UNIVERSITY OF EDUCATION, WINNEBA
COLLEGE OF AGRICULTURE EDUCATION
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MAMPONG ASHANTI

TWO INDIGENOUS CHICKEN ECOTYPES AND THEIR PLUMAGE COLOUR EFFECT ON GROWTH AND REPRODUCTIVE PERFORMANCE IN GHANA

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200029329

A DISSERTATION SUBMITTED TO THE SCHOOL OF GRADUATESTUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE (ANIMAL BREEDING AND GENETICS) IN THE UNIVERSITY OF EDUCATION, WINNEBA

AUGUST, 2022

DECLARATION

STUDENT'S DECLARATION

I, Rafat Quartey hereby declare that this submission is my own work towards the Master of Philosophy (Animal Breeding and Genetics) degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, or elsewhere except where due acknowledgment has been made in the text.

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Supervisors' declaration

We hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Education, Winneba

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DEDICATION

This work is dedicated to all those who in one way or the other have contributed to bringing me this far and all those who matter in my life, especially my relatives.

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ABSTRACT

The aim of this study was to determine the ecotype and plumage colour effect on growth and reproductive performance of two indigenous chickens in Ghana. Ninety-six birds consisting of Forty-eight birds from each of the two ecotypes and twenty-four from two separate plumage colours, white and brown were selected randomly for the experiment. The experiment was a 2 X 2 Factorial with ecotype and plumage colour as the factors. The results showed no significant difference (*P>0.05*) in the 2, 4, 6, 8 and 10 week body weights and body weight gain between the two different plumage colours of the two chicken ecotypes. Egg weight recorded significant difference between the two plumage colours of the two chicken ecotypes with the brown plumage colours of the savannah and forest performing better than the white plumage colours. There was no significant difference in feed intake, feed conversion ratio and hen day egg production between the two plumage colours of the two chicken ecotypes. Reproductive performance of the plumage colours of the two chicken ecotypes were only significant (*P<0.05*) for the hatchability of fertile eggs with the brown plumage colours of the two chicken ecotypes having significantly higher (*P<0.05*) hatchability than their white counterparts. Age at first egg, fertility of egg set and hatchability of egg set were not significant *(P>0.05).* 2, 4 and 8 week body weight of the two chicken ecotypes showed significant *(P<0.05)* difference whiles 6 and 10 week body weight showed no significant *(P>0.05)* difference. The result also showed no significant difference (*P> 0.*05) in 2, 4, 6, 8 and 10 week body weight gain. The Percentage fertility of eggs between the two chicken ecotypes was statistically higher (*P<0.05*) for the savannah chicken ecotypes than the forest chicken ecotypes and the percentage hatchability of fertile eggs was statistically better (*P<0.05*) in the forest chicken ecotypes than the Savannah chicken ecotypes. Age at first egg and percentage hatchability of egg set showed no significant difference ($P>0.05$). The study indicated that there was a correlation ($P<0.05$) between average body weight and egg weight and hen day egg production of the plumage colours and the ecotypes respectively. The study showed positive correlation between body temperature and plumage colour. Brown plumage colours of the savannah and forest ecotypes had higher (41.03^{0}C and 41.20^{0}C) body temperature than their white counterparts. Ecotype by Colour interaction effect on average egg weight and percentage hatchability were significant ($P<0.05$). All other traits were not significant ($p>0.05$). The brown coloured bird of the forest and savannah chicken ecotypes showed good production and reproductive potentials.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Poultry are the cheapest and well-recognized source of animal protein in developing countries (Ravindran, 2012; Rahman *et al.,* 2013; Khobondo *et al.,* 2015) providing both eggs and meat of which chicken is the commonest. Chicken breeds in Ghana comprise both indigenous and exotic breeds (which are commonly used for commercial production). In addition to the provision of meat and eggs, indigenous chickens have both economic and socio-cultural uses such as income to farm families, sacrifices and gifts for rural and peri-urban dwellers (Padhi, 2016) in the country and across the continent. According to Besbes *et al.* (2012), "Family Poultry" production is used to describe small scale poultry production systems usually found in rural communities and mostly by individual families as a means of obtaining food security, income and gainful employment. This term therefore best describes indigenous chicken farming which is mostly backyard based.

Indigenous chickens comprise about 60 to 80% of the national flocks of poultry in Africa and Asia (Dana *et al.,* 2010; Dana *et al.,* 2011; Darres, 2012; Gwaza *et al.,* 2016, Khobondo, 2018). They are characterized by slow growth rate, fewer eggs, and small body size but resistant to disease and other infestations, tolerant to various forms of climatic conditions and good scavengers for food (Nigussie *et al.,* 2015). According to Okeno *et al.* (2012), indigenous chicken rearing is one of the most viable activities of rural households to improve their livelihood and socio-economic challenges such as malnutrition, poverty etc. Though indigenous chickens are considered low performers, they possess positive characteristics over the imported breeds such as adaptation to local conditions, resistance to disease and pests attack, have brooding abilities, and scavenge for feed (Tarwireyi and Fanadzo, 2013).

Chicken production conditions which include nutrition, housing, health care and the general management system, all of which are characteristics of the environment is an important component that helps improve performance (Olaniyi *et al.*, 2012). Rearing condition affects performance such as growth, egg production as well as health and well-being (Olaniyi *et al.*, 2012). Rahman *et al.* (2013) noted that for meat production, feeding of high protein-energy diet to native chickens resulted in better performance in terms of feed conversion ratio and live weight. Ogbu *et al.* (2015) also observed that genotype and feed type influenced growth performance in local chickens.

Economically, plumage colour is one of the qualitative traits of indigenous chicken which is of importance to farmers. Genetically, it is described as monogenic trait based on different pigmentation and it is attributed to melanin which is responsible for the production of varieties of plumage colours in chickens (Dana *et al.*, 2010). According to Hua *et al.* (2020), plumage color is an important characteristic of birds. In turkeys Safiyu *et al*. (2019), indicated that, plumage colour significantly influence weight gain at the grower phase. They also stated that weight gain was significantly higher in black plumage coloured turkeys than turkeys with white plumage colour. Egg mass according to Addison (2013) was higher in the brown plumage birds than in the white plumage coloured birds at temperature of 27^{O}C. In ducks, it has been demonstrated by Barnejee (2013), that plumage colour has a significant influence on live body weight of adult Muscovy ducks. In naked neck chickens, black plumage coloured roosters showed better semen quality and enhanced fertility rate (Abbass *et al.*, 2017). Mróz *et al.*

(2016), stated in their study on guinea fowls that, there is a correlation between plumage colour and some production traits. They observed that, from the 10th week of age, pearl grey guinea fowls showed higher body weight than black, white and ash varieties.

1.2 Problem statement

Many indigenous poultry breeds have been isolated from planned breeding and genetic programmes in several developing countries (Ravindran, 2012). This is because the indigenous chickens are generally low performing group of animals and are characterized by poor growth rate, body weight, feed conversion efficiency, egg size and numbers (Dana, 2010; Dana and Waaij, 2014). Their low performances such as growth rate, body weight, egg size and numbers can be attributed to poor environmental and genetic conditions.

Indigenous chickens are often raised in rural communities on free-range system with often poor nutrition (Padhi, 2016). These add up to their slow growth rate and poor laying performance. Most breeding programmes conducted in Africa and the developing countries, aimed at improving the productivity of indigenous chickens relied on cross-breeding (Padhi, 2016; Khobondo, 2018) of the already improved foreign breeds with the local stock. Again, in most rural communities where livestock are allowed to scavenge for food, females are often mated by sires of unknown genetic composition (local and foreign), as a result of indiscriminate mating leading to cross-breeding with loss of genetic materials. This approach to breeding though has provided significantly higher productivity, has resulted in loss or dilution of the indigenous chickens' morphological characteristics, resistance to diseases and instinct to broodiness (Kejela, 2020).

The plumage colour of indigenous chickens is second in importance to live weight when it comes to the determination of market preferences (Dana *et al.,* 2010; Melesse and Negesse, 2011). However, most breeding programmes in Africa do not lay much emphasis on plumage colour effects on indigenous chicken performance. This is because farmers do not see its immediate impact on production performance. In certain communities in Africa, plumage colour of indigenous chickens have cultural and religious values (Goran *et al.,* 2016) and sometimes determine the purchase price of the bird. Producer, sellers and intermediary traders of chicken and other poultry species attach high market preference to plumage colour and feather distribution (Fitsum 2016). This suggests that some qualitative traits with specific characteristics should be carefully identified and considered for breeding of the local poultry species including chickens.

Local chickens in most parts of Africa have been characterized in different ways (Safiyu *et al.,* 2019) by different researchers. For instance, based on plumage colour Teketel (1986) characterized them Kei (red) or Tikur (black), whiles Halima *et al.* (2007) classified them based on the geographical area from which the bird originated. Several research work has been done on plumage colour in chicken. For instance, Çavusoglu and Petek (2021) studied the effects of season, plumage colour, and transport distance on body weight loss, dead-on-arrival, and reject rate in commercial end-of-lay hens whiles Rowe *et al.* (2010) worked on plumage colouration, ejaculate quality and reproductive phenotype in the red-backed fairy-wren. There is, however, little information on how plumage colour influences production and reproductive performance of local chickens. This is because according to Yousif and Etayeb (2011), poultry breeders in developing countries are more concerned with the improvement of production performance of the indigenous poultry species in terms of egg and meat which have direct economic benefits.

Devising a successful breeding plan for the improvement of poultry requires that much effort is placed in the local breeds and the improvement of their genetic characteristics for use by local farmers who keep a few of these birds at a time (Titus *et al.*, 2015). It is of importance for breeders to improve indigenous poultry by identifying alternative breeding goals using breed-specific attributes (Mtileni *et al.,* 2011) such as how plumage colour affect laying and growth. It is for this reason that the present study sought to research how plumage colour affects growth and reproductive performance of two indigenous chicken ecotypes in Ghana.

1.3 Objective of the study

The main objective of this study was to determine the effect of ecotype and plumage colour on growth, and reproductive performance of two indigenous chickens in Ghana.

1.4 Specific objectives

The specific objectives of this study were to determine the:

1. average values of production and reproductive traits of the two ecotypes
2. age at first egg, fertility, and hatchability of eggs of the two plumage colours and ecotypes
3. correlation between body weight and laying performance

4. effect of plumage colour and ecotype on body temperature

1.5 Significance of the study

The results from this work would create awareness on the potentials of the indigenous breeds and inform farmers, breeders and all stakeholders of the benefits of improving the local chicken breeds. It will also provide information on which ecotype and plumage colour exhibit good production and reproductive performance and assist farmers and breeders in selecting the appropriate ecotype for breeding. The research paper will also contribute to literature by outlining and documenting ecotypes that exhibit good production and reproductive traits. It will also provide information on ecotypes to select and act as a stepping stone in conducting further research on breeding programmes on indigenous chicken breeds.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Indigenous Chickens

Chickens are considered as one of the most important and widely distributed avian species of poultry birds of which the local breeds are popular among rural communities. It is a very good source of animal protein for human consumption (Dutta *et al.*, 2013), source of income and employment for local people (Ngongolo *et al.*, 2021). According to Buli (2017), indigenous village chicken is the most prominent class of livestock in Africa and constitutes about 60-80% of the total poultry population. In Ghana, poultry production is based on the traditional free-range, in which local chickens are raised in the country-side, peri-urban and urban centres as well as a commercial sector, in which exotic chickens are raised on intensive systems around the principal towns and cities (Osei-Amponsah *et al.*, 2015). Several studies on the genetic improvement of indigenous chickens have been conducted in several countries. Such instances include Khobondo *et al.* (2015); Oleforuh-okoleh *et al.* (2015); and Rege *et al.* (2011) all of whom studied breed improvement of different traits of economic importance in indigenous chicken.

