

**AKENTEN APPIAH MENKA UNIVERSITY OF SKILLS TRAINING
AND ENTREPRENEURIAL DEVELOPMENT**

**DETERMINATION OF GROWTH POTENTIALS OF TWO CHICKEN
STRAINS USING DAY OLD PHENOTYPIC MARKERS**

HUSAIN MOHAMMED SAKO

DECEMBER, 2024

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STRAINS USING DAY OLD PHENOTYPIC MARKERS**

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**A Thesis in the Department of Animal Science Education, Faculty of Agriculture
Education, Submitted to the School of Graduate Studies, in Partial Fulfillment of the
Requirements for the Award of the Degree of Master of Philosophy (Animal Science)
in the Akenten Appiah-Menka University of Skills Training and Entrepreneurial
Development**

DECEMBER, 2024

DECLARATION

Student's Declaration

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

HUSAIN MOHAMMED SAKO

Signature: Date:

Supervisors' Declaration

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

Dr. DUODU ADDISON

Signature: Date:

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DEDICATION

This work is dedicated to my Supervisor, Dr. Duodu Addison, my hardworking wife Mrs. Sahadatu Yakubu and the Sako family for their love and care.

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LIST OF ABBREVIATIONS

AgGDP	Agricultural Gross Domestic Product
ANOVA	Analysis of variance
BCS	Body condition score
BL	Back length
BMI	Body mass index
BRL	Breast length
BW	Body weight
CH	Circumference of the head
CP	Crude protein
DNA	Deoxyribonucleic acid
DOBW	Day old body weight
FAO	Food and Agriculture Organization
FCR	Feed conversion ratio
FI	Feed intake
HG	Heart girth
HOD	Head of Department
IPCC	Inter- governmental Panel on Climate Change
LSD	Least significant difference
LW	Live weight
ME	Metabolizable energy
ROBROC	Ross broiler chickens
SEC	Southern ecotype chickens
SSA	Sub Saharan Africa
TOBEC	Total body electrical conductivity

ABSTRACT

This study focused on assessing one-day old effect of some phenotypic markers on production traits in Ross broiler chickens (ROBROS) and Southern ecotype breeds of chicken (SEC) as an alternative for genetic markers. The study was conducted at the Akenten Appiah Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) Animal farm unit on Asante Mampong Campus of Ghana, from June to December, 2022. One hundred and eighty (180) Ross broiler and 180 Southern ecotype breeds of chicks were used for the research. For each breed, the chicks were put into four groups with 45 chicks in each group. Breast length (BRL), Back length (BL), Circumference of the head (CH) and day-old body weight (DOBW) were taken on the chicks at one day old in group 1, 2, 3, and 4 respectively using a tailor's tape and a weighing scale. Chicks within each group were classified into three (3) sub groups and considered as treatments (T) 1, 2 and 3. The treatments were described as higher (T1), medium (T2), and lower (T3) ranges based on the values obtained from the measurement and reared under randomised completely block design (RCBD). Data on production traits were taken up to week 8 for the Ross broiler and 18 weeks for the Southern ecotype chicken. The results from ANOVA using Statistix indicated that for the Ross broiler chickens, T1 in all the groups were significantly ($P < 0.05$) superior over T3 for feed intake, body weight, body weight gain and feed conversion ratio. T2 were significantly better than T3 in terms of body weight. For the Southern ecotype chickens, T1 were significantly ($P < 0.05$) better than T3 for feed intake, body weight, and body weight gain. However, for feed intake and body weight gain, T2 were significantly ($P < 0.05$) better than T3. Pearson correlation analysis also indicated a high, strong and significant ($P < 0.05$) correlation between day-old phenotypic markers with body weight. Regression equations of day-old phenotypic markers with body weight were positive and significant ($P < 0.05$) with coefficient of determination (R^2) ranging from 0.64 to 0.76 for Ross broilers and 0.81 to 0.95 for Southern ecotype chickens. CH and DOBW had the highest R^2 values and thus the best predictors of body weight. Breast length, back length, circumference of the head, and day-old body weight taken on the chicks at one day old were effective in predicting final body weight. It was concluded that, the four (4) phenotypic markers could be used for selection purposes efficiently.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Indigenous village chicken is the most dominant class of livestock in Ghana which makes up about 60-80% of the total poultry population (Hagan *et al.*, 2013). Traditional management practices are used by smallholder farmers to produce these birds which have adapted to a wide range of ecological settings (Dana *et al.*, 2010). There is a high preference for indigenous chicken products such as meat and eggs by majority of rural dwellers. This preference is as a result of attributes possessed by these animals such as toughness, pigmentation, taste, leanness and their suitability for special dishes. The demand for chicken meat is high among urban dwellers but limited in supply as a result of low productivity (Islam, 2000). Local chicken is the most populated genetic resource among the poultry family in Ghana as they can be found in almost every community. Their productivity is however low due to poor nutrition and low genetic potentials (Aboe *et al.*, 2006).

An improvement in the genetic potential of our local chicken is key to improving on their performance. Proper records on characteristics and performance, measurement and monitoring of body weight is necessary to designing an improvement program for livestock (Lesosky *et al.*, 2013). There is a general acceptance in the temperate zone that, the hardiness of local chickens can be exploited by breeding them in the most conducive environment, provided improvement are to be made through careful selection of superior genotypes (Hammond, 1947; Jenkins and Ferrell, 2006). Continuous data taken on morphological or linear body measurements in relation to the long bones of birds, can be used to determine the rate at which an animal's body shape changes, carcass composition and prediction of its live weight (Oke *et al.*, 2004).

Additionally, the relationship between body weight and linear body measurements are important not only in genetic improvement strategies but also useful in the prediction of body weight. Body growth and market value of chickens can also be determined by a number of body conformation traits. Poultry breeders have established that there is a relationship that exist between body weight and linear body parameters such as shank length, breast width, keel length, back length and thigh length (Attah *et al.*, 2004). The relationship existing among linear body parameters influences the performance and carcass value of animals. Body weight prediction, selection for breed superiority and breeding programmes can be determined from the relationship between body weight and linear body measurements (Sowande and Sobola, 2007). The use of body measurements to predict body weight of different animal species (e.g., cattle, sheep and goat) have been done by some authors outside the shores of the country (Goe, 2007).

1.2 Problem Statement

Developed countries have seen a massive improvement in their livestock sector as a result of a pivoted advancement from livestock technologies in relation to genetic improvement strategies such as use of genetic markers as compared to Africa countries (Marshall, 2014). Africa is faced with this slower rate of animal genetic improvement as a result of inadequate public and private sector investment, weak supportive policies and institutional arrangements (Marshall, 2014).

Genetic improvements in the tropics on native indigenous chicken genetic resources using genetic markers are either rare or non-existent as a result of logistical and financial constraints. Instead in most instances, developing countries use high yielding commercial lines developed for intensified management system for crossbreeding with native fowl to increase the egg and meat production of native chicken. The practice of

crossbreeding using native and exotic breed leads to genetic erosion of desirable traits that enable the native breeds to adapt to their environment (FAO, 2015). Genetic improvement programs in Ghana are at a minimal rate as far as local chicken breeds are concerned due to inadequate funding for research and logistical constraints. The effect of this is an increase in the importation of improved breeds from developed countries which ultimately affects the local poultry production sector and the country at large (FAO, 2015). It is advocated that extra effort in the improvement of local chickens in the areas of, management, breeding, feeding and health care can improve the productive performance of local chickens in Ghana (Hagan *et al.*, 2013).

1.3 Justification

The genetic potential of birds can be effectively promoted for efficient and effective productivity if improvement programs are to be initiated. Morphological markers can be used as an alternative to DNA selection technique to improving the genetic potential of our native chicken considering the logistical and financial constraints in the tropics (Yakubu *et al.*, 2009 and Lukuyu *et al.*, 2016). Relationship existing among body traits, Oke *et al.*, (2004) provides useful information on the performance, productivity and carcass characteristics in animals. In this regard, alternatively cheaper methods involving the use of simple tools to measure some body parts to determine the performance of chicken can be employed (Lesosky *et al.*, 2013). Considering the current lapse in our genetic improvement programs, the use of body measurements is an alternative to DNA technique in selecting for body weight among our local chickens. The exploitation of this alternative is key to enhancing the performance of our local chicken, an avenue for increasing the demand of local chicken and an ultimate improvement in the local poultry value chain.

1.4 Objectives

1.4.1 Main objective

The main objective of the study was to;

Determine growth potentials in Ross and Southern ecotype chickens using phenotypic markers taken at day old.

1.4.2 Specific objectives

The specific objectives were to determine;

- ❖ The effect of phenotypic markers taken at day old on production traits of chickens
- ❖ The correlation between the phenotypic markers taken at day old with body weight gain of chickens.
- ❖ Linear relationship between the phenotypic markers taken at day old with final chicken body weight.
- ❖ The best predictor of body weight of chickens using day-old phenotypic markers.

1.4.3 Significance of the study

The success achieved from this research will help to improve on breeding practices in Ghana. This will aid the selection of breeds with desirable traits using phenotypic markers taken at an early age as an alternative to molecular genetic markers.

It will also help conserve most of the superior traits possessed by local chicken in line with FAO's quest for conservation of animal genetic resources

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Local chicken production in the tropics

In Ghana, the indigenous village chicken is the most dominant class of livestock as it constitutes about 60-80% of the total poultry population. Their production capacity is not encouraging due to poor nutrition and low genetic potential (Hagan *et al.*, 2013). The local chicken production systems in Africa are mainly based on scavenging indigenous chickens found in almost all households in the rural areas (Hagan *et al.*, 2013). These chickens form an integral part of the farming systems requiring low-inputs with outputs accessible at both inter-household and intra-household levels. Most rural communities in Ghana consider rural poultry production as an important agricultural activity as it provides them with animal protein as well as a means to earn petty cash. Rural chickens play an active role in pest control mitigation efforts and are also used for traditional ceremonies as well as some festivals (Hagan *et al.*, 2013).

Indigenous chicken meat and eggs are preferred by majority of rural dwellers mainly because of their toughness, pigmentation, taste, leanness and suitability for special dishes. There is also a high demand for the meat by urban dwellers but the supply is limited due to low productivity (Hagan *et al.*, 2013). A better integration and improvement of livestock production into the small farm enterprise could contribute significantly to the improvement of the livelihood of small farmers. Small scale livestock business, particularly native chicken keeping, is normally considered as the most feasible option for poor small-scale farmers.

The sustainability of the native chicken rearing is also higher in terms of the adaptation of the chickens to the local environment, poor feed resources and their disease resistance (Hagan *et al.*, 2013). The continent of Africa is endowed with a wide range

of indigenous chicken breeds. History clearly shows that our chickens have been subjected to several genetic changes leading to a reduction in their sizes in areas of food scarcity and an increase in areas where food and water was adequate. The indigenous chickens show much resistant to most of the endemic poultry diseases and pests that affect the exotic chickens (Sil *et al.*, 2002). These chickens are generally less productive in terms of eggs and meat. In spite of these setbacks, they play a key role in the socio-economic wellbeing of the rural poultry farmers as they serve as a source of food and an avenue for petty cash generation. They are also considered valuable as a result of their ability to scavenge, disease tolerance, meat quality and general hardiness (Ssewanyana *et al.*, 2003).

Free-range chickens contribute immensely to the livelihoods of the households living in our rural communities. They are easily disposed of when the need arises by any of the family members. They generate manure and are required for some special festivals to meet social obligations as well essential for many traditional ceremonies and treatment of illness (Alabi *et al.*, 2012). Kolawole (2010), reported that their meat is tastier and as such is considered the highly preferred chicken meat. Sonaiya (1990), reports that as a result of little research efforts made on these indigenous chickens, they are rarely considered as a priority in economic development activities within the sub-region of Africa and has greatly influenced their potentials.

Following the recognition of our indigenous chicken as a gene pool for chickens characterized by high adaptability, vigour, hardiness as well as disease resistance, there is growing interest in the study of the various chickens indigenous to Africa as reported by (Adetayo and Babafunso, 2001; Naidoo, 2003, Demeke, 2004; Grobbelaar *et al.*, 2010 and Byarugaba, 2007). Most consumers have a high preference for local chicken

products because of the distinctive colour of their carcass, the tough muscle of the meat, shell colour and yolk colour (Grobbelaar *et al.*, 2010). The Southern African region has indigenous chicken breeds such as Potchefstroom koekoek, Venda, Ovambo, Naked neck, Natal game, Zulu and Nguni which are primarily adapted to that particular agro-ecological niche. These breeds have been endangered to many farmers and keepers as a result of their possession of some distinctive characteristics (Alabi *et al.*, 2012).

2.2 Prospects and constraints of indigenous chicken production in Africa

Rural poultry production is an important agricultural activity of almost all rural communities in Ghana providing scarce animal protein in the form of meat and eggs as well as being a reliable source of petty cash (Kitalyi, 1998). Village chickens in our continent are generally hardy, adaptive to rural environments, thrive on little or no inputs and can survive in areas characterized by changes in feed availability (Atansuyi *et al.*, 2017). Sonaiya (1990), reports that these indigenous chickens are widely distributed in the rural areas of tropical and sub-tropical countries where they are kept by majority of the rural small income earners for consumption, economic purposes or both. The productivity of village chickens is generally very low in Africa considering a number of production lapses confronting their production (Teketel, 1986). These chickens are generally produced or reared under extensive and semi-intensive systems but recently they have been managed under intensive systems with more efficient output per bird. Chickens are the most populous animal genetic resources kept in Africa and constitutes about 98% of the total poultry numbers (chickens, ducks and turkeys) (Gueye, 2003). Indigenous chicken accounts for 80% of the 120 million poultry birds raised in rural areas in Nigeria (RIM, 1992 and Udoh *et al.*, 2012). As a result of their extensive genetic diversity which allows for their rearing under varied environmental conditions, indigenous poultry species represent valuable resources for livestock

development in Africa (Adebambo, 2005). In Africa, our indigenous chickens are faced with low productivity attributed to the lack of improved poultry breeds, the presence of predators, poor feeding, housing and other management factors (Alemu, 1995 and Alemu and Tadelle, 1997). Indigenous chickens are more numerous than imported chickens, however little research work has been carried out on the breed in the areas of breed evaluation and feed supplementation (Brannang and Pearson, 1990; Abebe, 1992 and Negussie and Ogle, 2000).

