AKENTEN APPIAH-MENKAH UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

COEFFICIENT OF VARIATION COMPONENT ESTIMATES OF TRAITS OF AFRICAN GIANT RAT *(Cricetomys gambianus)*

FRANCIS NKRUMAH CUDJOE

2024

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BY

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A thesis submitted to the School of Graduate Studies, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in partial fulfillment of the requirements for the award of a Master of Philosophy degree in Animal Science (Animal Breeding and Genetics)

SEPTEMBER 2024

DECLARATION

STUDENT'S DECLARATION

I hereby declare that this thesis, with the exception of quotations and references contained in published works which have been duly acknowledged; is the result of my own original work and that no part of it has been presented for another degree at this university or elsewhere.

FRANCIS NKRUMAH CUDJOE

SIGNATURE: ……..…… DATE: ……..……...…….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines and supervision of thesis as laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

Dr. DUODU ADDISON

SIGNATURE: ……..…… DATE: ……..……...…….

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DEDICATION

I dedicate this thesis to the glory of God in whom I live.

I also dedicate this work to all those who have contributed tirelessly in diverse ways towards my education, especially my parents, Mr. Samuel Cudjoe and Mrs. Esther Donkoh, and my siblings, Bernard Cudjoe, Louis Cudjoe and Anna Takyiwaa Cudjoe.

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ABSTRACT

This study aimed to analyze the variance components of various traits in African giant rats (*Cricetomys gambianus*) to enhance their performance. The research was conducted from February 2023 to August 2023 at the Animal Science Farm of Akenten Appiah Menka University of Skills Training and Entrepreneurial Development, Mampong-Ashanti campus, Ghana. A total of 30 rats were involved, including 15 does and 15 bucks that were categorized into three age groups: neonatal (10), juvenile (10), and adult (10). Traits measured include, body weight/gain, docility, morphological traits and carcass characteristics. Behavioral docility was assessed using a 4-point scale measuring docility levels (1 - docile, 2 - flighty, 3 - restless, 4 - aggressive). The study employed a Randomized Complete Block Design (RCBD). Statistical analysis was performed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS for Windows, version 10). Means were separated using least significant differences (lsd). Body weight and weight gain were significantly influenced by age. Neonatal rats showed a higher body weight gain ($p < 0.05$), with greater variability than the other age groups. The average docility scores were 2.52 for males and 2.75 for females. In detail, neonates averaged a score of 2.34, juveniles 2.65, and adults 2.81. Sex and age significantly affected docility ($p < 0.05$). While low variability in docility was observed across sexes, high variability was noted among the neonates compared to adults and juveniles. The study indicated that sex significantly affected body length and tail length ($p < 0.05$), while other linear body measurements were not statistically influenced by sex. The dressing weight was significantly higher in males (1321 g) compared to females (1293 g). Protein content was higher in females (24.81%) compared to males (23.61%) ($p < 0.05$. The research concluded that age and sex significantly impact body weight, growth, and various morphological and carcass traits in African giant rats. The findings underscore the need for tailored management strategies based on age and sex to enhance growth and performance in this species.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

The world faces the challenge of feeding an ever-increasing population while conserving natural resources and biodiversity (Hoffman & Cawthorn, 2012). According to FAO (2022), an estimated one billion people worldwide suffer from protein deficiency. Due to rapid population growth, animal producers are unable to meet existing demands for meat, especially in developing countries, due to over-reliance on domestic animal species (Cooper, 2008). Increasing demand for animal protein and high prices associated with such products have increased reliance on local wildlife species for subsistence (Hoffman & Cawthorn, 2012; Booth *et al.,* 2021).

It is estimated that more than 71 genera and 89 species of rodents (Hystricomorphs) are hunted as game. In the tropical world, rodents are accepted as a popular source of protein (Oyarekua & Ketiku, 2010). According to records of European settlers, wildlife populations have been declining in Africa since the 19th century due to indiscriminate and unregulated hunting for meat (Hoffman & Cawthorn, 2012). These have destroyed the environment through bushfires and the production of unwholesome meat in the market, hence the need for domestication and improvement so they can be easily accessed. African giant rat (AGR) (*Cricetomys gambianus*) belongs to the family *Nesomyidae*. It is widespread in Sub-Saharan Africa and is an economically important rodent within Africa. It is one of the most common mammals exploited as bushmeat (Ahmad *et al.*,2019). It has been trained to aid in detecting landmines (Machang'u *et al*., 2004) and in diagnosing pulmonary tuberculosis (Weetjens *et al*., 2009). The African giant rat is Ghana's third most

preferred bushmeat (Bannor *et al.,* 2022). In Africa, wildlife is an important food item, especially for the people in rural areas. It accounts for about 20% of the mean annual consumption of animal protein (Valle, 2015). In captivity, the African giant rat can live up to 14 years and grow to a maximum body weight of 1.39 kg for does and 2.80 kilograms for bucks, and the meat is considered both desirable and of a high nutritional value (Oyarekua & Ketiku, 2010). The period during which a female African giant rat is pregnant, known as the gestation period, typically lasts 31 days, with a possible range of variation of 4 days (Lacasse *et al.,* 2005). The number of offspring born in a litter can vary between 1 and 5, with an equal distribution of males and females. Sexual maturity, defined as the age at which an individual can successfully reproduce, is reached at approximately 23 weeks after birth, with a possible range of variation of 12 days.

The African giant rat has not received much attention in literature. All known Prior research conducted in Nigeria has predominantly focused on the digestive system (Nzalak *et al.,* 2012), kidney morphology (Onyeanusi *et al.,* 2007), haematology (Oyewale *et al.,* 1998), nutritional value of raw African giant rat parts (Oyarekua & Ketiku, 2010), and nutritional value of processed rat meat (Oyarekua & Ketiku, 2010) of the wild type African giant rat. The African giant rat (*Cricetomys gambianus*) is highly overhunted in many parts of Africa, including Nigeria (Ajayi & Tewe, 1978; Oyarekua & Ketiku, 2010) and are frequently seen at night crossing roads, running along drains and house compounds (Nzalak *et al.,* 2012).

1.2 Problem statement

A "game" refers to any animal hunted in the wild to obtain meat. In Africa, these animals are commonly referred to as "bush meat" and include species such as antelope, squirrels, grass cutters, and even giant rats like the African giant rat (*Cricetomys gambianus*) (Oyeyinka *et al.*, 2019). Unfortunately, many of these species currently face the threat of overhunting, particularly in regions such as Nigeria and Ghana (Ajayi & Tewe, 1978; Oyarekua & Ketiku, 2010; Oyeyinka *et al.*, 2019). One serious challenge possibly associated with the overhunting of game animals could lead to a decline in their populations and threaten biodiversity in African ecosystems, leading to ecological imbalances in the region. One will argue that hunting of game, African giant rats, is necessary for survival and livelihoods for some dwellers in rural communities. To solve these three main challenges, i.e. (1) protecting the environment, (2) providing cheap and adequate animals as a source of protein, and (3) providing a means of livelihood for hunters in local communities, there is a need for the domestication of these animals.

According to Hoffman and Cawthorn (2012), one way of increasing protein production on a short-time basis is by domesticating some fast-breeding wild mammals acceptable to the people as a source of meat, of which the African giant rat falls into this category. Local farmers in Nigeria have attempted to domesticate the African giant rat. However, Ghana has slightly improved due to a lack of domesticated stock and scanty literature on these animals. The Ministry of Food and Agriculture has recognised this and AGR (African Giant Rat) has been listed in the Ghana National Livestock Breeding Policy (MoFA, 2004).

Breeders take advantage of variability within a trait to improve performance; therefore, the level of variability in a trait will determine a breeder's interest in that particular trait since variation serves as the raw material for breeders (Annor, 2018). Several studies have assessed the variation level in the most critical traits of conventional domestic animals and some non-traditional animals, such as guinea pigs by Quijandri *et al.,* (1983), rabbits by Iraqi (2008) and grasscutters by (Annor *et al.,* 2012); however, there is a lack of comprehensive understanding and accurate estimation of variation within the various traits of the African giant rat. This knowledge gap hinders the ability to fully characterise and identify the sources of variability in key traits such as body weight, docility, morphometric and carcass traits, which are vital for this species' sustainable management and conservation. To address this gap, there is a critical need for research that systematically evaluates and estimates the coefficient of variation components for a range of traits in the African giant rat. This will provide valuable insights into the genetic, environmental, and phenotypic factors influencing trait variability and ultimately support informed decision-making and effective management strategies for the conservation and sustainable use of this important species. Therefore, to facilitate the breeding of highly prolific, docile, and fast-growing African giant rats, there is a need to know the variability in traits of African giant rats across sexes and ages of the current population of captive AGR.

1.3 Objective of the study

1.3.1 Main objective of the study

The main objective of the study was to estimate the variance components of some traits of the African giant rat under captivity.

1.3.2 Specific Objectives of the Study

The specific objectives were to:

- Estimate the level of variation in growth parameters of African giant rats in captivity
- Measure the level of variation in docility of African giant rats in captivity
- Determine the level of variation in morphological traits
- Estimate variation levels in carcass traits of African giant rats under captivity.

1.4 Significance of the Study

This study will provide information on the level of variability in major growth parameters, docility, morphological and carcass traits of African giant rats under captivity. This information will help animal breeders and farmers learn how to rear and improve the performance of African giant rats. Information from this research would play a crucial role in domestication and assist in making effective management strategies for the conservation and sustainable use of this important species. In addition, the available information from this study could readily serve as reference data to enhance further research.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Rodents

The Rodentia is the largest group of mammals and comprises about 1,500 living species out of the approximately 4,000 living mammal species. Rodents are the most common non-flying mammals and are commonly known as pets, such as mice, rats, hamsters, and guinea pigs. The Rodentia also encompasses a variety of other species, including beavers, muskrats, porcupines, woodchucks, chipmunks, squirrels, prairie dogs, marmots, chinchillas, voles, lemmings, and others. It is important to note that rabbits are not included in rodentia; they differ from rodents in that they have an extra pair of teeth and other skeletal features. Lagomorpha is made up of rabbits, hares, and several other species. Shrews, moles, and hedgehogs are also not rodents; they are classified in the Mammal order Eulipotyphla).

Rodentia comprise the largest order of mammals in the world and include more than 30 families, 480 genera and over 2,200 species (Wilson & Reeder, 2005). The order's five primary families are Dipodidae (jerboas and jumping mice), Heteromyidae (pocket mice and kangaroo rats), Sciuridae (squirrels), and Muridae (rats and mice, accounting for 66% of all rodent species). In nearly every part of the world, rodent species may be found living in the wild. Their ability to thrive on a variety of diets, short gestation times, early sexual maturation, and big litter sizes, all of which make them good meat producers, are primarily responsible for their success. As a result, numerous societies have used mice as a food source, and at least 89 species are regarded as local delicacies (Fiedler, 1990). These are

sought after because they are simple to capture and frequently exempt from game regulations.

According to Hoffman and Cawthorn (2012), as reported by (Redhead & Boelen, 1990), rodents are a preferred protein source in the tropics, particularly in rural regions of western and southern Africa, where big animals are frequently in short supply. According to Oyarekua and Ketiku (2010), 20 to 90% of the animal protein ingested by rural West Africans comes from rodent species. According to Hoffman (2008), rats have the best chance of becoming valuable commercial commodities from all the wildlife species that may be used for human profit because of their high reproduction rates and easy husbandry needs. The flesh of rats also provides critical amino acids that are needed in the human diet in addition to valuable protein (Fiedler, 1990).

2.2 Domestication of rodents

Numerous rodent species have been domesticated in countries where rodents have been consumed for a long time and where the supply no longer fulfils the demand. Brazil, Columbia, and Venezuela have all conducted studies to enhance capybara domestication. In Latin America and West Africa, domestication techniques can be somewhat complex and straightforward. The landless poor, who may grow readily kept rodents like the guinea pig in Peru or the grasscutter and giant rat in Nigeria, adopt simple methods (Fiedler, 1990). Not all rodents make suitable domestication candidates. Mason and Mason (1984) list four qualities that a domestic animal in its most advanced form should have: it must be bred under human management, it must produce a good or service that is useful to people, it must be tamed (or be made to become so), and it must be selected away from the wild type.

According to Fiedler (1990), two rodent species in West Africa, the giant African rat (*Cricetomys gambianus*) and the grasscutter or cane rat (*Thryonomys swinderianus*), are now being domesticated. Primarily, due to reduced habitat and increased human populations, these two rodent species are no longer present in West Africa in sufficient numbers to satisfy human demand. The giant rat and grasscutter are considered delicacies by poor and rich Africans. In southern Nigeria, 71 % of survey respondents claimed they would eat giant rats. Ajayi and Olawoye (1974) found that acceptance was more apparent among younger and poorer populations. For the 1-1.5 kg giant African rat, large commercial raising facilities are being built in Nigeria (Tewe *et al.*, 1984). From the fifth generation forward, breeding methods significantly lowered agnostic behaviour and created submissive animals (Ajayi & Tewe, 1978). From infancy to adulthood, domestication expenditures were initially around $ 0.45/animal (Ajayi & Olawaye, 1974). Nevertheless, you may feed them kitchen leftovers.

2.3 Advantages of Utilizing Rodents for Food

Despite the wide variety of human eating habits, man has often chosen food based on opportunism and preference. While many of the items that people may eat are not medically healthy, rats make excellent nourishment for humans. Rodent meat supplies the human diet's protein and critical amino acids (Fiedler, 1990). One of the many vertebrate species that humans consume is the rodent. Wild birds, reptiles, and amphibians do not give as many eating benefits for human food as those supplied by rodents which are not employed as a food source to a considerable extent, (Eltringham 1984).

Since they are often plentiful and simple to capture, rodents are typically exempt from game legislation. Some rodents are even common when there are many people but few bigger animals (Den Hartog & de Vos, 1973). Although one species of rodent eaten by man weighs more than 50 kg, most are small enough to be consumed in one meal, thereby negating the necessity for refrigeration or other food-storage techniques like salting and drying Fiedler (1990).

In rodent populations, relatively high reproductive rates enable continual harvesting without depletion. Invertebrates such as insects provide the majority of the benefits for human consumption compared to rodents since they have a greater protein content (35–50%). Insect food supplies are, however, often quite seasonal. A lot of the rodent species that are consumed are pests in agriculture. Most West African rodent pest species are regularly eaten (Funmilayo, 1979). Despite decades or even centuries of human predation, most of these rodents still pose a pest problem and seriously harm crops. Occasionally, rodents have been consumed or used in unique situations. In Africa and South America, house rats (*Rattus sp.)* and guinea pigs (*Cavia porcellus*) have both been utilised for therapeutic purposes (Müller-Haye, 1984). Additionally, rodents are utilised in feasts, religious rituals, and trades for certain initiations (Sale, 1983; Müller-Haye, 1984). A social group (Secret Order of the Neotoma Eater) at the University of Arizona consumes pack rats (*Neotoma sp.*), claiming they are a delicacy (Fiedler, 1990).

2.4 Taxonomy and Distribution of African Giant Rat

Carleton & Musser (2005) identified four species of giant pouched rats, including *Cricetomys gambianus, Cricetomys emini, Cricetomys ansorgei,* and *Cricetomys kivuensis*,

in what is widely considered a reference and checklist for mammals. Even though they noted that Cricetomys existed in a variety of forms across its geographic range, the most significant publications before this, including Genest-Villard (1967) and Rosevear (1969), only identified two species. The first is the wide-snouted *C. gambianus*, which is found in the African savannahs and has a whitish-grey belly that is not very different from the flanks. The second is the Guineo-Congolian forest block's slim-snouted *C. emini*, which has a unique white belly and lives there. The only two species found in the genus Cricetomys are *C. gambianus* and *C. emini*, according to several publications such as (Freeman *et al*., 2006; Peterson *et al*., 2006), even after the publication of Carleton & Musser (2005). This viewpoint has been upheld in the most current IUCN Red List of Threatened Species (Van der Straeten, 2008). There have been several inquiries over the status of the extinct species. These include two of the taxa identified by Carleton & Musser (2005) as complete species: *C. ansorgei*, sometimes regarded as a savannah population of *C. gambianus* in East and southern Africa, and *C. kivuensis*, occasionally considered to be a montane population of *C. emini*, in the Democratic Republic of the Congo (DRC).