Selection and cross-breeding of indigenous chicken from the wide genetic pool and variability within the various ecotypes offer means through which genetic variation can be leveraged systematically to improve poultry productivity (Ayorinde *et al.*, 2012). They further assessed that the use of first filial generation (F1) cross-breeds, taken from parent stock with desirable traits, in production agriculture offers a means through which rapid performance improvement, that is productivity and fitness, can be achieved through additive gene effect to create animals that exhibit a more-desirable mixture of traits than is possible with either alone. Using this means, the genetic materials of the indigenous species can be maintained. Cross-breeding within and among species leads to offspring that are genetically fitter and have an average to above-average economic value than their parents (Wakchaure *et al.*, 2015). In Malawi, crossbreeding has been experimented to improve indigenous chickens, where Black Australorp males were crossed with local female chickens. This resulted in a progeny with higher body weight, fertility rate, hatchability and early sexual maturation (Khawaja *et al.*, 2013).

2.2 Socio-Economic Importance of Village Chicken Rearing

Poultry production is a business depending on the levels of production. The socio-economic importance of village chicken rearing is known to be multi-faceted and the system of production of scavenging chickens' is very complex (Desta and Wakeyo, 2012). This means indigenous chickens' play multi-functional roles to farmers keeping them. Poultry provides a major income-generating activity from the sale of birds and eggs. These birds also have bartering values when they are traded with other commodities in some communities (Padhi, 2016). Consumption of chicken meat provides a valuable source of protein in the diet (Moreda *et al.,* 2013) of farm families. Poultry also plays an important socio-cultural role in many societies. Chicken meat is the only special meal that some rural farm families can afford during religious festivities like New Year, Christmas and Easter (Belay and Oljira, 2019). Indigenous chickens are also used for spiritual purposes such as the sacrifice of indigenous chickens. Socio-culturally, white chicken symbolizes happiness, purity, joy and peace in the Sénoufo tradition of the people of Ivory Coast and are used in spiritual ceremonies whiles the black coloured feathers symbolizes misfortune and bad fate (Goran *et al.,* 2016).

2.3 Constraints to Chicken Rearing

The production of chickens just like any other domestic animal comes with its constraints. Indigenous chickens, though are hardier and resistant to some diseases are often affected by diseases that cause mortality and are more prominent in growers and adults (Maass *et al.,* 2012). This is because most backyard producers raise them on the free-range system thereby exposing these birds to disease-causing pathogens (Wang *et al.,* 2013). On the free-range system, predation and exposure to unfavourable environmental elements are also a major cause of mortality and loss of eggs in local chickens (Bestman and Bikker, 2020). However, smallholders' poultry is affected by many technical factors including low bio-security measures in the traditional production system which also pre-exposes these animals to risks (Dutta *et al.*, 2012) such as predation, run over by moving vehicles etc. Nutrition is poor in systems of production that allow animals to scavenge for feed (Yitbarek, 2017). Another major constraint to indigenous chicken production is the indiscriminate mating of chickens with exotic breeds which are raised on the extensive system of production (Dinka *et al.,* 2010). This will lead to loss of genetic materials (genetic erosion) of the local breeds and lead to the replacement of breeds. Productivity in indigenous chicken is low because of the low annual egg production per hen and their small body size and this accounts for the lack of investment in their production on large scale (N'dri *et al.*, 2016; Wambui *et al.,* 2018).

2.4 Poultry Management Systems

It is believed that in Africa, Asia and Latin America, about 80 percent of farmers keep poultry on the extensive system of management (FAO, 2004), It is practised in most rural communities of the country and the objectives behind this production are for household consumption of meat and eggs and as a source of additional income for the household (Husein, 2015). Chickens raised under this system are not confined but are allowed to scavenge for food over a wide area. This system of poultry production is more popular in low human population density areas like rural and small towns and is based entirely on low input-low output management. This low input – low out makes profitability low, thereby making the system not to be classified as a business-oriented entity. Rudimentary shelters, usually constructed with simple materials such as clay or wood may be provided, and these may or may not be used (Adomako 2009; Fitsum, 2016) by birds. In situations where shelters are not provided, birds sleep in trees around human settlements (Adomako 2009). The birds may roost outside, usually in trees, and nest in the bush. The flock size is usually small and contains birds of different species and varying ages. Backyard extensive systems of poultry production are housed at night but allowed free-range during the day. They are usually fed a handful of grains in the morning and evening to supplement scavenging (FAO, 2004)**.**

The Semi-Intensive System of chicken management is a combination of the extensive and intensive systems where birds are confined to a restricted area with access to shelter, fresh green forage, feed and water. They are commonly found in urban and peri-urban as well as rural situations (FAO, 2004). The Levels of inputs and investment including time attached to this system ranges from low to medium depending on the commercial value attached to the flock (Magothe *et al.*, 2012). The birds are provided with some form of housing usually made from simple shelters to proper chicken houses. Health care of animals depends on the commercial value attached to the enterprise. Because of the low levels of input, production in this system is lower than that of the intensive system of poultry management (Magothe *et al.*, 2012).

Another form of poultry management is the Intensive System. This system is used by medium to large-scale commercial enterprises and sometimes at the household level. Many birds can be raised within a building or a single structure. Birds are fully confined either in houses or cages (FAO, 2004). The system is a high input – high out production system that requires the owner to provide all the necessary feed, water, and health needs of the birds. This system is a business-oriented poultry production system. There are three main types of intensive systems. They are the deep litter, slatted floors and battery cage systems. In the deep litter system, birds are confined in a structure but can move about freely. The floor is covered with litter materials usually made of wood shavings, straws from rice or corn or any other suitable bedding material to absorb faecal matter (Sigroha et al., 2017).

Slatted floor system: The slatted floor is made of wire or wood or high-impact plastic or any other strong material instead of litter. With this system, birds have reduced contact with faeces. The Battery cage system is usually used for laying birds, which are kept throughout their productive life in cages (Lukanov, 2013).

2.5 Chicken breeds

Indigenous chicken populations are often classified and grouped according to geographical location such as the savannah and forest ecotypes or phenotypic characteristics such as the naked neck, normal feathers and the frizzle feathers (Manyelo *et al.,* 2020). Genetically, chickens have been classified using monogenic traits which is based on different pigmentation responsible for the production of plumage colour (Safiyu *et al.,* 2019). These different pigmentations can be attributable to melanin resulting in the variation of plumage colours in chickens (Dana *et al.,* 2010).

2.5.1 Commercial and *hybrid breeds*

Indigenous chicken breeds have over the years lost their commercial importance because they are not efficient at producing meat and eggs (Mazurkevych, 2015) as compared to the exotic breeds. Broilers and layers raised commercially are birds that have been developed by international poultry breeding companies (Mazurkevych, 2015). There are three main commercial poultry breeds. These are the layer breeds which are hens specifically bred and raised to produce eggs on a large scale. In the modern egg-producing industry, most of the laying hens are hybrid White Leghorns which are white egg producers or sex-linked hybrids that resemble New Hampshire Reds and Barred Plymouth Rocks which are typical brown egg producers (Mazurkevych, 2015). These hens can produce about 300 or more eggs per year. Layers are mostly small to medium in size (Moyle, 2011; Manyelo *et al.,* 2020) and do not produce a good carcass for consumption. The broilers are also commercial poultry which are efficient in converting feed into meat within a short period of time (Mbuza *et al.,* 2017; F.A.W, 2019). This means they are bred to be very fast growing to gain weight quickly. According to Mazurkevych (2015), broilers can achieve a 2.25kg market weight in five weeks. Meat birds are of either sex and have a strong frame and large capacity (Moyle, 2011).

Dual-purpose poultry breeds are those breeds that can both produce meat and lay eggs and are to some extent broody (Moyle, 2011). The hens lay fewer eggs than the specialized laying hens (layers), and the cockerels put on less meat than broilers and require more time to reach laying maturity. Dual-purpose chickens are those breeding lines in which both the males and the females can be used for production with the males being kept for meat production and the females as laying hens. The eggs of the hens are slightly smaller and fewer than the ones produced by layers (Brümmer *et al.*, 2018). They are between layers and broilers. Local breeds of chicken often have the form of a dual-purpose breed, although much less heavy in body form and size.

2.5.2 Naked Neck Chickens

Naked Neck chickens are a group of bare neck chickens with the neck absent of feathers. This absence of feathers at the neck region is caused by a single gene trait that affects the arrangement and number of feathers over the chicken's body (Mazurkevych, 2015)**.** The African Naked Neck chickens are thought to have originated from Malaysia (Khobondo *et al.,* 2015). The autosomal incompletely dominant naked neck (Na) gene is responsible for defeathering around the neck region, and also restricts the feathered area around the body by about 20 to 30% in heterozygous (Nana) and up to 40% in homozygous (NaNa) genotypes because of the incomplete dominance of the Na gene (Islam and Nishibori, 2009). The naked neck gene (Na) responsible for the general reduction of feathers over the body surface and usually around the neck region has shown very favourable test results under heat stress in various experiments (Thiruvenkadan *et al.,* 2010).

In their study, Abbass *et al.* (2017), Thiruvenkadan *et al.* (2010), and Adomako (2009) noted that the heterozygous naked neck layers had a significantly higher (*P<0.05*) number of eggs per clutch, and the number of eggs per bird, egg weight, egg mass and body weight under constant heat stress. The naked neck birds have a better ability to lose body heat and are superior in disease resistance which is associated with the Na gene. This results in higher productive performance under tropical environment conditions (Ariyadi *et al.*, 2015). The reduced feather coverage in naked neck birds facilitates their ability to dissipate heat and therefore improve their thermoregulation. This results in better relative heat tolerance in the birds in hot climatic conditions of the tropics (Adomako, 2009; Ariyadi *et al.*, 2015). Chickens are usually affected by high ambient temperatures which can lead to decreased feed intake and growth. This is because their feather coverage hinders internal heat dissipation leading to higher body temperatures (Asumah, 2015). However, this situation is less observable in the naked neck birds, making them perform slightly better than their counterparts. The naked neck birds have heavier Body weight as compared to the normal feathered and frizzle feather ones. This could be due to their 9 to 12 percent less feather coverage which reduces considerably the need for dietary nutrition, particularly protein which would otherwise have been converted into feather production to be utilized for body growth (Adomako, 2009). In a study conducted by Yakubu *et al.* (2008) and Adomako *et al.* (2009), to determine the productivity and egg quality traits of naked neck and full-feathered or frizzle feather chickens, it was established that there was a significantly (*P<0.05*) lower rate of mortality in NaNa birds 28.66% as against 36.85% in nana ones (Yakubu and Ogah, 2008). The male naked neck chicken has reddish colour around the neck region whiles the females have pale red to pale pink colour around the neck region (Plates 1 and 2).

