UNIVERSITY OF EDUCATION, WINNEBA

GENETIC IMPROVEMENT OF GROWTH TRAITS, DISEASE RESISTANCE AND DOCILITY OF FOUR VARIETIES OF LOCAL GUINEA FOWL IN GHANA

DUODU ADDISON

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DUODU ADDISON

A thesis in the Department of Animal Science Education, College of Agriculture Education, submitted to the School of Graduate Studies in partial fulfilment of the requirments for the award of the degree of Doctor of Philosophy (Animal Breeding and Genetics) in University of Education, Winneba.

JULY, 2019

DECLARATION

STUDENTS' DECLARATION

I, Duodu Addison, hereby declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …….

DATE: …..……...

SUPERVISOR'S DECLARATION

We hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the Univeristy of Education, Winneba.

PROF. S. Y ANNOR (Principal Supervisor)

Signature: ……

Date: ……

PROF. J. K. KAGYA-AGYEMANG (Co- Supervisor)

Signature: ……

Date: ……

DEDICATION

This work is dedicated to my parents, George Addison and Madam Akua Forkuo for giving me formal education.

My wife, Harriet and children: Faustina, Godwin and Ellen who exercised enviable patience during my constant absence from home and

My brothers Addison Edward and George Addison, and my friends Collins Boakye and Kwabena Annor for their support in life

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LIST OF ABBREVIATIONS AND ACRONYMS

HWT	Hatch weight
TMWT	Two month weight
FMWT	Four month weight
SMWT	Six month weight
EMWT	Eight month
TMWTG	Two month weight gain
FMWTG	Four month weight gain
SMWTG	Six month weight gain
EMWTG	Eight month weight gain
SVV	Survival
DOC	Docility
DRESSP	Dressing percentage
ATFE	Age at first egg
EGGWT	Egg weight
HDEP	Hen day egg production
FERT	Fertility
HATCH	Hatchability
SRBC	Sheep Red Blood Cell
RSRBC	Response to Sheep Red Blood Cell
FAO	Food and Agriculture Organization
h^2	Heritability
MoFA	Ministry of Food and Agriculture
SADEP	Smallholder Agricultural Development Project
IFAD	International Fund for Agricultural Development

AAGDS	Accelerated Agricultural Growth and Development Strategy
GPRS	Growth and Poverty Reduction Strategy
SADA	Savannah Accelerated Development Authority
r	Correlation coefficient
SAS	Statistical Analysis System
σ_g	Genetic standard deviation
σ^2_g	Genetic variance
σ_p	Phenotypice standard deviation
σ^2_p	Phenotypic variance

ABSTRACT

The goal of this work was to improve productivity of indigenous Guinea fowl varieties in Ghana. The objectives were to: (1) estimate average values of traits and verify sex and seasonal effects on traits; (2) determine disease resistance in local Guinea fowls using using SRBC as an indicator trait; (3) measure DOC in local Guinea fowls by the use of cage score and heterophil/lymphocyte ratio; (4) estimate phenotypic and genetic parameters and (5) estimate genetic gain of 3rd generation birds for body weight, disease resistance and DOC. The study was conducted at the Animal farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus, Ghana. Data used was obtained from four varieties of indigenous Guinea fowls which were randomly picked from a large population and reared from 2015-2018. Data was analyzed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS for Windows, version 7). Pearl Guinea fowls had better ($p<0.05$) body weight, body weight gain, EGGWT and HDEP relative to the other varieties. Keets hatched in the minor rainy and dry seasons had better ($p<0.05$) HWT. Body weight was higher ($p<0.05$) during the major rainy season at 8, 16, 24 and 32. Daily weight gain was higher ($p<0.05$) in the dry season at 8-16 weeks of age and was better ($p<0.05$) in the major and minor rainy seasons at 16-24 weeks. Lavender varieties laid their first eggs earlier ($p<0.05$) than their other counterparts. FERT was higher ($p<0.05$) in the Pearls than in the other varieties. Black strain showed the best ($p<0.05$) HATCH potentials. Lavender, White and Black strains produced more ($p<0.05$) protein in the meat compared to the Pearl. The White strain had the best ($p<0.05$) DRESSP. Lavender was the most ($p<0.05$) docile strain. Pre-brooding survival was higher ($p<0.05$) in the Pearls and lower ($p>0.05$) in the Black. Post-brooding survival was higher ($p<0.05$) in males than in females. FCR was better ($p<0.05$) for bids hatched during the dry season.

The Pearl genotype had the highest ($p<0.05$) immune competence. Antibody response to SRBC antigen was better ($p<0.05$) in females than in males. Intravenous injection was more effective ($p<0.05$) in presenting SRBC antigen to immunocompetent cells than the intramuscular injection. Body weight and EMWTG showed the highest ($p<0.05$) additive genetic variation. Direct heritability estimates in the Guinea fowls were high for HWT, 2 and 4 months body weight, moderate at 6 and 8 in both males and females. The heritability estimates of body weight gains were moderate at month 2 and 6 but low at month 4 and 8 in the males whereas in the female counterparts the estimates were moderate at month 2 and 4 and low at 6 and 8. Heritability estimates for SVV, DRESSP and FI were all low in the males and females apart from FI which was medium in the females. DOC and FCR heritability estimates were moderate in both males and females. Estimates of heritability of EGGWT and HDEP were high, moderate at ATFE and low for FERT and HATCH. Genetic and phenotypic correlations among HWT, TMWT, FMWT, SMWT, EMWT, TMWTG, FMWTG, SMWTG, EMWT, FI, FCR, DRESSP, SVV, DOC, ATFE, HDEP and EGGWT were moderate to high and positive.The mean response for each trait improved in the positive direction over the three generations of selection. ATFE, egg numbers and weight, growth traits and docility were affected to a very large extent by additive genetic effect and genetic selection can be used to improve them. Moderate to high positive genetic correlation existing in the SMWT, DOC and SVV is an indication that these traits could be exploited in multiple trait selection using the selection index.

Keywords: *Numida meleagris,* indigenous Guinea fowls, production, survival, sex, docility, indicator trait, genetic and phenotypic parameters, genetic gain.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to Study

The higher expectation of consuming two-thirds more animal protein than it is today due to populations and income growth (FAO, 2011), gives all animal scientists a charge to keep. Global demand for animal products is expected to double by 2050, based on estimates for irresistible growth of the world population, increasing incomes and further urbanization (FAO, 2009). According to the estimate, meat consumption is projected to rise to nearly 73% by 2050; dairy consumption will grow by 58% over current levels. Majority of the increased demand will occur in Asia, Africa and Latin-America, especially in the so-called middle-class of society. At present this middle-class comprises about two billion of the world's population of seven billion people, and is anticipated to increase to around five billion of a population of nine billion in 2050 (Kharas, 2010).

It is hard to visualize meeting projected demand by keeping twice as many poultry, 80% more small ruminants, 50% more cattle and 40% more pigs, using the same traditional methods of animal management and improvement systems, as well as the same level of natural resources. Increases in production will need to come from improvement programmes that can genetically advance the livestock for efficient and effective productivity. This indicates the need for rapid expansion of poultry enterprises at commercial level, rural and semi-urban areas and swift spreading of scientific tentacles to other species of poultry such as duck, quail, geese, pigeon, Guinea fowl, etc. which have not relatively received attention duly by investors, researchers and producers. Thus, the significance of rearing poultry species like the Guinea fowl, should

be considered with utmost concern as this bird is still being the suppliers of good quality but cheaper sources of animal protein to the rural family (Kusina *et al*., 2012).

The term "Guinea fowl" is the common name of the seven species of gallinaceous birds of the family Numididae, which is native to Africa. The strains are descended from the helmeted Guinea fowl (*Numida meleagris*). The potential for Guinea fowl production in the world as alternative poultry species is a promising enterprise (Nahashon *et al.,* 2006).

In many parts of the world, Guinea fowls are raised mainly for their meat and eggs. The young Guinea meat is tender and of fine flavour, resembling that of wild game bird (Teye and Adam, 2000). The meat is relatively lean and rich in essential fatty acids compared to chicken or duck meat. In Ghana, Teye and Adam (2000) mentioned that in addition to their main use as a source of income and protein, Guinea fowls also play important roles in the socio-cultural lives of many tribes. For example, they are exclusively used for the annual festival by the Dagombas and Gonjas; the pure white Guinea fowl is used for religious sacrifices and to perform certain funeral rites and the Frafras, Dagabas and Bulsas use Guinea fowl to welcome mothers-in-law (Teye and Adam, 2000 and Naazie *et al.,* 2002). The birds serve as the first source of income for other household needs. They also serve as a starting point for scaling over to small ruminant keeping and consequently to cattle keeping.

In relationship with its scavenging chicken counterpart, the Guinea fowl's advantages are: low production cost, premium quality meat, greater capacity to scavenge for insects and grains, better ability to protect itself against predators and better resistance to

common poultry parasites and diseases (Microlivestock, 1991; Ross and Shahram, 2012). Good foraging ability, hardiness and minimal production input requirements of Guinea fowl usually lead to reasonable profit to the farmers. Moreover, Guinea fowl has a unique ability to free range and is tolerant to most common diseases of chicken (Bonds, 1997; Dieng *et al*., 1999; Mandal *et al*., 1999). This indicates that there is opportunity for smallholder farmers to improve Guinea fowl production in order to increase household protein supply and increase family income.

There have been several Guinea fowl development projects in Ghana since independence. The first project was undertaken in the Northern Region from 1996-1999. This project was one of the components of the Smallholder Agricultural Development Project (SADEP), which was a follow- up project of the Smallholder Rehabilitation and Development Programme funded by the Government of Ghana and the International Fund for Agricultural Development (SRDP/IFAD). The main objective of the Guinea fowl project was to upgrade the productivity of the local Guinea fowl by increasing egg size and mature body weight through crossbreeding. Though these programmes generated interest among farmers and the demand for Guinea fowl keets far exceeded supply, the project did not put measures in place to ensure continuous supply of Guinea fowl keets to farmers when the projects were completed (Annor *et al.*, 2013).

The government of Ghana embarked on programmes like Accelerated Agricultural Growth and Development Strategy (AAGDS), Growth and Poverty Reduction Strategy (GPRS 11) and Savannah Accelerated Development Authority (SADA) which were

aimed at enhancing Guinea fowl production in the three Northern Regions of Ghana and reduction of poverty as well (GNA, 2013).

1.2 Problem Statement and Justification

A study by Annor *et al*. (2013) on the status of Guinea fowl farming in Ghana, revealed that the productivity of local Guinea fowl was comparatively low and irregular, with an annual egg production of about 100 eggs per bird, egg size between 30g and 32g, egg fertility rate of about 42%, hatchability rate of 45% and mature body weight of 1200g of both sexes as against 180, 60g, 88%, 83% and 2400g respectively for the European Guinea fowls.

The results of research carried out by the University of Development Studies together with field observations indicated that egg size and mature body weight of the crossbreds and purebred Guinea fowls generated under SADEP were larger than that of the local (SADEP, 1999). Demand for crossbred eggs was higher than that of the local, as the former were bigger than the latter.

According to Addo-Kwarfo *et al*. (2000), large-scale commercial Guinea fowl production in Ghana has not been possible due to high keet mortality, difficulty and/or inaccurate sexing methods, lack of genetically improved source of good quality day old keets among others. Again, inbreeding is a major concern associated with Guinea fowl production in Ghana. The consequence of inbreeding in most communities is reduction in growth rate and size of birds, poor reproductive performance, genetic defects and unexpected high mortality (Addo-Kwarfo *et al*., 2000). New genetic materials are

introduced into a community only when a farmer obtains eggs for hatching from other communities.

In an experiment to evaluate literature on challenges to commercialization of Guinea fowl on the African continent, Moreki and Radikara (2013) observed that although the origin of Guinea fowl is Africa, commercialization of these birds on the continent is still in its infancy. Adding that across Africa, Guinea fowls are reared at subsistence level with low levels of inputs committed resulting in low productivity. In rearing Guinea fowl, a myriad of challenges are experienced including inter alia inadequate nutrition, poor housing, high keet mortality, lack of health control and inadequate technical support from government extension services. In order to raise productivity of Guinea fowl enterprises, feed improvement, hygienic and sanitary preventive programme have to be applied. It is apparent that addressing these challenges will contribute to improved Guinea fowl production and make it an important supplier of high quality animal protein (meat and eggs) and a job creator for the rural populace.

A study conducted bu Addo-Kwarfo *et al*. (2000) to evaluate the socio-economic impact of small ruminants and Guinea fowls on poverty alleviation of households in the Northern region came out with the following conclusions and recommendations:

- There was very high mortality in Guinea fowls, which appeard to be age and/or season related. Causes of the high mortality of Guinea fowl keets need to be investigated.
- The local Guinea fowl breed (*Numida meleagris*) is the most prevalent species in the country. A breed improvement programme may prove to be more sustainable if not cheaper in the long run.

- There is a desire for improved guinea fowls. The conditions for survival of exotic birds must be ascertained at research level before distribution of birds to farmers.

These findings were in agreement with the SADEP report (1999), which indicated that future guinea fowl projects should look at the possibility of improving the local guinea fowls through selection, rather than resorting to the continuous importation of improved breeds from Europe.

In order to facilitate breeding of highly prolific, disease resistant, docile and fast growing Guinea fowls, it is essential to estimate genetic parameters of the local unimproved birds.

1.3 Objective of the Study

Main Objective

To improve productivity of local Guinea fowls in Ghana through genetic selection.

Specific objectives

1. To estimate average values of traits and verify strain, sex and seasonal effects on traits.
2. To determine disease resistance in local Guinea fowls using of Sheep Red Blood Cell (SRBC) as an indicator trait.
3. To measure docility in local Guinea fowls using cage score and heterophil/lymphocyte ratio
4. To estimate phenotypic and genetic parameters.

5. To estimate genetic gain in body weight, disease resistance and docility. of third (3^{rd}) generation offspring

1.4 Benefit of Project

The information produced can be used to formulate policies that would lead to sustainable use of Guinea fowl genetic resources. Animal breeders can use the results to develop breeding strategies to produce highly resistant, docile and fast growing birds. The results would call attention to known strengths and weaknesses of local Guinea fowls in Ghana. It is envisioned that the research will also generate a number of reports and publications in accredited journals and provide technical notes for Guinea fowl farmers in Ghana. .

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Guinea Fowl

Guinea fowls are popularly known as "pet speckled hen" (Farrell, 2010). The bird belongs to a group of Cartinatae (flying birds), order Galliformes (including pheasants, chickens and turkeys) and the family Numididae (that is the Guinea fowl of African origin) which makes them insect and seed-eating birds resembling partridges, but with featherless head and spangled grey plumage which makes them differ from the domestic chicken (Amberg, 2009). The genus has two types, *Numida ptilorhycha*, that is, the Blue- wattled Guinea fowl and *Numida meleagris,* that is, the Red- wattle Guinea fowl of West Africa (Farrell, 2010). Guinea fowls have been domesticated from many centuries. They are raised in large quantities in many European countries like France, Germany and Italy (Bell and Smith, 2003). They were raised as table birds by the ancient Greek and Romans. However Some Guinea fowls are still not domesticated and remain in the wild (Headley, 2003). The birds are endemic to the Africa continent and derived its name from Guinea. The wild Guinea fowl originated from West Africa but are now kept in many parts of Africa and Asia (Bell and Smith, 2003). They are found in open grasslands. However, they are also kept domestically throughout all of Africa, including Madagascar and the rest of the world. Historical records indicate that the Guinea fowl derives its name Guinea parts of the west coast of Africa. (Teye and Gyawu, 2002 and Dei and Karbo, 2004).

Guinea fowls are prone to run at a very far distance rather than to fly when alarmed (Amberg, 2009). They are short and broad-winged birds, very agile and powerful flyers, capable of hovering and even flying backwards when necessary (Dei and Karbo, 2004).

The birds can run to cover more than 10 km in a day. They make very loud sound when people encroach or disturb them. The head and upper neck are bare, but two species of a second genus have a bushy tuft of feathers on the crown (Dei and Karbo, 2004). The birds have the ability to scratch the soil for food as compared to the domestic chicken when they are kept under free range system (Farrell, 2010).

2.2 Guinea Fowl Varieties

There are several varieties of Guinea fowls in Europe, Asia, Latin America and Africa, especially in Sub-Saharan Africa (Teye and Adam, 2000). Some common varieties of the Guinea fowls include; the pearl, white, black, lavender, plumed, crested, grey-breasted, helmeted and white-breasted Guinea fowls (Oke *et al*., 2004). Three main varieties of domesticated Guinea fowls are known to be in Ghana, the United States, Europe, East and some parts of Africa. These include the Pearl (Plate 2.1), White (Plate 2.1) and Lavender (Plate 2.1) (Agbolosu *et al*., 2012).

2.2.1 Pearl Guinea fowl

Plate 2.1: Pearl Guinea Fowl
Source: University of Education Winneba, Mampong-Ashanti, Guinea fowl Unit.

2.2.2 White Guinea fowl

Plate 2.2: White Guinea Fowl
Source: University of Education Winneba, Mampong-Ashanti, Guinea fowl Unit.

2.2.3 Lavender Guinea fowl

Plate 2.3: Lavender Guinea Fowl
Source: University of Education Winneba, Mampong-Ashanti, Guinea fowl Unit.

Below is a list of the Guinea fowl genera, species and subspecies, presented in taxonomic order (Wikipedia, 2008; National Research Council (NRC), 1991; Ayorinde, 1999)

1. Genus *Agelastes- Phasiadus,* e.g. Black Guinea fowl, *Agelastes niger*
2. Genus *Numida,* e.g. Helmeted Guinea fowl, *Numida meleagris*
3. Genus *Guttera,* e.g. Plumed Guinea fowl, *Guttera plumifera*
4. Genus *Acryillium,* e.g. Vulturine Guinea fowl, *Acryllium vulturinum*

A research by Jacob and Pescatore (2011) revealed that, the grey-breasted and helmeted Guinea fowls are the most common varieties found in West Africa. These two varieties have several subspecies which differ in terms of size, shape, beak and the size and shape of the helmet on the crown (Jacob and Pescatore, 2011).

The Pearl Guinea fowl is a well known subspecies of the helmeted Guinea fowl and the commonest bird found in the Northern part of Ghana. The Pearl Guinea fowl (*Numida meleagris*) has a helmet on top of its head with horny cartilage which is used to determine the sex of the bird (Agbolosu *et al.,* 2012). The Pearl Guinea fowl is characterized by different colouring, which consists of the bare parts of the head, wattle and feathers (Oke *et al*., 2004). The Pearl Guinea fowl is a large bird with a round body between 40-71 cm in length, and weighs 700-1600 g. According to Sayila (2009), male Pearl Guinea fowls parade, chasing each other, to indicate the start of a breeding season. According to Headley (2003), the Pearl Guinea fowl has a round-shouldered, clad in sheer dark feathers with delicate white polka-dots. The plumage colour is purplish-gray dotted with white (Darre, 2007).

The White Guinea fowl has pure white feathers and is a sub-species of the helmeted Guinea fowl. It has a lighter skin as compared to the Pearl and the Lavender Guinea fowl. The White Guinea fowl lays purely white eggs and hatch white keets (Nahashon *et al*., 2006).

The Lavender Guinea fowls are the subspecies of the helmeted Guinea fowl. This variety is similar to the Pearl but with white plumage that is light gray or dotted with white. The Lavender Guinea fowl is a large bird with a round body. (Moreki and Radikara, 2013).

2.2.4 Black Guinea fowl

Plate 2.4: Black Guinea Fowl

The black guinea fowl (*Agelastes niger*) sometimes (*Phasidus niger*) is one of the two members of the genus *Agelastes* (Plate 2.4),. They live in groups during daytime and roost in trees at night. Their sound is very different from the other species of Guinea fowls. The black Guinea fowl often makes a soft; low- pitched whistling sounds reminiscent of the cooing of doves (Farrell, 2010).

2.3 Management of Guinea Fowls

Guinea fowls are kept traditionally under free range system just like the local chicken. The birds are left to scavenge around farmlands, open fields and compounds for food scraps, worms, insects, seeds, leaves and ripen fruits. Under the extensive system of management, different species of poultry birds which include guinea fowls, chickens, ducks and turkeys are kept together (Oke *et al*., 2004). This system of management is practised by smallholder farms but backyard poultry production in the urban areas is either intensive or semi-intensive (Dei and Karbo, 2004). In the extensive system of management, no standard poultry management practices are followed. The system is characterized by minimum inputs, with birds scavenging around the environment searching for their own food As a result of this free range system of management, Guinea fowl productivity is very low as compared to the other systems (that is the intensive and semi-intensive systems). Birds under this system of management can lay up to 50-60 eggs per season, each weighing averagely between 37 to 40 g (Alidu, 2014).

Intensive system of Guinea fowl production is practised in the developed countries where specialized breeds of Guinea fowl have been genetically improved and the production is commercialized (Cheng, 2010). In the intensive system of Guinea fowl production, standard poultry management practices such as proper housing, quality and

adequate supply of feed, water and disease control programmes are followed (Farrell, 2010).

Semi-intensive system of Guinea fowl management refers to the provision of permanent housing with access to the surrounding environment (Cassius and Radikara, 2013). Guinea fowls kept under the semi-intensive system are given a supplementary feed and water, diseases are controlled to enhanced productivity and the birds are allowed to get as much as they can from the environment (Cheng, 2010).

2.4 Economic Importance of Guinea Fowls

Guinea fowl production has numerous importance in Ghana which include income to farmers, employment and it serves as a rich source of protein to consumers. Its production is increasing gradually because the demand for Guinea fowl meat and eggs is gaining much popularity among Ghanaians (Annor *et al*., 2012). The acceptability of Guinea fowl and Guinea fowl products such as eggs and meat due to their limited cultural barriers and meat quality indicates that there is a potential market (Dei and Karbo, 2004). In Ghana, farmers involved in Guinea fowl production are reaping substantial financial returns from sales of live Guinea fowls and eggs. Guinea fowl production in Ghana provides a good avenue for poverty alleviation and improvement of human protein nutrition (Farrell, 2010).

Guinea fowl is noted as a promising genetic resource for developing a low-input poultry enterprise mostly in developing countries such as Ghana and has the capacity for reducing poverty (Teye and Gyawu, 2002). More than 80 percent of poultry rearing is found in the rural areas and this contributes substantially to the annual egg and meat

production (Dei and Karbo, 2004). Guinea fowl products including eggs, meat, manure and feathers play an important role in the growth of the economy (Teye and Gyawu, 2002). In the three Northern regions of Ghana, women and children play an important role in the management of Guinea fowls in the rural communities. Guinea fowls have the potential of ensuring food security of the farm family and contribute significantly to the socio-cultural practices of farmers such as sacrifices, funerals, payment of dowries and so on (Dei and Karbo, 2004). They are used for the annual Guinea fowl festival by the Dagombas and Gonjas in northern Ghana.

The pure, white Guinea fowl is used for religious sacrifices and to perform certain funeral rites. Customarily, among the Frafras, Dagabas and Bulsas Guinea fowls are used to welcome mothers-in-law. Moreover, in Senegal, almost 20% of the eggs produced are used for annual rituals. During the rituals, ceremonies and festivals, Guinea fowl meat is abundantly served (Teye and Adam, 2000). Moreover, Guinea fowl eggs are noted to have high chances of virility and sexual potency and are used for scientific research, mostly in animal physiology (Dei and Karbo, 2004).

2.5 Guinea Fowl Farming in Ghana

Most of the developing countries in the world including Ghana are currently experiencing increase in human population whiles poultry production which serves as a source of animal protein to the population is decreasing (Nahashon *et al*., 2006). Sustainable increase in livestock management and production would therefore be necessary in order to meet the demands of the human population (Sayila, 2009). For third world countries, Guinea fowl could become much more valuable than it is today. This is because the bird thrives under semi-intensive conditions and requires little

attention (Moreki and Mack, 2013). The World Bank has estimated that it will be relevant to increase meat production by about 80% between 2000 and 2030 (FAO, 2014). Guinea fowl is one of the most promising genetic resources which requires low input but it has higher output. The bird is one of the most profitable poultry enterprises in developing countries and it has the potential to increase the standard of living among farmers and reducing poverty (Teye and Gyawu, 2002). The productive of Guinea fowl in the rural areas provides a sustainable family income for small and marginal farmers. According to Arguelles *et al*. (2004) Guinea fowl is suitable for use in meat production to improve the local poultry industry due to its high acceptance by consumers, resistance to common poultry disease and can survive under harsh environmental conditions

In Ghana, Guinea fowls are commonly found in the Northern parts of the country particularly in the Northern, Upper East and Upper West regions (Naazie *et al.,* 2007). The productivity of the bird within these regions over the years has assumed much socio-cultural, economic and nutritional importance (Dei and Karbo, 2004). Guinea fowls are productive and very important in the lives of the people in the Northern, Upper East and Upper West regions of Ghana. The bird is common and found in almost every household in the Northern regions of Ghana. The bird has numerous and serve varied functions, including use for ceremonies, courtship and dowry, gifts as well as sacrifice (Dei and Karbo, 2004). Apiiga (2007) reported that the Guinea fowl is very important in the Upper East region where two out of five households own the bird. Northern, Upper East and Upper West regions form about 40 percent of the total landmark of Ghana. It is well known that within these regions, almost all household males and females as well as children rear Guinea fowls.

Local Guinea fowls can lay between 90- 120 eggs per annum. The birds are poor brooders and since it is not a good brooder (Apiiga, 2007; Farrell, 2010), the eggs are normally hatched by chicken and ducks (Apiiga, 2007). Guinea fowl eggs start to hatch from 26 to 28 days and the weight of keets range between 21 to 28 g (Farrell, 2010). It is therefore common to see a domestic chicken hen with a mixture of local chicks and keets in almost every household. These local chicks and keets are raised till the domestic chicken hen is ready to lay and brood over new eggs (Adjetey, 2006).

2.6 Performance of Local Guinea Fowls

2.6.1 Growth

Most researchers have indicated that local Guinea fowls have low body weight. The results of the study conducted by Fajemilehin (2010) on morphostructural characteristics of three varieties of grey breasted helmeted Guinea fowl in Nigeria showed that the body weight of three genotypes studied were low even at maturity (Table 2.1). Nwagu & Alawa (1995) also reported that indigenous Guinea fowl varieties have lower body weight than improved strains reared in developed countries such as France and Australia.

On account of low body weight of local Guinea fowl, it is suggestive that the local birds are the light strain types that are likely suitable for egg rather than for meat production. The low body weight of local Guinea fowl could also be due to the fact that the lower body weight and body structure of the birds suited for rapid flight and fast running, which are evolutionary adoptions for survival in the wild (Fajemilehin, 2010).

Table 2.1: Growth Performance of Local Guinea Fowls in Nigeria

Age (weeks) g	Pearl	Ash	Black
0	22.95	24.66	24.38
2	52.54	60.48	51.77
4	86.29	110.48	88.97
6	186.35	202.53	160.25
8	276.2	294.98	258.34
10	388.16	372.47	382.09
12	510.41	466.93	478.09
14	599.24	554.88	572.54
16	685.26	650.16	652.83
18	730.01	710.41	716.26
20	801.65	770.17	774.86
22	860.03	836.79	826.09
24	901.50	870.49	864.20
26	940.38	908.45	904.56
28	980.15	970.43	950.78

Source: Fajemilehin (2010)

Farming system and the energy and protein levels in the diets are the determinants of growth performance of avian species (Tougan *et al*, 2013). The low productivity of growth of local birds is partly due to poor management practices, in particular lack of proper health care, poor nutrition and poor housing (Mwalusanya *et al*., 2004).

It was reported in Malawi that the major constraints to the production of local chickens were outbreaks of Newcastle disease among chickens in the months of September to December every year, predators that feed on pigeons, chickens and ducks, and poor housing and prolonged weaning periods for chickens and ducks (Gondwe *et al*., 2005). Mburu and Ondwasi (2005) reported that local birds perform very well when extra feed, proper housing and disease-free environment are provided. When traditional breeding system was compared to improved breeding system, where birds were bred in chicken houses, received complete diet, were separated by sex and received veterinary care, the variation in performance of the birds was obvious (Table 2.2).

Table 2.2: Weight Performance of Local Guinea Fowl Produced Under Traditional and Improved Rearing Systems in some Countries.

Country	System of farming	Age (weeks)	Weight (g)
Benin	Traditional	12	376
Nigeria	Traditioanl	12	485
Benin	Improved	12	1151
Algeria	Improved	12	1008
Belgium	Improved	12	1800

Source: Halbouche *et al.* (2010) and Fajemilehin (2010).

Variations in body weight gain at different stages of growth in local Guinea fowls have been recorded by a lot of experimenters. Marizvikuru *et al*. (2008) reported significant difference in body weight gain of keets within pre-brooding stage. Kerketta (2012) also published results of weight gain at different weeks in Lavender Guinea fowl (treatment group) showing significant difference between 1st week and all other weeks up to 14th week except 8th and 12th weeks. However, Kerketta and Mishra (2016) recorded non-significant differences in body weight gain at 14th weeks of age for both Pearl and Lavender varieties. Non- significant differences in body weight gain is normally observed when there is favourable environmental condition for all the varieties of keets (Kerketta and Mishra, 2016). Significant differences in body weight gain may be attributed to variation in the genetic potentials of the birds (Nkafamiya *et al*., 2007).

In Ghana Iddrisu (2014) reported lower growth performance of local Guinea fowls in an 18 – week feeding trial conducted to assess the effect of four types of bovine blood blended with cassava, hereafter referred to as BBLOCAM, to partially replace maize on the growth performance, haematological and blood biochemical parameters of guinea fowl keets. Agbolosu *et al*. (2012) also recorded significant differences in body weight of local Guinea fowls from Upper East, Upper West and Northern regions of

Ghana and attributed the differences in growth performance to their source and genetic makeup.

Kerketia and Mishra (2016) reported lower feed consumption in Lavender group than Pearl group during 14 weeks of experimental period, however overall feed conversion ratio in Lavender group was significantly better ($p<0.05$) than Pearl group. Seabo *et al*. (2011) recorded values of FCR above 4.44 in guinea fowls fed commercial grower diet from 6 to 12 weeks of age under intensive system. Difference of diets, age, management regime as well as environmental factors could be responsible for the difference in FCR values.

