UNIVERSITY OF CAPE COAST

MORPHOLOGICAL AND MORPHOMETRIC TRAIT DIFFERENTIATION OF LOCAL QUAIL POPULATIONS IN SOME AGRO-ECOLOGICAL ZONES OF GHANA.

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BY

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Thesis submitted to the Department of Animal Science of the School of Agriculture, College of Agriculture and Natural Sciences, University of Cape Coast, in partial fulfillment of the requirement for the award of Master of Philosophy degree in Animal Science

SEPTEMBER 2023

DECLARATION

Candidate's Declaration

By signing this document, I certify that this thesis is the result of my own original research and that no part of it has ever been submitted for credit toward another degree at this university or anywhere else.

Candidate's Signature……………………………… Date…………………

Name: ………………………………………………….

Supervisors' Declaration

We thus state that the thesis' preparation and presentation were overseen in accordance with the standards for thesis supervision established by the University of Cape Coast.

Principal Supervisor's Signature …………………………… Date…………

Name: ……………………………………………………..

ABSTRACT

In this study, the morphological and morphometric traits of the local quail population in the Coastal Savanna, Semi-Deciduous Forest and Transitional Agro-ecological Zones (AEZs) of Ghana were investigated. In this mixed-methods study, a descriptive cross-sectional survey was employed. The survey included ninety (90) local quail farmers with thirty (30) keepers from each AEZs was selected to investigate their keeping aims, characteristics, trait preferences, and production systems. A questionnaire, observation, and direct measurement were employed to obtain data. Morphometric traits of Body Weight, Body length, Wing length, Shank length and Body girth (BW, BL, WL, SL, and BG) were measured. A sample size of 540 quails was selected with 180 from each AEZ (60males and 120females). The data was then analysed using Minitab-22 software. The study found that sex and AEZ had no significant ($p<0.05$) influence on the morphometric parameters examined except BW. Also, female quails were found to be significantly ($p>0.05$) heavier than males in all three AEZ. Again, the study found that survivability was the most preferred trait by the local quail farmers, followed by high egg laying capacity, early maturity, and resistance to most avian diseases among female quails. The findings of the canonical discriminant analysis indicated that the local quail populations in the Semi-deciduous Forest were closer to those in the Transitional zone than to those in the Coastal Savannah AEZ. A further examination of the qualitative characteristics uncovered two shank colors (yellow and pink) and four plumage colors (White, Black, Brown, and Red). All the quails within the three AEZ had pink skin color.

KEYWORDS

Phenotypic Characterization

Morphometric traits

Quail

Agro-ecological zone

Morphological traits

Mahalanobis distance

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I want to sincerely thank my major supervisor, Professor Julius Hagan of the Department of Animal Science, for his direction, wise counsel, and encouragement throughout this research. I am sincerely appreciative.

DEDICATION

To Esther Akosua Afrifa, my grandmother

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Background to the study

The initial State of the World's Animal Genetic Resources (AnGR) for Food and Agriculture states that "Characterization of AnGR encompasses all activities associated with the identification, quantitative description, documentation of breed populations and the natural habitats as well as production systems. According to FAO (2012), phenotypic characterizations is "a method of detecting and defining variability within and across various breeds of the organism in a given location and under particular management, taking into account the social and economic aspects that impact them." In this context, a breed is an organism within a local population that has a consistent look, behavior, and other characteristics that distinguish it from other organisms of the same species. There is scanty of knowledge on phenotypic characterizations of quails in Ghana and therefore the indigenous population of quails breeds in Ghana have not been classified into known strains. As a result, farmers have a tough time selecting the best performing strain for production. Quails (Coturnix *coturnix*) are members of the order *Galliformes*, the *Phasianidae* family, and the genus *Coturnix*. The quail is the smallest member of the edible and domesticated bird species that has been adopted for meat and egg production globally Wamuyu *et al.* (2013). Quails were initially domesticated as singing birds in Japan, according to Minvielle (2004). Quail farming has recently gained popularity in Ghana, and demand for quail eggs and meat is increasing Alkan *et al.* (2010). Quails have several advantages than other poultry species, according to Minvielle *et al*. (2004), including their small body size, fast growth rate, short generation interval, good reproductive potential, low feed requirement, better laying ability, shorter time of hatching, early sexual maturity, and high disease resistance. Despite their obvious benefits over other poultry species, quails remain neglected in Ghana and require greater attention and acceptance. According to Rosen (2014), the global population is expected to reach nine billion by 2050. With the world's population rapidly increasing, an alternate supply of protein meals is required. The United Nations Food and Agriculture Organization (FAO) advised a daily protein need of 34g per person per day for optimal health, productivity, and development, particularly in youngsters, the elderly, and pregnant women. However, according to FAO and the Ministry of Food and Agriculture (MOFA), the average protein consumption per person per day in Ghana is 16.2kg and 13.8kg, respectively, which is below the UN standards. As a result, Ghana has a high degree of malnutrition and undernourishment. Also, introducing game birds such as quails as a protein source, would complement the daily protein need. The acceptance of indigenous quail populations as agricultural birds by farmers in Ghana is mostly owing to their high production capability of around 300 eggs per year, as well as the excellent nutritional value of their flesh and therapeutic benefits of their eggs Hrncar, (2014). Furthermore, because their physiology is similar to that of humans, quails are commonly utilized as experimental laboratory animals Leroux *et al*. (2016). Despite the various benefits of quail meat and eggs, there are some drawbacks to their consumption. Bharat (2021) reported that consuming too much quail eggs and meat may raise the risk of hypotension. Second, over consumption of quail products releases excess antioxidants that are harmful to the human system. Antioxidants are in charge of removing free radicals from the body. Too much of an antioxidant, on the other hand, allows them to assault healthy cells and cause cancer. As a result, quail farming is currently facing a number of challenges, including a lack of proper knowledge on husbandry procedures under local climatic circumstances and marketing Omane *et al.* (2020). Despite several research on quails, the local quail populations in Ghana are not phenotypically described, making any effective breeding effort challenging. Quail farming is gaining popularity as a cheaper and more easily available animal protein source for both rural and urban people. There is currently no documented breed improvement work on quails in Ghana, hence it is necessary to identify accessible quail populations in order to determine a suitable breed development technique to be used. Any increase in accessible quail populations would go a great way toward increasing quail production, resulting in more animal protein in the country. Because most poultry research focus on chickens at the cost of other poultry species, quail production has grown in importance. As a result, extra resources must be directed into increasing quail production in order to promote food and nutrition security. Quail phenotypic assessment would also indicate their genetic potential for future improvement planning and development of appropriate breeding techniques. It would also help to determine the number, geographical distribution, and structure of the local population, as well as to describe distinctive qualities for breed improvement and conservation. According to the FAO's Global Plan of Action for AnGR FAO, (2012), understanding breed traits is critical for making informed decisions in livestock development and breeding programs. The goal of this study is to phenotypically examine the morphological and morphometric differences among local quail populations in some Agro-ecological zones of Ghana for future breed improvement programs.

Statement of the Problem

Concerningly, the rate of AnGR erosion in developing countries calls for human intervention through characterisation and conservation. A local animal population's genetic diversity can be estimated by characterization, inventory, and monitoring. As a result, the Global Plan of Action for AnGR prioritizes animal description in order to improve their long-term usage, development, and conservation Hoffmann, (2010). According to research conducted by MinZhang *et al*. (2017), around 200 different and appropriate quail breeds have been extinct. According to Aning (2006), local quail populations are also under jeopardy. This is due to the widespread killing of local quail populations in their natural environment. Furthermore, the introduction of novel Covid-19 had a significant impact on quail production and marketing, forcing many farmers to discontinue hatching their eggs. As a result, local quail populations in Ghana have declined dramatically. Therefore, characterizing the local quail population in Ghana is necessary for long-term management, conservation, and enhancement.

Justification of the Study

Because the local population of quails in Ghana are not divided into any recognized breeds, phenotypic characterization will be critical to establishing a baseline of data for planning breeding programs and conservation. The lack of knowledge on phenotypic characterization results in a significant loss of favorable traits in local populations. According to research on a worldwide view of livestock biodiversity and conservation undertaken by Ajmone-Marsan (2009), conservation of AnGR should be the concern of mankind and that it is critical in biological variety for providing the food, health, and other demands of the expanding world population. There is currently little information available in Ghana on the status of quail production, keepers' aims, trait preferences, and quail marketing and consumption. According to the FAO (2012), developing nations have an abundance of AnGR breeds that are yet to be recognized and characterized. As a result, the goal of this research is to uncover the morphological and morphometric differentiation of local quail populations in some AEZ of Ghana in order to have a complete inventory of this AnGR.

General Objective

This study's primary goal is to describe the morphological and morphometric differentiation of local quail populations in some AEZs of Ghana for potential breed improvement programs.

Specific objectives

1. To estimate the population size and structure as well as the morphological and morphometric characteristics of the local quail populations in the selected AEZ of Ghana.
2. To determine the effects of sex and AEZ on the morphological and morphometric traits of the local quail population.

3. To determine important trait preferences by the farmers for selection purposes.
4. To use canonical discriminant analysis in the morphometric differentiation and classification of the local quail populations in the selected AEZs of Ghana.

Research Questions

1. Is there a difference between the morphometric traits of local quail populations in the three AEZs of Ghana?
2. What is the effect of sex and AEZ on the morphological and morphometric traits of local quail populations?
3. What are the management practices and important trait preferences of local quail keepers in the selected three AEZs of Ghana?
4. What is the population size and structure of the local quail populations in the selected three AEZ of Ghana?
5. Would the differentiation between morphological and morphometric traits of local quail population provide baseline/reference data and guidelines for sustainable management, suitable genetic improvement and conservation?

The hypothesis of the study

The listed hypothesis below was generated to guide the study.

1. H_O: There is no significant difference among morphometric traits of local quail populations in the three AEZs of Ghana.

H_1: There is a significant difference among quantitative traits of local quail populations in the three AEZs of Ghana.

2. H_O: Sex and AEZ have no significant effects on the morphometric traits of local quail populations in Ghana.

$H_{1:}$ Sex and AEZ have significant effect on the morphometric of local quail populations in Ghana.

Limitations

The study used only primary characterization, which entails visiting the farm once for data collection via observation, interview, and questionnaire administration, rather than advanced characterization, which entails multiple visits to the farm to measure traits such as growth rate, reproductive performance, and heritability. The study only included three AEZs due to insufficient resources. Finally, due to a lack of resources such as advanced contemporary technology and funding, molecular and genetic characterization were not included in this work.

Delimitations

The study focused on only quails raised under an intensive system of poultry production at the Animal Research Institutions and large, medium and small-scale quail farms in Ghana.

Definition of Key Terms

Frizzle feather; Feathers that are curled and which curve outward and forward.

Crest; A globular tuft of feathers on the top of the head of birds

Sex-linkage: Connection between color and sex in poultry breeds

Spangle: Distinct marking of contrasting color at the extremity of a feather, proximally shaped like a well-defined V with a round end.

Mottled: Plumage in which a variable percentage of the feathers are tipped.

Production environment: it comprises the natural environment and the management environment in which a breed population is kept.

Natural Environment: can be specified by describing the climate, soil quality, terrain elevation and surface type, and disease and parasite challenges that prevail in the location where a breed population is kept.

Management environment: refers to any interventions that affect the conditions under which the breed population is kept.

The market targeted: they are marketing that producer of the breed generally target when they sell the animals or their product.

Niche markets: These are targetable subsets of a market sector. They can be defined as a narrowly defined group of potential customers.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

This chapter is divided into two sections that evaluate the literature. The first section discusses Characterisation of AnGR, the origin and domestication of quails, global quail production and population size, quail production in Ghana, production environment, quail feeding and nutritional requirements, productive and reproductive performance, quail production challenges, and the economic importance of quail. The second section also includes empirical facts and models that support the study.

Characterisation of AnGR

AnGR are an important component of global food security. Animal production contributes significantly to the gross domestic product of industrialized countries (GDP). Although livestock farming is the primary source of income for people in underdeveloped nations, it only accounts for roughly 30% of GDP. To achieve food security in Africa, efficient and effective animal production techniques are required FAO (2012). Following a country-by-country review of the condition of the World's AnGR for Food and Agriculture, it was determined that global food security had not been attained. That instance, in most underdeveloped nations, a huge population cannot achieve their daily protein requirements. The Global Plan of Action for AnGR, which will oversee the long-term usage, development, and conservation of AnGR, was spurred by this. AnGR characterization, inventory, and monitoring is the top strategic priority area. The characterization will indicate the risk status and will be used to regulate decision-making in development and breeding operations. Three key steps are involved in describing AnGR for food and agriculture: phenotypic, genetic, and molecular. Most AnGR in undeveloped nations are not classified to any recognized breeds. The local population of animals continues to occupy natural habitat, which is required for an accurate evaluation of variety and determining their danger status.

Molecular characterisation

Molecular characterization is a method of interrelated techniques used to unleash the genetic components of phenotypic traits, their patterns of inheritance from one generation to the next, within-breed genetic structure and levels of variability, and relationship within and between breeds. The genetic diversity of an organism can be measured based on morphological, biochemical, cellular, and DNA level. However, polymorphism due to differences in DNA sequence has proven to be the most efficient and accurate Peer *et al*. (2018). This involves measuring the degree of polymorphism in selected DNA markers to identify genetic variation at the population level. The first state of the World's AnGR for Food and Agriculture stated that molecular characterization should include analyzing functional and neutral genetic variability within and between populations. Molecular genetic diversity studies that seek to characterize indigenous breeds will provide options for informed utilization and management of AnGR. Thus, to adopt improvement and conservation programs, and to determine population trends of endangered species. With the allocation of limited resources, priority is given to breeds with genetic distinctiveness, adaptive traits, relative value for food, and agriculture. This involves the description of breeds in terms of relative allelic frequencies, degree of polymorphism, and grouping livestock breeds using molecular genetic distances between populations Gizaw (2011). The advantages of molecular genetic characterization are enormous. It measures the genetic constitution of a population and analyzes its uniformity, inbreeding, or introgression in the population. It also enables the selection of a species even at the embryonic and leads to a reduction in generation intervals. Molecular genetic information can be acquired on all selection species especially sex-limited traits that require the slaughter of the animal. Notwithstanding the above importance, molecular genetic characterization possesses several limitations. In developing countries, there are inadequate infrastructural facilities such as Polymerase Chain Reaction machine, Autoclave, Centrifuge, Thermocycler, Ultra-Violet transilluminator, and many others. There is also a high cost of chemicals, primers as well as the time consumed in sample collection and analysis. Research involving molecular genetics is highly sophisticated and needs specialists. Despite all the above challenges the technique is promising and it is frequently used in genetic characterization studies in developed countries. Molecular genetic characterization is the detection of genetic diversity within a population owing to differences in their DNA sequences or specific genes. The Global Plan of Action for AnGR recognized that if local populations of animals are characterized, the information obtained will guide decision-making in their development, sustainable utilization, conservation, and breeding programs. Whenever there is a separation of animals from their wild populations, there is an increase in the genetic potential of the species FAO (2015). Lamiaa (2017) studied the genetic relationships in the tree of life of some quail breeds through the use of molecular marker analysis. Their results showed highly polymorphic restriction profiles. There was a wide intraspecific genes variability among the quails studied and that genetic characterization and genetic relationship can be achieved through the use of Polymerase Chain Reaction-Random Fragment Length Polymorphism (PCR-RFLP) and Protein analysis. A study was also performed by (Esmailizadeh, Baghizadeh, & Ahmadizadeh, 2012) to identify quantitative traits loci (QTL) for growth in a commercial strain of quail population. Another study estimated some genetic parameters of bodyweights in Japanese quail and concluded that genetic correlation was higher than phenotypic. A team of researchers (Nishibori, Hayashi, tsudzuki, Yamamobo, & Yasue, 2001) also did a complete sequence of the Japanese quail mitochondrial genome and identified its genetic relationship with related species. The results showed a complete genetic diversity between breeds of the quail population when a phylogenetic tree was constructed. Also, the Japanese quail mitochondria DNA was the same as that of chicken in structure. A study on genetic map and QTL for behavioral and production traits in Japanese quail reported several QTL regions for social and emotional behaviors in quail. A genetic map was also constructed and could be positioned on several different linkage groups (Julien, Frederique, & Cecile, 2015). Genetic diversity and for that matter production traits are influenced by the addictive genetic make-up of the breed. (Islam, Faruque, Khatun, & Islam, 2014) researched with four quail breeds (Japanese, White, Black, Brown) and confirmed that their hatchability traits, body weight, and egg production performance were controlled by their genotypes. The egg production pattern of quails was also found to be influenced by both genetic and non-genetic factors when birds were fed with varieties of energy and protein feeds Adi *et al.* (2018). In all, the emergence of molecular markers (microsatellite) has paved the way to locate new genes which further help in quail research. Now, more comparative studies of molecular genetics can be done between quails and other avian species using microsatellites markers.