Clarifying the taxonomic statuses of the many forms known within Cricetomys is problematic since prior research relied on specimen collections that only covered a small portion of the globe. Moreover, these studies used phenotypic characteristics such as snout width (broad vs narrower snouts; Olayemi & Akinpelu, 2008), pelage colour (indistinctly white vs distinct white bellies; Rosevear, 1969; Happold, 1987), and ecology (savannah vs forest-dwelling populations; Genest-Villard, 1967; Peterhans *et al*, 2010; Van der Straeten, 2008). These methods have all produced identifications that show significant overlap for

the characteristics under consideration. Because of this, it is challenging to distinguish between species just based on physical characteristics, and the assigned taxonomic statuses of all Cricetomys species need to be further investigated (Carleton & Musser, 2005).

Olayemi *et al*., 2012, confirmed the presence of three out of the four species currently recognised under the genus Cricetomys, i.e. *C. gambianus, C. ansorgei,* and *C. emini* in their study, along with the unexpected presence of three additional so-far undescribed species, Cricetomys sp. 1 (forest zone, West Africa), Cricetomys sp. 2 (forest zone of Central Africa on the left bank of the Congo river), and Cricetomys sp. 3 (forest zone of Central Africa, right bank of the Congo River in Cameroon, Gabon, and the Republic of Congo). According to the National Research Council. (1930), Giant rats are commonly found from Senegal to Sudan and as far south as the northern region of South Africa. The main species is mainly found in moist savannas, patches of forests, and rainforests. However, it can also be found in all West African vegetation zones from the semiarid Sahel to the coast. It also exists at high altitudes up to about 2,000 m in West Africa and 3,000 m in eastern Africa. The rainforest species occurs in the great equatorial forest belts of Zaire and neighbouring Central African countries.

Plate 1.1: Eexperimental African giant rats in cages

The summary classification of the African giant rat as reported in www.itis.gov, CC0 https://doi.org/10.5066/F7KH0KBK is given as:

Kingdom	Animalia
Subkingdom	Bilateria
Infrakingdom	Deuterostomia
Phylum	Chordata
Subphylum	Vertebrata
Infraphylum	Gnathostomata
Superclass	Tetrapoda
Class	Mammalia (Linnaeus, 1758)
Subclass	Theria (Parker & Haswell, 1897)
Infraclass	Eutheria (Gill, 1872)
Order	Rodentia (Bowdich, 1821)
Suborder	Myomorpha (Brandt, 1855)
Superfamily	Muroidea (Illiger, 1811)
Family	Nesomyidae (Forsyth Major, 1897)
Subfamily	Cricetomyinae (Roberts, 1951)
Genus	Cricetomys (Waterhouse, 1840)
Species	*Cricetomys gambianus* (Waterhouse, 1840)

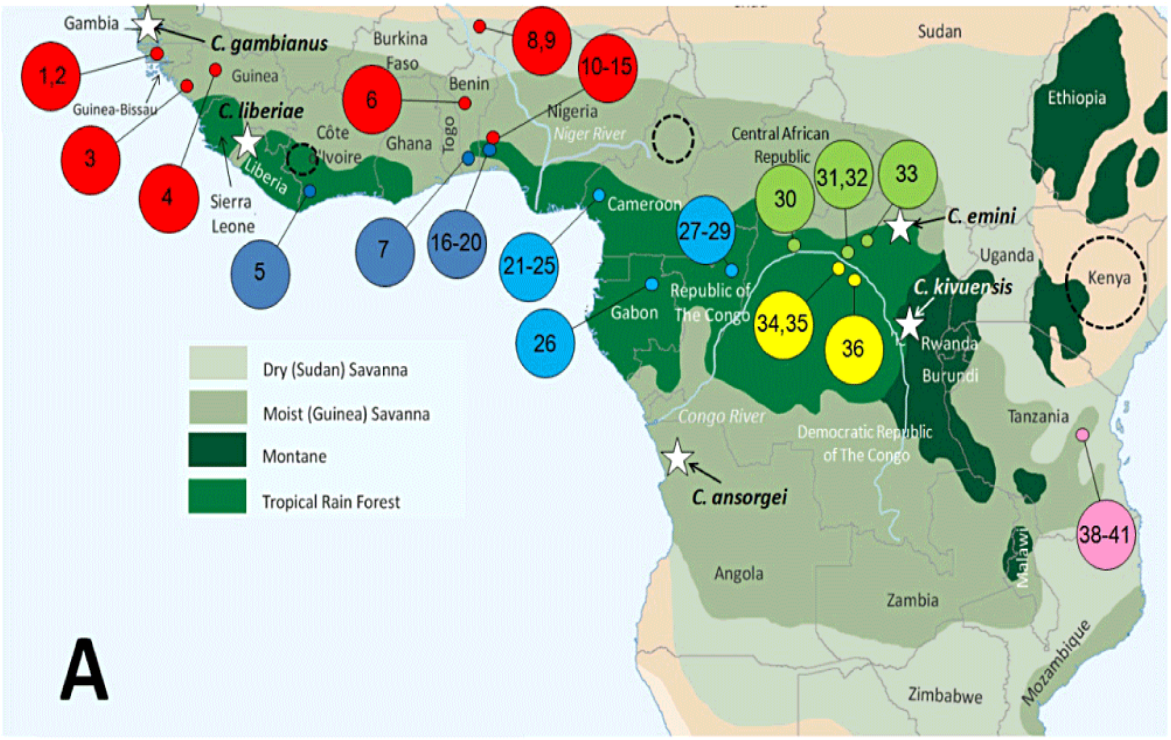

Plate 2. 1 Taxonomy and distribution of the African giant rats (Nesomyidae:
Sources: Zoological Journal of the Linnean Society, Volume: 165, Issue: 3, Pages: 700-719, First published: 26 June 2012, DOI: (10.1111/j.1096-3642.2012.00823.x)

2.5 General Behavior of African Giant Rat

According to Majer (1973), although Eisentraut (1965) and Ewer (1967) record climbing behaviour within the genus, they are essentially terrestrial. The roots of ancient trees, holes in decaying logs, strangleholds, and intricate chambered underground nests are all familiar places for rats to build their nests (Sanderson, 1940). Usually, there is only one animal per nest, except when the young are born. The previous chamber or burrow is often left empty when a new nest is built (Rosevear, 1969). According to Kalemba *et al.,* (2022), Giant-pouched rats are primarily terrestrial and use underground burrows. Previous reports indicate that burrows of *C. emini* can be found in dense forests as well as in open areas such as farmlands, fallow fields, and near abandoned houses in forest villages (Malekani,

1987). Most burrows have been observed in elevated places (mounds, deserted termitaries or beneath large trees), with at least two entrances, of which one is primarily used (Malekani 1987, 1990). The second entrance is typically closed by ground cover or located inside a hollow making it challenging to identify. As a result, in some cases, the burrow may seem to have only one entrance (Malekani, 1990). Additional evidence suggests one individual occupies one burrow at a time; females with juveniles have been observed to occupy one burrow for several months Kalemba *et al.*, 2022.

Rats are nocturnal animals primarily active in the early evening and just before sunrise. They engage in play behaviour (e.g. wrestling and chasing) from a young age, and these activities are important for establishing social ties, which adult rats will reinforce with grooming. These behaviours are key to maintaining harmonious groups and should not be misconstrued as aggression (Komorowska & Pellis, 2004). *C. gambianus* is herbivorous, feeding on leaves and fruits of wild and cultivated plants. They particularly love oil palm fruits (de Balsac & Lamotte, 1958). Squire (1962) mentions that *C. gambianus* is responsible for untold crop damage and stored products in the Northern Region of Ghana. Rosevear (1969) stated that Cricetomys is primarily nocturnal but is occasionally seen hunting for food in the daytime. Ewer (1967) observed the diurnal activity pattern of *C. gambianus* in captivity at the University of Ghana. She found that both sexes had a bimodal nocturnal activity pattern ranging between 2230 and 0500 hours, and the pause in activity, between 1 and 1.5 hours, centered around 0300 hours. Food collecting tests revealed a maximum activity period of 5.7 hours. In general, *Cricetomys* rodents are considered to be solitary and nocturnal, with two peaks of activity (bimodal activity pattern), generally

within the limits of dusk until dawn, with a reduction/cessation of activity during the few hours following midnight Kalemba *et al.,* 2022.

A study by Kalemba *et al.,* 2022, showed that *C. emini* burrows with entrances between 6 and 15 cm in diameter and the mean maximum diameter of burrow entrances was 11 cm (n = 27). This agreed with the burrows that Ajayi (1977) reported, who observed entrances between 4.5 cm and 15 cm in diameter for C. gambianus in a savanna area. Additionally, Ajayi (1977) reported that *C. gambianus* is known to have a maximum of four burrow exits in the savanna and human-modified landscapes.

2.6 Breeding, lactation and weaning of African Giant Rat

The period during which a female African giant rat is pregnant, known as the gestation period, typically lasts 31 days, with a possible range of variation of 4 days (Lacasse *et al.*, 2005). The number of offspring born in a litter can vary between 1 and 5, with an equal distribution of males and females. Sexual maturity, defined as the age at which an individual can successfully reproduce, is reached at approximately 23 weeks after birth, with a possible range of variation of 12 days. The weight of a newborn pup can range from 21 to 36 grams (Cooper, 2008). Does can produce up to 5 liters per year, with weaning occurring between days 26 and 35. There is a 2 % mortality rate before and after weaning. According to Cooper (2008), there is a lack of documented scientific evidence regarding the duration of the oestrus cycle in the giant rat. However, it may be inferred to be similar to other rat species, typically lasting 4-5 days. Furthermore, there is a shortage of documented evidence regarding the presence of vaginal plugs composed of coagulated semen as a reliable indicator of mating in the giant rat. According to (Ingweye & Kalio,

2020), reproduction in this species is abundant and occurs throughout the year. Female sexual maturity is reached at 20-23 weeks, and gestation typically lasts 28-42 days. Offspring are usually weaned at 21-26 days old but remain with their mother until 2-3 months. It was reported by Cooper 2008, that in the event of the demise of the dominant female, the sister rats effectively assume responsibility for the offspring and at least one will enter into estrus. While there is a lack of empirical evidence to support this, it is hypothesised that the sister rats respond to the young's vocalisations and provide appropriate care.

2.7 Feeding and Nutrition of Rodents

One of the most critical environmental elements determining the health and well-being of confined rodent colonies is access to food that offers appropriate nutrition. Supplying appropriate nutrition for confined rodents includes determining the needs for around 50 important elements, creating and producing a diet with the necessary nutrient concentrations, and monitoring diet quality variables (Knapka, 1999). According to Knapka (1999), captive rodent colonies should be provided with nutritionally balanced diets with only limited amounts of succulent foodstuffs. The practice of feeding rodent colonies specific cereal grains is discouraged since no single grain provides a balanced rodent diet.

According to Knapka, 1999, rodents' nutritional requirements are identical to other mammalian species. Rodents' quantitative dietary needs differ from other species due to their tiny body size and higher metabolic rate. Knapka (1999), emphasises that because various rodents' nutritional studies have been carried out under varied environmental

conditions and, in some cases, with different strains within a rodent species, published data on the dietary needs of diverse rodent species usually contain significant contradictions.

The African Giant Rat is an omnivorous rodent that feeds on various food items. Its diet includes insects, termites, fruit and vegetables. They have cheek pouches in which they carry food and other items intended for storage. In its natural habitat, this omnivorous animal consumes large quantities of vegetation (National Research Council 1995). The molar teeth are especially suited to grinding, and, like other species of rodents, the AGR has open-rooted incisors that grow continuously throughout its life. The AGR is simple-stomached like the guinea pig, mouse, and rabbit. Olawuwu *et al*. (2020) pointed out a contradiction between the protein requirement of AGR, where a study conducted by Ajayi & Tewe 1978, suggested that growth performance improved as the dietary protein level was raised from 10 to 13%. However, a further increase to 16% did not result in more significant growth and Cooper, 2008 also recommended a minimum of 20% crude protein as the dietary requirement for AGRs. Food-preference trials show that palm fruits and root crops (especially sweet potato) are preferred to grains and vegetables. Nutritional studies show that the animals can tolerate up to 7 % crude fibre in their rations. Although largely vegetarian, they eagerly consume dry and canned dog food.

Table 2.1 Food items fed to captive African giant rat

Type	English name	Scientific name
Tubers and underground stems	Yam	*Dioscorea spp*
	Cassava	*Manihot utilissima*
	Sweet potato	*Ipomoea batatas*
Fruits and grains	Rip and unripe mango	*Mangifera indica*
	Oil palm fruit	*Elaeis guinensis*
	Pineapple	*Ananas sativa*
	Maize	*Zea mays*
	Pawpaw	*Carica papaya*
	Avocado	*Persea Americana*
Legumes and nuts	Groundnut	*Arachis hypogaea*
	Palm kernel	
Leafy materials	Cabbage	*Brassica oleracea var. capitata*
	Carrot leaves and fruit	*Daucus carota subsp. Sativus*
	Guinea grass	*Panicum maximum*
	Elephant grass	*Pennisetum purpureum*
Others	Wheat bran	
	Bread	
	Kitchen leftover	

Source: Adu *et al*. (2017)

Table 2.2 Crude protein (CP) requirement of African giant rat, Rabbit, Guinea pig and Grasscutter from various literature.

Species	**Crude protein (CP)%**	**Source**
African giant rat (AGR)	14	Ajayi and Tewe, 1978
African giant rat (AGR)	20	Cooper, 2008
African giant rat (AGR)	27.8	Olawuwu *et al., 2020*
Grasscutter	18	Kusi *et al., 2012*
Rabbit	16	NRC, 1977
Rabbit	18	Sanchez, Cheeke & Patton 1985
Rabbit	15-18	Akande, 2015
Guinea pigs	18-20	Harknes *et al., 2002*

2.8 Diseases and Treatment of African Giant Rats

Parasitism has independently developed several times in a wide range of animal lineages. Observations on parasites that are not closely related have shown that several adaptations to parasitism have occurred, including modifications to physiology, morphology, and life cycle features. Ekeh and Ekechukwu (2009) found that the giant rat has been linked to parasites such as ectoparasites, endoparasites, and blood parasites. Due to their proximity to humans, these animals can potentially infect humans with viruses and act as a bridge between critical human illnesses and those that affect domestic and farm animals.

According to Cooper (2008), Giant rats are naturally infested with Hemimerus talpoides and may have ticks. The former is harmless and non-transmissible to other species, serving to eat dead skin and wax. Injection with one release% Ivomec® (ivermectin) (Aceta Pharma GmbH, Hamburg, Germany) at a dose of 200–400 µg/kg subcutaneously once a week for 3 weeks will eliminate ectoparasites (and many endoparasites). Studies have shown no adverse effects of ivermectin on pregnant rats (Peraira *et al.*, 2003). Topical liquid treatments with the active component ivermectin, such as Xenorelease 450 (Genitrix Ltd., Billingshurst, UK), may be beneficial when applied to the back of the neck. As a result, it functions as an endectocide to control mites, roundworms, and lice. Fenbendazole or piperazine can also be used to treat nematode infections (Cooper, 2008). Fenbendazole can be used to treat bladder threadworms, metronidazole to treat protozoa (but not in pregnant females), and praziquantel, niclosamide, or thiabendazole to treat cestodes. Pinworm infections in mice and rats may still be treated and eliminated with fenbendazole-medicated chow (Hill *et al*., 2006).