2.6.2 Reproduction

Reproductive performance of Guinea fowls have not been better in developing countries because the birds are mainly reared under extensive or semi-intensive systems (Karacay and Sarica, 2004; Kusina *et al.,* 2012;), which, when compared to intensive systems, offer a number of disadvantages to producers. Different ages of sexual maturity of Guinea fowl hens have been reported. According to Bernacki *et al.* (2013), the age of sexual maturity was between 28-32 weeks, but Hien (2002) found the onset of laying to be between 31-36 weeks, and Umut *et al.* (2016) reported that laying started from 36 weeks of age. The commencement of laying may differ according to location, season, variety and management-related factors. Guinea fowls are seasonal breeders. The short laying season is a limiting factor to their productivity. An average egg production of 54.2% for white Guinea fowl and 55.8% for grey Guinea fowl was reported by Bernacki *et al. (*2012). Bernacki *et al.* (2013) reported average egg production for different varieties of Guinea fowl to be 87-90 eggs per season; Konlan

et al. (2011) reported egg production per hen to be 100 eggs for a nine-month period; and Avornyo *et al.* (2007) reported egg production to be over 200 eggs per hen. The low total number of eggs collected in free-range systems may be attributed to various causes (Gueye, 2007), one of which is the differences in egg-production periods. Breeding and management also have an effect on the number of eggs laid. Houndonougbo *et al*. (2017) reported that egg production performances are strongly affected by the strain, climate and quality of feed. Extension of daylight can lead to increase in egg production in Guinea fowls (Moreki and Seabo, 2012). The egg-laying period can be extended and early fertility improved using artificial lighting (Houndonougbo *et al*., 2017)

Different mean egg weights have been reported for different Guinea fowl varieties. Brijesh *et al.* (2008) reported mean egg weights of 40.1g. Bernacki *et al.* (2013) also reported mean egg weights of 39.24g and 40.7g. However, Wilkanowska and Kokoszynski (2010) reported a higher mean egg weight (46.5 g) and a lower mean egg weight (39.2 g) for different guinea fowl varieties. Additionally, Nowaczewski *et al.* (2013) found difference between the egg weights of two Guinea fowl flocks (55.3 vs 40.7 g).

With demand increasing for guinea fowl products, the need for guinea fowl eggs for hatching purposes has gained much importance, which has in turn led to changes in breeding strategies. Fertility and hatchability are major constraints in guinea fowl production. The low fertility rate of the birds could be attributed to factors such as bad weather conditions, improper sex ratio and bad egg storage practices. Agbolosu *et al*. (2012) found fertility to be affected by weather conditions and geographical position,

adding that the improper storage of eggs prior to incubation could also contribute to low fertility rate in Guinea fowls. It is well documented that the Guinea fowls are monogamous in nature, and as a result egg fertility usually should be higher if birds are keptusing 1:1 male-female ratio compared to providing more number of females against a male (Khairunnesa *et al*., 2016). Konlan *et al.* (2011) in Ghana argued that the Pearls (common breed) are capable of laying fertile eggs throughout the year when given adequate supplementary feed and if supplied water *ad libitum*. Obike *et al*. (2014) obtained non- significant fertility of (49-67%) in indigenous Nigerian Guinea fowl strains (Black and Pearl). Konlan *et al.* (2011) recorded fertility rate of 69%. Royter and Arutyunyan (1990) found an overall fertility rate of about 65% and Bernacki *et al*. (2013) reported fertility rate of different Guinea fowl varieties to range between 85.2%-91.7%.

Research carried out by Dei and Karbo (2004) on egg size showed that hatchability of fertile eggs increased as egg size increased. Guinea fowl eggs exhibit low hatchability than chicken eggs mainly because of their thicker egg shells and sizes of the egg. Nwagu (1997) reported that egg shell accounts for about 15% of the total weight of Guinea fowl eggs as compared to egg shell from chicken which accounts for about 9% of the total weight of the egg. Royter (1980) showed that best hatching results are obtained when Guinea fowl eggs weighing not less than 38 g and not more than 51 g are incubated. Fisinin and Zlochevskaya (2004) reported hatchability values of between 73-90 % (naturally mated) and 70-80 % (artificially inseminated) of different Guinea fowl strains. Gueye (2007) also reported hatchability to be 72.9%. Avornyo *et al.* (2007) found hatchability rate of 70% and 88% hatchability was the results from Saina *et al*. (2005). Higher hatchability ranging between 45%-50% in naturally mated Guinea fowls

was reported by Royter and Arutyunyan (1990). Moreki and Radikara (2013) evaluated hatchability of Guinea fowl eggs according to weight and found that medium-size eggs (39-42 g) had the highest hatchability rate (69%). Other factors that affect the rate of hatchability include male and female ratio, nutrition of parents and egg storage conditions (Yamak *et al*., 2015).

2.6.3 Carcass

Different studies have recorded variations in dressing percentages of birds and have attributed it to the birds' strain, diets, management system and carcass dressing methods (Kerketta and Mishra, 2016). Ayorinde (1991) and Marek *et al.* (2008) reported dressing percentage values of 65-71 and 92-96 respectively in local Guinea fowls. Bernacki *et al*. (2012) and Adeyemo and Oyejola (2004) reported similar dressing percentage values. Carcass dressed weight (700.00-736.67g) of guinea fowls reported by Ebegbulem and Asuquo (2017) were similar to the range of 655 to 786g reported by Nobo *et al.* (2012) for 13 weeks old guinea fowls. Adjetey (2010) however reported higher carcass dressed weight ranges of 1015- 1056g 14 weeks of age. The dressing percentage (74.50, 75.17 and 75.83 percent) recorded in the study of Ebegbulem and Asuquo (2017) were slightly higher than 70.30 percent reported by Ogah (2011), but similar to the reports of Nobo *et al*. (2012) in 13 week old guinea fowls (60.47- 75.82 percent). Dressing percentages of 94.40 and 93.59 percent were given by Mareko *et al*. (2006) in 14 week old guinea fowls. Carcass dressing percentage has been suggested to be influenced by the stage of maturity of the birds, breed, degree of finish and the contents of the gut of the birds (Mareko *et al*., 2006). Comparing dressing percentage of broiler chicken and Guinea fowl, Agwunobi and Ekpenyong (1990) stated dressing percentage of 76 and 74% for Guinea fowl and broilers respectively.

The mean values for different proximate parameters in meat of Pearl and Lavender groups have been reported (Table 2.3). No significant (P>0.05) differences were observed in values of moisture, crude protein, total ash and cholesterol content in meat between Lavender than Pearl Variety (Kerketta and Mishra, 2016). It was revealed that nutritive value of meat of Pearl and Lavender varieties of guinea fowl were almost similar.

Table 2.3: The Mean Values for Different Proximate Parameters in Meat of Pearl and Lavender Groups.

Nutritive traits	Pearl	Lavender
Moisture (%)	68.16 ± 0.79	69.44 ± 0.67
Crude protein (%)	75.99 ± 1.36	78.37 ± 1.79
Total Ash (%)	4.11 ± 0.24	4. 39 ± 0.23
Cholesterol (mg/100g meat)	68.15 ± 3.10	71.39 ± 2.93

Source: Kerketta and Mishra (2016)

Mareko *et al*. (2008) observed lower moisture content (56.94±1.5 % for guinea fowls raised on concrete floor than the findings of Kerketta and Mishra (2016). The crude protein content in meat of Pearl guinea fowls in the report of Kerketta and Mishra (2016) was higher than that observed in pork (16.6%), chicken (17.6%), lamb (17.9%), beef (18.9%) as reported by Holland *et al*. (1992). Mareko *et, al*. (2008) observed 68.18±4.05 to 86.68±4.05 % crude protein for guinea fowls raised on concrete floor. The differences in protein value in the various findings may be attributed due to differences in climate and rearing system (Kerketta and Mishra, 2016).

The percentage of ash reported by Maria *et al*. (1998) for Guinea fowls raised in high environmental temperature was similar to what was observed under a typical intensive poultry system. Guinea fowls reared on concrete floor are devoid of pecking of feed on ground. This according to Kerketta and Mishra (2016) might be the cause of comparatively lower total ash percent in meat. Higher total ash content in meat of guinea fowl raised on concrete floor than soiled floor was also observed by Mareko, *et al*. (2008). The revealed cholesterol (mg/ 100 g) in meat of Pearl and Lavender guinea fowl (68.15±3.16 and 71.39±2.93, respectively) by Kerketta and Mishra (2016) differed non-significantly. However, it was lower than meat of red coloured broiler (80.30±2.83 mg/100 g) as observed by Adeyemo and Oyejola (2004) in their studies.

2.6.4 Docility

One of the most important traits which determine whether a bird is aggressive or easy to work with is docility. Burrow and Dillon (1997) defined docility as the behavioural reaction of an animal to human handling. The relation of docility to production traits makes it an important selection criterium. For instance, animals with good temperament have higher weight gains in feedlots **(**State of Queensland, 2019**).** It further stated that in Brahman derived breeds, steers with the best temperament (*longer flight times*) grew 0.38kg/day more than steers with the worst temperament (*fastest flight times*) and animals with poor temperament are more likely to produce progeny whose beef is of unacceptable eating quality. This is because stress depletes glycogen in nervous animals prior to slaughter, potentially resulting in dark-cutting meat or reducing the ability of the meat to age effectively post-mortem **(**State of Queensland, 2019**).** Lamb mortality was reported to be lower in less temperamental ewes than aggressive ones (Neindre *et al*., 1998)

There is frequent handling of animals in livestock production to carry out activities like dehorning, tagging, weighing, injecting among others. These activities are carried on well when the animals that are handled are docile (State of Queensland, 2019). It is important that animal producers select breeding stock with inherently good temperaments, so this desirable trait is passed onto their progeny. Research consistently shows that temperament is moderately to highly heritable, meaning selection to improve the temperament of progeny will be effective (Annor *et al*., 2011).

Both heterophil/lymphocyte ratio and cage score methods are used to measure docility in Guinea fowl. In the heterophil/lymphocyte (H/L) method blood is drawn from the experimental birds and the heterophil, lymphocytes counts and H/L ratios recorded (Dramani, 2018). Birds with higher heterophil/lymphocyte ratio are more docile than those with lower ratio. In cage score method docility is often assessed using subjective scoring test system (Pajor *et al*., 2008) in which animals may be described as fast flighty, slow flighty, calm, restless etc.

2.6.5 Survival

Successful Guinea fowl production depends mostly on survival of the bird. They are relatively ahead of the village chickens in terms of heat tolerance, self protection against predators and resistance to common poultry parasites and diseases (Kusina *et al.,* 2012) .However, Guinea fowl keets are more susceptible to most parasites and diseases which affect the production of other poultry species such as chickens and quails (Moreki, 2009). Khairunnesa *et al*. (2016) reported 90% survival in local Guinea fowls. Premavalli *et al.* (2012) reported 89% pre- brooding survival in Guinea fowl keets. Premavalli *et al.* (2012) also observed post brooding survival of 85% during 0-16

weeks. These high survival values may be due to the fact that Guinea fowls have high resistance to common poultry diseases, especially after brooding and in most cases disease is largely due to poor management Okaeme, 1986).

2.7 Guinea Fowl Strain Effects on Growth Performances

Guinea fowl has different strains, which include Pearl, White and the Lavendar (Dei and Karbo, 2004). The different strains of Guinea fowls have significant effect on body weight, growth rate, feed conversion ratio and daily feed intake. Different authors have conducted similar experiments other poultry species such as the Japanese quail, commercial layer chicken and Bangledesh native chickens and obtain similar results (Karima and Fathy, 2005). Hanusova *et al*. (2015) conducted an experiment on Japanese quail and reported that, the strain of Japanese quail had significant ($P<0.01$) influence on body weight, growth rate and feed intake at various stages of growth. Ashok and Prabakaran (2012) also reported that the strain of Japanese quail had significant ($p<0.01$) effect of genetic lines on body weight and daily feed intake at different ages of growth. A research conducted by Kumari *et al*. (2008) also recorded similar observations of the significant effect of genetic strain on body weights at different ages. However, a recent study by Mróz *et al*. (2016), reported non-significant effect on average body weight of Guinea fowl and the female birds were heavier than males.

Recent study conducted by Sahil *et al*. (2017), reported significant effect of different broiler strain on body weight gain (BWG), feed intake, feed conversion ratio (FCR), and water intake. They further reported that, at the age of 35 days, RIR cross-bred fed with basal diet reached an average BWG of 288.22 ± 3.55 g. Feed intake was

significantly higher ($P < 0.05$) in Hubbard strain (1091.33 ± 6.13) followed by RIR cross-bred (1037.34 ± 6.43) and Vencobb (1003.45 ± 6.90). Moreover, birds of RIR cross-bred, Vencobb, and Hubbard strains had an average feed: gain of 3.60 ± 0.05, 3.94 ± 0.03, and 4.36 ± 0.04, respectively. Similarly, birds of RIR cross-bred, Vencobb, and Hubbard strains had an average water intake of 1780.03 ± 6.35, 1785.06 ± 6.53, and 1810.84 ± 6.11, respectively. Furthermore, a systematic study by Apata *et al*. (2014) compared the growth performance of duckS and Guinea fowlS and concluded that ducks had significantly higher body weights than Guinea fowl. In contrast, Faruque *et al.* (2013) reported non-significant effect of genotype on matured body weight in Bangledesh native chickens.

2.8 Effect of non-Genetic Factors on Growth Performance

Non-genetic factors can be defined as anything that influences the animal's performance that is not related to the genetic makeup of the animal, starting at the earliest possible moment in life. There are several non-genetic factors which influence the growth performances and reproductive performance of indigenous Guinea fowls. These include: the generation of birds, sex, age and season of production (Marufa *et al*., 2017). Therefore it is very important to consider all these factors in the production cycle to achieve higher productivity. Non-genetic factors are either discrete or continuous. Body weight and growth rate of birds are mostly influenced by sex, season of hatch, management level and type of housing system (Monira *et al*., 2013).

2.8.1 Effect of season on growth performances

Season is one of the most important micro climatic factors affecting Guinea fowl production in Ghana and Africa. There are three major seasons in southern Ghana:

Major raining season, minor and dry seasons. Each of these seasons is identified principally by the change in ambient temperature, relative humidity and amount of rainfall (*Guobadia,* 1997). Seasonal variation is one of the major non-genetic factors affecting Guinea fowl production. High and very low environmental temperatures impair the growth and feed efficiency of Guinea fowl. *Guobadia* (1997) revealed a significant difference ($p < 0.05$) between two seasons on percentage egg production and egg hatchability, with a mean % egg production and hatchability of 74±.03 and 80.6 in the wet season and 53.67±0.01 and 55.9 respectively in the dry season. Rajini *et al*. (2009) reported that high temperature has significant ($p< 0.05$) effect on growth rate and body weight of poultry and this negative effect is more prominent in fast growing birds. Similar, Ashok and Prabakaran (2012) reported significant ($P<0.05$) effect of season of hatch on body weight and growth rate. A research conducted by Plavnik and Yahav (1998) on chicks hatched at different seasons (Autum, Spring and Summer), also found a significant effect of season of hatch on body weight of the birds at various ages of growth. Veldkamp *et al.* (2000) compared the feed conversion ratio (FCR) of turkeys subjected to different seasons, and obserced feed conversion ratio was better in turkeys that were kept in different season under high temperature treatment as opposed to the ones on low temperature.

2.8.2 Effect of sex on growth performances

The Sex of indigenous Guinea fowls is one of the most influential factors which affect the growth and reproductive performances of Guinea fowls. In general, it is well known that male Guinea fowls are heavier than their female counterparts. Research conducted by Umut *et al*. (2016) indicated that male guinea fowls had significantly ($P<0.05$) higher body weights than females at all ages. The authors observed that male guinea

fowls reached 1241.67 g at 18 weeks and females had a mean body weight of 1158.74 g at the same period. Kokosynski *et al*. (2011) reported that, sex had significant influence on the body weight, growth rate and feed cconversion ratio among indigenous Guinea fowls. The carcasses of females were heavier than those of males and dressing percentage was high and exceeded 70% in females as compared to the males. They further observed higher body weight and feed intake in females as compared to the males. Also, Kasperska *et al*. (2011) reported lower body weights in male Guinea fowls than female Guinea fowls.These researchers including Preemavalli (2017) who also found Guinea fowl males to be heavier than the females attributed the significant sex differences to better growth rate, feed intake and feed efficiency in males than females.

A systematic study by Adamski and Kuźniacka (2006) on pheasants revealed that, sex had significant influence on body weight of the birds. Baéza *et al*. (2001) found similar results, with higher average body weight for males of broiler strains at 42 days old. Fanatico *et al*. (2005) report that the effect of sex on the weight of the birds is usually observed in broilers and that the difference tends to increase with advancing age, whereas in the case of slow-growing birds, which are slaughtered at higher ages, this feature can generate a greater uniformity of lots. Ashok and Prabakaran (2012), reported significant effect of sex on body weight in Japanese quail at various ages except hatch weight. Khalid *et al*. (2012) reported higher body weight in male Sudanese native fowl than females. Apata *et al*. (2014) also reported significantly higher body weights in male ducks than female ducks; however, the authors found a higher body weight in Guinea hens than Guinea cocks.

2.8.3 Effect of generation on growth performances

According to Hussain *et al*. (2013) significant differences were observed in feed intake among different generations of Japanese quail. Birds in generation 2 had the highest feed intake (247.80g) whereas the lowest was observed in generation (227.56g). This might be due to increased body weight in progressive generations. The authors further observed significant differences in body weights among different generations in Japanese quail. Body weights in Generation 2 showed maximum weekly body weights at the age of day one, and 21 respectively. Significant differences among generations in body weight were also reported by Mohammed *et al*. (2006). Higher body weights in selected birds were also reported in other studies as well (Akram *et al*., 2012 and Anjum *et al*., 2012). Khaldari *et al*. (2010) reported a significant genetic improvement of 4 week body weight as 9.6, 8.8, and 8.2 g in generation 2, 3, and 4 respectively, in Japanese quails. Another research conducted by Kasperska *et al*. (2011) reported significant higher ($p<0.05$) growth rate in males compared to females.

Fajemilehin (2010) and Porwal *et al.* (2002) reported significantly highe ($P<0.05$) body weight of Guinea fowl with increasing age. Moreover, Hussain *et al*. (2013) further reported a significant difference in feed conversion ratio among different generations of Japanese quails. Similarly, Khaldari *et al*. (2010) reported higher feed conversion ratio in three selective generations of Japanese quail. Nahashon *et al*. (2006) also reported higher feed conversion ratio in male guinea fowls as compared to their female counterparts at 8 weeks of age

2.9 Haemagglutination in Birds

Haemagglutination is macroscopically visible and it is carried out in farm animals to determine the levels of antibodies present. Haemagglutination is the basis of tests to

detect the presence of viral particles (*Noah et al*., 2009). The test does not discriminate between viral particles that are infectious and particles that are degraded and no longer able to infect cells. Both can cause the agglutination of red blood cells. Through the process of haemagglutination silica acid receptors on the surface of the red blood cells (RBCs) bind to the hemagglutinin glycoprotein to produce a lot of antibodies (Hau and Hendriksen, 2005).

2.9.1 Antibody production in birds

Antibodies production in poultry birds such as Guinea fowl, chicken and quails are usually carried out by inoculating a foreign agent into the birds which elicits an immune system response (Parmentier and Mechteld, 1998). Immunoglobulins (Igs) or antibodies are molecules with a very huge variability in three dimensional shapes, which serve as the basis for immune response (Amemiya *et al*., 2007). These molecules are produced by adaptive immune system called B cells. This cell can bind selectively to the antigen's surface when their unique conformation fits on some foreign agent's segments. In addition, antibodies in poultry birds have a constant region that is used as a signal for cells and immune molecules to destroy disease causing microorganisms or pathogens. These features make antibodies valuable tools in biomedical and biotechnological applications (Cova, 2005).

Antibodies are extracted from the blood. Recently, interest in antibody poultry-based production has grown since antibodies can be obtained from all farm animals. This technique carried out by breeders and poultry farmers has many advantages compared to the traditional way, including larger protein quantities, a wider range of application and reduction in animal stress (Weigend *et al*., 1997). Antibody production in poultry

birds has been the subject of several studies including: bird handling, procedures for inoculation, types of antigens, the concentration, immunoglobulin uses and DNA vaccines. More than 30 years ago it was well known that poultry birds such as Guinea fowl, chicken and quails immune systems consist of innate, cellular, and humoral responses, just like mammal. Nevertheless, some differences at the molecular and organic levels are clearly distinguishable (Erf, 2004).

2.9.2 Response of birds to antigens

The immune system in poultry birds protects them from a variety of pathogens or disease causing microorganisms. Depending upon the type of pathogens, an immune system produces different responses that involve many components working in a coordinated fashion to eliminate the pathogen (Maynard and Georgiou, 2000). This system can recognize and destroy disease causing micro organisms using cells, molecules, and organs. In most living organisms, the immune system consists of innate and adaptive subsystems (Weigend *et al*., 1997). The subsystem identifies microorganisms that share characteristics on their surfaces, whereas the innate recognizes each foreign agent or disease causing micro organisms that induces an immune response (Maynard and Georgiou, 2000). The adaptive immune system has cellular which are produced by T cells and humoral which are produced by B cells components. These two types of cells are known as lymphocytes. The specific recognition of the adaptive immune system lies in its capability to create millions of antibodies; each antibody has the ability to recognize only a small set of antigens (Erf, 2004). A very important feature of the adaptive immune system is memory, meaning it remembers previously encountered antigens. In this way, responses to reinjection

(secondary response) are faster and stronger to fight off any disease causing micro organisms (Weigend *et al*., 1997).

2.9.3 Estimates of antibodies in haemagglutination test in birds

Heamagglutiuation test in birds is used for identification, quantitation and detection of serum antibodies (Phiri *et al*., 2007). The hemagglutination-inhibition (HI) assay is a classical laboratory procedure for effective identification, quantization and classification of hemagglutinating antibodies. For example, in Avian Influenza (AI) Virus, the hemagglutination-inhibition (HI) assay is used to identify the hemagglutinin (H) subtype of unknown antibodies. Since the haaemagglutination-inhibition (HI) assay is quantitative, it is frequently used to evaluate the antigenic relationships between different AI virus isolates of the same antibodies. The basis of the HI test is inhibition of haemagglutination with subtype-specific antibodies (Pederson, 2008)). The use of haemagglutination-inhibition (HI) assay in poultry birds such as Guinea fowl, chicken and quails is a relatively inexpensive procedure utilizing standard laboratory equipment, is less technical than molecular tests, and is easily completed within several hours (Pederson, 2008)). However, when working with uncharacterized antibodies subtypes, the reagents required for identifying antigentically distinct antibody specificities from multiple lineages of a single hemagglutinin subtype and this requires extensive laboratory support for the production and optimization of reagents (Pedersen, 2008).

2.10 Disease Resistance and the Use of Sheep Red Blood Cells as a Measure of Disease Infestation in Birds (Indicator Trait).

Poultry birds such as Guinea fowl are prone to infection with different kinds of pathogens which include viral, bacterial and helminthes (Boa-Amponsem *et al*., 2000). These invasions result in disease onslaughts that lower the economic returns and productivity of the poultry rearing enterprises through weight loss, morbidity and mortality. In this regard, to reduce this huge loss in Guinea fowl production, vaccination is an important intervention towards improving the productivity of poultry farming in the rural areas (Henning *et al*., 2013). Routine vaccination schedules for vaccines such as Newcastle disease and Gumboro are strictly followed (Boa-Amponsem *et al*., 2000). In contrast, under the rural set up, Guinea fowls are reared on free range and do not usually undergoe regular vaccination or deworming which result in high mortalities. This lack of regular interventions in Guinea fowl farming in the rural areas gives rise to various kinds of infections and worm/helminth infestations that are normally observed. Factors such as helminth and worm infestation are known to affect the growth rate of chickens (Katoch *et al*., 2012). It is well known that all village chickens are infested by gastrointestinal helminths (Phiri *et al*., 2007).

Immunization of Guinea fowl with sheep red blood cell (SRBC) antigen is one way of evaluating the immune response of the birds to antigens. Since local Guinea fowls are usually pre-exposed to many kinds of infections, stimulation with sheep red blood cell (SRBC) is a convenient way of evaluating the immune response (Katoch *et al*., 2012). Katoch *et al*. (2012) reported that, the response of chickens to SRBC showed that deworming prior to vaccination did not have a detectable modulatory effect on the immunity of the chickens. Other studies reported by Horning *et al*. (2003) observed that

deworming chickens gives rise to higher antibody titres compared to non dewormed chickens.

2.11 Docility and Temperament in Birds

Guinea fowls and Ostriches are relatively wild birds as compared to the domestic chicken. These birds demonstrate a strong interest in humans when much attention is given to them right from day old (Jones, 1995). Human imprinting of chicks could therefore facilitate the cooperation of birds for assisted reproduction technology purposes, improving the quality of human–bird interactions, consequently promoting the welfare of the birds and reduce the aggressive nature of these birds (Jones, 1995). Among the breeds of Guinea fowls, the Pearl variety seems to have a milder temperament (Skinner-Noble *et al*., 2003). Skinner-Noble *et al*. (2003) reported that chicks exposed to more human presence and care are more docile towards humans, as opposed to those exposed to free range system. The authors further suggest that human imprinted chicks and chicks reared under standard husbandry practices are more docile than chicks reared by foster parents. Hence, such expression of friendly behaviour and apparently reduced fear towards humans could potentially lead to tamer birds, improved welfare and subsequently more efficient production. High aggressiveness (fear of humans) of inanimate stimuli or sudden environmental changes can seriously damage the productivity in layers and broilers (Jones, 1996).

2.11.1 Effects of strain of Guinea fowl on docility

Docility is one of the most important traits which determine whether the bird is aggressive or easy to work with. The domestic chicken by nature is a wary, shy animal with limited ability, short-term flexibility and in the longer term, it displays a good

ability to adapt to different environmental conditions and climate change (Sang *et al*., 2006). However, the indigenous Guinea fowl by nature is very aggressive, short-term flexibility and in the longer term it has high resistance to common poultry disease and can survive under harsh environmental conditions. It has excellent vision and hearing as compared to the domestic chicken. Docility rate of the Pearl, White, Lavender and Black Guinea fowls have an important influence on its reaction to any stimuli they encounter in their environment. The stimuli may be from other birds, their environment, people or any other thing or occurrence (Teklewold *et al*., 2006). Some strains of indigenous Guinea fowls are more docile than others and this characteristic responds to selection pressure. The White and the Pearl strains of Guinea fowls are quite docile than the Lavender and the Black Guinea fowls. The black Guinea fowl is more aggressive than all the other strains of Guinea fowls (Amberg, 2009).

2.11.2 Methods of estimating docility in birds

There are numerous ways by which docility in animals are measured. It is often estimated using subjective scoring system (Pajor *et al*., 2008; Pajor, 2011). This scoring method uses cage score on a scale of 1 to 4 (Hoppe *et al*., 2010) which describes an animal as being docile, calm, restless, flighty, nervous, wild, aggressive among others. Measurement of Heterophil/lymphocyte ratio of the blood is also used to determine docility in animals (Deborah *et al*., 2014). Docile animals or birds have higher Heterophil/lymphocyte ratio. Blood plasma cortisol levels are higher in non-docile animals than in docile ones (Gauly *et al*., 2001). Using the behavioural docility score and the H/L ratio, Dramani (2018) revealed that Guinea fowls were not generally aggressive in nature as only 1.3% of the experimental birds were seen as being aggressive; there were no significant effects of docility on feed intake and weight gain

of the Guinea fowls; there was no significant influence of docility on heterophil-lymphocyte ratio of the Guinea fowls but the variety factor had significant effect on H/L ratios and H/L counts; the Lavendar recorded the lowest H/L ratio among the three varieties which was statistically significant. With the use of H/L ratios, Dramani (2018) reported that the pearl would easily be stressed followed by the white and then Lavendar.

Using cage score method in cattle, Neindre *et al*. (1995) recorded docility score of 3.5. Annor *et al*. (2011) reported docility score of 2.6 in an experiment to determine average docility values in grasscutters. Amberg (2009) reported similar docility values in Guinea fowls and concluded that the white and the pearl strains of Guinea fowls are quite docile than the lavender Guinea fowls. He added that the black Guinea fowl is more aggressive than all the other strains of Guinea fowls.

2.12 Phenotypic and Genetic Parameters

Phenotypic and genetic parameters are very important in animal production for commercial farmers and breeders, especially for breeding value estimation and selection decisions (Grosso *et al.,* 2010). Among these parameters are variance, standard deviation, covariance between traits, heritability, repeatability, phenotypic correlations, genetic correlations, environmental correlations and coefficient of variation of traits. In the construction of selection index equations, phenotypic, genetic and environmental correlations are needed. Before economic values for selection index equation are calculated, phenotypic and genotypic parameters have to be estimated (Annor *et al.,* 201). Breeding values and response to selection cannot be computed without phenotypic and genotypic parameters (Anang *et al*. 2000). A measure of the

relative spread of the trait around the mean (coefficient of variation) is a standardized measure of variation in the trait (Annor *et al.,* 2012). Therefore, for any genetic improvement program, knowledge of genetic parameters is essential to achieved higher genetic gain and productivity. Genetic improvement in traits of animals depends on heritability which is used to predict response to selection. According to Anang *et al*. (2000) phenotypic and genetic parameters varies among breeds of the same species.

2.12.1 Variation in traits

Animal breeding discipline mainly aims at study the variation that is observed between animals for several characteristics in livestock populations. Variation according to Annor (2018) is defined as any observable or measurable difference between cells, individual organisms, or groups of organisms of any species caused either by genetic differences (genotypic variation) or by the effect of environmental factors on the expression of the genetic potentials (phenotypic variation). Variation may be shown in physical appearance, metabolism, fertility, mode of reproduction, behaviour, learning and mental ability, and other obvious or measurable characters. The above description of variation classifies phenotypic variation into genetic or environmental. Genotypic variations are caused by differences in number or structure of chromosomes or by differences in the genes carried by the chromosomes (Sanford *et al*., 2018).