Genetic Characterisation

Genetic characterization of traits of economic importance such as adaptability, productivity, physical appearance, and current state of a population concerning inbreeding and genetic drift using population size. FAO (2012) reported the sequencing of the total genome of the five main livestock species and the development of technologies for measuring polymorphisms at loci spread across the entire genome. These technologies include the use of microsatellite markers, Single Nucleotide Polymorphism markers (SNP), and other tools for characterization and genetic diversity studies. Many developing countries have utilized these tools in the characterization and conservation of livestock species and also for breeding programs.

Phenotypic Characterisation of AnGR

Phenotypic characterisation is the first point of contact for assessing the danger level of an unremarkable local population of quails. According to FAO (2012), phenotypic characterisation is the process of identifying unique breed populations and defining their external and production attributes in a certain environment and under particular management, while taking into consideration the social and economic aspects that affect them. This method includes quantitative and qualitative trait evaluation, a description of the production environment, livestock keeping goals, and livestock keepers' trait preferences.

Origin and Domestication of Quails

The quail belongs to the Aves class, the order Galliformes, the families Phasianidae (Old World Quail) and Odontophoidae (New World Quail), and the species *Cortunix* Qureshi *et al*. (2016). They are warm-blooded, somewhat migratory birds that are sensitive to their surroundings Nasr *et. al*. (2019). A domestic animal is described as "one that has been maintained in captivity for the purpose of economic benefit to a human community that retains total authority over its reproduction, territorial organization, and food supply" Lukanov, (2019). Domestication is the process through which trapped animals adapt to man and his environment (Lukanov, 2019). Mysterud (2010) defined a domesticated animal as one that has gained or possesses various genetic, morphological, reproductive, and behavioral features and attributes that distinguish it from wild animals. The degree to which AnGR has been domesticated is determined by human control over breeding, mortality, food availability, space, and the altered phenotypic features (Mysterud, 2010). Quails were domesticated in China as pet and singing birds before spreading to Japan, Europe, America, and other areas of the world.

However, over the twentieth century, quail production became highly profitable, and focus turned to its meat and eggs (Ainsworth et al., 2010;

Minvielle, 2004, Lukanov, 2019). There are around 20 wild species and 70 domestic types in the worldwide quail population. According to Ainsworth *et al*. (2010), there are differences between domestic and wild quails, despite the fact that domestic quails evolved from wild ancestors. Qureshi *et al*. (2016) discovered that domestication of wild quails resulted in changes to both qualitative and quantitative features. Furthermore, quails' multifunctionality has shifted them away from their predecessors, allowing them to be employed as productive, experimental, and decorative birds (Lukanov and Ivelina, 2019). Humans' inadvertent or purposeful treatment and involvement of animals in order to meet their requirements results in the animals adapting to the alterations. This alteration separates the domesticated species from their wild type species. Only a small number of the more than 10,000 bird species have been domesticated as sources of food for people, according to the second report on the condition of the world's agriculture and food production (FAO) (2012). According to the paper, a wild bird's capacity to become domesticated depends on its propensity for breeding in captivity, rate of growth, behavioral characteristics that permit human management, and typically, its expression of a non-carnivorous diet. The Japanese quail (Coturnix japonica) was found in Japan in the seventh century as a wild type, according to (Hristo & Ivelina, 2020). By the end of the 19th century, the quail had begun to be domesticated, which changed some of its economic characteristics. According to research on the domestication modifications in Japanese quail by Hristo and Ivelina (2020), the East Asian domesticated varieties have undergone morphological, productive, reproductive, behavioral, and ethological changes that set them apart from their wild predecessors. The main reason why quails were domesticated by humans is so that they could produce their meat and eggs. Due to their visual appeal, several of the breeds are also kept as pets.

In the twenty-first century, quails—fighting and singing birds—are used as test subjects in laboratories. The breed experienced metamorphosis as a result of their multifunctionality, which presently sets them apart from their ancestors (Hristo & Ivelina, 2020). According to Balnave *et al*. (2014), domesticating wild animals would occur in three steps. This comprises directed, prey, and commensal behavior. A group of creatures that were drawn to human habitats and eventually became imprisoned as a source of food is known as the first stage, or the commensal. Humans capture animals for meat at the second stage of the prey life cycle. These animals are killed for their flesh, but they also provide milk, wool, and leather, among other things. They can also be used to plow agricultural land. Last but not least, some animals are purposefully mistreated by people for things like riding and sports. A general theory of animal domestication was put forth by Zahid *et al*. (2017), who claimed that "selection for tameness induced a mild neural crest cell deficit during embryonic development, which attenuated behavior and also modified several morphological and physiological traits related to domestication."

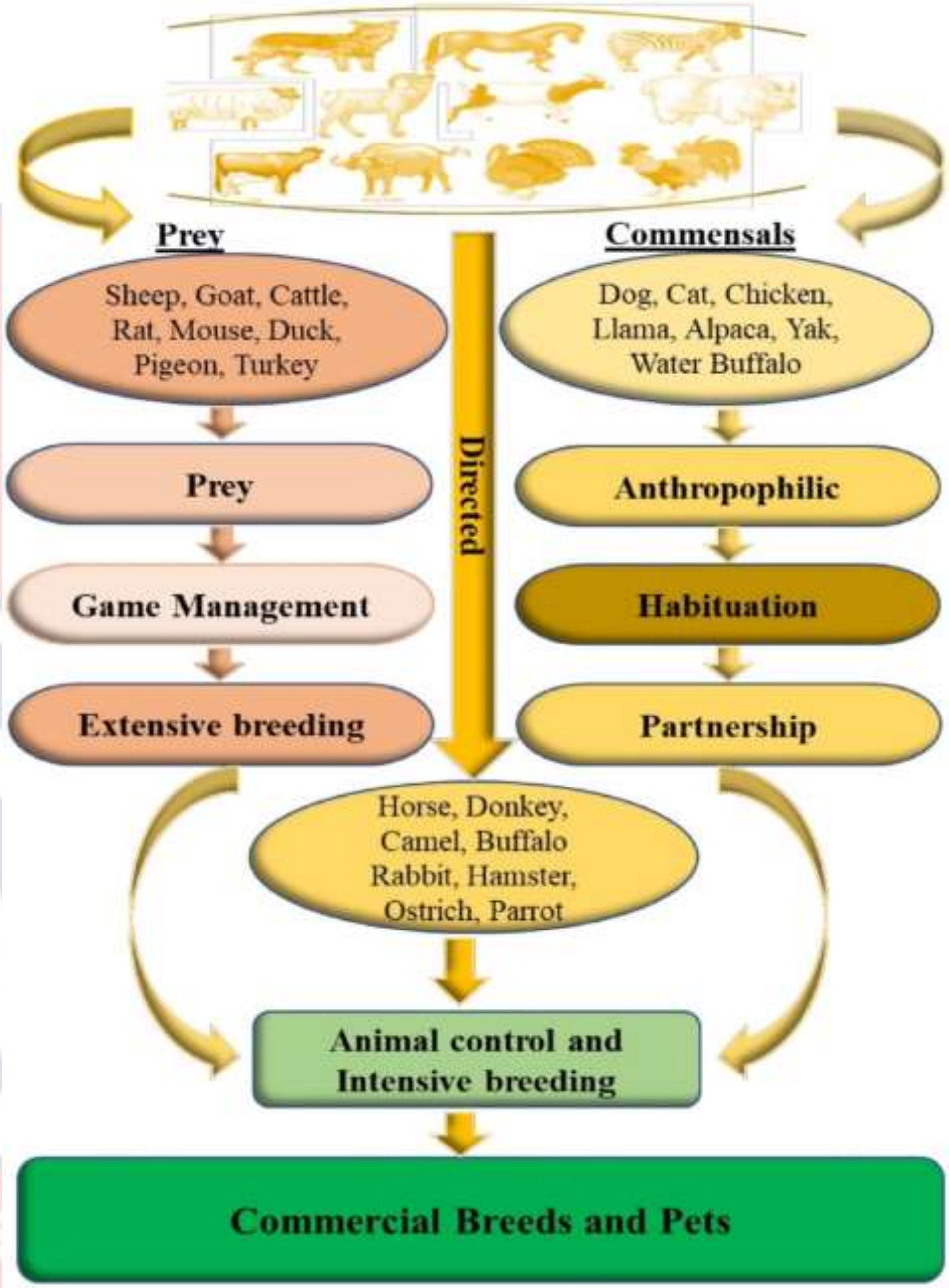


Figure 1: The domestication process of quail

Global quail production and Population size

With an estimated yearly output of nearly nine billion quails, China is known as the world's greatest quail producer. But when it comes to quail egg eating, Japan leads the way. Quail are mostly produced in nations like Italy, Spain, Brazil, the United States, France, and Japan. In terms of production volume, quail ranks in second place to chicken. Despite the widespread acceptance of chicken and other types of poultry, quail farming is progressively expanding and attracting a lot of interest on a global scale. Quail meat production accounts for 0.2% of all poultry meat produced worldwide.

Production Environment of quail

Quail can be managed and produced using a variety of production systems, depending on the breed type, input and output levels, intended use, and flock size. The most preferred method for raising commercial quails for meat and eggs is intensive management Wamuyu *et al.* (2017). A deep litter system and battery cage are parts of an intensive quail production system. The thorough system makes sure that the birds are safe from predators and harsh weather. Animals are often not exposed to illnesses, in contrast to the complex manufacturing system.

According to Qureshi *et al.* (2016), quails' performance is impacted by environmental factors such as diet. Quails can adapt well to most climatic situations, but their home must be favorable and appropriate. Birds kept indoors experience less mortality, predator exposure, and pathogen exposure. The battery cage and the deep litter system are the two basic housing arrangements that are advised for quail production. Battery cages have wire-mesh flooring so that droppings and garbage may be readily collected. Wamuyu *et al*. (2017) suggested that due to good management techniques and the restriction of the birds' flying modes, quails perform typically better in battery cages than in deep litter. The inability of the bird to fly whiles in the cage increases feed efficiency and also prevent diseases. The author concluded by advising that the floor density of the battery cage and deep litter system used to produce quail should be 200 cm2/layer.

However, compared to purchasing a battery cage, building a deep litter system is far simpler and less expensive. According to Momoh *et al*. (2014), different housing systems have an impact on the productive and reproductive qualities of Japanese quails. In contrast to Momoh *et al*. (2014), Olawumi (2015) investigated if the production system for quails altered the features of their carcasses. As a result, the live body weight and other carcass parameters were the same for quails raised in battery cages and deep litter systems. Anima (2017) conducted research on the performance of Japanese Quail in Egypt and found that the housing system had no discernible impact on the productive qualities. The housing system utilized in the production of poultry guarantees that the birds are protected from harsh environmental conditions, improving performance. The mortality, exposure to predators, and viruses that because disease are all decreased when birds are kept in a litter house. Adi *et al*. (2018) also came to the conclusion that a stocking density of 77 birds/m2 may improve performance after examining the effects of sex and stocking density on the productive and reproductive performance of quail.

Figure 2: Housing system of local quail population within the Coastal Savanna AEZ

Productive and Reproductive performance

Generally, the productive and reproductive performance of most quail breeds has been reported by several researchers to be higher than most species of the avian. The conclusion of a study by Hiemel, Sejuti, & Jahid, (2020) on morphometric, productive, and reproductive performances of Japanese quail (Coturnix japonica) showed a higher productive and reproductive performance as compared to chicken which has become the most accepted on the global market. From the study, if the management and rearing systems of quails are been properly checked, it would enhance their productivity and reproductive performance. Zahid & Hamid (2017) stated that female quails can lay about 250 to 300 eggs per year which makes them highly prolific and they commence laying at six weeks of age. A study on the impacts of heat stress on the reproductive and productive performance of quails by Alagawany, *et al.* (2017) came to the conclusion that quails are negatively impacted by heat stress. Thus, heat stress reduces egg mass, egg output, feed efficiency, and growth rate. The research also revealed that heat stress had a negative impact on bird productivity, reproduction, and welfare. To diffuse the argument of Alagawany *et al.* (2017) and to ascertain the "reproductive potential and egg-laying performance of quails in savannah ecological zone of Ghana" Timothy & Imoro (2020) conducted a study and the results showed that the productivity and reproductive performance of quails are not affected by heat stress.

Furthermore, the savannah ecological zone of Ghana is highly desirable and serves as the natural habitat for the production of quails. Another study by Timothy & Imoro, (2020) on the "growth, reproductive and survival of quails in savannah ecological zone of Ghana" confirmed that the growth and reproductive performance of quails are not affected by the dry guinea savanna ecological zone. They, therefore, recommended to the local poultry farmers to utilize the climatic conditions to increase their production of quails in Ghana. The argument was however spiced by Santos *et al.* (2019) who determined the productive performance of Japanese quails after subjecting them to different environmental conditions and reported that a production environment with high air velocity increased egg production and feed intake. Temperature and air velocity were also shown to have an effect on productive performance, with the exception of egg weight and feed conversion. They determined that air velocity is vital in removing heat from the bird's surface. Furthermore, Hassan, Ayman, Heba, & Magda, (2019) investigated the "growth and reproductive performance of Japanese quails under diverse light conditions" and discovered that Japanese quails reared under red color light had a greater body weight than those reared under green and white color light. Thus, birds subjected to red color light attain sexual maturity than those reared under white and green color light. They, however, concluded that growth and reproductive performances are enhanced when Japanese quails are reared under red color light.

Miska *et al.* (2010) reported that quails are monogamous birds whiles Hussen and Hassan, (2016) considered them to be polygamous. However, studies have shown that quails undergo a transitional state between monogamy and polygamy during mating periods. Several factors stimulate mating which includes ambient temperate, access to adequate food, and the effect of sex hormone concentrations. Minville *et al.* (2004) therefore recommended that the mating ratio of domesticated quails should be 1:2 to 1:4 which should be proportional to the production environment. Wild Japanese quails tend to express nesting and brooding behavior but this behavior is absent in domestic quails as quoted by Qureshi *et al.* (2016). In addition, the domestication of quail from the wild type also influenced changes in other sexual and reproductive behaviors such as vocalization, mating calls, aggression, and fighting. Thus, the sound produced by domesticated Japanese quails and its wild type are not the same. Mizutani *et al.* (2003), however, reported a contrasting view and stated that both the domesticated Japanese quails and the wild-type Japanese quail produces identical sounds. Wild Japanese quails make a unique sound during feeding, when frightened, and also during mating. The expression of aggression and fighting in both domesticated Japanese quail were found to be the same as the wild Japanese quail. It is reported by Minville *et al.* (2004) that male wild Japanese quail reaches sexual maturity at 52 days of age whiles the females attain sexual maturity at 63 days of age. Early sexual maturity is one key production trait in quail which is influenced by external and internal factors. Male quails attain sexual maturity at 52 days of age whiles females at 63 days of age. This trait is, however, affected by different feeding patterns and production environments. One common feature of the Japanese quail which is influenced by domestication is its high egg-laying capacity. Additionally, productive traits such as fertilization, hatchability were also boosted due to domestication. Several factors induced this economic trait in the domestic Japanese quail which include the elimination of the brooding instinct, early onset of sexual maturity, absence of seasonal reproductive pattern, and lowered sensitivity to stress. It is reported that the wild Japanese quail lay eggs whose weight is about 7.6g in contrast to the domesticated Japanese quail which lay eggs of average weight 9-14g.

Another study to assess the influence of light intensity on the performance and welfare of Japanese quail (Mohammed, Hesham, Rania, Ayman, & Islam, 2019) found a favorable link between light intensity and reproductive performance. This suggests that light intensity is one of several variables influencing poultry productivity and reproductive success. Low light intensity, on the other hand, resulted in bigger egg weight and improved egg quality. It is realized from the study of Omane *et al*. (2020) about the reproductive performance of quail that the mean age at first egg ranged from 45.3 to 58.9 days. The findings of this report concur with the study of Khan, (2020) which is also measured a range of 50.94-61.22 days in Egypt. Similar research was also conducted in Nigeria where Rosen *et al*. (2014) studied the growth of egg production and reproduction performance of quails and recorded 54.49 days. In Egypt, a comparative study was performed among three lines of Japanese Quails to identify the role of plumage color in the productivity and reproductive performance. The study revealed that brown colored quails are good meat producers while white colored quails are associated with better egg production.

However, black colored quails showed the least productive characteristics. In Ghana, the productive and reproductive performance of quail was adversely influenced by inbreeding owing to the strict intensive management system which only allow for indiscriminate mating. The management system practiced by quail farmers was prone to inbreeding depression which results from mating of closely related relatives. Identical-by-descent bird mate among themselves and results in increased homozygosity, which, in turn, reduces performance of production traits. Inbred animals are homozygous for more loci (genes). Inbred organisms have lower fitness level through the expression of deleterious alleles. Alleles are different variants of a gene.