There have been few studies on these indigenous chickens, however the studies on these chickens were not tangible enough to show the relative effect of genetic and non-genetic factors on their performance (Alemu and Tadelle, 1997). The local chicken production systems in Africa are mainly based on scavenging indigenous chickens found in almost all households in the rural areas. They are characteristically an integral part of the farming systems requiring low-inputs with outputs accessible at both inter- household and intra-household levels (Kitalyi, 1998). According to Alders and Spradbrow (2000), village chickens also fulfill a number of other functions for which it is difficult to assign any monetary value. These include the fact that rural chickens play an active role in pest control and are used for traditional ceremonies and festival.

According to Islam (2000), indigenous chicken meat and eggs are preferred by majority of rural dwellers mainly because of their toughness, pigmentation, taste, leanness and suitability for special dishes. There is also a high demand for the meat by the urban dwellers but the supply is limited due to low productivity. A better integration and improvement of livestock production into the small farm enterprise could contribute significantly to the improvement of the livelihood of small farmers. Small scale livestock development particularly native chicken keeping is normally considered as

the most feasible option for poor small-scale farmers (Phalarak, 1985). The sustainability of the native chicken rearing is also higher in terms of the adaptation of the chickens to the local environment, poor feed resources and their disease resistance (Hagan *et al.*, 2013).

2.3 Animal breeding and productivity in Africa

Smallholder farms are associated with about 75% of the livestock in Africa notwithstanding, their subsistence is derived mainly from crops, with livestock providing the major source of cash income. 25% of the remaining Africa's livestock are found largely in the herds and flocks of pastoralists who are dependent upon their animals for both food and income. About 40% of the land area of the subcontinent are affected by the tsetse- transmitted disease, trypanosomiasis with only small number of trypano-tolerant cattle, sheep and goats found in those infected areas (Brumby and Trail, 1982). The distribution of Africa's livestock is such that about one third are found in the highland areas where temperate conditions prevail. As a result of favourable environmental conditions, the remaining livestock population are found in the lower-elevation areas with environments ranging from arid to wet tropical. Crossbreeds between indigenous and imported breeds of cattle perform well in the more favourable areas, particularly in the highlands, but in the lowlands the indigenous cattle usually outperform introduced breeds and their crosses. Overall results indicate that the indigenous breeds are well adapted to local environments, and that any increase in the genetic potential of these breeds can only be exploited if nutritional, disease and climatic stresses are reduced (Brumby and Trail, 1982).

2.4 Animal breeding strategies and current issues in Africa

In Africa, the human population is rising at an estimated rate of 2% per annum and is forecasted to reach 1.9 billion by the year 2050. Urbanisation which is also a central propelling condition is showing advances in Africa with an estimated growth rate of 3.5% within the last two decades. In the year 2010, Africa's urban population was approximately 36% and is projected to increase to 50% and 60% by 2030 and 2050, respectively (Wurzinger *et al.*, 2014).

There has been a shift in the diet of Africans towards more meat and dairy products. This situation serves as a drive for urbanisation to be accelerated. Population growth and urbanisation are two major factors that leads to high consumption of meat and dairy products with growth rates of 2.7% and 3.5-4.0 % per year respectively. The growing demand is considered a big opportunity for the large number of smallholder farmers in Africa to escape poverty and to supply chicken and chicken products in a growing market (Wurzinger *et al.*, 2014). The livestock production systems in Africa are confronted with several challenges. These challenges include, a predicted increase in temperature and a simultaneous decrease in precipitation for many African regions which will increase vulnerability of livestock-keeping communities was reported by the IPCC report 2014. The setbacks that are likely to be associated with this situation includes higher prevalence of diseases and parasites and more and longer droughts. Disease and parasite tolerance efforts therefore need to be included in future breeding programs (Wurzinger *et al.*, 2014). Some other factors to be considered are heat stress and tolerance of salty water, range-land degradation, increased variability in access to water, fragmentation of grazing areas, changes in land tenure from communal towards private ownership and hence restricted mobility, in-migration of non- pastoralists into grazing areas, lack of opportunities to diversify livelihoods, conflict and political crisis,

weak social safety nets, and insecure access to land, markets, and other resources (Wurzinger *et al.*, 2014).

One quarter of the world's estimated 752 million poor livestock keepers live in Africa with about 85% of them experiencing extreme poverty conditions within SSA. Investment levels are well below the levels required to sustain agricultural research and development (R&D) needs in Africa. Sub-Saharan Africa as a whole invested 0.51% of AgGDP on average which is below the set target of 1% in the year 2011 (Wurzinger *et al.*, 2014). There is a strong consensus that suggests that improved livestock production can significantly change the livelihoods of many families but regrettably the commitment by governments is extremely poor. There is no 'blueprint' set of interventions in Africa given the diverse production systems. For a long time, cross-breeding with often exotic breeds from temperate climates have been considered a taboo by scientists and the international community based on worries about loss of genetic diversity (Wurzinger *et al.*, 2014). Despite the scientific criticism of indiscriminate cross-breeding, many farmers in favorable environments and with market opportunities at hand go for this option (Marshall, 2014). Farmers in Africa are willing to invest in crossbred animal nutrition, animal health and accept higher work load as the higher input pays off despite the fact that crossbred animals production come with higher requirements. Much research is required to look into the breeds involved, blood levels of the constituent breeds, sustainable research strategies and its effective implementation for many regions of the continent taking into consideration prevailing condition (Wurzinger *et al.*, 2014).

There is a great challenge in the establishment of functional breeding programs under small holder conditions. There have been past genetic improvement strategies but could

not withstand the test of time due to the under listed conditions: (a). Over reliance on breed replacement and/or indiscriminate cross-breeding of indigenous with exotic breeds with no plan on maintenance of suitable exotic blood levels and no selection on the dam line; (b) incompatibility of introduced genotypes with producers' breeding objectives, management practices and environmental conditions; (c) lack of comprehensive approach to design simple but effective breeding strategies instead of adopting complex breeding programs that require many logistics and technologies; and (d) insufficient or no systematic breed evaluation studies ensuring fair comparison of the relative merit of indigenous and exotic breeds under typical environment considering the role of G & E (genetic & environment) interaction (Wurzinger *et al.*, 2014)

In addition, smallholder production systems are characterized by small animal numbers per household, single-sire herds/flocks, lack of systematic animal identification, absence of performance and pedigree recording, illiteracy, poor infrastructure and ill-functioning institutions. The movement of pastoral flock introduces additional challenges in recording and selection (Wurzinger *et al.*, 2014).

2.5 Importance of animal breeding

Animal breeding practices are geared towards the improvement of traits of economic values. Body weight as an important economic trait in the selection of superior animals require an appropriate and accurate estimation to enhance livestock breeding and production. Knowledge pertinent to the live weight of an animal is an important tool in the decision-making process of farmers. Estimation of market prices for live animals, determining correct dosages in drug administration, determining animal's feed

requirements for growth, maintenance, and production are examples of such decisions considered (Marshall, 2014).

2.6 Linear body measurements and growth in birds

The skeleton carries the body and is closely related to the muscles. It determines the shape of the body and other related body characteristics (Khatab *et al.*, 1992). A higher percentage of the meat in birds is distributed to the breast and thighs. Birds that are good for fattening can be easily determined when the breast area is checked (Al-Fayadh *et al.*, 2011). Al-Hajo (2005) has indicated that, an increase in the weights of the main cuttings is a natural result of increased bone lengths, which are the natural determinants of the skeletal muscles. Al-Shemery (2014) has stated that the relative weight of the main cuttings ranged between 30.91-34.79% for the breast and 15.50-18.59% for the thigh in different types of imported and local chicken carcasses. Ukwu *et al.*, (2014) have justified the significance of the linear relationship between live body weight and body measurements to predict body weight. It has been described also as a quick method for selection and breeding programs (Abdel-Lattif, 2019).

2.7 Relationship between external morphometric traits and semen characteristics

Reproduction is an important facet of poultry production that determines the continuity of poultry species. To predict fertility in natural mating and artificial insemination, semen evaluation is required (Udeh, 2012). In the avian species, the hen produces an egg in which if fertilized, the offspring will undergo growth and development outside the body of the hen. Thus, fertility of the egg is male and female dependent. Semen quality characteristics such as semen volume, semen colour, mass activity, sperm motility, sperm concentration, percentage live sperm cells, percentage dead sperm cells and percentage abnormalities are major determinants of the fertilizing ability of breeder

cocks (Udeh, 2012). Poultry breeders require accurate and reliable prediction equations for estimating semen characteristics from In Vivo measurements. In the determination of semen characteristics, the most accurate method for the evaluation is the collection of semen followed by microscopic examination. This method however comes with a lot of stress experienced by the bird, inefficiency in terms of time and cost. In Vivo estimation of semen attributes based on the correlation between some morphometric traits and semen parameters requires simple, reliable and indirect methods. Series of studies have reported that ornamental traits are good indicators of semen quality (Galal *et al.*, 2002; El-Sahn, 2007; Galal, 2007; and Gebriel *et al.*, 2009). In the developing world alternative means of evaluating semen qualities of breeder males that are used in poultry breeding and also to assist the rural dwellers who do not have access to the laboratory for semen evaluation is under development. The need has become necessary as current evaluation techniques are stressful, time consuming and expensive. A successful breeding programme in poultry requires the availability of sexually matured cock and hen. Galal *et al.*, (2002) reported a positive correlation between semen volume and comb length and comb height.

2.8 Methods of estimating body weight/live weight

A number of techniques are available for estimating an animal's body mass and body composition. Some of these techniques use simple, inexpensive equipment, and others require sophisticated expensive equipment. The simplest way of estimating an animal's mass is to weigh it. In extreme circumstances where a scale may not be available, an alternative method is to measure a body part and relate the measurement to body weight. Shank length has been a major morphological measurement that is commonly measured and related to body weight in poultry. Lerneryy (1937) reported a linear relationship between BW and shank length. Tierce and Nordskog, (1985) determined a formula for

estimating body weight in chickens as: shank length (mm) $=\alpha W(\text{kg})^B$. Body conformation (especially breast width) is different among breeds of chickens and as such different coefficients and exponents are needed for different breeds of chickens.

Estimation of body weight by measuring a part of the body trunk rather than an extremity is more common in livestock. Body weight estimate in cattle can be determined by measuring the heart girth, the circumference of the animal posterior to the front legs (Willoughby, 1975). Information on body composition can be valuable in the following ways: Those producing and selling animal products need information on body composition, nutritionist also need information about body composition to determine how much of the energy that an animal eats. Parameters such as body composition and energy content can be estimated using a number of methods. The most direct and accurate way is to euthanize the animal, grind the whole animal, sample it appropriately, and then collect appropriate data (Willoughby, 1975). Polleymounter *et al.*, (1995) estimated fat content by using organic solvents and energy content using bomb calorimeter. Indirect methods are also used to estimate body composition (Blaxter, 1989). The first method involves an estimation of body water content by dilution of an injected compound and then estimating body fat content based on the inverse relationship of body fat and body water. A second method is to measure ^{40}K , which is proportional to lean body mass. A third method uses weighing in water because the specific gravity of fat is less than the specific gravity of the lean body (Pesti and Bakalli, 1997). The latter method was applied in energy studies with beef cattle (Lofgreen, 1964). The fat content and subsequently energy content of cattle carcasses was estimated by making reference to the empty body weight measured in water. Body compositions of humans were also estimated from skinfold thickness and body density.

Abdominal fat in broilers was related to abdominal skin thickness (Pym and Thompson, 1980 and Mirosh and Becker, 1984).

The determination of energy gain by animals have been estimated from the development of indirect methods (Blaxter, 1989). The first method involves the measurement of carbon and nitrogen balance and a second is to measure the gaseous exchange of CO₂ and O₂. Electronic devices have been evaluated for their ability to detect body composition in recent times. Liu and Stoffer (1995) estimated the fat content of specific parts of cattle and hogs using ultrasonic systems. X-ray absorptiometry and TOBEC near infrared interactance have been tested with birds (Roby, 1991; and Mitchell *et al.*, 1997). An indirect procedure offers the potential to harmlessly determine body composition and energy content of live animals. This principle is referenced to TOBEC (Walsberg, 1988; and Staudinger *et al.*, 1995).

Estimating relationships among variables, as well as predicting one variable from another has been determined with Multiple Linear Regression as an available tool. Many researches have revealed that linear body measurement traits are good predictor of body weight in different chicken genotypes such as Senegal Indigenous chicken, Chinese indigenous Dagor chickens, Ugandan indigenous chickens and two commercial meat type (Ross and Anak Titan) chicken genotypes (Gueye, *et al.*, 1998; Tyasi, *et al.*, 2017; Semakula, *et al.*, 2011; and Ajayi, *et al.*, 2008). There exists a wider variation in terms of body conformation among different breeds of chickens. As such, different coefficients and exponents are needed for different breeds of chickens (Ikeh & Okwesili, 2021). Research and management activities including assessment of growth rates, responses of animals to different diets and environmental conditions and

determination of feed requirements are all tied to the live weight (LW) of an animal as the basis for their determination.

In the determination of responses to genetic selection, knowledge of animal weight and weight changes are an important management tool (Lukuyu *et al.*, 2016). Using a calibrated electronic or mechanical scale is the most widely accepted method globally for measuring live weight. In a smallholder farming context however, such devices for measurement is not readily available. As a result of lack of technical skills in operating and maintaining the equipment, rural farmers may be constrained (Dingwell *et al.*, 2006; Kashoma *et al.*, 2011; and Musa *et al.*, 2011). Farmers and livestock traders are not accurate at estimating cattle LW, with underestimates of 46 % and overestimates of 25 % reported (Machila *et al.*, 2008).

It is however not easily applicable to the genotypes found in smallholder farms in the developing countries since the dairy cattle are cross- breeds of exotic breeds with different types of indigenous cattle which may differ in body structure (Alsiddig *et al.*, 2010). A number of advantages are associated with the use of linear measurements which is more objective as compared to assessing the live weight of cattle by visual assessment and scoring which is a subjective approach (Essien and Adesope, 2003). Since the weights measured with a weighing scale can be subject to short-term effects such as gut fill, urination and defecation, some authors have suggested the use of linear body measurements as a more reliable approach (Russell, 1975). With simple measuring tape, linear body measurements can be taken at lower costs at a higher relative accuracy and consistency (Guilbert and Gregory, 1952; and Heinrichs *et al.*, 2007). After 15 years of research, Touchberry and Lush (1950) concluded that a single measurement of each characteristic was accurate enough for most practical purposes

provided one ensured that no gross errors occurred. This conclusion was made after repeated analyses of measurements on wither height, chest depth, body length, heart girth and paunch girth done by three researchers.