2.5.3 Frizzle Feathered Chicken

These are chickens with genetic modification that causes their feathers to curl back towards the bird's head instead of lying naturally (Mazurkevych, 2015; Sholeh *et al.*, 2020)(Plate 3). It is a mutant gene in the chicken which makes the plumages grow curve outward, instead of the usual lying smoothly along the body of the bird (Dunga, 2013). The frizzling (F) gene which results in the contouring of the feathers reduces the insulating power of the feather cover thus making it easier for the birds to reduce body heat (Asumah, 2015; Hagan *et al.,* 2011). The frizzle gene (F) is believed to have a favourable effect on the bird's productivity such as egg production (Thiruvenkadan *et al.,* 2010) and have significantly higher hatchability than those from naked neck and the normal feathered hens (Adomako, 2009). He also asserted that frizzle feathered (Ff) chicks between day-old and 6 weeks had a significantly lower ($P<0.05$) rate of mortality as compared to the naked neck (Nana) and normal feathered chicks. This, therefore, shows that there is a good chance of survivability of the frizzle feathered chicken which can be translated into economic importance (profit) if they can be raised to reach market stage with their superiority in performance as compared to normal feathered birds (Adomako *et al.,* 2014; Reddy *et al.,* 2015). According to Fathi *et al.* (2013) sires of Frizzle-feathered genotype, chickens have the highest fertility of 90.5% and hatchability of 91.4%. Frizzle plumage may cause the acceleration of basal metabolism due to the loss of body heat, leading to alterations in organ size such as enlargement of the heart, spleen, gizzard, and alimentary canal as well as lack of hypodermal fat deposits and numerous physiological anomalies like higher feed intake, oxygen consumption, heart rate, the volume of circulating blood as well as delayed sexual maturity or decreased fertility.

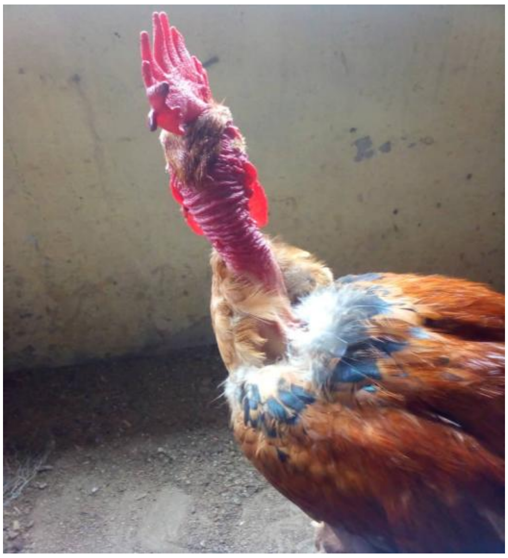


Plate 1: Male necked neck chicken (Quartey, 2021)

Plate 2: Female necked neck chicken (Quartey, 2021)

Plate 4: Normal feathers (Quartey, 2021)

2.5.4 Normal feathers

Normal Feathered (Indigenous) chickens make up the majority of the total local chicken population in various African countries (Nigussie *et al.,* 2014; Chigoma and Tanganyika, 2017) including Ghana (Plate 4). Normal feathered chickens according to Moreki *et al.* (2014) has higher hatchability as compared to the naked neck chickens.

2.6 Plumage colours of Indigenous Chicken

Indigenous chickens come in different varieties of plumage colours; which may be either multi-coloured or single colours. These colours included white, black, barred, red, brown, grey or a mixture of two or more of these shades (Adomako, 2009; Wiener and Wilkinson, 2011; Fathi *et al.,* 2017). Adomako (2009) also stated that birds with special plumage colours such as all white, all black and all red, command relatively higher prices when sold than birds with mixed colour effects. This is because it is believed that one only looks for a bird with a special colour when it is needed for rituals or some religious purposes.

Plumages colours of birds arise from the coloured pigments (melanin) that are present in the Keratin. These melanins which are divided into Eumelanin and Phaeomelanin range from black to light tan and can also produce grey shades with the proportion and amount of which account for the different plumage colours (Corti and Vogelaar, 2010; Van *et al.*, 2020). They further stated that the pigments responsible for the red shade colours are Phaeomelanin, while eumelanins produce the black shade colours (Plate 5 to 8). Chickens exhibit a wide range of colours than the more common blacks, browns, reds, oranges and yellows (Corti and Vogelaar, 2010). There are other less common colours which include violet, green and among others. Violet and White according to

Corti and Vogelaar (2010) are normally structural colours just like the colour green, although green may often be a mixture of structural and pigmental colours.

Plate 5

Plate 6

Plate 7

Plate 8

Plate 5 - 8: Different plumage colours (Quartey, 2021)

2.7 Body Weight and Body Weight Gain

The Body weight of chickens are an important variable that determines the market value of a bird. This means that the observed body weight differences between indigenous chicken ecotypes would reflect varying market values for these ecotypes (FAO, 2012). Location, according to Zaman *et al.* (2018), showed significant differences in body weight of hens. This may be attributed to variations in protein sources available in the different locations. However, Jahan *et al.* (2011) reported that there was no significant difference ($P>0.05$) between location and body weight. Chicken body weight at 20 days of age ranged from 41g to 100 g, and at 70 days from 142g to 492 g (FAO, 2004). At age of lay, the body weight of hens weigh approximately 1.2 kg. Live body weights of indigenous chicken ecotypes from one day old to 20 weeks of age has been recorded to show significant difference ($p \leq 0.05$) among birds (Ngeno *et al.*, 2012).

Chick weight and weekly weight gain from day-old to the end of week 2 has been reported to be significantly higher in homogeneous naked neck chicks than in heterogeneous naked neck chicks except at the end of week 2 where the body weights of chicks were not significantly different (Adomako, 2009). FAO (2004) also noted that adult body weight and egg weight vary considerably among indigenous chicken populations. In broilers, the body weight changes of Sasso C44 during the starter and finisher phase shows a significant difference ($P<0.05$) in mean daily body weight gain, final body weight and mean total body weight gain (Yitbarek, 2017). Yitbarek (2017) also reported that the body weight change of birds during the finisher phase was not statistically different ($P \geq 0.05$) in the mean daily weight gain, final body weight and mean total body weight gain among the treatment groups. The author also noted that the daily body weight gain for male broiler birds was 46.4g and 38.6 g for female broilers in 49 days of growth period.

2.8 Feed consumption, Feed conversion ratio and Body weight gain

Historically, improvement in feed efficiency is achieved mainly through improvement in growth rate, body weight or egg-laying performance (Mebratie, 2019). Body weight and feed efficiency traits have in recent years received major consideration in the poultry industry due to their economic and environmental implications (Mebratie, 2019). Body weight is the live weight of an animal at a specific age while feed efficiency is the ability of an animal to convert a kilogram of feed into a kilogram of body weight (Willems *et al.*, 2013; Mebratie, 2019). According to Mebratie (2019), there is a moderate genetic correlation (0.30-0.50) within production traits (body weight and body weight gain) and between body weight and feed intake (0.49-0.63) as well as high genetic correlation between feed intake and body weight gain (0.82-0.89).

In layers, just like meat-type birds, the feed conversion ratio varies with feed intake whiles egg production in laying birds is considered an index of efficiency. Layers raised in a floor system fed more and had more room to move and perform their natural behaviour and spend their energy as compared to those raised in restricted cages and therefore have increased egg production (Viana *et al.*, 2020). They also asserted that, the higher feed intake of layers raised in a floor system may result in the higher bird body weight gain.

Feed intake (FI) is the most important factor that influences both the body weight gain (BWG) and feed conversion ratio (FCR) in broilers and egg size and numbers in layers. Birds may not perform to their full potential unless they consume their full nutritional requirement each day (Balami *et al.*, 2018). The most important trait in poultry production that impact the profitability of farmers of any kind is feed conversion (Thiruvenkadan *et al.,* 2010). Feed expenses are the main cost in layer (egg) and broiler (meat) production and this may account for more than 60% of the total production costs (Aggrey *et al.,* 2010). Feed conversion ratio (FCR) is a measure of how well a flock converts feed intake into live weight and eggs laid and provides an indicator of management performance, and also profit at any given feed cost (Aviagen, 2011). They also noted that solving or preventing FCR problems in a flock requires both good planning and good management practices. Anything that affects live weight, feed intake or feed wastage will influence FCR. There is a direct relationship between feed conversion and egg numbers in layers and body weight gain in broilers. According to Thiruvenkadan *et al.* (2010), feed conversion into eggs is primarily a function of egg numbers. Feed conversion also influences body weight (in meat or egg-producing birds) and egg size.

Osei-Amponsah *et al.* (2015) noted that egg production can be affected by feed consumption (quality and quantity) which shows the substantial variations in egg production abilities of different chicken ecotypes. Indigenous chickens have been noted for their low output in terms of egg numbers, sizes and weight as well as slow growth rate and low body weight. These low performance of indigenous chickens has been partly attributed to environmental effects such as poor management practices which include poor nutrition (Dutta *et al.,* 2013). Feed consumption is also affected by high ambient temperature when chickens suffer from heat stress due to difficulty in heat dissipation. In other words, feed consumption decreases with an increase in temperature. If the environmental temperature falls below the birds' zone of comfort (i.e. birds become cold), feed intake will increase but the extra energy provided by this increase in feed intake will be used to maintain body temperature of the birds. This consequently affects feed consumption and ultimately results in a decrease in growth and productivity (Asumah, 2015). Indigenous chicken on free-range usually needs enough energy to scavenge around. When birds are fed on low energy diet, feed consumption tends to be higher. The high feed consumption compensates for the energy level in the feed.

2.9 Production and reproductive Performance of Indigenous Chicken

Production and reproductive traits of chickens are economic traits that bring income to farmers and their families. Age at first egg, egg size and numbers, body weight gain and body weight of live and slaughtered birds are a few of these traits that generate returns. It has been reported by Adomako (2009) that age at first egg and egg size to body weight ratio was significantly better ($P<0.05$) in some breeds as against others. Age at first egg and egg size to body weight ratio, hen-housed rate of lay and hen-day rate of lay he noted did not differ significantly ($P>0.05$) between birds in the three locations under consideration. This could therefore mean that birds within the same ecotype may have similar reproductive and productive traits. He also reported a mean age at first egg around 138 days with hen day and hen house egg production at 64 and 60% respectively. Ngeno *et al.* (2012) also reported the mean sexual maturity as determined by the age at first lay of the indigenous chickens at 189.9 days (6.33 months). Osei-Amponsah *et al.* (2015) also reported age at first egg of 165 days (5.5 months) for indigenous chickens in Ghana. This value is significantly later than that of the value of (Adomako, 2009; Ngeno *et al.,* 2012).