Population structure and estimation of inbreeding rate

Inbreeding coefficient or inbreeding level is the probability that two alleles at a locus are identical by decent or probability that an individual has two identical alleles for the same gene. Inbreeding coefficient in a population can be estimated by the use of pedigree records and also by molecular information. Inbreeding coefficient range from 0-1 where a value lower than 0.05 is considered desirable. All animals in a population are related and therefore, the average increase in inbreeding coefficient (F) across generation or from one generation to the next is called rate of inbreeding (ΔF). Increased in the rate of inbreeding results in decreased in genetic diversity. Therefore, rate of inbreeding (ΔF) = $(F_{t+1})/(1-F_t)$

However, inbreeding coefficient (F) = $\sum(1/2)^{n1+n2} * (1+ F_A)$

where F is the inbreeding coefficient

F_A is the inbreeding coefficient of the common ancestor

n1= Number of generations of the sire back to the same common ancestor

n2=Number of generations of the dam back to the same ancestor

and n2 are the number of generations separation the birds from their parent or ancestors. It can be inferred from the equation above that the rate of inbreeding is proportional to the population size (active breeding population) and not the total population size. Therefore, the rate of inbreeding could also be associated to the active breeding population by the equation below;

(ΔF) = $\frac{1}{8Nm} += \frac{1}{8Nf}$, where Nm is the total number of breeding males and Nf is the total number of breeding females. According to FAO, (2012) the rate of inbreeding in a population must be kept below 1% or preferably below 0.5%. This is to ensure risk management of the population and not for insurance since alleles and genes at the locus do not have equal effects. Sometimes an increase of 1% in homozygosity of the population could be deleterious to the population.

Also, inbreeding depression refers to the reduction in performance and viability due to the increase in inbreeding levels or reduced genetic variation.

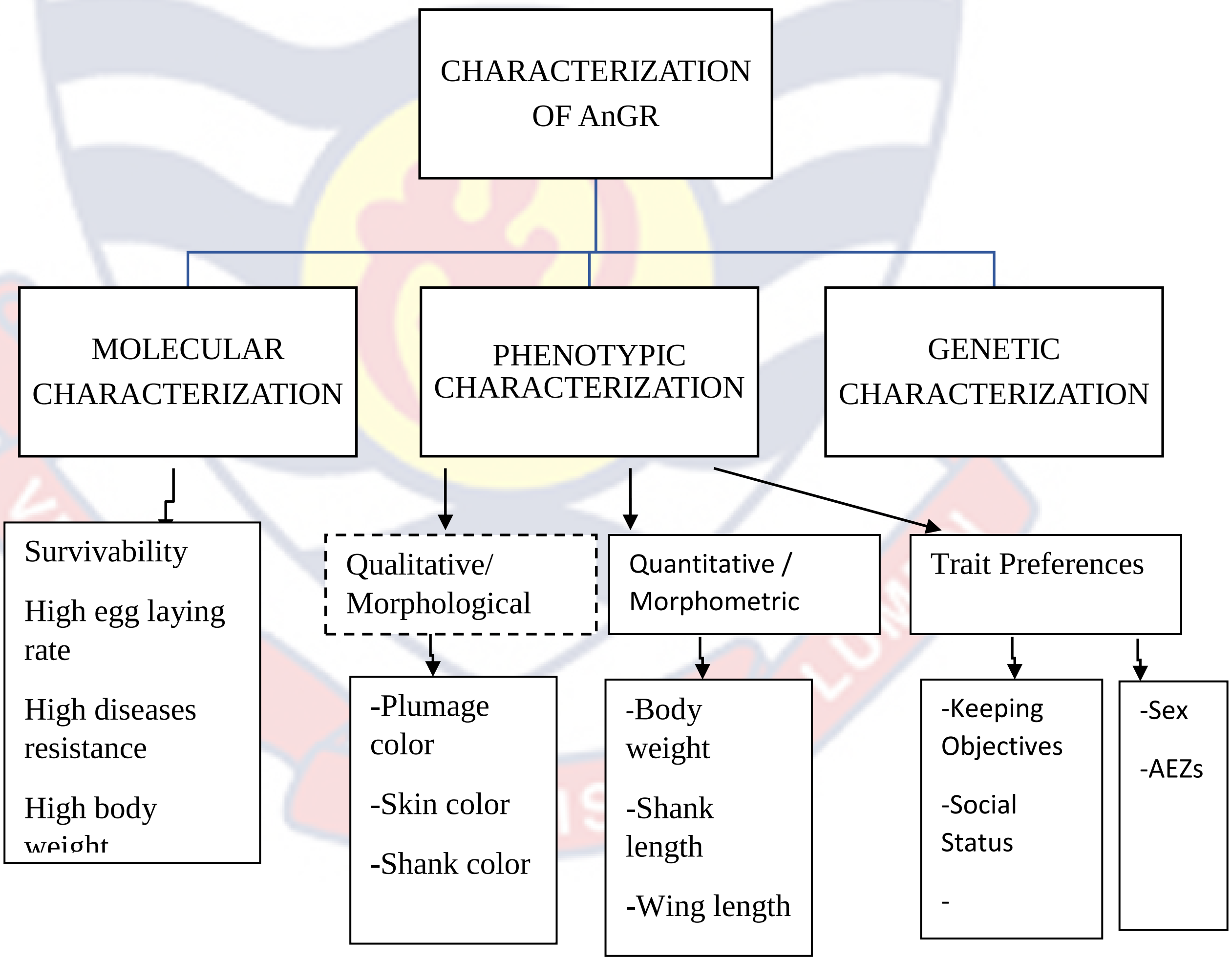
Challenges confronting quail farming in Ghana

In Ghana, non-traditional local quail production is also an industry that is not exempted from the numerous challenges that the poultry sector is battling. In addition to the challenges that the whole poultry sector faced by the emergence of the Coronavirus Disease 2019 (COVID-19), there is a unique setback that hinders the growth of commercial quail farming in Ghana. These restrictions include those related to marketing, transportation, and production management. Abou *et al*. (2016) examined the major issues affecting the quail business in Nigeria, including the high death rate of day-old quail chicks, an unpredictable market, expensive feeding and shipping costs, a lack of government assistance, poor agricultural equipment, and insufficient funding. Wayumu *et al*. (2017) highlighted that other factors that lead to the decline of the quail business include poor housing systems, theft, predation, a lack of expertise, changes in market pricing, an inability to access loans, and misunderstandings regarding rules governing urban agriculture. To add with, the size of commercial quail about its market price when compared to other poultry species such as chicken and duck continues to lower and has rendered low customer acceptability. Many regard quails as too small to be on the market and not attractive for established institutions like hotels and restaurants as commercially breed chicken are generally accepted. Moreover, the sector also struggles with ‘avian diseases, poor health care, and the high cost of feed. In most developing countries such as Ghana, cereal like maize, soya bean is produced to feed the human population and this increases the production cost of quail when raised with cereal meal.

Economic importance of quail

The economic importance for the domestication of local quail populations as an agricultural species is its ability to produce consumable eggs and meat with unique flavor and taste Lukanov (2019). The cost involved in quail production and maintenance is relatively low as compared to raising chicken and other poultry species. Also, its smaller body size coupled with short generation interval ensures early maturity which reduces the cost of production. Most breeds of quail are known to be resistant to diseases thereby saving the cost of vaccination. The faster growth rate associated with the short generation interval per year has rendered it an excellent species as a laboratory animal. There are several health benefits of consuming quail eggs and meat. The regular consumption of quail eggs improves the rate of metabolism, strengthens the bone, assist to accelerate recovery from illness or deformities, ensure constant levels of blood sugar levels. Quail eggs also tend to detoxify the body and serve as anti-aging agents, reducing the loss of hair and nails. With this regard, global annual quail production for meat and eggs stands at 1.4 billion. Regardless of the smaller size of quail eggs compared to chicken eggs, it is packed with more quality nutrients that are needed by the body. Modern studies on the nutritional content of quail eggs revealed higher calorie and protein value, higher fat content, and less bad cholesterol as well as a higher proportion of yolk and albumen. Furthermore, eggs are rich in antioxidants, vitamins, and mineral salts. The regular consumption of quail eggs improves the rate of metabolism, strengthens the bone, assist to accelerate recovery from illness or deformities, ensure constant levels of blood sugar levels. Quail eggs also tend to detoxify the body and serve as an anti-aging agent, reducing the loss of hair and nails. On the other hand, quail meat is also packed with rich health and nutritional benefits. The world population has continued to increase exponentially and it has become necessary to locate alternative sources of animal protein to augment the existing ones. According to FAO (2012) the world population is projected to hit nine billion by 2050, and thus there is the need for an alternative source of food that is rich in nutrients to curb malnutrition challenges. The introduction of poultry birds especially quails in recent times has been recommended by FAO (2012) in nutrition and food security intervention programs for most developing countries.

Figure 3: Samples of quail Eggs



Source: Author's Construct (2022)

Sex Determination

In general, determining sex in most chicken species is difficult, resulting in financial losses in commercial farms Akintan (2017). This includes quails, which cannot be distinguished by sex at an early stage of development. Quail sex differences do not become apparent until the contour feathers grow at 2 weeks of age or later. Visual sexing is a unique method of determining a bird's sex. This is made possible in Quails by variances in the hues of the breast feathers. Males have brownish-red feathers, while females have gray feathers with black speckles. Some species' breast feather colors, however, stay same in both sexes even beyond adulthood. Araby *et al*. (2018) further said that the vent inspection technique is a popular sexing procedure in quails. As a result, developed quails may be sexed by looking at the vent or cloaca. When the cloaca is squeezed, sexually active men frequently create white foam, whereas females do not. The use of color marker genes for autosexing is another strategy used in sexing day-old quail chicks.

Breeds of quail

According to Lamia (2017), there are around 130 quail breeds, but only two are suitable for commercial use. The Japanese quail (Coturnix coturnix japonica) and the European quail (Coturnix coturnix Coturnix) are the two species (Calvaho & Noguira, 2020). The most widespread species in Europe is the European quail, sometimes known as the common quail. It weighs around 135g and measures 16 to 18 cm in length. It has eye stripes and plumage ranging from brown to white. The Pharoah or Coturnix Quail is another name for the Japanese quail. The predominant color of Japanese quail is cinnamon-brown or grey with brown flecks. In mature plumage, females have light breast feathers with black markings. The mature male, on the other hand, has dark, slightly scarlet plumage on his breast and cheeks. There is albino, white, isalline, silvery, brown, mixed, and black color variations of the Japanese species. They mature at roughly 6-7 weeks of age, with an average body weight of about 90g and some weighing up to 300g.

Studies on the Morphometric traits of quail

Body Weight (BWT)

Body weight is a critical quantitative property that is used to determine a variety of other economic parameters in farm animals. This implies that body weight is used to assess growth, feed efficiency, economic and market decisions, and customer acceptance in general Momoh *et al*. (2014). (Kadraoui, Mennani, & Semir, 2019) did a study on the phenotypic and morphometric characteristics of numerous strains of quails bred in Algeria and determined that the average male body weight is 171.39g, while the female counterpart weighs 181.34g. Female quails are therefore 10g heavier on average than males, although there is no significant difference in linear body dimensions like as wing length, body length, wingspan, thigh length, and keel length. The morphometric, Japanese quail (Coturnix japonica) productive and reproductive capabilities were also tested in Sylhet, Bangladesh, and all morphometric features measured were considerably different. In contrast to earlier research, (Tsachalidis, Paralikidis, Tsiompanoudis, & Trikilas, 2007) discovered that gender has no effect on the bodyweight of quail.

As a result, the bodyweight difference between male and female quail is not statistically significant. It is important to note that one of the most recent studies on the morphometrical comparisons between the sexes of common quail in the Pakistani district conducted by Wajahat, Usama, Iqra, and Hafiz (2021) produced findings that were in conflict with the study by Tsachalidis, *et al.* (2007). According to the findings of their investigation, there is a gender difference in body weight and body length. A wild Japanese quail's typical live weight ranges from 85 to 110g, with males being lighter than females. Domesticated quails, on the other hand, are heavier than wild Japanese quails, with weight varying according on production environment and breed. Adi *et al*. (2018) revealed in their study to determine the sex of quails at an early stage of life that there was no significant difference in body measures between male and female quails ($p>0.05$) during the first week of life, but the variance begins from week 2. Talukder *et al*. (2020) claimed that the body weight of chicken rises as the bird grows older. Vargas-Sanchez *et al*. (2019) reported the body weight of domesticated quail at the second and eighth weeks to be 35.23g and 143.78g, respectively.

In an effort to determine the body weight difference between male and female quails, Wayumu *et al*. (2017) found that there is no appreciable variation in body weight between male and female farm-reared quails. However, Wayumu *et al*. (2017) discovered a significant difference in body weight between male and female wild quails. Therefore, it was found that female quails were 5g heavier than males, which is consistent with the findings of (Tavaniello, 2014; Qureshi *et al*., 2016; & Kadraoui *et al*., 2020) who discovered that female quails were slightly heavier than male domestic quails but lower than the findings of wajahat *et al.* (2017). According to Minvielle *et al*. (2004) quails produced for meat on farms are heavier than quails raised in the wild. Furthermore, it was acknowledged by (Nurinc *et al*., 2015; Adi *et al*., 2015) that quail sex affected their body weight. The live body weight of a developed quail was also discovered by Momoh *et al*. (2014) to be 89.8g as opposed to Tsachalidis *et al*. (2007), who reported that quail's male and female body weights are 103.6g and 110.5g, respectively. Wajahat *et al*. (2021) also state that the body weights of male and female wild quail are 72g and 78g, respectively. A similar discovery was reported on European quail, where males had lower body weight than females Tsachalidis *et al*. (2007). Naveed *et al*. (2020) discovered a significantly significant difference in body weight in a study of 28 quails in Pothohar, Pakistan. Hamad *et al*. (2019) investigated the influence of age and sex on various physical and chemical properties of quail corpses and discovered that, unlike other poultry species, quails are sexually dimorphic birds, with females having bigger body size than males. This data also supports the findings of Jun *et al*. (2015), who discovered that the live body weight of quails increases with age. Male and female quail live body weights at 6, 9, and 12 weeks were reported to be (155g, 165g, 178g,) and (190g, 174g, 208g), respectively. Female quails had a higher average live body weight (191.111g) than males (166.11g). Another study indicated that weight increased as the birds aged, using linear body measurement to predict body weight in Japanese quail. After two, four, six, and eight weeks, the body weight was 38.31g, 81.12g, 121.38g, and 132.15g, respectively. Jun *et al*. (2015), on the other hand, found lower body weight and linear body measurements than prior researchers (Julien *et al*. (2015); Himel *et al*. (2020); Epko *et al*. (2020). As a result, it is a genuine portrayal of morphometric features predicted from birds from various populations and production situations (Adi *et al*., 2018). Female birds were also found to be considerably ($p>0.05$) heavier than their male counterparts. According to Alagawany *et al*. (2017), the average body weight at hatch, 2, 4, and 6 weeks was 9.15g, 43.18g, 111.90g, and 172.21g. Andre, (2021) measured the body weight of quail and determined that the average body weight is 7.6g, 20.2g, 43.1g, 76.8g, 114.5g, 149.0g, and 178.0g. Ajmone-Marsan *et al*. (2009) observed that the mean body weight of Japanese quail at 14, 28, and 42 days of age was 51.2g, 119.2g, and 176g, respectively. Ainsworth *et al*. (2010) investigated the impact of gender on body weight and discovered that females were heavier than men.

Body size differentiation of local quail populations

Wing Length (WL)

Wamuyu *et al*. (2017) discovered that female farm-reared quails have greater wing lengths (100cm) than males in an attempt to explore the morphometric features of quails (89.7cm). However, as assessed by Wamuyu *et al*. (2017) there was no significant variation in wing length (96cm) between wild quails. This work is comparable to that of (Udoh *et al*., 2020; & Qureshi *et al*., 2016), who examined the wing lengths of farm-reared and wild quails and found no difference. On the contrary, research on quails (Wajahat *et al*., 2021; Qureshi *et al*., 2016 & Santhi *et al*., 2017) revealed that wing length varies considerably across sexes, with a 0.5mm variation

Shank Length (SL)

To further understand the morphometric characteristics of quails, Chimezie *et al*. (2017) assessed the shank length at 2, 4, 6, and 8 weeks of age to be 1.94cm, 2.44cm, 2.44cm, and 2.52cm, respectively. Male and female farm-raised quails have the same shank length (Wayumu *et al*., 2017; & Kadraoui *et al*., 2020). However, female and male wild quails had different shank lengths, as determined by Wayumu *et al*. (2017). According to the study, female quails had a shank length of 31 cm as opposed to 30.7 cm in males. Therefore, farm-raised quails have a longer shank length than wild quails. Hanusova *et al*. (2016) also found that the length of the quail's shank affects both feed intake and production characteristics. Momoh *et al*. (2014) also reported that the average shank length of a developed quail is 3.9cm.