Heinrichs *et al.*, (2007), concluded from an experiment they conducted on heart girth measurements that the estimate of liveweight was highly repeatable for multiple measurements on heart girth by one person or for measurements by many individuals. This conclusion was drawn after they examined the repeatability of heart girth (HG) measurement and obtained standard deviations (SDs) of 2.19 cm among 26 observers and 2.74 cm within any one observer. Prediction of live weight of various types, age groups and breeds of cattle have been conducted by several scientist.

In previous studies it was revealed that, body measurements were found to be useful in predicting weight of indigenous cattle such as Ndama of West Africa, Bali of Indonesia, working Oxen in Ethiopia, Sudanese Kenana cattle, Nguni-type cattle of South Africa and the short-horn zebu cattle of Tanzania (Essien and Adesope, 2003; Goe *et al.*, 2001; Gunawan and Jakaria, 2010; Kashoma *et al.*, 2011; Musa *et al.*, 2011; Nesamvuni *et al.*, 2000; and Sandford *et al.*, 1982). Body linear measurements were also found to be useful in predicting weight of exotic beef cattle (Ozkaya and Bozkurt, 2009; and Van Marle-Köster *et al.*, 2000) and dairy cows (Heinrichs *et al.*, 1992; and Yan *et al.*, 2009). Body linear measurements were used to identify and characterize two breeds of zebu cattle in Kenya (Mwacharo *et al.*, 2006). All the measurements were found to exhibit statistically significant effects on breed group, age group, sex and colour pattern. Estimation of live weight in goats involves the conventional method of using weighing balance. In the rural communities under field condition where goats are reared mainly for sale, these scales are not in use partly due to cost, labour and technicality involved

in their usage. This has posed a challenge to the marketing of live animal in relation to price setting. Simple and easily measurable morphological traits such as linear body measurements are used to estimate live weight of animals especially goats (Olatunji-Akioye and Adeyemo, 2009).

Pesmen and Yardimci (2008) indicated that different models might be needed to predict body weight in different environmental conditions, breed, age and gender. The use of linear body measurements in estimating live weight in goats have been reported by several authors (Fajemilehin and Salako, 2008; Adeyinka and Mohammed, 2006; Nsoso *et al.*, 2004; and Islam *et al.*, 1991). Most of these reports are however limited to research institutes without major effect on the goat based population (Sam *et al.*, 2016).

2.9 Guinea Fowl production and prospects

Meat and meat products are main sources of high-quality protein and their amino acid content usually makes up for deficiencies in the staple foods. Poultry production is considered as an alternative way to eliminate poverty and render support to ensure food security for socio-economically disadvantaged rural households (Branckaert and Gueye, 1999). In developing countries, guinea fowl production could become much more beneficial than it is today (Moreki, 2010). It survives under semi intensive and extensive conditions, forages well, and requires little attention from the farmer (Siana, 2005). The guinea fowl also retains many of its wild ancestor's characteristics. They are able to produce well in cool and hot conditions because they are hardy and resistant to environmental challenges (Siana, 2005). Guinea fowls are economically more suitable to tropical regions because of their adaptations to traditional breeding systems as compared to chickens (Moreki, 2009). Guinea fowls occur in few areas in Asia and

Latin America but are widely distributed in Africa (Solomon, 2012). Classical potential for industrial scale production is shown by French broiler and layer guinea fowl breeds.

2.10 Prediction of body weight with body conformation traits

It has been established that apart from body weight, there are a number of other conformation traits that are good indicators of body growth as well as determinants of market value of chickens. Several researches by various animal breeders have tried to establish the relationship that exist between body weight and linear body parameters such as shank length, breast width, keel length, neck length, back length and thigh length (Ukwu *et al.*, 2014). The performance and carcass value of animals can be determined from the valuable information provided by the relationship existing among linear body parameters (Ukwu *et al.*, 2014). Prediction of body weight from the relationships between body weight and linear body measurements is very key. It can also be applied speedily in selection and breeding programs. To predict body weight of different animal species (e.g. cattle, sheep and goat) from the use of body measurements have been done by some authors (Attah *et al.*, 2004; Sowande and Sobola, 2007; and Goe, 2007).

However, there is little information on the prediction of body weight of chickens using linear body measurements (Momoh and Kershima, 2008). Proper recording of characteristics and performance, including measurement and monitoring of body weight is a requisite for designing an appropriate improvement programme for poultry. Body weight is used in evaluating type, function and potential values of animals intended for use as breeding stock, meat, egg and milk production, draught power as well as estimating growth, health and feed efficiency (Lesosky *et al.*, 2013). Pinto *et al.*, (2006) reported that, the usefulness of the chicken for commercial purposes is

influenced by significant variables such as body weight at various ages and performance characteristics.

Under field conditions, it is difficult to undertake accurate and proper assessment of body weight (Atansuyi *et al.*, 2017). It is however mostly determined by visual appraisal, a method which is associated with a lot of errors and hence inaccurate especially when it is done by different evaluators (Chitra *et al.*, 2012). Methods with high applicability and reliability have been developed to estimate body weight on-farm where weighing scales are not usually available. Body weight prediction models (both linear and non-linear) using the linear body components have been developed by several authors from the strong association existing between body weight and linear body parts (Grossma *et al.*, 1985; and Lukuyu *et al.*, 2016). The effectiveness of these models however depends on the linear body measurements under consideration (Assan, 2015). Accurate estimation of body weight could be influenced by other factors such as breed, sex and age (Lesosky *et al.*, 2013). Correlations and equations of prediction are very specific to strain, age of bird and stage at which carcasses were processed for analysis (Musa *et al.*, 2006; and Ojedapo *et al.*, 2008). Hence, these factors have been used in body weight prediction by various authors (Tsegaye *et al.*, 2013; and Rashid *et al.*, 2016). Regression models have majorly been established for estimating body weight from body traits. Some authors have reported that these models allow an objective evaluation of body weight and are useful in selection criteria (Amao *et al.*, 2012; and Ojedapo *et al.*, 2010). For instance, prediction of marketable weight of broilers at an early age using breast girth as a prediction tool can assist in early selection of broilers.

Prediction from quadratic regression was found to be the most reliable when compared to simple linear regression and polynomial models (Semakula *et al.*, 2011). In

comparison of functions with regards to prediction of body weight and other traits, cubic function was the most accurate in predictability as compared to quadratic and linear functions (Yakubu *et al.*, 2009; and Ojedapo *et al.*, 2012). Adebayo *et al.*, (2012) in another study reported multiple regressions as the best predictor of body weight from linear body components in relation to quadratic and exponential functions.

2.11 Relationship between body weight and linear body measurements

The Nigerian Nsukka ecotype indigenous chicken is one of the most populous indigenous genetic resources among poultry that can be found in almost every community in Nigeria. They have adapted to a wide range of ecological settings and provides suitable alternatives to smallholder poultry production in developing countries (Daikwo *et al.*, 2015). Researchers have therefore employed scientific tools in improving the Nigerian heavily local chicken (Agbo *et al.*, 2018; and Ikeh *et al.*, 2020). Breeders have improved the performance of indigenous chicken by genetic improvements through breeding programs (Agbo *et al.*, 2018). Body weight (BW) is an essential economic trait breeder want to select and possibly improve (Tyasi *et al.*, 2017). In animal production, BW is significant for any selection and breeding program, feeding, vaccination, and drug dosages (Tyasi *et al.*, 2020).

Important implications have been established from the relationship between BW and other linear body measurements and as such the success and progress of a breeding program relies on the ability to establish relationships that exist between identified traits (Tyasi *et al.*, 2020). Body weight is used in determining the growth rate of an animal and pricing during marketing. Estimating relationships among variables, as well as predicting one variable from another utilizes Multiple Linear Regression as an available tool. Linear body measurement traits are good predictors of BW in different chicken

genotypes such as Senegal Indigenous chicken (Gueye *et al.*, 1998), Chinese indigenous Dagor chickens (Tyasi *et al.*, 2017), Ugandan indigenous chickens (Semakula *et al.*, 2011) and two commercial meat type (Ross and Anak Titan) chicken genotypes (Ajayi *et al.*, 2008). Different coefficients and exponents are needed for different breeds of chickens because body conformation is different among breeds of chickens (Ikeh and Okwesili, 2021).

2.12 Variations in morphometric traits among local chicken

In Ghana almost, every community is endowed with domestic local chicken (*Gallus gallus domesticus*) which makes them the populous genetic resources among poultry. These domestic chickens are kept mainly by smallholder farmers under traditional management practices, and have adapted to a wide range of ecological settings. Nondescript and hyper-variable phenotypic landscape are used to characterize these chickens (Dana *et al.*, 2010; Egahi *et al.*, 2010; and Melesse and Negesse, 2011). Striking morphological variations in plumage colour and pattern, comb shape, ear lobe colour, and shank colour, are shown by these local chickens. Other common characteristics within the flock of local chicken include naked neck, frizzled feathers, single, pea, rose and cushion combs (Hassabellah *et al.*, 2014; Negesa *et al.*, 2014 and Liyanage *et al.*, 2015). Single comb (the wild type) is recessive to all comb types, except the comb- less variant whiles the causative genetic variants for some morphological traits were mapped to their respective genomic region.

Apart from the comb- less variant, single comb (the wild type) is recessive to all comb types. The causative genetic variants for some morphological traits were mapped to their respective genomic region (Wragg *et al.*, 2012). To fulfill versatile needs as a result of their broader breeding objectives, smallholder farmers keep flock of diverse

phenotypes (Moges *et al.*, 2010). Smallholder farmers keep chickens not only for eggs and meat production but also to satisfy their visual appeal and to meet their cultural and religious needs. They usually do so by some sort of selection based on visual traits (Dana *et al.*, 2010; and Melesse and Negesse, 2011). The availability of genetic variation which can be ascertained through characterization studies forms the basis for which future improvement and sustainability of local chicken production systems is dependent on (Benitez, 2002). Knowing the variations of morphological traits is fundamental to characterization of local genetic resources since morphological traits constitute major components of phenotypes in animal genetic resources. In the contrasting of size and shape of animals, morphometric measurements have been found useful (Latshaw and Bishop, 2001 and Ajayi *et al.*, 2008). Also, in describing the uniqueness of animal genetic resources and providing data for conservation of poultry genetic resources, phenotypic characteristics are very important. Morphological traits of local chicken were affected by the variability in the age, sex and comb type of birds in an experiment conducted at Gomoa West District in Ghana. Female counterparts were not superior in all measurements of the head and body as compared to their male counterparts (Latshaw and Bishop, 2001 and Ajayi *et al.*, 2008).

It was noticed that cushion comb type chickens were superior to all birds of other comb types in all head and body measurements. Feather distribution affected body weight and thigh circumference while skin colour affected chest circumference and hip length (Birteeb *et al.*, 2016). A project was carried out to characterize local chicken populations and it was observed that they had mostly non-patterned plumage, white skin and shanks, single combs and normal feathering (Osei Amponsah, 2010).

Molecular characterization approach also indicated that they constitute a single, randomly mating unselected population, with high genetic diversity, and are as well a

valuable resource for conservation and improvement (Osei-Amponsah *et al.*, 2010). There is little data on the productive performance of Ghanaian indigenous chickens, especially under improved management conditions (Osei-Amponsah *et al.*, 2012).

2.13 Sustainability of local chicken production

It is estimated that about one quarter of the population of Africa are already facing chronic food insecurity because human population growth has surpassed food production (FAO, 2007). The protein gap expectantly is expected to be bridged by poultry meat and eggs due to its short generation interval, high rate of productivity, quick turnover rate, higher feed efficiency, and low labour and land requirements (Ojedapo *et al.*, 2008). In the tropics especially, poultry keeping is a suitable venture as it is characterized by low capital investment, rapid return and easily adaptable enterprise. An appreciable amount of poultry products in developing countries come from local birds (most especially chicken) kept under extensive system in the backyards of almost all rural households (Kumaresan *et al.*, 2008). Indigenous chickens play a significant role in providing people with additional income, meat and eggs (Osei Amponsah, 2010). Scavenging village chickens exhibit a number of functions such as cultural, social, nutritional, economic and sanitary in daily life in the villages (Sekeroglu and Aksimsek, 2009). Inadequacy of feed is one of the major environmental hinderances of chicken production in the tropics.

Indigenous chickens are generally poor producers of eggs and meat as compared to exotic chickens. Indigenous chickens are gradually being replaced by commercial strains in many developing countries (Dana *et al.*, 2011). Several attempts have been made to increase production levels by using chicken stocks of higher potential but this effort has been impaired by the need for fast-growing stocks characterized by higher

feeding and management levels, far beyond the capability of average producers in the tropics. Sustainability of such efforts is also marred by competition with humans for feed ingredients.

These programs to sustain the poultry industry is becoming unsustainable as a result of unreliable supply, high costs of acquiring and maintaining exotic breeding cocks, reduced broodiness and ability to evade predation by the crossbred birds, and incompatibility of genotypes with farmers breeding objectives and production systems (Lwelamira *et al.*, 2008). Small scale producers therefore dominate the chicken production industry in the tropics as their activities is characterized by the usage of indigenous stocks and low-input production systems (Ali *et al.*, 2002). Smallholder poultry production with unimproved stock and locally available low-cost resources can be the most appropriate production system despite the low productivity of these local birds (Mengesha *et al.*, 2008). As a result of the introduction of exotic breeds under various rural development programs in the past, the purity of native breeds has become questionable (Tharkur *et al.*, 2006). The need for conservation and improvement of animal genetic resources has been globally accepted as an ultimate means to preserve these indigenous breeds (FAO, 2007).

For breeding programs to be formulated to propel further improvement in production traits, knowledge on performance of economic traits in chickens is vital (Niranjan *et al.*, 2008). Sound formulation of strategies targeted towards the improvement of local chickens is the direct positive impact of this knowledge. Production potentialities of indigenous chickens can be determined by trials under controlled environments, especially when compared to the scavenging village conditions (Gondwe and Wollny, 2005).

2.14 Livestock genomics for developing countries

The livestock sector plays a vital role in sustaining livelihoods as well as food and nutrition security in developing countries. The livestock raised by the rural poor serve many purposes including savings and insurance, food security in terms of meat and milk, income, livelihood diversification and thus risk reduction, inputs to crop production, transportation, allowing households to benefit from common-property resources (such as communal grazing areas), and fulfilling social obligations amongst others (Herrero *et al.*, 2013; and Marshall *et al.*, 2014).