Generally, not all variation in observed phenotypes is a result of differences in genetic makeup between animals. Part of it is determined by variation in what we call the environment which can be defined as anything that influences the animal's performance that is not related to the genetic makeup of the animal, starting at the earliest possible moment in life (Annor, 2018).

Variations caused by environmentally may result from one factor or the combined effects of several factors, such as climate, food supply, and actions of other organisms. Environmental influences early in life may influence the phenotype later in life. However, not all early influences have a lasting effect. Some of the influences will be reversible or of insignificant influence (Sanford *et al*., 2018). These variations do not involve any hereditary alteration and in general are not transmitted to future generations; consequently, they are not significant in the process of evolution (Sanford *et al*., 2018).

Genetic variation is an important force in evolution as it allows natural selection to increase or decrease frequency of alleles already in the population. Genetic variation is advantageous to a population because it enables some individuals to adapt to the environment while maintaining the survival of the population. With more variation, it is more likely that some individuals in a population will possess variations of alleles that are suited for the environment. Those individuals are more likely to survive to produce offspring bearing those alleles. Animal breeders consider variation among animals as valuable and worthwhile to study and are interested in its use for selection.

Variation in traits among indigenous Guinea fowls depends on access to genetic variation and effective methods for exploiting it through selective breeding. Local Guinea fowls in the tropics have high genetic variability which influences growth and reproduction. Increasing the production efficiency of indigenous Guinea fowls requires genetic improvement of their economically important traits (Umut *et al*., 2016). For

example the black Guinea fowls are characterized by small body size and flighty nature, some varieties have fancy colour pattern of mottling, extension and spotting. However, the Pearl variety is known to be hardy and quite adapted to the local environment as compared to the other varieties. The relationship between production traits in Guinea fowls such as body weight, egg size and egg number and reproduction traits such as fertility and hatchability are of interest as they can affect the rate of genetic progress from one generation to another or from parents to their young.

2.12.1.1 Estimation of phenotypic and genetic variances

Genetic models are used to estimate phenotypic and genetic variances (Berker, 1984). Phenotypic (σ^2p) and genotypic (σ^2g) variances are obtained according to Baye (2002) as: $\sigma^2g = MSp - MSe/r$ and $\sigma^2p = MSg/r$, where *MSp and MSg,* are mean squares of phenotypes and of genotypes respectively and *r* is the number of replications. Animal breeders use genetic models to predict which animal is genetically the best. With genetic models, breeders can separate the genetic and environmental factors contributing to the phenotype. The phenotypic value is the sum of the genotypic value plus the environmental effect, or mathematically: P = G + E. In terms of variation of phenotypes, we can write that the phenotypic variance is the sum of the genetic variance and the environmental variance. In symbols, the variance in P equals the variance in G plus the variance in E (i.e. $\sigma^2_P = \sigma^2_G + \sigma^2_E$) (Annor, 2018).

The values for G in the genetic model P = G + E are determined by different types of genetic effects. The genotypic value of an animal is the sum of the effects of all alleles affecting the trait and the interactions among these alleles. Therefore, the genotypic value can be decomposed into additive genetic effects of alleles and remaining

interaction effects (edeX, 2017). These interaction effects can be split up into dominance effects which are interactions in alleles at the same locus, and epistatic effects which are interactions in alleles at different loci. In an equation, the genotypic value is written as the sum of additive genetic, dominance and epistatic effects or mathematically, G = A + D + I. Because gametes are haploid, parents transmit only one set of chromosomes to their offspring. Therefore, only the additive genetic effect is transmitted from parent to offspring (Annor, 2018). The dominance and epistatic effects are not transmitted from parent to offspring. The additive genetic effect is known as the breeding value. The aim in animal breeding is to improve the next generation of animals by selection. Animal breeders are therefore primarily interested in the breeding values of animals. Therefore, the genetic model can now be simplified: the phenotypic value is modeled as the breeding value plus a residual effect or in symbols P = A + E. The residual effect not only includes the environmental effect, but also the dominance and epistatic effect.

Information on variation in economic trait in Guinea fowl is scanty. However, reports from other livestock species have indicated that traits related to natural fitness (reproduction and survival) have low genetic variation whereas body weight and growth traits have medium to high genetic variation (edeX, 2017). Traits with moderate to high genetic diversity respond highly to artificial selection whereas those with low genetic diversity respond slowly (Nicholas, 1987)

Variation in traits among indigenous Guinea fowls depends on access to genetic variation and effective methods for exploiting it through selective breeding. These traits are generally controlled by many genes (Dana *et al*., 2011). Increasing the production efficiency of indigenous Guinea fowls requires genetic improvement of their

economically important traits (Umut *et al*., 2016). For example the black Guinea fowls is characterized by small body size and flighty nature, some breeds have fancy colour pattern of mottling, extension and spotting. However, the pearl variety is known to be hardy and quite adapted to the local environment as compared to the other breeds. The relationship between production traits in Guinea fowls such as body weight, egg size and egg number and reproduction traits such as fertility and hatchability are of interest as they can affect the rate of genetic progress from one generation to another or from parents to their young.

2.12.2 Heritability of traits

One of the key concepts in animal breeding is heritability**.** Heritability is defined as the proportion of phenotypic variance due to additive genetic effects or the proportion of the total phenotypic variance which results from differences in heredity (Annor, 2018). Heritability describes the strength of inheritance of a trait. It is the ratio of the additive genetic variance to the phenotypic variance (σ^2_A/ σ^2_P).

Heritability can be put into broad or narrow sense. The broad sense heritability which is mathematically expressed as σ^2_G/ σ^2_P is of theoretical interest. The σ^2_G is the sum of the additive genetic, the dominance and epistatic variances which include all of the effects of the entire heredity of an individual. The ratio σ^2_A/ σ^2_P gives heritability in the narrow sense. This includes mainly additive genetic effects. Heritability in the narrow sense may be defined as that portion of the phenotypic variance due to additive genetic variances (Annor, 2018). The narrow sense heritability determines the extent to which the phenotype is determined by genes transmitted from parents to offspring. Heritability in the narrow sense is more useful in most animal improvement programmes.

Theoretically, heritability can range from 0 to 1.0 or 0-100% in terms of percentages but the extremes are rarely encountered in practice in quantitative traits of economic importance.

Heritability is a statistic used in the fields of animal production, breeding and genetics that estimates the degree of variation in a phenotypic trait in a population. Heritability is an important concept in quantitative genetics, particularly in selective breeding and behaviour genetics (Wills, 2007). Heritability occurs in animal from one generation to another or from parents to their young ones due to genetic variation between individuals in that population. Variations in a trait are characterized as genetic and non-genetic factors (Falconer *et al*., 1995). Heritability is estimated by comparing individual phenotypic variation among related individuals in a population. In indigenous Guinea fowls, heritability might also increase if the environmental variation decreases, causing individuals to show less phenotypic variation. Heritability increases when genetic factors are contributing more to variation or because non-genetic factors are contributing less variation among breeds of the same species (Wray and Visscher, 2008).

One of the most important functions of heritability is its predictive role. It indicates the degree of correspondence between phenotypic value and the value of individuals judged by the average of their offspring (breeding value). If a breeder chooses individuals to be parents according to their phenotypic values, his success in changing the characteristics of the population can be predicted only from knowledge of the degree of correspondence between phenotypic values and breeding values i.e. heritability (Annor *et al*., 2018). For this reason heritability is used in almost every formula

connected with breeding methods and many practical decisions about procedure depends on its magnitude. Heritability estimates indicate the amount of progress that might be made in selection for a particular trait. The anticipated progress or change in trait improvement programmes is the heritable fraction (h^2 in the narrow sense) of the superiority of the selected parents over the average of the population from which they were chosen (Annor *et al*., 2018).

The intensity of selection determines the superiority of the parents but only the superiority of the parents resulting from additive genetic differences will be covered on the average in the offspring. For this reason a practical definition of heritability is: For a given trait heritability is that fraction of the superiority of the parents above their contemporaries which on the average is passed on to the offspring. Heritability values also give an indication of the method of selection to employ. High heritability estimates indicate that the trait is influenced by additive gene action mainly and that selection on the basis of individual's own phenotype is effective. Low heritability estimates indicate that non-additive gene actions may be more important in the expression of the trait than additive gene action and that greater attention should be paid to the performance of collateral relatives and progeny tests. A reliable estimate of heritability is also needed to decide which breeding plan is likely to be most effective (Ayorinde *et al.,* 1988). Lowly heritable traits show greater improvements on crossbreeding. Traits with high heritability values do not respond much to crossbreeding. In such cases it is better to mate the best male to the best females within the same breed (outcrossing).

2.12.2.1 Estimation of heritability

Several methods can be used to estimate heritability of traits in animal. Regression of offspring on parents and half-sib analysis are common examples of these methods. For regression of offspring on parents, the procedure begins by obtaining measurements of traits on the parents and their progenies.The measurements are corrected for such influences as age or sex, when these are likely to influence the measurements. From these paired observations it is possible to calculate the regression coefficient of offspring on parents (Klein *et al*., 1973),

$$b_{op} = \frac{\text{covariance offspring and parent}}{\text{variance of parent}}$$

The variance of parents is equal to the phenotypic variance. The covariance of offspring and parent is equal to half the additive genetic variance.

$$b_{op} = 1/2\sigma^2_A/\sigma^2_P = 1/2h^2$$

$$2\, b_{op} = h^2$$

One of the most commonly used methods of estimating heritability is by calculating the variance of half sib family means. The variance of half sib family means can be shown to equal $1/4\sigma^2_A$ = one quarter the additive genetic variance (Becker, 1984). The design is useful for animals which give birth to only one offspring at a time and which have long generation intervals such as cattle.

In animals, there is a tendency for some trait groups to have a high heritability while others have a low heritability. Morphological traits such as stature or length of limbs have high heritabilities, usually above 0.4. Traits like body weight or milk production have moderate heritabilities, typically in the range of 0.2 to 0.4 .Traits related to fitness, such as number of eggs or survival have low heritabilities, usually below 0.2

(Annor, 2018). Table 2.3 shows heritability estimates of growth, morphological and egg traits in some chicken breeds as reported by some researchers.

Table 2.4: Heritability (h2±S.E) Estimates of Growth, Morphological and Egg Traits in some Chicken Breeds

Breed/Strain	Age	h2S	h2D	Source
Rajasri	BWO	0.25±0.08	0.25±0.08	Reddy et al. (2016)
Vanaraja male Line	BW2	0.10±0.05	0.10±0.05	Padhi et al.(2012d)
Assel	BW6	0.42±0.18	0.42±0.18	Haunshi et al. (2012
Dwarf Chicken	BW20	0.51±0.39	0.51±0.39	Rajkumar et al. (2011)
Aseel	SL4	0.16±0.12	0.16±0.12	Haunshi et al. (2012)
Dwarf	SL6	0.36±0.17	0.36±0.17	Rajkumar et al (2011b
Dwarf chicken	ASM22	0.18±0.21	0.18±0.21	Rajkumar et al (2011b)
PD-1	EW36	0.43±0.20	0.43±0.20	Padhi et al. (2015a)

H^2S= Sire heritability, h^2D= Dam heritability, BWO= Body weight at day old, BW2= Body weight at week 2,SL= Shank length at week 6, ASM = Age at sexual maturity at week 22 and EW =Egg weight at week 36

The heritability estimates are similar to findings of other researchers who worked on various livestock species. Ayorinde *et al.* (1988) and Sanjeev *et al.* (1997) reported that the heritability estimates for body weight of the indigenous Guinea fowl ranges from 35% at day old to 40% at 16 weeks of age and heritability estimates of 49% for body weight at 16 weeks of age. Udeh (2017) and Hernandez and Segura (1994) reported 0.80 and 0.87 respectively for body weight. Oni *et al*. (1991) reported heritability estimates of 0.413 and 0.044, 0.387 and 0.279 for body weight at 16 and 20 weeks in two strains of Rhode Island chickens. Osei-Amponsah *et al*. (2013) reported range of heritability as 0.31 to 0.70 for bodyweight of Ghanaian local chicken from 0 to 40 weeks. Jilani *et al*. (2007) conducted a genetic study on Rhode Island Red and reported the heritability estimates of body weight at 8 and 20 weeks of age as 0.45 ± 0.13 and 0.41 ± 0.12 respectively. Singh *et al*. (2008) studied the performance of CARI-Dhanraja broilers and found that the heritability estimates of body weights at day old, 6 and 8 weeks of age ranged from low to moderate.

2.12.3 Phenotypic and genetic correlations

Correlation is an index of linear association between two or more variables. It is a measure of how well two variables vary together. It is defined simply as a measure of strength of the linear association between two variables (Ayizanga and Ahunu, 2013). It does not distinguish one variable as independent and the other as dependent variable. A correlation coefficient (r) has no unit and usually takes on values ranging from negative one to one ($-1 \leq r \leq 1$). The linear association between two variables (correlation) can be positive, negative or zero. A positive correlation indicates a direct association which means that if one variable increases, the other also increases or they both decrease in the same direction.

Correlation can be categurized into three different types - phenotypic correlation (r_P), genetic correlation (r_G) and environmental (r_E).Phenotypic correlations measure association between observed performances of animals. Genotypic correlations on the other hand, measure association between breeding values whiles environmental correlation correlations measure association between random environmental effects (Wagner and Zhang, 2011). In multivariate quantitative genetics, a genetic correlation is the proportion of variance that two traits share due to genetic causes (Neale and Maes, 1996). A genetic correlation between two traits will tend to produce phenotypic correlations and the phenotypic correlation will be limited by the degree of genetic correlation and also by the heritability of each trait (Sodini *et al.,* 2018). Phenotypic correlation may be due to genetic, environmental or due to the combination of both factors (Falconer and Mackay, 1996). Knowledge of correlations among economic traits is essential in any breeding experiment, as the direction and magnitude of these

correlations would determine the genetic changes in the principal as well as in the correlated traits **(**Balakrishna, 2018**)**.

A negative correlation indicates an inverse association between the variables. This means that as one variable increases the other tends to decrease. Two variables have zero correlation when they have no association. Correlation can be low (≤0.30), medium or moderate (≥0.31-0.50) and high (≥0.51) **(**Balakrishna, 2018**)**.

2.12.3.1 Estimation of correlation

Genetic correlations among traits can be estimated using parent-offspring regression analysis. Under this method, parent-offspring covariances can be used to estimate the genetic correlation. The same statistical procedures are used to estimate heritability. This analysis follows that four covariances between parent and the mean of his/her offspring are obtained as described below (Becker, 1984);

$^{cov}x_1z_2$= covariance of trait 1 in parent and trait 2 in offspring

$^{cov}x_2z_1$= covariance of trait 2 in parent and trait 1 in offspring

$^{cov}x_1z_1$= covariance of trait 1 in parent and trait 1 in offspring

$^{cov}x_1z_2$= covariance of trait 1 in parent and trait 1 in offspring

Phenotypic correlations among traits can also be estimated using Pearson's product moment correlation for males (Ayizanga and Ahunu, 2013) as shown below:

$$r = \frac{COVxy}{SxSy}$$

Where:

r =Phenotypic correlation,

Sx = Standard deviation of variable x

Sy = Standard deviation of variable y

Table 2.5: Genetic (upper diagonal) and Phenotypic (below diagonal) Correlations between Body Weights (BW) and Shank Length (SL) at Different Ages in Vanaraja Female Line (PD-2) Birds.

	BWO	BW2	BW4	BW6	SL4	SL6
		0.25±0.28	0.27±0.35	0.16±0.29	0.22±0.51	0.14±0.29
BWO			0.89±0.04	0.99±0.0 1	0.71±0.13	0.99±0.03
				0.82±0.06	0.90±0.06	0.73±0.09
BW2	0.06				0.67±0.14	0.99±0.02
BW4	0.01	0.15				0.57±0.17
BW6	0.03	0.57	0.18			
SL4	0.01	0.11	0.72	0.12		
SL6	0.03	0.50	0.16	0.80	0.11	

Source: Balakrishna (2018)

Daikwo, (2011) also reported consistently higher genetic correlations between body weights at different ages (Table 2.4). The strong and positive genetic relationships as observed between body weights at various ages could mean that the same genes are controlling body weight at different ages (Momoh, 2014). It is explained further that high genetic correlations between body weights at early ages with body weights at later ages could indicate that selection for body weight at early ages would improve body weight at later ages (maturity). However, genetic correlation greater than 1 is above the parametric range. El-Full (2001) and Daikwo (2011) also recorded values greater than 1 for genetic correlation between body weights in Japanese quails. Problems associated with small data size, sampling error and data imbalance (unequal group sizes) could indicate very high genetic correlations between traits involved, which sometime could be outside parametric range (Momoh *et al*., 2014). Yewadan (2000) reported high positive genetic and phenotypic correlations between 4-month weight and 8-month weight in the grasscutter. Koots *et al*. (1994) also reported medium to high positive phenotypic and genetic correlations among body weight and growth traits in beef cattle.

Growth and egg production are economically the most important traits in small holder poultry production systems. The correlations between body weights, growth rate, feed intake, egg production and feed conversion ratio varies among birds (Chambers, 1993). Similarly, the correlations between body weights, growth rate and egg production in indigenous Guinea fowls also varies among the Pearl, the Lavender, the White and the Black. Anang *et al*. (2000) reported that the correlations between body weights, feed intake and egg numbers did not converge for growth and egg traits in weeks 6, 8, and 12 in White Leghorn hens. Phenotypic and genetic correlations of the body weight at hatch and weight in week 2 reported by Anang *et al*. (2000) were generally low. Osei-Amponsah *et al*. (2013) reported that the genetic and phenotypic correlations between body weight and shank length were generally high and positive. This means that similar genes affect body weight and shank length. The authors further reported that the high genetic variance within the local chicken in terms of body weight and shank length could be due to the lack of selection within the local chicken population. Kabir *et al.* (2006) also reported higher and positive genetic and phenotypic correlations between body weight and shank length.

Moderate to high positive genetic correlation and moderate positive phenotypic correlation among egg characteristics have been reported by Koots *et al*. (1994). Momoh *et al*. (2014) observed low to high negative genetic correlations and low to moderate negative phenotypic correlation among egg traits and explained that different genes control these traits which could mean that selection for higher performance in one of them will bring about decrease in performance in the other.

Moderate to high positive genetic correlation between survival and hen day egg production, fertility and hatchability and moderate positive phenotypic correlation between survival and age at first egg was interpreted as selection for higher hen day egg production and earlier age at first egg could improve survival (Hansen *et al.,* 2010) and selection for higher fertility could also improve hatchability.

2.13 Genetic Gain from Selection

What any breeding program aims to achieve is to improve an animal population genetically. In the breeding objective, breeders defined the traits that are important, as well as the direction of change. Usually, the breeder wants to maximize this genetic improvement (called genetic gain or selection response), while minimizing any negative effects (edeX, 2017). The genetic level of a population can be increased through selection of best candidates to be parents of the next generation. This increase in the genetic level or change is called genetic gain. The amount of genetic gain that can be obtained depends on the proportion of the animals that are selected as parents and also on how accurately the animals are ranked, and how much genetic variance there is for the trait.

The formula for calculating genetic gain is $\Delta G = \frac{i * rIH * \sigma A}{L}$

The delta G tells how much better the population gets each year. To calculate genetic gain the selection intensity i, the accuracy of selection r_{IH} and the genetic standard deviation sigma A are multiplied. What is obtained is then divided by generation interval. Another way genetic changes (selection responses) can be estimated is by finding deviations of the means of the selected line from its unselected control line per generation (Vivian, 2013). In order to calculate approximately the magnitude and direction of the average genetic change in the selection criteria per generation

regression of the cumulated responses on generation numbers is used. Expected direct genetic change in one generation of selection for each trait in a selection criteria is estimated by: $\Delta Gi = hi.\sigma gi$, where, h is the square root of heritability of the i-th trait, σgi is the genetic standard deviation of the i-th trait (Yamada, 1958 and Vivian, 2013).

Schmidt *et al*. (2006) estimated genetic gain using deviation between selected lines and the respective unselected lines at 42 days of age in order to develop the commercial broiler stocks. After 15 years of selection, he reported that in female lines, body weight improved 504, 548 and 587 g; average breast area increased 27.60, 16.99 and 26.43 cm^2; adjusted feed conversion (42-49 d) improved -1.46; -0.97 and 1.76 units, and egg production varied 6.99, 7.12 and –3.43% units. In male lines, body weight improved 758 and 408 g; average breast area increased 31.95 and 19.38 cm^2 and adjusted feed conversion improved (42-49 d) –0.99 and 1.26. His conclusion was that breeding program involving selection was effective to generate genetic gain. Generally, simultaneous inclusion of traits in selection index, while selectionis in a positive direction for respective traits, improves performance of the selected individuals (Vivian, 2013).

Large phenotypic and genetic variations exist within indigenous breeds and varieties. Application of genetics and selective breeding towards improving these local breeds is a necessity. Strandberg and Malfors (2006) noted that selection within populations aims for genetic improvement which has continuous and long lasting effects. Enhancement of quantitative traits by selection depends upon increasing the frequency of advantageous genes. Thus, a breeding approach which employs development of pure breeds and selection within local breeds is useful. For rapid development and

improvement of traits in the local birds, many traits that are economically important should be considered and genetically evaluated.

Variable response in a selection experiment according to Hill (1972) is caused by genetic drift, individual measurement sampling, genotype - environment interactions and time trends in environment and natural selection. Selection response tends to decrease and eventually disappears in long-term selection applied to a closed population as a result of increase in homozygosity or genetic drift due to inbreeding (Nwagu *et al*., 2007).

Generally, the synchronization of two or more traits in the selection index, while selection is in a positive direction for the respective traits, improves the performance of the selected individuals in these traits (Hill, 1972).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Introduction

The research was an experimental work. It was a performance evaluation study on four local Guinea fowl varieties (Pearl, Lavender, White and Black).The study was partition into five substudies which included growth performance, disease resistance, behavioral, relationship between traits and response to selection.

3. 2 Location and Duration of the Study

The study was conducted at the Poultry Section of the Animal Farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus. The duration of the study was three years (2015-2018). Mampong-Ashanti lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana along the Kumasi-Ejura road. Mampong lies on latitude 07˚ 03' N and longitude 01˚ 24'W on an altitude of 289.7m above sea level. The rainfall pattern is bimodal, with the major rainfall season occurring from April to July with 1000mm of rainfall while the minor season occurs from August to November with 350mm of rainfall. The average daily temperature is between 25°C and 30°C and the average relative humidity of the area is 70% (MSD, 2015).

3.3 Experimental Birds

The base population was established from 930 growers (16 weeks old) donated to the University of Education, Winneba, College of Agricultural Education by Akate Farms and Trading Company Ltd which purchased the parents from various villeges located

in the Ashanti Region of Ghana. The Ashanti Region is centrally located in the middle belt of Ghana. It lies between longtitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N. The region shares boundaries with four of the sixteen political regions, Brong-East and Ahafo in the north, Eastern Region in the east, Central Region in the south and Western North Region in the south weat.

The region occupies a total land area of 24,389 square kilometers representing 10.2 percent of the total land area of Ghana. The region has a population density of 148.1 persons per square kilometer, the third after GreaternbAccra and Central Regions. More than half of the region lies within the wet, semi-equatorial forest zone (MoFA, 2005).

Due to human activities and bushfires, the forest vegetation of parts of the rgion, particularly the north-eastern part, has been reduced to savanna. The region has an average annual rainfall of 1270mm and two rainy seasons. The major rainy season starts in March, with a major pick in May. There is a slight dip in July and another peak in August, tapering off in November. December to February is dry, hot and dusty.The average daily temperature is about 27ºC. Much of the region is situated between 150 and 300m above sea level. The economically active population in the region is engaged in agriculture, excluding fishing, with 44.5% of them employed in that sector (MoFA, 2005). The region contributes quite significantly to poultry population in the country.

The base population was highly diverse, both genetically as well as phenotypically and their nicking ability indicated that they were pure local breeds. The were 380 males and 550 females out of the 930 birds. The best one hundred and thirty-two birds (22 males and 110 females) were selected based on own performance (body weight) to use as the

base stock after taking six month body weight. This corresponded to 5.8% proportion selected for males and 20% in the females. The lines of the birds were identified at day old with the use of wing tag. The selected birds comprised four strains (84 Pearls, 18 Lavenders, 18 Whites and 12 Blacks). Twenty-two groups (base lines) were formed from the one hundred and thirty-two selected birds in the ratio 5:1 (5 females and 1 male). There were 14 groups of the Pearls, 3 groups of the Lavender, 3 groups of the White and 2 groups of the Black.The birds were classified as keets (0-8weeks), growers (after brooding to point of laying – 9 to 22 weeks) and layers (22 to 72 weeks). The type of family used was half sibs. There were another four hundred and thirty-three unselected birds which were studied alongside the selected ones.

3.4 Management of Birds

3.4.1 Housing

The birds were raised in a slated wooden floor pen partitioned into 24 compartments. Each cage contained 6 birds and measured 1.5m by 3m. Each compartment had a trap nest for individual recording of egg production. During feed intake and docility measurement the birds were housed singly in three-tier wooden cages (Plate 3.1). Cages were also housed in a sandcrete building roofed with corrugated iron sheets.

Plate 3.1: Three-tier Wooden Cage

3.4.2 Feeding and watering

The birds in all treatments were fed similar diet containing 22% of crude protein and 2950 kcal/kg metabolizable energy as the starter diet for the first eight weeks (Table 3.1). During the grower phase the birds were fed diet containing 20% of protein and 2800 kcal/kg metabolizable energy (ME) and a layer diet of 17.5% of protein and 2780 kcal/kg was fed to the layers. Feed and water were given *ad libitum*.

Table 3.1 Feed Composition of Experimental Diet

Ingredients	Starter (kg)	Grower(kg)	Layer(kg)
Maize	57.5	58	53
Wheat bran	11	21	20
Soya bean meal	8.5	5	8
Tuna	11	6	7
Russia fish	9	7	3
Oyster shells	1.5	1.5	7.5
Calcium	0.5	0.5	0.5
Vitamin Premix	0.5	0.5	0.5
Salt	0.5	0.5	0.5
Total	100	100	100

3.4.3 Health management

Proper hygienic practices which involed routine removal of droppings under the slated floor, washing and cleaning of feed and water troughs regularly with soap and water were followed to control diseases and pests. The experimental birds were vaccinated against coccidiosis, Newcastle and fowl pox diseases. Procedures for vaccinarionn were as recommended by the Veterinary Directorate of the Ministry of Food and Agriculture and dosages were given according to manufacturer's specification. Livesol was used to control worms at three months interval. The general medication and vaccination schedule that was followed is in Appendix A

3.4.4 Identification and recording

All the birds were identified at hatch (day old) by rubber wing tags. The following information were recorded:

- The sire and dam of newly hatched keets
- Date of hatch
- Sex of keets
- Line of keets
- Season of hatch

3.4.5 Incubation of eggs and brooding

The eggs selected for artificial incubation were without pee wee and jumb-sized; dirty, cracked or blood-stained eggs were discarded. The eggs were fumigated with a mixture of 20ml Formalin (40%) and 10gm Potassium permanganate, in an airtight wooden box. The procedure used was similar to that used by Hagan (2010). The selected eggs were then incubated in a 7,000-capacity combined Setter/Hatcher Humidaire incubator, which turned automatically at 90^0 every 30 minutes. The eggs were incubated at a

temperature of 37.9^{0}C and 76% relative humidity for 24 days. The eggs were candled at day 14 and moved to the hatcher compartment at day 24. The temperature and relative humidity for the last three days were 36.7^{0}C and 80% respectively.

Day-old keets were then taken to a brooding room immediately for brooding at the Poultry Section of the Animal farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus.The Guinea fowl keets were kept at a temperature of 35^{0}C with adequate drinker and feeder spaces provided. Light was provided for 24 hours during brooding to avoid pilling and death. The temperature was reduced gradually at the rate of 3.50C on weekly basis as brooding progressed (Momoh *et al.,* 2014). The brooding phase lasted for 8 weeks (56 days). At the end of the brooding phase they were randomly distributed and raised on a slated wooden floor pen partitioned into 20 compartments with each compartment measuring 3m x 4m and housing 30 keets.

3.4.5 Data collection

The following parameters were measured on each bird: hatch weight, 2,4,6 and 8 month body weight, day old to two month daily gain, two month to four month daily gain, four to six month daily gain and six to eight month daily weight gain. In addition, dressing percentage, Protein %, Ash%, cholesterol and Moisture %, content of the meat, feed intake, feed conversion ratio (FCR), survival (mortality) and behavioral (docility) were also measured.

3.4.5.1 Production traits

Body weight, growth rate, feed intake and feed conversion ratio defined below were the measurements taken.

3.4.5.1.1 Body weight

Mettler Toledo digital scale manufactured in Switzerland (0.05gm sensitivity) was used for measuring all weights measured (g). Below are the description of growth traits and how they were measured.

Hatch weight (HWT): Weight of day old keets taken on the day they were hatched, within 24 hours.

Two month weight (TMWT): Weight of keets measured at 60 days (2 months)

Four month weight (FMWT): Weights of growers measured at 120 days (4 months)

Six month weight (SMWT): This was measured at 180 days (6 months)

Eight month weight (EMWT): Weights of birds measured at 240 days (8 months).

3.4.5.1.2 Egg characteristics

Eggs weight: Eggs were sampled and weighed by using Mettler Toledo digital scale manufactured in Switzerland (0.05gm sensitivity).

Hen-day egg production: This was calculated as the percentage of the number of eggs laid to the number of hen days (Number of laying days x Number of birds alive).

3.4.5.1.3 Growth rate

Two month daily gain (TMWTG): Weight gain (g) from hatch to end of brooding (60 day) divided by the number of days to end of brooding.

Four month daily gain (FMDTG): Weight gain (g) from end of brooding to four (4) months divided by the number of days from end of brooding to four (4) months.

Six month daily gain (SMDTG): Weight gain (g) from four (4) months to six (6) month divided by the number of days from four (4) months to six (6) month.