Body Length (BL)

The body length of farmed quail was measured by Fayeye *et al*. (2013) in Nigeria at 2 and 8 weeks of age, and they discovered a rise from 11.84cm to 19.45cm. According to Tsachalidis *et al*. (2007), the total body length of male and female quail is 19 cm and 19.3 cm, respectively. This study supports their findings. The considerable disparity in quail body length was also noted by Udoh *et al*. (2020). Wajahat *et al*. (2021) also found that a wild male and female quail's total body length is 24.7cm and 22.9cm, respectively. Similar findings were published by Qureshi *et al*. (2016), who found that male and female body lengths varied substantially, with males (233.75mm) being longer than females (227.81mm). Female quails have greater body lengths than males, according to Tsachalidis *et al*. (2007). Qureshi *et al*., 2016; Udoh *et al*., 2020; and Wajahat *et al*., 2021 demonstrated the contrary. Furthermore, according to Chimezie *et al*. (2016) body length rose from 12.41cm at week 2 to 18.60cm at week 8. Also, in Bangladesh, Talukder *et al*. (2020) estimated the total body length of quail as 18.05cm, which is less than the report of Chimezie *et al.* (2016).

Body girth (BG)

At weeks 2 and 8, Tavaniello *et al*. (2014) measured the body girth of farmed quail and found that it was 8.02 cm and 13.67 cm, respectively. Chimezie *et al*. (2016) reported an increase in body girth from 9.11 cm at week 2 to 14.43 cm at week 8, and the measured values are lower than those reported by them. The findings of Udoh *et al*. (2020) and Chimezie *et al*. (2016) show that sex and the environment of production have a significant impact on the morphometric characteristics of local quail populations.

Morphological traits

Qualitative or morphological qualities must be measured in order to characterize the differences between individual local populations and closely related individuals. Morphological measurement is also used accurately to determine animal sex. This means that the physical appearance of quail varies according on their developmental stage. Male and female quail chicks under one week old normally have the same plumage color. Quails' plumage exhibits sexual dimorphism, allowing them to discriminate between men and females. The exterior physical form, shape, color, and look of a live animal are examples of qualitative features. The discrepancies in these qualities may be classified into a few distinct types known as discontinuous variation. Typically, they are expressed as discrete or categorical variables. Because all qualitative features are governed by genes rather than environmental variables, they may be properly documented and predicted for specific local animal populations. Qualities of quail include plumage color, skin color, and shank color. Some qualitative qualities are also employed for animal identification when permanent identification of individual animals is not possible. Some, on the other hand, are used to categorize local animal populations based on sex, age, and strain. The domesticated quail's plumage colors include golden, Tuxedo, brown, and white. Minvielle (2004) discovered that the skin color of domestic quail's ranges from white to yellow to blue-black, with comparable characteristics seen in shanks.

Plumage Colour differentiation of local quail population

The color of an avian's plumage is a trait shared by all species. Feathers serve three primary functions in living birds. First, they offer insulation, allowing the birds to maintain a steady internal temperature in a wide variety of changeable external circumstances. Second, feathers can be used to hide a bird or to entice a mate. Third, the various sizes and forms of feathers allow birds to fly. In poultry, there are two forms of color. These are patterns of primary and secondary colors. A color pattern that manifests on specific feathers is known as a secondary color pattern. for instance, mottled, single and double lacing. A primary color pattern covers the animal's entire body. Think about the Silver Columbian design. The neck, wings, and tail of the white bird known as the Silver Columbian are covered in black dots. The secondary color pattern genes change the color of the background, which is principally regulated by the E-locus gene. As a result, multiple genes interact to define feather color and pattern. Sara *et al*. (2008) observed that by mixing different plumage colors, the Japanese quail may express a wide range of plumage colors, including black, yellow, white, wild-type, and other intermediate colours. According to Tanasorn *et al*. (2013), the colors of birds are determined by a combination of structural and chemical colors emitted by melanocytes. The pigment that gives a bird its color is made up of two forms of melanin: brown/black eumelanin and yellow/red pheomelanin. The degree of tyrosinase secretion determines the formation of each melanin. High tyrosinase activity results in melanin synthesis, whereas low activity leads in pheomelanin formation. Quail feather coloring includes:

- ❑ Pharoah (Rusty brown presented underbelly and an original brown color on the head and upper body)
- ❑ English White (White all over in both males and females),
- ❑ Manchurian Golden (Light rusty all over with a pattern, males have a darker rusty color presented on the head while females are lighter in color)
- ❑ Italian (Beige with striated marking. Males are presented with brown faces
- ❑ Tibetan (Dark British Range-dark chocolate all over with a spot of white under the beaks
- ❑ Rosetta (British Range-Red-brown chocolate all over
- ❑ Silver- Light grey all over

- Tuxedo- White and brown mix
- Cinnamon (Red Range- Light brown all over
- Scarlet (Red Golden-Red-brown all over
- Roux- Lighter than the Pharoah (wild) version
- Golden Tuxedo- White feathers all over with blonde feathers presented.
- All other color variants are due to mutations

Several researchers (Wajahat *et al*., 2021; Sara *et al*., 2016; Minvielle *et al*., 2004; & Santos *et al*., 2019) after comparison of three quail lines based on colors agreed that brown quails perform better in meat and egg than black colored quails. Minvielle *et al*. (2004) also added that bodyweight abdominal fat, as well as egg characteristics, are influenced by the plumage color of quail. Tsachadilis *et al*. (2007) recommended that white colored quails should be selected for meat production whiles the brown color performs better in egg-laying.

Wild/Pharaoh/Brown (male) **Wild/Pharaoh/Brown(female)**

Wild/Pharaoh/Brown Tuxedo(male)

Wild/Pharaoh/Brown Tuxedo (female)

Golden Manchurian(male)

Golden Manchurian(female)

Autumn Amber

Black Barred Italian

Australian Redhead

Rosettas

Rosetta Tuxedo

Tibetan Tuxedo

Barred

American Pharaoh

 Silver/Cream	 Tuxedo
 Blue quail	 Charcoal

	
Red Range	**Scarlet**
	
Roux Dilute	**Roux Tuxedo**

Texas A& M White

Tibetan Tuxedo

Figure 4: Differentiation in plumage colour of wild and domestic quail populations

Shank and Skin colour

The color of quail shanks (foot) is formed by the mix of hues in the top and deeper skin. The color of the quail shank is determined by three different genes. The Z chromosome serves as the sex-linked host chromosome. Tsachalidis *et al*. (2007) and Wamuyu *et al*. (2017) discovered variations in the color of the shank and skin of wild and farm-raised quails in Kenya. According to their findings, both male and female wild quails had the same skin and shank color, which were yellow and pink or red, respectively. The skin and shank colors of farm-raised quails (males and females) were the same and were pink and white, respectively. Wamuyu *et al*. (2017) found differences in the shank and skin color of wild and domesticated farm-feared birds.

Fig.5 Variation in shank length of local quail population

Trait Preferences

The phenotypic characterisation of AnGR allows for the economic assessment of non-productive features. In Ghana and other developing nations, the goal of growing a certain type of livestock comprises a variety of adaptive features and non-marketable utility activities. These duties include identifying important qualities and classifying them in order of preference based on the keeper's purpose. Also, by documenting preferences for a certain breed, the economic relevance of the breed under discussion may be determined. Thus, information on livestock keepers' preferences and views of a breed and its features is critical for genetic improvement and conservation efforts FAO (2012). According to Ekpo *et al*. (2020) the reasons for quail production by many farmers in developing nations include survival, early maturity, carcass weight, and higher body size. Ofori & Hagan (2021) investigated the characteristics and trait preferences of WAD keepers in Ghana and discovered that the farmers' most valued morphometric qualities were survival, quick growth rate, and big litter size.

Correlation among morphometric trait of quail

The two most common strategies for assessing the connection between two quantitative variables are correlation and linear regression. Correlation determines the strength of a linear link between two variables, whereas regression analyzes relationships as equations. The degree of link between two quantitative variables that have been evaluated is expressed by the correlation coefficient. Additionally known as Pearson's correlation, it is frequently denoted by the letter r. Correlated qualities are those in which changes in one cause changes in the other. Both genetic and environmental variables influence the correlation of two phenotypic features. Genetic correlation is the total of a gene's addictive influence on a certain attribute. Environmental correlation, on the other hand, refers to the connection caused by non-addictive hereditary elements or environmental variables such as diet, housing, medicine, climate, and so on. Fayeye (2014) states that the correlation between two attributes might range from +1 to -1, with a low (0.4), medium (0.4-0.6), or high correlation (above 0.6). A correlation value near -1 indicates a strong negative linear relationship, a correlation coefficient near 0 shows no linear relationship, and a correlation coefficient near +1 indicates a strong positive linear relationship. Correlation may be expressed mathematically as follows: $r\ (xy) = \frac{cov(xy)}{\sqrt{var(x).var(y)}}$

Symbolically,

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Were,

cov(XY) – the covariance between traits x and y var(x) – the variance for trait x

var(y) – variance for trait y

$r_{(XY)}$ – the correlation coefficient of the linear relationship between the traits x and y

x_i – the measured values of trait x

$\bar{x}$ – the mean of the values of trait x

y_i – the measured values of trait y

$\bar{y}$ – the mean of the values of trait y

Fayeye *et al*. (2013) discovered that body weight grew from two to six weeks of age and subsequently dropped with age in their study of the association between body weight and linear body measures in Japanese quail. At weeks two, four, and eight, the connection between body weight and linear body measures was substantially significant (p>0.05). According to Fayeye *et al*. (2014) the highest association between body weight and body girth was discovered in the second week of birth. This shown that quail body weight is directly related to body measures, particularly body girth and body length. Raji *et al*. (2009) discovered favorable associations between an AnGR body weight and numerous linear body metrics Fayeye *et al*. (2013) and Raji *et al*. (2009) reported similar results to Dudusola *et al*. (2018), who predicted body weight using linear body measurements and showed a positive connection with all linear body parameters except drumstick length at week 2. The best association (0.82) (p>0.05) was found between body weight and body girth during the second week of life, according to Dudusola *et al*. (2018). Significant linear measurements show that a rise in body weight resulted in an increase in linear body measurement over the course of a week. Body girth showed the highest association value with body weight at week 2 (0.82) and week 4 (0.72), which coincided with the findings of Rosen *et al*. (2014). According to the findings of several other investigations, the indirect method of calculating body weight by employing body measures is a critical, faster, simpler, and less expensive technique, particularly in remote regions where resources such as weight scales are unavailable Olawumi (2015). Furthermore, the association between body weight and linear body measures is crucial not only in forecasting body weight but also in genetic improvement tactics utilized by animal breeders. At weeks 6 and 8, the correlation estimates for wing length, shank length, and drum stick was between -0.19cm and 0.28cm. Raji *et al*. (2009) discovered strong positive associations between body weight and linear body measures.

According to Raji *et al*. (2009), body girth exhibited the highest association with body weight, followed by body length. Because of the close association between body girth and body weight, the existence of vital bones, muscles, and viscera may be related to the presence of vital bones, muscles, and viscera. Dudusola *et al*. (2018). Gurcan *et al*. (2010) investigated the association between live weight and different body measures in local quail populations and discovered that live body weight and body length were statistically significant for both female and male animal groups ($p>0.05$). The strongest correlation coefficient ($r=0.47$) was reported by Gurcan *et al*. (2010) between live body weight and body length. Rathert and Uckardes, 2017 discovered a substantial positive association between live weight and body length beginning in the second week when determining the sex of Japanese quails (Coturnix *coturnix* japonica) using zoometric data. The study concluded that zoometric assessment of quail live body features is valid for identifying local birds by sex in the early stages of life.

Canonical Discriminant analysis in morphometric differentiation and classification

In Nigeria, Opoola *et al*. (2020) used discriminant analysis of morphostructural traits of locally adapted turkey to distinguish between them. It was discovered that linear body measurements might be modified to forecast body weight in locations without access to measuring scales. The measurements of body weight, breast circumference, wing span, tail length, and bill length are the morphostructural characteristics that can most clearly distinguish between the different species of birds. Canonical correlation analysis was performed on the egg production traits of quails in another study by Rahimzadeh *et al*. (2017) in Nigeria, and the results showed that the first canonical correlation between the first and second pair of canonical variates was 0.41 and statistically significant ($p>0.05$). Also, canonical weights and loading from canonical correlation analysis indicated that weight at sexual maturity (SMW) had the largest contribution as compared with hatch time and chick length to variation of egg number of total 10 weeks, egg weight of total 10 weeks. The results also stated that the coefficient of variation for chick length had the lowest (1.57%) whiles the highest variation was hatch time (10.54%). In other words, when the Wilks Lambda values for the significant test of the canonical correlation coefficient were evaluated, it was proved that the first canonical correlation coefficient (0.41) calculated between only the first canonical variable pair was found statistically significant (p>0.05). Meanwhile, the canonical correlation coefficient between the second canonical variable pairs was found non-significant (p> 0.05). The outcome of this study is similar to the findings of Hidalgo *et al*. (2014) and Ribeiro *et al*. (2016), who reported that the first canonical variates as 0.658 and 0.1208, respectively.

The findings of the work of Mnisi *et al*. (2013) who studied canonical discriminant analysis of morphometric traits in indigenous chicken genotypes; naked neck (nn), frizzled feather (FF), and normal feather (NN) in Nigeria showing naked neck with the least of all body parameters. It was reported that two discriminant functions were extracted resulting in 100% total variance. In all, body weight, thigh length, body width had the highest discriminatory power of all the variables. The pair-wise square Mahalanobis distance closer relationship between normal feather and naked neck (3.371) and a greater distance between normal feathered and frizzled feathered chicken (4.620). The two functions yield Wilks lambda value of (0.895, 0.956) which is similar to Gurcan *et al*. (2010). This outcome is essential to understanding the genetic diversity of the chicken genotypes and can help to start a program for the preservation of the chicken genetic resources.

Conservation of Quail

Rapid climate changes and the subsequent threat it causes to AnGR is stimulating conservation activities in the last decade FAO (2015). Many countries across the globe are adopting conservation strategies to save endangered livestock species. Conservation of AnGR refers to all activities taken to protect wild species and their production environment to maintain their local populations. In situ and ex-situ conservation methods remain untargeted and most livestock species are not conserved in most developing countries such as Ghana. The major factors that threaten the extinction of wild species include habitat destruction, overexploitation, poaching, pollution, and climate change. When the production environments of wild species are being destroyed, it divides the populations into smaller groups. Smaller populations of AnGR are endangered and can easily go extinct. In Ghana, the rate of trapping wild species as a source of food is higher than the species tend to recover. This leads to overexploitation of our AnGR and a decline in their population over time. The displacement of AnGR from their natural habitat by pollutants also threatens them with extinction. One major effect of the increased world population is the generation of pollutants that leads to climatic change. The increase in temperature, changes in rainfall patterns, and severe drought negatively affect the survival of quails.

Methods of Conservation

The vast majority of livestock breeds in the world are in danger of going extinct, thus conservation initiatives are crucial to preserving these animals for future generations. The Global Plan of Action for AnGR (FAO, 2012), in which the strategic Priority area 3 is projected towards conservation, clearly states this action of protecting animals. Whether the animals are kept in vivo or in vitro, there are two ways to conserve AnGR. Whether it occurs in situ or ex-situ, in vivo methods can be divided into two categories. The keeping of animals in their traditional production environment is referred to as in situ while ex-situ is the keeping of the animals under established normal management conditions such as zoological parks or experimental farms outside the natural habitat of the species. It can be inferred that all in vitro conservation methods are ex-situ. In vitro conservation (Cryo-conservation) on the other hand, is the keeping of the genetic material under cryogenic conditions (cell and tissues) that tend to generate live animals and local populations. In Ghana, in vitro method has not been our main concern and is not widely implemented due to a lack of skilled personnel, infrastructure, funds, and modern equipment for its utilization. According to the first SoW-AnGR, the conservation of livestock species has economic, social, cultural, and environmental significance. It is also immensely used in research and training. Conservation of AnGR is important for food security. and food product quality.

Constraints to Conservation

In Ghana, the characterization of AnGR is affected by the following constraints; lack of funding, lack of technical skills and knowledge especially on genetic and molecular characterization, inadequate infrastructure and technical resources, lack of awareness on the part of the policy makers and keepers, lack of adequate policies and planning, and lack of coordination. Consequently, about 80 percent of AnGR in Ghana are not characterized and conserved.