Other sectors in the associated value chain such as input providers, traders, processors and retailers also benefit from the livestock sector through the provision of employment and income. Food and nutritional security of the poor is a critical issue as far as livestock production is concerned. They provide quality protein and micronutrients essential for normal development and good health when even consumed in even small amounts (Grace *et al.*, 2018; and Smith *et al.*, 2013). In developing countries, statistics show that the demand for animal source foods is increasing at a faster rate. It is estimated that, in low income countries the demand in 2030 for beef, milk, poultry and eggs will be 124, 136, 301, and 208% over that in 2000, respectively (FAO, 2011). Population growth, income growth and increasing urbanization are largely the main drivers for this demand increase (Delgado, 2005 and Thornton, 2010).

Appreciable increases in livestock production within developing countries is the tool to ensuring that this demand is met (Steinfeld *et al.*, 2006; and Thornton, 2010). Though to achieve this in a sustainable fashion, it is anticipated to be challenging, but with a key component of this target to increasing livestock productivity, the gap can be bridged. Critical interventions in the areas of animal feed, health and genetics will help

to increase livestock productivity in developing countries. These interventions take the form of capacity building of the livestock keepers and other value chain actors, ensuring the availability and accessibility of inputs, provision of new technologies or customization of existing technologies, support to private and/or public sector involvement, and advocacy for supportive policies (Delgado *et al.*, 2001).

In some small-holder and pastoral sectors where livestock are primarily kept for savings and insurance purposes, such that maintaining a livestock asset base is more important to the household than improving livestock productivity, the provision of incentives for increased productivity can also be important. These incentives when provided could be beneficial in the following ways; increasing livestock income through facilitating access to strong and stable markets and ensuring that intra-household benefit from the livestock enterprise is equitable (Marshall, 2014). Livestock development programs such as equality, food safety and environmental sustainability are other issues which could be affected through increased livestock productivity. Intervention packages typically need to be customized for both the diverse and dynamic livestock systems within developing countries. The livestock systems in developed countries have benefited from livestock technologies and genetic improvement strategies than African livestock systems (Marshall, 2014). Sustainable breeding programs as well as the use of reproductive technologies such as artificial insemination is few in Africa and is limited to specific livestock sectors. The lack of public and private sector investment; lack or weak supportive policies and institutional arrangements; the heterogeneity of livestock systems, farm-scales, management practices, and needs and preferences of livestock keepers; poor infrastructure; and limited capacity in the field of animal breeding and reproduction, amongst others are contributing factors to this menace (Kosgey and Okeyo, 2007; Rege *et al.*, 2011; and Marshall, 2014). Decision makers are

rapidly recognizing the potential of genetic improvement to increase livestock productivity with countries now explicitly including genetic improvement within their national livestock development plans (Marshall, 2014).

Structured genetic improvement programs are being implemented in Africa. These structured genetic improvement programs implemented in Africa vary by system. Breed-substitution with other African breeds, breeds from other tropical countries such as India and Brazil, as well as breeds from elsewhere; cross-breeding, most commonly where a highly adapted but lowly productive indigenous breed is crossed with a poorly adapted but highly productive exotic breed; and less commonly within-breed improvement are some of the systems currently in Africa (FAO, 2015). To ensure sustainability of these programs, explicit attention is being paid to the development of working models. This is so because it has been well demonstrated that the models implemented in developed countries cannot be directly applied (FAO, 2015).

The application of genomics is just beginning to emerge, often overcoming a constraint that would otherwise exist, such as lack of recorded pedigree. Some of these applications include; the determination of breed composition of animals in the absence of pedigree data for in situ comparison studies and the application of genomic selection in breed improvement programs (Marshall *et al.*, 2019).

2.15 Morphometric traits and growth performance in livestock

In determining many characteristics of farm animals, especially the economically important characteristics, live body weight plays an important role (Pesmen and Yardimci, 2008). It is practical, faster, easier and cheaper predicting live weight using body measurements especially in the rural areas where the resources are insufficient for

the breeder (Nsoso *et al.*, 2003). As a result of unavailability of weighing scales, which are costly to obtain, need for technical maintenance and heavy to transport to farmers house especially in remote and rural areas, the fundamental knowledge of body weight estimation of these cattle is often unavailable. These farmers heavily rely on questionable estimates of the body of their animals leading to inaccuracies in decision-making and husbandry (Moaeen-ud-Din *et al.*, 2006). In the absence of weighing scales, the main method of determining the weight of animals is to estimate the weight using a number of body characteristics that are readily measured. To determine a weight-prediction equation, weight is regressed on body measurements (Yakubu, 2010; and Kashoma *et al.*, 2011). Selection efficiency for growth by enabling the breeder to recognize early maturing and late maturing animals of different sizes could be improved from the accuracy of functions developed to predict body weight from linear body measurements. The use of body linear measurements to estimate the live body weight in cattle has been reported in several studies (Goe *et al.*, 2001; Mekonnen and Biruk, 2004; and Abdelhadi and Babiker, 2009). In estimating the live weight for all classes of crossbred dairy cattle and Boran cattle, it has been reported that hearth girth can be used with a high degree of accuracy (Msangi *et al.*, 1999).

To predict live body weight of Brahman crossbred cattle, heart girth as a single predictor can be used. Rashid *et al.*, (2016) , reported that heart girth and body length combined together gave the best fitted prediction models with live body weight in all age categories. Different management, environment and enterprise feeding conditions influences growth traits. Evaluation on a morphological basis such as linear body measurement is important for determining useful information on the suitability of animals for selection and on the outcome resulting from genetic improvement programs. Notwithstanding, linear body measurements have been suggested measures

base on body conformation of animals (Janssens and Vandepitte, 2004; and Janssens *et al.*, 2004). Evaluation systems have changed from conformation scale towards scoring on a linear measurement scale since the early 1980s. Linearly measured traits showed higher heritabilities than subjectively scored traits as reported by (Thompson *et al.*, 1983). It was also reported by Serenius *et al.*, (2001) and Gutierrez and Goyache, (2002) that a shift towards linear measurement in order to improve the genetic evaluation in beef cattle was ideal for a better outcome. Linear body measurements such as chest girth and body length have been proposed as indirect selection criteria for genetic improvement of meat production in cattle (Kahi and Hirooka, 2005; and Maiwasha *et al.*, 2002) and for prediction of live weight, growth traits (Mohammed and Amin, 1997) and carcass traits in cattle (Afolayan *et al.*, 2002). Linear body measurements have been found to have a strong positive relationship with growth traits in cattle due to them having moderate to high heritabilities (Afolayan *et al.*, 2007). Praharani (2009) also reported a moderate to high heritability rates ranging from 0.3 - 0.4 for weaning and yearling weight of Bali cattle. He also revealed that selection program will be more effective and efficient in improving the genetic merits in Bali cattle. Simultaneous selection for body measurements and growth traits likely weaning and yearling weight is feasible for Bali cattle (Gunawan and Jakaria, 2010). Selection for either weaning weight or yearling weight traits will result in an increase in heart girth in Bali cattle as a result of the high correlation between heart girth and the two growth traits, and selection for this two traits should be practiced with caution (Gunawan and Jakaria, 2010).

2.16 Chick factors affecting growth performance

Identification of non-invasive tools for prediction of growth performance at an early age is gaining more importance in commercial broilers. Hatchling length is considered

more efficient for early prediction of growth in broilers than traits like day old chick weight, hatchling length and shank length. In evaluating lean growth in broilers, body mass index and ratio of chick weight to length is considered to be more reflective (Michalczuk *et al.*, 2011). Growth performances of broilers are greatly influenced by chick weight and morphometric traits like chick length and shank length. Morphological traits positively affected slaughter yield at market age (Michalczuk *et al.*, 2011; Wolanski *et al.*, 2006; and Willemsen *et al.*, 2008). In assessing the growth performance of chicken, chick weight is considered an easily measurable trait as compared to other traits (Michalczuk *et al.*, 2011). Chicks with higher initial body weight have better subsequent growth up to market age (Michalczuk *et al.*, 2011; Wolanski *et al.*, 2006; and Willemsen *et al.*, 2008). Due to the presence of unabsorbed residual yolk in the abdomen of chicks, chick weight as a predictor of growth performance is biased (Mukhtar *et al.*, 2013). Chick length at day old is reported to have a positive effect on body weight, growth performance and carcass weight at market age (Molenaar *et al.*, 2008; and Petek *et al.*, 2010). Chick weight and length is also reported to have a positive association with shank length, as shank length marketedly affects growth performance of chicks (Wolanski *et al.*, 2006; Willemsen *et al.*, 2008 and Msoffe *et al.*, 2001).

Lean growth in broilers is of much significance in recent times as a result of an appreciation of health consciousness by most consumers. It is described as the ratio of body weight to length square (BMI) or length. Fast growing broilers have less demand than slow growing colored broilers developed from indigenous breeds (Jiang and Yang, 2007). This is as a result of their meat being of high quality in terms of appearance, less fat, taste as well as better performance in tropical climate. During an early phase of growth (up to 2 weeks), chick weight on day 1 had significant effect on live body weight

of colored broilers. Initial chick length also markedly affected body weight up to 6 weeks. Chick body mass index (ratio of chick weight to length square) and shank length however had no effect on post-hatch growth performance of colored broiler (Jiang and Yang, 2007).

2.17 The state of morphological measurements and growth performance in various continents and species

The mathematical relationships between linear body parameters and body weight is not a new phenomenon. The relationships have been studied in organisms ranging from humans, large ruminants, small ruminants and poultry in the last two decades (Patbandha *et al.*, 2017). Reports on the relationship between morphological measurements and growth has been reported in Southern Africa, West Africa, East Africa, North Africa with few of these reports from the Indian sub-continent, Middle East, South America, Eastern Europe and Indonesia (Tyasi *et al.*, 2018; Egena *et al.*, 2014 and Assan, 2013). In marketing and selection of individuals for breeding, the relationship between linear body measurements and body weight is important (Ogah *et al.*, 2009). Linear body measurements can be used to select breeding stock as well as predict future growth of an individual and its offspring (Caglayan *et al.*, 2011 and Abdullah and Shaker, 2018).

Live weight including carcass weight of a chicken can also be estimated using these parameters. Most farmers and consumers incur losses during informal marketing transactions as a result of underestimation of weights (Tabassum *et al.*, 2014). Various algorithms are used to determine relationships and also to find out the linear measurements that best predict chicken weight for a particular species or breed at a specific age (Malomane *et al.*, 2014 and Ojedapo *et al.*, 2012). A lot of efforts have

been made to develop mathematical models to describe the relationship between body weight and linear body measurements. Many names thus have been given as principal component analysis, path analysis and factor analysis (Abdullah and Shaker, 2018). The best predictor of weight in a breed or species may change over time and thus the prediction of weight may only be true for specific ages of chicken (Dahloum *et al.*, 2016). The prediction of body weight has been demonstrated to be dependent on species, breed, strain and sex ((Malomane *et al.*, 2014 and Ogah, 2011). According to a number of authors, body weight has been positively correlated with some linear body parameters such as shank Length, keel Length, and body length (Petrus *et al.*, 2019).

2.18 Morphometric markers and growth performance in West African Shorthorn cattle

The West African Savannah Shorthorn cattle plays a vital role in sustaining the livelihood strategies of the local people in most parts of West Africa (Rege, 1999). They are under threat due to poor feeding, poor health and reproduction management systems (Dossa and Vanvanhossou, 2016). To use live weight in a sustainable fashion, the development of strategies that better integrate genetic improvement, adequate nutrition, good animal health, marketing and other management aspects as recommended by Food and Agricultural Organization is required (FAO, 2011). A proper recording of the animal characteristics and performances, including the measurement and monitoring of its live bodyweight (LW) is crucial to achieve this goal. To evaluate the type, function and potential values of animals intended for use as breeding stock, meat production, milk production and draught power, live weight is useful (Lesosky *et al.*, 2013). Accurate estimation of live weight is influenced by several parameters including animal breed, sex and age. LW prediction model for three age groups of buffaloes with

morphometric measurements and body condition score (BCS) have been developed (Younas, Khan, and Schlecht, 2013). BCS could be used to rapidly and easily estimate LW in absence of weighing scale or tape if it is directly related to LW (Nicholson and Sayers, 1987). Morphometric measurements (chest girth, rump width, body length, chest depth, height at withers and height at sacrum) were linearly, positively and significantly correlated with LW. Body condition scores (BCS) were also weakly related to LW and then are less reliable to predict Somba LW (Vanvanhossou *et al.*, 2018).

2.19 Chicken breeding

According to Maack, (1972), chicken breeding is an aspect of the application of basic genetic principles of inbreeding, line breeding, and crossbreeding. It also focuses on intensive mass selection to bring about rapid and cheaper gains in broilers and maximum egg production for the egg-laying strains. Moreover, he also adds that, maximum application of hybrid vigour, through inbreeding and crossbreeding has been given recognition. The single-comb White Leghorn, the Rhode Island Red, the New Hampshire, the Barred Plymouth Rock, the White Plymouth Rock, the Black Australorp, and the White Minorca has extensively been used in crossbreeding for improving egg production (Maack, 1972). White Plymouth Rock or New Hampshire crossed with White or Silver Cornish or crosses utilizing widely diverse inbred strains within a single breed has equally been used extensively in crossbreeding for improving on broiler lines. As a result of this progressive effort, there has been massive improvements in weight gains and quality as well as plumpy meaty carcasses (Maack, 1972).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area and Duration

The experiment was conducted at the Akenten Appiah Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) Animal farm unit in Asante Mampong Municipality within the Ashanti region of Ghana. Asante Mampong lies in the transitional zone between the Guinea savannah zone of the north and the tropical rain forest of the south of Ghana on latitude 07° 04 North and longitude 01° 24 West and an altitude of about 457m above sea level (Geodatos, 2020). The average annual rainfall in the area is 1270mm, with a mean relative humidity of 70% and a daily temperature range of 25°C to 30°C. The experiment lasted for 8 months as it commenced on 5th August, 2022 and ended on 5th April, 2023.

3.2 Experimental birds

The experiment was conducted in two phases. One hundred and eighty (180) Ross broiler chicks (ROBROC) purchased from Holland Akokor farms in Asuofia was used for phase 1 of the experiment. One hundred and eighty (180) Southern ecotype

indigenous day-old chicks (SEC) from a parent stock in the school farm obtained by artificial incubation was also used for phase 2 of the experiment. The chicks were put into four groups each on the day of arrival by means of randomization whilst they were under brooding with each group comprising of 45 chicks. Breast length (BRL) measurements were taken on the chicks in group 1, back length (BL) on the chicks in group 2, circumference of the head (CH) on the chicks in group 3, and day- old body weight (DOBW) on the chicks in group 4 for both Ross broiler chicks (ROBROC) and Southern ecotype chicks (SEC). BRL, BL and CH were measured using a tailor’s tape whilst DOBW was also measured using a weighing scale. For each group, the values obtained were ranked and in turn classified into three ranges of measurement. The three ranges of measurements were considered as treatments in each of the four groups with each treatment replicated three times.