Studies using rats that were naturally infested with Syphacia muris and kept in forced-air, individually ventilated cages showed that ivermectin given orally at a dose of 2 mg/kg for 3 treatments at 7- or 9-day intervals resulted in eradication (Huerkamp, 1993).

When cages have sharp edges and unsanitary environments, abscesses could happen more frequently. Although there have been no confirmed reports in the UK, the African giant rat has been linked, along with two other imported African species, to the spread of the monkeypox virus in the Democratic Republic of the Congo (Hutin *et al.*, 2001), the United States (Hutson *et al*., 2007), and possibly the Caribbean (Cooper, 2006).

Other diseases/infections associated with the giant rat should be noted, as they could be transmissible to owners, especially if caught, tamed and reared from the wild. These include cestode infestations (Lacasse *et al*., 2005), nematodes (Diouf & Duratte-Desset, 2002), leptospira serovar infection (Machangu *et al.*, 2004), trypanosomiasis (Herder *et al.*, 2002), rickettsia (Julvez *et al.*, 1997), Leishmania tropica (Johnson *et al.*, 1993), Potiskum virus (Omilabu *et al.*, 1989), Ife virus (Ezeifeke *et al.*, 1987), coagulase-positive Staphylococci (Adegoka *et al.*, 1985) helminth infections (Ibrahim *et al.*, 1984) and coccidia (Ajayi & Tewe, 1978).

In a study by Ekeh and Ekechukwu (2009), they recovered 2503 intestinal parasites, with nematodes having the highest prevalence (87.4%) and cestodes having the second-highest prevalence (12.6%). There were no acanthocephalans found. Nippostrongulus braziliensis (65.9%) was the nematode with the highest prevalence, followed by Strongyloides ophidae (33.8%), while Capillaria columbae (0.32%) had the lowest prevalence. Only one species of Cestode, Hymenolepis diminuta (12.6%), was less prevalent.

Table 2.3 Gut parasitic fauna of the African giant rat (Cricetomys gambianus) in a semi-urban tropical community

Parasite species	**Number recovered**	**Prevalence**
Nematode	2186	87.41
Nippostrongylus braziliensis	1440	65.9
Strongyloides ophidae	739	33.8
Capillaria columbae	7	0.32
Cestode	315	12.6
Hymenolepis diminuta	315	12.6

Source: Ekeh and Ekechukwu, (2009)

2.9 Unorthodox uses of African giant rat.

Presumably, most people in rural areas only consider the AGR as a source of delicacy in their food; far from that, The African giant rat (Cricetomys gambianus) has emerged as a significant asset in the field of medicine due to its unique capabilities and characteristics. According to Cangel, 2014, the African Giant Pouched Rat *Cricetomys gambianus* has been trained to smell tuberculosis and land mines in some regions of Africa.

Additionally, the rat's use in disease research, particularly in cancer and diabetes, has provided valuable insights into these conditions. Furthermore, its cultural significance in traditional medicine practices in certain African cultures is also highlighted. Overall, the African giant rat has proven to be a versatile and valuable resource in the medical field. According to Kanaan *et al.* (2021), in the hope of developing a viable alternative to or adjunct to microscopy, APOPO is exploring the use of African giant pouched rats (Cricetomys gambianus) to detect the presence of TB. These large and long-lived rats, which are native to much of Africa and have an excellent sense of smell, detect TB by sniffing sputum samples. They are trained to respond consistently in one way (pause) if the sample contains the TB bacillus (is positive) and respond in another way (not pause) if the sample does not contain the bacillus (i.e., is negative). Each rat can test hundreds of samples daily, allowing inexpensive testing Georgies *et al.* (2018).

Giant African pouched rats recently have been used as mine-detection animals in Mozambique. To provide an example of the wide range of problems to which operant conditioning procedures can be applied and to illustrate the common challenges often faced in applying those procedures, (Poling *et al.*,2010; Poling *et al.*,2011). To Cooper (2008),

African giant rats' unique physiology and genetic makeup have rendered them valuable subjects for disease research, particularly in studying conditions such as cancer and diabetes. Their use in research has provided valuable insights into the pathophysiology of these diseases, contributing to the development of potential treatments and therapeutic interventions.

2.10 Docility of Rodents

Dramani, 2018, defined docility as the differences between individual animals in their behavioural response to alarming or challenging situations where individuals are often consistent in how they respond when the challenge is repeated. In situations involving human interactions, such as handling or moving animals, these differences in animal behaviour are of particular importance to humans. Some animals are calm and docile, while others are distressed and struggle to escape (Haskell *et al.,* 2014). Haskell *et al*. (2014), observed coherence of responses in the animal and varying effects between animals or groups of animals, which have traditionally been identified by a wide variety of labels depending on whether users are from psychology, agricultural livestock, or behavioural ecology backgrounds. It is called an animal temperament or a docility in animal science. Temperament has been widely used in animal husbandry since the 1960s (Tulloh, 1961; Burrow, 1997). Intense selection for increased animal production is suspected to have led to increased problems with temperament, including increased aggression in handling and increased excitement in response to restraint (Norris *et al.,* 2014). Aggressive behaviour or poor docility is considered a bad trait in farming operations, and animals with such a characteristic are usually culled (Kenttamies *et al.,* 2006). Researchers and farmers are thus increasingly paying attention to livestock reactions during handling and use these to

describe animal docility (Paranhos da Costa *et al*., 2002), especially with emerging evidence that docility is correlated with ease of handling and economically important traits. Docility occurs across all types of production environments. It includes maternal behaviour (Jarvis *et al*., 2005), aggressiveness (D'Eath *et al.*, 2002a), social behaviours (Lovendahl *et al.*, 2005), reactions to humans (Barozzo *et al.*, 2012), feeding behaviours, daily activities and handling responses to new objects or situations (Yoder, 2010). The recent changes in animal husbandry practices that reduce labour and increase herd size tend to result in less human contact, likely to have led to an increased tendency of poor animal behaviour (Holl *et al*., 2010). Animals perceive handling as stressful because they cannot familiarise themselves with humans (Brouček *et al.*, 2008). According to Norris *et al*., 2014, animal behaviour or temperament is an essential trait in livestock as it affects not only man's safety and the welfare of animals but also their productivity at the farm level. In livestock, low performance, health and carcass quality have been linked to a lack of good temperament. Docility is thus increasingly becoming a focus of many studies aiming at its inclusion in animal breeding programs. Most studies on docility and its relationship with production showed that the trait has moderate to large additive genetic variation, which could be exploited in breeding programs (Norris *et al.*, 2014). Docility could be an indicator of economically important traits that are difficult to measure.

In many new and challenging situations, such as interactions with other animals or entering a new field or pen, fear or excitement may be expressed by animals. Still, it is mainly during handling that this characteristic becomes a problem. There are many ways in which a frightened response to handling can manifest itself. The animals may struggle, show

agitated movements, try to escape, vocalise, show increased respiration rates, defaecate, show changes in their ears, head and tail positions, and facial expressions, and be more or less motivated to move away from the handling area or handler (Haskell *et al.*, 2014). The challenge is to find a scale or measure that adequately represents these varied responses.

2.10.1 Importance of Temperament in Animal Husbandry

Animal behaviour, including measures of docility, is important to livestock producers from a human safety perspective and due to potential correlations to economically relevant traits. It is important to consider temperament traits, such as fear or aggression, which affect how the animal responds to the conditions of husbandry and handling on the farm and to the transport procedures. The interaction between stock people and animals is common in commercial farming systems. Previous research on various livestock species has demonstrated that these interactions can significantly impact the productivity and welfare of the animals (Hemsworth, 2003). Routine behaviours such as daily inspection, handling, and movement of animals within the farm, which may seem harmless to stock people, can lead to animals developing a high level of fear towards humans. This fear can hinder animal production and welfare, as fearful animals may sustain injuries while trying to avoid humans during routine activities. Studies in the dairy, egg, and pig industries have shown negative associations between fear of humans and productivity. In contrast, gentle handling has been identified as a potential method to reduce the fear of humans in a wide range of species. For example, in chickens, birds that were gently handled, spoken to, and offered food were calmer than those that were stressed (by being shouted at) or ignored (Jones & Waddington, 1992).

Farm animals are subjected to daily handling and management by caregivers, such as feeding, cleaning, medication and other husbandry practices. A negative behavioural response to handling and management procedures can significantly affect productivity. More temperamental animals have poorer growth performance, carcass characteristics, and immune responses. According to Cooke *et al.,* 2009 animals with bad temperaments altered their metabolism and breakdown of nutrients to compensate for a behavioural stress response, resulting in a further reduced availability of nutrients supporting the body's functions. The hormonal mechanisms regulating the reproductive process in women, including ovulation, conception, and pregnancy, are directly disturbed by hormone production that occurs when responding to stress, primarily cortisol. In support of this, Breuer *et al*. (2000) indicated that temperament can affect virtually all aspects of production, such as growth, reproduction, immunity, meat quality, and milk yield. Docility is linked to fitness (Réale *et al.,* 2000, 2009), while it also influences the productivity of livestock farming enterprises (Norris *et al.,* 2014). For instance, fearful cows produce lighter calves at birth that grow less well than those produced by non-fearful (i.e. docile) cows (Turner *et al*., 2013).

2.10.2 Effect of sex on docility

According to Dramani *et al. (*2018), The effect of sex as a factor on temperament is debatable. The effect of sex on temperament ratings is influenced by using several cattle breeds, with females having a better score than males. Voisinet *et al.,* 1997; Another study from Burrow, 1997 and Voisinet *et al*., 1997, also suggests that males are calmer compared to females. However, the effects of sex on velocity exit were not observed in studies carried out by Burdick *et al.* 2009 and Burdick *et al.* (2011). In another work by Dramani *et al.*

(2018) they observed that, sex did not significantly influence docility in Guinea fowls. Similar findings were also reported by Annor *et al*. (2011), who recorded no significant influence of sex on the docility of grasscutter. A significant effect of sex on temperament has been reported in some studies. Research studies have consistently shown that female cattle, specifically heifers, exhibit higher levels of excitability and are more challenging to manage than their male counterparts, known as steers. This is supported by various scientific sources, including studies conducted by Stricklin *et al.* (1984), Voisinet *et al.* (1997 a,b), Lanier *et al.* (2000), and Gauly *et al.* (2001). These results clearly show that, although females may show higher phenotypic and genetic variability for specific traits, animal temperament traits can be considered to be governed by the same pool of genes between sexes.

2.10.3 Effect of Age on Docility

The effect of age on docility in animals can vary depending on the species and individual characteristics. Younger animals may be more skittish and less accustomed to human interaction, making them less docile than older animals. However, with proper socialisation and gentle handling, younger animals can be trained to be more docile over time. According to Alvarenga *et al*., (2023), young calves, such as weaned at a young age, usually show a fear of handling due to the novelty of handling, coupled with increased exposure to a variety of potential stressors, including breaking the bond between dam calves, changing the diet, and regrouping with unfamiliar animals.

Additionally, research has indicated that the more often animals are handled or interacted with by humans, the lower their average temperament score becomes, as long as the handler approaches them calmly (Parham *et al.,* 2019; Alvarenga *et al.*, 2022). In other words, one

would expect the average temperament to decrease (animals become more docile) as the age increases. On the contrary, Alvarenga *et al.,* 2023 observed an opposite behavioural pattern in cattle. They reported that the average temperament scores slightly increased as the animals aged, suggesting a sensitisation across the years instead of habituation. In short, habituation can be defined as decreased responsiveness to a stimulus, while sensitisation is increased responsiveness to a stimulus. Habituation is often associated with adaptation.

2.10.4 Estimation of docility

The average docility score in prior tests with other animals was 2.6, as measured in a study on cage-reared grasscutters in a tropical climate, where the evaluation was based on a four-point scale (i.e., 1–4). The non-docile grasscutters (score 4) panic when people approach and try to escape their cages or pens, in contrast to the docile (scoring 1) animals, who adapt well to life in confinement and get acclimated to man rapidly (Annor *et al.,* 2011). To measure docility accurately, the techniques are constantly being improved and refined, according to Norris *et al.,* 2014. The temper is measured using scores first developed in the 1960s. Both objective and subjective methods are used to assess the temperaments, Stricklin *et al.* 1984. Fordyce *et al*. (1982) developed a series of animal temperament tests to evaluate cattle, e.g., the flight range test, pen score, and rope scores. The flight speed test, more often referred to as exit velocity, was developed by Burrow *et al*. (1988) for a more effective assessment of bovine temperament. Exit velocity is an objective measure, while pen scores and chutes are subjective according to nature (Dramani, 2018). However, Cooke & Bohner (2010b) stated that there are several methods for evaluating docility, ranging from simple visual observations to assessments that require computerised techniques; these methods can be divided into restrained, non-restrained, and phenotypic

evaluations. The most frequent animal temperament measurements are chute score, pen score, exit velocity, and heterophil/lymphocyte ratio.

As new measurements emerge, further physiological and performance associations with temperament have been established. Another reliable indicator of stress and docility is eye temperature, according to the latest study by Geburt *et al.* (2015) with German Simmental and Charolais heifers. They observed that the more stressed animals had been less docile and hard to deal with. In this way, Objective and Procedural methods have been used over the last few years. According to Duodu *et al*, (2020), both heterophile/lymphocyte ratio and cage scoring methods were used to measure docility in Guinea fowl. In the heterophile/ lymphocyte (H/L) method, blood was drawn from the experimental birds, and heterophil, lymphocyte count, and H/R ratios were recorded (Dramani, 2018), as reported by (Duodu *et al*, 2020).

2.11 Meat quality and carcass characteristics of African giant rat

One of the crucial elements affecting meat quality and customer acceptance is its nutritional content. The amounts of protein and lipids are the primary determinants of meat quality. Triglycerides are the primary lipids found in meat fat and phospholipids, cholesterol, and other lipids. The phospholipids component of meat fat is more stable than the triglycerides and cholesterol components (Adu *et al*., 2017). African giant rat meat has a lower cholesterol content (70 mg/100 g vs. 135 mg/100 g fresh weight) and a higher protein content (20-24.5% vs. 14-25%) than other meats like rabbit meat (Oyarekua & Ketiku, 2010; Adu *et al.,* 2017). Compared to beef, mutton, and chevon, it has a very high mineral content, much like rabbit meat (Table 2.4).