Summary of Review

This chapter of the research captured the relevant literature needed for the establishment of the conceptual framework of the study. The focus was on studies conducted on phenotypic characterization of local quail populations which constituted both qualitative and quantitative traits. Even though some of the empirical findings of the qualitative and quantitative traits shared common values, there were also several inconsistencies in the measurement of the morphometric traits among the researchers in the scientific community. The findings of some studies revealed that there was no significant difference among morphometric traits of quails while other researchers reported contrasting findings. Also, the results of other studies have indicated that there is no significant difference among male and female domesticated quails whiles other studies also concluded that female quails were relatively heavier than male quails. Again, the empirical review showed that a positive correlation exists between the body weight and all linear body measurements such as body length and body girth except drumstick length. The bests correlation was acquired between body weight and body girth at the 2^{nd} week of age. Thus, it was concluded that body girth and body length could be used as means to assess and select Japanese quails for body weight.

CHAPTER THREE

MATERIALS AND METHODS

Introduction

This chapter interprets the materials and methods used in the study. It explains the research design, study area, and the rationale for choosing them. Additionally, it demystifies the population, sampling frame, sample size, data collection methods, instruments used in data collection, and the analytical tools used.

Research Design

The study employed a descriptive cross-sectional survey. This survey allows a researcher to describe a population's characteristics, and behaviors. The study aimed at describing the characteristics of local quail keepers, production environment, population size, structure as well as trait preferences and therefore, the survey was appropriate.

Study Area

The research was conducted in selected three AEZs of Ghana namely; Coastal Savannah, Semi-deciduous Forest, and the Transitional zone. These study areas were selected because according to a report by the Ghana Poultry Association, these areas are having the highest number of commercial quail farms in Ghana. Quails raised under an intensive system were included in the study. An AEZ is a land resource mapping unit, defined in terms of climate, land features (landform, soils, slope,) and land cover, and having a specific range of potential and constraints for agricultural land use.

Table 1: Description of the AEZs of the Study Area

characteristics	Transitional zone	Semi Deciduous Forest	Coastal Savannah
Climate			
-Temperature	25-36°C	24-31°C	24-30°C
-Relative Humidity	50-70%	60-80%	70-85%
-Rainfall	1100-1400mm	1200-1600mm	600-1200mm
Terrain features (land features)			
-Longitude	001°43'-001°57'W	001°29'-001°40'W	000°09'-002°02'W
-Latitude	07°36'-08°03'N	06°14'-06°36'N	05°00'-05°45'N
-Elevation	317-428m	260-400m	75-140m
-Slope	Very variable (hilly, fairly flat, and undulating)	Very variable (hilly, undulating, steep, and mountainous)	Very variable (hilly, flat, undulating, and mountainous)
-Soil type	Sandy-loam	Sandy-loamy	Clayey-loam
-Soil pH	Neutral (pH between 5.5 and 8.5)	Neutral (pH between 5.5 and 8.5)	Neutral (pH between 5.5 and 8.5)
-Surface condition (main substrate on which animals are generally maintained)	Variable substrate types (sandy, natural vegetation)	Variable substrate types (sandy, natural vegetation)	Variable substrate types (sandy, natural vegetation)
Land cover or vegetation	Woody savannah with a ground layer of grasses, scattered shrubs, baobab, and shea nut trees	Presence of tall trees interspersed with evergreen undergrowth	Coastal shrub in the upland interspersed with grasses
Land use	Cultivation of cash crops (cashew, cocoa, mango), arable crops (maize, cassava, etc), and rearing of livestock	Cultivation of cash crops (cocoa, oil palm, teak), arable crops (maize, cassava, cowpea), and rearing of livestock	Cultivation of cash crops (pineapple, cocoa, orange), arable crops (maize, rice, cassava, vegetables), and rearing of livestock

Sources: FAO (2012)

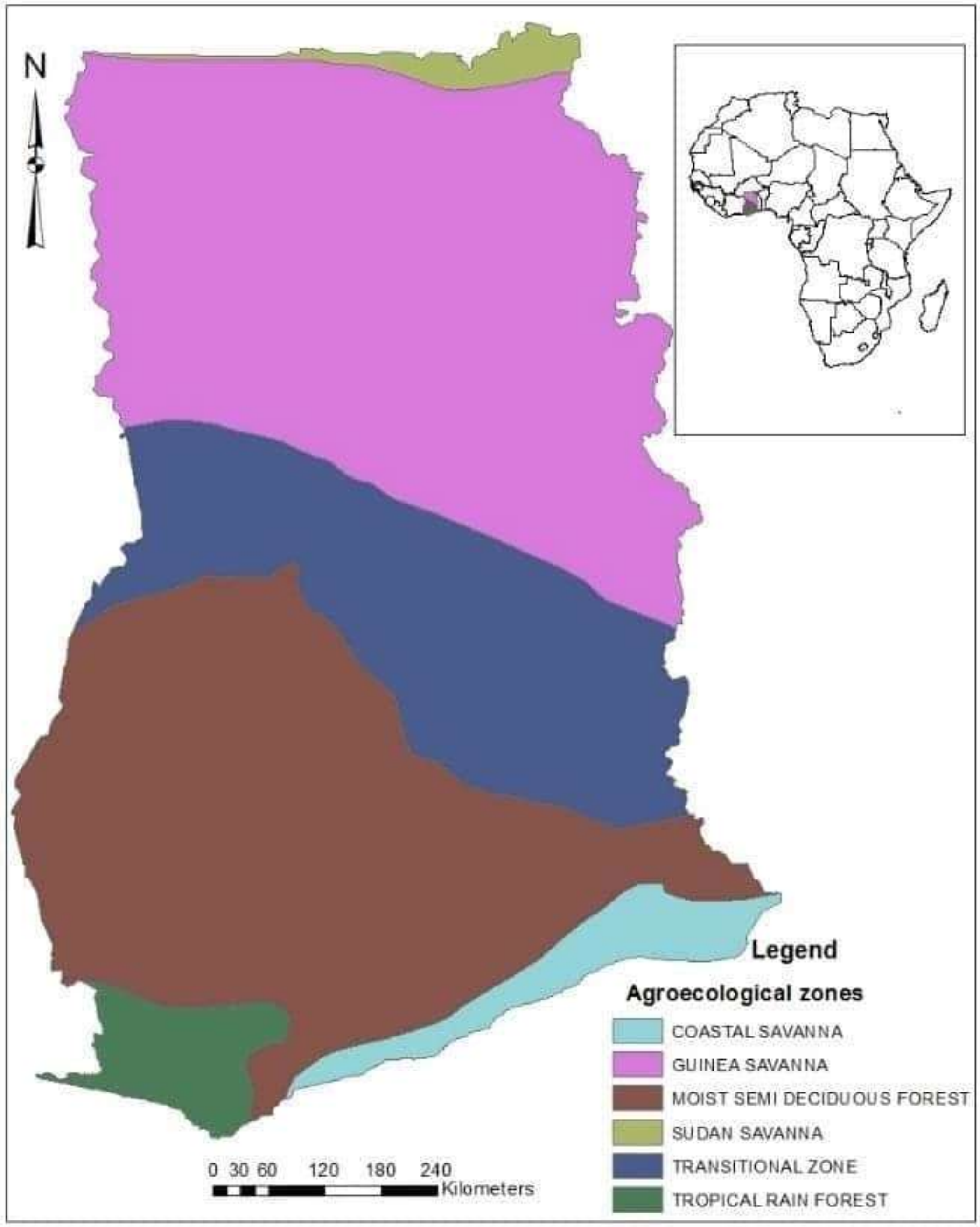


Figure 6: Geographical map showing the six AEZs of Ghana

Sampling frame

A combination of snowball and simple random sampling was used in the study Wamuyu *et al.* (2013). A total of ninety (90) quail keepers (30 farmers from each AEZ) were selected as respondents to questionnaires to describe the production system, keeping objectives, trait preferences, and socio-economic conditions as well as management practices of quail's farms in the three AEZ.

Table 2: Sampling Locations of the Study

AEZ	District/Municipality	Communities	Number of farms identified
Coastal	Cape Coast North	Akotokyir	1
Savanna	KEEA District	Elmina	1
	Kpone Katamanso	Afieye,Ashiyie,Sebrepor Oyibi	4
	Ablekuma Central	Amrahia,Frafraha,Chorkor,Gbawe,An	5
	Adenta municipality	yaa	5
		Lebanon,Atadeka,Zenu, Jericho,	
	Ashaiman Municipality	Afariwa	5
	Ga East Municipality	Weija, Botiano, Engleshie Amanfrom	
		Kwabenya,Ashorman,Dome	
	Ga West Municipality		3
		Sakomono, Community 25	
	KorleyKlottey Mu.	Dawhenya	3
	Tema Metropolis	Community1, Community 25	
	Ningo Prampram	Dodowa, Sege	
			2
			2
			1
Semi	Atwima Kwanwoma	Kotwi, Trede, Sabin Akrofuom and	5
Deciduous		Pakyi No.2	
Forest	Adansi South	Hweremoase, Kyiraburoso, Ayokoa ,	4
		Akwanserem	
	Ejisu-Juaben Mun.	Edwenase, Fumesua	2
	Abuakwa district		
	Asokore Mampong	Apirede	1
	Bantama municipality	Adum, Ayigya	2
	Afigya-Sekyere Dist.	Effiduase,Kona,Antoa,Nkawie	4
Transitional	Sunyani West District	Techiman,Chiraa,Tanoso,Fiapre	4
zone	Techiman Municipal	Berekum,Tuobodom,Akrofufu	3
	Berekum Municipal.	Wenchi, Kato	2
	Wenchi Munic.	Jinijini,Nsawkaw, Droboso	3
	Berekum West	Dormaa Ahenkuro	1
	Dormaa Central Muni.	Wamfie, Asuotiano,Mmrom	3
	Dorma East District	Nkrankwanta	1
	Dorma West	Sampa,Ayomso, Nkrampaso	3
	Jaman North	Kintampo	1
	KintampoSouth Mun.	Akumadan,Buoyem,Krabonso	3
	Nkuranza South	Busunya, Abease	
	Atebubu Amantin Mu.	Kwame Danso, Mankranso	2
	Wenchi Municipal	Kojo-Aduam, Pramso,Droboso	3
	Jaman South	Sampa	1

Table 3: Number of quails sampled for morphometric traits study

AEZ	Number of Sampled Quails		Overall
	Male	Female	
Coastal Savannah	60	120	180
Semi-Decidous Forest	60	120	180
Transitional zones	60	120	180
Total	120	360	540

Sample size

Animal management

The quails were kept under intensive systems of poultry production. All local quail populations involved in the research were properly taken good care of and fed with a balanced diet *ad libitum*. The determination of the sample size for a simple random sample that guided the study was following the FAO, (2012) recommended formula which is as shown below:

$$n = \left(\frac{z}{m}\right)^2 p(1-p)$$

$n = \left(\frac{1.96}{0.05}\right)^2 0.50(1-0.50)$=384

Thus, n= sample size; z= the z value (1.96 for 95 percent confidence level); m= margin of error (0.05 for +/- 5 percent); and p= the estimated value for the proportion of the sample that would be responsive to the survey conducted (0.05 for 50 percent).

Sometimes the finite population correction (FPC) factor was taken into consideration in calculating sample size for simple random samples. Although it has a negligible effect on the sample size when the sample is small relative to the population. However, in a very large population (10 percent or more) the FPC factor is appreciable. Therefore, the sample size equation for the new sample size is given by:

$$n' = n/(1+\frac{n}{N})$$

$n' = 384/(1+\frac{384}{6044000})$=383.9756

Thus, N= Population size; the population of quails in Ghana. N= new sample size=384

Data collection procedures

Ethical clearance was sought from the Institutional Review Board (IRB) of the University of Cape Coast before the collection of the data. A combination of a structured questionnaire and the use of direct observation, interview, and measurement of external body parts were used to collect qualitative and quantitative data which span over 3 months (March, April and May 2022). The questionnaire included both close-ended and open-ended questions. The morphometric traits that were measured were Body length (BL), Wing length (WL), Body girth (BG), and Shank length (SL) using a tape measure, and Body Weight (BW) using a digital hanging spring balance.

Collection of qualitative data from farms

Semi-structured questionnaires were used to collect data on the demographic characteristics of the quail keepers, keeping objectives, traits preferences, production management system, flock size and structure, production constraints, availability of resources, disease epidemics and farm labor divisions. Informal inquiries were also made from local agricultural officers including extension and veterinary officers to cross-check the validity of information on health-related issues (especially diseases). The Global Positioning System (GPS) Essentials' App was downloaded and installed on a smartphone and used to take GPS readings of the geographical location of quail farms in the study areas.

Data collection for phenotypic and genetic differentiation of qualitative traits

Visual assessments were made in identifying the qualitative traits when 6 mature quails were randomly selected to assess their phenotypic differences and these traits were; plumage color (white, black, brown, golden and tuxedo), Skin color (white, pink), shank color; (white, yellow, and pink).

Data collection for quantitative traits

The quantitative traits which were measured using a digital hanging spring balance, vernier caliper and measuring tape respectively were:

- **Body Weight (BW)** (g): This was recorded to two decimal places using a sensitive digital hanging spring balance (Fayeye *et al*., 2013).
- **Body Length (BL)**-the length was taken from the nasal opening, along its gently stretched neck and back, to the tip of its pygostyle Fayeye *et al*. (2013).
- **Shank Length (TL)**- length of the shank from the hock joint to the spur of either leg or footpad by a set of Venier calipers Fayeye *et al*. (2013).
- **Body Girth (BG)** was taken as measuring tape was looped around the region of the breast under the wings Chimezie *et al*. (2016).

- **Wing Length (WL)** was the distance from the humerus coracoid junction to the distal tip of the phalanges digits, using a tape measure Dudusola *et al*. (2018)

Ethical Clearance

All participants in the study gave their informed consent, and a training session for the data collection team members was organized. Farmers were thus offered the option to participate in the research after being fully informed of its goal. Additionally, the farmers' identities were kept secret, and their comments weren't shared. Furthermore, all other relevant information that was taken from different scholars were acknowledged and referenced.

Data Management, Processing, and Analysis

The collected data were cleaned and coded. Minitab-22 was then used to analyze the data using descriptive and inferential statistics. The hypothesis was tested using generalized linear model.

- Descriptive statistics were used to analyze the qualitative and quantitative traits
- Analysis of Variance (ANOVA) was conducted using the General Linear Model (GLM) of Minitab 22. Mean separation for parameters exhibiting significant differences was done by using the Tukey HSD test.
- Simple correlation analysis was used to estimate the relationship among morphometric traits.

- Discriminant analysis of multivariate analysis was used to validate the differences in the populations according to morphological attributes of quails.

Statistical analysis of quantitative traits

Analysis of variance (ANOVA)

The collected data for quantitative traits were analyzed using analysis of variance (ANOVA) by the Generalized Linear Model (GLM) of Minitab-19. The significant difference between means, least significant difference (lsd) was used to separate the means. The effect of sex and AEZ on BW and linear body traits were tested using the model:

$$Y_{ijk} = \mu + S_i + A_j + E_k + e_{ijk}$$

Where,

Y_{ijk} = individual observation of each body traits;

μ = overall mean;

S_i = effect of ith sex (i = male, female);

A_j = effect of j^{th} age (j = 6 weeks);

E_k = effect of k^{th} AEZ (k = Transitional-1, Semi Deciduous Forest-2, and Coastal Savannah-3);

e_{ijk} = random error associated with each record

Multivariate (Discriminant) analysis

The canonical discriminant and stepwise discriminant analysis of Minitab-19 was used to differentiate and classify local quail populations from the three AEZ using the Mahalanobis distance.

$$D^2 = (x - m)^T \cdot C^{-1} \cdot (x - m)$$

Where,

D^2–: the Mahalanobis squared distance

x–: the vector of observation of morphometric trait

m–: the vector of mean values of independent morphometric variables

T–superscript: Transposed matrix

C^{-1}–: the inverse covariance matrix of independent morphometric variables

Analysis of the demographic characteristics of local quail keepers

Information on the quail keepers was analyzed using descriptive statistics (frequency and percentages) to show flock structure and social status while means and standard deviation were used to describe the flock size. The quail keeper's trait preference was ranked using pairwise comparison and the mean rank was computed.

Pilot Study

A pilot study was carried out in the Western region to pretest the instruments for the quail farmers to ensure reliability and validity. Ten quail farmers were used in the pilot study and a questionnaire was administered to them. The area was selected for piloting because of the availability of quails and also the presence of similar characteristics of the AEZs as compared to the three AEZs under study.

Test for Validity and Reliability

The validity and reliability of the items in the questionnaire were tested using data from the pilot study. The results showed a Cronbach's alpha (α) of

0.765 which concurs with Cooper, (2005) who emphasized that a reliability coefficient of 0.7 or better is acceptable. This showed that the instrument was good and can be used for the collection of the data. Also, Cronbach's alpha was computed for each sub-section of the questionnaire.