The ranges were;

Ross broiler Chickens:

	Higher	Medium	Lower
Group 1	5.91-6.45cm,	4.81-5.9cm	4.0cm-4.8cm
Group 2	6.1-6.55cm,	5.46- 6.00cm	5.0-5.45cm
Group 3	6.9-7.2cm	6.4-6.8cm	6-6.3cm
Group 4	70-79g	60-69g	50-59g

Southern ecotype chickens:

	Higher	Medium	Lower
Group1	5.21-6.1cm	4.41-5.2cm	3.7-4.4cm
Group 2	5.61-6.55cm	5.06-5.55cm	4.15-5.05cm
Group 3	5.71-6.30cm	5.41-5.70cm	4.70-5.40cm
Group 4	31-35g	26-30g	20-25g

A total of 36 experimental pens were used for each of the experimental phases 1 and 2 representing the total number of treatments in each phase of the experiment.

3.3 Management of experimental birds

3.3.1 Housing

The birds were managed under deep litter intensive production system. The floor of the house was made of concrete and covered with wood shavings around 4-6 inches deep three days before the chicks arrived. It was done to help absorb water and fecal droppings in order to prevent pathogen built up and enhance optimal performance by the birds. A floor space of 2 square feet was allowed for a bird. Energy saving bulbs were used in the pen to supply enough light for optimal growth and development. The house was divided into 36 experimental pens.

3.3.2 Brooding

Charcoal in earthen wear pots were used to supply the heat. The house was preheated at a temperature of 33°C within 3-4 hours before the birds arrived. The chicks were brooded for 2-3 weeks under a temperature range of 30-33°C and 40-60% humidity. During the brooding period, black polyethene strips were used to cover the vents and open spaces to improve on heat sustenance within the brooder house for optimal performance by the chicks.

3.3.3 Feeding

The broiler chicks were fed on calculated amounts of commercial broiler starter diet containing 21% CP and 2900 Kcal ME/kg from 1-4 weeks of age followed by a finisher diet containing 19% CP and 3000 Kcal ME/kg from 5 – 8 weeks of age. The Southern ecotype indigenous chicks were also fed on calculated amounts of commercial broiler

starter diet containing 21% CP and 2900 Kcal ME/kg from 1-8 weeks of age followed by a finisher diet containing 19% CP and 3000 Kcal ME/kg from 9 – 18 weeks of age. Water was provided to the birds ad libitum.

3.3.4 Diseases and parasites control

Disinfectant (Omnicide) solution was prepared and used to control harmful microorganisms present in the pen, litter and the surroundings of the birds with the aid of a knapsack sprayer. The feed and water troughs as well were also washed thoroughly with detergent, washed in disinfectant solution and dried to make them pathogen free and harmless. A standard vaccination schedule was used as a guide to provide medication for these birds for the entire experimental period according to the standards of the Ghana Veterinary services directorate of Ministry of Food and Agriculture.

3.4 Data collection and parameter estimation

3.4.1 Model for predicting body weight

The simple linear regression model used for predicting final body weight:

$Y = H + \beta X$ simple linear regression model for predicting body weight in Ross and Southern Ecotype chickens.

Where Y = dependent variable (body weight)

X = independent variables (BRL, BL, CH & DOBW)

H = the intercept

β = the slope

Correlation was also determined as;

$$r = \frac{\text{CovXY}}$$

$$\sqrt{(\text{VarX})(\text{VarY})}$$

Where r = correlation coefficient

Cov_{XY} = covariance of X and Y variables

$\sqrt{(\text{Var}X)(\text{Var}Y)}$ = Product of standard deviation of X and Y variables

3.4.2 Phenotypic markers

Phenotypic parameters were taken for both experimental phases 1 and 2. These measurements included Breast length (BRL), Back length (BL), Circumference of the head (CH) and day-old body weight (DOBW). The phenotypic markers were described as follows;

- ❖ **Breast length** as the distance between the mid- region of the breast when positioned ventrally using a tailor's tape.
- ❖ **Back length** as the distance from the nadir of the neck curve to the base of the tail using a tailor's tape.
- ❖ **Circumference of the head** as the circular distance along the mid-region of the head using a tailor's tape.
- ❖ **Day-old body weight (DOBW)** as the weight of the chick at day old using a weighing scale.

3.4.3 Production traits

Production traits measured during the experimental period included, average weekly feed intake (AWFI), average weekly body weight (AWBW), average weekly body weight gain (AWBWG), and feed conversion ratio (FCR). Data on production traits were taken on weekly basis for 8 weeks and biweekly basis for 18 weeks for Ross broilers and Southern ecotype chickens respectively.

The parameters were computed as follows;

- ❖ **Average weekly feed intake (AWFI)**

The total quantity of feed given to the birds less the quantity left after a week divided by the total number of birds;

$$\text{AWFI} = \frac{\text{Feed supplied in a week} - \text{Feed leftover in the week}}{\text{Total number of birds/replicates}}$$

❖ **Average weekly body weight (AWBW)**

The weight a bird gained in a week since the last weight using a weighing scale;

$$\text{AWBW} = \frac{\text{Weekly weight of birds weighed/replicate}}{\text{Number of birds weighed}}$$

❖ **Average weekly body weight gain (AWBWG)**

The weight a bird gained from the current weight less the weight the bird gained during the last weight;

$$\text{AWBWG} = \text{Current average weekly body weight} - \text{Initial average weekly body weight}$$

❖ **Feed conversion ratio (FCR)**

The conventional measure of a bird's production efficiency was feed conversion efficiency (FCR), expressed as grams of feed consumed per unit of body weight gain;

$$\text{FCR} = \frac{\text{Weekly feed consumption/replicate}}{\text{Body weight gain in a week}}$$

3.4.4 Data analysis

The data was managed in mx Excel spreadsheet version 2019 and analyzed using analysis of variance (ANOVA) with Statistix software version 9 and means separated using least significant difference (LSD). Correlation and regression analysis were also determined using Statistix software Version 9.

The statistical model used to analyse the body weight data:

$Y_{ijk} = \mu + S_i + T_j + e_{ijk}$, where

Y_{ijk} = the observed k variable in the i th sex and j th genotype

μ = overall mean of the observed variables

S_i = effect due to i th sex of chickens (i = male and female)

T_j = effect due to j th genotype of chickens (j = Ross and Southern ecotype chickens)

e_{ijk} = random residual error.

CHAPTER FOUR

4.0 RESULTS

4. 1 Results on the effect of phenotypic markers on production traits in Ross broiler chickens (ROBROC).

4.1.1 Effect of phenotypic markers on feed intake in Ross broiler chicken

Table 4.1.1a. Effect of breast length (BRL) as a phenotypic marker on feed intake (FI) in Ross broiler chickens.

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BRL1	202.37	438.99	781.3	1086.0	1330.1	1431.0 ^a	1488.8	1595.9
BRL2	202.50	437.28	779.5	1083.6	1328.0	1429.0 ^b	1486.9	1593.3
BRL3	199.80	441.65	773.6	1083.0	1327.7	1426.8 ^c	1488.6	1594.2
SEM	1.13	3.45	4.17	1.05	1.07	0.59	1.48	0.96
P-value	0.12	0.50	0.27	0.09	0.15	0.01	0.44	0.11

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range,

BRL2: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

There was no significant difference ($P > 0.05$) between T1 (BRL1), T2 (BRL2) and T3 (BRL3) for feed intake in weeks 1,2,3,4,5,7 and 8. Notwithstanding, in week 6, T1 was significantly outstanding ($P < 0.05$) over T2 for feed intake. T1 was also significantly better ($P < 0.05$) than T3 for feed intake. Comparatively, T2 was also significantly

outstanding ($P < 0.05$) over T3 for feed intake. T1 had higher values for feed intake as compared to T2 and T3.

Table 4.1.1b. Effect of back length as a phenotypic marker on feed intake in Ross broiler chickens

^{a-c} indicates significant difference between means within the same column at 5% significant level, **BL1**: back length higher range,

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BL1	201.16	439.67	779.8 ^a	1084.0	1327.8	1428.0 ^a	1488.4 ^a	1593.4 ^a
BL2	201.69	439.94	777.9 ^a	1082.1	1325.8	1426.7 ^b	1486.9 ^b	1592.0 ^b
BL3	198.64	439.67	762.9 ^b	1082.0	1326.3	1426.0 ^b	1486.0 ^c	1592.0 ^b
SEM	1.84	2.03	1.58	0.86	1.46	0.30	0.30	0.43
P-value	0.31	0.98	0.00	0.13	0.43	0.01	0.00	0.04

BL2: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

There was no significant difference ($P > 0.05$) between T1 (BL1), T2 (BL2) and T3(BL3) for feed intake in weeks 1,2,4 and 5. However, in weeks 3,6,7 and 8 there was a significant difference between the treatment means. In weeks 3,6,7 and 8, T1 was significantly superior ($P < 0.05$) over T2 and T3 for feed intake. T2 was also significantly outstanding ($P < 0.05$) over T3 in weeks 3,6, and 7 for feed intake.

Table 4.1.1c. Effect of head circumference as a phenotypic marker on feed intake in Ross broiler chickens

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
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CH1	203.49	443.15 ^a	779.96 ^a	1085.2	1330.1 ^a	1429.8	1489.8	1595.3 ^a
CH2	201.25	441.06 ^{ab}	777.73 ^a	1083.2	1327.9 ^b	1428.0	1487.9	1593.3 ^{ab}
CH3	197.14	435.98 ^b	765.3 ^b	1080.7	1325.4 ^c	1424.0	1483.8	1591.1 ^b
SEM	2.38	2.00	3.14	1.36	0.11	1.79	2.16	1.11
P-value	0.12	0.05	0.02	0.07	0.00	0.07	0.11	0.04

^{a-c} indicate significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

No significant difference ($P > 0.05$) was marked for T1 (CH1), T2 (CH2) and T3 (CH3) in terms of feed intake in weeks 1,4,6 and 7. In weeks 2,3,5 and 8 however, there was a significant difference ($P < 0.05$) associated with T1, T2 and T3 for feed intake. In weeks 2,3,5 and 8, T1 was significantly outstanding ($P < 0.05$) over T2 and T3 for feed intake. T2 was also significantly better ($P < 0.05$) than T3 for feed intake in weeks 2,3,5 and 8. T1 had higher values for feed intake followed by T2 and T3.

Table 4.1.1d. Effect of day-old body weight on feed intake in Ross broiler chickens

TREATMENT S (g)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
DOBW1	200.13	439.43 ^a	775.45 ^a	1081.9 ^a	1326.6 ^a	1426.1 ^a	1489.5	1592.2
DOBW2	197.39	437.26 ^a	774.16 ^a	1078.6 ^{ab}	1323.3 ^b	1423.5 ^a	1484.8	1589.2
DOBW3	192.47	430.27 ^b	757.6 ^b	1073. ^b	1319.8 ^c	1417.6 ^b	1477.3	1584.6
SEM	2.36	1.88	3.67	1.94	0.92	1.45	4.56	2.55
P-value	0.07	0.02	0.01	0.03	0.00	0.01	0.12	0.09

^{a-b} indicate significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

There was no significant difference ($P > 0.05$) between T1 (DOBW1), T2 (DOBW2) and T3 (DOBW3) for feed intake in weeks 1,7 and 8. T1 was significantly superior ($P < 0.05$) over T2 for feed intake in weeks 2,3,4,5 and 6. T1 was also significantly

superior ($P < 0.05$) over T3 for feed intake in weeks 2,3,4,5 and 6. T2 as well was also significantly better ($P < 0.05$) than T3 for feed intake in weeks 2,3,4,5 and 6.

4.1.2 Effect of phenotypic markers on body weight in Ross broiler chickens

Table 4.1.2a. Effect of breast length (BRL) as a phenotypic marker on body weight (BW) in Ross broiler chickens

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BRL1	162.00 ^a	531.00 ^a	948.30 ^a	1520.00 ^a	2205.00 ^a	2761.70 ^a	3451.70 ^a	4015.00 ^a
BRL2	156.67 ^{ab}	515.00 ^b	921.67 ^a	1496.70 ^a	2171.70 ^a	2720.00 ^a	3400.00 ^a	3953.30 ^a
BRL3	143.33 ^b	431.67 ^c	781.67 ^b	1421.70 ^b	2060.00 ^b	2398.30 ^b	2871.70 ^b	3258.30 ^b
SEM	4.81	3.37	31.25	20.93	23.43	27.58	47.16	40.74
P-value	0.04	0.00	0.01	0.02	0.01	0.00	0.00	0.00

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range,

BRL2: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

T1, T2, and T3 exhibited a higher significant superiority ($P < 0.05$) for body weight from week 1 to week 8. T1 (BRL1) for ROBROC were significantly outstanding ($P < 0.05$) over T3 (BRL3) in terms of body weight from week 1 to week 8. There was also a high significant superiority ($P < 0.05$) shown by T2 (BRL2) over T3 (BRL3) for body weight from week 2 to week 8. There was however no significant difference ($P > 0.05$) between T1 (BRL1) and T2 (BRL2) on body weight from week 3 to week 8.

Table 4.1.2b. Effect of back length (BL) as a phenotypic marker on body weight (BW) in Ross broiler chicken

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BL1	168.33	518.33	915.00 ^a	1501.70 ^a	2235.00 ^a	2855.00 ^a	3586.70 ^a	4191.70 ^a
BL2	156.67	505.00	893.33 ^{ab}	1471.70 ^a	2183.30 ^a	2805.00 ^a	3530.00 ^a	4155.00 ^a
BL3	148.33	466.67	806.67 ^b	1380.00 ^b	1931.00 ^b	2378.30 ^b	2968.30 ^b	3368.30 ^b
SEM	8.60	21.73	31.66	17.29	49.86	112.38	166.35	163.97
P-value	0.17	0.15	0.05	0.00	0.01	0.02	0.03	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BL1**: back length higher range, **BL2**: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

There was no significant ($P > 0.05$) difference between T1, T2 and T3 for body weight in weeks 1 and 2. In weeks 3,4,5,6,7 and 8 however, there was a significant difference between T1, T2 and T3 for body weight. T1 was significantly better ($P < 0.05$) than T3 for body weight from week 3 to week 8. T2 was also significantly superior ($P < 0.05$) over T3 for body weight from week 4 to week 8.