Table 2.4 Chemical composition of African giant rat meat compared to other meat types

Species	**AGR**	**Grasscutter**	**Rabbit**	**Chicken**	**Goat**	**Sheep**	**Pig**	**Cow**
Moisture (g/100 g)	65.8	67.0 – 71.2	67.9	67.6	76.6-78.6	55.8	64.8	55.0– 73.8
Energy (J/100 g)	1630	678 – 804	1749	1782	849	3124	1054	3168
Protein (g/100 g)	20-24.5	17.8 –18.3	14– 25	21.8	20.38	21.02	19.4	16.3
Lipids (g/100 g)	2.45-2.64	6.50 – 10.1	3.0 – 6.0	11.0	3.16	8.47	13.4	28.0
Cholesterol (mg/100 g)	70.2	48.5 – 53.4	135	76.0	94.0-100.3	78.2	70-73.1	58.9-68.6
Ash (g/100 g)	1.44	0.9	1.1	0.9-1.2	0.95-1.2	1.0	0.8	1.0
Iron (mg/100 g)	73	2.8	1.1-1.3	1.5	3.3	3.1	3.1	5.1
Calcium (mg/100 g)	55 -60	83.0	22.0	10.0	25.3	3.0	3.0	3.9
Phosphorus (mg/100 g)	750	111	222-230	150-180	57.8	80.0	73.0	57.0

g = grams, mg = milligram, AGR= African giant rat

Source: Adu *et al.,* 2017; Ilesanmi & Jonathan, 2018 and Oyarek & Ketiku, 2010

2.12 Morphological traits

Morphology deals with the size, shape, and structure of an animal or one of its parts. Morphological characteristics or traits of animals are used to classify and identify species or breeds (Annor *et al.,* 2011). Morphological body measurements can be used as indicators of sexual dimorphism in animals (Durowaye *et al.,* 2021) and in predicting livestock's live weight. Farmers will still be able to estimate the approximate weight of their animals for any husbandry practice. They need the length using simple measuring tapes if they can't afford expensive or frequently purchased weighing scales. Several individual researchers have used linear body measurements to predict the live weight of several livestock species, including goats, sheep, cattle, rabbits, and pigs. According to (Brown *et al*. 1973; 1974) and as reported by Annor *et al*. (2011), body shape, measured objectively, could also improve the selection of growth by allowing breeders to identify early-maturing and late-maturing animals of different sizes. The coat colour, body length, height, girth, height at withers, heart, tail length, head length, tail type and hair type are important physical or morphological information that may be required to classify uncharacterised populations (Annor *et al*., 2011).

2.13 Phenotypic and genetic parameters

As an indication of phenotypic and genetic diversity, phenologic and genetic parameters will be used. These parameters are the mean, variance, standard deviations, coefficient of variation, gene correlation, trait repeatability, etc. (Annor *et al*., 2011). Correlation with phenotypic, genetic and environmental factors is required to determine selection index equations. Specifically, these parameters must be estimated before weighting factors for the selection index equations can be calculated (Annor *et al*, 2011). In determining

breeding values and calculating selection response, phenotypic and genetics are also important factors, according to (Harris *et al.,* 1984).

2.14 Variation in traits

To improve the performance of specific traits, animal breeding disciplines are primarily concerned with studying variability and changing the genetic condition of a given trait population. According to Annor 2018, the breeder will use a raw material known as variation, defined by Annor 2018 as an invisible or measurable difference between individual populations, to achieve this objective. Variations can be detected in terms of physical appearance, metabolism, fertility, reproduction method, behaviour, learning and mental capacity and other noticeable or measurable features (Duodu *et al.* 2020).

Phenotypic variation is considered genotypic and environmental, as described in the preceding description of variability. Genotypic variations are caused by differences in the number or orientation of chromosomes or by differences in the gene carried by the chromosome (Hallin *et al.,* 2018). Annor, 2018 asserted that variability amongst individuals in a population is usually caused by genetic differences and differences in non-genetic effects (environmental effects) such as management, nutrition, age and sex. Genetic variations, in that they allow for natural selection to increase or reduce allele frequency within the population, are an essential force of evolution, as outlined by Duodu *et al.* 2020. Genetic variation benefits a population by allowing some individuals to adapt to their environment and ensuring that the population continues to survive. More variation is likely to lead to variations in alleles that suit the environment for some population individuals. These individuals are at a higher risk of surviving, resulting in offspring that bear these

alleles. Animal breeders consider variation among animals as valuable and worthwhile to study and are interested in its use for selection (Duodu *et al.*, 2020).

There is little information on variation in African giant rat (AGR) traits. However, reports from other livestock species have indicated that traits related to natural fitness (reproduction and survival) have low genetic variations. In contrast, body weight and growth traits have medium to high genetic variations (Annor *et al.*, 2011). Moderate genetic variation has been reported in morphological traits and docility (Annor *et al.*, 2011).

2.14.1 Estimation of variance

The term variance refers to a statistical measurement of the spread between numbers in a data set. More specifically, variance measures how far each number in the set is from the mean (average) and, thus, from every other number in the set. Variance is often depicted by this symbol: σ^2. Variance is defined as the average squared deviation (Annor, 2018). According to Annor (2018), the difference between the observation and the mean of the observation is defined as a deviation. The difference can be positive, negative, or zero. Traits showing large variability (variance) levels are easy to improve upon.

The unit of variance is the square of the unit of measurement. Sample variance can be computed using the formula below:

$S^2 = \frac{\sum_{i=1}^{N} xi^2 - \frac{(\sum_{i=1}^{N} Xi)2}{N}}{N-1}$

$\sum_{i=1}^{N} Xi^2$ is known as the sum of squares.

$\frac{(\sum_{i=I}^{N} Xi)2}{N}$ is a correction term or correction factor.

N-1 is the degree of freedom.

2.14.2 Estimation of coefficient of variation

The coefficient of variation measures the variability of a series of numbers independently of the unit of measurement used for these numbers. To do so, the coefficient of variation eliminates the unit of measurement of the standard deviation of a series of numbers by dividing it by the mean of these numbers (Abdi, 2010). It represents the ratio of the standard deviation to the mean and is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different (Annor, 2018). The coefficient of variation can be used to compare distributions obtained with different units, such as, for example, the variability of the weights of newborns (measured in grams) with the size of adults (measured in centimetres).

Furthermore, it is worth noting that the population coefficient of variation γ is a pure number free from units of any measure. Using the coefficient of variation is an advantage since it allows direct comparisons between two populations in terms of their variability. It is sometimes a more informative quantity than variance (σ) (Ahmed, 2002). In several areas of the Brazilian agricultural survey, the classification of CV% has attracted attention (Vaz *et al.* 2017). The first proposal was made in 1985 by Gomes, who had greatly assisted and

established a comparison with other studies. According to Gomes (1985), CV% is classified as low (CV%<10%), medium (CV% between 10% and 20%), high (CV% between 20% and 30%), and very high (CV%>30%). In their 2002 study on the CV% of grasses, Clement & Muniz determined that a standard classification has an unclear interpretation for different types of variables. The CV% should, therefore, be given a special classification for each of these factors or areas of interest. Costa *et al*. (2002) categorised CV: CV% ≤ Mdcv - PSCV rated "low"; Mdcv - PScv < CV% ≤ Mdcv + PScv rated "medium"; CV% > Mdcv + PScv rated "high", where Mdcv is the sampling median of the coefficient of variation and PScv is the pseudo-sigma of the coefficient of variation. The pseudo-sigma, by Costa *et al.* (2002), follows: PS = (Q3-Q1)/1,35, where Q3 is the third quartile of sampling CV% and Q1 is the first quartile of sampling CV%. It is a more reliable methodology in the case of nonnormalities. To know whether a particular coefficient of variation is large or small requires experience (Annor, 2018)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and Duration of the Study

The study was conducted at the animal farm of the Department of Animal Science Education, Akenteng Appiah Menka University of Skills Training and Entrepreneurial Development, Mampong-Ashanti campus. The duration of the study was from February 2023 to August 2023. Mampong-Ashanti lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana along the Kumasi-Ejura road. Mampong lies on latitude 07^0 $03^{'}$ N and longitude 01^0 $24^{'}$W at an altitude of 289.7m above sea level. The dry season occurs from December to March (Meteorological Service Department, 2019). The vegetation in Mampong Ashanti is transitional savanna woodland, which is suitable for livestock rearing due to prevailing conducive rearing temperatures. The rainfall pattern is bimodal, with the major rainfall season occurring from April to July with 1000mm of rainfall, while the minor season occurs from August to November with 350mm of rainfall. The average daily temperature is between 25^0 C and 30^0 C and the average relative humidity of the area is 70% (MSD, 2019). Mampong Ashanti is suitable for rearing and producing African giant rats since most animal feed ingredients are readily available and cheap in this area.

3.2 Experimental animals and sources

The breeding stock for the study was purchased from various sources in the Ashanti and Greater Accra regions in 2022. The sources included Kodei, Asante Mampong, Ejura, and Kofiase in the Ashanti Region and Nungua in the Greater Accra Region of Ghana. The base population comprised 15 does and 15 bucks. Of these numbers, 10 were neonates, 10

were juvenile and 10 were adult. There were no pedigree records of animals. They were wild African giant rats that had been domesticated for some time. Some portion of the animals were also trapped in the bush.

3.2.1 Experimental design

A total of thirty (30) African giant rats comprising ten (10) adults, ten (10) juveniles and ten (10) neonates were tested for variations in growth parameters, docility and morphological traits in Randomised Complete Block Design (RCBD).

3.2.2 Animal trapping

Metal live box traps of various sizes and manufacturers were baited with peanuts, maize, and baked cake made from ground beans. Trapping occurred both in bushes and residential areas; since the AGRs are nocturnal animals, traps were set before dusk and checked at dawn; the traps were retrieved during the day to prevent captured animals from dying. The trap, capture, and handling methods utilised in the study were in accordance with the American Society of Mammalogists' guidelines (Gannon *et al.*, 2007).

3.3 Management of Animal

3.3.1 Housing

The giant rats were housed in pairs in three-tier wooden cages. Cages were also housed in concrete buildings roofed with corrugated iron sheets. Individual cage measured 60 cm X 50 cm X 40 cm.

Wooden cages were portioned by 2 mm diameter wire mesh. The sides and floor of the wooden cages were covered with wire mesh. Galvanised wire mesh was also used to line

the exposed surfaces of wood to prevent animal gnawing. The roof of each wooden cage was slanted and lined with felt to aid in the cleaning and drainage of liquid from stacks above.

3.3.2 Feeding and watering

The African giant rats are omnivorous rodents, so they were fed with varying feedstuffs. Palm fruit, cassava, and maize were given to the animals at different percentages based on their body weight. In addition, leafy vegetables such as cabbage and carrot leaves were offered to the animals. Kitchen leftovers were also provided to the animals. In conclusion, all feedstuffs listed in Table 3.1 were offered to the animals. Water was given to them ad-lib. The animals' feed was supplemented with a concentrate containing 14% crude protein (Annor *et al*. 2011). The feed ingredient of the concentrate supplement is presented in Table 3.1.

Table 3.1 Composition of concentrate supplement

Feed Ingredient	**Percentage composition**
Maize	50
Wheat bran	37
Soyabean	9.0
Oyster shell	3.0
Salt	0.5
Vitamin premix	0.5

Source: Annor *et al*. (2011)

Concentrate was fed at 20-50 g/head/day, depending on the animal's size. Water was offered *ad libitum.* Supplementary feed and water were provided in an earthen pot trough.

Plate3.1 Feed ingredient and feeding of AGR

3.3.3 Health Care

Cleaning of cages and African giant rats' houses was done daily. Feed and water troughs were cleaned daily as well. The animals were constantly monitored for abnormal behaviour or ill health signs. Routine deworming was carried out using either dried pawpaw seeds or albendazole, 2.5%. De-worming was carried out regularly. Sick and animals showing ill health were isolated from the cages and treated.

3.3.4 Identification of the animals

Plastic ear tags were used to identify the animals. Each sex in each cage was given different shapes, distinguish between cages, and colours to distinguish between sexes. Age groups

were estimated by Ajayi (1975) and Olude *et al.* (2016) (Neonates: 0–70g; Juveniles: >70g but less than 500g; Adults: > 500g).

3.4 Parameters measured and methodology

3.4.1 Body weight and weight gain assessment methodology

Live weight measurements were taken from each of the thirty AGRs when brought into the experimental house using a weighing balance (50 kg x 200 ModeI 250, Salter, England) and empty metal cages. The difference between the weight of an empty metal cage and that of the same cage containing each AGR was recorded as the LW of the AGR. LWs of pregnant females were not included in the data obtained. The weight of the AGRs was taken using the same approach every two weeks for six months, during which the experiment lasted. The weight measured at the end of the previous week was deducted from that of the current week to obtain the weight gained.

3.4.2 Docility Assessment Methodology

During the behavioural docility test, the researcher evaluated the AGR's ability to tolerate human presence, new objects, human interactions, and handling. The resulting score, as shown in Table 3.3, was measured on a scale of 1 to 4, as documented by Annor *et al*. (2011), Dramani (2018), and Duodu *et al.* (2020). The study lasted for five weeks, during which the docility test was conducted twice a week with a five-day break between each test. All AGRs, regardless of sex or initial weight, underwent the docility test one month after arrival. To evaluate the rats' temperament, they were subjected to a range of tests, including the novel object, human presence, handling, and touch tests (as outlined in Table

3.2). The tests were conducted systematically by the same individual, each following immediately after the other at brief intervals while the AGRs remained in their cages.

Table 3.2 Description of the test methods used to assess the temperament of the African Giant Rat

Test	Description	Test Objective
Human presence/Moving person Test (HPT)	A person walks up very close to the cage	To ascertain the AGR's reaction to a moving person and/ or human presence
Touch/Contact Test (CT)	A person tries to make a physical contact with the rat	To test the capability of the rat to accept a person making contact or touching
Novel Object Test (NOT)	A person throws a novel object (Red ball) in the cage of the rat	To test the ability of the rat to react to an unknown (novel) object
Handling Test (HT)	A person physically handles the rat for 5 seconds	To test the ability of the rat to accept handling

3.4.2.1 Behavioural Docility Test

Throughout the evaluation process, each AGR was assigned a docility score (DS) based on a subjective assessment by two evaluators utilising a 4-point scale defined by Annor *et al.* (2011), with certain modifications as detailed in Table 3.3. The DS was determined by averaging the scores provided by both evaluators for each point in time. Eight tests were conducted on each AGR to obtain the average docility score for the period. The resulting average docility score from the eight individual tests conducted on each animal was subsequently utilised in the analysis. The scoring system relied on various measures of

behavioural components, which indicated the level of resistance exhibited by African giant rats during the behavioural test (refer to Table 3.3 for additional information). These assessments were conducted by experienced evaluators who remained consistent throughout each behavioural test.

Table 3.3 Docility Scoring codes and descriptions representing the behavioural traits of the AGR.

Scale/ Score	Code	Test	Reactions (behaviour) of AGR
1	Docile	✓ HPT	□ The AGR does not react to an observer. □ Allow the observer to approach. □ The AGR maintains its proximity
		✓ NOT	□ AGR is quiet, calm, and moves way slowly
		✓ CT	□ Undisturbed and stands or moves slowly
		✓ HT	□ Allow to be picked up and handled easily.
2	Flighty	✓ HPT	□ Aware of an observer, the AGR stands away from the observer in a corner
		✓ NOT	□ The AGR runs/moves away from the object.
		✓ CT	□ Constant and moderate movements
		✓ HT	□ Tries to escape. Struggles a little and stop
3	Restless	✓ HPT	□ Frighten and move away on sighting an observer and persistently looking for escape holes along the cage. The AGR hardly stands at one point.
		✓ NOT	□ The AGR runs/moves away from the object, continuously moving in the cage during the time of assessment.
		✓ CT	□ The AGR jumps and makes sharp cry(ies)
		✓ HT	□ While in hand, struggles and tries biting you.
4	Aggressive	✓ HPT	□ The AGR begins to move vigorously and continuously along the cage and attempts to escape, sometimes with a sharp cry
		✓ NOT	□ AGR jumps and raises its feet off the cage floor and makes a persistent noise
		✓ CT	□ It is difficult to touch the AGR.
		✓ HT	□ Can't touch the animal or bite you while holding it

HPT – Human Presence Test, NOT – Novel Object Test, CT – Contact/Touch Test, HT – Handling Test

3.4.3 Morphometric characteristics

Data on the morphological characteristics of 30 animals (15 females and 15 males) was also obtained. The animals were reared from the day of captivity until 6 months under captivity. Body weights and linear body measurements on the animals were recorded at the beginning of the experiment and every 2 weeks until the 6 months under captivity. The following morphological traits were measured in centimeters (cm) with a tape measure:

Body length (BL): Distance from the tip of the nose to the tip of the tail.