Fertility and hatchability have significant effect on the level of reproduction in poultry. Alewi *et al.* (2013) recorded an average fertility and hatchability performance of local broody hens in southern Ethiopia at 73.7 and 85.8% respectively. Males tend to have higher body weight as compared to female birds at 20 weeks of age (Adomako, 2009). Adomako (2009) also reported a (*P<0.05*) in birds reared under the intensive system as against those kept under the semi-intensive and the extensive system. Sapkota *et al.* (2020) also reported that the overall mean hatchability over the total number of incubated eggs and the total number of fertile eggs set was 85.0 and 90.3 percent in local chicken whiles Woldegiorgiss (2015) reported 79% hatchability in local chicken in Ethiopia. Hatchability of eggs varies across seasons and nutrition has an influence on the hatchability levels of indigenous chickens. High ambient temperature and low humidity lower the rate of hatchability (Idowu *et al.*, 2018). Sapkota *et al.* (2020) again reported significant differences in fertility among local chickens and further stated that fertility among local chickens increased by 7.7, 8.3 and 8.8 percent in first, second and third generations respectively when compared to the initial parent stock.

According to Abdel-Ghany and Abdel-Ghany (2011), the average egg weight during 90 days laying period for a selected line recorded a positive and higher correlation with egg number (0.71) at the first 90 days of laying. The authors also recorded a positive and moderate correlation between body weight at sexual maturity for the selected line had positive and moderate correlation with egg number (0.49) and egg weight at first 90 days of laying (0.68). Table 1 shows some production and reproductive traits in selected countries. Dudusola *et al.* (2020) in determining the effect of laying age and plumage colour on internal and external quality characteristics of noiler chicken eggs noted that there were no significant differences in the egg weight, shell thickness and percentage shell thickness among the three plumage colours (black, brown and barred) of noiler birds under consideration.

In a study conducted by Rizzi (2018), it was observed that final body weight at 200-day old chickens was significantly higher ($p<0.01$) in birds with chamois plumage as compared to those of silver colour. This observation was attributed to the feathering process which may be an influencing factor in the growth rate of the birds.

Table 2.1: Selected Production and Reproduction performance of Indigenous Chicken in Some African Countries

Country	**Reproductive Performance**			**Production Performance**		**Reference**
	Fertility of eggs *(%)*	**Age at first egg *(months)***	**Hatchability of fertile eggs *(%)***	**Mature body weight (Female) *(kg)***	**Egg weight *(g)***	
Nigeria	74.44	5.3	82.09	1.5	38.64	(Ukwu *et al.,* 2014; Oleforuh-okoleh *et al.,* 2015)
Tanzania	-	6-8	83.6	1.5	44.1	(Mwalusanya *et al.*, 2002; Guni *et al.*, 2013)
Kenya	70	6-8	70	1.0-1.5	47.4	(Magothe *et al.*, 2012)
Ivory Coast	-	6-8	50-90	1- 1.5	35	(Goran *et al.*, 2016)
Ethiopia	71.11	5.7-6.4	80	1.81	38	(Tadese, 2017)
Ghana	-	6-8	77	1.13	42.80	(Adomako, 2009)

Further observations indicated that both male and female birds with white and chamois plumages showed a significantly higher body weight ($p<0.05$) than that of chickens with silver plumage colours. Sarker *et al.* (2014) also stated that chicken types and plumage colours show highly significant ($p < 0.05$) effects on body weight of Bangladeshi indigenous chickens. In their study, Abbass *et al.* (2017) noted that semen volume was higher ($P<0.05$) in heavy black-feathered chickens than in brown plumage coloured ones while it did not differ significantly ($P>0.05$) with white indigenous chicken breeds. The heavy black plumage coloured birds also had better semen quality than the others. This could indicate male fertility will be higher in black plumage coloured birds as compared to those of other plumages.

2.10 Some factors that impact production and reproductive performance of Chickens

2.10.1 Environmental factors

2.10.1.1 Temperature* and *heat stress

Heat stress in poultry production is a situation where too much heat is absorbed by the birds which may lead to stress, illness or even death (Ranjan *et al.,* 2019; Bekele, 2021). It causes high body temperature, hot, dry skin and lack of sweating. It may also cause neurological symptoms such as paralysis and unconsciousness, heatstroke and even death in animals (Ranjan *et al.,* 2019; Bekele, 2021). High environmental temperatures can cause reproductive failures such as drop in egg production, poor egg quality (Getabalew and Negash, 2020). In male birds, semen quality and level of production may be reduced due to high environmental temperatures (Ayo *et al.*, 2011; Igbokwe, 2018). Poor semen quality will therefore reduce fertility and hence hatchability will also be affected.

According to Igbokwe (2018), during heat stress situations, birds will drink more water to cool off and reduce their body temperature. In this situation, they eat less and growth or egg production may fall as a result. At relatively low ambient temperature of 7◦C and below, Ayo *et al.* (2011) noted that layer birds become depressed, drowsy, fall in egg production levels and quality whiles broilers show impaired growth performance. Birds exposed to high environmental temperatures shows behavioural, physiological and immunological responses, which impose detrimental consequences to their productivity (Bekele, 2021).

The impact of high ambient temperature may increase or decrease due to the plumage colour of the bird. White coloured birds are better able to reflect heat than brown or black coloured birds (Hill and Wall, 2017). In another study, Ayo *et al.* (2010), noted about 20% feed intake reduction in situations where layer birds are heat-stressed during the hot-dry season. This resulted in a significant reduction in hen-day egg production. Ranjan *et al.* (2019) stated that feed intake during temperature ranges of 22-32°C is reduced by 1.2% for every 1°C rise and up to 5% reduction in feed intake for 1°C rise in temperature ranges of 32-38°C. Bekele (2021) also explained that above 30°C, feed and energy intake in chickens' declines to such levels that birds are no more able to compensate for it, leading to a rapid fall in production and a rise in the rate of mortality.

2.10.1.2 Nutritional factors

Layer and broiler chickens just like any other poultry species under production require a completely balanced meal. This balanced diet will help to sustain egg production or growth rate over the period (Jacob *et al.,* 2003). They further stated that inadequate nutrition can cause a stop in laying or in the case of young birds retard growth and delay reproductive maturity. Inadequate levels of energy, vitamins, protein or minerals or any nutritional requirement in a diet can cause a drop in production. (Ibrahim *et al.*, 2018). Production and reproductive performances of chickens are also more likely to be impacted when certain nutrients are absent in their diets. For instance, the eggshell in birds are composed primarily of calcium carbonate. However, according to Jacob *et al.* (2003) calcium requirement for young layers or pullets is relatively lower during the growing phase, but its requirement during the laying phase is relatively higher. When this mineral requirement is not met, egg production levels will reduce, quality lowered, shells may be thinner and breakages more likely to occur. Consequently, production will decrease. Also, as calcium levels are depleted in a bird, its bones become brittle and in some cases, they are unable to stand.

2.10.1.3 Health management

The proper functioning of the immune system is of great importance in the defence against bacterial, fungal and viral pathogens (Assersohn *et al.*, 2021). Disease outbreaks in poultry at different stages of their lives can impact production and reproductive traits in birds. The extent of reproductive disease in poultry may differ with the bird's age, immunity, physical form and the strain of the causative organism (Hassan, 2020). For instance, Infectious Bronchitis virus, which is a respiratory disease, at its peak may lead to a severe fall in egg production, reduction in eggshell quality and watery albumen in laying hens whiles other infections such as Newcastle and Marek's disease can cause mortality in birds (Hassan, 2020).

2.10.2 Genetic factors

The genetic structure of a bird as inherited from its parents determines the possible performance of the animal. Even though the environment affects an animal's performance, its genetic makeup plays a significant role in determining its potential. Offspring that inherit traits with high heritability will express those traits. This means that in selecting chickens for breeding, breeders need to select for traits with moderate to high heritability.

2.11 Effect of plumage colour on production and reproductive performance

Many studies have indicated that hens with coloured feathers lay bigger size eggs than hens with white plumages (Halaj and Golian, 2011). According to Rayan *et al.* (2013), plumage colour affects egg weight and egg characteristics in laying birds. They further noted that brown coloured birds laid eggs with better characteristics than white coloured birds. However, in their study on Noiler chickens in Nigeria, Dudusola *et al.*, (2020), concluded that plumage colour did not influence egg weight and external egg characteristics.

The effect of plumage colour observed on age at sexual maturity and body weight at first egg has been observed to show significant difference in light and heavy local chicken ecotypes (Ogbu *et al.*, 2015) in Nigeria with brown feathered chickens having significantly better performance when compared to their white plumage counterparts. This means that plumage colour has effect on age at sexual maturity and weight at first egg. Dogara *et al.* (2021) also observed significant difference in laying characteristics of brown, spotted and black plumage coloured birds indicating that spotted plumage coloured birds had better value of age at sexual maturity, average egg numbers per hen,

hen housed and day egg productions. They also noted that black plumage birds had the highest value for most egg quality traits and body weight at first egg. Several studies have demonstrated that plumage colour has significant influence on the live body weight and laying performance of poultry species (Barnejee, 2013). Adetunji and Ola, (2020) also noted that plumage colour has influence on production indices in the Noiler hens with black plumages having better production values followed by brown and barred coloured birds.

2.12 Disease and Parasites

Chickens are fragile animals and can succumb to diseases very easily especially when young. Disease is any abnormality which disturbs the daily movement and activity of an animal by injuring either internal or external part of the body (Adekunle, 2019). Mortality in chickens may be as a result of several factors. The most prevailing factors in most free range farms are as a result of predation, diseases, unfavourable weather conditions, accident and lack of or inadequate feed/water (Conteh and Gogra, 2020). In Africa, studies have shown that predation is a major cause of premature death in poultry production (Ahmed, 2018; Dinka *et al*., 2010) after diseases. Predators which cause major mortality in chicken production include hawks, dogs, cats, snakes crows among others.

Indigenous chickens are more resistant to diseases and parasites than the imported breeds. However, it is one of the major constraint to their development, survival and productivity (Dutta *et al.*, 2012) in developing countries. Studies on the health of these birds have revealed that, there are a number of diseases and parasites that commonly affect indigenous chickens. The most common diseases are Newcastle Disease, chronic respiratory disease, fowl pox, coccidiosis, fowl typhoid, infectious coryza among others (Conteh and Gogra, 2020). Newcastle Disease is known to be the most devastating, causing severe losses to farmers (Magothe *et al.,* 2012). This disease according to Magothe *et al.* (2012) has also been reported to be the most important in other developing countries. Diseases such as Newcastle, Chronic respiratory disease, and infectious coryza normally occur during dry seasons because dry conditions favour the spread of the disease-causing microbes (Magothe *et al.,* 2012; Kayang *et al.,* 2018; Conteh and Gogra, 2020). Others such as Fowl pox, coccidiosis, fowl typhoid and salmonellosis occur during wet seasons causing heavy losses *(Magothe et al.,* 2012).