Eight month daily gain (EMDTG): Weight gain (g) from four (6) months to six (8) month divided by the number of days from four (6) months to six (8) month.

3.4.5.1.4 Feed intake and feed conversion ratio

Feed intake (g) It was calculated as the difference between the initial feed offered to birds and the feed left over. It was taken every three days with Mettler Toledo digital scale manufactured in Switzerland (0.05gm sensitivity)

Feed conversion ratio (FCR) was computed as the feed intake divided by the total weight gain. Arithmetically, $\text{FCR} = \frac{\text{Total feed intake (g)}}{\text{Total weight gain (g)}}$

3.4.5.2 Reproductive traits

Age at First Egg (AFE): This was the age of the birds when the first egg was laid.

Percentage fertility: It was calculated by expressing the total number of fertile eggs as a percentage of the total number of eggs set.

Percentage hatchability: It was also determined by expressing the total number of eggs hatched as a percentage of total number of fertile eggs.

3.4.5.3 Carcass analysis

At the end of 32 weeks (8 months), ten males and ten females from the Pearl, five males and five females from the Lavender, five males and five females from the White and four males and four females from the Black groups were randomly selected for slaughter. Birds were withdrawn from feed at 24 hours before slaughter. Each live bird was weighed with Mettler Toledo digital scale manufactured in Switzerland (0.05gm sensitivity) and given identification tags to differentiate them especially during scalding and removal of feathers. The birds were then stuck with a sharp knife to cut the jugular

veins and were allowed to bleed for about 60 seconds, after which they were scalded in warm water (70^{O}C). Manual plucking of feathers was done and viscera organs were removed at the vent area through an incision. They were re-weighed after evisceration to obtain carcass weight. The live weight and carcass weight were determined before separation, to determine the dressing out percentage of birds, which is expressed as; $= \frac{\text{carcass weight}}{\text{live weight}} \times 100$

The following carcass yield parameters were taken: Live weight, Bled weight, Defeathered weight, Dressed weight. Meat samples were selected from the edible parts of each of the birds slaughted and analysed for protein, ash, energy, cholesterol and moisture. Biochemical analysis of carcass was done at Biochemistry laboratory of Kwame Nkrumah University of Science and Technology on the following parameters: Protein %, Ash %, Energy KJ, cholesterol % and Moisture %, content of the meat.

3.4.5.4 Survival traits

Survival was defined as a trait of offspring. Pre-brooding survival: survival from day old to brooding = 1; died = 0. Post-brooding survival: survival after brooding to maturity (8 months) = 1; died = 0.Percentage survival was therefore calculated as:

$$SVV = \frac{\text{Number of live birds}}{\text{Total number of birds}} \times 100$$

3.4.5.5 Behavioural traits (Docility)

The ability of the birds to accept human presence (docility) was tested using 150 birds (90 females and 60 males) which were selected at random. The birds were put into individual cages after brooding (2 months). A docility test was conducted weekly, one

month after the birds have settled in their individual cages and early in the morning when the birds had not been disturbed. This test continued till the birds were six months old. The behavioural response of the birds to human presence was tested using cage score on a 1 to 4 scale (Hoppe *et al*., 2010) and measurement of Heterophil/lymphocyte ratio (Deborah *et al*., 2014) as follows:

Cage score:

1. = **Non-aggressive** (docile) - walks slowly, can be approached closely by humans, not excited by human presence.
2. = **Slightly Aggressive -** runs along boundaries, will stand in corner if humans stay away.
3. = **Moderately Aggressive -** runs along boundaries, look for exits and will run eagerly if humans move closer.
4. = **Very Aggressive –** excited in human presence, runs into boundaries, hitting gates and walls of the cage, avoids humans etc.

The average docility score from the 12 individual tests on each animal was used in the analysis. Measurement of Heterophil/lymphocyte ratio (Deborah *et al*., 2014) was the second method. Blood sample of 2ml was drawn from the medial vein of each of the birds for heterophil/lymphocyte test at Mampong Government Hospital laboratory using the protocol in Appendix B.

3.4.6 Statistical analysis

The data collected were analyzed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS for Windows, version 7). The means were separated by using the probability of difference (PDIFF) procedure of SAS (SAS, 2008). The

behavioural response of the birds to human presence was analyzed using Generalized Linear Mixed Models (GLMM) with GLIMMIX procedure of SAS (SAS, 2008).

The model considered was:

i) $y_{ij} = \mu + B_i + e_{ij}$

Where: y_{ij} = Trait performance of the ith bird at a particular age: μ = overall mean common to all observations: B_i= fixed effect of i^{th} strain (i=1, 2, 3, 4): e_{ij} = error term that cannot be explained.

(ii) $y_{ijk} = \mu + S_i + T_j + ST_{ij} + e_{ijk}$

Where y_{ijk} is the trait performance of the ith sex of keet of the jth seasonal effect;

μ is the overall mean common to all the observations;

Si is the effect of the ith sex of keet, i = 1,2;

Tj is the effect of the j *th* seasonal effect; j = 1,2;

ST_{ij} is the interaction effect between the i *th* sex of variety and j *th* seasonal effect and e_{ijk} is the random error term.

3.5 Estimation of Performance Influenced by Strain, Sex and Seasonal Effects.

3.5.1 *Birds*

Records from 1530 keets reared over 3 year period were obtained for the evaluation of performance influenced by strain, sex and seasonal effects. Records were taken on each bird from day old to 8 months.

3.5.2 Housing, feeding, medication and parameters measured

These have been discussed in section 3.3.

3.5.3 Seasons

There were three seasons which consisted of major rainy season, minor rainy season and dry season (from Marchl to June, July to mid-November and late November to end of February respectively).

3.6 Determination of Disease resistance in Local Guinea Fowls using Sheep Red Blood Cell (SRBC) as an Indicator Trait.

3.6.1 Objectives

The objectives of the immunological study were to:

- Determine whether SRBC can be an indicator trait for disease resistance
- Determine strain and sex effects on antibody titers in local Guineafowls
- Estimate SRBC concentration effects on antibody titers in local Guinea
- Estimate route of administration of SRBC antigen on antibody titers in local Guinea fowls

3.6.2 *Birds, data collection and management of birds*

Three hundred and twenty (320) growers aged12 weeks old, comprising 40 males and 40 females from each of the four indigenous Guinea fowl strains (Pearl, Lavender, White and Black) were randomly selected using random digits table and assigned in 4x2 factorial design (4= strains and 2= SRBC concentrations). Each of the four varieties was replicated four times with twenty (20) growers per replicate in a Randomized Complete Block Design (RCBD). RCBD was used because there were more than two treatments and the experimental units were also heterogenous. They were fed similar

diet containing 22% of protein and 2950 kcal/kg metabolizable energy. Feed and water were given *ad libitum*. All the birds were grown intermingled, and not vaccinated before the experiment (Li *et al*., 2000).

Half of each strain as well as sex were intravenously injected with 0.1ml (100µl) 1.0% suspension of SRBC antigen diluted in Phosphate Buffered Saline through the medial wing vein and the other half given 0.1ml 0.25% intramuscularly through the breast muscle.

Blood samples were collected at 5, 7, and 9 d post-immunization from inoculated birds through the medial wing vein using 1ml cyringe and needle. The corrected blood was immediately put in antiquagulant tubes and shaked gently to avoid lyse and quagulation of the blood. Total antibody titers were measured by agglutination assays according to Parmentier *et al. (2002)*. The procedure followed was similar to that used by Boa-Amponsem *et al*. (1997).

The blood samples were sent to the University loboratary and centrifuged at 3000rpm for 5 minutes using 6,000 Capacity Centrifuge – c2 series, after which the plasma was extracted into Eppendorf tubes using micro pipette (0-100ul and 2-200ul) in Bio safty 3 ESCO. Ductless Fume Hooh. The extracted plasma was stored at -20ºC in Chest freezer manufactured by BRUHM. Wells of microtitre plate (Plate 3.2) were filled each with 50µl of Phosphate Buffered Saline (PBS). Fifty microlitres (50µl) of the thawed test plasma was added and serially diluted using the two (2) fold serial dilution. The last volume of the diluents in the multi channel pipette was discarded. Fifty microlitres (50µl) of two percent (2%) SRBC suspension was added to all the wells starting from

the lowest concentrated wells. The control experiment was set using plasma of untreated birds. Microlitre plate was shaken manually and incubated for 45 minutes at 37^0C using DB Thermal system Ltd UK laboratory incubator. Microtitre wells that showed partial or complete Haemaglutination Inhibition (HAI) was taken as end point and expressed as 2^x units/50µl, where x=highest HAI. Total antibody titres to SRBC were determined by agglutination routine procedures as described by Van der Zijpp and Leens (1986). Only primary immune response was considered.

3.6.3 Statistical analysis for the determination of disease resistance using SRBC.

The data collected were analyzed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS for Windows, version 7). The means were separated using the probability of difference (PDIFF) procedure of SAS (SAS, 2008). The linear model below was considered.

$$Y_{ijklmn} = \mu + G_i + C_j + D_k + E_l + F_m + (GC)_{ij} + (GD)_{ik} + (GE)_{il} + (GF)_{im} + (CD)_{jk} + (CE)_{jl} + (CF)_{jm} + (DE)_{kl} + (DF)_{km} + (EF)_{lm} + (GCDEF)_{ijklm} + e_{ijklmn}$$

Where Y_{ijklmn} = performance of the ith variety group of jth concerntration

μ = overall mean common to all the observations

G_i = effect due to ith strain (I = 1, 2, 3, 4)

C_j = effect due to jth sex (1, 2)

D_k = effect due to kth days (5, 7, 9)

E_l = effect due to lth concentration (1, 2)

F_m = effect due to mth route (1, 2)

GC_{ij} = interaction effect between the ith strain and jth sex

GD_{ik} = interaction effect between the ith strain and kth day

GE_{il} = interaction effect between the ith strain and lth concentration

GF_{im} = interaction effect between the ith strain and mth route

CD_{jk} = interaction effect between the jth sex and kth day

CE_{jl} = interaction effect between the jth sex and lth concentration

CF_{jm} = interaction effect between the jth sex and mth route

DE_{kl} = interaction effect between the kth day and lth Concentration

DF_{km} = interaction effect between the kth day and mth route

EF_{lm} = interaction effect between the lth concentration and mth route

e_{ijklmn} = the random error term

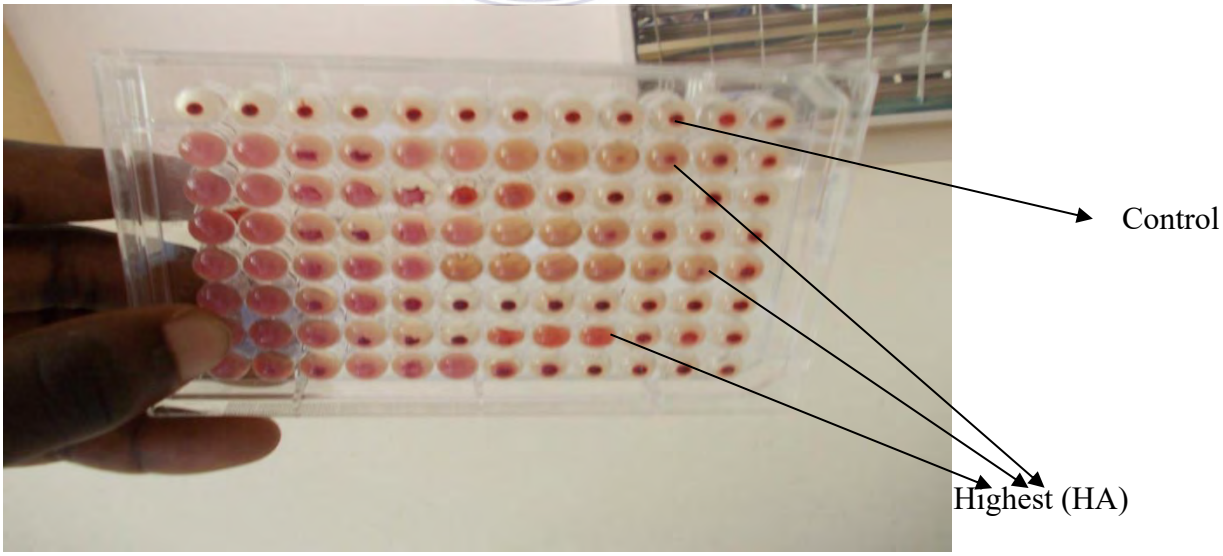


Plate 3.2: SRBC Hemaglutination (HA) Test in Local Guinea Fowls.

3.7 Estimation of phenotypic and genetic parameters.

3.7.1 Objectives

The objectives of the study were to:

- Estimate genetic variation (diversity) in the traits
- Estimate heritability of traits
- Estimate phenotypic and genetic correlation between traits

3.7.2 Experimental birds, data collection and management of birds

The records used in this experiment were collected from six hundred birds (300 males and 300 females) produced from randomly selecting and mating 110 dams and 22 sires of this base population, between May, 2015 to July, 2017. Seven hundred and eighty (780) records were collected from the birds during this period. Tables 3.2 and 3.3 show the traits measured and the number of records obtained per trait for males and females respectively. Management of birds and data collection followed the procedure described in sections 3.3 and 3.4.3 respectively.

Table 3.2: **Summary of the Distribution of Data used for Estimating Parameters in Local Male Guinea Fowls**

Parameter	Acronym	Number of records	Mean	Range	Standard deviation
Hatch weight, g	HWT	300	25.95	23.4-28.5	1.06
2- month body weight, g	TMWTG	286	461.09	409.1-528	31.84
4- month body weight, g	FMWT	286	815.59	637.67-1070.2	71.73
6-month body weight, g	SMWT	286	1578.76	1420.3-1773.3	61.19
8- month body weight, g	EMWT	286	1759.69	1505-1955	58.85
Daily gain from 1-2 months, g/day	TMWTG	286	7.35	3.9-9.94	0.95
Daily gain from 2-4 months, g/day	FMWTG	286	7.67	5.18-9.98	0.60
Daily gain from 4-6 months, g/day	SMWTG	286	12.71	11.32-14.20	0.72
Daily gain from 6-8 months, g/day	EMWTG	286	4.26	1.32-10.64	0.88
Antibody response to SRBC (ABR)	SRBC	144	7.68	4.50-11.50	0.62
Docility score	DOC	288	2.91	1.20-3.60	0.44
Dressing percentage, %	DRESSP	104	64	57-78	0.06
Feed intake, g/day	FI	124	56.73	46.72-69.25	2.24

Feed conversion ratio	FCR	124	4.03	2.38-5.49	0.41

Table 3.3: Summary of the Distribution of Data used for Estimating Parameters of Local female Guinea Fowls

Parameter	Acronym	Number of records	Mean	Range	Standard deviation
Hatch weight (g)	HWT	300	26.88	23.2-28.9	1.09
2-month weight (g)	TMWTG	292	456.77	408.75-573.5	34.28
4-month weight (g	FMWT	292	828.45	534-987	49.93
6- month weight, (g)	SMWT	292	1583.19	1398.5-1699.5	49.34
8- month weight, (g)	EMWT	292	1810.21	1590-2132	53.41
Daily gain from 1-2 months (g/day)	TMWTG	292	7.82	6.19-9.67	0.56
Daily gain from2 -4 months, (g/day)	FMWTG	292	7.03	4.98-9.91	0.68
Daily gain from 4-6 months, (g/day)	SMWTG	292	12.66	13.15-10.12	0.45
Daily gain from 1-2 months, (g/day)	EMWTG	292	4.18	1.73-11.37	0.78
Survival	SVV	144	7.48	4.00-10.40	0.61
Docility score	DOC	288	3.07	1.20- 3.90	0.44
Dressing percentage (%)	DRESSP	104	63	49-74	0.03
Feed intake (g/day)	FI	124	57.47	47.17-67.57	2.43
Feed conversion ratio	FCR	124	4.21	2.43-6.90	0.61
Age at first egg (days)	ATFE	292	210.22	185-235	5.41
Egg weight (g)	EGGWT	168	41.06	37.8-49.2	1.24
Hen-day egg production (%)	HDEP	168	71.06	55- 79.8	5.57
Percentage fertility (%)	FERT	168	59	36-73	0.03
Percentage hatchability (%)	HATCH	168	48	10-71	0.03

3.6.3 Statistical analysis

Phenotypic and genetic parameters estimated were phenotypic and genetic variances, genetic coefficient of variation, heritability and genetic and phenotypic correlation using sire-son and sire-daughter regression for all the parameters except egg characteristics where dam-daughter regression was used. Regression of offspring on parent was used because the population was not inbred and was randomly mated.

Phenotypic ($\sigma^2 p$) and genetic ($\sigma^2 g$) variances were obtained according to Baye (2002) as: $\sigma^2 g = MSp - MSe/r$ and $\sigma^2 p = MSg/r$, where *MSp and MSg,* are mean squares of phenotypes and of genotypes respectively and *r* is the number of replication.

The mean values were used for genetic analyses to determine genetic coefficient of variation (GCV), according to Singh and Chaudhury (1985) as:

$$GCV(\%) = \frac{\sqrt{o^2 g}}{x} \text{ X } 100$$

where: $\sigma^2 g$ = genotypic variance and x = sample mean.

Genetic coefficient of variation was used as a measure of ability of a trait to respond to selection and to determine genetic diversity of a trait in relative terms (McLennan & Lewer, 2005). Coefficient of variation was classified as low (0-20%), medium (> 20-< 40%) and high (≥ 40%). (Annor *et al*., 2012).

The linear statistical model for estimation of heritability was:

$Z_i = \beta X_i + e_i$

where Z_i = the mean of the offspring of the ith sire, X = the observation on the ith sire, β = the regression of Z on X and

e_i = the error associated with the Z's.

Heritability:

$$h^2 = 2\,\frac{cov_{xz}}{\sigma^2 X} = 2b$$

where b = the regression of offspring on parent

Standard error (S.E) of the heritability was calculated according to Klein *et al*. (1973) as:

$$s_b^2 = \frac{\sum_z 2 - \frac{(\sum xz)2}{\sum x\,2}}{n-2}$$

$$S.E.(b) = \sqrt{\frac{s_b^2}{\sum_x 2}}$$

S.E. (h^2) = 2 S.E. (b)

where b = the regression of offspring on parent.

Genetic and Phenotypic correlation:

Estimate of genetic correlations among the traits were obtained using the Arithmetic method below (Becker, 1984):

$$r_G = \frac{cov_{x1z2} + cov_{x2z1}}{\sqrt{cov_{x1z1}\, cov_{x2z2}}}$$

Where:

r_G = genetic correlation

$^{cov}x_1z_2$ = covariance of trait 1 in parent and trait 2 in offspring

$^{cov}x_2z_1$ = covariance of trait 2 in parent and trait 1 in offspring

$^{cov}x_1z_1$ = covariance of trait 1 in parent and trait 1 in offspring

$^{cov}x_1z_2$ = covariance of trait 1 in parent and trait 1 in offspring

Approximate standard error (S.E.) of the genetic correlation was obtained using the following formula (Falconer, 1981):

$$\textbf{S.E.}\ (r_G) = \frac{1-r_G^2}{\sqrt{2}} \sqrt{\frac{S.E.(h_1^2)\ S.E.\ (h_2^2)}{h_1^2\ h_2^2}}$$

Phenotypic correlations among traits were estimated using Pearson's product moment correlation (Ayizanga and Ahunu, 2013) below:

$$r = \frac{cov_{xy}}{s_x\ s_y}$$

Where:

r =Phenotypic correlation,

Sx = Standard deviation of variable x

Sy = Standard deviation of variable y

The standard error of the phenotypic correlation coefficient, S.E. was calculated using:

$$S.E. = \sqrt{\frac{1-r^2}{n-2}}$$

3.7 Estimation of Genetic Gain of the 3rd Generation Offspring

3.7.1 *Objectives*

The objectives of the study were to:

- Construct selection index to be used for multiple trait selection
- Estimate selection differential and selection intensity
- Estimate genetic changes

3.7.2 Methodology

Records obtained from 657 birds belonging to three generations, that is from 2015 to 2018 of the local Guinea fowl under selection for body weight, disease resistance and docility (selection criteria) were used for this study. Description and measurement of the traits followed the procedure described in section 3.4.4.

3.7.3 Procedure for selection

In each generation of selection, an index was constructed using data collected on the following traits which had better relative economic values (HWT, TMWT, SMWT, RSRBC and DOC). For all the traits considered in this study, the direction of selection was positive. Genetic and phenotypic parameter estimates (heritabilities and correlations) were estimated using sire-son and sire-daughter regression analysis method described by Becker (1984) in order to calculate the properties of the selection index. The total number of records used for the first, second and third generations (G0, G1, and G2) respectively were 440, 856 and 1233 for.

Table 3.4: Heritability Estimates (h^2) and Mean ± SD of Traits Used to Construct the Index.

Trait		G_O		G_1		G_2
	h^2	mean ± SD	h^2	mean ± SD	h^2	mean ± SD

Body weight						
HWT (g)	0.17	25.68 ± 2.37	0.68	25.64 ± 2.46	0.71	23.80 ± 2.45
TMWT (g)	0.68	329.29 ±69.85	0.53	328.95 ± 70.01	0.59	459.23 ±14.54
SMWT (g)	0.43	1192.20 ±194.05	0.40	1470.96 ±87.45	0.40	1601.72 ± 89.77
Disease resistance						
RSRBC	0.20	7.58 ± 1.79	0.17	7.26 ± 1.76	0.18	6.60 ± 1.86
Docility						
Cage score	0.40	2.97 ± 0.7	0.34	3.37 ± 0.68	0.38	3.42 ± 0.72

HHWT = Hatch weight, TMWT = Two month weight, SMWT = Six month weight, RSRBC = Response to sheep red blood cell

Heritability and means ± standard deviations (SD) as well as genetic and phenotypic correlations of the traits used in the index calculations for 1st, 2nd and 3rd generations are shown in Tables 3.4 and 3.5, respectively.

Economic values for each trait were estimated using the existing market values of each trait such that the relative economic values changed with each generation. The selection index calculations were solved using Mathcad 7 professional (Mathsoft applications). The general solution to the index equation was $b = P^{-1}Ga$ according to Becker (1984), where P = phenotypic variance-covariance matrix; b = vector of partial regression coefficients (weights); G = genetic variance - covariance matrix; and a = vector of relative economic values. Only hens which ranked equal and above the index score were selected as parents of the next generation. Males were selected based on their mature body weight - average selection intensity of 5% was used for the cocks.

Table 3.5: Phenotypic (rp) and Genetic (rg) Correlation by Generation

Trait	G_0		G_1		G_2	
Body weight	Rp	rg	rp	rg	rp	rg
HWT –TMWT	0.19	0.35	0.23	0.42	0.31	0.30
TMWT-SMWT	0.3	1.04	0.45	0.57	0.29	0.48
SMWT-HWT	-0.03	-0.46	0.11	-0.43	-0.3	-0.37
Disease resistance						
SVV-HWT	0.03	-2.1	0.04	-0.77	-0.02	-0.82
SVV-TMWT	0.32	0.57	0.41	0.45	0.52	0.65
SVV-SMWT	0.03	0.45	0.01	0.47	0.04	0.33

SVV-DOC	0.05	0.58	0.17	0.61	0.03	0.56
DOCILITY						
DOC-HWT	0.1	-0.93	0.4	-0.88	0.6	-0.58
DOC-TMWT	-0.13	-0.67	-0.10	-0.71	-0.22	-0.63
DOC-SMWT	-0.34	-0.5	-0.43	-0.08	-0.36	-0.8

HHWT = Hatch weight, TMWT = Two month weight, SMWT = Six month weight, SVV = .Survival, DOC = Docility, G_0= Generation 1, G_1= Generation 2 and G_2= Generation 3

3.7.4 Estimation of selection differential and selection intensity

The deviation of the average value of selected birds from the average value of the population from which they were selected, for each trait, was calculated as the within-generation changes induced by selection (selection differential (ΔS)). The value obtained was divided by the mean phenotypic standard deviation of the whole population to obtain the mean selection intensity - given in units of standard deviations - for the three generations of study (Ayyagari *et al*., 1980).

Cumulative selection differential associated with each individual was measured as the mean of selection differentials (ΔS) in the parental generation plus the mean cumulative selection differential from each previous generation (G) as follows:

$G0 = C\Delta S0 = \Delta S0$, $G1 = C\Delta S1 = \Delta S1 + \Delta S0$ and $G2 = C\Delta S2 = \Delta S2 + C\Delta S1$ (Leymaster *et al*., 1979).

3.7.5 Estimation of genetic changes

The genetic changes (selection responses) were estimated as deviations of the means of the selected line from its unselected control line per generation. Regression of the cumulated responses on generation numbers was done in order to estimate the magnitude and direction of the average genetic change in the selection criteria per generation. Expected direct genetic change in one generation of selection for each trait in the selection criteria was estimated by: $\Delta G_i = h_i.\sigma_{gi}$, where, h is the square root of

heritability of the i-th trait, σ_{gi} is the genetic standard deviation of the i-th trait (Yamada, 1958).

CHAPTER FOUR

4.0 RESULTS

4.1 Estimation of Performance Influenced by Strain, Sex and Seasonal Effects.

4.1.1 Effect of strains on production traits

Body weight, daily weight gain, egg weight, hen day egg production, feed intake and feed conversion ratio of the Pearl, Lavender, White, and the Black local Guinea fowls are presented in Table 4.1. There was no significant difference ($p>0.05$) among the strains with respect to day old weight, post brooding daily weight gain, feed intake and feed conversion ratio. Body weights at weeks 8, 16, 24 and 32 were significantly different ($p<0.01$) among the strains with the Pearl and White strains having the heaviest weights at week 8. However, the Lavender and the Black did not differ significantly ($p0>.05$) from each other at this age. Body weights at weeks 16 and 24 showed similar trend with the Pearls being significantly ($p<0.01$) heavier compared to their counterparts however the other three strains did not differ significantly ($p>0.05$) from one another. Though at week 32 the Pearls were significantly ($p<0.05$) heavier than their contemporaries, the White at this age was heavier than the Black but the White and Lavender were similar ($p>0.05$) in weight. In terms of pre brooding daily weight gain, the Pearls grew significantly faster ($p<0.05$) than the Lavender and the Black but not the White. However, prebrooding daily dain between the Lavender, White and the Black Guinea keets were not significantly different ($p>0.05$).

The Pearls produced eggs which were significantly heavier ($p<0.05$) than those of the Lavender, White and the Black. The egg weight of the White and the Black did not differ significantly ($p>0.05$). Again, the Pearls were outstanding ($p<0.05$) in terms of

percent hen day egg production followed by the Lavender and the White with the Black varieties having the least.

Table 4.1: Effect of Guinea Fowl Varieties on Production Traits

Body weight (g)	**Pearl**	**Lavender**	**White**	**Black**	**SEM**	**P-value**
Day old,	24.5	24.8	25.1	25.7	0.35	0.09
8 Weeks,	430^{a}	398^{b}	416^{a}	357^{b}	15.9	0.01
16 Weeks,	768^{a}	695^{b}	714^{b}	694^{b}	14.5	0.01
24 Weeks,	1520^{a}	1440^{b}	1470^{b}	1430^{b}	14.4	0.01
32 Weeks,	1730^{a}	1640^{bc}	1680^{b}	1590^{c}	18.4	0.01
PRBDWG (g/bird)						
0-8 Weeks,	7.24^{a}	6.66^{b}	6.98^{ab}	5.92^{b}	0.27	0.01
PSBDWG (g/bird)						
8-16 Weeks,	6.82	6.59	6.54	6.79	0.21	0.54
16-24 Weeks,	12.7	12.6	12.6	12.3	0.21	0.7
24-32 Weeks,	3.59	3.18	3.52	2.84	0.25	0.1
Egg production						
Egg weight (g)	41.31^{a}	40.13^{b}	38.29^{c}	38.76^{c}	0.14	0.01
Hen day egg production (%)	66.66^{a}	56.13^{b}	57.50^{b}	51.19^{c}	0.74	0.01
Feed intake						
24 Weeks, g/bird	54.2	52.1	53.7	53.4	0.95	0.24
Feed conversion ratio						
24 Weeks	4.43	4.26	4.33	4.44	0.11	0.5

^{abc} Means bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means p = probability of main effects
PRBDWG= Pre brooding daily weight gain PSBDWG= Post brooding daily weight gain

4.1.2 Effect of variety on reproductive traits

The mean age at first egg, percent fertility and hatchability of the four local Guinea fowl varieties are presented in Table 4.2. Lavender varieties attained significantly (P<0.05) earliest age at first egg as compared to the other varieties. However, age at first egg of the Pearls, White and Black varieties were not significantly different (P>0.05). There were significant differences (p<0.05) among the strains in terms of percent fertility and hatchability. The Pearl variety had significantly (p<0.05) highesr percent fertility than their counterparts. This was followed by the Lavender and the Black with the White having the lowest percent fertility. Percent hatchability was the best (p<0.05) in the Black varieties compared to the other three varieties. The Pearl variety also had significantly (P<0.05) higher percent hatchability than the White and

Lavender varieties. However, the Lavender and the White showed no significant differences (P>0.05) in their hatchability.

Table 4.2: **Effect of Varieties on Reproductive Performance of Four Varieties of Local Guinea Fowls**

Reproductive performance	Pearl	Lavender	White	Black	SEM	P-value
Age at first egg/day	212.56[a]	192.22[b]	208.23[a]	211.34[a]	2.25	0.02
Fertility (%)	56.037[a]	53.817[b]	30.918[d]	48.014[c]	1.079	0.022
Hatchability (%)	29.115[b]	24.049[c]	21.945[c]	37.510[a]	1.928	0.031

[abcd] Means bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means

4.1.3 Effect of strain on biochemical profile

The biochemical profile of the meat of the four varieties of local Guinea fowls is presented in Table 4.3. There were significant differences (p<0.05) in the percent protein, ash and moisture profile amongst the four Guinea fowl varieties. The results showed that the percentage cholesterol level in the meat was not significantly (p>0.05) affected by the Guinea fowl varieties. Percent protein in the meat was not significantly (p>0.05) different among the Lavender, White and the Black but all the three were significantly (p<0.05) better compared to that of the Pearl. The Pearl varieties had significantly (p<0.05) higher percent ash than the other three varieties. The percent ash for the other varieties were similar. The Pearl and the Black varieties had significantly (p<0.05) higher percent moisture values than that of the Lavender and the White. Additionally the values for the White was significantly (p<0.05) higher than than that of the White.