Height-at-withers (HW): Distance from the surface of a platform (Table top) to the withers

Heart girth (HG): Circumference of chest

Tail length (TL): Distance from the base of the tail to the tip

Head length (HL): Distance from the tip of the nose to the level of the 7^{th} cervical vertebrae.

In comparing the body morphometrics among the age groups, the gains, i.e., the difference between two successive measurements, were used in the comparison rather than the actual values used in the comparison among the sexes. The difference between two consecutive measurements of morphological traits was used in the analysis; for example, the difference between body length in the first and second months was used. This was done to ascertain how the various age groups increase in the morphological traits considered in this study.

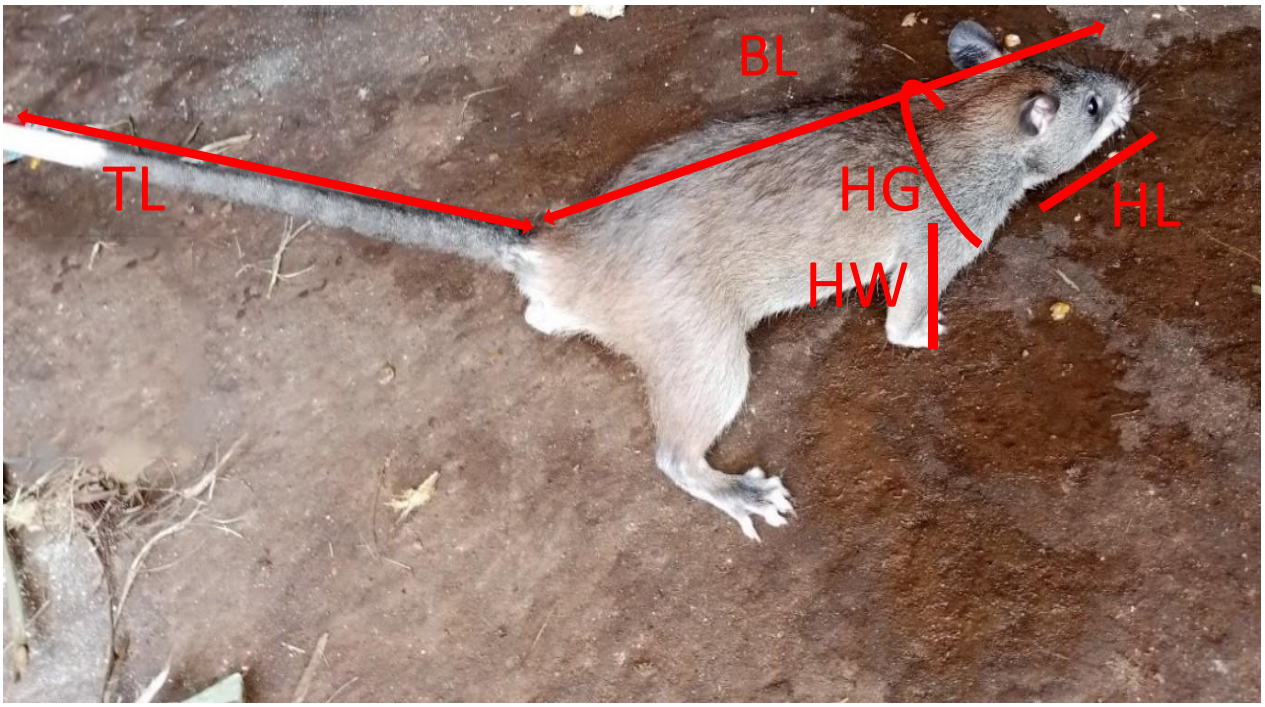

Plate 3.2: illustration of linear body measurement

3.4.4 Carcass Characteristics Assessment

Twenty (20) AGRs comprising ten males and ten females were sampled for the carcass analysis. Before slaughtering, the AGRs were starved overnight but had free access to water. To minimise pain, farmed African giant rats were stunned with a captive bolt pistol (Matador SS3000, Termet, France) before slaughter, followed by a ventral neck incision with a sharp knife (GIESSER, Germany). Giant rats were sacrifised using the scalding method as previously described (Omole *et al.*, 2005). Briefly, the rats were sacrified and allowed to bleed for about 5 min before further processing. The furs of the slaughtered giant rats were removed using a scalding method (dipped in hot water and scraped with a knife). The giant rats were eviscerated, and samples were taken to the laboratory for further processing. After slaughtering, carcasses were gutted and weighed. The following carcass parameters were studied: Live weight, slaughter weight, fore legs weight, hind legs weight,

liver weight, heart weight, kidney weight, head weight, chemical composition, pH, and sensory analysis.

3.4.4.1 Proximate analysis of African giant rat

A sample of the fresh meat from each animal was sent to the biological lab of AAMUSTED for proximate analysis to determine the meat's ash, crude protein, fat, and moisture content. Moisture, fat, and ash contents were determined using the AOAC (2000) methods.

3.4.4.1.1 Moisture content determination

Moisture content was determined using official methods of the Association of Official Analytical Chemists (1990). Ten (10 g) of African giant rat samples were oven-dried (Wagtech®, UK) at 105˚C till constant weight. The percentage of moisture content was calculated as:

$$Percent\ Moisture = \frac{(\text{Weight of sample } - \text{Weight of dried sample})}{\text{Weight of sample}}\ x\ 100$$

3.4.4.1.2 Crude fat determination

Two grams (2.0 g) of African giant rat thigh meat samples were used to determine crude fat based on the Soxhlet Extraction Method of AOAC (1990). The fat obtained was cooled in a desiccator, weighed and expressed as a percentage of the initial weight of the sample using the formula:

$$\%\ Crude\ Fat = \frac{\text{Weight of fat residue}}{\text{Weight of sample}}\ x\ 100$$

3.4.4.1.3 Ash determination

A 10.0 g of African giant rat thigh meat samples were placed in a drying oven at 105 °C for 24 hours. After cooling, triplicate 2.0 g samples were put in a muffle furnace (Ceramic Fibre Muffle Furnace, China) and the temperature increased gradually to 550 ± 5 ℃ for at least 8 hours until constant weight was obtained. Ash content was determined as follows:

$$\text{Ash } \% = \frac{\text{Weight of Ash}}{\text{Weight of African giant rat meat Sample}}\ x\ 100$$

3.4.4.1.4 Protein determination.

The method described by the Association of Official Analytical Chemists (AOAC, 1990) and using an Automatic Kjeldahl Protein Analyser (BIOBASE®, China) was used to determine the total nitrogen amount in triplicate samples. Two grams (2 g) of African giant rat thigh meat was used to determine the percentage of total nitrogen in samples. A nitrogen-to-protein conversion factor of 6.25 was used to estimate protein in African giant rat thigh meat samples. % Crude Protein = % Nitrogen x 6.25.

3.4.4.2 pH Determination.

The pH measurement of the animal's carcass was taken 45 minutes after slaughtering, according to Zuber *et al.* (2021). A portable Hanna pH meter (Hanna Instruments, Woonsocket, RI) was used to measure the pH level in the quadriceps femoris of the thigh. To ensure accuracy, the pH meter was calibrated using pH 4 and pH 7 buffer solutions, which helped maintain the pH level within the range of pH 4 and 7 ± 0.05.

3.4.4.3 Sensory evaluation of the meat

The process of assessing the sensory properties of the African giant rat meat was derived from Teye *et al.* (2020) methodology with minor adjustments. The panellists' preliminary screening involved a duo-trio test to gauge their taste sensitivity. Following this stage, a group of fifteen participants, comprising AAMUSTED faculty staff and students, were selected from the preliminary screening and trained according to the 1993 guidelines of the British Standard Institution for rating meat products. The meat products were sliced into uniform sizes of 2 cm × 2 cm × 2 cm and wrapped in aluminium foil with random three-digit numbers. To ensure that the panellists' results were not influenced by one another, they were positioned in different areas of the laboratory. Moreover, the panellists were given water and bread as neutralisers while tasting the items. The samples were evaluated for colour, aroma intensity, tenderness, juiciness and overall acceptability.

A five-point category scale, as described by Teye *et al.* (2015) and Teye *et al*. (2020) with few modifications, was used to describe the products as follows:

Colour: very pale (1), pale (2), intermediate (3), dark (4), very dark (5)

Tenderness: very tough (1), tough (2), intermediate (3), tender (4), very tender (5)

Juiciness: very dry (1), dry (2), intermediate (3), juicy (4), very juicy (5)

Flavour intensity: very weak (1), weak (2), intermediate (3), strong (4), very strong (5)

Overall acceptability: dislike very much (1), dislike (2), intermediate (3), like (4), like very much (5)

3.5 Estimation of coefficient of variation of traits

The coefficient of variation of the traits was estimated using the formula;

CV= $\frac{\sigma}{\mu} \times 100,$ where

$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_1 - \bar{x})^2}{n-1}}$ is the standard deviation of the observation.

Xi = Value of the *ith* point in the data set

$\bar{x}$=The mean value of the data set

n=The number of data points in the data set

μ is the mean of the observation.

Plate 3.3 Weighing of some carcass characteristics

3.6 Data and Statistical Analysis

The data obtained from the growth parameters, morphological traits and docility were summarised and organised using MS Excel (2019). The effects of sex and age on docility scores, body weight, body weight gain, morphological traits, carcass and sensory traits were analysed using Generalized Linear Mixed Models (GLMM) with the GLIMMIX procedure of SAS (2008). Means were compared using the Fisher Least Significant Difference (lsd) test ($p < .05$). The model used for the analysis was;

$$Y_{ijklm} = \beta_0 + \beta 1S_i + \beta 2A_j + b_k + r_{klm} + \Sigma e_{ijklm}$$

Where:

Yij is the response variable (e.g., body weight, body weight gain, morphological traits, docility) of the *i*th rat at the *j*th time point

$\beta 0$ is the overall intercept,

$\beta 1$ is the fixed effect of sex, i= 1,2;

$\beta 2$ is the fixed effect of age, j= 1,2,3;

b_k is the random effect of the *k*-th individual rat (accounting for repeated measures within individuals),

r_{klm} is the random effect of the *l*-th replicate nested within the *k*-th individual and the *m*-th block,

Σ_{eijklm} is the random error term.

CHAPTER FOUR

4.0 RESULTS

4.1 Effect of sex and age on body weight and body weight gain of African giant rat

Table 4.1 shows the effect of sex on body weight and CV in percentage representing the spread of data of African giant rats under captivity for 1, 60, and 165 days.

Table 4.1 Least square means and Coefficient of variation of body weight and body weight gain of AGR

Age group	NO	Body weight (g)	CV%	Body weight gain/d (g)	CV%
1-day UC neonate	10	22.78[c]	5.35	4.92[a]	0.50
1-day UC juvenile	10	358.31[b]	2.18	4.09[b]	3.19
1-day UC adult	10	667.51[a]	1.73	3.62[c]	1.54
SED		4.559		0.649	
P – value of 1 day UC		*<.001*		*<.001*	
60-days UC neonate	10	318.39[c]	41.97	5.67[a]	9.38
60-day UC juvenile	10	603.72[b]	14.20	4.57[b]	4.31
60-day UC adult	10	879.76[a]	7.75	3.60[c]	7.60
SED		4.941		0.775	
P – value of 60 day UC		*<.001*		*<.001*	
165-days UC neonate	10	913.56[c]	26.51	5.10[a]	4.40
165-days UC juvenile	10	1083.83[b]	15.94	3.80[b]	2.67
165- days UC adult	10	1258.58[a]	9.82	2.34[c]	1.32
SED		4.618		0.612	
P – value of 165 day UC		*<.001*		*<.001*	
Sex group					
1-day UC male	15	384.90	73.59	4.12	14.02
1-day UC female	15	346.80	75.39	4.17	13.33
SED		121.90		0.101	
P – value of 1- day UC		*0.758*		*0.831*	
60-days UC male	15	632.50	39.13	4.52	15.83
60-days UC female	15	597.20	38.03	4.60	13.84
SED		106.20		0.204	
P – value of 60- day UC		*0.743*		*0.835*	
165-days UC male	15	1106	13.76	4.13	27.72
165-days UC female	15	1081	12.09	4.03	24.23
SED		65.30		0.214	
P – value of 165- day UC		*0.708*		*0.707*	

UC = under captivity. NO =Number of animals, cm= centimetre, CV= Coefficient of variation, P Value = Probability value of test of main effects. [ab] Subclass means having superscripts in common are not different.at P<0.05. g= grams, SED= Standard error of difference.

Table 4.1 shows that the body weight of the adult African giant rat was significantly ($p < 0.05$) higher on day 1, 60, and 165 under captivity, followed by juvenile and then neonate. The results also showed that age had a significant ($P < 0.05$) effect on body weight in the AGR from day 1 to day 165 under captivity. No significant differences ($p \geq 0.05$) among the sexes regarding body weight were observed in the present study. Table 4.1 shows that although the body weights of the males were higher throughout the experimental period, they were not significantly ($p \geq 0.05$) different from the females. Similar findings were recorded in the body weight gain in terms of sex. There were no significant differences ($p \geq 0.05$) among the sexes in terms of body weight gain, however, Table 4.1 shows a significant difference ($p < 0.05$) among the age group in terms of body weight gain. Neonate recorded the highest body weight gain throughout the experimental period, followed by the juvenile age group, which was also a significant different ($p < 0.0.05$) from the adult age group. Table 4.1 shows that all age groups recorded low CV values for both body weight and body weight gain on day 1 of captivity; however, the CV values increased to moderate to high values on day 60 of captivity. Neonate recorded a CV value of 41.97 % in terms of body weight, followed by 14.20 % for juveniles and 7.75 % for adults. Although the CV values increased for the body weight gain for all age groups, they were still low throughout the experimental period.

The coefficient of variation values in percentages was very high for both males (73.59 %) and females (75.39) for day 1 under captivity; however, the CV values reduced to moderate values of 39.13 % and 38.03 % for males and females, respectively, for day 60 under captivity. The CV values were further reduced to low values of 13.76 % and 12.09 % for

males and females respectively for day 165 under captivity for body weight but the CV values for the sex group were low to moderate for body weight gain

4.2 Docility Result

4.2.1 The Frequency and Proportions of Observations of the Fixed Factors

Table 4.2 presents the distribution of sex and age categories within the population of experimental African giant rats. Most observed African giant rats exhibited flighty behaviour, while those with docile behaviour were in the minority. The population consisted of three age groups: neonatal, juvenile, and adult, each with equal representation.

Table 4.2A Proportions of the observations for sex and age group on the Docility status of the African Giant rats

Criterion	Category	Number of observations	Percentage(%)
Docility status	Docile	7	5.83
	Flighty	54	45.00
	Restless	51	42.50
	Aggressive	8	6.67
	Total	120	100
Sex	Female	60	50
	Male	60	50
	Total	120	100
Age group	Neonate	40	33.33
	Juvenile	40	33.33
	Adult	40	33.33
	Total	120	100

Out of the 120, there were equal observations recorded on both males and females. Moreover, the majority of the AGRs (45.5%) showed flighty behaviour, which was slightly higher than the AGRs which exhibited aggressive behaviour (42.2%), as indicated in Table 4.2A. Based on the findings above, it was inferred that flighty behaviour is the most prevalent trait of docility among the African giant rat population, contrary to the prevailing belief that they are predominantly aggressive when in captivity.

