch weight is a function of individual egg weight but not a function of egg size.

- Growth and reproductive activities is not solely a function of feed consumption rather, a combination of other natural phenomenon such as time and season.
- Among the treatments, the cover crops served as the best medium to raise snails while trying to simulate their natural environment than the cassava and the conventional paddocks.

6.5 Contribution to Knowledge

From the study, the following contributions were made:

- Snails can be reared all year round under a dense cover crop that is drought tolerant of which Calapogonium is a good example.
- Cassava could not support growth and reproductive performance as much as the cover crops due to the dietary protein levels, temperature and relative humidity in the pen.
- The cost of establishing the screened paddock was higher than the open paddock but the advantage of rearing snails under the screened paddock outweighed the open and conventional paddocks.
- Snails reared in the open or screened paddock using crops as cover appeared moist, radiant and attractive as those in the wild unlike the snails reared in the conventional paddock.
- Unhatched snaillets within the egg aestivated when the weather was not favourable. This means that adverse weather condition is a factor to egg hatchability.
- Concentrates can be used as bait for snails in the paddock for easy harvesting as snails were found to cluster round feed spot in the pens.

6.6 For Further Studies

Research on alternative materials to regulate the temperature and relative humidity of snails reared in a screened paddock. The goal would be to avoid the cost of purchasing anti-UV ray net which is expensive and scarcely available.

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APPENDICES

Appendix 1: Photograph of snails used for the experiment



Appendix 2: Photograph of a snail whose shell thickness is being measured with a caliper



Appendix 3: Photograph of a snail whose length is being measured with a measuring tape



Appendix 4: Photograph of a snail whose weight is being measured with an electronic weighing scale

Appendix 5: Photograph of egg clutches being weighed with an electronic weighing scale.



Appendix 6: Photograph of incubators in the the incubating unit



Appendix 7: Photograph of snaillet crawling out of the egg inside the incubator



Appendix 8: Photograph of snaillets hatched from *Centrosema* treatment



Appendix 9: Photograph of snaillets hatched in *Calapogonium* treatment



Appendix 10: Photograph snaillet at first week on hatching



Appendix 11: Photograph of snaillet at four weeks post hatching



Appendix 12: Photograph of snail at eight weeks post hatching



Appendix 13: Breakdown of the cost incurred during the experiment

COST INCURED ON THE EXPERIMENT (₦)					
MATERIAL COST	UNIT	PRICE	TOTAL (GROSS)	TOTAL (S.P)	TOTAL (O.P)
1½ Galvanized pipe	30.00	4,500.00	135,000.00	135,000.00	-
2” Galvanized pipe	8.00	6,500.00	52,000.00	52,000.00	-
2/4 Galvanized pipe	24.00	2,200.00	52,800.00	52,800.00	-
Anti UV ray net	3.00	24,000.00	72,000.00	72,000.00	-
Chain link	10.00	2,000.00	20,000.00	10,000.00	10,000.00
Galvanized wire mesh *	7.00	6,500.00	45,500.00	22,500.00	22,500.00
Poultry wire mesh *	5.00	12,000.00	60,000.00	30,000.00	30,000.00
Binding wire (hard) *	12.00	500.00	6,000.00	3,000.00	3,000.00
Binding wire (soft)	10.00	500.00	5,000.00	5,000.00	-
Screening net	5.00	5,500.00	27,500.00	27,500.00	-
2 x 2 wood *	38.00	1,100.00	41,800.00	20,900.00	20,900.00
Total Cost of materials			517,600.00	430,700.00	86,400.00

LABOUR COST

Labour for screen house structure *	1.00	47,000.00	47,000.00	47,000.00	-
Labour for the pen demarcation *	1.00	25,000.00	25,000.00	12,500.00	12,500.00
Labour cost for paddock maintenance *	1.00	20,000.00	20,000.00	10,000.00	10,000.00
Cost of getting planting materials *	1.00	10,000.00	10,000.00	5,000.00	5,000.00
Cost of site preparation *	1.00	45,000.00	45,000.00	22,500.00	22,500.00
Site demarcation and fence re-enforcement *	1.00	23,500.00	23,500.00	11,750.00	11,750.00
Total labour cost			170,500.00	108,750.00	61,750.00
Total cost for paddock establishment			688,100.00	539,450.00	148,150.00
PRODUCTION COST					
Cost of snails *	350.00	200.00	70,000.00	35,000.00	35,000.00
Cost of feed *	1.00	6,000.00	6,000.00	3,000.00	3,000.00
Total production cost			76,000.00	38,000.00	38,000.00
OTHER COST					
Measuring tape *	1.00	5,000.00	5,000.00	2,500.00	2,500.00
Cement	1.00	5,000.00	5,000.00	5,000.00	-
Digital scale *	1.00	7,500.00	7,500.00	3,750.00	3,750.00

Thermo hygrometer *					
	1.00	10,000.00	10,000.00	5,000.00	5,000.00
Irrigation materials *					
	1.00	20,000.00	20,000.00	10,000.00	10,000.00
Miscellaneous *					
	1.00	20,000.00	20,000.00	10,000.00	10,000.00
Total Other Cost			67,500.00	36,250.00	31,250.00
TOTAL COST			831,600.00	613,700.00	217,400.00
				73.80 %	26.14 %

COST ANALYSIS

SUMMARY	TOTAL COST	SCREENED PADDOCK	% COST	OPEN PADDO CK	% COST
Total Cost of materials	517,600.00	430,700.00	83.21	86,400.00	16.69
Total labour cost	170,500.00	108,750.00	63.78	61,750.00	36.22
paddock establishment	688,100.00	539,450.00	78.40	148,150.00	21.53
				0	
Running cost					
Total production cost	76,000.00	38,000.00	50.00	38,000.00	50.00
Total Other Cost	67,500.00	36,250.00	53.70	31,250.00	46.30
Cost of running the experiment	143,500.00	74,250.00	51.74	69,250.00	48.26

% Cost

*** Shared cost**

G – Gross

S.P - Screened paddock

O.P - Open paddock