Table 4.3: Effect of Variety on the Biochemical Profile of the Local Guinea Fowls

Biochemical profile	Pearl	Lavender	White	Black	SEM	P-value
Protein (%)	12.988[b]	13.118[a]	13.134[a]	13.141[a]	0.031	0.002
Ash (%)	1.733[a]	1.676[b]	1.692[b]	1.643[b]	0.021	0.021
Cholesterol (%)	2.383	2.395	2.375	2.373	0.011	0.524
Moisture (%)	75.015[a]	74.702[c]	74.855[b]	75.061[a]	0.021	0.014

[abc] Mean
s bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means

4.1.4 Effects of varieties on carcass characteristic, docility and survival

Table 4.4 shows the effect of varieties on the carcass characteristics, docility and survival of the local Guinea fowls. The Pearl had significantly (p<0.05) higher pre-brooding survival percentage than their counterparts. The Lavender did not differ significantly (p>0.05) from the White but both were better than the Black. Post brooding survival and heterophil-lymphocyte ratio were not significantly (p>0.05) affected by the Guinea fowl varieties. With respect to the dressing percentage, the Whites had significantly higher (p<0.05) dressing percentage than the other varieties. The Pearl and the Black varieties also had significantly higher (p>0.05) dressing percentage than the Lavender varieties. Cage score docility measurement was significantly (p<0.05) better in the Lavender compared to the other three varieties. The other varieties had similar values (p>0.05).

Table 4.4: The Carcass Characteristic, Docility and Survival of the Four Varietiess of Local Guinea Fowls

Parameters	Pearl	Lavender	White	Black	SEM	P-value
Carcass						
Dressing (%)	62.812[b]	57.669[c]	68.903[a]	62.866[b]	1.671	0.002
Docility						
Cage score	3.11[a]	2.66[b]	3.24[a]	3.11[a]	0.08	0.02
Heterophil-lymphocyte ratio	0.04	0.04	0.03	0.03	0.02	0.24
Survival						
Pre-brooding survival (%)	86.8[a]	75.8[b]	70.0[b]	50.6[c]	3.64	0.02
Post-brooding survival (%)	94.2	97.3	90.7	100	2.71	0.19

[abcd] Means bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means

4.1.5 *Effect of sex on Guinea fowl traits*

The effect of sex on production traits of the local Guinea fowls strains are presented in Table 4.5. There were no significant differences (p>0.05) observed between the males and the females local Guinea fowls in any of the production traits measured in this experiment.

Table 4.5: Effect of Sex on Production Traits of Local Guinea Fowl Strains

Body weight (g/bird)	**Female**	**Male**	**SEM**	**P- value**
Day old,	24.86	25.14	0.27	0.48
8 Weeks,	398.81	402.34	12.42	0.84
16 Weeks,	720.78	715.68	10.77	0.74
24 Weeks,	1463.42	1464.66	11.36	0.94
32 Weeks	1663.99	1658.14	14.63	0.78
Pre brooding daily weight gain				
0-8 Weeks, g/bird	6.23	6.29	0.21	0.85
Post brooding daily weight gain				
8-16 Weeks, g/bird	6.88	6.50	0.17	0.10
16-24 Weeks, g/bird	12.47	12.60	0.18	0.64
24-32 Weeks, g/bird	3.34	3.22	0.19	0.67
Feed intake				
24 Weeks, g/bird	54.26	52.42	0.75	0.09
Feed conversion ratio				
24 Weeks g/bird	4.46	4.27	0.09	0.12

SEM= standard error of means p = probability of main effects

4.1.6 *Effects of sex on biochemical profile, carcass characteristics, docility and Survival*

The effect of sex on biochemical profile, carcass characteristics, docility values and survival traits of the local Guinea fowls are shown in Table 4.6. There was no significant difference (P<0.05) between the dressing percentage, docility scores and percent pre- brooding survival of the males and females in this study. Percent protein, energy and post brooding survival of the males were significantly higher (P<0.05) than othose of the females. On the other hand, percent ash, and moisture scores were significantly higher in the females than in their male counterparts.

Table 4.6: Effects of Sex on the Biochemical Profile, Carcass Characteristics, Docility and Survival Traits.

Biochemical profile	Female	Male	SEM	P- value
Protein (%)	12.833[b]	13.357[a]	0.027	0.021
Ash (%)	1.822[a]	1.550[b]	0.013	0.021
Energy (kj)	445.35[b]	459.79[a]	0.667	0.002
Moisture (%)	75.089[a]	74.727[b]	0.017	0.002
Carcass characteristic				
Dressing (%)	62.129	63.996	1.314	0.369
Docility				
Cage score	3	3.06	0.05	0.42
Heterophil-lymphocyte ratio	0.03	0.01	0.01	0.39
Survival				
Pre-brooding survival, %	70.07	71.56	2.3	0.62
Post-brooding survival, %	92.51[b]	98.65[a]	1.75	0.02

[ab] Means bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means p = probability of main effects

4.1.7 Effect of season on production traits

Table 4.7 shows the seasonal effects on the production traits of the local Guinea fowls. There were no significant differences (P<0.05) among the seasons in terms of age at first lay, egg weight, percent hen day egg production and feed intake. However, seasons significantly (P<0.05) influenced day old weight, body weight at week 8, pre-brooding daily weight gain and post brooding daily weight gain from week 16-24.

Body weight at week 16 and daily weight gain at week 24-32 were significantly (P<0.05) higher in the dry and major rainy seasons compared to that in the minor season. The trend changed with respect to the results of the effect of season on body weight at weeks 24 and 32 where the performance of the birds in the major rainy season significantly (P<0.05) improved followed by the dry season with those occurring in the minor season recording the least performance. Post brooding daily weight gain at week 8-6 was significantly (P<0.05) higher in the dry season compared to the major and minor rainy seasons. However, this performance was similar between the major and

minor seasons. FCR was significantly (P<0.05) best in the minor season followed by the major season with the poorest in the dry season.

Table 4.7: **Effect of Season on Production Traits**

Growth parameters	Dry Season	Major Rainy Season	Minor Rainy Season	SEM	p-value
Body weight					
Day old, g/bird	25.6[a]	24.4[b]	25.5[a]	0.24	0.02
8 Weeks, g/bird	368[b]	432[a]	421[a]	11.4	0.02
16 Weeks, g/bird	801[a]	817[a]	536[b]	13.5	0.02
24 Weeks, kg/bird	1.51[b]	1.57[a]	1.31[c]	13.5	0.02
32 Weeks, kg/bird	1.73[b]	1.80[a]	1.45[c]	17.9	0.02
PRBDWG					
0-8 Weeks, g/bird	5.72[b]	6.80[a]	6.61[a]	0.21	0.02
PSBDWG					
8-16 Weeks, g/bird	7.18[a]	6.19[b]	6.34[b]	0.16	0.02
16-24 Weeks, g/bird	11.9[b]	12.7[a]	12.9[a]	0.18	0.02
24-32 Weeks, g/bird	3.58[a]	3.91[a]	2.35[b]	0.2	0.02
Egg parameters					
Age at first egg (Days)	205.81	207.42	205.03	2.13	0.73
Egg weight (g)	39.72	39.54	39.61	0.13	0.56
HDEP (%)	57.96	58.05	57.61	0.7	0.92
Feed intake					
24 Weeks, g/bird	53.6	53.6	52.8	0.87	0.85
Feed conversion ratio					
24 Weeks, g/bird	4.58[c]	4.35[b]	4.17[a]	0.09	0.02

[abc] Means bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means p = probability of main effects
PRBDWG= Pre brooding daily weight gain PSBDWG= Post brooding daily weight gain
HDEP= Hen day egg production

4.1.8 Effect of season on reproductive performance, biochemical profile, carcass characteristics, docility and survival traits

Effect of season on reproductive performance, biochemical profile, carcass characteristics, docility and survival traits of the local Guinea fowls are presented in Table 4.8. Percent hatchability, docility and survival traits of the birds did not show significant (P>0.05) differences among the seasons. Conversely, the percent fertility of the birds significantly (P<0.05) increased in the dry season compared to the major and minor seasons which showed no significant difference (P>0.05) in percent fertility. On the biochemical profile of the varieties, the percent protein and energy were all significantly (P<0.05) higher in the minor season than the values recorded in the dry

and major rainy seasons. These parameters were not significantly different (P>0.05) in the dry and major rainy seasons. In terms of percent ash and moisture, significantly (P<0.05) higher values were recorded during the dry and major rainy seasons as against the values recorded in the minor season. Dressing percentage was significantly better (P<0.05) in the major rainy season followed by the dry season and lowest in the minor season.

Table 4.8: Effect of Season on Reproductive Performance, Biochemical Profile, Carcass Characteristics, and Docility and Survival Traits of Local Guinea Fowls.

Reproductive performance	Dry Season	Major Rainy Season	Minor Rainy Season	SEM	P-value
Fertility (%)	50.317[a]	45.425[b]	45.848[b]	1.016	0.001
Hatchability (%)	29.755	26.644	28.064	1.821	0.395
Biochemical profile					
Protein (%)	13.019[b]	13.003[b]	13.264[a]	0.032	0.002
Ash (%)	1.718[a]	1.734[a]	1.607[b]	0.015	0.002
Energy (kj)	451.16[b]	450.24[b]	456.31[a]	0.742	0.002
Moisture (%)	74.967[a]	74.965[a]	74.791[b]	0.021	0.002
Carcass characteristics					
Dressing (%)	63.623[b]	68.345[a]	57.218[c]	1.541	0.002
Docility					
Cage score	3.03	3.05	3.01	0.08	0.95
Heterophil-lymphocyte ratio	0.003	0.070	0.001	0.02	0.08
Survival					
Pre-brooding survival (%)	74.66	67.23	70.55	2.99	0.08
Post-brooding survival (%)	95.21	96.84	94.69	2.05	0.65

[abc] Means bearing different superscripts in the same row are different at p<0.05.
SEM= standard error of means p = probability of main effects

4.2 Determination of Disease Resistance in Local Guinea Fowls with the Use of Sheep Red Blood Cell (SRBC) as an Indicator Trait.

All two way interactions among fixed factors showed no significant differences and were therefore ignored. The control experiment showed no Haemaglutination Inhibition (Plate 1) and was not considered in the discussion.

4.2.1 Strain and sex effects on antibody titres

Strain and sex effects on antibody titers of the local Guinea fowls are shown in Table 4.9. There were significant ($p<0.05$) influences of strains and sex on antibody titres. Antibody titers were significantly ($p<0.05$) highest in the Pearl strain compared to their other counterparts. Similar ($p>0.05$) antibody titres were recorded among the Lavender, White and the Black strains. The female Guinea fowls had better ($p<0.005$) antibody titers than the males.

Table 4.9: Effect of Variety and Sex on Antibody Titres of Four Guinea Fowl Varieties Inoculated with SRBC Antigen

Factor	Mean Antibody Titre ABR
Strain	
Pearl	$8.16^{a} \pm 0.181$
Lavender	$5.93^{b} \pm 0.181$
White	$6.31^{b} \pm 0.181$
Black	$5.96^{b} \pm 0.181$
P-value	0.003
Sex	
Female	$7.16^{a} \pm 0.220$
Male	$6.02^{b} \pm 0.226$
P-value	0.005

[a–b] Means within a column for breed and sex with different superscripts differ at $P \leq 0.05$.

4.2.2 Effect of days and concentration on antibody titers

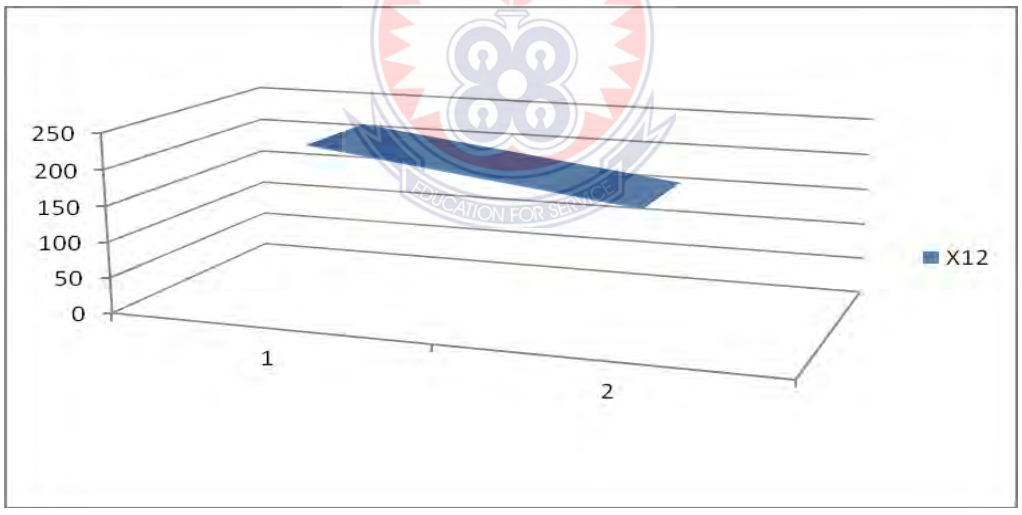
Table 4.10 shows the effect of days and SRBC concentration on antibody titers in local Guinea fowls. Both days and concentration had little or no ($p>0.05$) effect on antibody titers in the local Guinea fowls studied in this experiment.

Table 4.10: **Means of Effect of Days and Concentration on Antibody Titres in Local Guinea Fowls**

Factor	Level	Antibody Titre ABR
Day		
	5	6.12 ± 0.296
	7	6.67 ± 0.159
	9	6.98 ± 0.290
P-values		0.24
Concentration		
	1	6.67 ± 0.129
	2	6.51 ± 0.128
P-values		0.37

1= 1.0% concentration of SRBC and 2= 0.25% concentration of SRBC

4.2.3 Effect of route of SRBC antigen administration on antibody titers



Route (1= Intravenous; 2= Intramuscular)

Figure 2: **Effect of Route of SRBC Antigen Administration on Antibody Titres in Local Guinea Fowls**

Figure 4.1 presents the effect of route of administration of SRBC antigen on the strains of local Guinea fowls. Route of administration significantly ($p<0.05$) influenced antibody titers in the local Guinea fowls. Injection by intravenous was more effective than intramuscular in antibody titers production of the birds.

4.3 Estimation of Phenotypic and Genetic Parameters.

4.3.1 Variance and coefficient of variation components estimates of traits

Table 4.11 presents estimates of components of variance and coefficient of variation of traits of local Guinea fowls. The values of phenotypic and genetic variances of both males and females were generally high for TMWT, FMWT, SMWT and EMWT. Feed intake was next to. Hatch weight TMWT, FMWT, SMWT and EMWT, TMWTG, FMWTG, SMWTG, EMWTG, SVV, DOC, DRESSP and FCR had the lowest $\sigma^2 p$ and $\sigma^2 g$.

With the exception of CVg of EMWTG which was medium in the males, all the other traits had low genetic diversity (variability) in both sexes. Conversely, there were some specific differences with respect to the traits that had low CV. While the CV_g of HWT, FMWT, SMWT, EMWT, TMWTG, SMWTG, DOC and DRESSP were higher in the males relative to their corresponding CV_g in the females, TMWT, FMWTG, SRBC, FI and FCR were lower in the males than their corresponding CV_g in the females. The results of coefficient of variation indicated that the genetic variance of six to eight month weight gain was generally higher than those of all other traits in both the sire and dam. This was followed by docility and the feed conversion efficiency in males while in females eight month weight gain was followed by FCR before docility.

Table 4:11 Estimates of Variance Components and Coefficient of Variation of Body Weights, Growth Rates, Survival, Carcass and Feeding Traits in Guinea Fowls

	Male			Female		
Parameter	σ^2p	σ^2g	CV_g (%)	σ^2p	σ^2g	CV_g (%)
HWT	1.568	1.129	4.09	1.458	1.196	4.07
TMWT	1536.447	1014.055	6.91	1678.945	1175.261	7.51
FMWT	9529.113	5145.721	8.8	5418.799	2492.648	6.03
SMWT	7800.481	3744.231	3.88	6406.275	2434.385	3.12
EMWT	10184.85	3462.85	3.34	8913.447	2852.303	2.29
TMWTG	2.046	0.9	12.91	0.823	0.313	7.15
FMWTG	1.374	0.357	7.79	1.524	0.457	9.62
SMWTG	1.608	0.515	3.7	0.861	0.207	2.37
EMWTG	3.242	0.778	20.71	3.422	0.616	18.78
SVV	2.153	0.387	8.1	1.719	0.378	8.22
DOC	0.527	0.19	14.98	0.397	0.19	14.2
DRESSP	0.002	0.004	9.88	0.003	0.001	5.02
FI	17.956	5.028	3.95	16.464	5.927	4.24
FCR	0.422	0.169	10.2	0.844	0.371	14.47

σ^2p = Phenotypic variance; σ^2g = Additive genetic variance; CVg = Genetic coefficient of variation
HWT=Hatch weight, TMWT= 2 month weight, FMWT=4 month weight, SMWT=6 month weight, EMWT=8 month weight, TMWTG= 2 month weight gain, FMWTG=4 month weight gain, SMWT=6 month weight gain, EMWTG=8 month weight gain, SVV= Survival, DOC= Docility and DRESSP= Dressing percentage.

4.3.2 Variance and coefficient of variation components estimates of egg traits

Estimates of the components of variance and coefficient of variation of egg traits are presented in Table 4.12. The values of phenotypic and genetic variances were high for age at first egg and hen-day egg production and low for egg weight, fertility and hatchability. All of the egg characteristics had low CV_g.

Table 4.12: Estimates of Variance Components and Coefficient of Variation of Age at First Egg, Egg Weight, Hen Day Egg Production, Fertility and Hatchability in Guinea Fowls

Parameter	σ^2p	σ^2g	CV_g (%)
Age at first egg	86.2	29.308	2.58
Egg weight	2.67	1.547	3.03
Hen-Day egg production	39.82	31.063	7.84
Fertility (%)	0.01	0.001	5.36
Hatchability (%)	0.01	0.001	6.59

σ^2p = Phenotypic variance; σ^2g = Additive genetic variance; CVg = Genetic coefficient of variation

4.3.3 *Heritability estimates of traits*

In Table 4.13 are heritability estimates of body weight and body weight gain at various ages, antibody response to SRBC (Survival), docility, dressing percentage, feed intake and FCR in local Guinea fowls in Ghana. Estimates of heritability of body weight were high at hatch, month 2 and month 4, moderate at 6 and 8 in males. These were not different in the females with the exception of month 4 weight which was medium. Heritability values for body weight decreased with the age of the birds.

The heritability estimates of body weight gain on the other hand did not follow a particular trend with respect to age in both sexes. However, these were moderate at month 2 and 6 but low at month 4 and 8 in the males whereas in the female counterparts the estimates were moderate at months 2 and 4 and low at months 6 and 8. Heritability estimates for survival, dressing percentage and feed intake were all low in the males and females apart from feed intake which was medium in the females. Though both docility and FCR heritability estimates were higher in females compared to males, they were all moderate and ranged between 0.32 and 0.48.

Table 4.13: Heritability Estimates of Traits of Indigenous Guinea Fowls

Traits	NB (Males)	$h_s^2 \pm$ S.E	NB (Females)	$h_d^2 \pm$ S.E
Hatch weight	300	0.72 ± 0.30	300	0.82 ± 0.35
2-month weight	296	0.66 ± 0.35	296	0.70 ± 0.38
4-month weight	295	0.54 ± 0.28	294	0.46 ± 0.27
6-month weight	295	0.48 ± 0.28	294	0.38 ± 0.29
8-month weight	295	0.34 ± 0.29	294	0.32 ± 0.3
Daily gain from 1-2 months	296	0.44 ± 0.40	296	0.38 ± 0.4
Daily gain from 2-4 months	295	0.26 ± 0.40	294	0.30 ± 0.4
Daily gain from 4-6 months	295	0.32 ± 0.30	294	0.24 ± 0.25
Daily gain from 6-8 months	295	0.24 ± 0.32	294	0.18 ± 0.32
Antibody response to SRBC	72	0.18 ± 0.26	72	0.22 ± 0.3
Docility	144	0.32 ± 0.25	144	0.48 ± 0.3
Dressing percentage	52	0.26 ± 0.30	52	0.28 ± 0.26
Feed intake	62	0.28 ± 0.29	62	0.36 ± 0.29
FCR	62	0.40 ± 0.30	62	0.44 ± 0.3

h_s^2 = Heritability from sire-son regression
h_d^2 = Heritability from sire-daughter regression
S.E = Standard error; NB= Number of observations

4.3.4 Heritability estimates of egg characteristics

Table 4.14 shows heritability estimates of egg characteristics in local Guinea fowls in Ghana. Estimates of heritability of egg weight and hen-day egg production were high, moderate for age at first egg and low for fertility and hatchability.

Table 4.14: Heritability Estimates of Egg Characteristics of Local Guinea Lowls

Trait	No records	$h_f^2 \pm$ S.E
Age at first egg	589	0.34 ± 0.16
Egg weight	168	0.58 ± 0.21
Hen-day egg production	168	0.78 ± 0.17
Fertility	168	0.08 ± 0.15
Hatchability	168	0.12 ± 0.17

h_f^2= Heritability from dam-daughter regression.
S.E = Standard error

4.3.5 Genetic and phenotypic correlations

The results of genetic and phenotypic correlations are presented in Table 4.15 (for males) and Table 4.16 (for females). In males, hatch weight (HWT) was highly correlated genetically with TMWT (0.56) but was lowly correlated genetically with EMWT (0.18). It correlated negatively low with SMWT (-0.17) but there was no

genetic correlation between HWT and FMWT. In females, HWT lowly correlated genetically with TMWT (0.13) and lowly negatively correlated with FMWT (-0.00) and EMWT (-0.02) but the genetic correlation between HWT and SMWT was negatively high (-0.75). Phenotypically, HWT was moderately correlated with TMWT (0.33), correlated negatively low with FMWT (-0.2) and SMWT (-0.29) but positively low with EMWT (0.01) in the males. However, in females, HWT correlated positively low with TMWT (0.05) and EMWT (0.29) but negatively low with FMWT (-0.26) and SMWT (-0.23) phenotypically.

Two month weight (TMWT) in males was highly correlated genetically with SMWT (1.3) and EMWT (1.02) but not important with FMWT. While, in females TMWT moderately correlated genetically with FMWT (0.44), highly correlated with SMWT (0.75) but lowly correlated genetically with EMWT (0.05). Two month weight (TMWT) in males lowly correlated phenotypically with the weights of the other ages whereas in the female TMWT was moderately correlated phenotypically with SMWT (0.37) but lowly with FMWT (0.24) and EMWT (0.01). Four month weight (FMWT) showed similar trend in both males and females with respect to genetic and phenotypic correlations. It was highly correlated genetically with SMWT and EMWT but moderately correlated phenotypically with SMWT and EMWT. Six month weight (SMWT) in males was highly correlated genetically with EMWT (1.03) but phenotypically, the correlation was low (0.26) while in females SMWT highly correlated genetically with EMWT (1.2) but moderately correlated phenotypically with EMWT (0.42)

Genetic correlation between HWT and SMWTG was low (0.26) but those between HWT and all other body weight gain were high (0.54, 0.64 and 0.78) in males while this correlation in females was low between HWT and TMWTG (0.11) and negatively low between HWT and FMWTG (-0.12) but negatively moderate between HWT and SMWTG (-0.46) and moderate between HWT and EMWTG (0.35). Phenotypic correlation between HWT and SMWTG was moderate (0.38) whereas between HWT and TMWTG, EMWTG were low and negatively zero between FMWTG (0.12, 0.2 and -0.00 respectively) in males. However, in females, phenotypic correlation existed between HWT and all of the weight gains were low (0.07, 0.15 and 0.21) except FMWTG which was not important.

Genetic correlation between TMWT and TMWTG and FMWTG were high (1.02 and 0.83 respectively) but between TMWT and SMWTG was low(0.25) and not important with EMWTG in males but in the females, genetic correlation was only high between TMWT and TMWTG (0.75) and low between FMWTG (0.23) and SMWTG (0.15) and negatively moderate between EMWTG (-0.32). Phenotypic correlation in both males and females were moderate between TMWT and FMWTG (0.49 and 0.46 respectively) and low between TMWT and TMWTG (0.11 and 0.09 respectively) and negatively low between TMWT and EMWTG (, -0.28, and -0.04 respectively) and negatively low between TMWT and SMWTG (-0.23) in males and positively low between TMWT and SMWTG (0.02) in females.

Genetic correlation between FMWT and TMWTG and FMWTG were not important but FMWT correlated genetically negatively moderate with SMWTG (-0.37) and high with EMWTG (1.2) in males whereas genetic correlation between FMWT and

TMWTG in females was negatively high (-0.89) but high with FMWTG and EMWTG and low with SMWTG (1.3, 0.66 and 0.05 respectively). Phenotypic correlation between FMWT and FMWTG and EMWTG showed similar trend in both males and females (moderate). The correlations were moderate (0.39 and 0.34 for males and 0.35 and 0.36 for females). However, phenotypic correlation between FMWT and TMWTG (-0.2) and SMWTG (-0.25) were both negatively low in males but in females the correlation was negatively moderate with TMWG (-0.32) and negatively low with SMWTG (-0.02). In males, high genetic correlation existed between SMWT and FMWTG (0.85), SMWT and SMWTG (0.6), SMWT and EMWTG (0.92) but between SMWT and TMWTG was moderate (0.39) whereas in females, high genetic correlation existed between SMWT and TMWTG (1.1), SMWT and FMWTG (1.4) but between SMWT and SMWTG was low (0.19) and negatively high between SMWT and EMWTG (-1.2). Phenotypic correlation between SMWT and TMWTG, SMWT and SMWTG and SMWT and EMWTG were all low in males but between SMWT and FMWTG was moderate (0.11, 0.07, 0.26 and 0.44 respectively) whereas in the females, phenotypic correlation was low between SMWT and TMWTG (0.12), SMWT and SMWTG (0.17) and negatively low between SMWT and EMWTG (-0.16) but moderate between SMWT and FMWTG (0.35). High genetic correlation were observed between EMWT and TMWTG (0.53) and between EMWT and EMWTG (0.74) but between EMWT and FMWTG was low (0.19) and between EMWT and SMWTG (-0.06) was negatively low in males. Genetic correlation observed in the females between EMWT and TMWTG, EMWT and FMWTG and EMWT and EMWTG were high but between EMWT and SMWTG was negatively low (0.60, 0.51, 1.10 and -0.01 respectively). In males, phenotypic correlation was low between EMWT and TMWTG (0.03) and EMWT and FMWTG (0.18) but negatively low between

EMWT and SMWTG (-0.19) and moderate between EMWT and EMWTG (0.3). However, phenotypic correlation in females were moderate between EMWT and FMWTG, EMWT and EMWTG but low between EMWT and TMWTG and negatively low between EMWT and SMWTG (0.34, 0.35, 0.17 and -0.03 respectively).

In males, two month weight gain (TMWTG) was highly correlated genetically with SMWTG (0.82) and EMWTG (0.64) but the genetic correlation between TMWTG and FMWTG was negatively moderate (-0.43). This was different in the females. Genetic correlation between TMWTG and FMWTG (-0.53) was negatively high, between TMWTG and SMWTG was high (1.4) but between TMWTG and EMWTG showed no genetic correlation. Phenotypic correlation in males, between TMWTG and FMWTG was moderate (0.49), negatively low between TMWTG and SMWTG (-0.25) and negatively moderate between TMWTG and EMWTG (-0.30) whereas in females phenotypic correlation between TMWTG and FMWTG was also moderate (0.42) but was negatively low TMWTG and SMWTG (-0.02) as well as between TMWTG and EMWTG (-0.02).