Table 4.2B Means and Coefficient of Variation for the Effects of Age Group and Sex on Docility on weekly basis

Variable	Weekly docility scores												
	NO	**WK 1**	**CV %**	**WK 2**	**CV %**	**WK 3**	**CV %**	**WK 4**	**CV %**	**WK 5**	**CV %**	**Avg**	**CV %**
Sex group													
Male	15	2.83	11.19	2.64[a]	16.76	2.55[a]	12.57	2.37[a]	6.86	2.21[a]	11.46	2.52[a]	8.07
Female	15	2.98	8.08	2.81[b]	10.99	2.73[b]	8.83	2.61[b]	10.06	2.51[b]	20.41	2.73[b]	6.85
SED		0.147		0.172		0.132		0.089		0.145		0.095	
P - value		*0.062*		*<.001*		*<.001*		*0.003*		*<.001*		*<.001*	
Age group													
Neonate	10	2.94	*12.82*	2.56[a]	19.31	2.22[a]	6.67	2.05[a]	17.22	1.94[a]	27.73	2.34[a]	16.72
Juvenile	10	2.99	9.21	2.74[b]	7.83	2.59[b]	11.16	2.50[b]	6.53	2.41[b]	7.24	2.65[b]	8.36
Adult	10	3.10	8.46	2.91[b]	9.81	2.81	10.71	2.68[b]	2.65	2.56[b]	11.14	2.81[b]	8.52
SED		0.197		0.210		0.159		0.164		0.155		0.139	
P - value		*0.683*		*0.002*		*<.001*		*0.005*		*<.001*		*<.001*	

NO =Number of animals, cm = centimetre, CV= Coefficient of variation, P Value = Probability value of test of main effects. [ab] *Subclass means having superscripts in common are not different.at P<0.05. WK= Weeks, SED= Standard error of difference, AVG= Average*

4.2.2 Effect of Sex on Docility

Sex significantly ($p < 0.05$) influenced the docility of the African giant rat from the second week to the end of the experimental period and on the average docility score. Table 4.2B shows that Docility was not significantly influenced ($p \geq 0.05$) by sex in the first week as both male and female African giant rats recorded restless docility scores of 2.83 and 2.93 for males and females, respectively, on the 1 – 4-point scale on docility (Table 3.2). Table 4.2B shows a significant difference between docility among the sexes of African giant Rats as docility scores of the males were significantly ($p < 0.05$) lower than that of the females. The males recorded a flighty docility score of 2.64 as against a restless docility score of 2.81 by the females in the 2nd week.

Table 4.2B shows that the docility score kept improving and decreasing until it reaches 2.21 for males and 2.51 for females in the last week of the docility study. The table further shows that on average, the males recorded a docility score of 2.52, which is flighty, and the females recorded a docility score of 2.73, which is restless according to the 1 – 4 point scale on docility (Table 3.2). Males recorded a low CV value ranging from 6.86 % to 16.76 % throughout the experimental period, which is not different from females, who also recorded a low CV value ranging from 8.08 % to 20.41 %. On average, the CV values recorded by the African giant rats were 6.85 % and 8.07 % for females and males, respectively, which is low.

4.2.3 Effect of Age Group on Docility

Age group significantly ($p < 0.05$) influenced the docility of the African giant rat from the second week to the end of the experimental period and, on average, docility score, similar

to what happened in the sexes. Table 4.2B indicates that age did not significantly impact docility during the initial week of the study. African giant rats in the neonatal, juvenile, and adult age groups all had similarly high docility scores of 2.94, 2.99, and 3.10, respectively, on a 1-4 point scale. (See Table 3.2). The docility score for the neonatal age group was significantly ($p < 0.05$) lower than the juvenile and adult age group however, there was no significant difference ($p \geq 0.05$) between the docility score of the juvenile and the adult age group in the 2nd week.

Table 4.2B shows that the docility score keeps improving and decreasing until it reaches 1.94 for the neonatal age group, 2.41 for the juvenile age group and 2.56 for the adult age group in the last week of the docility study. On average, the neonatal, juvenile, and adult age groups recorded docility scores of 2.34, 2.64, and 2.81, respectively, falling within the flighty to restless category on the 1-4 point docility scale (Table 3.2). African giant rats in the neonatal age group recorded a CV value ranging from low to moderate values of 6.67 % - 27.73 %, which was quite different from low CV values recorded by the juvenile age group of 6.53 % -11.16 % and 2.65 % - 11.11 % for the adult age group. On average, the coefficients of variation of the neonatal age group were 16.77 %, 8.36 % for the juvenile age group, and 8.52 for the adult age group.

4.3 Morphological traits

4.3.1 Effect of sex on morphological traits

Table 4.3A shows the effect of sex on morphological traits and CV in percentage representing the spread of data of African giant rats under captivity for 1, 30, 60, 90 and 120 days.

Table 4.3A Means and coefficient of variations for linear body measurement for AGR among sexes

Sex group	NO	BL (cm)	CV (%)	TL (cm)	CV (%)	HL (cm)	CV (%)	HG (cm)	CV (%)	HW (cm)	CV (%)
1 day UC											
Male	15	61.11[a]	9.47	28.81	5.67	4.95	8.04	10.01	7.89	5.60	7.90
Female	15	55.63[b]	6.33	27.39	5.43	4.93	11.07	9.97	7.52	5.54	3.42
SED		2.141		0.748		0.214		0.344		0.154	
P- Value		*0.020*		*0.074*		*0.926*		*0.909*		*0.700*	
30 days UC											
Male	15	63.68[a]	9.22	30.67[a]	4.78	5.31	7.02	11.11	7.12	6.53	8.45
Female	15	57.75[b]	6.46	28.91[b]	5.07	5.20	11.21	10.99	5.37	6.42	4.14
SED		2.200		0.700		0.219		0.313		0.194	
P- Value		*0.015*		*0.022*		*0.621*		*0.984*		*0.580*	
60 days UC											
Male	15	66.26[a]	9.34	31.91[a]	4.66	5.66	5.90	12.17	6.78	7.34	7.66
Female	15	59.86[b]	6.14	30.24[b]	4.66	5.51	11.20	12.09	4.83	7.20	3.47
SED		2.277		0.690		0.223		0.320		0.192	
P-Value		*0.012*		*0.026*		*0.597*		*0.805*		*0.480*	
90 days UC											
Male	15	68.35[a]	9.19	33.13[a]	5.17	6.01	5.03	13.20	6.22	7.94	7.79
Female	15	61.19[b]	6.04	31.59[b]	4.67	5.86	10.80	13.00	3.88	7.72	5.18
SED		2.340		0.759		0.222		0.303		0.230	
P-Value		*0.007*		*0.027*		*0.539*		*0.517*		*0.352*	
120 days UC											
Male	15	70.93[a]	8.69	34.54[a]	5.35	6.27	4.19	14.05	5.30	8.39	7.85
Female	15	64.06[b]	7.55	32.79[b]	4.57	6.10	9.46	13.85	3.84	8.15	4.85
SED		2.498		0.797		0.201		0.288		0.240	
P-Value		*0.005*		*0.041*		*0.413*		*0.496*		*0.330*	

NO= Number of animals, cm= centimetre, CV= Coefficient of variation, P Value = Probability value of test of main effects. [ab] *Subclass means having superscripts in common are not different.at P<0.05. Body length (BL); tail length (TL); head length (HL); heart girth (HG); height-at-withers (HW). UC= Under captivity, SED=Standard error of difference*

The result from Table 4.3A indicated that, apart from body length, which was significantly ($p < 0.05$) higher in males than in females, the other linear body measurements were not significantly ($p \geq 0.05$) different among sexes on the 1st day under captivity. The CV values recorded on the 1st day under captivity were generally low in both sexes and in all morphological traits. Table 4.3A shows that on the 1st day of captivity, males had slightly higher body measurements for all morphological traits than females but, there was no significant ($p > 0.05$) difference between the two sexes for all measurements except body length. However, in 30, 60, 90, and 120 days under captivity, males had significantly longer ($p < 0.05$) body and tail lengths ($p < 0.05$) than females. Other morphological traits such as head length, height at withers, and heart girth were not significantly influenced by sex throughout the experimental period. The coefficients of variations recorded by both sexes throughout the experimental period were relatively low for all morphological traits considered in this study, representing a low spread of morphological traits in African giant rats.

4.3.2 Effect of age on morphological traits

Table 4.3B shows the effect of sex on linear body measurement gains. The difference between two successive measurements of morphological traits was used in the analysis; for example, the difference between body length in the first and second months was used. This was done to ascertain how the various age group increases in the morphological traits considered in this study.

Table 4.3B Means and coefficient of variations for linear body measurement gains for AGR among Age group

Age group	No	BLG(cm)	CV%	TLG(cm)	CV%	HLG(cm)	CV%	HGG(cm)	CV%	HWG(cm)	CV%
1st month											
Neonate	10	3.95[a]	9.84	1.25[b]	25.17	0.90[a]	21.08	1.93[a]	4.22	1.37[a]	7.56
Juvenile	10	4.44[a]	11.47	2.27[a]	21.82	0.54[b]	41.99	0.64[b]	41.99	0.94[b]	30.53
Adult	10	3.24[b]	11.66	1.34[b]	26.10	0.61[b]	47.17	0.40[c]	21.88	1.04[b]	24.04
SED		0.237		0.219		0.071		0.098		0.128	
P-value		*<.001*		*<.001*		*<.001*		*<.001*		*0.013*	
2nd month											
Neonate	10	4.67[a]	14.42	1.78	28.90	1.21[a]	18.84	1.93[a]	2.67	1.32	7.30
Juvenile	10	3.56[b]	8.42	1.87	21.97	0.92[b]	35.68	0.78[b]	22.56	1.02	53.03
Adult	10	2.38[c]	28.46	1.32	34.69	0.84[b]	24.1	0.44[c]	17.77	1.01	23.88
SED		0.355		0.252		0.048		0.065		0.148	
P-value		*<.001*		*0.092*		*0.045*		*<.001*		*0.677*	
3rd month											
Neonate	10	6.85[a]	32.81	3.15[a]	19.09	1.31[a]	8.43	0.88[a]	4.62	1.21	6.20
Juvenile	10	5.48[b]	11.41	2.55[a]	18.87	0.65[b]	17.98	0.40[b]	38.19	1.20	57.40
Adult	10	3.94[c]	28.14	1.31[b]	48.01	0.44[c]	21.35	0.25[c]	30.60	1.21	17.98
SED		0.216		0.314		0.057		0.057		0.138	
P-value		*<.001*		*<.001*		*<.001*		*<.001*		*0.142*	
4th month											
Neonate	10	6.13[a]	20.86	2.83[a]	14.41	0.81	36.94	0.28[a]	34.70	1.23[a]	15.57
Juvenile	10	4.65[b]	10.44	2.51[a]	21.27	0.41	17.64	0.15[b]	50.07	0.93[b]	40.98
Adult	10	2.22[c]	30.55	0.25[b]	37.9	0.31	20.36	0.14[b]	37.42	0.91[b]	15.3
SED		0.164		0.216		0.079		0.042		0.096	
P-value		*<.001*		*<.001*		0.657		0.009		0.041	
5th month											
Neonate	10	4.45[a]	27.09	2.71[a]	2.88	0.43	35.2	0.20	36.21	0.97[a]	22.27
Juvenile	10	3.78[b]	14.11	2.18[b]	22.87	0.21	15.2	0.15	37.16	0.41[b]	33.7
Adult	10	0.71[c]	48.71	0.21[c]	51.23	0.21	7.23	0.27	40.2	0.31[b]	1.50
SED		0.222		0.170		0.053		0.055		0.049	
P-value		*<.001*		*<.001*		*0.071*		*0.130*		*<.001*	

NO=Number of animals, cm= centimetre, CV= Coefficient of variation, P Value = Probability value of test of main effects. [acb] Subclass means having superscripts in common are not different.at P<0.05. Body length gain (BLG); tail length gain (TLG); head length gain (HLG); heart girth gain (HGG); height-at-withers gain (HWG). UC = Under captivity, 1 M = gain in 1st Month under captivity,2M = gain in 2nd Month under captivity, etc. SED = Standard error of difference

Table 4.3B shows that age significantly influenced gains in all linear body measurements considered in this study in the first month. In terms of body length gain, neonatal and juvenile age groups were significantly ($p < 0.05$) higher than body length gain in the adult age group; however, the two were not significantly ($p \geq 0.05$) different from each other, although the gain in body length was higher in the juvenile age group. Head length gain (HLG), heart girth gain (HGG), and height at withers (HWG) were significantly ($p < 0.05$) higher in the neonatal age group than the other two groups, but, juvenile and adult age groups were not significantly ($p \geq 0.05$) different from each other relating to Head length gain (HLG), and height at withers (HWG) in the first month of the study.

The juvenile and adult age groups recorded moderate to high CV values, whereas the neonatal age group recorded low to moderate CV values in the first month of the study for the linear body measurement of the African giant rat. The highest CV value, which was 47.17%, was recorded by the adult age group in HLG, followed by a CV value of 41.99 by the juvenile age group for HWG in the 1st month of the study. Tail length gain (TLG) and HWG were not significantly ($p \geq 0.05$) influenced by age in the 2nd month of the study. The neonatal age group recorded a significantly ($p < 0.05$) higher body length gain than the juvenile, which was also significantly higher than the adult age group in the 2nd month of the study. Similarly, head length gain (HLG), and heart girth gain (HGG), were significantly ($p < 0.05$) higher in the neonatal age group, followed by the juvenile age group, which was also higher than the adult age group in HGG but was not significantly ($p \geq 0.05$) different in HLG in 2nd month. The juvenile and adult age groups exhibited moderate to high coefficient of variation (CV) values, while the neonatal age group

displayed low to moderate CV values during the second month of the study. Specifically, the juvenile age group in HWG recorded the highest CV value of 53.03 %, followed by a CV value of 35.68 % for the juvenile age group in HLG during the same period. Table 4.3B depicts that except for heart at withers gain (HWG), which was not significantly different among the age groups, the other morphological traits considered were influenced by age group in the third month. Linear body measurements were significantly ($p < 0.05$) higher in the neonatal age group, followed by the juvenile and adult. The peak coefficient of variation (CV) value for the morphological traits was observed in the third month of the study. Specifically, the juvenile group recorded a CV value of 57.40 % for HWG.

There was no significant ($p \geq 0.05$) influence of age on HLG in the 4th and 5th months and similarly for HGG, which was also not significantly ($p \geq 0.05$), influenced by age group in the 5th month. However, all other body measurements considered in this study were significantly ($p < 0.05$) influenced by sex in the 4th and 5th months of the study. The adult group recorded higher CV values in the 5^{th} month than the neonatal age group.

On average, the juvenile age group recorded the highest CV values for HWG and HGG, and the adult age group recorded the highest values for BLG and TLG.

4.4 Carcass Results

The effect of sex on carcass traits, organ weight, and proximate composition of African giant rats is presented in Table 4.4.

Table 4.4 Effect of sex on Carcass analysis and proximate analysis of African giant rat

Carcass Parameter	Male (g)	Female (g)	Male CV%	Female CV%	*SED*	*P- value*
NO	**10**	**10**				
Live weight	2227[a]	2215[b]	4.76	3.26	*60.88*	*0.008*
Slaughtered weight	2000	1900	4.08	49.33	*43.21*	*0.226*
Dressing weight	1321[a]	1293[b]	8.61	12.14	*21.32*	*0.004*
Dressing percentage	59.31	58.37	8.32	13.41	*0.041*	*0.074*
Forelegs	97.32[a] (7.37)	81.18[b] (6.26)	5.33	7.21	*3.496*	*0.002*
Hind legs	188.4[a] (14.26)	141.6[b] (10.95)	7.80	19.32	*13.88*	*0.010*
Head weight	80.68[a] (6.10)	65.19[b] (5.04)	7.88	14.30	*5.04*	*0.015*
Organs						
Kidney weight	5.38[a] (0.40)	4.56[b] (0.35)	8.86	8.24	*0.268*	*0.016*
Liver weight	28.71 (2.22)	31.12 (2.35)	10.15	2.51	*1.21*	*0.273*
Heart weight	4.78 (0.40)	5.40 (0.41)	16.92	11.78	*0.031*	*0.412*
Proximate composition						
Protein (%) /2 g	23.61[b]	24.81[a]	8.24	10.32	*0.064*	*0.041*
Fat (%)/2 g	6.68	6.11	8.23	14.21	*0.071*	*0.321*
Moisture (%) /2 g	62.41[a]	61.22[b]	14.32	9.31	*0.881*	*0.003*
Ash (%) /2 g	1.11[b]	1.51[a]	13.2	8.26	*0.041*	*0.031*

NO =Number of animals, CV Coefficient of variation, P Value = Probability value of test of main effects. [ab] Subclass means having superscripts in common are not different.at P<0.05. g= grams, Figures in the parenthesis indicate the percentage of dressed weight, SED= Standard error of difference.