Table 4.1.2c. Effect of head circumference (CH) as a phenotypic marker on body weight (BW) in Ross broiler chicken

TREATMENS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
CH1	160.00	501.67 ^a	917.33 ^a	1486.70 ^a	2065.00 ^a	2696.70 ^a	3456.70 ^a	3995.00 ^a
CH2	161.67	508.33 ^a	896.67 ^a	1450.00 ^a	2023.30 ^b	2651.70 ^b	3401.70 ^a	3950.00 ^a
CH3	145.00	416.67 ^b	771.67 ^b	1310.00 ^b	1838.30 ^c	2205.00 ^c	2776.70 ^b	3123.30 ^b
SEM	6.38	27.97	22.05	41.45	6.38	3.96	36.82	33.31
P-value	0.10	0.05	0.01	0.03	0.00	0.00	0.00	0.00

^{a-c} indicates significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

Ross broiler chickens with T1, T2 and T3 did not show significant difference ($P > 0.05$) for body weight in week 1. ROBROC with T1 (CH1) were significantly better ($P < 0.05$) than ROBROC with T3 (CH3) for body weight from week 2 to week 8. T2 (CH2) for ROBROC were also significantly superior ($P < 0.05$) over T3 (CH3) for body weight from week 2 to week 8.

Table 4.1.2d. Effect of day - old body weight (DOBW) on body weight (BW) in Ross broiler chicken

TREATMENTS (g)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
DOBW1	163.33	531.67	923.33 ^a	1515.00 ^a	2253.30 ^a	2885.00 ^a	3615.00 ^a	4221.70 ^a
DOBW2	155.00	516.67	908.33 ^a	1486.70 ^a	2210.00 ^a	2840.00 ^a	3565.00 ^a	4181.70 ^a
DOBW3	153.33	485.00	821.67 ^b	1401.70 ^b	1958.30 ^b	2415.00 ^b	2991.70 ^b	3406.70 ^b
SEM	5.44	18.00	27.82	15.33	41.85	108.09	163.45	165.22
P-value	0.25	0.13	0.04	0.00	0.00	0.02	0.03	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range **SEM**: standard error of means.

No significant difference ($P > 0.05$) was shown by T1, T2 and T3 for body weight in weeks 1 and 2. However, there was a significant difference ($P < 0.05$) shown by the treatment means from week 3 to week 8. T1 (DOBW1) for ROBROC were significantly better ($P < 0.05$) than T3 (DOBW3) on body weight from week 3 to week 8. T2 (DOBW2) for ROBROC were also significantly superior ($P < 0.05$) over T3 (DOBW3) in terms of body weight from week 3 to week 8. For body weight, T1 (DOBW1) for ROBROC were not significantly better ($P > 0.05$) than T2 (DOBW2) from week 1 to week 8.

4.1.3 Results on performance of phenotypic markers on body weight gain (BWG)

Table 4.1.3a. Effect of breast length (BRL) on body weight gain in Ross broiler chickens

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BRL1	102.00	369.0 ^a	417.3	640.0 ^a	685.00	556.67 ^a	690.00 ^a	563.33 ^a
BRL2	96.67	358.33 ^a	406.6	575.0 ^b	675.00	548.33 ^a	680.00 ^a	553.33 ^a
BRL3	90.00	288.33 ^b	350.0	571.6 ^b	638.33	338.33 ^b	473.33 ^b	386.67 ^b
SEM	3.50	4.97	30.03	20.18	26.17	41.05	22.28	17.53
P-value	0.06	0.00	0.16	0.04	0.28	0.01	0.00	0.00

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range,

BRL2: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

There was no significant difference ($P > 0.05$) between T1, T2 and T3 for body weight gain in weeks 1,3 and 5. There was however a significant difference ($P < 0.05$) between T1,T2 and T3 for body weight gain in weeks 2,4,6,7 and 8. T1 (BRL1) for ROBROC were significantly better ($P < 0.05$) than T3 (BRL3) for body weight gain in weeks 2,4,6,7 and 8.

Table 4.1.3b. Effect of back length (BL) as a phenotypic marker on body weight gain in Ross broiler chickens

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BL1	101.67	350.0	396.67 ^a	586.7	733.33	620.00	731.67	605.00 ^a
BL2	93.33	348.3	388.33 ^a	578.3	711.7	621.67	725.00	625.00 ^a
BL3	90.00	318.3	340.0 ^b	573.3	551.67	446.67	590.00	400.00 ^b
SEM	10.27	16.38	13.64	15.87	64.02	63.74	54.71	35.43
P-value	0.55	0.20	0.02	0.71	0.08	0.08	0.10	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BL1**: back length higher range,

BL2: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

No significant difference was shown by T1, T2 and T3 for body weight gain in weeks 1,2,4,5,6 and 7. There was a significant difference in weeks 3 and 8 for body weight gain between T1, T2 and T3. In weeks 3 and 8, T1 was significantly better ($P < 0.05$) than T3 for body weight gain. T2 was also significantly superior ($P < 0.05$) over T3 for body weight gain in weeks 3 and 8. The body weight gain values obtained by T1 was higher followed by T2 and T3.

Table 4.1.3c. Effect of head circumference (CH) as a phenotypic marker on body weight gain in Ross broiler chickens

TREATMENTS (cm)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
CH1	95.00	341.7	415.6 ^a	569.3	578.33	631.67 ^a	760.00 ^a	538.33 ^a
CH2	98.33	346.7	388.3 ^b	553.3	573.33	628.33 ^a	750.00 ^a	548.33 ^a
CH3	88.33	271.7	355.0 ^c	538.3	528.33	366.67 ^b	571.67 ^b	346.67 ^b
SEM	5.44	27.03	9.75	56.59	38.51	7.57	33.36	40.78
P-value	0.28	0.08	0.01	0.86	0.43	0.00	0.01	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

The three ranges of head circumference measurement (T1, T2 and T3) showed no significant difference ($P > 0.05$) for body weight gain in weeks 1,2,4 and 5. In weeks 3,6,7 and 8, the three treatments showed a significant difference ($P < 0.05$) for body weight gain. T1 was significantly outstanding ($P < 0.05$) over T3 in weeks 3,6,7 and 8 for body weight gain. T2 was also significantly better ($P < 0.05$) than T3 for body weight gain in weeks 3,6,7 and 8

Table 4.1. 3d: Effect of day-old body weight (DOBW) on body weight gain in Ross broiler chickens

TREATMENTS (g)	WK 1 (g)	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
DOBW1	98.333	368.33	391.67	591.6	738.3 ^a	631.67	730.00	606.67 ^a
DOBW2	90.00	361.67	391.67	578.33	723.33 ^a	630.00	725.00	616.67 ^a
DOBW3	95.00	331.67	336.67	580.00	556.6 ^b	456.67	576.67	415.0 ^b
SEM	5.18	15.15	20.34	16.99	53.27	67.30	55.54	33.40
P-value	0.36	0.14	0.08	0.71	0.04	0.09	0.08	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

The three treatments for day-old body weight (DOBW1, DOBW2 and DOBW3) as a marker were not significantly different ($P > 0.05$) in weeks 1,2,3,4,6 and 7 for body weight gain. There was however a significant difference ($P < 0.05$) shown by the three treatments in weeks 5 and 8 for body weight gain. T1 was significantly superior ($P < 0.05$) over T3 in weeks 5 and 8 for body weight gain. Likewise, T2 was also significantly outstanding ($P < 0.05$) over T3 for body weight gain in weeks 5 and 8.

4.1.4 Effect of phenotypic markers on feed conversion ratio (FCR)

Table 4.1.3a: Effect of breast length (BRL) as a phenotypic marker on feed conversion ratio in Ross broiler chickens

TREATMENTS (cm)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BRL1	1.98	1.19 ^b	1.87	1.90 ^a	1.94	2.58 ^b	2.16 ^b	2.83 ^b
BRL2	2.09	1.22 ^b	1.92	1.89 ^a	1.97	2.63 ^b	2.19 ^b	2.88 ^b
BRL3	2.23	1.53 ^a	2.26	1.71 ^b	2.08	4.24 ^a	3.14 ^a	4.14 ^a
SEM	0.08	0.04	0.18	0.05	0.07	0.32	0.10	0.14
P-value	0.10	0.00	0.18	0.03	0.27	0.01	0.00	0.00

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range,

BRL2: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

For feed conversion ratio, the three ranges of breast length measurement as a treatment (BRL1, BRL2 and BRL3) were not significantly different ($P > 0.05$) in weeks 1,3 and 5. The three treatments were significantly different ($P < 0.05$) for feed conversion ratio in weeks 2,4,6,7 and 8. T1 for ROBROC were significantly better ($P < 0.05$) than T3 for feed conversion ratio in weeks 2,4,6,7 and 8. This indicates that, T1 had lower values for FCR indicating a higher feed conversion efficiency as compared to T3. ROBROC with T2 were also significantly superior ($P < 0.05$) over ROBROC with T3 for feed conversion ratio in weeks 2, 6,7 and 8.

Table 4.1.4b: Effect of back length (BL) as a phenotypic marker on feed conversion ratio in Ross broiler chickens

TREATMENTS (cm)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
BL1	1.98	1.25	1.96 ^b	1.85	1.81	3.21	2.05	2.63 ^b
BL2	2.19	1.26	2.00 ^b	1.88	1.86	2.34	2.06	2.55 ^b
BL3	2.22	1.39	2.25 ^a	1.89	2.45	2.34	2.52	4.02 ^a
SEM	0.22	0.07	0.08	0.05	0.23	0.31	0.18	0.27
P-value	0.53	0.20	0.05	0.79	0.09	0.07	0.10	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BL1**: back length higher range,

BL2: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

T1, T2 and T3 for ROBROC were not significantly different ($P > 0.05$) for feed conversion ratio in weeks 1,2,4,5,6 and 7. However, T1, T2 and T3 showed a significant difference ($P < 0.05$) for feed conversion ratio in weeks 3 and 8. T1 were significantly superior ($P < 0.05$) over T3 for feed conversion ratio in weeks 3 and 8. T2 were also significantly superior ($P < 0.05$) over T3 for feed conversion ratio in weeks 3 and 8. T1 had lower FCR values translating into higher feed conversion efficiencies followed by T2 and T3.

Table 4.1.4c: Effect of head circumference (CH) as a phenotypic marker on feed conversion ratio in Ross broiler chickens

TREATMENTS (cm)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
CH1	2.14	1.32	1.87 ^b	1.93	2.32	2.26 ^b	1.96 ^b	2.97 ^b
CH2	2.05	1.29	2.00 ^b	1.98	2.33	2.27 ^b	1.98 ^b	2.92 ^b
CH3	2.23	1.60	2.15 ^a	2.01	2.51	3.88 ^a	2.60 ^a	4.63 ^a
SEM	0.10	0.12	0.04	0.19	0.17	0.03	0.12	0.39
P-value	0.31	0.10	0.01	0.91	0.52	0.00	0.01	0.02

^{a-b} indicate significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

The three treatments (CH1, CH2 and CH3) associated with head circumference as a marker were not significantly different ($P > 0.05$) for feed conversion ratio in weeks 1,2,4 and 5. The three treatments (CH1, CH2 and CH3) however were significantly different ($P < 0.05$) in weeks 3,6,7 and 8 for feed conversion ratio. T1 were significantly better ($P < 0.05$) than T3 for feed conversion ratio in weeks 3,6,7 and 8. This indicates that, the FCR values obtained by T1 were lower and better than that obtained by T3 corresponding to higher feed conversion efficiencies. T2 were also significantly better ($P < 0.05$) than T3 for feed conversion ratio in weeks 3,6,7 and 8 characterized by higher feed conversion efficiencies.

Table 4.1.4d: Effect of day-old body weight (DOBW) on feed conversion ratio in Ross broiler chickens

TREATMENTS (g)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
DOBW1	2.03	1.19	1.98	1.83	1.79 ^b	2.30	2.06	2.62 ^b
DOBW2	2.19	1.20	1.97	1.87	1.83 ^b	2.30	2.06	2.58 ^b
DOBW3	2.02	1.30	2.26	1.85	2.40 ^a	3.12	2.57	3.84 ^a
SEM	0.10	0.06	0.11	0.05	0.19	0.32	0.18	0.23
P-value	0.30	0.24	0.10	0.79	0.05	0.10	0.08	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

For ROBROC, T1, T2 and T3 were not significantly different ($P > 0.05$) for feed conversion ratio in weeks 1,2,3,4,6 and 7. Week 5 and 8 however showed a significant difference between the three treatments (T1, T2 and T3) in terms of feed conversion ratio. T1 were significantly better ($P < 0.05$) than T3 for feed conversion ratio in weeks 5 and 8. T2 were also significantly outstanding ($P < 0.05$) over T3 for feed conversion ratio in weeks 5 and 8. The FCR values obtained by T1 were higher and characterized by higher feed conversion efficiency as compared to T2 and T3.

4.2 Effect of phenotypic markers on production traits in Southern ecotype chicken

(SEC)

4.2.1 Effect of phenotypic markers on feed intake for Southern ecotype chicken

Table 4.2.1a: Effect of breast length (BRL) on feed intake in Southern ecotype chickens

^{a-c} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range,

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
BRL1	94.03 ^a	126.50 ^a	156.23 ^a	192.03 ^a	227.60 ^a	253.13 ^a	277.73 ^a	293.40 ^a	316.20 ^a
BRL2	87.00 ^a	115.77 ^b	143.60 ^b	175.80 ^a	215.47 ^a	241.50 ^a	265.40 ^a	281.53 ^a	296.63 ^a
BRL3	71.30 ^b	96.40 ^c	126.63 ^c	147.20 ^b	182.63 ^b	209.77 ^b	233.53 ^b	249.70 ^b	269.20 ^b
SEM	3.49	3.44	3.62	7.03	5.57	6.37	7.59	9.44	7.62
P-value	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01

BRL2: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

The three treatments (BRL1, BRL2 and BRL3) associated with breast length as a marker in SEC were significantly different ($P < 0.05$) for feed intake from week 2 to week 18. T1 characterized by higher feed intake values were significantly superior ($P < 0.05$) over T3 for feed intake from week 2 to week 18. T1 was also significantly better ($P < 0.05$) than T2 for feed intake in only weeks 4 and 6. T2 as well were significantly outstanding ($P < 0.05$) over T3 for feed intake from week 2 to week 18 marked by higher feed intake values.