Ecto-parasites such as lice, fleas, ticks and mites and endo-parasites like helminthes and coccidia are important parasites of poultry (Bhat et al., 2014; Assefa, 2017; Meta et al., 2018) which affects their normal body functioning, growth and development.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and Duration of Experiment

This study was conducted at the Poultry Unit of the Department of Animal Science, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Mampong campus in the Ashanti Region of Ghana. Mampong is geographically located in the transitional zone of Ghana about 60 kilometres north of the regional capital, Kumasi and lies between Latitude 07.78^{o} N and longitude 01.40^{o}W on an altitude of 289.7m above sea level. The Municipality lies within the wet semi-equatorial forest zone lying between the Guinea Savannah to the North and Rain Forest to the South. It has a bimodal rainfall pattern with an average annual rainfall of 1365mm. The major rainy season begins from March to August whiles the minor occurs between September to November. The average daily temperature and humidity were 25^{o}C - 30^{o}C and 70% respectively (MSD, 2020). The experiment was conducted from October 2020 to August 2021.

3.2 Experimental birds

The base population for the experiment were from eggs gathered from twenty-four (24) matured chicken comprising 5 males and 19 females acquired from the Northern, Eastern, and Ashanti Regions of Ghana with the birds from Eastern and Ashanti Regions classified as forest ecotype and the birds from the Northern Region as the Savannah ecotype. They comprised two (2) males and nine (9) females from the forest ecotype and 3 males and ten (10) females from the savannah ecotype. One hundred and twenty (120) eggs from each ecotype were set for hatching and One hundred (100) day-old chicks were brooded for Six (6) weeks of which Ninety six (96) birds consisting of thirty-six (36) females and twelve (12) males from each ecotype were selected randomly for the experiment. Based on plumage colour, birds were grouped as white and brown each with eighteen (18) birds per ecotype. There were six (6) birds per replicate for each of the plumage colours. There were two treatments and three replicates each for the two plumage colours.

3.3 Management of experimental birds

3.3.1 Housing

Birds for the experiment were housed in 71 by 23 cm wood-wire mesh pens. Brooding of the experimental birds were managed based on the two ecotypes in two different but similar deep litter system for the first six weeks and then moved into similar pens of the same dimensions.

3.3.2 Feeding* and *watering

The experimental animals were fed on formulated feed comprising starter, grower and layer diets based on National Research Council (1994) recommendation for poultry. Water was provided *ad-libitum* whiles measured amount of feed was provided to the birds. Data from feed given and feed leftovers were recorded on weekly basis to determine quantity of feed consumed each week. Measurements were done using a portable electronic scale (0.1).

Table 3.1: Composition feed for starter and layer birds

Ingredient	Percentage (%)		
	Starter	**Grower**	**Layer**
Maize	54.5	58	53
Wheat bran	11	21	21
Soya bean	11	5	7
Tuna fish	12	6	7
Anchovy	8	7	3
Oyster shell	2	1.5	7.5
Dicalcium phosphate	0.5	0.5	0.5
Premix	0.5	0.5	0.5
Salt	0.5	0.5	0.5
Total	100	100	100
ME(Kcal/kg)	2800	2800	2900
CP (%)	21	17	22

3.3.3 Health management

The experimental birds were not vaccinated throughout the experiment but were given antibiotics at periodic intervals to prevent disease infestation. Internal biosecurity such as restricted access to visitors, daily washing of water troughs and quarantining of sick birds were strictly adhered to. This was done to prevent the introduction and spread of diseases.

3.4 Experimental design

The experiment was a 2 X 2 Factorial experiment with ecotype and plumage colour as factors and (2) levels of ecotype (Forest and Savannah) and plumage colours (White and Brown).

3.5 Data collection

3.5.1 Production parameters

Data on production parameters were recorded and calculated as follows:

3.5.1.1 Body Weight

Body weight (g/bird) was obtained by weighing birds in each replicate and determining the average. This was done using an electronic hanging scale with precision of 0.1g

3.5.1.2 Body Weight Gain

Body weight gain in a particular week was calculated as:

$$\text{Weight gain (g/bird/day)} = \frac{Final\ weight - initial\ weight}{Number\ of\ weighted\ birds\ x\ Number\ of\ days}$$

3.5.1.3 Weekly Feed intake

Feed intake in each replicate was estimated using the formula below:

$$FI\ \text{(g/bird/day)} = \frac{Feed\ given - Feed\ leftover}{Number\ of\ birds\ x\ Number\ of\ days}$$

3.5.1.4 Age at first egg

This was taken as the number of days from hatch to the first day an egg was laid

3.5.1.5 Egg Weight

Mean egg weight was obtained by weighing samples of eggs from each of the replicate. The eggs were weighed immediately after collection.

3.5.1.6 Hen day egg production (HDEP)

Hen-day egg production was calculated as the percentage of the number of eggs laid to the number of hen –day. It is given by:

$$HDEP(\%) = \frac{Number\ of\ eggs\ laid}{Number\ of\ hen - day}\ x\ 100$$

The number of hen-days = Number of laying days x Number of birds alive

3.5.1.7 Hen house egg production (HHEP)

Hen house egg production (HHEP) was computed as:

$$HHEP\ (\%) = \frac{Total\ Number\ of\ eggs\ laid}{Number\ of\ birds\ housed\ at\ the\ start\ of\ the\ laying}\ x\ 100$$

3.5.1.8 Feed Conversion Ratio

The feed conversion ratio was calculated as the amount of feed consumed to produce a kilogram of weight. Feed conversion ratio (FCR) was computed as:

$$FCR = \frac{Feed\ intake\ (g)}{Body\ weight\ gain\ (g)}$$

3.5.2 Reproductive parameters

Data on reproductive parameters were measured as follows:

3.5.2.1 Fertility of eggs

Fertilized eggs were determined by candling on the 14th day of incubation. This was done using a touch light. The percentage fertility was calculated as:

$$Fertility\ of\ eggs\ (\%) = \frac{Total\ number\ of\ fertile\ eggs}{Total\ number\ of\ eggs\ set}\ x\ 100$$

3.5.2.2 Hatchability of fertile eggs

Percentage hatchability of fertile eggs was expressed as:

$$Hatchability\ of\ fertile\ eggs\ (\%) = \frac{Total\ number\ of\ chicks\ hatched}{Total\ number\ of\ fertile\ eggs}\ x\ 100$$

3.5.2.3 Hatchability of egg set

This is expressed as:

$$Hatchability\ of\ egg\ set\ (\%) = \frac{Total\ number\ of\ chicks\ hatched}{Total\ number\ of\ eggs\ set}\ x\ 100$$

3.5.3 Body temperature

Body temperature measurements were recorded within the laying period. Clinical thermometer was used in the measurement of the body temperature.

3.6 Statistical analysis

The analysis of the data was done using GenStat 11.1 (2008) software. Data were presented using descriptive statistics and ANOVA tables. Where significant differences were observed, the least-squares means were separated using LSD. Estimation of mean values with statistically significant differences was set at $P<0.05$. All data were analyzed for the main effect of ecotype and plumage colour. Microsoft Office Excel 2007 was used to analyse the correlation between plumage colour and body temperature, and body weight and laying performance.

The model of the study was:

$$yijkl = \mu + Vi + Rj + VRij + \Sigma ijkl$$

Where:

yijk = Individual Observation

μ = Population Mean

Vi= effect of ith ecotype, i = 1 and 2

Rj = effect of jth plumage colour, j = 1 and 2

VRij = interaction between ith ecotype and jth plumage colour

Σijk = Residual error assumed normally and distributed independently

CHAPTER FOUR

4.0 RESULTS

4.1 Estimation of Average values of production traits of the two plumage colours

4.1.1 Average production performance of the two plumage colours

The average values of production performance of the two plumage colours are shown in Table 4.1a

Table 4. 1a: Average values of bi- Monthly body weights of two the plumage colours

Production Performance	Savannah Ecotype (Colour)		Forest Ecotype (Colour)			
	Brown	**White**	**Brown**	**White**	**SEM**	**P- value**
2 WBWt (g)	1096	1218	1207	1141	140.0	0.915
4 WBWt (g)	1450	1462	1508	1383	187.2	0.971
6 WBWt (g)	1508	1570	1761	1577	193.9	0.813
8 WBWt (g)	1665	1725	1992	1758	177.5	0.605
10 WBWt (g)	1957	1933	2149	1955	178.2	0.811

WBWt = *Weekly Body Weight. SEM: Standard error of means.*

There was no significant difference (*P>0.05*) in the 2, 4, 6, 8 and 10-week body weights of the two plumage colours of the two chicken ecotypes. It was observed that the white plumage coloured birds of the Savannah ecotype had higher mean body weight in the 2, 4, 6 and 8 week but had a lower mean body weight in the 10 week when compared to their brown coloured counterparts. The brown plumage coloured birds of the Forest ecotype also recorded higher mean values in all the parameters as against those of their white counterparts. The results also showed that the brown plumage coloured birds of the Forest ecotype had the highest mean body weight between the two plumage colours of the two ecotypes as represented in Table 4.1a.

4.1.2 Average production performance of the two plumage colours

The average values of production performance of the two plumage colours are shown in the Table 4.1b

Table 4. 1b: Average values of bi-Monthly Body Weight Gain of the two plumage colours

Production Performance	**Savannah Ecotype (Colour)**		**Forest Ecotype (Colour)**			
	Brown	**White**	**Brown**	**White**	**SEM**	**P-value**
2 WBWtG (g)	15.66	17.40	17.25	16.30	1.999	0.915
4 WBWtG (g)	20.07	20.9	21.5	19.8	2.67	0.971
6 WBWtG (g)	21.5	22.4	25.2	22.5	2.77	0.813
8 WBWtG (g)	23.8	24.6	28.5	25.1	2.54	0.605
10 WBWtG (g)	28.0	27.6	30.7	27.9	2.55	0.811

WBWtG = Week Body Weight Gain. *SEM: Standard error of means.*

There was no significant difference (*P>0.05*) between 2, 4, 6, 8 and 10-week body weight gains of the two plumage colours of the two different ecotypes. However, birds with white plumage colours of the Savannah ecotype had relatively higher mean body weight gain for 2, 4, 6 and 8 weeks. The 10-week mean body weight gain for the Brown plumage colour of the Savannah ecotype was higher than that of the White coloured birds. On the other hand, the brown coloured birds of the Forest ecotypes recorded higher mean body weight gain for the 2, 4, 6, 8, and 10-week body weight gain as compared to their white plumage coloured counterparts. The brown plumage coloured birds of the forest ecotype had the highest mean body weight gain for the 4, 8 and 10-week Body weight gain than both the brown and white coloured birds of the savannah and the white plumage coloured birds of the forest ecotype. The white coloured birds of the forest ecotype also had higher average values than their savannah counterpart for their 6, 8 and 10-week body weight gain but had lower values for the 2 and 4 week body weight gain. The brown feathered chickens of the forest ecotype had a relatively higher average gains than among the different plumage colours of the two ecotypes under consideration (Table 4.1b).