4.4.1 Effect of sex on carcass characteristics of African giant rat

Table 4.4 shows that sex significantly ($p < 0.05$) influenced all the carcass traits considered in this study except for slaughtered weight and dressing percentage. Although slaughtered weight was not significantly ($p \geq 0.05$) influenced by sex, the females recorded the highest CV value of 49.33 %, while the males recorded a CV value of 4.08 %, which was the lowest for the males.

Males exhibited significantly ($p < 0.05$) higher dressing weight (1321 g) than females (1293 g). Additionally, the weight of forelegs, hindlegs, and head were significantly higher in males than females. The coefficient of variation (CV) values were generally low for males across all carcass traits, while females exhibited low to moderate CV values.

4.4.2 Effect of Sex on selected organ weight of African giant rat

The result from Table 4.4 shows that kidney weight was significantly influenced by sex. The kidney weight of the males was 5.38 g, which was significantly ($p < 0.05$) higher than the females with a kidney weight of 4.56 g. The liver weight of females was greater than that of males, but the difference was not statistically significant ($p \geq 0.05$). Sex did not significantly influence the heart weight of the African giant rat in this study. The coefficient of variation (CV) values for males ranged from 8.86 % to 16.99 %, while for females, the range was 2.51 % to 11.78 %, indicating slightly higher variability in males than females.

4.4.3 Effect of sex on Proximate composition of raw meat of African giant rat.

The fat content of the males (6.68 %) was higher than that of the females (6.11 %), but they weren't significantly ($p \geq 0.05$) different from each other. The data presented in Table 4.4 indicates that the protein content of the meat from female subjects (24.81 %) was

significantly higher ($p < 0.05$) than that of male subjects (23.61 %). A similar trend was observed for ash content, with the percentage of ash being significantly influenced by sex. Specifically, the ash content percentage of the females (1.51 %) was significantly higher ($p < 0.05$) than that of the males (1.11 %). In contrast, the moisture content of the meat was significantly ($p < 0.05$) higher in males (62.415 %) than in females (61.22 %). Additionally, the coefficient of variation (CV) values were low for both sexes, ranging from 8.24 % to 14.32 % for males and 8.26 % to 14.21 % for females.

4.5 Sensory traits and pH of the African giant rat meat

The sensory properties of the hind limbs of male and female African giant rats are presented in Table 4.5. It was observed that the hind limbs of both sex were highly rated across all sensory dimensions. The females exhibited a marginally higher mean colour score (3.67) in comparison to the males (3.60). Notably, tenderness emerged as the most highly rated attribute across gender groups, with male specimens achieving a score of 4.80 and females a slightly superior score of 4.87. This indicates a consensus on the meat's exceptional tenderness, albeit with minor variations between the genders. The scores for juiciness were closely matched, with males receiving an average score of 3.80 and females having a marginally higher score of 3.93. Similarly, aroma scores were proximate, with males scoring 3.93 and females scoring an even 4.00. Regarding overall acceptability, the meat received high ratings from both sexes, with males rated at 4.47 and females slightly lower at 4.40, suggesting high acceptance among consumers. The pH levels, indicative of the meat's slight acidity, showed no significant variation attributable to gender.

Furthermore, the recorded coefficient of variation values for sensory traits and pH levels in the African giant rats were notably low across both sexes. This implies a minimal degree of variability in the sensory attributes and pH levels of the meat among the studied subjects, thus suggesting a degree of homogeneity in these characteristics regardless of sex.

Table 4.5 Effect of sex on Mean sensory scores of processed African giant rat Thigh meat

Sensory trait	Boiled and grilled thigh meat				
	Male		Female		
	Mean	**CV%**	**Mean**	**CV%**	**SED**
Colour	3.60	4.56	3.67	3.64	0.081
Tenderness	4.80	4.19	4.87	4.82	0.064
Juiciness	3.80	7.04	3.93	3.05	0.123
Aroma intensity	3.93	4.56	4.00	5.73	0.246
Acceptability	4.47	14.07	4.40	12.86	0.077
Ph	5.70	2.28	5.64	1.59	0.067

CV= Coefficient of variation, SED= Standard error of difference.
Colour: *very pale (1), pale (2), intermediate (3), dark (4), very dark (5)*
Tenderness: *very tough (1), tough (2), intermediate (3), tender (4), very tender (5)*
Juiciness: *very dry (1), dry (2), intermediate (3), juicy (4), very juicy (5)*
Flavour intensity: *very weak (1), weak (2), intermediate (3), strong (4), very strong (5)*
Overall acceptability*: dislike very much (1), dislike (2), intermediate (3), like (4), like very much (5)*

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of fixed factors on body weight and weight gain.

5.1.1 Effect of Sex on Body weight, body weight gain, and variability in body weight

Sexual dimorphism, characterised by variations in size, shape, and other attributes across sexes, is a phenomenon generally observed across the animal kingdom. The insignificant difference in weight and weight gain observed between males and females African giant rats was not in agreement with the findings of Dzenda *et al*. (2011), who reported that the mean LW of male AGRs was 1.28 ± 0.01 kg, and the value was significantly ($P < 0.01$) higher than that of 1.14 ± 0.02 kg recorded in the females. Differences in the results of the two studies could be a result of differences in the experimental unit as in the present study, the AGRs were domesticated for a while and hence were provided quality feed irrespective of sex, but in the study conducted by Dzenda *et al*. (2011), there was no domestication.

Although body weight and weight gain weren't influenced significantly by sex, lower body weight and corresponding weight gain recorded in females agree with Maric *et al.* (2022), who reported that female rats tend to be more active than male rats, which may partially explain the less pronounced weight gain seen in female rats. The insignificant body weight and body weight gain recorded in the study could result from the homogeneity of feed and treatment administered to the AGRs. The size of the cage could also serve as a limiting factor to the movement and activeness of females, as Maric *et al.* (2022) reported, thereby conserving their energy to match the males in terms of body weight, hence the insignificant difference.

Table 4.1 indicates that on day 60 of captivity, both male and female percentages were very high, with a variation coefficient of 39.13 %) and 38.03 %, respectively, whereas the CV values decreased slightly to 39.13 % and 38.03 % for males and females during Day 60 in captivity. The result from the present data is in concordance with Elamin *et al.* (2012), who reported similar findings in rabbits in a study conducted in Sudan. Elamin *et al.* (2012) recorded a high coefficient of variations (20.92) in body weight in Rabbits. These coefficients are higher than those of Orheruata *et al.* (2006) in rabbits. In addition, Shahin & Hassan (2000) recorded similar high body weight variability ranging from (21.1 % to 27.6 %). The variability in body weight recorded in the present study was higher than the reports of Udeh & Okonta (2013), who recorded the variability in the body weight of grasscutters at 11 %. The coefficient of variation of body weight was slightly higher in males than females throughout the experimental period, although they were both high to moderate; it shows that body weight is more variable in males than females. The recorded high body weight variability shows the possibility of selection and further suggests that the body weight of AGRs can be improved easily by breeding programs because the variation serves as raw material for the breeder.

5.1.2 Effect of age on Body weight, body weight gain, and variability in body weight

Body weight was higher in adults than in juveniles and neonates, which is unsurprising. Significantly higher body weight gain in neonates observed in the present study was similar to the findings of Ajayi 1977. Similar findings were reported by (McCutcheon & Marinelli, 2009 and Ghasemi *et al.*, 2021) that rats' body weight changes considerably During the first two months of postnatal life. Also (Pappas & Nagy, 2019) indicated in their findings that, regarding BW, there is an increase in age in both rodents and humans. Several cross-

sectional and longitudinal studies have shown that rodents' BWG and BW increase during the early to middle-age period. The present study is in concordance with Ghasemi *et al.* (2021), who reported that post-maturity growth in Wistar rats occurs at a slower rate. High body weight gain in young AGRs may result from higher cell division at the early stage of life, and as the AGR ages, the rate of apoptosis exceeds the rate of cell division, thereby accounting for low body weight gain in adult AGRs.

The relatively higher coefficients of variation (CV) in body weight observed in neonates suggest considerable variability among neonates, which may be attributed to genetic diversity, nutritional intake, and environmental conditions during early development (Smith *et al.,* 2020).

In contrast, the juvenile age group displayed lower CV values of 15.94% and 14.22% on the same days. This reduction in variability could indicate that as individuals mature, their body weight becomes more stable and less influenced by external factors. The juvenile stage often involves a more consistent diet and living conditions, which may contribute to this observed decrease in variability (Seniczak *et al.,* 2022). Furthermore, the adult age group recorded the lowest CV values of 7.75% and 9.82%. This finding aligns with the expectation that adult individuals typically reach a more uniform body weight as they have completed their growth phases and are less susceptible to the fluctuations seen in younger age groups (Sun & Du, 2023). The stability in body weight among adults suggests that they have adapted to their environments, leading to a more homogenous population in terms of body weight.

The present study's result shows that the variability in body weight in the neonatal age group is relatively higher than in other age groups of AGR. This implies that ranking and selection based on the body weight of African giant rats for breeding programs will be easier to achieve during the early and middle ages of their life because of the high variability of body weight during these stages. Relatively low variability in body weight in the adult age group means that as the African giant rats age, they turn to be similar in body weights; therefore, the differences between individual body weights decrease, which will pose a challenge to a breeder in selecting the best performers in terms of body weight at that age. This became obvious because the neonatal age group recorded a decreased coefficient of variation values of 26.51 at day 165 under domestication compared to 41.97 at day 60 under domestication.

5.2 Docility of African Giant Rats

According to the data presented in Table 4.2A, the African giant rats appear to possess a flightier to restless docility trait rather than the previously believed trait of aggression. Their domestication and interaction with humans may have influenced this shift towards more amicable characteristics. However, the study indicated that only a small percentage (5.83 %) of the rats exhibit truly docile behaviour, suggesting that many still retain their innate wild nature. In Table 4.2B, the average docility score obtained from the experiment (2.7) is similar to that of grasscutters (2.6), as reported by Annor *et al*. (2011), who also observed that grasscutters tend to be restless. Notably, the docility score for African giant rats is higher than that of guinea fowl (2.13) reported by Dramani, 2018. The difference in docility score between the present study and that of the docility score of the guinea fowls reported by Dramani, 2018 could be a result of distinctness in the experimental unit. Also,

Guinea fowls were domesticated in Ghana way back when compared to African giant rats and grasscutters. There is, therefore, a particular need for breeders to include docility in the breeding objectives of Non-traditional animals, such as AGR improvement programs (NRC, 1991; Mensah & Okeyo, 2005; Annor *et al*. (2011).

5.2.1 Effect of sex on docility and variability in docility

The sex of the AGR significantly influences the behavioural pattern of the African giant rat. Male and female AGR showed changes in their behaviour throughout the period when the test was performed. Both males and females were observed, on average, to be flighty and restless, respectively (2.24 and 3.09 respectively). It should be noted that the effect of sex on temperament is debatable. The findings support the results of Voisinet *et al.* (1997) research, which examined various cattle breeds and found that females had higher temperament scores than males, indicating that male cattle were typically tamer than females. This also aligns with Burrow (1997) study on Bos indicus crossbreds. The results of the present study contrast those of Annor *et al.* (2013), who found no correlation between sex and docility in grasscutters. This finding is also inconsistent with Burdick *et al.* (2009, 2011) cattle studies, who similarly found no correlation between sex and docility. Similarly, Pajor *et al.* (2008) and Pajor (2011) reported no significant difference ($P < 0.05$) in temperament scores between male and female sheep.

In addition, Dramani (2018) reported that sex significantly did not influence docility in Guinea fowl in his study. The difference in docility between the sexes could be attributed to the fact that females are more active than males, which is supported by Maric *et al*. (2022), who reported that female rats tend to be more active than male rats.

Throughout the experimental period, male and female African giant rats consistently demonstrated low to medium variation coefficients (CV), ranging from 6.86 % to 16.76 % and 8.08 % to 20.41 %, respectively. On average, female rats recorded a CV value of 6.85 %, while their male counterparts recorded a slightly higher average CV value of 8.07 %. On average, although males recorded somewhat higher coefficient of variation values than females, the level of variability in terms of docility wasn't vastly different. This implies that both sexes of African giant rats exhibit similar docility scores (1-4 docility scale), accounting for the low and similar coefficient of variation values recorded in this study.

5.2.2 Effect of age on docility and variability in docility

The study results revealed that the docility of the African giant rat was significantly impacted by age group ($p < 0.05$) from the second week until the end of the experimental period. The average docility score was also influenced in the same way by age group, similar to what was observed in both sexes. Furthermore, Table 4.2B indicates that age did not significantly impact docility during the initial week of the study. High docility scores recorded across all age groups in the first week of the study may be due to the animals showing a fearful response to handling due to the novelty of being handled coupled with greater exposure to a variety of potential stressors, including the change of diet and re-grouping with unfamiliar animals, all this may exacerbate this response as described by Enríquez *et al.* (2011). The gradual decline in docility score as the days increase didn't come as a surprise because, according to research, there exists an inverse relationship between the frequency of handling or animal-human interaction and the average temperament score of the animal, provided that the handler adopts a calm approach in handling the animal. This suggests that excessive animal-human interaction may lead to a

decrease in the animal's temperament score (Parham *et al.,* 2019; Alvarenga *et al.,* 2022; Alvarenga *et al.,* 2023).

The average docility score implies that the neonatal age group was flighty while the juvenile and adult age groups were restless, which conforms to a study by Alvarenga *et al.* (2023) on cattle; they reported in their research that 'The average cow at weaning temperament score (animals older than 2 years) increased slightly with age'. This particular finding came as a surprise because one would expect the average temperament to decrease (animals become more docile) as age increases. However, Table 4.2B suggests that as animals grow older, their temperament scores tend to rise, which may indicate a sensitisation effect rather than habituation. Habituation is a process where an organism becomes less responsive to a stimulus over time, while sensitisation involves an increase in responsiveness to a stimulus. Blumstein (2016) states that habituation is commonly associated with adaptation. Another possible hypothesis to explain this result may be as a result of the unpleasant experience the African giant rats within the adult and juvenile age group may have encountered in the wild, as previous negative experiences can trigger subsequent fearful responses to handling due to memory acquisition (Ede *et al.,* 2019; Lecorps *et al.,* 2019).

The coefficients of variation for neonates are, on average, 16.77 %, while for juveniles and adults, they are 8.36 % and 8.52 %, respectively. This data highlights the significant differences in variability across different age groups and underscores the importance of considering age when analysing such data. According to Table 4.2B, the average African

giant rat in the neonatal age group has higher variability in docility than the juvenile and adult age groups. This suggests that selecting African giant rats based on their docility for breeding programs will be easier during their early stages of life due to the significant variation in docility during this period. Breeders rely on variation to identify individuals with desirable traits that can be selected for breeding. Without variation, there would be no basis for selection and improvement of traits.