Table 4.2.1b: Effect of back length (BL) as a phenotypic marker on feed intake in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
BL1	97.03 ^a	122.70 ^a	151.57 ^a	186.17 ^a	219.47 ^a	250.77 ^a	272.13 ^a	289.77 ^a	310.27 ^a
BL2	90.00 ^a	113.73 ^b	146.33 ^a	177.90 ^a	212.87 ^a	241.87 ^a	263.27 ^a	278.40 ^a	293.73 ^a
BL3	73.30 ^b	97.27 ^c	126.47 ^b	150.50 ^b	185.03 ^b	212.33 ^b	229.83 ^b	243.37 ^b	262.27 ^b
SEM	3.58	3.06	4.65	8.65	5.89	6.91	7.96	10.86	9.08
P-value	0.01	0.00	0.01	0.03	0.01	0.01	0.01	0.03	0.01

^{a-c} indicates significant difference between means within the same column at 5% significant level, **BL1**: back length higher range,

BL2: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

The three ranges of back length measurement (BL1, BL2 and BL3) associated with SEC and designed as treatments were significantly different ($P < 0.05$) for feed intake from week 2 to week 18. T1 for SEC had higher feed intake values and were significantly superior ($P < 0.05$) over T3 for FI from week 2 to week 18. T1 were significantly superior ($P < 0.05$) over T2 for feed intake in only weeks 4 and 6. T2 were also significantly better ($P < 0.05$) than T3 for feed intake from week 2 to week 18 characterized by higher and outstanding FI values.

Table 4.2.1c: Effect of head circumference (CH) as a phenotypic marker on feed intake in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
CH1	95.66 ^a	173.37 ^a	156.73 ^a	190.63 ^a	230.03 ^a	248.77 ^a	277.73 ^a	286.43 ^a	321.63 ^a
CH2	88.66 ^b	111.40 ^b	151.37 ^a	181.77 ^a	223.00 ^b	239.83 ^a	267.80 ^b	275.37 ^a	308.50 ^b
CH3	71.60 ^c	94.60 ^b	131.63 ^b	157.13 ^b	202.37 ^c	210.33 ^b	244.50 ^c	240.63 ^b	286.03 ^c
SEM	2.11	19.22	4.78	7.36	1.74	6.92	3.00	10.76	2.09
P-value	0.00	0.03	0.01	0.02	0.00	0.01	0.00	0.03	0.00

^{a-c} indicate significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

Head circumference as a marker in three ranges noted as treatments were significantly different ($P < 0.05$) for feed intake from week 2 to week 18. T1 (CH1) for SEC were significantly better ($P < 0.05$) than T3 (CH3) for feed intake from week 2 to week 18 marked by higher FI values. T1 (CH1) for SEC were significantly better ($P < 0.05$) than T2 (CH2) for feed intake as well in weeks 2,4,10,14 and 18. T2 (CH2) for SEC were also significantly superior ($P < 0.05$) over T3 (CH3) for feed intake in weeks 2,6,8,10,12,14,16, and 18.

Table 4.2.1d: Effect of day-old body weight (DOBW) on feed intake in Southern ecotype chickens

TREATMENTS (g)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
DOBW1	93.77 ^a	124.90 ^a	161.33 ^a	189.26 ^a	232.78 ^a	255.93 ^a	275.29 ^a	296.06 ^a	322.00 ^a
DOBW2	87.66 ^a	117.49 ^a	146.61 ^b	173.47 ^a	218.83 ^a	241.05 ^b	262.61 ^a	282.06 ^a	299.73 ^a
DOBW3	74.17 ^b	99.77 ^b	131.11 ^c	150.77 ^b	186.37 ^b	213.97 ^c	230.74 ^b	252.13 ^b	270.82 ^b
SEM	2.94	3.06	3.39	6.92	5.75	4.46	7.83	8.30	8.48
P-value	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01

^{a-c} indicates significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

Day- old body weight as a phenotypic marker in three ranges noted as treatments were significantly different ($P < 0.05$) for feed intake from week 2 to week 18. T1 (DOBW1) for SEC were significantly better ($P < 0.05$) than T3 (DOBW3) for feed intake from week 2 to week 18 associated with higher FI values and peaked performance. T2 (DOBW2) for SEC were also significantly superior ($P < 0.05$) over T3 for feed intake from week 2 to week 18. However, T1 for SEC were significantly superior ($P < 0.05$) over T2 for feed intake in only weeks 6 and 12.

4.2.2 Effect of phenotypic markers on body weight in Southern ecotype chicken

Table 4.2.2a: Effect of breast length (BRL) as a phenotypic marker on body weight in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
BRL1	83.00 ^a	222.67 ^a	352.00 ^a	531.67 ^a	698.33 ^a	850.00 ^a	1018.30 ^a	1153.30 ^a	1301.70 ^a
BRL2	81.66 ^a	208.33 ^a	310.00 ^a	478.33 ^a	623.33 ^b	721.67 ^b	843.30 ^b	961.70 ^b	1096.70 ^b
BRL3	56.66 ^b	134.33 ^b	218.33 ^b	345.00 ^b	456.67 ^c	576.67 ^c	700.00 ^c	805.70 ^c	901.70 ^c
SEM	6.19	8.41	22.57	28.23	24.53	28.80	33.57	35.19	38.37
P-value	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00

^{a-c} indicates significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range, **BRL2**: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

The three ranges for breast length (BRL1, BRL2, BRL3) as a phenotypic marker which were categorized and used as treatments were significantly different ($P < 0.05$) for body weight in SEC from week 2 to week 18. T1 (BRL1) for SEC were significantly superior ($P < 0.05$) over T3 (BRL3) for body weight from week 2 to week 18 consistently associated with higher FI values and outstanding performance. T2 (BRL2) for SEC were significantly better ($P < 0.05$) as well than T3 (BRL3) for body weight from week 2 to week 18. T1 for SEC were also significantly superior ($P < 0.05$) over T2 for body weight from week 10 to week 18.

Table 4.2.2b: Effect of back length (BL) as a phenotypic marker on body weight in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
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BL1	90.00 ^a	224.00 ^a	341.67 ^a	521.67 ^a	703.33 ^a	846.67 ^a	996.67 ^a	1141.70 ^a	1286.70 ^a
BL2	81.66 ^a	188.33 ^b	275.00 ^b	410.00 ^b	551.67 ^b	675.00 ^b	820.00 ^b	931.70 ^b	1053.30 ^b
BL3	55.00 ^b	132.00 ^c	214.33 ^c	334.33 ^c	441.67 ^c	555.00 ^c	676.67 ^c	783.30 ^c	891.70 ^c
SEM	5.18	7.43	13.27	12.45	18.00	19.05	19.19	16.38	19.84
P-value	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

^{a-c} indicate significant difference between means within the same column at 5% significant level, **BL1**: back length higher range, **BL2**: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

There was a significant difference ($P < 0.05$) between the three treatments associated with back length for SEC from week 2 to week 18 for body weight. T1 (BL1) for SEC were significantly superior ($P < 0.05$) over T3 (BL3) for body weight from week 2 to week 18 highly marked by higher BW values. T2 (BL2) for SEC were also significantly superior ($P < 0.05$) over T3 (BL3) for body weight form week 2 to week 18. T1 (BL1) for SEC were significantly better ($P < 0.05$) than T2 (BL2) for body weight from week 4 to week 18.

Table 4.2.2c: Effect of head circumference (CH) as a phenotypic marker on body weight in Southern ecotype chickens

TREATMENTS	WK 2	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
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(cm)	(g)								
CH1	78.66 ^a	206.67 ^a	332.67 ^a	515.00 ^a	675.00 ^a	825.00 ^a	980.00 ^a	1113.30 ^a	1256.70 ^a
CH2	75.00 ^a	161.67 ^b	260.00 ^b	416.67 ^b	568.33 ^b	678.33 ^b	793.33 ^b	931.70 ^b	1056.70 ^b
CH3	53.33 ^b	141.67 ^b	217.33 ^b	346.67 ^b	465.00 ^c	581.67 ^b	710.00 ^b	813.30 ^b	928.30 ^b
SEM	6.98	15.72	25.70	32.64	35.96	43.07	48.61	58.35	64.69
P-value	0.04	0.03	0.03	0.02	0.01	0.01	0.01	0.02	0.02

^{a-c} indicates significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

Head circumference in three ranges (CH1, CH2 and CH3) as a phenotypic marker in Southern ecotype chickens were significantly different ($P < 0.05$) for body weight from week 2 to week 18. SEC with T1 (CH1) were significantly better ($P < 0.05$) than the T3(CH3) for body weight from week 2 to week 18 marked by higher and outstanding BW values. SEC with T1 (CH1) were significantly better ($P < 0.05$) than T2 (CH2) for body weight from week 4 to week 18. However, T2 for SEC were significantly superior ($P < 0.05$) over T3 for body weight in weeks 2 and 10.

Table 4.2.2d: Effect of day – old body weight (DOBW) on body weight in Southern ecotype chickens

^{a-c} indicates significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight

TREATMENTS (g)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
DOBW1	91.66 ^a	228.33 ^a	346.67 ^a	531.67 ^a	708.33 ^a	828.33 ^a	986.67 ^a	1093.30 ^a	1233.30 ^a
DOBW2	83.33 ^{ab}	195.00 ^b	268.33 ^b	406.67 ^b	573.33 ^b	688.33 ^b	820.00 ^b	930.00 ^b	1038.30 ^b
DOBW3	80.00 ^b	158.33 ^c	225.00 ^c	340.00 ^c	463.33 ^c	571.67 ^c	653.33 ^c	793.30 ^c	905.00 ^c
SEM	3.33	5.44	6.66	11.14	16.24	21.51	11.30	12.87	20.11
P-value	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

Day-old body weight as a phenotypic marker in three ranges were significantly different ($P < 0.05$) for body weight from week 2 to week 18 characterized by higher variation in BW values. T1 (DOBW1) for SEC were significantly better ($P < 0.05$) than T3 (DOBW3) for body weight from week 2 to week 18. T1 (DOBW1) for SEC were also significantly better ($P < 0.05$) than T2 (DOBW2) for body weight from week 2 to week 18. T2 for SEC were also significantly better ($P < 0.05$) than T3 for body weight from week 4 to week 18.

4.2.3 Effect of phenotypic markers on body weight gain in Southern ecotype chickens

Table 4.2.3a: Effect of breast length (BRL) as a phenotypic marker on body weight gain in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
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BRL1	53.00 ^a	139.67 ^a	129.33	179.67 ^a	166.67 ^a	151.67 ^a	168.33 ^a	135.00 ^a	148.33 ^a
BRL2	53.33 ^a	126.67 ^a	101.67	168.33 ^a	111.67 ^b	98.33 ^b	121.67 ^b	118.33 ^b	135.00 ^a
BRL3	26.66 ^b	77.67 ^b	84.00	126.67 ^b	145.00 ^a	120.00 ^b	123.33 ^b	105.67 ^c	96.00 ^b
SEM	4.66	6.75	16.76	6.15	10.09	8.97	5.18	2.90	8.11
P-value	0.01	0.00	0.12	0.00	0.01	0.01	0.00	0.00	0.01

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range, **BRL2**: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

There was a significant difference ($P < 0.05$) between the three treatments (BRL1, BRL2 and BRL3) associated with breast length for body weight gain in weeks 2,4,8,10,12,14,16 and 18. There was however no significant difference ($P > 0.05$) between T1, T2 and T3 for body weight gain in week 6. T1 was significantly superior ($P < 0.05$) over T3 in weeks 2,4,8,12,14,16 and 18 for body weight gain marked by higher and better BWG values. T1 was also significantly better ($P < 0.05$) than T2 for body weight gain in weeks 10,12,14 and 16. T2 as well was significantly outstanding ($P < 0.05$) over T3 in weeks 2,4,8,16 and 18 for BWG. T1 was also significantly better ($P < 0.05$) than T2 in weeks 10,12,14 and 16 for body weight gain.

Table 4.2.3b: Effect of back length (BL) as a phenotypic marker on body weight gain in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
BL1	56.66 ^a	134.00 ^a	117.67 ^a	180.00 ^a	181.67 ^a	143.33 ^a	150.00 ^a	145.00 ^a	145.00 ^a
BL2	55.00 ^a	106.67 ^b	86.67 ^b	135.00 ^b	141.67 ^b	123.33 ^b	145.00 ^a	111.67 ^b	121.67 ^b
BL3	32.00 ^b	77.00 ^c	82.33 ^b	120.00 ^b	107.33 ^c	113.33 ^b	121.67 ^b	106.67 ^b	108.33 ^b

SEM	3.64	3.52	9.34	9.17	10.91	4.08	8.27	8.44	6.01
P-value	0.00	0.00	0.04	0.01	0.01	0.00	0.05	0.02	0.01

^{a-c} indicates significant difference between means within the same column at 5% significant level, **BL1**: back length higher range,

BL2: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

Back length in three ranges as a phenotypic marker in SEC were significantly different ($P < 0.05$) for body weight gain from week 2 to week 18. T1 for SEC were significantly better ($P < 0.05$) than T3 in terms of body weight gain from week 2 to week 18 characterized by higher and better BWG values. T1 for SEC were significantly superior ($P < 0.05$) over T2 for body weight gain in weeks 4,6,8,10,12,16 and 18. T2 for SEC however were significantly superior ($P < 0.05$) over T3 for body weight gain in weeks 2,4,10 and 14.

Table 4.2.3c: Effect of head circumference (CH) as a phenotypic marker on body weight gain in Southern ecotype chickens

TREATMENTS (cm)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
CH1	48.66 ^a	128.00 ^a	126.00 ^a	182.33 ^a	160.00 ^a	150.00	155.00 ^a	133.33	143.33 ^a
CH2	48.33 ^a	86.67 ^b	98.33 ^{ab}	156.67 ^{ab}	151.67 ^a	116.67	128.33 ^b	138.33	125.00 ^b

CH3	31.00 ^b	88.33 ^b	75.67 ^b	129.33 ^b	118.33 ^b	110.00	115.00 ^b	103.33	115.00 ^b
SEM	4.19	10.40	12.92	10.88	9.42	16.64	8.44	12.13	6.59
P-value	0.02	0.03	0.04	0.02	0.02	0.14	0.02	0.08	0.03

^{a-c} indicates significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

There was a significant difference ($P < 0.05$) between T1, T2 and T3 for body weight gain in weeks 2,4,6,8,10,14 and 18. However in weeks 12 and 16, T1, T2 and T3 were not significantly different ($P > 0.05$) for body weight gain. T1 for SEC were marked with high significant superiority ($P < 0.05$) over T3 for body weight gain in weeks 2,4,6,8,10,14, and 18. T1 for SEC had better values ($P < 0.05$) than T2 for body weight gain in weeks 4,6,8,14 and 18. T2 for SEC in week 16 however were significantly better ($P < 0.05$) than T1 for body weight gain. T2 for SEC were also significantly superior ($P < 0.05$) over T3 for body weight gain in weeks 2,10 and 16.