Chapter Summary

A descriptive cross-sectional survey was adopted in the study to examine the trait preferences of the local quail farmers. The snowball and simple random sampling techniques were employed to determine the sample size. In all, a sample size of 384 was used in the study. Also, the questionnaire included open-ended and close-ended questions. A Cronbach's alpha of 0.765 was obtained in the pilot study which proved the reliability of the instrument for the research. The data obtained were analyzed through descriptive and inferential statistics. To be specific, the descriptive statistic included frequency and percentage whiles the inferential statistics consisted of analysis of variance (ANOVA), and canonical discriminant analyses.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter summarizes the study's findings and discusses the implications of the research questions on phenotypic characterization of the local quail population. The chapter is divided into two sections: the first discusses the demographic characteristics and trait preferences of local quail keepers, while the second discusses the effect of sex and AEZ on morphological and morphometric traits.

Demographic characteristics of local Quail keepers

The research engaged ninety (90) local quail farmers from three AEZ of Ghana. It comprised 30 local quail keepers from each AEZ. The characteristics provided in-depth knowledge about the local quail keepers with regards to their source of income, duration of raising quails and their purpose of keeping quails. The results are presented in the tables that follows;

Table 4: Demographic characteristics of local quail keepers

Demographic characteristics		Frequency (N)	Percentage (%)
Source of income	Personal saving	89	98.9
	Loans	**	**
	Grant	1	1.10
	NGO’s support	0	0.00
Duration of raising Quails	<1year	1	1.10
	2-5 years	85	94.4
	>5years	4	4.40
Purpose of keeping Quails	Food	2	2.20
	Income	88	97.8
	Hobby	**	**
	Pet	**	**
Overall	***	90	100

Source: Field survey (2022)

Gender activists across the globe are working tirelessly to ensure even distribution of people based on gender at all human production sectors. However, this study presents an outcome that contradict the goals of gender activist with majority of quail farmers in the selected AEZ being predominantly male. This threatens gender equality and the efforts to bridge the gap between men and women engagement in economic development activities of the country especially in the aspect of animal production. In Ghana, men are regarded as the care takers of the home and hence they initiate most economic activities including animal farms in order to perform their responsibilities. The lower number of females in quail farming depict that most of them are supporters of their husband rendering secondary activities in the farm such as feeding, watering, cleaning and ensuring animal welfare. The dominance of males in quails production is not a different phenomenon since it agrees with the study of Ekpo *et al*. (2020) who reported that 93.3% of males in Benin are into quail farming. It is worth mentioning that quail farming is a simple and easy to do task and hence more women could take active role in it.

It is also encouraging to know that the majority of the farmers involved were from the economically active population of young people. This finding is consistent with the findings of Ekpo *et al*. (2020), who found that a large proportion (90%) of quail farmers in Benin are young. To combat poverty and malnutrition in Ghana, the government launched the Youth in Agriculture Programme (YIAP) and Planting for Food and Jobs, both of which provide opportunities for young people to improve their standard of living. As a result, it stands to reason that if the active working population is given the necessary training and resources (equipment, income in the form of grants, etc.), their energies can be channeled towards quail farming, which will contribute significantly to the country's Gross Domestic Product (GDP). Finally, it will create employment for the youth, generate income and also increase global food security. Interestingly, 97.8 % of the farmers reported that their main purpose of engaging in quail farming is for income whiles the remaining (2.20%) raised them as source of food.

It was also observed from the study that the main source of income was personal savings (98.9%) which was seen to be too negligible to engage in commercial quail farm. Although majority of them were highly educated (95%)

and lived in the urban center, they engaged in it as a part time job. The Government through the Ministry of Food and Agriculture could support quail farmers through the provision of subsidized feed, research grants, and equipment to enable them maximize their production.

To add with, a study of the duration of raising quails in the selected AEZ showed that most of the farmers (94.4%) are beginners and inexperienced. Quail is considered as non-indigenous breeds of livestock whose origin could be traced to China. According to Wamuyu *et al*. (2017), some Ghanaian expatriates introduced them into the country less than a decade ago and hence its production is in the embryonic stage.

Table 5: Population History

Population history	Frequency (F)	Percentage (%)
Source of breeding stock		
Friends	96	95.6
Institutional farms	3	3.30
Foreign breeds	1	1.10
Breeding centers	**	**
Type of farm		
Peasant farms	98	97.8
Institutional farms	2	2.2
Large scale farms	**	**
Breeding center	**	**

Source: Field survey, 2022.

Table 5 shows that majority of the quail farmers (95.6%) obtain their breeding stock from friends. Few of them acquire their breeding stock at institutional farms (3.3%) and through importation (1.10%). The management practice of local quails practiced in Ghana usually do not allow natural brooding. Therefore, most of the farmers hatch the eggs by using incubator or resorting to commercial hatchery services. As clearly indicated in the table 3, (97.8%) are peasant farmers with only 2.2% experimental stations such as Center for Scientific and Industrial Research (CSIR-Animal Research). Comparing the flock size of the last five years shows decline in the population of quails raised in Ghana. This may be due to the outbreak of the novel Corona Virus (COVID-19) diseases which adversely affected the production and marketing of Quails in Ghana. During the total lock-down period, Quail farmers were unable to acquire enough feed and also to sell their product since local and regional were their main target market. The Rampant emergence of bird flu in some part of the country also affected quails within the AEZs under study.

Table 6: Flock Management

Flock management	Frequency (N)	Percentage (%)
Reproduction strategy		
Controlled mating	**	**
Uncontrolled mating	90	100
Reproduction method		
Pen mating	90	100.0
Artificial incubation	0	0.00
Type of Reproduction		
Natural incubation	**	**
Artificial incubation	90	100
Reproduction season		
Major rainy season	**	**
Minor rainy season	90	0.00
Dry season	**	**
All season	90	100

Source: Field survey, 2022.

It is apparent from the table 6 above that local quail farmers implement uncontrolled mating. Thus, a mating ratio of 1:3-1:5 male/female ratio are allowed throughout all seasons of the year. Findings from the research showed that they mature at 6 weeks of age and lay throughout the year. In all, total eggs per year is estimated to be 301 with an average egg weight of 11g. This outcome agrees with the result of Wamuyu *et al*. (2018) who reported an average weight of Japanese quail as 11g. It was also discovered from the studies that the percentage hatchability ranged from 50% -80%. This means after 14 days of incubation, more than half of the eggs are hatched to day old chicks.

It was also discovered from the studies that the quails were raised under intensive system of animal production. The farmers wholly provided all feed (grower starter and layer mash) and water needed *ad libitum*. The birds were not allowed to scavenge and hence their droppings were collected and used as manure for crop production. The housing system was a battery cage and deep litter system which serves several functions including protecting the birds from predators, easy collection of eggs and droppings and easy provision of feed and portable water.

Figure 7: Housing system of local quail as observed in the Coastal Savanna AEZ.

Figure 8: Housing system of local quails in the Transitional AEZ

The results of the investigation showed that the birds were never vaccinated and also not subjected to preventive endo and ecto-parasite control of any form. However, sick birds were given traditional treatment and occasional veterinary treatment. This is owing to the highly resistant nature of the birds to most avian diseases.

Table 7: Flock structure and Population size of local quail populations within the three AEZs of Ghana.

AEZ	Flock structure and size	Frequency (N)	Percentage (%)
	Adult females (> 6 weeks)	14042	53.9
	Adult males (>6 weeks)	4482	17.2
Coastal Savanna	Pullets (2-5 weeks)	4661	17.9
	Chicks (< 1 weeks)	2850	53.1
	Total flock size	26035	100
	Average flock size	432.33±33.04	
	Adult females	9725	62.4
Semi-deciduous	Adult males	3001	19.2
	Pullets	1640	10.5
	Chicks	1200	7.7
	Total flock size	15566	100
	Average flock size	505.22±30	
Transitional zone	Adult females	7900	63.28
	Adult males	2705	21.67
	Pullets	1040	8.33
	Chicks	840	6.72
	Total flock size	12485	100
	Average flock size	450.45±77	

N=number of quails in each group

The study involved 26035 local quails within the coastal savanna AEZ with a flock structure of chicks (53.12%), pullets (17.9%), hen (53.9%) and cockerels (17.2%). The average flock size was estimated to be 432.33±33.04. The reported flock size is similar to, but higher than what was recorded by Himel *et al.* (2020). The average flock size showed that most of the farmers are new in quail farming and hence managed smaller number of quails as compared to developed countries with huge number of quails. The higher percentage of chicks could be attributed to the use of incubators in hatching the eggs which enhances hatchability percentage as compared to natural brooding. Also, a higher number of sexually active females were reported than males since average mating ratio of 1:4 was applied. It can be inferred from the flock structure that more sexually active female quails should be kept to lay more eggs in order to increase the flock size. Furthermore, there were more local quails in the coastal savanna AEZ than the semi-deciduous forest and the transitional zone. This could be due to the availability of breeding stocks as well as resources needed to initiate quail farming.

The findings of the current study agrees with the report of Kadraoui *et al*. (2020) on the argument that quails are raised mainly for food (meat and egg). They also serve other secondary functions such as for research, medicinal purpose, pest control, pet among many others. Although food was checked as the main role, its eggs were on higher demand than meat in Ghana. The adaptability behavior of quails was observed as moderately adaptive and also highly resistant to diseases.

Table 8: Trait preferences for selection of male local quails

Traits	Mean rank
Survivability	8.0
Mating capability	7.0
Early maturity	6.0
Carcass weight	5.0
Disease resistance	4.0
Body size	3.0
Docility	2.0
Plumage color	1.0

1= least preferred trait; 8= most preferred traits

Livestock breeding involves the selection of desirable traits for improvement. In quail production, keepers have several preferable traits for selection and breeding purposes. Within the AEZ studied, male quails were mostly selected based on survivability with plumage color being the least preferred. Again, the ability for the male quails to mate was also ranked second highest since production of fertile eggs was needed for hatching. Therefore, the selection of male quail for breeding would be for survivability, mating capability and early maturity.

Table 9: Traits preferences for selection of female local quail population

Trait preference	Mean rank
Survivability	11.0
Early maturity	10.0
Egg weight	9.0
High egg laying rate	8.0
Body size	7.0
Carcass weight	6.0
Disease resistance	5.0
Egg size	4.0
Egg weight	3.0
Docility	2.0
Egg shell thickness	1.0

1= least preferred trait; 11= most preferred traits

Survivability was declared the highly ranked traits for female quails alongside early maturity, high egg laying rate, mating capability, disease resistance among others. In all, plumage color was the least preferred trait since it does not have economic value when it comes to local quail meat production and selection for breeding. The ability to define breeding goals depends on identifying livestock keeper's trait preference. Therefore, the breeding goal for female quail breeding program could be to increase survival, early maturity, high egg laying rate, disease resistance among other traits. This report is similar to the findings of Ofori & Hagan, (2021) whose work on the characteristics and trait preferences of west African dwarf goat keepers in Ghana revealed survivability as the most preferred trait in WAD goat.

Threats to Quail genetic resource

In Ghana, the rearing of local quails is threatened by predators such as snakes, rodents and other poisonous insects. This is owing to the confined nature of their housing system which subjects them to predators. Intense pecking during mating also leads to physical injury of the birds, and subsequently lead to death. The *ad libitum* provision of feed leads to the quails eating more than their nutritional requirement and subsequent laying of oversize eggs which lead to the death of some birds.

Part 2: Effect of sex and AEZs on the qualitative and quantitative (morphometric) traits of quail.

Table 10: Distribution of qualitative traits of local quail population and morphological characteristics in three AEZ of Ghana.

AEZ	Trait		sex		
			Male (N)	Female (N)	Total
Coastal savanna	Plumage pattern	Single coloured	22	30	52
		Double coloured	10	45	55
		Multi-coloured	27	45	72
Semi-deciduous		Single coloured	20	40	60
		Double	15	34	49
		Multi-coloured	25	46	71
Transitional zone		single	17	40	57
		Double	13	25	38
		Multi-coloured	30	55	85

N= number of quails

Table11: Distribution of plumage color within the three AEZ of Ghana

AEZ	Trait	Category	Sex		
			Male(N)	Female(N)	Total
Coastal Savanna	Plumage color	White	13	20	33
		Black	10	12	22
		Brown	35	68	103
		Rosetta	2	20	22
Semi-Deciduous Forest		White	15	21	36
		Black	20	9	29
		Brown	22	80	102
		Rosetta	3	10	13
Transitional Zone		White	20	34	54
		Black	10	16	26
		Brown	20	30	50
		Rosetta	10	40	50
Coastal Savanna	Skin Color	Pink	60	120	180
		White	0.00	0.00	0.00
	Shank Color	Pink	50	100	150
		Yellow	10	20	30
Semi-Deciduous		Pink	52	100	152
		Yellow	8	20	28
Transitional zone		Pink	45	80	125
		Yellow	15	40	55

N= number of quails

Plumage Color

Table 8 shows the distribution of qualitative (morphological) traits of local quail population within the selected AEZ under study and proved that Brown is the most dominant plumage color, which is followed by the recessive White, and other combination of genes as a result of mutation to yield Black, Tuxedo and then Rosetta. This plumage color variation has been reported by Hristo & Ivelina, (2020) in their study on the domestication changes in Japanese quail and stated that Japanese quail has undergone series of changes that have brought variety of plumage colors including Brown, White, Black, Tuxedo, Rosetta among other mutations. The current study is in agreement with the outcome of Hristo & Ivelina (2020) and Reda *et al*. (2021) in that both reported Brown as dominant plumage color in quail with White being recessive and other intermediate colors. Although there was variation in the plumage colour of the local quail populations, it could not be used in the differentiation of sex of the population.

Figure 9: Different plumage colors of local quail populations

Skin Color

The local quail population studied in the three AEZs revealed that all of the birds (100%) had pink skin. In comparison, this finding is consistent with the findings of Wayumu *et al*. (2017), who discovered that farm-raised quails, whether male or female, had pink skin. Pink is a color that most meat consumers find appealing and acceptable, and this could increase the acceptability of local quail meat for consumption in Ghana.

Fig. 10: Differentiation in skin colour of local quail population

Shank Color

It was also discovered from the research that majority of the quails had a shank color of Pink with the minority being yellow. According to Wayumu *et al*. (2017) farm reared quails had a shank color of White whiles wild quails had pink or red shank color. This finding does not align with the results of the current work. The differences in the shank color between the present study and that of Wamuyu *et al*. (2017) could be due to different strain analyzed with distinct genetic materials that expresses unique phenotypic traits.

Figure 11: Variations in shank color of local quail populations in some AEZs of Ghana.

Variations in morphometric traits of local quail populations as influenced by sex and AEZ.

The morphometric traits of the local quail populations including BW, SL, BG, BL, and WL were measured to highlight how each trait contribute to the total variations within the population. The variations within the population would have implications on adaptation, behavior and health of local quail populations.

Table 12: Effect of Sex and AEZ on the morphometric traits of local quail population in three AEZ of Ghana.

Factor/Trait	BW(g)	SL (cm)	BG (cm)	BL (cm)	WL (cm)	N
AEZ						
Coastal Savanna	187.6 ± 1.79[a]	3.8 ± 0.02	8.8 ± 0.02	17.6 ± 0.06[b]	9.73 ± 0.04	180
Semi-Deciduous	211.6 ± 1.79[b]	3.9 ± 0.02	8.8 ± 0.03	18.1± 0.06	9.57 ± 0.04	180
Transitional Zone	218.3 ± 1.79[c]	3.9 ± 0.02	8.8 ± 0.23	18.2 ± 0.06	9.57 ± 0.04	180
Sex						
Male	202.5 ± 1.75[a]	3.9 ± 0.02	8.8 ± 0.01	18.0 ± 0.04	9.66 ± 0.03	360
Female	209.2 ± 1.24[b]	3.9 ± 0.01	8.8 ± 0.01	17.9 ± 0.05	9.58 ± 0.04	180

BW: Body Weight, BL: Body length, BG: Body girth, SL: Shank length, WL: Wing Length, AEZ: Agro-ecological zones, N: Number of observations

[abc]Means that do not share a letter down a column are significantly different (P≤0.05)

Body weight (BW) of quails

The results of the study showed that sex significantly ($p<0.05$) affected body weight within the AEZs with the females having higher means of weight than the males. It could be inferred from the trend of the BW that there exists a proportional increase in body weight with age. However, the increase in BW declined at certain point in their growth usually after 72 weeks of age. The outcome of the current research showed that the average BW of a matured quail within the three AEZ are 187.68g, 211.66g, and 218.32g for Coastal Savanna, Semi-deciduous forest and Transitional zone respectively. Also, the mean BW for male was obtained as 202.52g whiles the females recorded average BW of 209.25g. This showed that female quails are significantly ($p<0.05$) heavier than males at maturity. This report agrees with the study of Rathert & Uckardes, (2017) who recorded no significant difference ($p>0.05$) between male and female quails in body measurement during first week of its life but the variation commences at 2 weeks of age and thereafter. On the contrary, a study conducted by Cooper *et al*. (2005), Tavaniello, (2014), Qureshi *et al*. (2016), Kadraoui *et al*. (2020), & Wayumu *et al*. (2013) discovered no Significant ($p>0.05$) difference between male and female quail at all ages. Furthermore, the findings from this research revealed that female quails are 10g heavier than males at maturity which is similar to the findings obtained by Tsachalidis *et al*. (2007). The difference in body weight at maturity (6 weeks of age) between male and female quails could be due to the development of the sex cell (eggs in females) and sperms (in males). The imbalance secretion of growth hormones at maturity could leads to the differences in the BW. A fully developed egg cell has an average weight of 10g whiles the weight of sperm is less than 1g. The difference in weight between the two-sex cell could bring about the BW difference between male and female quails. Several researchers have reported that female quails are 10g heavier than the males. To add with, the BW of quails was significantly ($p<0.05$) influenced by the AEZ. Differences in BW within and between AEZs could be attributed to environmental factors and management practices such as nutrition, animal welfare, and housing systems. The transitional zone had the highest BW (218.32g), followed by the Semi-deciduous Forest (211.66g) and Coastal Savanna (187.68g) AEZ. This result could be attributed to improved selective breeding and good management practices among local quail populations within the transitional zone.