Table 4.15: Genetic (above Diagonal) and Phenotypic (below Diagonal) Correlations among 14 Traits (Sire-son Regression)

	HWT	TMWT	FMWT	SMWT	EMWT	TMWTG	FMWTG	SMWTG	EMWTG	SVV	DOC	DRESSP	FI	FCR	
HWT			0.56	.	-0.17	0.18	0.54	0.64	0.21	0.78	-3.73	-1.81	-1.15	-0.13	-0.07
SE			*0.23*	.	*0.34*	*0.41*	*0.31*	*0.34*	*0.42*	*0.21*	*0.49*	*1.25*	*0.4*	*0.46*	*0.39*
TMWT		0.33		.	1.34	1.02	1.02	0.83	0.25	-	1.3	-0.32	-2.65	-0.51	-0.63
SE		*0.19*		.	*0.32*	*0.02*	*0.02*	*0.2*	*0.47*	-	*1.03*	*0.41*	*0.55*	*0.39*	*0.27*
FMWT		-0.2	0.29		0.93	1.3	-	-	-0.37	1.2	0.75	-0.49	0.95	0.72	0.67
SE		*0.2*	*0.19*		*0.05*	*0.33*	-	-	*0.43*	*0.26*	*0.27*	*0.34*	*0.05*	*0.25*	*0.24*
SMWT		-0.29	0.23	0.35		1.03	0.39	0.85	0.6	0.92	0.97	-0.67	-0.35	0.51	0.4
SE		*0.19*	*0.19*	0.14		*0.03*	*0.21*	*0.19*	*0.52*	*0.1*	*0.04*	*0.26*	*0.51*	*0.41*	*0.39*
EMWT		0.01	0.19	0.39	0.26		0.53	0.19	-0.06	0.74	0.65	-0.54	-0.03	0.78	0.91
SE		*0.2*	*0.2*	0.13	*0.14*		*0.45*	0.78	*0.31*	*0.38*	*0.45*	*0.41*	*0.7*	*0.26*	*0.1*
TMWTG		0.12	0.11	-0.2	0.11	0.03		-0.43	0.82	0.64	1.7	0.4	-0.01	0.89	0.65
SE		*0.2*	*0.2*	0.19	*0.2*	*0.2*		0.68	0.21	0.64	*1.54*	*0.5*	*0.73*	*0.14*	*0.34*
FMWTG		-0.004	0.49	0.39	0.44	0.18	0.49		-0.16	-0.49	0.79	-0.28	0.02	0.48	0.14
SE		*0.18*	*0.17*	0.18	*0.18*	*0.2*	*0.17*		0.83	0.77	*0.4*	*0.72*	*0.94*	*0.69*	*0.75*
SMWTG		0.38	-0.23	-0.25	0.07	-0.19	-0.25	-0.24		0.27	0.49	0.13	-0.62	-0.42	-0.66
SE		*0.17*	*0.19*	0.15	*0.2*	*0.15*	*0.19*	*0.19*		0.74	*0.63*	*0.6*	*0.45*	*0.58*	*0.34*
EMWTG		0.2	-0.28	0.34	0.26	0.31	-0.3	0.18	0.06		0.84	0.43	-0.19	0.7	0.76
SE		*0.19*	*0.18*	0.14	*0.15*	*0.14*	*0.2*	*0.2*	*0.2*		*0.29*	*0.59*	*0.85*	*0.43*	*0.3*
SVV		-0.21	0.27	-0.06	0.07	0.08	0.28	-0.28	0.16	0.03		1.09	-2.52	0.93	0.29
SE		*0.19*	*0.2*	0.15	*0.15*	*0.16*	*0.19*	*0.19*	*0.15*	*0.15*		*0.14*	*0.92*	*0.12*	*0.68*
DOC		*0.18*	0.1	-0.21	-0.24	-0.11	0.09	-0.46	-0.05	0.17	0.2		0.49	0.35	0.24
SE		*0.2*	*0.2*	0.15	*0.14*	*0.15*	*0.2*	*0.18*	*0.16*	*0.16*	1.6		*0.51*	*0.56*	*0.51*
DRESSP		-0.41	-0.23	0.1	0.00	-0.01	-0.23	0.36	-0.12	-0.01	-0.18	0.08		0.94	1.4
SE		*0.18*	*0.19*	0.15	*0.15*	*0.15*	*0.19*	*0.19*	*0.19*	*0.15*	0.15	0.15		*0.09*	*0.16*
FI		-0.18	-0.32	0.33	0.2	0.29	-0.32	-0.01	-0.15	0.17	0.15	0.01	0.04		1.01
SE		*0.2*	*0.19*	0.14	*0.15*	*0.14*	*0.19*	*0.2*	*0.14*	*0.15*	0.15	0.14	0.15		*-0.01*
FCR		-0.24	-0.17	0.33	0.21	0.31	-0.16	0.18	-0.13	0.18	0.13	0.01	0.11	0.23	
SE		*0.18*	*0.2*	0.15	*0.15*	*0.14*	*0.2*	*0.2*	*0.15*	*0.15*	0.14	0.14	0.16	0.14	

Hatch weight (HWT); two month weight (TMWT); four month weight (FMWT); six month weight (SMWT); eight month weight (EMWT); two month weight gain (TMWTG); four month weight gain (FMWTG); six month weight gain (SMWTG); eight month weight gain (EMWTG); survival (SVV); docility score (DOC); dressing percentage (DRESSP); feed intake (FI); feed conversion ratio (FCR) and standard error (SE)

Genetic correlation existed in males, between FMWTG and SMWTG was negatively low (-0.16) and negatively moderate between FMWTG and EMWTG (-0.49) where in females genetic correlation existed between FMWTG and SMWTG was low (0.07) and no genetic correlation existed between FMWTG and EMWTG in the females. Negatively low phenotypic correlation was observed between both FMWTG and SMWTG (-0.24) and between FMWTG and EMWTG (-0.18) in males but in females phenotypic correlation was negatively low between FMWTG and SMWTG (-0.1) and low between FMWTG and EMWTG (0.11). Six month weight gain (SMWTG) lowly correlated genetically with EMWTG (0.27) in males while in females, genetic correlation between SMWTG and EMWTG was negatively high (-0.80). Phenotypic correlation observed between SMWTG and EMWTG (0.06) was low in males and negatively low in females (-0.03).

Genetic correlation in males was negatively high between HWT and SVV (-3.73), HWT and DOC (-1.81), HWT and DRESSP (-1.15) but negatively low between HWT and FI (-0.13) and between HWT and FCR (-0.07) whereas in females genetic correlation was negatively moderate between HWT and SVV (-0.47), negatively low between HWT and DOC (-0.05), HWT and DRESSP (-0.16) but low between HWT and FI (0.02) and moderate between HWT and FCR (0.31). Phenotypic correlation between HWT and SVV, FI and FCR in males were all negatively low (-0.21, -0.18 and -0.24 respectively) but negatively moderate between HWT and DRESSP (-0.41) and low between HWT and DOC (0.18). Phenotypic correlation between HWT and SVV, DOC, FI and FCR in females on the other hand, were all low (0.26, 0.01, 0.23 and 0.12 respectively) but moderate between HWT and DRESSP (0.4)

Two month weight (TMWT) in males was highly correlated genetically with SVV (1.3) and was highly negatively correlated genetically with DRESSP (-2.65), FI (-0.51) and FCR (-0.63) but genetic correlation between TMWT and DOC was negatively moderate (-0.32). In females, TMWT was lowly correlated genetically with FI (0.25) and lowly negatively correlated genetically with SVV, DRESSP and FCR (-0.16. -0.01 and -0.06 respectively) but genetic correlation between TMWT and DOC was negatively high (-1.01). Two month weight (TMWT) in males was lowly correlated phenotypically with SVV (0.27) and DOC (0.1) but lowly negatively correlated phenotypically with DRESSP (-0.23) and FCR (-0.17) but moderately negatively correlated phenotypically with FI (-0.32). Two month weight (TMWT) in females on the other hand, was moderately correlated phenotypically with SVV (0.37) and moderately negatively correlated phenotypically with DOC (-0.35) and FI (-0.39) but lowly negatively correlated phenotypically with DRESSP (-0.15) and FCR (-0.01).

Table 4.16: Genetic (above Diagonal) and Phenotypic (below Diagonal) Correlations among 19 Traits (Sire and Dam-daughter Regression)

	HWT	TMWT	FMWT	SMWT	EMWT	TMWTG	FMWTG	SMWTG	EMWTG	Surval	Dscore	Dress%	ATFE	EGGWT	HDEP	FERT	HATCH	FI	FCR
HWT		0.13	-0.003	-0.75	-0.02	0.11	-0.12	-0.46	0.35	-0.47	-0.05	-0.16	2.43	0.53	-0.18	0.03	0.56	0.02	0.31
SE		0.34	0.35	-0.75	0.45	0.47	0.53	0.37	0.54	0.42	0.37	0.44	-1.61	0.20	0.20	0.67	0.38	0.42	0.35
TMWT	0.05		0.44	0.73	0.05	0.75	0.23	0.15	-0.32	-0.16	-1.01	-0.01	0.69	-0.3	0.02	0.17	0.57	-0.25	-0.06
SE	0.21		0.32	0.21	0.50	0.23	0.31	0.52	0.63	0.59	-0.01	0.50	0.19	0.28	0.23	0.74	0.42	0.44	0.43
FMWT	-0.26	0.24		1.1	1.2	-0.89	1.33	0.05	0.66	-0.11	-0.19	0.16	-3.7	0.31	-0.04	0.01	-1.4	0.64	0.78
SE	0.2	0.19		0.10	0.23	0.15	0.48	0.55	0.41	0.63	0.41	0.51	-4.88	0.29	0.24	0.79	-0.62	0.29	0.18
SMWT	-0.23	0.37	0.42		1.2	1.1	1.4	0.19	-1.2	-0.07	-0.32	1	.	-0.53	0.05	-0.02	0.77	0.4	0.55
SE	0.19	0.18	0.14		0.26	0.22	0.49	0.04	0.36	0.72	0.44	0.00	.	0.26	0.27	0.90	0.30	0.47	0.36
EMWT	0.29	0.1	0.43	0.42		0.60	0.51	-0.01	1.10	0.73	-0.35	-0.58	1.15	0.12	-0.59	0.9	1	0.87	0.95
SE	0.2	0.2	0.14	0.14		0.41	0.61	0.59	0.16	0.37	0.48	0.44	0.16	0.40	0.20	0.19	0.00	0.15	0.06
TMWTG	0.07	0.09	-0.32	0.12	0.17		-0.53	1.36	.	.	-0.45	.	.	.	1.30	.	1.77	-0.21	-0.71
SE	0.21	0.19	0.19	0.2	0.2		0.60	0.63	.	.	0.46	.	.	.	0.22	.	-1.85	0.62	0.30
FMWTG	-9.26	0.46	0.35	0.35	0.34	0.41		0.07	.	.	-1.16	.	.	.	-0.14	.	-0.08	0.37	-0.08
SE	0.2	0.18	0.19	0.19	0.19	0.18		0.83	.	.	-0.23	.	.	.	0.35	.	0.97	0.63	0.67
SMWTG	0.15	0.02	-0.02	0.17	-0.03	-0.02	-0.1		-0.80	0.16	-0.11	-3.82	-0.58	.	0.52	.	.	0.10	-0.50
SE	0.2	0.19	0.16	0.15	0.15	0.2	0.2		0.35	0.82	0.57	-9.47	0.34	.	0.23	.	.	0.64	0.45
EMWTG	0.21	-0.04	0.36	-0.16	0.35	-0.02	0.11	-0.03		1.43	-0.52	-2.77	0.37	.	-0.48	.	.	1.57	1.35
SE	0.19	0.2	0.14	0.15	0.14	0.2	0.2	0.15		2.38	0.55	6.10	0.58	.	0.32	.	.	1.25	0.64
Survival	-0.26	0.37	-0.11	-0.01	0.03	0.31	0.47	0.1	-0.1		0.07	-0.8	.	.	0.45	0.34	1.11	0.9	0.75
SE	0.18	0.18	0.16	0.16	0.16	0.19	0.18	0.15	0.15		0.65	0.29	.	.	0.29	1.07	-0.23	0.14	0.30
Dscore	-0.01	-0.35	-0.47	-0.43	-0.41	-0.31	-0.22	0.03	-0.04	-0.1		-0.01	.	.	-0.49	0.19	-0.2	0.58	0.33
SE	0.2	0.19	0.14	0.14	0.14	0.19	0.19	0.15	0.15	0.15		0.54	.	.	0.19	0.79	0.64	0.28	0.43
Dress%	-0.35	-0.15	0.23	0.07	-0.03	-0.14	0.47	-0.24	-0.15	-0.11	-0.19		.	.	.	.	.	-0.82	1.31

Table 4.16 Continued

SE	0.19	0.2	0.15	0.14	0.14	0.2	0.18	0.14	-0.15	0.15	0.17		.	.	.	.	.	0.20	0.40
ATFE	0.42	0.24	-0.2	-0.23	0.06	0.16	0.11	-0.2	0.19	0.49	0.14	0.07		-0.32	0.25	-0.15	-0.48	.	.
SE	0.18	0.19	0.19	0.19	0.2	0.2	0.2	0.15	0.15	0.17	0.2	0.19		0.26	0.21	0.71	0.46	.	.
EGGWT	0.35	-0.07	0.36	-0.25	0.00	-0.07	0.11	0.19	-0.19	0.16	-0.15	0.12	0.07		0.42	0.88	0.48	0.73	.
SE	0.19	0.18	0.19	0.7	0.17	0.2	0.2	0.15	0.15	0.18	0.18	0.15	*0.19*		1.75	-0.49	1.62	0.30	.
HDEP	0.23	0.06	-0.09	0.04	-0.27	0.36	0.1	-0.17	0.08	0.08	-0.25	0.08	-0.13	0.15		0.73	-0.53	0.56	0.73
SE	0.18	0.2	0.19	0.2	0.19	0.19	0.2	0.15	0.15	0.2	0.19	0.15	*0.2*	*0.09*		0.99	1.53	0.44	0.12
FERT	0.25	0.09	-0.01	-0.24	0.39	0.47	-0.09	0.19	-0.25	0.09	-0.12	-0.04	0.08	0.19	0.2		-0.57	0.05	0.01
SE	0.25	0.2	0.17	0.19	0.18	0.18	0.2	0.15	0.14	0.19	0.2	0.15	*0.2*	*0.08*	*0.08*		1.44	0.63	0.85
HATCH	0.25	0.12	-0.2	0.17	0.12	0.04	-0.19	0.11	-0.13	0.21	-0.02	0.17	-0.2	-0.01	0.02	-0.02		-1.2	-0.43
SE	0.19	0.2	0.18	0.2	0.2	0.2	0.2	0.15	0.15	0.18	0.2	0.15	*0.2*	*0.09*	*0.08*	*0.09*		-0.28	0.57
FI	-0.23	-0.39	0.34	0.27	0.38	-0.32	-0.01	-0.09	0.2	0.16	0.14	-0.09	0.1	0.3	0.27	0.37	-0.33		0.91
SE	0.19	0.18	0.14	0.15	0.14	0.19	0.2	0.15	0.18	0.15	0.16	0.15	0.18	0.18	0.19	0.17	0.19		0.11
FCR	-0.12	-0.01	0.31	0.19	0.03	0.04	-0.01	-0.13	0.18	0.19	0.05	0.1	0.06	0.05	0.23	0.2	-0.13	0.19	
SE	0.2	0.2	0.15	0.14	0.15	0.2	0.2	0.15	0.18	0.15	0.15	0.15	0.2	0.21	0.19	0.2	0.19	0.15	

Hatch weight (HWT); two month weight (TMWT); four month weight (FMWT); six month weight (SMWT); eight month weight (EMWT); two month weight gain (TMWTG); four month weight gain (FMWTG); six month weight gain (SMWTG); eight month weight gain (EMWTG); survival (SVV); docility score (DOC); dressing percentage (DRESSP); age at first egg (ATFE); egg weight (EGGWT); hen day egg production (HDEP); percent fertility (FERT); percent hatchability (HATC); feed intake (FI); feed conversion ratio (FCR) and standard error (SE).

Genetic correlation between FMWT and SVV, DRESSP, FI and FCR in males, were high (0.75, 0.95, 0.72 and 0.67 respectively) but negatively moderate between DOC (-0.49) whereas in females genetic correlation between FMWT and SVV and DOC were negatively low (-0.11 and -0.19 respectively) but low between FMWT and DRESSP (0.16) and high between FMWT and FI (0.64) and between FMWT and FCR (0.78). Phenotypic correlation between FMWT and SVV (-0.06) and DOC (-0.21) were negatively low but between FMWT and DRESSP (0.1) was low. FI and FCR moderately correlated phenotypically with FMWT (0.33). However, the observed phenotypic correlation between four month weight (FMWT) and SVV (-0.11) in females, was negatively low and negatively moderate between FMWT and DOC (-0.47) but low between FMWT and DRESSP (0.23) and moderate between FMWT and FI and FCR (0.34 and 0.31) respectively.

Genetic correlation existed between SMWT and SVV (0.95) and FI (0.51), in males, were high and moderate between SMWT and FCR (0.4) but negatively high between SMWT and DOC (-0.67) and negatively moderate between SMWT and DRESSP (-0.35). However, in females, genetic correlation existed between SMWT and SVV (-0.07) was negatively low, moderately negative between SMWT and DOC (-0.32), high between SMWT and DRESSP and FCR (1and 0.55 respectively) and moderate between SMWT and FI (0.4). Phenotypic correlation existed between SMWT and SVV, FI and FCR in males, were all low (0.07, 0.2 and 0.21 respectively) and negatively low between SMWT and DOC (-0.24) but zero between SMWT and DRESSP (0.00) while in females, SMWT negatively correlated phenotypically low with SVV (-0.01) and negatively moderate with DOC (-0.43) but low with DRESSP (0.07), FI (0.27) and FCR (0.19).

In males, genetic correlation recorded was high between EMWT and SVV (0.65), EMWT and FI (0.78), low between EMWT and FCR (0.19), negatively high between EMWT and DOC (-0.54) and negatively low between EMWT and DRESSP (-0.03) but in the females, genetic correlation recorded was high between EMWT and SVV (0.65), between EMWT and FI (0.87), between EMWT and FCR (0.95) but negatively moderate between EMWT and DOC (-0.35) and negatively high between EMWT and DRESSP (-0.58). Low phenotypic correlation existed between EMWT and SVV (0.08) in males, low between EMWT and FI (0.29), moderate between EMWT and FCR (0.31), negatively low between EMWT and DOC (-0.11) and negatively low between EMWT and DRESSP (-0.01) whereas in females low phenotypic correlation was recorded between EMWT and SVV (0.03) and EMWT and FCR (0.03) but was negatively moderate EMWT and DOC (-0.41), negatively low EMWT and DRESSP (-0.03) and moderate between EMWT and FI (0.38).

Two month weight gain (TMWTG) was highly correlated genetically with SVV (1.7), FI (0.89), FCR (0.65), moderately correlated with DOC (0.4) and lowly negatively correlated genetically with DRESSP (-0.01) in males. However, in females, both SVV and DRESSP did not show genetic correlation with TMWTG but negatively moderate genetic correlation existed between TMWTG and DOC (-0.45) and low genetic correlation was recorded between TMWTG and FI (0.21) while negatively high genetic correlation was observed between TMWTG and FCR (-0.71). Phenotypic correlation in males was low between TMWTG and SVV (0.28) and TMWTG and DOC (0.09) but negatively low between TMWTG and DRESSP (-0.23), TMWTG and FCR (-0.16) and negatively moderate between TMWTG and FI (-0.32). In females on the other hand, phenotypic correlation between TMWTG and SVV (0.31) was moderate, negatively

moderate with DOC (-0.31) and FI (-0.32) but negatively low with DRESSP (-0.14) and low with FCR (0.04).

Genetic correlation in males was high between FMWTG and SVV (0.79), negatively low between FMWTG and DOC (-0.28), low FMWTG and DRESSP (0.02) and FMWTG and FCR (0.14) but moderate between FMWTG and FI (0.48). No genetic correlation existed between FMWTG and SVV and FMWTG and DRESSP in the females but negatively low genetic correlation existed between FMWTG and DOC (-0.16) and between FMWTG and FCR (-0.08) but moderate genetic correlation was recorded FMWTG and FI (0.37). Phenotypic correlation in males was negatively low between FMWTG and SVV (-0.28), FMWTG and FI (-0.01), negatively moderate between FMWTG and DOC (-0.46), moderate between FMWTG and DRESSP (0.36) and low between FMWTG and FCR (0.18) but in females phenotypic correlation was negatively low between FMWTG and DOC, FI and FCR (-0.22, -0.01and -0.01 respectively) but moderate between SVV (0.47) and between DRESSP (0.47).

Genetic correlation was moderate between SMWTG and SVV (0.49) in males, low between SMWTG and DOC (0.13) and negatively high between SMWTG and DRESSP (-0.62) and between SMWTG and FCR (-0.66) but negatively moderate between SMWTG and FI (-0.42) whereas in females SMWTG correlated lowly with SVV (0.16) and FI (0.10) but negatively low with DOC (-0.11) and negatively high with DRESSP (-3.82) and FCR (-0.50). Six month weight gain (SMWTG) phenotypic correlation in males, was low with SVV (0.16) and negatively low with DOC, DRESSP, FI and FCR (-0.05, -0.12, -0.15 and -0.13 respectively). In females, SMWTG was

correlated phenotypically low with SVV (0.1) and DOC (0.03) and negatively low with DRESSP (-0.24), FI (-0.09) and FCR (-0.13).

Eight month weight gain (EMWTG) in males was highly correlated genetically with SVV, FI and FCR (0.84, 0.7 and 0.76 respectively) but moderately with DOC (0.43) and negatively low with DRESSP (-0.19) but in females, EMWTG was highly correlated genetically with SVV, FI and FCR (1.43, 1.57 and 1.35 respectively) and negatively highly with DOC (-0.50) and DRESSP (-2.77). Low phenotypic correlation was observed in males between EMWTG and SVV, DOC, FI and FCR (0.03, 0.17, 0.17 and 0.18 respectively) but between EMWTG and DRESSP (-0.01) was negatively low whereas in females, phenotypic correlation was negatively low between EMWTG and SVV (-0.1), DOC (-0.04) and DRESSP (-0.15) but low between FI (0.2) and FCR (0.18).

Genetic correlation between SVV and DOC, and SVV and FI, in males, were high (1.09 and 0.93 respectively) but those between SVV and DRESSP, and SVV and FCR were negatively high and low (-2.52 and 0.29) respectively. However, in females, genetic correlation was low between SVV and DOC (0.09), negatively high between SVV and DRESSP (-0.8) but high between SVV and FI (0.9), and SVV and FCR (0.75). Phenotypic correlation in males, were low between SVV and DOC (0.2), SVV and FI (0.15) and SVV and FCR (0.13) but negatively low between SVV and DRESSP (-0.18) whereas in females, phenotypic correlation was negatively low between SVV and DOC (-0.1), and between SVV and DRESSP (-0.11) but low between SVV and FI (0.16), and SVV and FCR (0.19)

Docility (DOC) was moderately correlated genetically with DRESSP (0.49) and FI (0.35) but lowly correlated genetically with FCR (0.24) in males but in females, DOC negatively lowly correlated genetically with DRESSP (-0.01) but highly correlated genetically with FI (0.58) and moderately correlated genetically with FCR (0.33). Docility in males, was lowly correlated phenotypically with DRESSP (0.08), FI (0.01) and FCR (0.01) while in females, docility negatively lowly correlated phenotypically with DRESSP (-0.19) but lowly correlated phenotypically with FI (0.14) and FCR (0.05).

In both males and females, DRESSP was highly correlated genetically with FI and FCR (0.94 and 1.4 respectively for males, and 0.82 and 1.31 respectively for females). Phenotypic correlation were low between DRESSP and FI (0.04) and DRESSP and FCR (0.11) in males but in females, negatively low DRESSP and FI (-0.09) and low DRESSP and FCR (0.1) were recorded.

Correlation between FI and FCR was high genetically and low phenotypically in both males and females (1.01 and 0.91, and 0.23 and 0.19 respectively).

Genetic correlation between HWT and ATFE, EGGWT and HATCH were high (2.43. 0.53 and 0.56 respectively) but genetic correlation between HWT and HDEP was negatively low (-0.18) and positively low between HWT and FERT (0.03). Phenotypic correlation on the other hand was positively moderate between HWT and ATFE (0.42), and HWT and EGGWT (0.35) but positively low between HWT and HDEP, FERT and HATCH (0.23. 0.25 and 0.25 respectively).

Two month weight (TMWT) was correlated positively high genetically with ATFE (0.69) and HATCH (0.57) but negatively moderate with EGGWT (-0.30), positively low with HDEP (0.02) and FERT (0.17) whereas TMWT was correlated positively low phenotypically with ATFE (0.24), HDEP (0.06), FERT (0.09) and HATCH (0.12) but negatively low with EGGWT (-0.07).

Genetic correlation existed between FMWT and ATFE, and FMWT and HATCH were negatively high (-3.7 and -1.4) correspondingly. However, moderate genetic correlation existed between FMWT and EGGWT (0.31), low genetic correlation existed between FMWT and FERT (0.01) and negatively low genetic correlation was recorded between FMWT and HDEP (-0.04). Phenotypic correlation between FMWT and these egg traits, on the other hand, were all negatively low (ATFE (-0.2), HDEP (-0.09), FERT 9-0.010 and HATCH (-0.2)) except FMWT and EGGWT which was positively moderate (0.36).

No genetic correlation existed between SMWT and ATFE but high negative genetic correlation (-0.53) and low negative genetic correlation (-0.02) were recorded between SMWT and EGGWT and between SMWT and FERT in that order. Again, genetic correlation existed between SMWT and HDEP was positively low (0.05) and positively high between SMWT and HATCH (0.77). Six month weight (SMWT) correlated phenotypically negatively low with ATFE (-0.23), EGGWT (-0.25) and FERT (-0.24) but positively low with HDEP (0.04) and Hatch (0.17).

Positively high genetic correlation was observed between EMWT and ATFE (1.15), EMWT and FERT (0.9) and EMWT and HATCH (1) but between EMWT and EGGWT was positively low (0.12) and negatively high genetic correlation existed between

EMWT and HDEP (-0.59). Low phenotypic correlation was observed between EMWT and ATFE (0.06) and between EMWT and HATCH (0.12) but phenotypic correlation between EMWT and EGGWT was zero (0), negatively low between EMWT and HDEP (-0.27) and positively moderate between EMWT and FERT (0.39).

There were no genetic correlation between TMWTG and ATFE, TMWTG and EGGWT, TMWTG and FERT but positively high genetic correlation existed between TMWTG and HDEP (1.30) and between TMWTG and HATCH (1.77). Phenotypic correlation was positively low between TMWTG and ATFE (0.16), TMWTG and hatch (0.04) but negatively low between TMWTG and EGGWT (-0.07) and positively moderate between TMWTG and HDEP (0.36) and between TMWTG and FERT (0.47).

Four month weight gain (FMWTG) showed no genetic correlation ATFE, EGGWT and FERT but negatively low genetic correlation were observed between FMWTG and HDEP (-0.14) and between FMWTG and HATCH (-0.08). Phenotypic correlation between FMWTG and ATFE, FMWTG and EGGWT, and FMWTG and HDEP were all positively low (0.11, 0.11and 0.1respectively) but negatively low with FERT and HATCH (-0.19).

Six month weight gain (SMWTG) correlated genetically negatively high with ATFE (-0.58) and positively high with HDEP (0.52) but no genetic correlation existed between SMWTG and EGGWT, SMWTG and FERT and SMWTG and HATCH. Negatively low phenotypic correlation was recorded between SMWTG and ATFE (-0.2) and SMWTG and HDEP (-0.17). However, phenotypic correlation between SMWTG and

EGGWT, SMWTG and FERT and SMWTG and HATCH were all positively low (0.19, 0.19 and 0.11respectively).

Positively moderate genetic correlation existed between EMWTG and ATFE (0.37) while negatively moderate genetic correlation existed between EMWTG and HDEP (-0.48) with no genetic correlation between EMWTG and EGGWT, EMWTG and FERT and EMWTG and HATCH. Eight month weight gain (EMWTG) lowly positively correlated phenotypically with ATFE (0.19) and HDEP (0.08) but lowly negatively correlated phenotypically with EGGWT (-0.19), FERT (-0.25) and HATCH (-0.13).

Survival (SVV) showed no genetic correlation with ATFE and EGGWT but there were positively moderate genetic correlation between SVV and HDEP (0.45), SVV and FERT (0.34) and positively high genetic correlation between SVV and HATCH (1.11). Phenotypically, correlation between SVV and ATFE was positively moderate (0.49) and positively low between SVV and EGGWT (0.16), SVV and HDEP (0.08), SVV and AFERT (0.09) and SVV and HATCH (0.21).

Genetically, DOC did not show correlation with ATFE and EGGWT but negatively moderate genetic correlation existed between DOC and HDEP (-0.49), positively low genetic correlation was observed between DOC and FERT (0.19) and negatively low genetic correlation was recorded between DOC and HATCH (-0.2). Docility (DOC) correlated phenotypically positively low with ATFE (0.14) and negatively low with EGGWT (-0.15), HDEP (-0.25), FERT (-0.12) and HATCH (-0.02).

Dressing percentage (DRESSP) did not show genetic correlation with any of the egg traits considered in this study. However, phenotypically, DRESSP correlated positively low with ATFE (0.07), EGGWT (0.12), HDEP (0.08) and HATCH (0.17) and negatively low with FERT (-0.04).

Genetic correlation was negatively moderate between ATFE and EGGWT (-0.32), and ATFE and HATCH (-0.48) but positively low between ATFE and HDEP (0.25) and negatively low between ATFE and FERT (-0.15). Age at first egg (ATFE) did not show genetic correlation with FI and FCR. Positively low phenotypic correlation existed between ATFE and EGGWT (0.07), ATFE and FERT (0.08), ATFE and FI (0.1), and ATFE and FCR (0.06). However, ATFE correlated negatively low phenotypically with HDEP (-0. 13) and HATCH (-0.2).

Genetic correlation between EGGWT and HDEP, and EGGWT and HACTH were positively moderate (0.42 and 0.48 correspondingly). Positively high genetic correlation between EGGWT and FERT (0.88) and EGGWT and FI (0.73) were observed but no genetic correlation was observed between EGGWT and FCR. Egg weight showed positively low phenotypic correlation with HDEP (0.15), FERT (0.19) and FCR (0.05) but negatively low phenotypic correlation with HATCH (-0.01) and positively moderate phenotypic correlation with FI (0.3).

Positively high genetic correlation existed between HDEP and FERT (0.73), HDEP and FI (0.56), and HDEP and FCR (0.73) but negatively high genetic correlation existed between HDEP and HATCH (-0.53). Penotypically, HDEP correlated positively low with FERT (0.2), HATCH (0.02), FI (0.27) and FCR (0.23).

Negatively high genetic correlation existed between FERT and HATCH (-0.57) but genetic correlation existed between FERT and FI, and FERT and FCR were positively low (0.05 and 0.01respectively). Phenotypic correlation however, was negatively low between FERT and HATCH (-0.02), positively moderate between FERT and FI (0.37) and), positively low between FERT and FCR (0.2).

Genetic correlation between HATCH and FI was negatively high (-1.2) and negatively moderate between HATCH and FCR (-0.43). However, phenotypic correlation between HATCH and FI was negatively moderate (-0.33) and negatively low between HATCH and FCR (-0.13)

4.4 Genetic Gain of the 3rd Generation

4.4.1 Selection differential, selection pressure and selection intensity

Summary of the selection differentials, phenotypic standard deviations, genetic response from G0 to G2 for the selection traits - HWT, TMWT, SMWT, SVV and DOC - are shown in Table-4.17. Table-4.17 also shows the advancement of selection from G0 to-G2 in the selected populace. The mean response for each trait improved in the positive direction over the three generations of selection. Average response/generation was positive in all traits considered.

Table 4.17: Selection Differential, Selection Intensity, Realized Response, and Estimated Response per Generation.