4.1.3 Average production performance of the two plumage colours

The average values of production performance of the two plumage colours are shown in Table 4.1c.

Table 4. 1c: Average values of Feed intake, FCR, Hen house egg production, egg weight and numbers of the two plumage colours

Production Performance	**Savannah Ecotype (Colour)**		**Forest Ecotype (Colour)**			
	Brown	**White**	**Brown**	**White**	**SEM**	**P- value**
Feed Intake (g)	77.8	68.5	78.3	81.7	4.03	0.198
FCR	2.36	1.96	2.34	2.32	0.274	0.700
HDEP (%)	9.13	9.33	8.40	9.84	1.297	0.792
Egg Weight (g)	31.52^{a}	28.30^{b}	30.37^{a}	29.77^{a}	0.548	0.019

Means bearing different superscript in the same row are significantly different (P<0.05). SEM: Standard error of means. FCR= Feed conversion ratio. HDEP= Hen Day Egg Production

There was no significant difference (*P>0.05*) in feed intake and feed conversion ratio between the different plumage colours of the two ecotypes. Feed intake and FCR of the white plumage coloured birds of the savannah ecotype was lower among the groups. Hen-day egg production (HDEP) was not significantly different (*P>0.05*) in Brown and White coloured birds of both ecotypes. The brown coloured birds of each ecotype had higher Hen-day egg production than the white coloured birds. There were no mortalities throughout the experiment making the mean values of Hen House Egg Production (HHEP) the same as HDEP.

The study recorded a significant difference (*P<0.05*) in egg weight among the two plumage colours of the two ecotypes. The brown plumage coloured birds had significantly higher mean egg weight as compared to the white coloured birds in the two ecotypes. The brown plumage coloured birds of the Savannah ecotype recorded the highest egg weight of 31.52g followed by the brown feathered birds (30.37g) and the white-feathered birds of the forest ecotype. The white feathered birds of the Savannah ecotype recorded the least egg weight of 28.30g. There was no observable superiority in egg weight among the brown feathered birds of the Savannah and the brown and white feathered birds of the forest ecotypes.

4.2 Estimation of Average values of production traits of the two ecotypes

4.2.1 Average production performance of the two ecotypes

The average values of production performance of the two ecotypes are shown in Table 4.2a.

Table 4.2a Average values of bi-Monthly Body weight of two indigenous chicken ecotypes

Production Performance	Savannah Ecotype	Forest Ecotype	SEM	P-value
2 Week Body Weight(g)	1282[a]	1106[b]	39.0	0.033
4 Week Body Weight (g)	1592[a]	1125[b]	57.3	0.004
6 Week Body Weight (g)	1650	1390	93.5	0.120
8 Week Body Weight (g)	1765[a]	1594[b]	35.5	0.027
10 Week Body Weight (g)	1840	1713	44.5	0.114

SEM: Standard error of means.

The result shows that body weight at different ages varies among the two chicken ecotypes. The study recorded a significant difference (*$P<0.05$*) between the 2, 4, and 8-week body weight of the two ecotypes. However, there were no significant differences (*$P>0.05$*) in the 6 and 10-week body weight between the two ecotypes. The Savannah chicken ecotype recorded higher average body weight values when compared to the Forest ecotype in the 2, 4, 6, 8 and 10-week body weight. (Table 4.2a).

4.2.2 Average production performance of the two ecotypes

The average values of production performance of the two ecotypes are shown in Table 4.2b.

Table 4.2b Average values of bi Monthly body weight gain of two indigenous chicken ecotypes

Production Performance	Savannah Ecotype	Forest Ecotype	SEM	P-value
2 Week Body Weight Gain (g)	23.5	23.1	1.49	0.879
4 Week Body Weight Gain (g)	28.9	29.1	2.37	0.953
6 Week Body Weight Gain (g)	33.4	30.8	2.21	0.452
8 Week Body Weight Gain (g)	37.5	33.9	1.99	0.271
10 Week Body Weight Gain (g)	41.0	38.9	2.63	0.596

SEM: Standard error of means.

The results shows that there was no significant difference (*P>0.05*) between 2, 4, 6, 8 and 10-week body weight gains of the two indigenous chicken ecotypes. The Savannah chicken ecotype, however, had a higher average value in 2, 6, 8 and 10-week body weight gains over the Forest ecotype but the Forest chicken ecotype recorded slightly higher average gains in the 4-week body weight gain (Table 4.2b).

4.2.3 Average production performance of the two ecotypes

The average values of production performance of the two ecotypes are shown in Table 4.2c

Table 4.2c: Average values of feed intake, FCR, Hen House Egg Production and Egg weight of two indigenous chicken ecotypes

Production Performance	Savannah Ecotype	Forest Ecotype	SEM	P-value
Feed intake(g)	2460^a	2318^b	36.3	0.050
FCR	2.160	2.330	0.1227	0.383
HDEP (%)	4.24	4.29	0.149	0.833
Egg Weight (g)	29.91	30.07	0.314	0.737

HDEP = Hen Day egg production. FCR= Feed conversion ratio. SEM: Standard error of means

Feed intake was significantly better (*P<0.05*) in the Forest ecotype (2318g) as compared to those of the Savannah ecotype (2460g). The study also indicates that there was no significant difference (*P>0.05*) in Feed conversion ratio (FCR), Hen house egg production and Egg weight. The forest ecotype recorded higher figures for Hen day egg production (4.29), and egg weight (30.07g) as compared to those of the Savannah ecotypes. The mean values of FCR was lower in the Savannah ecotype (2.160) over those of the Forest ecotype (2.330) (Table 4.6).

4.3 Reproductive performance of the two chicken plumage colours

4.3.1 Average reproductive performance of the two plumage colours

The average reproductive performance values (age at first egg, fertility of eggs, hatchability of fertile eggs and hatchability of egg set) of the two plumage colours are shown in Table 4.3 below.

Table 4.3: Average reproductive performance of the two plumage colours

Reproductive Performance	Savannah Ecotype (Colour)		Forest Ecotype (Colour)			
	Brown	White	Brown	White	SEM	P-value
AFE (days)	167.7	188.3	176.3	170	0.548	7.07
FE (%)	74.6	75.0	81.0	84.4	5.43	0.542
HFE (%)	57.4[a]	22.2[b]	64.2[a]	56.9[a]	9.03	0.042
HES (%)	44.0	34.3	47.8	44.3	5.22	0.356

AFE= Age at First Egg, FE= Fertility of Eggs, HFE= Hatchability of Fertile Eggs, HES= Hatchability of Egg Set. Means bearing different superscripts in the same row are significantly different (P<0.05). SEM: Standard error of means.

There was no significant difference (*P>0.05*) in age at first egg, fertility of eggs and hatchability of egg set among the plumage colours. However, the brown feathered chickens of the savannah ecotype reached reproductive maturity earlier (167.7 days) than the white-feathered birds (188.3days) of the same ecotype. The white plumage coloured birds of the forest ecotype also reached reproductive maturity earlier (170 days) than their brown (176.3 days) plumage counterparts. The brown feathered chickens of the Savannah ecotype reached laying age earlier among the plumage colours of the two ecotypes. Fertility of eggs was higher in the white plumage coloured birds when compared to their respective ecotypes. The forest chicken ecotype had higher fertility of eggs than the savannah chicken ecotype. Hatchability of egg set of eggs was below 50% for all the plumage colours but it was higher in the brown feathered birds of the two chicken ecotypes. The brown plumage coloured chickens of the forest ecotypes had higher percentage total hatchability. The result also shows a significant difference (*P<0.05*) in the hatchability of fertile eggs. The brown plumage birds of the two ecotypes recorded higher mean hatchability of fertile eggs as compared to those of the white plumages (Table 4.3).

4.4 Reproductive performance of the two chicken ecotypes

4.4.1 Average reproductive performance of the two chicken ecotypes

The average values of reproductive traits of the two indigenous chicken ecotypes are shown in Table 4.4 below.

Table 4.4 Average values of reproductive performance of two indigenous chicken ecotypes

Reproductive Performance	Savannah Ecotype	Forest Ecotype	SEM	P- value
Age at first egg (days)	181.3	173.2	5.61	0.361
Fertility of eggs (%)	87.8[a]	79.7[b]	1.89	0.039
Hatchability of fertile eggs (%)	43.2[b]	57.2[a]	2.51	0.017
Hatchability of egg set (%)	41.5	44.9	3.97	0.571

SEM: Standard error of means.

Results of this study shows that there was no significant difference (*P>0.05*) in age at first egg and percentage hatchability of egg set between the two chicken ecotypes. It, however, indicated that the Forest chicken ecotype had a higher percentage (44.9%) than the Savannah ecotype (41.5%). Fertility of eggs and hatchability of fertile eggs recorded significant difference (*P<0.05*) among the two chicken ecotypes. The forest chicken ecotypes reached reproductive maturity (173.2 days) earlier than their savannah counterparts (181.3days). The Savannah ecotype had higher percentage fertility of eggs (87.8%) over (79.7%) of the forest ecotype. This notwithstanding, the Forest chicken ecotype had higher (57.2%) rate of hatchability of fertile eggs over the Savannah ecotype (43.2%) (Table 4.4).

4.5 Correlation between body weight and laying performance of the two plumage colours of the Savannah chicken ecotypes

Table 4.5 Correlation between average body weight and egg-laying performance in the two plumage colours of the Savannah chicken ecotype

Trait	Brown	P-Value	White	P-Value
AEW	0.991566*	0.019528	0.384472*	0.002423
HDEP	0.994875*	0.017235	-0.06972*	0.002407

*AEW= Average egg weight, HDEP= Hen Day egg Production. * =P<0.05*

The result shows that there was a highly positive correlation (*P<0.05*) between body weight and laying performance in the brown plumage colour of the Savannah chicken ecotype. However, there was a negative correlation (*P<0.05*) between body weight and hen day egg production of the white plumage coloured birds with the brown plumage colour recording a positive correlation. There was a positive correlation (*P<0.05*) between body weight and average egg weight in both brown and white plumage colours of the savannah chicken ecotypes (Table 4.5).

4.6 Correlation between body weight and laying performance of the two plumage colours

of the two plumage colours of the Forest chicken ecotype

Trait	Brown	P-Value	White	P-Value
AEW	-0.60062*	0.008796	0.505255*	0.000879
HDEP	-0.98221*	0.010253	0.151296*	0.000853

*AEW= Average egg weight, HDEP= Hen Day egg Production. * =P<0.05*

Table 4.6 shows that there was negative correlation *(P<0.05*) between body weight and laying performance in the brown plumage coloured chicken ecotypes of the forest ecotype. The White plumage coloured chickens recorded positive correlation *($P<0.05$)* between body weight and laying performance.