Body Length (BL)

The current study showed a BL of 17.98cm and 18.01cm for male and female matured quail respectively. Thus, sex had no significant ($p>0.05$) influence on the BL of quail at maturity. In Nigeria, it was discovered in the study of Fayeye *et al*. (2013) that the body length (BL) of domesticated quail at 2 and 8 weeks of age to be 11.84cm and 19. 45cm respectively. Also, Wajahat *et al*. (2021) reported that the BL of a wild male and female quail is 24.7cm and 22.9cm respectively. The differences in BL between the work of Fayeye *et al*. (2013) and the current research could be due to environmental factors as well as different breeds used. On the other hand, a similar outcome was obtained by Dudusola *et al*. (2018) and Talukder, *et al*.., (2020) who measured the total BL of quail as

18.05cm. The results of Tsachalidis *et al*. (2007) took a different path in that female quails were noted to have longer BL than males which disagree with the result of the present work. Meanwhile, AEZ was noted to have a significant ($p<0.05$) effect on BL in that quails within the Coastal savanna had shorter BL compared to those in the Semi-deciduous Forest and Transitional zone. The differences in BL could be owing to genetic diversity among the population and also management practices.

Wing Length (WL)

According to the study, WL was unaffected ($p>0.05$) by gender. In all three AEZ, the measured WL for male and female participants in the study was 9.58 cm and 9.66 cm, respectively. This result is comparable to that of Peer *et al*. (2018), who found that the average WL of farm-raised quail was 11.12 cm. The study's usage of a different strain with a unique genetic makeup may be the cause of the 1.12 cm difference. The current finding, however, debunks the claims made in the reports by Wajahat *et al*. (2021), Qureshi *et al*. (2016), and Cindy *et al*. (2001) that WL differs significantly across sexes. Additionally, WL of developed quail was significantly influenced by AEZ ($p<0.05$). Quails in the Coastal Savanna(9.73cm) AEZ had longer WL than those in the Semi-Deciduous Forest (9.57cm) and Transitional Zones (9.57cm) AEZ, it was observed. The results of Kadraoui *et al*. (2020), who reported that WL is impacted by AEZ, are consistent with this observation. However, Kadraoui *et al*. (2020) reported on WL which were higher than the results of the current study.

Shank Length (SL)

A mature local quail population was studied to determine the impact of sex on SL, but no significant (p>0.05) difference was found. A mature male and female quail's average SL were found to be 3.90 cm and 3.92 cm, respectively. The findings of this study outperform those of Dudusola *et al*. (2018), who found that an 8-week-old quail had an average SL of 2.44 cm. The new findings are also higher than those of Wayumu *et al*. (2013), who calculated a domestic quail's SL to be 2.94 cm. The disparities between the outcomes of the present study and the report of Wayumu *et al*. (2013) could be due to variations in factors such as management practices, strains with distinct genetic materials as well as AEZ.

Body Girth (BG)

Again, the body girth of quail has been measured by several authors in different studies including Fayeye *et al*. (2013) which measured the BG to be 8.02cm and 13.67cm for 2- and 8-weeks old quails. Also, Dudusola *et al*. (2018) reported a BG of 9.11cm and 14.43cm for 2 and 8 weeks respectively. The current study depicts an average BG of a mature male and female quail as 8.85cm and 8.88cm respectively. This report agrees with the earlier report of Fayeye *et al*. (2013) but lower which may be due to genetic factors.

Pearson correlation among quantitative variables measured (Body weight and linear body traits).

Correlation among morphometric traits of quails were analysed to elucidate how different traits are interrelated and potentially influenced by genetics and environmental factors. This enables researchers to identify patterns, adaptability, and potential evolutionary influences within quail populations.

Table 13: Pearson correlation among morphometric traits

Trait	BW (g)	SL (cm)	BG (cm)	BL (cm)
SL (cm)	0.043			
BG (cm)	0.022	-0.023		
BL (cm)	0.224	0.050	0.052	
WL (cm)	-0.098	0.023	-0.015	-0.086

Pearson correlation is significant at (p> 0.05)

Table 13 shows the Pearson correlation among the morphometric traits which shows both negative and positive significant (p<0.05) correlation coefficients among the various traits measured. Body length, which ranged from 0.01-0.224, had the strongest correlation. At maturity, there was also a low negative correlation between body weight and some linear body traits (shank length and body girth). This means that an increase in body weight has no discernible effect on the linear body measurement. After 24 weeks, the body weight gradually decreased with no change in the linear body traits. This finding contradicts the findings of Chimezie *et al*. (2022), who discovered a significant (p<0.05) high and positive correlation coefficient between body weight and other linear measurements in both sexes. The difference between the current study and that of Chimedzie *et al*. (2022) could be due to the age of the quails used in the study. Chimedzie *et al*. (2022) considered day old chick to 8 weeks old whiles the present study involved only mature quails from 6 weeks old and beyond. The highest correlations observed was between BW and BL which implies that improvement in these linear traits could lead to a subsequent improvement in BW and vice versa. The Pearson correlation between the morphometric traits was generally significant ($p<0.05$), with both low negative and moderate positive correlation. When compared to the findings of Chimezie *et al*. (2022), the results show a similar trend. The current study found a weak (0.00-0.24) phenotypic relationship between body weight and linear body measurements such as SL, WL, BL, and BG. The lack of correlation between linear body traits and body weight suggests that they may not be good predictors of body weight. As a result, during breeding programs, the selection of these linear body traits may not coincide with an increase in body weight. However, moderate correlation was observed between body weight and body length depicting that an increase in BL will lead to appreciable improvement in the body weight. This finding agrees with the study of Obike *et al*. (2016); Tsachadilis *et al*. (2017) who reported a high positive correlation between BW and BL of quail. Undoubtedly, the findings of the present study seem to be lower than what has been reported by earlier researchers in the study area. A case in point is the study by Wamuyu *et al*. (2017) who reported a high positive correlation between body weight and body length as the quail advances in age from 0-8 weeks old. Admittedly, this study considered birds from matured age of 6-72 weeks where growth has plateaued and increases in age does not appreciate with morphometric traits.

Multivariate Discriminant Analysis of morphometric traits for classification and differentiation of local quail population in Ghana.

As previously stated, multivariate analyses of morphometric traits are used to evaluate total variation within and between populations when all morphometric variables are considered at the same time, with the goal of differentiating and classifying populations. The canonical discriminant and stepwise discriminant analyses were used in the current study to differentiate and classify the three local quail populations from the three corresponding AEZ of Ghana.

Classifying and differentiating the three populations

Table 14: Tests of Equality of Group Means

Trait	Wilks λ	F-statistics	Sig.
BW	0.76	83.45	0.00
SL	0.94	15.86	0.00
BG	1.00	0.01	0.99
BL	0.91	27.27	0.00
WL	0.98	4.28	0.00

The variation in morphometric traits between the three AEZ is similar to what Obike *et al*. (2016) reported in Japanese quail. According to Obike *et al*. (2016), morphometric measurement is useful in identifying differences between local quail populations. Therefore, morphometric measurements are helpful for the discrimination of local quail populations. The results of the stepwise discriminant analysis show that BW was the most vital trait in discriminating between the three AEZ with a F-value of 83.45. Also, BL was the second trait with the highest discriminating power with F-value of 27.27 which is closely followed by SL (15.86) and WL (4.28). Body girth recorded the least discriminating power with F-value of 0.01.

Table 15: Total sample Standardized canonical coefficient, canonical correlation and total variations explained by each canonical variable

Traits	Linear discriminant coefficient 1	Linear discriminant coefficient 2
BW	0.82	-0.53
BL	0.47	0.18
BG	0.04	-0.02
SL	0.35	0.85
WL	-0.03	0.05
Eigenvalue	0.47	0.003
% of variance	99.30	0.7
Cumulative variance explained	99.30	100
Canonical correlation (r)	0.56	0.058
Chi-square	206.39	1.80
Wilk's Lambda	0.68	0.99
P-value	0.00	0.41

Table 15 shows the Eigenvalues, cumulative variance, canonical correlation and standardized discriminant coefficient depicting the total variations explained among the local quail populations within the three AEZ by each canonical variable. Two discriminant function were extracted whose significance was tested with the Wilks' Lambda (0.68, 0.99) and Chi-square (206.39, 1.80) and provided validity for the canonical discriminant analysis. The first canonical variable explained 99.3% of the total variation, which is reasonable, whereas the second canonical variable explained only 0.7%. It is clear that only Can 1 is required to explain the total variation (100%) within the population for the traits used in this study. The canonical discriminant analysis in this study demonstrated how each morphometric trait contributes to the total variation of the population. BW and BL were discovered to have the highest weight in discriminating among the population. Furthermore, BW received a high weight in the two canonical variables, indicating its importance in both discriminating and classifying the population. Overall, linear discriminant coefficient 1 (CAN 1) had greater power than linear discriminant coefficient 2 (CAN 2), implying that Can1 is the most discriminating variable in distinguishing the local quail population. The canonical variate is formed by adding each independent variable measured. The canonical correlation between the first canonical variate (r=0.56) and the AEZ and the second canonical variate (r=0.058) was significant, indicating that linear discriminant coefficient 1 explained 56% of the total variation among the three populations. The variations in morphometric traits among the three AEZ could be due to different strains and also development of adaptive features for survival within each AEZ. This observation was similarly reported by Ogah *et al*. (2011). Thus, Can1 showed it relevance in discriminating between the local quail population and was confirmed by the discriminating function coefficient in Table 16 below.

Table16: Classification Matrix of the Number of Observations and percentage Classified into Populations of local Quail based on Morphometric Traits

Populations (P)	P1	P2	P3
P1 (Coastal Savanna)	129	50	31
	71.7		
P2 (Semi-Deciduous)	44	22	43
		12.2	
P3 (Transitional zone)	7	108	106
			58.9
Prior probability	0.33	0.33	0.33
Error level for Populations	28.3	87.8	41.1

Except for those in the semi-deciduous forest, discriminant analysis was used to classify the majority of the individual local quail populations into their respective populations. The Coastal savanna had the highest similarity to the local quail population (71.7%) with an error level of 28.3%, while the Semi-deciduous forest had the lowest (12.2%) with an error level of 87.8%. Furthermore, with an error level of 41.1%, 58.9% of the local quail population was correctly classified as transitional. The findings of the studies were consistent with the findings of Himel *et al.* (2020).

Discrimination plot of three local quail populations indicating differentiation and similarity (classification) based on Mahalanobis distance.

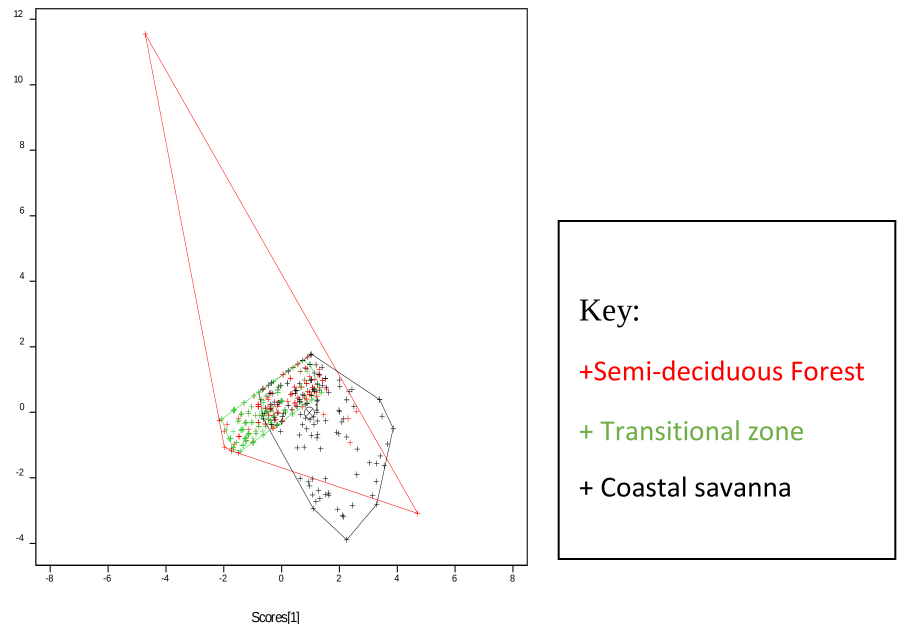


Figure 12: Canonical representation of the three AEZ of the local quail population showing degree of differentiation and similarity based on Mahalanobis distance

Table 17: Pairwise square Mahalanobis Distance between local Quail Populations based on Morphometric Traits

	P1	P2	P3
P1(Coastal Savanna)		1.75	2.46
P2(Semi Deciduous Forest)			0.085
P3(Transitional zone)			

Table 17 indicates the pairwise squared Mahalanobis distance and probability values which shows the degree of differentiation of the local quail population within the three AEZ. Apparently, quails within the Semi-deciduous forest and the Transitional zones were closest (0.085) whiles the largest evaluated

Mahalanobis distance (D^2) was found between the Coastal Savanna and the Semi-deciduous forest (2.46). The shortest distance between Semi-deciduous forest and the transitional zone could be an indication of indiscriminate inbreeding activities as well as the geographical proximity of the two AEZ and hence they share similar genetic materials. The largest estimated distance between the transitional zone and the coastal savanna could be due to reduced interbreeding activities between the two populations. The local quails were strictly managed by the intensive system and also there exist large geographical separation between the two AEZ. According to the Ghana Poultry Associations these AEZ are the center of the highest commercial farms with installed incubation machines where day old chicks are hatched and distributed to the other AEZ. Thus, the day-old quail chicks are hatched and distributed to the other AEZ which promote inbreeding and reduces genetic diversity and fitness level. This is because there are no controlled system of mating and quails hatched in one generation are allowed to mate among themselves.

Table 18: Population structure, rate of inbreeding and inbreeding coefficient of quails within the three AEZ.

AEZ	**Coastal Savanna**	**Semi-Deciduous**	**Transitional zone**
No. of breeding males	4482	9725	2705
No. of breeding females	14042	3001	7900
Total No. of breeding quails	18524	12726	8060
Effective population size	13590.2	9173.3	16128
Inbreeding coefficient	0.000037	0.000054	0.000062
Rate of inbreeding(ΔF)	0.000037	0.000054	0.000062

The result from Table 18 above shows the probability that quails within an AEZ would have similar alleles as their parents. It was deduced that quails within the coastal savanna AEZ recorded the highest level of inbreeding whiles those in the semi-deciduous forest had the lowest. The higher level of inbreeding within the coastal savanna AEZ may be due to mating system being practiced. The intensive management practice only allowed polygyny where the offspring of one generation are also allowed to mate among themselves. This subsequently leads to the decrease in the fitness level of the population. The outcome of this study concurs with the work of Raji *et al*. (2009) which reported high inbreeding coefficient in quail population.

The influence of AEZ, and Sex, on the morphometric traits of local quail population in Ghana.

Table 12 shows that the descriptive statistics of the morphometric traits studied in the local quail populations show a significant ($p<0.05$) difference between the three AEZ. AEZ had a significant ($p<0.05$) effect on the local quail population's body weight (BW), but had no effect on other linear body traits such as body length (BL), shank length (SL), or wing length (WL) except body girth (BG). Although the quails were kept under similar management practices in all the three AEZ, average body weight of a mature quail in the Transitional zone were noted to be heavier (218.32g) than those in Coastal Savannah (187.68g) and Semi-deciduous Forest (211.66g). However, the variation in the local quail populations between the three AEZ may not be due to genetic factors. This could be due to variations in environmental factors such as medication, nutrition, housing, light intensity and humidity which affect growth of birds Momoh *et al*. (2018). To add with, birds in the Transitional zone were heaviest because it was found to be the Centre where most livestock feed in the country are produced. Hence, feeds were readily available in quantity and with lower price as compared to the other two AEZ.