Trait	Gen	ΔS	σ_P	I	CΔS	ΔG_i	RR	CSR
HWT	G_O	2.11	4.90		2.11	3.77	3.14	3.14
	G_1	3.26	5.07		5.37	3.45	5.57	8.71
	G_2	3.97	5.26		9.34	3.73	8.48	17.19
	Mean	3.11	5.08	0.62				
TMWT	G_O	16.53	18.15		16.53	12.34	159.96	159.96
	G_1	17.19	18.14		33.72	9.53	221.54	381.50
	G_2	17.68	21.43		51.40	12.64	334.21	715.71
	Mean	17.13	19.24	0.89				
SMWT	G_O	30.32	34.53		30.32	14.85	518.90	518.90
	G_1	29.40	38.35		59.72	15.34	884.40	1403.30
	G_2	33.25	40.02		92.97	16.01	1088.64	2491.94
	Mean	30.99	37.63	0.82				
SVV	G_O	1.55	2.90		1.55	0.58	4.47	4.47
	G_1	0.93	2.97		2.48	0.50	6.00	10.47
	G_2	2.06	3.30		4.54	0.59	9.50	19.97
	Mean	1.51	3.06	0.49				
DOC	G_O	0.77	1.85		0.77	0.74	0.11	0.11
	G_1	0.56	1.81		1.33	0.62	2.55	2.66
	G_2	0.36	1.78		1.69	0.68	2.83	5.49
	Mean	0.56	1.81	0.31				

Gen. = Generation; ΔS = Selection Differential; σ_P = Phenotypic Standard Deviation; I = Selection intensity; CΔS = Cumulative Selection Differential; ΔGi = Expected Direct Genetic Gain; RR = Realized Response; CSR = Cumulative Selection Response;

CHAPTER FIVE

5.0 DISCUSSION

5.1 Productive Performance of the Local Guinea Fowls as Influenced by Genetic and non-Genetic Factors.

5.1.1 Effect of strains on production traits

5.1.1.1 Effect of strains on body weight

The mean day-old body weights of the four varieties of Guinea fowl keets in the present study was close to those reported by Kerketia (2012) -23.3-25.18g. Porwal *et al.* (2002) and Saina *et al*. (2005) reported similar body weights in day-old keets of Guinea fowl varieties (24.82-28.5g). Conversely, lower body weights (20.98–23.26 g) compared to the values of Guinea fowl varieties evaluated in this study were obtained from Lavender, Pearl, White and Black keets by Ayorinde *et al.* (1988).

The mean body weights of the four strains of local Guinea fowl obtained in this study, with respect to increase in body weight, is in agreement with the findings of Mabel (2018), Porwal *et al*. (2002) and Fajemilehin (2010) who reported that body weight of Guinea fowls increased with age. The consistent higher body weight showed by the Pearl variety as compared to the other three varieties in this experiment agrees with the results of Fajemilehin (2010) who observed similar trend in Guinea fowls in Nigeria though he studied three varieties. Again, the mean body weight of the strains realised in this study between 8- 32 weeks, though were higher than those obtained by Fajemilehin (2010), most experimenters including Bernachi *et al*. (2012), Kerketta (2012) and Ayorinde (1991) reported higher body weights (1208–1550 g) in 12-week-old Guinea fowl compared to the birds in this study. Higher body weights were recorded from French Guinea fowl that has been improved for meat (Baeza *et al.,* 2001b).

The lower body weight of the local strains of Guinea fowl observed in the present study might be due to genetically slower growth rate characteristic of these birds. It has been reported that Guinea fowls tend to be genetically slow in growth (Ayorinde and Ayeni, 1983). Folasade and Obinna (2009) also attributed differences in body weight of Guinea fowls varieties they studied to the significant effects of genetic groups. Houndonougbo *et al.* (2017) attributed the far lower growth performance of local Guinea fowls compared to the growth performance displayed by the improved birds in Europe to lack of genetic improvement in the local strains. With respect to low live weight of the local Guinea fowls, Centre for Agriculture and Bioscience (CAB) International (1987) remarked that it could be due to the fact that the lower body weight and body structure of Guinea fowl makes them suited for rapid flight and fast running, which are evolutionary adoptions for survival in the wild. On account of low body weight of these four different genotypes, it is concluded that the local Guinea fowls are the light strain types that are likely suitable for egg rather than for meat production (Kerketta and Mishra, 2016). However, the higher growth attributes of the Pearl Guinea fowl varieties in this study makes them the preferred varieties amongst the four when considering the genetic improvement of the varieties to broiler bird.

5.1.1.2 Effect of strains on body weight gain

The significant difference in body weight gain which occurred only on the 8th week (pre brooding daily weight gain) in this study is in agreement with the findings of Fajemilehin (2010) who reported significant ($P<0.05$) difference in body weight gain of keets at 8 weeks in variety differences experiment conducted. The non-significant differences in body weight gain of keets between 8 and 16 weeks in the present study

closely agrees with no significant differences observed by (Kerketta and Mishra, 2016) in the mean weight gain between Pearl and Lavender varieties at the end of their experimental trial. The significant differences in body weight gain may be attributed to the variation in genetic potentials of the keets. This is because feed intake is the major environmental factor that influences both the body weight gain and feed efficiency in meat-type poultry (Nahashon *et al.,* 2006; Nkafamiya *et al*., 2007) but feed intake in the present study was not significantly different, therefore the observed significant difference in daily weight gain might be as a results of genetic differences between the strains. This can be further explained by the assertion by Albert *et al*. (2005) that the phenotypic performance of organisms is determined by both genotype and environment. Contrary to Kerketta (2012), published results of weight gain at different weeks in Lavender Guinea fowl (treatment group) showing significant ($P<0.05$) difference between 1st week and all other weeks up to 14th week except 8th and 12th weeks. Non- significant differences in body weight gain at 16th, 24th and 32th weeks of age (post brooding daily weight gain) is an indication that the environmental condition of the study area was similar for all the Guinea fowls strains. This assertion is consistent with the report of Kerketta and Mishra (2016) who recorded non- significant differences in body weight gain at 14th weeks of age for both Pearl and Lavender varieties and attributed it to the favourable environmental condition for all the varieties.

5.1.1.3 Effect of strains on egg production

The significantly heavier mean egg weight produced by the Pearl strain compared to the Lavender, White and the Black disagrees with the results from Wilkanowska and Kokoszynski (2010) who reported significant higher egg weight in the White compared to Pearl grey Guinea fowl (46.5 vs. 39.2 g). Song *et al*. (2000) reported little higher egg

weight (46.7g) in grey Guinea fowl (Lavender). However, the egg weight of grey Guinea fowl (40.1 g) obtained by Kuzniacka *et al*. (2004) and 40.7g for white, and 40.8g for grey varieties reported by Bernacki *et al*. (2013) are similar to those obtained in this study. The significant egg weight difference of the strains found in this experiment is in line with Nowaczewski *et al*. (2008) who reported significant bigger egg weight in meat-type Guinea fowl originating from France (55.3 g) compared to those from Poland (40.7 g). Contrary to the present report, the previous findings by Obike *et al*. (2011) indicated no significant differences in egg weight between different Guinea fowl breeds (Pearl = 37.7 g, Black = 37.9 g). Differences in egg weight in the present study could be attributed to variation in body weight of the strains studied because according to Obike *et al*., 2011) egg size is usually positively related to the body size of the laying hens.

Reproductive period in Guinea fowl should be at least 22 weeks (Royter and Guseva, 1987). The number of eggs obtained in this study are more than averaged egg production of 54.2% during the reproductive period for white Guinea fowl and 55.8% for grey Guinea fowl (Bernacki *et al.,* 2012) but lower than that in an earlier report by Ayorinde *et al*. (1989) who obtained 80-90% of eggs in his assessment of 4 colour varieties of Guinea fowl. The comparatively low egg laying rate found in this study can be attributed to the differences in egg-production periods. Konlan *et al*. (2011) and Bernacki *et al.* (2013) had an egg-production period of about six to nine months, compared to five to seven month's egg collection in the present study.

The second factor that could have contributed to the low egg production is that the parent stock, were being selected for growth traits but not for egg production. This may

be supported by the assertion by Yamak *et al*. (2015) that total egg production is affected by breeding objective (traits selected to be improved in a breeding programme) and production system, with free range production reported to have relatively low production yields. Konlan *et al*. (2011) found a laying rate of 37% over a nine-month production period of free range production system. Houndonougbo *et al*. (2017) reported that egg production performances are strongly affected by the strain, the climate and the quality of feed. Extention of daylight can also lead to increase in egg production in Guinea fowls (Moreki and Seabo, 2012).

5.1.1.4 Effect of strains on feed intake and feed conversion ratio

Feed intake and FCR among the Guinea fowl varities studied were not different. This finding disagrees with that reported by Kerketta and Mishra (2016). In the experiment it was observed that total feed consumption was lower for the Lavender Guinea fowls compared to the Pearl Guinea fowls. However, the total FCR of the Lavender Guinea fowl was better than that of the Pearl Guinea fowls. Though there were no significant differences in the FCR values of 4.43, 4.26, 4.33 and 4.44 obtained respectively in this study for the four strains of Guinea fowls. These were better than 6.37 observed by Seabo *et al*. (2011) in Guinea fowls fed commercial grower diet from 6 to 12 weeks of age under intensive system. Difference in diets, age, management regime as well as environmental factors could be responsible for the difference in FCR values between the present and previous results. The wild behaviour, the characteristic timid but very active flighty and noisy temperament might also account for the lower feed conversion efficiency of the Guinea fowl (Nwagu and Alawa, 1995).

5.1.2 Effect of strains on reproductive traits

The significant differences in age at first lay observed in this study is in line with the findings of Oke *et al*. (2003) whose results showed significant differences in age at first lay and average age at sexual maturity in Guinea fowls fed diet containing different energy and protein levels. The age at first lay between 27 and 29 weeks confirms the report by Ikani and Dafwang (2004) that Guinea fowls start to lay at 6 to 7 months. The age at first lay of a Guinea fowl hen varies from 26 to 32 weeks (Belshaw, 1985 and Nwagu, 1997) was also in agreement with the present findings. Age at first lay was earlier in the current study compared to the previous one which occurred between 32, 36 and 37 weeks in traditional method of rearing in Nigeria (Ayorinde *et al*., 1988). The differences in age at first lay could be due to variation in the management practices in terms of diet fed to the birds. This is supported by the findings of Oke *et al*. (3003) that birds on the diet with 2750kcal/kg ME and 18% protain attained sexual maturity at significantly (p<0.05) earlier age than other energy and protein levels considered in the experiment. Another factor believed to have influenced age at first lay was the live weight of Guinea hens at point of lay (Ayorinde and Ayeni, 1983). The obvious implication of this is that there is a point-of-lay body composition that Guinea fowl pullets must attain before the onset of egg production. Soller *et al*. (1984) and Ayorinde and Oke (1995) had earlier indicated this.

The significant effect of the genetic groups on fertility for Pearl, Lavender, White and Black Guinea fowls respectively in the current investigation where the pearl strain was superior supports the findings of Konlan *et al.* (2011) in Ghana. They argued that the Pearls (common breed) are capable of laying fertile eggs throughout the year when given adequate supplementary feed and if supplied water *ad libitum*. The significant

influence of breed on fertility of eggs in the current study disagrees with those observed by Obike *et al*. (2014) who obtained non- significant effect on fertility between 49-67% in indigenous Nigerian Guinea fowl strains (Black and Pearl). Konlan *et al.* (2011) recorded fertility rate of 69%. Royter and Arutyunyan (1990) found an overall fertility rate of around 65% and Bernacki *et al*. (2013) reported fertility rate of different Guinea fowl varieties to range between 85.2%-91.7%. The lower fertility rate obtained in this present study compared to the previous findings could be attributed to factors such as weather conditions, sex ratio and egg storage. Agbolosu *et al*. (2012) found fertility to be affected by weather conditions and geographical position adding that improper storage of eggs prior to incubation could also contribute to low fertility rate in Guinea fowls. It is well documented that the Guinea fowls are monogamous in nature, and as a result egg fertility should usually be higher if birds are kept 1:1 male-female ratio compared to providing more number of females to a male (Khairunnesa *et al*., 2016)

Higher hatchability ranging between 45%-50% in naturally mated Guinea fowls was reported by Royter and Arutyunyan (1990). Moreki and Radikara (2013) evaluated hatchability of Guinea fowl eggs according to weight and found that medium-size eggs (39-42 g) had the highest hatchability rate (69%). Although the mean egg weight in the present study falls within this range 39-42g, the current hatchability rate falls far below the previous findings cited here. This may be due to the frequent electrical power fluctuations experienced during the incubation period. Low hatchability could also be due to the incubation of all eggs regardless of their age. Royter (1980) showed that best hatching results are obtained when Guinea fowl eggs weighing not less than 38 g and not more than 51 g are incubated. Fisinin and Zlochevskaya (2004) found hatchability values between 73-90 % (naturally mated) and 70-80 % (artificially inseminated) of

different Guinea fowl strains. Gueye (2007) also reported hatchability to be 72.9%. Avornyo *et al.* (2007) found hatchability rate of 70% and 88% hatchability was the results from Saina *et al*. (2005). Differences in hatchability in the current study and that of other authors could be attributed to the effect of feed, breed, temperature, testicle weight among others. Other factors that affect the rate of hatchability include male and female ratio, nutrition of parents and egg storage conditions (Yamak *et al*., 2015). The environmental changes associated with the hot dry season seem to be detrimental either to egg hatchability because of problems during brooding or male semen quality and sexual activity. Sperm quantity and quality depend on the weight of the testicles which are affected by environmental factors such as lighting, temperature and feeding (Le Coz-Douin, 1992).

5.1.3 Effect of strain on biochemical profile

The mean crude protein of Lavender, White and Black varieties in this study were significantly higher than that of the Pearl. Crude protein also differed ($p<0.05$) in Guinea fowl groups investigated under concrete and earth floors at weeks 16-18 (Mareko *et al*., 2008).The crude protein content in present investigation is in line with the findings of Saina (2005) in Guinea fowls managed under intensive (75.4%) and semi-extensive (72.7%) systems of management respectively in Zimbabwe. Fresh Ostrich meat crude protein content reported by Fisher and Wiebe (2006) was 17.48%. The overall recorded crude protein content in the meat of the four Guinea fowl varietiess in the present experiment was higher than that observed in lamb (17.9%), beef (18.9%) pork (16.6%), chicken (17.6%) as reported by Holland *et al*. (1997). Hoffman *et al*. (2000) also reported lower crude protein value in breast muscle of South African broiler chicken (20.52-21.35%) and in meat of white and coloured broiler lines.

The crude protein in the present experiment was lower than that reported by Viljoen *et al.* (2005) for freeze dried Ostrich meat (90.40%). The differences in protein value in present and previous findings may be attributed to differences in climate and rearing system. According to Carragher and Mathews (1996) varying nutritive valus obtained in different studies may include physiochemical properties of meat are affected by intrinsic factors and also by sample preparation and analytical methods (Holland *et al*., 1997).

The effect of the different varieties on percentage of ash in this investigation where the pearl strain was superior differed from the findings of Kerketta and Mishra (2016) who reported no differences in the percentage of ash in the varieties of Guinea fowls they studied. Maria *et al*. (1998) recorded similar results from Guinea fowls they investigated in high environmental temperature. However, the range of ash in the present study compares well with the range of 1.07-1.46% from four South African chicken strains (Hoffman *et al*., 2000). The findings in this study is far lower than that reported by Mareko *et al*. (2008) who reported 6.60+0.7% and 18.15+0.7% ash in Guinea fowls reared on concrete and earth floors at 16 weeks and 26 weeks of age respectively. The comparatively lower total ash content in meat of the Guinea fowl strains in this study might be ascribed to the fact that the birds were raised on slated floor and did not get the chance of pecking feed from the ground (Kerketta and Mishra, 2016).

The non-significant effect of variety on cholesterol of carcass in this study is consistent with the findings of Kerketta and Mishra (2016) who reported that Guinea fowl genotypes had non-significant influence on cholesterol composition.

The observed significant influence of the genetic groups on moisture content of Pearl, Lavender, White and Black which ranged between 74-75% in the current investigation was higher than the findings of Mareko *et al*. (2008) who observed lower moisture content (56.94%) for Guinea fowls raised on concrete floor. The average moisture level of 75% in the present study closely agrees with that reported by other experimenters on animal lean tissue composition. Gracey *et al*. (1999) also reported an average of 75% across meat sources FAO (1992) reported 74% and Mareko *et al*. (2008) also observed 70%. An analogous moisture range of 69.91-71.76% for breast muscle for four broiler strains used in the South African poultry industry was also reported by Hoffman *et al*. (2000). The higher percentage moisture values in the present study compared to the lower values obtained by Mareko (2008) may be due to the fact that fat and dry matter which form tissues in the meat were not matured because the percentage moisture level has been found to be inversely related to fat and dry matter content. As fat and dry matter increases, moisture levels in tissues declines (Warriss, 2000).

5.1.4 Effects of varieties on carcass characteristic, docility and survival

The significant effect Guinea fowl varieties on dressing percentage in the present study was lower than reported by Mareko *et al.* (2008) (92.96- 94.40%), Bernacki *et al*. (2012) (75%) and Adeyemo and Oyejola (2004) (87.4 %). It was however similar to the findings of Ayorinde (1991) who reported dressing percentage rrange between 65-71% for Guinea fowl and Nobo *et al*. (2012) who also reported 75.82±2.99 in female and 74.10±2.99% in male birds. Comparing dressing percentage of broiler chicken and Guinea fowl, Agwunobi and Ekpenyong (1990) reported dressing percentage of 76 and 74% for Guinea fowl and broilers respectively. Studing the effect of management

system on fattening of Guinea fowl, Ayorinde and Ayeni (1986) reported a higher dressing percentage of 81.5% for birds kept in deep litter system compared to 79.4% for those kept in battery cages at 20 weeks of age. Kerketta and Mishra (2016) associated the variation in dressing percentages observed in different studies with the birds strain, diets, management system and carcass dressing methods. The significant differences observed among the varieties in this experiment indicate that there was effect of variety on the dressing percentages. It has been further stated that carcass yield may be affected by animals' stage of maturity, breed and the intestinal content (Warriss, 2000).

Docility is one of the most important traits which determine whether the bird is aggressive or easy to work with. Unlike the heterophil/lymphocyte ratio method, the cage score method of docility measurement showed significant differences among the Guinea fowl strains in this present study. The average docility score of 3.03, obtained in this study is above the average score of 2.6 on a scale of 1 to 4 in genetics of grasscutter (Annor *et al.,* 2011). The birds in this study were within the range score 3 and 4 i.e. moderately aggressive and very aggressive. This scoring system is similar to the one used in scoring cattle which describes 3.5 cage score as intermediate and acceptable for animals which exhibit moderate behaviour (Neindre *et al*., 1995). The outstanding performance of the Lavender over the scores of the Pearl, White and the Black strains with respect to docility disagrees with the findings of Amberg (2009) for Pearl and White, that the white and the Pearl strains of Guinea fowls are quite docile than the Lavender Guinea fowls. He added that the Black Guinea fowl is more aggressive than all the other strains of Guinea fowls which is contrary to that reported in this study. The significant differences in docility amongst the Guinea fowl varieties

in this study could be attributed to variations in body weight of the birds. This is in line with the report that cattle with higher body weights are more docile than those with lower body weights. Additionally they tend to grow faster during fattening than the aggressive animals (Burrow and Dillon, 1997).

Among the essential things needed for successful Guinea fowl production is their ability to survive. The mean percent of 70.8% for pre- brooding survival in the present investigation is lower than 90% recorded by Khairunnesa *et al*. (2016). Premavalli *et al.* (2012) also reported 89% pre- brooding survival in Guinea fowl keets. The lower pre- brooding survival in the present investigation might be due to the susceptibility of keets in the juvenile stage. Guinea fowl keets are more susceptible to most parasites and diseases which affect production of other poultry species such as chickens and other species (Moreki, 2009). The 94.6% post brooding survival reported in the present study is higher than 85% recorded during 0-16 weeks from Premavalli *et al.* (2012). These higher survival values may be due to the fact that Guinea fowls have high resistance to common poultry diseases, especially after brooding and in most cases disease is largely due to poor management Okaeme (1986).

5.1.5 Effect of sex on Guinea fowl production traits

The non-significant differences between males and the females on body weights of the birds at 8th and 16th weeks in this study agrees with Singh and Hussain (1998) who reported non-significant effect of sex on body weight at 8th and 16th weeks in Guinea fowl. Correspondingly, non-significant sex difference was also observed by Nahashon *et al*. (2006b). On the contrary, most experimenters have reported significant differences between sexes in Guinea fowls in most of the parameters they measured.

Kokosynski *et al*. (2011) observed higher body weight in females compared to their males. Male Guinea fowls were observed to have faster growth and bigger body sizes than females (Nahashon *et al*., 2006 and Nobo *et al*., 2012). Non-significant differences of body weight gain between males and the females in this study disagrees with Kokosynski *et al*. (2011) who reported that sex had significant influence on the body weight, weight gain and feed conversion ratio among indigenous Guinea fowls. Kokosynski *et al*. (2011) also reported that sex had significant influence on the body weight, growth rate and feed cconversion ratio among indigenous Guinea fowls. Del Castilho *et al*. (2013) also found similar results in their studies in broilers with higher average body weight recorded for males of broiler strains than females. Ashok and Prabakaran (2012) reported significant effect of sex on body weight in Japanese quail at various ages except hatch weight

The similar feed intake and FCR recorded in male and female birds in the current study contradicts the finding of Devi *et al*. (2012) in Japanese quail, where female birds had significantly higher feed intake than the male birds.

5.1.6.1 Effects of sex on biochemical profile and carcass characteristics, docility and survival traits.

Unlike Okoro *et al*. (2011) who found no significant sex effect (P>0.05) on protein in a study conducted to establish the blood characteristics of helmeted Guinea fowl as well as to evaluate the sex and system of management effect on haematology and serum biochemistry, the present study recorded significant sex effect on protein of Guinea fowl males and females. The significantly higher crude protein of the males in this study disagrees with the findings of Obese *et al*. (2018) who evaluated the effect of age, breed

and sex on haematological and blood biochemical parameters in helmeted Guinea fowl and reported that protein and sodium levels were higher in females than those in males. The results demonstrated that age, sex and breed are factors that influence the productivity and health of the helmeted Guinea fowl. Ash and moisture content observed in this study contradicts the findings of Abdullah and Matarneh (2010) who indicated that there was no significant difference in the ash and moisture between male and female Guinea fowls.

5.1.6.2 Effects of sex on carcass characteristics

The non- significant difference between male and female birds in terms of dressing percentage in the present study agrees with the observations of Premavalli *et al*. (2012) who noticed no significant difference between male and female Guinea fowls. Similar observations were also made by Singh *et al*. (1999) and Premavalli *et al*. (2012). On the contrary, Kokoszynski *et al*. (2011) reported that the female Guinea fowls had better carcass characteristics which may be due to use of different selection criteria for growth and different nutritional and managemental strategies adopted for raising the birds. Nobo *et al*. (2012) and Baeza *et al*. (2001) have reported that male Guinea fowl had better carcass characteristics than females. This observation my be accounted for by the dissertation reported by Premavalli *et al.* (2012) that carcass dressing percentage is influenced by the stage of maturity, degree, breed and the amount of offals.

In this experiment, both male and female Guinea fowls did not differ in docility using both temperament tests. This agrees with the observation of Pajor *et al*. (2008) and Pajor (2011) whose reports indicated no significant difference between temperament scores for the two sexes in sheep but detected differences between temperament scores

of different litter sizes. The current results contradict the findings of Hoppe *et al*. (2010) who used similar method to assess the temperament in cattle and reported that male cattle have a more favorable temperament and are easier to handle than their female counterparts in a study to examine temperament traits of beef cattle using two different test procedures (the crush test and the flight-speed test). This conforms to the findings of Gauly *et al*. (2001) who observed higher behavioral agitation in female cattle during human handling. The docility scores in this experiment 3.0 and 3.06 for females and males respectively are above the mean score 2.5 obtained for grasscutters (Annor *et al*., 2011). The scores of the Guinea fowls in this study fall between 3 and 4 on the scale of docility measurements used (Moderately Aggressive - runs along boundaries, look for exits and will run eagerly if humans move closer). This confirms to the assertion by (Teklewold *et al*. (2006) that indigenous Guinea fowls by nature are aggressive, short-term flexibility and in the longer term it has high resistance to common poultry disease and can survive under harsh environmental conditions. Listing number of factors that militate against Guinea fowl production, Teye and Adam (2000) mentioned loss of birds and eggs through picking by predators, worm infestation and inability to produce docile Guinea fowls. It is in line with this that Mensah and Okeyo (2006) recommended the inclusion of docility in the breeding objectives of animal improvement programmes.

Pre-brooding survival was not significantly influenced by the effects of sex in the present experiment. Literature provides little information on pre- brooding survival rates of sexes. This could be attributed to the difficulty in sexing keets at the pre-brooding stage. Guinea fowls are difficult to sex – it's hard to tell keets apart until they are at least 8-10 weeks of age when they start to call (Daniels, 2009). Correspondingly, Fisher and Wiebe (2006) reported no significant difference in survival between the

sexes in studying wild birds. The outstanding post brooding survival is in agreement with the findings of Nsoso *et al*. (2003) who reported that Guinea fowls adapt well to unfavorable weather conditions and survive with limited feed resources. Guinea fowls also have better resistance to common diseases and parasites, short reproduction cycles and limited cultural barriers on consumption (Saina *et al*., 2005 and Nahashon *et al*., 2006)

5.1.7.1 Effect of season on body weight and weight gain

The significant influence of seasonal effects on body weight and daily weight gain in this study is in accordance with the assertion of Ashok and Prabakaran (2012) who reported significant ($P<0.05$) effect of season of hatch on body weight and growth rate. This corresponds with the results reported by Agbolosu *et al*. (2012) but disagrees with that of Ali (2006) who reported that body weight of broiler chicks hatched in different seasons were not significantly different. The statistical differences ($P<0.05$) in body weight and daily weight gain at various stages of growth (8^{th}, 16^{th}, 24^{th} and 32^{nd} weeks) observed among the seasons in the present study is similar to the findings of Ashok and Prabakaran (2012) whose systematic study on chicks hatched at different seasons (Autum, Spring and Summer), showed a significant effect of season of hatch on body weight of the birds at various ages of growth.

The outstanding body weight and daily weight gain of the birds in the major rainy season compared to the other seasons in the present study is in line with the conclusion made from a study on commercial Arbor Acres broilers which were reared to sexual maturity in spring and summer, that body weight of chicks was significantly higher in spring than in summer (Settar *et al*. 1999).This significant performance of the birds in

the major rainy season may be attributed to the relatively low temperature which is normally experienced in the rainy season. Ashok and Prabakaran (2012) concluded that seasonal effects may be due to climatic effects, heat stress, as well as the health and feed consumption of chicks. According to Plavnik and Yahav (1998) there is a negative correlation between body weight of chickens and an increase in temperature.

It is in line with this that Eberhart and Washburn (1993) reported that natural heat stress reduces growth rate and that the effect of heat-stress was more prominent in fast-growing commercial broiler stocks than in non selected broiler lines. Under warm conditions, birds do not reach their full genetic potentials for growth, body weight and egg production because dissipation of their excessively produced internal heat is hindered by the feathers (Cahaner *et al*., 2008). Balnave (1996) reported that high environmental temperatures are the most important inhibiting factors to poultry production in hot regions.

5.1.7.2 Effect of season on egg production

In the present study the mean age at first lay, egg weight and percentage hen day egg production in the dry, major and minor seasons did not differ. However, Kumari *et al*. (2008), reported that season of hatch had significant influence on the egg qualities of Japanese quail in a study where hens of hatch 7 produced significantly heavier eggs and consequently recorded higher means for egg weight compared to that of the birds of hatch 8. *Guobadia* (1997) reported a significant difference obtained in the percentage hen day egg production with a better mean % of hen day egg production in the wet season compared to the dry season

5.1.7.3 Effect of season on feed intake and FCR

There was no significant difference in feed intake among Guinea fowls hatched in the major and minor seasons but there was significant seasonal effect on FCR of the birds. The non-significant effect of season on feed intake in the present study is contrary to the report that high temperatures during dry season decrease feed intake (Plavnik and Yahav, 1998). However, the significant reduction in FCR is in accordance with the observation of Plavnik and Yahav (1998) that dry season couple with abnormal temperatures decrease feed efficiency of broiler chickens. The reduction in FCR in the dry season could be attributed to heat stress which forces the birds to use a proportion of the energy they obtained from their feed for heat dissipation instead of using it for production (Gowe and Fairfull, 1995). In another rescent study when Veldkamp *et al.* (2000) compared feed conversion ratio (FCR) of turkey subjected to different seasons, the was observed that conversion ratio was better in turkeys that were under high temperature treatment as compared to the ones on low temperature.

5.1.8 Effect of season on reproductive traits

This results, on the part of fertility, agrees with Babiker and Musharaf (2008) but on hatchability, it disagrees with their statement that seasonal changes is well-noted for its influences on the reproductive performances of poultry birds mainly fertility and hatchability values of eggs. Correspondingly, Jesuyon and Salako (2013) also found a significant seasonal effect on fertility and hatchability of eggs in Bovan Nera and Isa Brown Nigerian local chickens. The highest fertility occurring in the dry season in this study conforms to the findings of Jagarajan (1992) who reported a significant seasonal effect on fertility of eggs; where he observed that the highest egg fertility was found in Rhode Island Red during the summer. Contrary, Ozcelik *et al.* (2006) reported

significantly higher percentages of hatchability and fertility of eggs were observed from chickens that were raised in winter than those raised in summer. The differences in performance among the seasons may be attributed to variation in temperature. Bordas and Merat (1990) and Younis and Cahaner (1999) reported that at high ambient temperature, hens under heat stress had a deterioration in egg productivity. This may be due to the full plumage cover of the birds as well as internally generated heat which might have warmed birds because the birds have poor dissipation of heat (Cahaner *et al*., 2008).