The adult African giant rats have relatively low variability in docility, which means that as they get older, their docility becomes more similar. As a result, the differences in docility scores between individuals get smaller, making it difficult for breeders to choose the best docile performers at that age.

5.3.1 Effect of sex on linear body measurement of African giant rat and coefficient of variation within linear body measurement

Table 4.3A shows that apart from body length and tail length, which was significantly ($P < 0.05$) higher in males than the females, the other linear body measurements were not significantly ($P \geq 0.05$) different among sexes throughout the experimental period. Gueye *et al.* (1998) and Misshohou *et al*. (1998) reported similar observations in the chicken, (Egena *et al*. 2010 and FaÃ *et al*.2019) reported the influence of sex on the body length of guinea pigs which agrees with the findings of the current study. However, Elamin *et al.* (2012) reported no significant differences between body lengths in male and female rabbits. Contrary to the present study, Annor *et al.* (2011) and Jayeaola *et al*. 2009 recorded significantly higher tail lengths and body lengths in female grasscutters than in males, which is exactly the opposite of the present study's findings. The difference between the tail lengths could result from differences in experimental units as grasscutters have

relatively short tails that can easily be detached from the body while the African giant rat tail is longer relative to the rat's body size compared to other rat species.

Although the other linear body measurements studied were higher in the males, they were not significantly ($P \geq 0.05$) different from the females. This observation is in line with the submission of various workers. Appau *et al.* (2022) submitted that there was no significant influence of sex on all morphometric traits considered in guinea pigs in their study. Elamin *et al.,* 2012 similarly reported that there was no sexual dimorphism in head length (HL), heart girth (HG) and height at withers (HW) in rabbits. On the contrary, Annor *et al.* 2011 observed higher head length (HL), heart girth (HG), and height at withers (HW) in female grasscutters. In addition, Ige *et al.,* 2015 observed that females were significantly ($P < 0.05$) superior to males in all the body measurements taken in White Fulani cattle. The differences may be due to the genetic composition of the animals, as earlier noted by Udeh *et al.* (2011).

For successful management of African giant rat reproduction, farmers must be able to differentiate between male and female animals. While identifying the sex of most livestock species is not a challenge, it can be difficult for rodents. Identifying the sex of rats typically involves observing variations in their genitalia. Male rats have testes and a penis, while female rats have mammary glands (possibly with visible nipples) and a vaginal opening with a distinct clitoris. While these characteristics are usually distinguishable in sexually active males and lactating females, they may be more challenging or impossible to discern in non-reproductive rats or early stages of life. In light of the above constraints, body length

could be used for sex determination in non-reproductive rats since it significantly differed between the sexes throughout the experimental period.

The coefficient of variation (7.55 % and 9.47 % for females and males respectively) observed for body length in the present study is in line with 7.05 % and 12.88 % reported by Ige *et al.* (2015) in white Fulani cattle. Elamin *et al*. (2012) recorded similar low coefficient of variation values (11.63 % and 7.92 %) for females and males, respectively, for body lengths in rabbits; however, contrary to this study, the CV values he recorded were higher in females than in males. According to Bene *et al.*,2007, in a study comparing body measurements of beef cows of different breeds, the CV% values for various measurements ranged from 2.47 % to 12.83 %. The coefficient of variation values recorded for all linear body measurements was not different between the sexes as all the values were low (3.42 % - 11.21 %). With a low observed coefficient of variation values of sexes, the level of variability within morphological traits of the African giant rats is low irrespective of the sex involved. This directly implies that ranking and selection of African giant rats based on morphological traits will be quite cumbersome since these traits don't vary much between individuals within the population, hence the low coefficient of variation values.

5.3.2 Effect of age on linear body measurement of African giant rat and coefficient of variation within linear body measurement

All things being equal, old mammals will have higher morphological traits than young ones in this study. To prevent this bias, gains in morphological traits, i.e., the difference between two successive measurements, were used to make a reasonable comparison. Table 4.3B shows that, on average, the rate of gain in all the linear body measurements considered in

this study was higher in the neonatal age group followed by the juvenile age group. The present study depicts that as the animal is young, the rate at which the body parts increase is very high compared to as the animal ages. This didn't come as a surprise since similar trends were recorded in the body weight gain of the African giant rat. This possibly explains the higher weight gain in the neonatal group compared to the juvenile and adult groups. Significant increases in linear body measurements in young African giant rats may be due to increased cell division in early life. As the animals age, the cell death rate exceeds the cell division rate, leading to decreased linear body measurements in adult and old African giant rats. However, the observed differences could also be attributed to other factors, such as diet, exercise, or environmental conditions, due to the uniformity of the experimental conditions.

The coefficient of variation observed in this data ranges from medium to high values. The values observed in the adult age group were more variable than those of the juvenile and neonatal groups because the adult group observed higher coefficients of variation values than the other two groups. From Table 4.3B, it can be deduced that as the African giant rats age, the rate at which they accumulate cells varies a lot, hence the high coefficient of variation.

5.4 Carcass traits

5.4.1 Effect of sex on carcass traits of African giant rat and variability between sexes

In evaluating the quality of African giant rat carcasses, it was crucial to consider several factors. These include the live weight of the animal before slaughter, the weight of the carcass, the percentage of the carcass weight in relation to the live weight, and the weight of the significant parts, such as the hind and forelimbs. Table 4.4 shows that the significant

($p < 0.05$) influence of sex on carcass traits considered in this study is in consonance with Mark, 1990 and Tarhyel *et al.,* 2012, who reported that males significantly differed from females in live weight and other characteristics due to a higher metabolic rate in males. In contrast, Yalçin *et al.* (2006) also reported that females showed higher live weight ($P < 0.05$) but lower dressing percentage due to the higher incidence of gut content. The live weight (2227 g and 2215 g for males and females, respectively) of the African giant rat observed in this study was higher than 1033 g and 916.6g for males and females, respectively, observed by Ajayi, 1977 and 1432 g observed by Josephl & Abikoye (1997). This observed variation may be due to differences in experimental diets and the genetic endowments of the experimental units. Interestingly, at a 5 % probability level, there was no significant difference between the dressing percentage of the giant rat in both sexes. This is in line with Ajayi (1977), who reported no significant influence of sexual dimorphism on the dressing percentage of giant rats. However, the dressing percentages (Table 4.4) observed in the present study were higher than 51.5 % and 51.6 % for males and females, respectively, reported by Ajayi 1977. On the contrary, Josephl & Abikoye (1997) observed a significant difference in dressing percentage between males and females of giant rats. The dressing percentage observed in the giant rat is higher than that of most of the animals in the rodent family, as reported in various literature. Unlike the present study, previous research conducted by Kokoszyński *et al.* (2011), Śmiecińska *et al*. (2022), and Bernacki *et al*. (2012) indicated that female guinea fowl had higher carcass dressing percentages than their male counterparts. Nevertheless, the discrepancies in the average values of this measurement were not considered statistically significant ($P > 0.05$) in the studies mentioned above. In addition, Choat *et al.* (2006) observed no effect of sex on

carcass weight in cattle. Compared to other mammals, the high dressing percentage observed in the African giant rat makes it an ideal candidate for meat production, considering space, gestation period, litter size, and capital involvement.

The weight of forelegs, hindlegs, and head weight were all significantly higher in males than females, accounting for higher live weight in males. Unlike the present study, Yalçin *et al.* (2006) observed higher forelegs and hindleg weight in female rabbits than males, but they weren't significantly different. The values of the forelegs and hind legs did not agree with those reported by some researchers (Pla *et al.,* 1997; Piles *et al.,* 2000; Yalçın *et al.,* 2003). The observed discrepancies between the present and previous studies result from the different experimental animals used in the respective study. The higher weights of the fore and hindlimbs observed in males imply that the males are more economically significant than the females since this is the most preferred part of the giant rat meat Oyeyinka *et al.* (2019).

The coefficient of variation values observed in the present study were similar to what Yalçin *et al.* (2006) reported on rabbits. The CV values were higher in female giant rats than in the males in the present study, which implies that data on carcass traits discussed above are more variable in the female population of the African giant rat than in the males. Selection and ranking based on the foreleg, hindleg, and head weight will be easier in the female population than in the males, hence the higher variability in females.

5.4.2 Effect of Sex on selected organ weight of African giant rat

There was no significant difference in organ weights except for kidney weight in male and female giant rats. The current study is in line with the findings of Ajayi, 1977 who reported similar kidney, liver, and heart weight in giant rats. Contrary to the present study, Josephl & Abikoye (1997) observed significantly higher kidney, liver, and heart weights in male African giant rats than in females. However, the organ weights as a percentage of dressed weight, as reported by Josephl & Abikoye (1997), were 0.56% for the heart, 0.45% for the kidney, and 1.44% for the liver, which aligns with the findings of the present study. Similarly, Annor et al. (2013) reported similar values in grasscutters.

The present investigation results align with the research conducted by Ghosh & Mandal (2008), Sen & Bhagwan (1999), and Farghaly & El-Mahdy (2012) regarding rabbits. According to Sen and Bhagwan (1999), most traits were not affected by sex, except for the weight of the alimentary canal and its contents, which were 16.4 % - 22.8 % of the body weight and significantly higher ($P < 0.05$) in females. However, their findings differed from those of others (Rao et al., 1978; Nofal et al., 1995), who reported lower values. Farghaly and El-Mahdy (2012) also discovered that sex had no significant effect on various organ weights, except for the liver weight, which was significantly higher ($P < 0.01$) in females than males.

The coefficient of variation for these traits was generally low in the females and the males. A coefficient of variation value of heart weight was observed to be 16.92 % for males and 11.78 % for females, similar to the 19.7 % followed by Ghosh & Mandal (2008) in rabbits. Although the coefficient of variation of these traits was generally low in both sexes, in

males, it was higher than in females in all the traits considered, indicating higher data spread and variability in the discussed traits in males than in females.

5.4.3 Effect of sex on Proximate composition of raw meat of African giant rat.

Findings from the present study have indicated that the nutrient content of raw meat from African giant rats is significantly influenced by their sex, which is not in agreement with Ghosh & Mandal (2008), who observed no significant difference in the meat chemical composition in male and female rabbits. Interestingly, the fat content remains consistent between male and female rats. The study found that the moisture, protein, and ash contents of thigh meat in male and female African giant rats align with previous research conducted by Oyarekua & Ketiku (2010) and Oyeyinka *et al.* (2019). However, the fat content observed in this study (approximately 6 %) was lower than previously reported values (around 11.4 %) by Oyarekua & Ketiku (2010). These variations in fat content may be attributed to factors such as genetics, diet, and feeding patterns. Notably, the low-fat content of giant rat meat may offer potential health benefits for individuals with fat-related health concerns the elderly people.

The moisture content of 62.41 % for males and 61.22 % for females observed in the present study was lower than what was observed by Annor *et al.* 2013 77.7 % in male grasscutters and Mostert & Hoffman (2006) 74.49 % and 74.14 % in male and female African antelope respectively. African giant rat meat is higher in protein and lower in fat compared to more common meat sources such as chicken (20.0 and 11.2 %), lamb (15.7 and 14.0 %), and pork (11.9 and 45.0 %) (Singh 1997a).

In addition to water, protein plays a vital role in lean body tissue as it constitutes around 23-24 % of body weight. Its importance lies in regulating and maintaining essential body functions such as blood clotting, cell repair, enzyme production, and hormone transportation. A diet low in protein can hinder anabolism, which may decrease the size of vital organs such as the heart and liver (Oyarekua & Ketiku, 2010). For this reason, the African giant rat should be considered an important meat source since it has a high protein content. The coefficient of variation values recorded in both sexes for the chemical composition traits of the African giant rats were generally low. Therefore, there was little variability in the traits of both sexes of the African giant rat.

5.5 Effect of Sex on Sensory Traits and pH of African Giant Rat

The mean sensory scores of the processed meat were very similar in both sexes. Sex type did not significantly ($P < .05$) affect the sensory properties of the processed African giant rat thigh meat. The findings of the present study are congruent with (Oyeyinka *et al.,* 2019), who reported in their findings that the sensory traits of African giant rats were not significantly influenced by sex. Kokoszynski *et al.* (2021) reported that the sensory properties of breast muscles in 16 - week-old guinea fowl were not affected ($P > 0.05$) by sex or age. However, the muscles evaluated in the cited study scored lower for sensory attributes (3.5 –3.7 points on a 5-point scale) than those analysed in the current experiment. Similarly, Gasperlin *et al.* (2006) observed no significant difference in male and female rabbit meat sensory traits. An imperative aspect of meat quality is its colour, which is determined by the myoglobin pigments present in the muscles. Myoglobin, being a protein, is vulnerable to modifications in response to external environmental conditions (de Figueiredo *et al.,* 2020). Variations in pH and temperature can lead to protein denaturation,

causing changes in its structure and efficacy (Neethling *et al.*, 2017). This research finding indicates that the instrumental colour parameters of African giant rat meat were not impacted by sex.

Meat tenderness and juiciness are primarily determined by the proportions and diameters of white and red muscle fibres Śmiecińska *et al*. (2022). According to Listrat *et al.* (2016), tenderness may be determined by the type and number of muscles fibres, the rate of post-mortem proteolytic changes, storage time, ultimate pH, and water-holding capacity. In the present study, meat tenderness and juiciness were not influenced by sex; this could be due to the smaller difference or the same in slaughter age adopted in the present study.

Another important factor that affects meat quality is pH. A high pH value shortens meat shelf life since it creates a more favourable environment for bacteria (Aberle *et al.*, 2001; Chen & Smith, 2015; Sarica *et al*., 2019). The pH of the meat was not influenced by sex, as all the values were not significantly different. Similarly, Ludwiczak *et al.* (2016) reported no effect of sex or muscle type was found ($P > 0.05$) on the pH of the meat of French loop rabbits. Similar values were observed by Josephl & Abikoye (1997); however, contrary to the present study, he inferred that pH was significantly higher in males than females. Also, sex significantly affected the meat pH of indoor guinea fowl (Sarica *et al*., 2019). As found in other studies (Hernández *et al.*, 1997; Pla *et al.*, 1997) and in our work, pH was not altered by sex. The present findings regarding the slight sensory traits and pH level variations exhibited by male and female African giant rats are of great significance for future research and a deeper understanding of this species. The implications of these

discoveries could have far-reaching effects on advancing knowledge in this area and contribute to developing novel approaches for studying and conserving this unique species.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Based on the findings of this experiment, the following conclusions were made:

1. The neonatal age group has higher body weight gain than the juvenile and adult age groups; in addition, higher variability exists in the body weight of the neonatal age group.
2. A high and similar variability regarding body weight was observed in male and female African giant rats.
3. The docility of the African giant rat was significantly influenced by sex and age. The docility trait of the African giant rat was that of restlessness.
4. Docility scores in the neonatal age group were more variable than others; however, little variation was observed in both sexes.
5. Body length and tail length are higher in males than females; little variability exists between both sexes, but adults are more variable in linear body measurements than neonates and juveniles.
6. Raw African giant rat thigh meat is rich in protein and very low in fat in females than males.
7. Sensory and chemical composition of the African giant rat meat was not significantly influenced by sex.
8. The level of variability in the carcass and sensory traits of the African giant rat was low and similar in both sexes.

6.2 Recommendations

1. Selection of African giant rats based on body weight should be done during the early stages since there is higher variability in body weight at early ages.
2. The docility trait should be included in the breeding objectives of the African giant rat to achieve a more acceptable docility score.
3. The African giant rat meat has a low-fat content, making it a favourable choice for adults and individuals with coronary heart disease. As such, the study suggests adding it to family menus and restaurant offerings to pique the interest of all generations in consuming meat.
4. Further studies should be conducted to evaluate the heritability of these traits in the African giant rat.

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