Table 4.6: Correlation between average body weight and egg-laying performance

4.7 Correlation between body weight and laying performance of the two Chicken Ecotypes

Table 4.7: Correlation between average body weight and egg-laying performance of the two chicken ecotypes

Trait	Forest Ecotype	P-Value	Savannah Ecotype	P-Value
AEW	0.064099*	0.001086	-0.38835*	0.000276
HDEP	0.183864*	0.001052	-0.32576*	0.000443

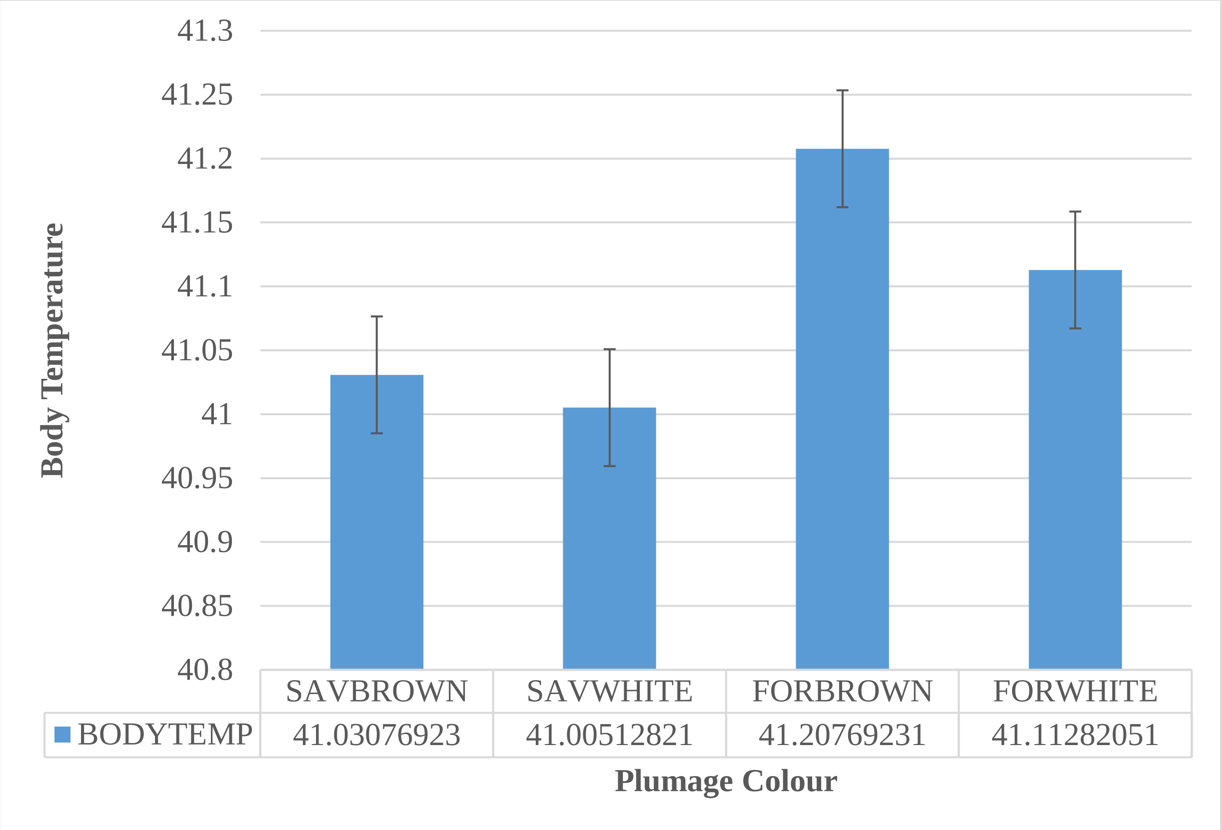
*AEW= Average egg weight, HDEP= Hen Day egg Production. * =P<0.05*

Table 4.7 shows that there was significantly positive correlation ($P<0.05$) between body weight and laying performance of the Forest chicken ecotype. The Savannah chicken ecotype recorded significantly negative correlation ($P<0.05$) between body weight and laying performance.

4.8 Effect of plumage colour on body temperature

4.8.1 Effect of plumage colour on body temperature of the two chicken ecotypes

The figure below shows the effect of plumage colour on body temperature of the two chicken ecotypes (Fig 4.1).



BODYTEMP = Body Temperature. SAVBROWN = Savannah Ecotype Brown Colour, SAVWHITE =Savannah Ecotype White Colour, FORBROWN = Forest Ecotype Brown Colour, FORWHITE= Forest Ecotype White Colour.

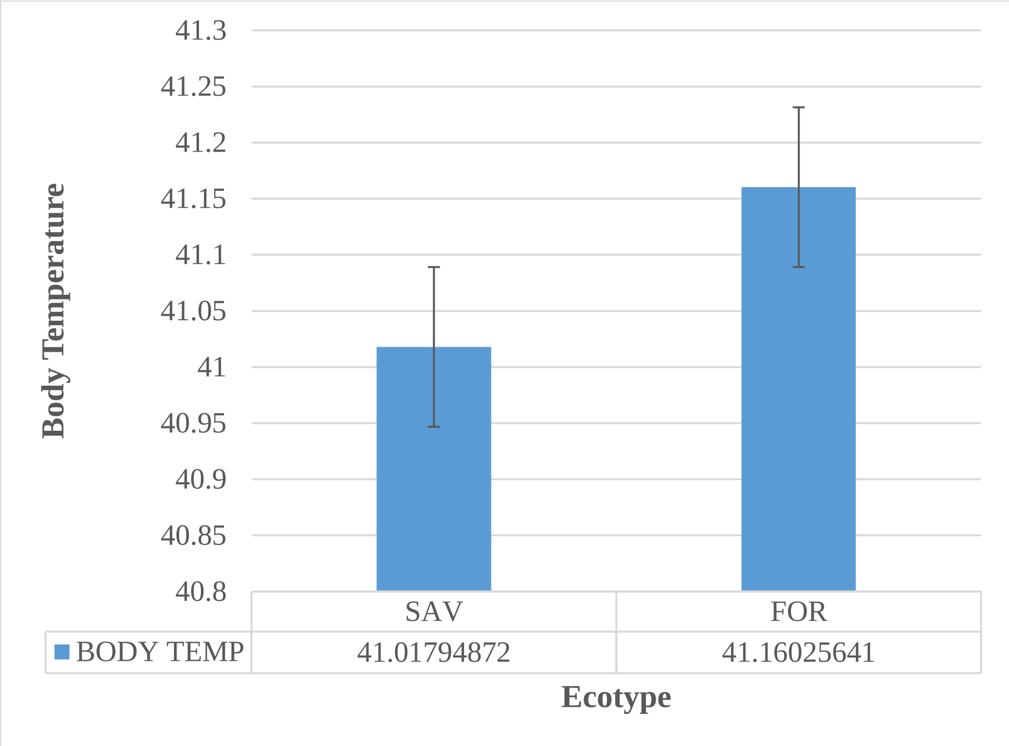
Figure 4.1: Effect of plumage colour on body temperature

Figure 4.1 shows the effect of plumage colour on body temperature of the two different chicken ecotypes. The brown plumage colours of the forest and savannah ecotypes recorded higher average body temperatures of 41.20^{o}C and 41.03^{o}C respectively whiles their white plumage coloured counterparts lower body temperature values of 41.11^{o}C and 41.01^{o}C respectively.

4.9 Effect of ecotype on body temperature

4.9.1 Effect of ecotype on body temperature

The figure below shows the effect of ecotype on body temperature (Fig 4.2).



BODYTEMP = Body Temperature. SAV = Savannah Ecotype, FOR = Forest Ecotype.

Figure 4.2: Effect of ecotype on body temperature.

Figure 4.2 shows the effect of ecotype on body temperature. It was noted that the forest chicken ecotype recorded higher body temperature (41.16 ^{o}C) whiles the savannah chicken ecotypes recorded (41.02 ^{o}C).

4.10 Interaction of fixed effect on production and reproductive traits

4.10.1 Interaction effect of fixed effect on production **and** *reproductive traits*

Interaction of fixed effect on production and reproductive traits are presented in table

4.8Table 4.8 Interaction of fixed effect on production and reproductive traits

Trait	**Ecotype*Environment Interaction**	
	Savannah	**Forest**
Body Temperature	ns	ns
Feed Intake	ns	ns
Average Egg Weight	*	ns
Age at First Egg	ns	ns
Hen-Day Egg Production	ns	ns
Fertility of Eggs	ns	ns
Hatchability of Fertile Eggs	*	ns
Hatchability of Egg Set	ns	ns
Feed Conversion Ratio	ns	ns
2-Week Body Weight	ns	ns
4- Week Body Weight	ns	ns
6- Week Body Weight	ns	ns
8- Week Body Weight	ns	ns
10- Week Body Weight	ns	ns
2- Week Body Weight Gain	ns	ns
4- Week Body Weight Gain	ns	ns
6- Week Body Weight Gain	ns	ns
8- Week Body Weight Gain	ns	ns
10- Week Body Weight Gain	ns	ns

ns = P>0.05; ns=Not significant

Ecotype by Colour interaction affected ($P<0.05$) average egg weight and Hatchability of fertile eggs in the brown and white plumage coloured chickens of savannah ecotype but were insignificant ($P>0.05$) in all other traits. Interaction on all traits of the two plumage colours of the forest chicken ecotype were insignificant ($P>0.05$) (Table 4).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Estimation of Average values of production traits of the two plumage colours

The observed result in body weight was in contrast with Al-khalifa and Ragheb (2013), who observed a significant difference in growth parameters of brown and white plumage coloured chickens. This result was however consistent with Wantasen *et al*. (2014) in native chickens raised in a semi intensive system. This finding may be as a result of nutrition, rearing management as well as similarity in genetic variation among the two plumage coloured birds (Patricio *et al*., 2012). Birds raised within similar environment and fed similar nutrition with less genetic variation are more likely to have similar growth performance considering similarity in their origin.

The findings on body weight gain was inconsistent with Al-khalifa and Ragheb (2013), who observed that overall body weight gain for the brown pullets were significantly better than the white pullets in their experiment on the diversity of poultry products by producing high quality brown eggs. The no significant differences recorded in body weight gains may be due to similarities in genotype and environment such as feed consumption pattern, nutrition, and physiological conditions in which the birds were raised (Mazurkevych, 2015)

The non-significant difference in feed conversion ratio of the brown and white plumage colours contradicts the observations of Adetunji and Ola (2020) who recorded significant difference in feed conversion ratio in their study on the productive performance of three plumage varieties of noiler hens in Nigeria but agrees with the results of Addison (2013) in brown and white layers parents in Ghana. The result of non significance in feed intake was also similar to those Addison (2013) in his study on the effect of naked neck, frizzle and normal feather genotypes on laying performance and pterylosis of brown and white layer parents in Ghana. This may be attributed to similarity in environment in which the experiment was conducted. Birds raised in similar environment (similar nutrition, health and management) are more likely to consume feed and perform similarly (Dos Santos *et al*., 2017). The similarity in feed intake and FCR can also be assigned to flock size, good temperature and ventilation (Aviagen 2011).