The outcome of the current work showed that age only influenced the body weight. Thus, after 8 weeks, there was no increase in the quail's linear body traits. Reda *et al*. (2019) discovered that sex significantly ($p<0.05$) influenced most morphometric traits in Japanese quail at all ages in a study on the effect of sex on the morphometric traits of Japanese quail. The outcome was predictable because growth increases with age, plateaus, and then gradually declines depending on the genetic composition of the species. Body weight (BW) was found to decrease in all three AEZ as the birds aged, usually after 12 weeks. The effect of age on morphometric traits reported is similar to that reported in chicken Momoh *et al*. (2011). Furthermore, Sex had significant ($p<0.05$) effect on BW in all the three AEZ. It was detected that the average BW of a mature female quail was 209.25kg, whiles the males were 202.52g. Since all management conditions were made available for both sexes, therefore, this variation could be due to genetic factors. According to kadraoui *et al*. (2020) the variation in BW of quail becomes notable after maturity (6 weeks old). It is at this stage of their growth cycle where eggs are developed in the females whiles the males produces sperms. The variation in the weight of the sex cell could be the cause of the difference in body weight of male and female quails. On average, a matured egg was 11g which was similar to the difference in BW between the sexes. Also, the hormonal imbalance at the state of maturity could be the cause of the differences in BW since different hormones are stimulated and secreted at maturity in males and females.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study was geared towards describing the morphological and morphometric traits of local quail populations in some AEZs of Ghana. The outcome of the study provided the avenue for sustainable utilization, genetic improvement and conservation of the local quail population. The study showed that there was no significant difference (p>0.05) between the morphometric traits measured except BW. The BW for the selected AEZs were 218.32g, 211.66g and 187.68g for Transitional zone, Semi-Deciduous and Coastal Savanna AEZs respectively. Also, Female quails were observed to be heavier (209.25g) than males (202.52g) quails. AEZs and sex had no significant effect (p>0.05) on mophorlogical traits with skin color (pink), shank color (yellow and pink), plumage color (white, black, brown and red). Mahalanobis distance was also used to evaluate the degree of differentiation and similarity of the local quail population. It was found that the shortest distance between Semi-Deciduous Forest and Coastal Savanna AEZs whilst the longest distance was determined between Coastal Savanna and Transitional zone. The canonical discriminant analysis also showed that BW was the trait with the highest discriminating power which contribute the most to the total variation among the quail population.

Conclusions

In alignment with the specific objectives of the study, the work discovered the following findings.

1. Sex and AEZs had no significant effect ($p>0.05$) on morphometric traits of local quail populations except BW. Female quails were noted to be significantly ($p<0.05$) heavier (209.25g) than males (202.52g) within the selected three AEZ. Also, the BW of quails within the three AEZs were 218.32g, 211.66g, 187.68g for Transitional zone, Coastal Savanna and Semi-Deciduous Forest respectively.
2. It was revealed that sex and AEZ had no significant ($p>0.05$) effect on morphological traits measured. The observed morphological traits among the local quail populations were skin color(pink), shank color (yellow and pink) and plumage color (white, brown, black and red).
3. The local quail keepers agreed that survivability was the most preferred trait followed by high egg laying rate, early maturity, diseases resistance among others.
4. From the study, the population size of local quail within the coastal savanna, semi-deciduous forest and transitional zone were 26035, 15566 and 12485 respectively. The average flock size for coastal savanna, semi-deciduous and transitional zone was 432.33±33, 505.22±30 and 450.45±77 respectively.

5. Finally, the canonical discriminant analysis of the morphometric differentiation and classification of the local quail populations showed that quails within the Semi-deciduous Forest are closer (0.085) to those in the Transitional zone than those in the Costal Savannah AEZ. Also, there was relatively a large gap between local quails in the transitional zone and the Coastal savanna AEZ.

Recommendations

With regard to the findings and the conclusions drawn from the investigation, the following recommendations are made for practical application of the research.

1. Local quail keepers could mix all the different colors in cage since they belong to the same strain.
2. Local quail keepers could adopt battery cage system of production which could decrease rate of pecking which is a major challenge in the deep litter system during mating.
3. One major challenge of keeping quails was the marketing of the products (eggs and meat) and therefore farmers should form an association to set up local and regional quail market between each AEZ.
4. In order to ensure effective utilization and conservation of the species, quails could be added to the national animal breeding station at Centre for Scientific and industrial research (CSIR-Animal research) for controlled mating to be performed.

Areas for Further Studies

1. The study could be replicated to include other AEZs in the country to identify it effects on the local quail populations.
2. The study involved primary characterization where by quails kept by local farmers where involved. However, further studies should be carried on secondary characterization where by day old chick are raised at experimental farms to estimate heritability and correlations for reproductive and survivability traits of the flock.
3. The study was focused on phenotypic characterization and hence further studies on molecular genetic characterization could help to elucidate the phylogenetic relationships among the local quail populations.

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APPENDICES

APPENDIX A: QUESTIONAIRE USED FOR PHENOTYPIC CHARACTERISATION OF LOCAL QUAIL POPULATION IN SOME AEZS OF GHANA

Dear respondent,

This questionnaire is developed to be used for the phenotypic characterization of local quail populations in three AEZs of Ghana. According to (FAO, 2012) "Phenotypic characterization of AnGR is the process of identifying distinct breed populations and describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors that affect them." In order for proper management and planning of AnGRs at the local, national, regional and global levels, characterization research must be conducted to highlight the genetic potential of the organism. The Global Plan of Action for AnGR FAO (

2012) reported that "A good understanding of breed characteristics is necessary to guide decision-making in livestock development, sustainable utilization, conservation and breeding programs". This research is being conducted by a Master of Philosophy student (**Richard Asante Botwe**) of the Department of Animal in partial fulfillment of the program. This aspect of the work includes phenotypic characterization, description of production environment, natural environment, management environment, socio-economic characteristics, and description of local populations special qualities. The study would include survey, observation, Questionnaire, taking of photographs of the birds, housing structures as well as direct measurement of the quails by the research team. The study is purely directed towards academic work to be used for national and global development. The research team would be very honored if you could permit us to have access to your resources and also in responding to our questionnaire. I therefore ask for your maximum co-operation and assure you that the data generated will be treated with outmost confidentiality.

Agreement Note

In response to the objective of the research explained above and assuring me of absolute confidentiality,

I ………………………………………………………………………………………

hereby accept to participate in this research. Also, all resources including the quails can be observed, body parts measured and photograph of birds and housing structures taken for the studies.

Signature/thump print of respondent

……………………………………..

Mobile Number………………………

SECTION A: Demographic Characteristics of Respondents

ID	Variables	Description
1.	**Location of farm**	GPS: AEZ: District: Town:
2.	**Sex**	Male [ ] Female [ ]
3.	**Age**	<20 [ ] 20-40[ ] 41-60 [ ] > 61[ ]
4.	**Level of Education**	No formal Education [ ] Secondary Education [ ] Tertiary Education [ ]
5.	**Main occupation**	Farmer [ ] Salaried Worker [ ] Other [ ]
6.	**Source of income**	Personal saving [ ] Loans from Banks [ ] |Research Grunt [ ] NGO's support [ ]
7.	**Purpose of keeping quails**	Food [ ] Income [ ] Hobby [ ] pet[ ]
10.	**Type of Holding**	Peasant farm [ ] Commercial farm[ ] Breeding center [ ] Experimental station [ ]
11.	**Flock size**	<100 [ ] 101-500 [ ] 501-1000 [ ] >1000 [ ]
12.	**Flock composition Number of;**	Hen [ ] Cockerels [ ] Pullets [ ] Chicks [ ]
	Total Population size	Estimated: Counted:
	Trend of population size	Stabel [ ] Increasing [ ] Decreasing [ ]
	Reproduction strategy	Controlled mating [ ] Uncontrolled mating [ ]
	If controlled, what method	Hand mating [ ] Artificial insemination [ ]

	Type of reproduction	Natural incubation [ ] Artificial insemination [ ]
	Reproduction season	Major raining season [ ] Minor rainy season [ ] Dry season [ ] All season [ ]
	Production	Age at first egg (weeks) .... Total egg per year .... Egg per clutch .... Egg weight (g) .... Egg width (cm)... Egg length (cm) .... Number of days for hatching .... Percentage hatchability (%).......................
13.	**Source of Quails**	Imported [ ] wild population [ ] local breeding farms [ ]
14.	**If imported, years of importation**	>1[ ] 2-4[ ] 5-10[ ] >10[ ]

ID	Variables	Description
15.	**Market orientation**	Fully market oriented [ ] mixed market [ ] Subsistence market [ ]
16.	**Target market**	Local [ ] Regional[ ] National [ ] international[ ]
17.	**Product targeted at niche market**	Yes [ ] No [ ]
18.	**Established market for breeding animals and genetic materials**	Yes [ ] No [ ]
19.	**Main role and use of Quails**	Food [ ] Research [ ] Medical purpose[ ] Feathers[ ] Pest control [

		] Social and religious ceremonies [ ]
20.	**If the main use is food, specify…**	Eggs [ ] Meat [ ]
21.	**Main causes of diseases**	Bacterial [ ] viral[ ] Fungal [ ] rickettsial [ ]
22.	**Disease's occurrence**	Eradicated [ ] Rare[ ] Frequent [ ] Emerging[ ]
23.	**Veterinary treatment**	Never [ ] Occasionally[ ] Regularly [ ]
24.	**Feed availability**	Not restricted [ ] Frequently restricted[] Restricted[ ]
25.	**Feed type**	Concentrates [ ] industrial by products [ ] Other [ ]
	Watering	Ad libitum portable water provided [ ] Occational drinking water provided [ ] Animal find their own source of water [ ]
26.	**Type of Reproduction**	Uncontrolled [ ] Controlled[ ]
27.	**If controlled, which method**	Hand or pen mating [ ] Artificial insemination [ ] Embryo Transfer [ ]
	Housing system	Deep litter system [ ] Battery Cage [ ]

APPENDIX B: QUESTIONAIRE ON CHARACTERIZATION OF QUAILS

	HEALTH AND MEDICATON	Are birds Vaccinated? Never [ ] Occasionally [ ] Regularly [ ]
		Are birds subjected to preventive endo and ecto-parasite control? Never [ ] Occasionally [ ] Regularly [ ] Treatment given to sick birds? Never [ ] Occational Veterinary treatment [ ] Regular veterinary treatment [ ] Ocational traditional treatment [ ] Regular traditional treatment [ ]
	Adaptive ability behavior	Very aggressive [ ] Aggressive [ ] Docile [ ] Very docile [ ]
	Adaptation to climate	Very adapted [ ] Adapted [ ] Moderately adapted [ ] Not adapted [ ] Highly susceptible [ ]
	Resistance to common poultry disease like Newcastle and Avian influenza	Highly resistant [ ] Resistant [ ] Moderately resistant [ ] Not resistant [ ] Highly susceptible [ ]

Trait Preferences

Indicate your trait preference by ranking the trait from 1-10 (male quail)

	Trait preference	Rank
1.	Early maturity	
2.	Body size	
3.	Survivability	
4.	Docility	
5.	Carcass weight	
6.	Mating capability	
7.	Plumage color	
8.	Disease resistance	
9.		

Trait preference of farmer for female quails.

	Trait preference	Rank
	Early maturity	
	Body size	
	Survivability	
	Docility	
	Carcass weight	
	Broodiness	
	Egg size	
	Disease resistance	
	Egg weight	
	Egg shell thickness	
	High egg laying rate	

ID	ABBREVIATION	MEANING
1.	**AEZ**	AEZ
2.	**BWT**	Body Weight
3.	**SL**	Shank Length
4.	**WS**	Wing Span
5.	**PC**	Plumage color
6.	**SC**	Shank Color
7.	**EYC**	Eye color
11	**WL**	Wing Length
12.	**pp**	Plumage Color

Variable	Description	Code
AEZ	Coastal savanna	**1**
	Semi- Deciduous Forest	**2**
	Transitional Forest	**3**
SEX	Female	**0**
	Male	**1**
Plumage Pattern	Plain	**1**
	Barred	**2**
	Laced	**3**
	mottled	**4**
Shank Color	White	**1**
	Yellow	**2**
	Blue-Black	**3**
	White	**1**
Skin color	Yellow	**2**
	Blue-Black	**3**

Estimation of the inbreeding coefficient and rate of inbreeding of the population.

Coastal Savanna	Semi-Deciduous Forest	Transitional zone
$N_e = \frac{4(Nm)(Nf)}{Nm+Nf}$ $\frac{4(275)(283)}{(275)(853)}$ = 275.92	$N_e = \frac{4(Nm)(Nf)}{Nm+Nf}$ $\frac{4(2050)(6040)}{(2050)(6040)}$ = 6122.12	$N_e = \frac{4(Nm)(Nf)}{Nm+Nf}$ $\frac{4(1950)(4960)}{(1950)(4960)}$ **2799.42**
$F = \frac{1}{2Ne}$ $=\frac{1}{2(275.97)}$ =0.0018	$F = \frac{1}{2Ne}$ $=\frac{1}{2(6122.12)}$ = 0.000082	$F = \frac{1}{2Ne}$ $=\frac{1}{2(2799.42)}$ = 0.00017
$\Delta F = \frac{1}{8Nm} + \frac{1}{8Nf}$ $=\frac{1}{8(275)} + \frac{1}{8(853)}$ =0.0006	$\Delta F = \frac{1}{8Nm} + \frac{1}{8Nf}$ $\frac{1}{8(2050)} + \frac{1}{8(6040)}$ 0.000082	$\Delta F = \frac{1}{8Nm} + \frac{1}{8Nf}$ $\frac{1}{8(1950)} + \frac{1}{8(4960)}$ 0.000089

Analysis of the morphometric differences among the local quail population.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sex	1	5445	5445.0	9.88	0.002
AEZ	2	93508	46753.8	84.83	0.000
Error	536	295427	551.2		
Lack-of-Fit	2	543	271.4	0.49	0.612
Pure Error	534	294885	552.2		
Total	539	394380			

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sex	1	0.0107	0.01070	0.13	0.722
AEZ	2	2.6673	1.33363	15.83	0.000
Error	536	45.1564	0.08425		
Lack-of-Fit	2	0.2227	0.11137	1.32	0.267
Pure Error	534	44.9337	0.08415		
Total	539	47.8344			

Linear Discriminant Function for Groups

	1	2	3
Constant	-1326.7	-1350.3	-1353.6
BW (g)	0.3	0.3	0.3
SL (cm)	48.7	50.8	50.8
BG (cm)	183.9	183.7	183.6
BL (cm)	27.2	27.9	28.0
WL (cm)	30.9	30.5	30.5

Grouping Information Using the Tukey Method and 95% Confidence

AEZ	N	Mean	Grouping	
1	180	9.72593	A	
3	180	9.57037		B
2	180	9.57037		B

Means that do not share a letter are significantly different.

Grouping Information Using the Tukey Method and 95% Confidence

AEZ	N	Mean	Grouping	
3	180	18.2030	A	
2	180	18.1308	A	
1	180	17.6475		B

Means that do not share a letter are significantly different.

Grouping Information Using the Tukey Method and 95% Confidence

AEZ	N	Mean	Grouping
1	180	8.86968	A
2	180	8.86968	A
3	180	8.86690	A

Means that do not share a letter are significantly different.

Grouping Information Using the Tukey Method and 95% Confidence

AEZ	N	Mean	Grouping	
2	180	3.96824	A	
3	180	3.95935	A	
1	180	3.81491		B

Means that do not share a letter are significantly different.

Statistics

Variable	Sex	Total Count	N	N*	Mean	SE Mean	StDev	CoefVar
BW (g)	1	60	60	0	182.55	2.30	17.80	9.75
	2	120	120	0	191.93	1.66	18.20	9.48
SL (cm)	1	60	60	0	3.7867	0.0536	0.4152	10.96
	2	120	120	0	3.8267	0.0329	0.3608	9.43
BG (cm)	1	60	60	0	8.8500	0.0298	0.2311	2.61
	2	120	120	0	8.8875	0.0191	0.2097	2.36
BL (cm)	1	60	60	0	17.550	0.177	1.368	7.79
	2	120	120	0	17.704	0.105	1.151	6.50
WL (cm)	1	60	60	0	9.6500	0.0817	0.6331	6.56
	2	120	120	0	9.7833	0.0702	0.7690	7.86

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
AEZ	2	93508	46753.8	83.45	0.000
Error	537	300872	560.3		
Total	539	394380			

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
AEZ	2	2.667	1.33363	15.86	0.000
Error	537	45.167	0.08411		
Total	539	47.834			

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
AEZ	2	0.0009	0.000463	0.01	0.990
Error	537	25.4361	0.047367		
Total	539	25.4370			

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
AEZ	2	32.85	16.4241	27.27	0.000
Error	537	323.40	0.6022		
Total	539	356.25			

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
AEZ	2	2.904	1.4519	4.28	0.014
Error	537	182.228	0.3393		
Total	539	185.131			