5.1.9 Effect of season on chemical composition

Contrary to the results of the studies of Bianchi *et al.*(2007) who, with the exception of crude fat content, stated non-significant effects of season on chemical composition of the chicken carcass, season showed significant difference in all the chemical composition of the Guinea fowl carcass (protein, ash, energy and moisture) analysed in the present experiment. The significant seasonal effect on chemical composition of the carcass in this study agrees with the findings of Charati and Esmailizadeh (2013) that seasonal changes significantly affect the carcass parameters in poultry birds. Season and its associated weather variations may be responsible for the significant difference in all the chemical composition of the Guinea fowl carcass analysed in the present experiment. According to Song and King (2015) heat stress, is one of the most important environmental stressors challenging meat production world-wide and its detrimental effects on production range from reduced growth to decreased quality of meat.

The seasonal effects significantly manifested in the dressing percentage of the current study, confirming the observations of Charati and Esmailizadeh (2013) that season significantly influenced the dressing percentage in birds. Geldenhuys *et al.* (2013) reported that live and dressed carcass weight, as well as the dressing percentage of Egyptian geese, a southern African gamebird species, were not affected ($P > 0.05$) by season.

The significantly higher dressing percentage observed in the major rainy season in this study is in line with the findings of Alberta.ca (2000) who reported that dressing percentages increase in major rainy season as animals shed their winter coat but disagrees with the statement from Demircan *et al*. (2007) that carcass weight and dressing percentage of cattle fed during warm season was higher than those fed during hot and cold seasons. The variations in performance among the seasons may be ascribed to effect of weather conditions on feather or hair coat. Any weather condition that affects the feather or hair coat of an animal can have an impact on that animal's dressing percentage (Alberta.ca, 2000).

5.2 Determination of Disease Resistance in Local Guinea Fowls Using Sheep Red Blood Cell (SRBC) as an Indicator Trait.

5.2.1 *Strain and sex effects on antibody titers*

The significant influence of variety on antibody titres in the present study compares well with the findings of Boa-Amponsem *et al*. (2000) who reported significant differences in White Leghorn males from lines selected 24 generations for high antibody titers to an intraveinous inoculation with 0.1 mL of a 0.25% suspension of SRBC. Similar results were reported by Martin *et al*. (1990) and Baclmans *et al*. (2005).

Li *et al*. (2000) also observed similar findings in Turkeys from a random bred control line (RBC2) and its subline (F) selected for increased 16-wk body weight which were tested for primary and secondary antibody responses to SRBC antigen and Brucella abortus antigen (BA).The relatively higher antibody titres of 8.16, 5.93, 6.31 and 5.96 for Pearl, Lavender, White and Black respectively observed in this study than the values of the previous reports 3.79, 2.17 and 1.17 for normally feathered, naked neck and frizzle birds respectively reported by Baclmans *et al*. (2005) and 6.8, 5.3 and 2.8 in White leghorn lines reported by Boa-Amponsem *et al*. (2001) may explain the findings of Houndonougbo *et al*. (2017) and Kusina *et al*. (2012) who stated that Guinea fowl species are resistant to most poultry diseases.

Evaluation of T lymphocytes subpopulations may provide some clues in understanding the variation of the antibody responses between the strains. This is because the SRBC antigen is classified as a thymus-dependent (TD) antigen that obviously needs the help of T lymphocytes to produce antibodies. It seems that growth selection might have resulted in correlated changes of T cell subpopulations, therefore affecting antibody production (Li *et al*., 2000). The better response to antibody titers of the Pearl strain than other strains in the present study could be attributed to the stronger genetic disease resistant potentials (higher levels of T lymphocytes subpopulations) the birds in this variety possessed which explains the reason why they are common (Konlan *et al*., 2011) in all the areas Guinea fowls are reared in the country.

Significant sex effect observed on antibody response to SRBC antigen in this study compares well with the result of Li *et al*. (2000) who reported that there were significant sex differences in total titers at 4, 7, and 14 days in Turkey lines they studied. Correspondingly, this result is in agreement with previous results in chickens (Sarker

et al., 1999; Leitner *et al*., 1992). The outstanding female response to SRBC antigen in antibody production in the present experiment conforms to the report by Paavonen *et al.* (1981) that females usually exhibit a higher capacity for antibody formation after immunization. The differences in antibody response between the sexes may be ascribed to influence of sex hormones. According to the report of Krzych *et al*. (1981) and Eiginger and Garrett (1972), estrogen and androgen have distinct influence on the immune system in mammalian species.

5.2.2 *Effect of days and concentration on antibody titres*

Non- significant ($p>0.05$) differences in antibody titres in post injection days (5, 7 and 9) in the current experiment is consistent with the findings of Lepage *et al*. (1996) who reported Non- significant ($p>0.05$) differences in antibody titres from 5 to 8 days post injection. Several researches established the statistical ($p<0.05$) dosage effect on antibody titres to SRBC antigen in chickens (Boa-Amponsem *et al*., 2000 and Kreukniet *et al.,* 1992) but in terms of influence of different concentrations of SRBC suspension on antibody response, little work has been done on it.

5.2.3 *Effect of route of SRBC antigen administration on antibody titers in local Guinea fowls*

The significant effects of route of SRBC inoculation on primary antibody response of local Guinea fowls in the current investigation is in agreement with the findings of Boa Amponsem *et al.* (2001) who reported that within the HA line antibody titers were consistently higher for intravenous than intramuscular injected chickens. In this study, primary antibody response to intravenous injection was higher than the response to intramuscular injection of SRBC as it was also reported by Kreukniet *et al*. (1992).

Better effect of intravenous injection on antibody response to SRBC compared to intramuscular injection reported in other studies and that in the current study may be due to differences in the functions of the ellipsoid-associated cells and peritoneal cavity cells. Van der Zijpp and Nicuwland (1986) postulated that the ellipsoid-associated cells were more effective in presenting SRBC antigen to immunocompetent cells than the antigen-presenting cells of the tissue or the peritoneal cavity.

5.3 Estimation of Phenotypic and Genetic Parameters

5.3.1 Variance and coefficient of variation components estimates of traits

Estimates of phenotypic and genetic variances of traits in the indigenous Guinea fowls are very little in the literature. The current results obtained in this work are comparable to what generally pertains to other livestock species. The highest degree of additive genetic variation shown by body weight followed by feed intake in the present study has been reported (Søndergaard *et al.*, 2002). Reproduction and survival traits have low genetic variation whereas body weight and growth traits have medium to high genetic variation (Yu-shi *et al*., 2017; Annor *et al*., 2012). However, genetic variation in growth rate in this study is lower than reported by other scientists who studied other species of faem animals (Annor *et al*., 2012). Significant genetic variation has been reported for feed intake and feed efficiency for beef cattle (Archer *et al*., 2002).

Genetic variation in feed intake in this study is lower than reported in other species. The low additive genetic co-efficient of variation obtained for traits in this study is probably due to the low genetic standard deviation, relative to the mean values of the traits. Genetic diversity, that is, the heritable variation within populations is usually acted upon by selection, be it natural or artificial. Differential survival of individuals in

a particular population in each generation due to selection ultimately results in changes in gene frequencies, hence evolution of such populations. Genetic diversity therefore allows for evolution as well as artificial selective breeding to occur (Mensah and Okeyo, 2006). Additive genetic variance is variance of breeding values. Therefore, medium to high genetic diversity in body weight will contribute to high response to artificial selection in these traits (Annor *et al*., 2012).

5.3.2 Heritability estimates of traits

The results of heritability obtained in this study for body weight showed a declining trend in both males and females as birds grew older. The decreased in heritability estimate with age as observed in this study had been reported earlier by Saatci *et al*. (2002) and Daikwo (2011) for Japanese quails and Prado-Gonzalez *et al*. (2003) who worked on broiler breeders and reported similar decreasing heritability values (0.21, 0.20, 0.13 and 0.07) with increasing age of birds (4, 8, 12 and 16 weeks). The results however, disagree with the findings of Chambers (1990) who reported that heritability for body weight of broilers tends to increase with age. The results also disagrees with the report by Resende *et al*. (2005) who also reported that heritability estimates increase with age in Japanese quail and broiler chicken. Momoh *et al*. (2014) reported increasing heritability estimate with age in domestic pigeon. Oni *et al*. (1991) reported heritability estimates of 0.413 and 0.044, 0.387 and 0.279 for body weight at 16 and 20 weeks respectively in two strains of Rhode Island chickens. Osei-Amponsah *et al*. (2013) reported an average h^2 estimate of 0.54 for bodyweight of Ghanaian local chicken from 0 to 40 weeks which falls within the range reported in this study. The heritability of body weight at day 1and 2, 4, 6, 8 months ranged between 0.32 and 0.72 in males and 0.32 and 0.82 in females which is medium to high. This confirms the finding by

Ayorinde *et al.* (1988) and Sanjeev *et al.* (1997) that the heritability estimates for body weight of the indigenous Guinea fowl ranges from 35% at day old to 40% at 16 weeks of age and heritability estimates of 49% for body weight at 16 weeks of age. Udeh (2017) and Hernandez and Segura (1994) reported 0.80 and 0.87 respectively for body weight. Higher heritability estimates between 0.72–0.82 for hatch weight observed in the present study could be due to the intensive selection the birds had undergone for growth traits (Aggrey *et al.,* 2010).

The moderate to high h^2 estimates for body weight implies that additive genetic variance made a greater contribution to the total phenotypic variance compared to environmental and gene combination variance. This implies that mass selection for any of the aforementioned trait could result in rapid improvement. The moderate to high heritability estimates obtained for body weight at ages 1 day, 2, 4, 6 and 8 months indicates that response to selection for body weight at these ages could be rapid.

The heritability estimates of body weight gain on the other hand did not follow a particular trend with respect to age in males whereas in females weight gain declined with increased in age. Estimates generally ranged from low (0.24) to medium (0.42) for males and low (0.18) to medium (0.34) in females. Heritability values for body weight gain obtained in this study are similar to those reported by Momoh *et al.* (2014) who obtained low to medium heritability estimates 0.19-0.42 in the Japanese quails. The low heritability estimates of body weight gain at months 4, 6 and 8 in males imply that response to selection for body weight at these months could be slow.

The low heritability estimates for fertility, hatchability and survival respectively is in line with the assertion by Annor *et al*. (2012); Nicholas, (1987); Blair, (1989) and Ude

et al. (2017) that reproductive and survival traits in livestock tend to have low heritability. Natural selection of fitness traits (reproduction and survival) leads to loss of genetic variation, which results in low heritability (Annor *et al*., 2012; Nicholas, 1987; Van Vleck *et al*., 1987). Low heritability also suggests that factors other than additive genetic effects, which may or may not be subject to control by producers, accounted for substantial variation in these traits.

The medium heritability values for docility in both males and females in this study suggest that docility is affected by additive genetic effects. These heritability results confirm the results of Komai *et al.* (1959) who investigated the genetic basis of social aggressiveness in birds and documented heritability estimates of 0.34 in Leghorn birds and 0.39 in birds from other strains, while overall heritability was 0.30. These findings indicate that selection to change the aggressiveness will be effective in birds, both between and within varietiess.

The low heritability estimates for dressing percentage in Egyptian local chicks (Abdellatif *et al*., 1989) is in conformity with the results in this study.

Several studies have shown that the heritabilities for FCR and FI are moderate to high in chickens (Aggrey *et al*., 2010; Varkoohi *et al*., 2010). In Arkansas broilers, Aggrey *et al.* (2010) reported that the heritability estimates of FCR and FI were medium which are similar to 0.44 and 0.36, respectively obtained in the females in this study. The value of FCR 0.40 of the males in the present study also agrees with these findings but the FI value obtained for the males 0.28 is close to the findings of Yuan *et al*. (2015) who reported that the estimates of heritability for FCR and FI were 0.19 and 0.21 at 37 to 40 weeks of age respectively, and 0.13 and 0.29 at 57 to 60 weeks of age respectively.

Both FCR and FI had moderate heritability in females and FCR in males; consequently, genetic selection for FCR and FI can improve feed efficiency in female local Guinea fowls and FCR for the male counterpart.

The moderate heritability estimate obtained for age at first egg (0.34 ± 0.16) in this study is close to 0.48 reported by Momoh (2014) but higher than 0.18, 0.27 and 0.31±0.18 documented by Daikwo (2011) in Japanese quail. The heritability value of 0.58 obtained for egg weight is higher than 0.37 reported by Daikwo (2011). The h^2 estimate obtained for egg number (hen-day egg production), 0.78, was above the range of 0.30- 0.41 reported by Tawefeuk (2001) during a 70 days egg production period in Japanese quails but falls within the heritability estimates of egg number that ranged from 0.40-0.88 for 12-15 weeks period of egg production in Quail (Helal, 1995). High heritability estimates recorded for egg weight and number and moderate estimate for age at first egg in the current study indicate that improvement in these traits would be possible using individual selection method. Differences in heritability estimates for different populations can be expected since heritability is a property of the population and the size or magnitude of the estimate is highly affected by such factors as selection, environmental deviations, method of estimation and sampling error due to small data or sample size (Prado-Gonzalez *et al*., 2003). Environmental factors such as high temperature, humidity and poor management conditions are known to increase the residual variance and decrease the heritability estimate.

5.3.3 Genetic and phenotypic correlations

The higher genetic correlations between body weights at different ages than their respective phenotypic correlations have been reported by several others (Farahat, 1998

and Daikwo, 2011).The moderate to high positive genetic correlations obtained between (HWT) and TMWT, TMWT and SMWT, TMWT and FMWT, TMWT and EMWT, FMWT and SMWT, FMWT and EMWT, SMWT and EMWT, HWT and TMWTG, HWT and FMWTG, HWT and EMWTG, TMWT and TMWTG, TMWT and FMWTG, FMWT and FMWTG, FMWT and EMWTG, SMWT and TMWTG, SMWT and FMWTG, SMWT and SMWTG, SMWT and EMWTG (0.92), EMWT and TMWTG, EMWT and FMWTG, EMWT and EMWTG, TMWTG and SMWTG, TMWTG and SMWTG, TMWTG and EMWTG, HWT and FCR, TMWT and SVV, FMWT and SVV, FMWT and DRESSP, FMWT and FI, FMWT and FCR, SMWT and SVV, SMWT and FI, SMWT and FCR, SMWT and DRESSP, EMWT and SVV, EMWT and FI, EMWT and FCR, TMWTG and SVV, TMWTG and FI, TMWTG and FCR, TMWTG and DOC, FMWTG and SVV, FMWTG and FI, SMWTG and SVV, EMWTG and SVV, EMWTG and FI EMWTG and FCR, EMWTG and DOC, SVV and DOC, SVV and FI, SVV and FCR, DOC and DRESSP, DOC and FI, DOC and FCR, DRESSP and FI, DRESSP and FCR, FI and FCR, HWT and ATFE, HWT and EGGWT HWT and HATCH, TMWT and ATFE, TMWT and HATCH, FMWT and EGGWT, SMWT and HATCH, EMWT and ATFE, EMWT and FERT, EMWT and HATCH, TMWTG and HDEP, TMWTG and HATCH, SMWTG and HDEP, EMWTG and ATFE, SVV and HDEP, SVV and FERT, SVV and HATCH, EGGWT and HDEP, EGGWT and HACTH, EGGWT and FERT, EGGWT and FI, HDEP and FERT, HDEP and FI and between HDEP and FCR indicates that genetic improvement in anyone of them can improve the other (Hansen *et al.,* 2010). The high genetic association between body weights at early ages with body weights at later ages could indicate that selection for body weight at early ages would improve body weight at later (maturity) ages (Momoh *et al.,* 2014).The observation also means that selection for SVV can improve

higher HDEP and earlier ATFE and selection for higher FERT could also improve hatchability (Hansen *et al.,* 2010) The association between body weight and egg weight was similar to the findings of Ayorinde *et al*. (1988) who observed a fairly high association between egg production and weight gain in the Black and Pearl Guinea fowl. This means that point of lay does not terminate live weight increases in the Guinea fowl (Ayorinde *et al*., 1988)

Similar results to this work on genetic correlations have been reported in other livestock species. Daikwo (2011) and Momoh *et al.* (2014) reported high genetic correlations between body weights at different ages in Japanese quails. Yewadan (2000) reported high positive genetic correlations between 4-month weight and 8-month weight in the grasscutter. Koots *et al*. (1994) also reported medium to high positive genetic correlations among body weight and growth traits in beef cattle. The realization of these results could be attributed to the fact that many of the body weights and gains were measured at different ages (Koots *et al.,* 1994). On the other hand, genetic correlation higher than 1 as obtained among some of the traits (e.g. between FMWT and EMWT) is exceeding parametric range. El-Full (2001) and Miyumo *et al*. (2018) also recorded values greater than 1 for genetic correlation between body weights in Japanese quails and in feed efficiency in indigenous chicken in Kenya respectively. This may be due to problems associated with small data size, sampling error and data imbalance (unequal group sizes) which could indicate very high genetic correlations between traits involved, which sometime could be outside parametric range (Momoh *et al.,* 2014)..

The moderate to high negative genetic correlations observed between HWT and SMWT, HWT and SMWTG, TMWT and EMWTG, FMWT and TMWTG, FMWT and SMWTG, SMWT and EMWTG, TMWTG and FMWTG, FMWTG and EMWTG,

HWT and SVV, HWT and DOC, HWT and DRESSP, TMWT and DRESSP, TMWT and FI TMWT and FCR, TMWT and DOC, FMWT and DOC, SMWT and DOC, SMWT and DRESSP, EMWT and DOC, EMWT and DRESSP, TMWTG and DOC, TMWTG and FCR, SMWTG and DRESSP, SMWTG and FCR, SMWTG and FI, EMWTG and DOC, EMWTG and DRESSP, SVV and DRESSP, TMWT and EGGWT, FMWT and ATFE, FMWT and HATCH, SMWT and EGGWT, EMWT and HDEP, SMWTG and ATFE, EMWTG and HDEP, DOC and HDEP, ATFE and EGGWT, ATFE and HATCH, HDEP and HATCH, FERT and HATCH, HATCH and FI, and between HATCH and FCR indicates that genetic improvement in any of them will decrease the development of the other. Specifically, the high negative genetic correlation between HWT and SMWT means that heavy mothers lay small eggs. This may be the reason why poultry layers are usually light weight. Nayak *et al*. (2015) also reported high negative (-1.726) genetic correlation between 5th and 20th week body weight in female colored synthetic broiler breeder chicken of Odisha, India.

The moderate to high positive phenotypic correlations between HWT and TMWT, TMWT and SMWT, FMWT and SMWT, FMWT and EMWT, SMWT and EMWT, HWT and SMWTG, TMWT and FMWTG, FMWT and FMWTG, FMWT and EMWTG, SMWT and FMWTG, SMWT and FMWTG, EMWT and FMWTG, EMWT and EMWTG, TMWTG and FMWTG, HWT and DRESSP, TMWT and TMWT, FMWT and FI, FMWT and FCR, EMWT and FI, EMWT and FCR, TMWTG and SVV, FMWTG and DRESSP, FMWTG and SVV, HWT and ATFE, HWT and EGGWT, FMWT and EGGWT, EMWT and FERT, TMWTG and HDEP, TMWTG and FERT, SVV and ATFE, EGGWT and FI, and between FERT and FI, means that any of these traits can be used to measure the other in a selection programme (Annor *et al*., 2012).

The moderate negative phenotypic correlations between FMWT and TMWTG, TMWTG and EMWTG, HWT and DRESSP, TMWT and FI, TMWT and DOC, TMWT and DOC, SMWT and DOC, EMWT and DOC, TMWTG and FI, TMWTG and DOC, FMWTG and DOC, and between HATCH and FI could mean that the traits involved cannot be used as measures for each other and selection cannot bring about correlated response in them (Annor *et al*., 2012)

5.3 Genetic Gain of 3rd Generation Offspring.

The increased of HWT, TMWT, SMWT, RSRBC AND DOC with each succeeding generation is in line with the findings of Vivian (2011) who reported that selection for high productivity increased with each succeeding generation in a genetic evaluation. Selection of a Nigerian local chicken ecotype carried out over three generations also showed similar trend. This is in affirmation with the work of Ayyagari *et al.* (1985) who reported that selection for production in white leghorn population was effective in increasing the performance of selected strains.

Sharma *et al*. (1983) showed that selections on the basis of an index (using data on body weight at 8 weeks, egg production to 300 days, and percent hatchability) was relatively more proficient than tandem selection or independent culling levels selection for all traits except hatchability. Verma *et al*. (1984) compared index selection and mass selection for various traits such as body weight at 8 and 20 weeks of age, 35-week egg weight, age at sexual maturity, and egg production to 260 days of age in white leghorn strains. For aggregate genetic response, Ayyagari *et al*. (1985) found index selection to be more efficient than direct selection for egg production, egg weight at 35week of age,

initial egg weight, 20-week body weight and 8-week body weight in white leghorn population.

Potential causes of variable response in a selection experiment are genetic drift, individual measurement sampling, genotype - environment interactions and time trends in environment and natural selection (Hill, 1972). Conversely, the effects of selection on responses in the current experiment could not possibly have been affected by drift since selection was carried out within a short period of time (only in three generations). Selection response tends to decrease and eventually vanish in long-term selection applied to a closed population as a result of increase in homozygosity or genetic drift due to inbreeding (Nwagu *et al.,* 2007). The present study was a short-term selection.

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CHAPTER SIX

6.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of New Findings

6.1.1 *Average values of traits and verification of sex and seasonal effects on traits.*

6.1.1.1 Body weight and weight gain

- Pearl Guinea fowls have the potential of providing very good body weight, body weight gain, egg weight and hen day egg production relative to the other strains
- At 8 Weeks of age the White had higher body weight and daily weight gain compared to the Lavender and the Black.
- Keets hatched in the Minor rainy and dry seasons had better hatch weight than those hatched in the Major rainy season.
- Body weight was higher during the Major and Minor rainy seasons at 8th week but at 16th week it was higher in the Major rainy and Dry seasons.
- Superior body weight was recorded during the Major rainy season at 24 and 32 weeks of age.
- Pre- brooding daily weight gain was higher in the Major and Minor rainy seasons.
- Daily weight gain was higher in the Dry season at 8-16 weeks of age and was better in the Major and Minor rainy seasons at 16-24 weeks.

6.1.1.2 *Reproductive traits*

- Lavender strain has the ability to lay eggs earlier than their counterparts.
- Pearls have the potentials for higher fertility rate compared to the other strains.
- Black strain had better hatchability potentials.

- Season did not influence age at first lay and percent hatchability.

6.1.1.3 *Biochemical profile*

- Pearls' meat had more ash than meat from other varieties
- Meat from Lavender, White and Black strains had more protein compared to the Pearl.
- Lavender strains have the ability to produce more cholesterol than the other three strains
- Pearl and Black strains had better moisture content
- Production of protein was better in males than in females. On the other hand, percent ash, and moisture scores were higher in the females than in their male counterparts.
- Protein production was higher in the minor season than in the dry and major rainy seasons.
- Ash and moisture content in the birds were higher during the dry and major rainy seasons as against the minor season

6.1.1.4 Carcass characteristic

- The White strain had better dressing percentage
- Dressing percentage was significantly better in the major rainy season followed by the dry season and poor in the minor season.

6.1.1.5 *Docility*

- Season did not influence docility in the Guinea fowls.

6.1.1.6 *Survival*

- Pre-brooding survival was higher in the Pearls and lower in the Black
- Post-brooding survival was higher in males and lower in females
- Season did not influence survival in the Guinea fowls

6.1.1.7 Feed intake and feed conversion ratio

- No significant difference was observed in both feed intake and feed FCR of the strains
- Feed conversion ratio was higher during the dry season

6.1.2 Determination of disease resistance in local guinea fowls through the use of Sheep Red Blood Cell (SRBC) as an indicator trait

6.1.2.1 Strain and sex effects on antibody titers

- The Pearl genotypes have high potential for immune competence.
- Antibody response to SRBC antigen was better in females than the males.

6.1.2.2 Days and concentration on antibody titers

- Different post injection days and SRBC concentration did not influence antibody response in the birds.

6.1.2.3 Route of SRBC antigen administration on antibody titers

- Intravenous injection was more effective in presenting SRBC antigen to immune competent cells than the intramuscular injection

6.1.3 Genetic and phenotypic parameters.

6.1.3.1 Variation in traits

- Body weight and 8-month weight gain showed the greatest additive genetic variation, with survival, docility, dressing percentage, age at first egg, egg weight, egg number, fertility, hatchability traits, feed intake and FCR showing relatively low additive genetic variation.

6.1.3.2 Heritability of traits

- Direct heritability estimates in the Guinea fowls were high for hatch weight, month 2 and month 4 weights, moderate for 6 and 8 in both males and females with the exception of month 4 weight which was medium in females.
- The heritability estimates of body weight gains were moderate for month 2 and 6 but low for month 4 and 8 in the males whereas in their female counterparts the estimates were moderate for month 2 and 4 and low for 6 and 8.
- Heritability estimates for survival, dressing percentage and feed intake were all low in the males and females apart from feed intake which was medium in the females.
- Docility and FCR heritability estimates were moderate in both males and females.
- Estimates of heritability of egg weight and hen-day egg production were high, moderate at age at first egg and low for fertility and hatchability.

6.1.3.3 Phenotypic and genetic correlation of traits

- Genetic and phenotypic correlations among some of the traits studied in the present experiment (hatch weight, two-month weight, four-month weight, six-month weight, etc) were moderate to high and positive.
- Selection for any one of the traits involved will improve the other

- Genetic correlation between hatch weight and age at first egg, hatch weight and egg weight, and hatch weight and hatchability were high and positive.
- There was unfavourable genetic correlation between hatch weight and hen day egg production, and between hatch weight and fertility of eggs
- Genetic improvement in age at first egg could decrease egg weight, hatchability and fertility of eggs in Guinea fowls.
- Genetic improvement in hatch weight, could improve age at first egg, egg weight and hatchability.
- As two month weight in male increases, survival also increases.
- Genetic improvement in two-month, six month and eight-month weights could improve survival.
- Docility is not a good indicator trait of egg characteristics measured in the current study.

6.1.4 Genetic gain

- The simultaneous inclusion of the three traits (body weight, docility, and survival) in the selection index, while selection was in a positive direction for the respective traits, improved the performance of the selected individuals in these traits.

6.2 Conclusions

The mean values of traits obtained in this study are analogous to values from similar studies conducted by other scientists on indigenous Guinea fowls.

- Strain and season influenced production, reproduction, biochemical, carcass, survival and docility traits of indigenous guinea fowls.
- Sex did not influence production traits of the birds.

- Pearl strains should be used to achieve higher productivity.
- For better hatch weight Keets should be hatched in the Minor rainy and dry seasons.
- The Guinea fowls used feed efficiently and hah better fertility in the dry season
- The pearl varieties had high potential for immune competence.
- Antibody response to SRBC antigen was better in females than in males.
- Intravenous injection was more effective in presenting SRBC antigen to immunocompetent cells than the intramuscular injection.
- Different post injection days and SRBC concentration did not influence antibody response.
- SRBC antigen could potentially be used as an indicator trait for disease resistance in Guinea fowls.
- Body weight and 8-month weight gain showed the greatest additive genetic variation, with survival, docility, dressing percentage, age at first egg, egg weight, egg number, fertility, hatchability, feed intake and FCR showing relatively low additive genetic variation.
- Lavender was the most docile variety.
- Direct heritability estimates in the Guinea fowls were high for hatch weight, 2 and 4 month weights, moderate at 6 and 8 months in both males and females with the exception of 4 month weight which was medium in females.
- The heritability estimates of body weight gains were moderate at month 2 and 6 but low at month 4 and 8 in the males whereas in the female counterparts the estimates were moderate at month 2 and 4 and low at 6 and 8.
- Heritability estimates for survival, dressing percentage and feed intake were all low in the males and females apart from feed intake which was medium in the females.

- Docility and FCR heritability estimates were moderate in both males and females.
- Estimates of heritability of egg weight and hen-day egg production were high, moderate at age at first egg and low for fertility and hatchability
- Low heritability estimates of fertility and hatchability, carcass and survival imply that response to selection for those traits could be slow.
- The results of heritability could be used to initiate Guinea fowl selection breeding programmes.
- Moderate to high positive genetic correlation between SMWT, DOC and SVV indicates that these traits could be used in a multiple trait selection using the selection index.
- Selection based on an index should be applied in breeding programmes for the development and/or improvement of growth, docility, and survival traits in the indigenous Guinea fowls.

6.3 Recommendations

- Effect of 1:1 sex ratio should be investigated in Guinea fowls.
- Future studies should look again at effects of sex on production traits in local Guinea fowls.
- Effect of dosage and concentration of SRBC should be investigated in Guinea fowls.
- Future studies should also look at effects of variation in T cell subpopulations and secondary inoculation on antibody response in these birds.
- Scientists should carry out research to find seasonal effect on antibody response to SRBC antigen in local Guinea fowl.

- The Pearl is recommended for commercial production or breed improvement programme.
- Scientists should carry out research to find out whether weight at first egg has influence on egg production.
- Selection based on an index should be applied in breeding programmes for the development and/or improvement of body weight, docility and survival in the indigenous Guinea fowls
- The selection programme in this experiment should be continued until optimum response is attained

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APPENDICES

APPENDIX A

Medication and Vaccination Schedule

Age (Days)	Medication
1-2	Glucose in Water
6	Antibiotic (TCN)
10	Coccidiostat (Amprolium)
16	Newcastle
23	Gumboro
25	Antibiotic (TCN)
30	Coccidiostat (Amprolium)
35	Dewormer (Levasol)
38	Fowl pox vaccination
44	Coccidiostat (Amprolium)
49	Newcastle (Lasota) vaccination
52	Antibiotic (TCN)
56	Dewormer (Levasol)
60	Coccidiostat (Amprolium)
84	Fowl pox vaccination
98	Dewormer (Levasol)
112	Newcastle (lasota) vaccination

APPENDIX B

Protocol for Heterophil/ Lymphocyte Test

Step	Activity
1	Take the samples of blood
2	Put samples in EDTA Tube
3	Mix content for about 1 minute
4	Remove the cover of tube
5	Put content in heamatology machine (TV 3000)
6	Type the labels on tube in the machine
7	Press enter four times on the aspirator
8	Waite and print the results