The insignificant difference in hen day egg production (HDEP) recorded by the Brown and white plumage coloured birds was inconsistent with the findings of Addison (2013) who observed significant difference in some egg production parameters in three chicken genotypes of brown and white plumage colours. It was inconsistent with Al-khalifa and Ragheb (2013) who noted that Lohmann brown chickens had better laying performance over the Lohmann white. This result was however in line with Bhuiyan and Swick (2016) in Hyline Brown layer hens in Australia.

The significant difference in egg weight of this study was in contrast with the findings of Khawaja *et al.* (2012) who observed no significant difference in egg weight between brown and white feathered Lohmann chickens. However, this result is consistent with the findings of Dahloum *et al.* (2018) and Ragheb *et al.* (2013) who recorded higher egg weight of brown feathered birds over white-feathered birds. The recorded average values of between 29.77 and 31.52 in egg weight between the two plumage colours were however lower than that of Adetunji and Ola (2020) in Nigeria who also recorded significant difference in egg weight of values between 55.39 and 59.32 in different plumage coloured chickens. The observed differences in egg weight may be attributed to differences in age of birds at first lay (Dogara *et al.*, 2021). Birds which lay earlier tend to lay heavier eggs as they mature in age. Egg weight is also dependent on the intensity of laying. A probable explanation to the variation observed in egg weight of the different plumage colours might be due to genetic differences (genes associated with feather coloration and egg laying) (Khan *et al.,* 2017).

5.2 Estimation of Average values of production traits of the two ecotypes

The significant differences in body weight at 2, 4 and 8 weeks recorded in this study were in tandem with the findings of N'dri *et al.* (2018) who observed a difference in body weight of three chicken ecotypes but were in contrast with Djermanovic and Mitrovic (2017) who recorded no significant difference in laying hens on production traits of broiler parents. The result of 4 and 8 week body weight agrees with Dorji *et al.* (2015) who recorded no significant difference in body weight at different growth stages of indigenous chickens in Bhutan. Tyasi *et al.* (2019) also noted that there were significant differences in body weight of both pure and crossbred South African indigenous chickens at 4 and 8 weeks which were similar to the present findings at 4 but not at 8 weeks of age. There was, however, a contradiction between the two studies at 10 week body weight. The recorded mean body weight of the current study were lower than the values of Bamidele *et al.* (2020) of 2355.1g. This result may be attributed to differences in the genotype of the chicken ecotypes (Faruque *et al*., 2013). This is because animals with different genetic make-up are more likely to perform differently considering their similar environment.

The body weight gain of no significant difference at 2, 4, 6, 8 and 10 weeks of the two different plumage colours were contradictory to the findings of Okoro *et al*. (2017) who noted significant differences in two strains of indigenous chickens in South Africa at different ages and Hussen *et al*. (2018) in local horro ecotype crossed with exotic dominant red barred D 922 chickens at different age groups. According to them management could bring about significant changes in growth and production performance of indigenous chicken ecotypes adapted to tropical conditions. Weekly body weight gain in the present study at 2 and 4 weeks were similar to those of Gomes *et al*. (2022). The similarity in body weight gain may be due to the similarity in environment in which the birds were raised. Under similar production conditions the two chicken ecotypes are more likely to have similar performances (Niknafs and Nejati- Javaremi, 2012).

The findings on feed intake in this study were similar to the findings of Clark *et al.* (2019) who also recorded significant difference in feed intake in layer hens selected for high or low feed conversion ratio. These findings however contradicts those of Van *et al.* (2020) who recorded no significant difference in feed intake in two Vietnamese indigenous chickens. According to Amao (2017) and Tallentire *et al.* (2016), animals with different genetic composition and physiological differences have different feed intake.

The results of FCR of the two ecotypes in the present study contradicts the findings of Zeleke *et al.* (2020) who recorded significant difference between different chicken breeds in Ethiopia and Clark *et al.* (2019) who observed differences in FCR in layer Chickens. Body temperature, health of birds and feed wastage in the poultry house are factors that affect feed intake and subsequently affect feed conversion ratio in chickens (KPF, n.d.). High or low body temperature in chickens affect their feed conversion levels. Nutritional quality also has effect on FCR

The non-significantly difference in egg weight of the two chicken ecotypes contradicts the findings of Abudabos *et al.* (2017). Abudabos *et al.* (2017) recorded higher egg weight values when compared to the value of the present study. The mean egg weight values of 29.91g and 30.07g for both savannah and forest chicken ecotypes were lower than the values 41g and 40.5g of Hagan *et al.* (2013) for both Savannah forest and chicken ecotypes in Ghana.

5.3 Average reproductive performance of the two plumage colours

The figures recorded for age at first egg of the two plumage colours were inconsistent with the findings of Adetunji and Ola (2020), Oleforuh-Okoleh *et al.* (2015), and Dogara *et al.* (2021) who recorded significant difference in chicken breeds of different plumage colours in Nigeria but was similar to the range recorded by Magothe *et al.* (2012) and Asumah (2015) in Ghana and Kenya respectively. Asumah (2015) concluded that similarity in age at first egg may be attributed to better management practices which enhanced growth.

The insignificant difference in fertility of eggs was different from the values obtained by Bobbo *et al.* (2013) and Tadese (2017) in Nigeria and Ethiopia respectively but similar to the findings of Ukwu *et al.* (2014) in Nigeria. This may be attributed to similarity in photostimulation (environmental) by the two plumage colours of the birds resulting in less robust photo-induced reproductive (physiological) development including having lower circulating levels of reproductive hormones (Salvante *et al.*, 2013) due to the young age of birds when eggs were collected for hatching.

The significant difference in hatchability of fertile eggs was consistent with that of Dunga (2013) who made similar observations in local chicken breeds but inconsistent with the observations of Nigussie *et al*. (2015) in Ethiopia. Health, nutrition and age of the flock, egg size and weight may be assigned as the reason for the observed differences in hatchability of fertile eggs. However, the insignificant difference recorded in the hatchability of egg set contradicts that of Ajayi and Agaviezor (2016) in pure and crossbred indigenous chickens in Nigeria but similar to that of Kumar *et al.* (2016) in India. The similarity in fertility and hatchability of egg set among the different plumage colours in the present study may be as a result of specific breed similarity and the environment (Ramaphala and Mbajiorgu 2013, Duodu *et al*., 2018).

5.4 Average reproductive performance of the two ecotypes

The significant difference in fertility of eggs and hatchability of fertile eggs were in accordance with the findings of Abudabos *et al.* (2017) and Ajayi and Agaviezor (2016) who also recorded significant difference in fertility and hatchability of fertile eggs in pure and crossbred indigenous chickens in Saudi Arabia and Nigeria respectively. Mean Fertility of eggs figure of 83.7% was higher in the present study when compared to the value of 74.24% of Abudabos *et al.* (2017) and Ajayi and Agaviezor (2016). The significant difference in fertility and hatchability of eggs observed may be assigned to genetic variations, physiological, environmental factors (storage temperature, humidity), egg production rate, and sperm quality (Faruque *et al*., 2013; Duodu *et al*., 2018). This is because hens were of different ecotypes and therefore had differences in genetic make-up. The result of hatchability of fertile eggs may also be attributed to humidity fluctuations in the incubator, management of eggs during incubation as it was maintained manually (Faruque *et al*., 2013; Desha *et al*., 2016). The findings of hatchability of egg set of not significant were also similar to those of Abudabos *et al.* (2017) but different from Desha *et al*. (2016) in indigenous chickens in Saudi Arabia and Bangladesh respectively.

The non-significant difference recorded for age at first egg between the two chicken ecotypes in the present study was consistent with Kumar *et al.* (2016) in India and Fitsum (2016) in Ethiopia. According to Kingori (2012), the environment such as quality of nutrition, health of birds and time and consistency of feeding may affect the age at which birds first lay.

5.5 Correlation between body weight and laying Performance of the two plumage colours

The positive correlation between body weight and laying performance of the two plumage colours of the two chicken ecotypes with the exception of the brown feather coloured birds of the forest ecotype were similar to those of Yaman *et al.* (2020) and Asumah (2015) who observed a correlation between body weight of local chicken and egg weight in Indonesia and Ghana respectively. The positive correlation recorded may be as a result of genetic as well as hormonal factors (Lindsay *et al.*, 2011; Du *et al.*, 2020).

5.6 Correlation between body weight and laying Performance of the two chicken ecotypes

The results of the savannah chicken ecotype were similar to Alshami (2014) who obtain a negative correlation between body weight and some egg laying characteristics in layer chickens. The results also corresponds with the findings of Dogara *et al.* (2021) who observed a low correlation among most egg characteristics of local chicken strains in Nigerian. The results of the forest chicken ecotype were similar to the findings of Krajisnik *et al.* (2018) who noted positive correlation between body weight and laying performance of broiler hens.

5.7 Effect of plumage colour on body temperature

The significant difference observed in the effect of plumage colour on body weight was consistent with the findings of Addison (2013), who noted that plumage colour has an effect on body temperature. He noted that, white plumage coloured birds reflect sun beams and therefore had lower body temperature than the brown plumage coloured birds. This may be attributed to the environmental temperature, season in which the experiment was conducted and the colour of the plumages (Stuart-fox *et al.*, 2017). Dark colours (brown) tend to absorb heat whiles bright colours (white) reflect heat.

5.8 Effect of ecotype on body temperature

The significant difference recorded were inconsistent with those of Iyasere *et al.* (2019) in Nigerian indigenous hens during brooding and Nwankwo *et al*. (2012) in three strains of egg type chickens in Nigeria. The differences in body temperature may be due to differences in physiology and/ or biological effect (Makram *et al*., 2021) of the two ecotypes. Animals of different origin may be more immune to certain levels of temperatures.

5.9 Interaction of fixed effect on production and reproductive traits

Effect of ecotype by colour interactions were significant on average egg weight and hatchability of fertile eggs in the savannah chicken ecotype. This result of egg weight and hatchability of fertile eggs were in agreement with Addison *et al.* (2020) and Addison (2013) respectively. The superior performance of the savannah chicken ecotype in average egg weight and hatchability of fertile eggs is an indication that selection for improvement or ranking of breeds across environment can be done base on the plumage colour of birds from that ecotype. This is an indication that different ecotypes perform differently in different environment. Ecotype by plumage colour may impact significantly on average egg weight and hatchability of fertile eggs across different environment (Burrow, 2012).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the results of this study, the following were the conclusions made on the forest and savannah chicken ecotypes and their plumage colours:

1. Brown coloured birds of the forest and savannah chicken ecotypes have higher egg weight which is an indication of good production potentials for breeding study.
2. Brown coloured birds of the Savannah ecotype and the White coloured birds of the Forest ecotype reach reproductive maturity earlier.
3. Hatchability of fertile eggs were relatively higher in the brown plumage coloured birds of the two chicken ecotypes.
4. Plumage colour and ecotypes has effect on body temperature
5. Savannah chicken ecotypes have high body weight

6.2 Recommendations

1. The indigenous chicken ecotypes have good production, reproductive potentials and wide varieties of plumage colours. These features can be used for future breed improvement programmes.
2. Further studies with indigenous chickens from varied ecological zones which encompass broader geographical locations should be conducted.

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