Table 4.2.3d: Effect of day-old body weight (DOBW) on body weight gain in Southern ecotype chicken

TREATMENTS (g)	WK 2 (g)	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
DOBW1	58.33 ^a	136.67 ^a	118.33 ^a	185.00 ^a	176.67 ^a	120.00	158.33 ^a	106.67 ^b	140.00 ^a
DOBW2	53.33 ^b	111.67 ^b	73.33 ^b	138.33 ^b	166.67 ^a	115.00	131.67 ^a	110.00 ^b	108.33 ^b

DOBW3	56.66 ^{ab}	78.33 ^c	66.67 ^b	115.00 ^c	123.33 ^b	108.33	81.67 ^b	140.00 ^a	111.67 ^b
SEM	1.36	2.72	2.72	7.20	14.01	16.47	10.88	2.72	8.50
P-value	0.05	0.00	0.00	0.00	0.04	0.78	0.00	0.00	0.03

^{a-c} indicates significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

SEC with T1, T2 and T3 were significantly different ($P < 0.05$) for body weight gain in weeks 2,4,6,8,10,14,16 and 18. In week 12 however, SEC with T1, T2 and T3 were not significantly different ($P > 0.05$) for body weight gain. T1 for SEC were significantly better ($P < 0.05$) than T3 for body weight gain in weeks 2,4,6,8,10,14, and 18 referenced by higher and better BWG values. T1 for SEC were significantly better ($P < 0.05$) than T2 for body weight gain in weeks 4,6,8 and 18. T2 was Significantly superior ($P < 0.05$) than T3 for body weight in weeks 4,8,10, and 14. T3 was also significantly outstanding ($P < 0.05$) over T2 for body weight gain in week 16.

4.2.4 Effect of phenotypic markers on feed conversion ratio in Southern ecotype chickens.

Table 4.2.4a. Effect of breast length (BRL) as a phenotypic marker on feed conversion ratio in Southern ecotype chickens

TREATMENTS (cm)	WK 2	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
BRL1	1.81 ^b	0.90	1.21	1.06	1.37	1.67 ^b	1.65 ^b	2.17	2.13 ^b
BRL2	1.63 ^b	0.91	1.49	1.04	1.50	2.46 ^a	2.19 ^a	2.37	2.21 ^b

BRL3	2.69 ^a	1.26	1.53	1.17	1.64	1.78 ^b	1.92 ^{ab}	2.36	2.81 ^a
SEM	0.15	0.12	0.31	0.10	0.10	0.18	0.14	0.12	0.21
P-value	0.01	0.07	0.57	0.47	0.13	0.02	0.04	0.29	0.05

^{a-b} indicate significant difference between means within the same column at 5% significant level, **BRL1**: breast length higher range,

BRL2: breast length medium range, **BRL3**: breast length lower range, **SEM**: standard error of means.

SEC with T1, T2 and T3 were significantly ($P < 0.05$) different for feed conversion ratio in weeks 2,12,14 and 18. However, T1, T2 and T3 for SEC were not significantly different ($P > 0.05$) for feed conversion ratio in weeks 4,6,8,10 and 16. T1 for SEC had lower but better values ($P < 0.05$) than T3 for FCR in weeks 2 and 18. T1 for SEC were also significantly better ($P < 0.05$) than T2 for FCR in week 12 and 14 marked by lower but better values. T2 for SEC were significantly superior ($P < 0.05$) over T3 for FCR in week 2 and week 18.

Table 4.2.4b: Effect of back length (BL) as a phenotypic marker on feed conversion ratio in Southern ecotype chickens

TREATMENTS (cm)	WK 2	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
BL1	1.72 ^b	0.91 ^b	1.29	1.03 ^b	1.20 ^b	1.76	1.82	2.02 ^b	2.14
BL2	1.65 ^b	1.06 ^{ab}	1.72	1.32 ^a	1.52 ^{ab}	1.97	1.81	2.50 ^a	2.42
BL3	2.29 ^a	1.27 ^a	1.53	1.25 ^{ab}	1.72 ^a	1.88	1.89	2.28 ^{ab}	2.42
SEM	0.14	0.08	0.14	0.08	0.12	0.09	0.16	0.10	0.11

P-value	0.01	0.02	0.09	0.05	0.02	0.18	0.87	0.02	0.10
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^{a-b} indicate significant difference between means within the same column at 5% significant level, **BL1**: back length higher range,

BL2: back length medium range, **BL3**: back length lower range, **SEM**: standard error of means.

The three ranges for back length associated with Southern ecotype chickens were significantly different ($P < 0.05$) for feed conversion ratio in weeks 2,4,8,10 and 16. However, the three ranges for back length were not significantly different ($P > 0.05$) for FCR in weeks 6,12,14 and 18. SEC with T1 had lower but better values ($P < 0.05$) than SEC with T3 for feed conversion ratio in weeks 2,4 and 10. SEC with T1 had lower but superior values ($P < 0.05$) than SEC with T2 in weeks 8 and week 16. However, SEC with T2 were significantly superior ($P < 0.05$) over SEC with T3 for FCR in only week 2.

Table 4.2.4c: Effect of head circumference (CH) as a phenotypic marker on feed conversion ratio in Southern ecotype chickens

TREATMENTS (cm)	WK 2	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
CH1	1.98	1.35	1.25	1.04	1.45	1.69	1.80 ^b	2.19	2.24
CH2	1.83	1.29	1.55	1.16	1.47	2.19	2.35 ^a	2.00	2.47
CH3	2.36	1.09	1.77	1.24	1.71	1.85	1.90 ^b	2.35	2.49

SEM	0.21	0.19	0.24	0.14	0.09	0.22	0.12	0.26	0.13
P-value	0.14	0.43	0.21	0.47	0.08	0.18	0.02	0.49	0.21

^{a-c} indicates significant difference between means within the same column at 5% significant level, **CH1**: head circumference higher range, **CH2**: head circumference medium range, **CH3**: head circumference lower range, **SEM**: standard error of means.

The three ranges of head circumference as a marker associated with the Southern ecotype chickens were not significantly different ($P > 0.05$) for FCR in weeks 2,4,6,8,10,12,16 and 18. However, T1, T2 and T3 were significantly different ($P < 0.05$) for FCR in only week 14. In week 14, T1 for SEC had lower but superior values ($P < 0.05$) than T3 for FCR. T3 for SEC also had better values ($P < 0.05$) than T2 for FCR in week 14.

Table 4.2.4d: Effect of day-old body weight (DOBW) on feed conversion ratio in Southern ecotype chickens

TREATMENTS (g)	WK 2	WK 4	WK 6	WK 8	WK 10	WK 12	WK 14	WK 16	WK18
DOBW1	1.61 ^a	0.91 ^b	1.36 ^b	1.03 ^b	1.319	2.23	1.74 ^b	2.77 ^a	2.32 ^b
DOBW2	1.64 ^a	1.05 ^b	2.00 ^a	1.25 ^a	1.33	2.13	2.02 ^{ab}	2.56 ^b	2.78 ^a

DOBW3	1.30 ^b	1.28 ^a	1.96 ^a	1.31 ^a	1.51	1.97	2.84 ^a	1.80 ^c	2.43 ^b
SEM	0.04	0.06	0.05	0.06	0.11	0.24	0.29	0.05	0.10
P-value	0.00	0.01	0.00	0.03	0.28	0.59	0.04	0.00	0.02

^{a-c} indicates significant difference between means within the same column at 5% significant level, **DOBW1**: day old body weight higher range, **DOBW2**: day old body weight medium range, **DOBW3**: day old body weight lower range, **SEM**: standard error of means.

T1, T2 and T3 associated with SEC in relation to day-old body weight as a marker were significantly different ($P < 0.05$) for FCR in weeks 2,4,6,8,14,16 and 18. In weeks 10 and 12 however, the three treatments (DOBW1, DOBW2 and DOBW3) for day-old body weight were not significantly different ($P > 0.05$) for FCR. T1 for SEC were significantly better ($P < 0.05$) than T3 for FCR in weeks 4,6,8 and 14. T3 were also significantly better ($P < 0.05$) than T1 for FCR in weeks. T1 for SEC had lower but better values ($P < 0.05$) than T2 for FCR in weeks 6,8 and 18. Notwithstanding, T2 had lower but superior values ($P < 0.05$) than T1 for FCR in week 16. T3 for SEC had better values ($P < 0.05$) than T2 for FCR in week 2 and 18. T2 for SEC also had better values ($P < 0.05$) than T3 for FCR in week 4 and 14.

4.3 Correlation between phenotypic markers on body weight gain in Ross broiler chickens and Southern ecotype chickens

Table 4.3.a: Correlation Matrix among breast length, back length, head circumference and day-old body weight on body weight gain in Ross broiler chickens

	1	2	3	4
1. Breast length	1	0.940*	0.970*	0.940*

2. Back length	1	0.900*	0.990*
3. Head circumference		1	0.890*
4. Day old body weight			1

Numbers against the parameters in columns correspond with variables in rows

* = significant at $p < 0.05$

There was a significant positive correlation between breast length and back length for body weight gain marked by a correlation coefficient of 0.94. With a correlation coefficient of 0.97, there was a high positive correlation between breast length and head circumference. A high positive correlation existed between breast length and day-old body weight on body weight gain with a correlation coefficient of 0.94. The correlation between back length and head circumference was characterized by a correlation coefficient of 0.90. Back length and day-old body weight also exhibited an extremely stronger positive correlation for body weight gain with a correlation coefficient value of 0.99. Head circumference and day-old body weight also showed a high positive correlation for body weight gain with a correlation coefficient value of 0.89 significant at ($P \leq 0.05$).

Table 4.3b: Correlation Matrix among breast length, back length, head circumference and day-old body weight on body weight gain in Southern ecotype chickens

	1	2	3	4
1. Breast length	1	0.930*	0.860*	0.910*
2. Back length		1	0.940*	0.930*
3. Head circumference			1	0.910*

Numbers against the parameters in columns correspond with variables in rows * = significant at $p < =0.05$

A high positive correlation marked by a correlation coefficient value of 0.93 was associated with breast length and back length on body weight gain. There was a high correlation between breast length and head circumference on body weight gain with a correlation coefficient of 0.86. Remarkably, there was a high positive correlation between breast length and day-old body weight for body weight gain with a correlation coefficient of 0.91. Back length and head circumference also saw a high positive correlation for body weight gain with a correlation coefficient of 0.94. With a correlation coefficient of 0.93, there was a strong positive correlation between back length and day-old body weight for body weight gain. A high positive correlation with a correlation coefficient of 0.91 was attributed to head circumference and day-old body weight for body weight gain.

4.4 Linear regression of phenotypic markers on body weight using simple linear regression models in Ross and Southern ecotype chickens

Table 4.4a: Linear regression of phenotypic markers on body weight in Ross broiler chickens

MARKERS	PREDICTION EQUATIONS	R ²	ADJUSTED R ²	LS
BRL	BW= 1350.070 + 445.460BRL	0.710	0.670	*
BL	BW= -970.800 + 845.510BL	0.680	0.640	*

CH	BW= -2994.460 + 1014.250CH	0.760	0.730	*
DOBW	BW= 778.540 + 50.940DOBW	0.640	0.600	*

BW- body weight, BRL- breast length, BL- back length, CH- circumference of the head, DOBW- day old body weight, R² – coefficient of determination, LS- level of significance, *significant at P<0.005

There was a significant (P < 0.05) linear relationship between body weight of Ross broilers and BRL, BL, CH, and DOBW. It can also be seen that body weight could easily be predicted from the four measurements considering the highly significant (P < 0.05) R² values ranging from 0.64 – 0.76.

Table 4.4b: Linear regression of phenotypic markers on body weight in Southern ecotype chickens

MARKERS	PREDICTION EQUATIONS	R ²	ADJUSTED R ²	LS
BRL	BW= 272.370 +284.520BRL	0.910	0.890	*
BL	BW= -402.290 + 279.500BL	0.940	0.930	*
CH	BW= -770.880 + 333.190CH	0.810	0.790	*
DOBW	BW= 139.550 + 32.830DOBW	0.950	0.940	*

BW- body weight, BRL- breast length, BL- back length, CH- circumference of the head, DOBW- day old body weight, R² – coefficient of determination, LS- level of significance, *significant at P < 0.005

There was a significant (P < 0.05) positive linear relationship between body weight and BRL, BL, CH, and DOBW with high coefficient of determination (R²) values ranging from 0.81 to 0.95. The predictive equations showed that, there were significant (P < 0.05) relationships between body weight and the four measurements. The high R² values obtained from this research indicates that the predictive equations could be used to predict body weight efficiently.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of phenotypic markers on production traits in Ross Broiler Chickens (ROBROC)

5.1.1 Effect of phenotypic markers on feed intake in Ross broiler chicken (ROBROC)

5.1.1a: Effect of breast length (BRL) as a phenotypic marker on feed intake (FI) in Ross broiler chickens (ROBROC)

The significant effect of breast length on feed intake agrees with the findings of Quisenberry, *et al.*, (1971); and Sharma *et al.*, (2015), who reported that longer breast length is associated with increased feed intake. These authors concluded that feed intake

generally was highly related to the phenotypic markers they considered in their research including breast measurements. They further alluded that phenotypic markers could be considered as an efficient tool for selection purposes. Similarly, studies have found that animals with higher body conformation and depth tend to consume more feed, leading to improved productivity (Michalczuk *et al.*, 2011). They attributed this performance ascribed to chickens having longer breast length to the possession of higher crop volume as well as higher muscle mass that requires more energy and feed to maintain. The outstanding performance for body weight by Ross broiler chickens having higher breast length as compared to those with medium and lower ones could also be aligned to their higher growth and metabolic rates.

However, the relationship between breast length and feed intake is not universally agreed upon. Some studies have reported contradictory findings, such as no significant correlation (Amao *et al.*, 2011; and Adebayo *et al.*, 2012) between breast length and feed intake. This variation in result outcome could be attributed to differences in the breeds of animals used for their research as well as methodological differences.

Despite these complexities, the most of evidence suggests that breast length is an important factor influencing feed intake in Ross broiler chickens. This positive correlation is also observed in other species, such as Marshall chickens (Amao *et al.*, 2012) and goats (Chitra, 2012). Therefore, understanding the relationship between breast length and feed intake is crucial for optimizing poultry production and feed efficiency.

5.1.1b: Effect of back length as a phenotypic marker on feed intake in Ross broiler chickens

The higher superiority in performance for feed intake by Ross broiler chickens with higher back length as compared to those with medium and lower back lengths support the result outcome by Ojedapo *et al.*, (2010); and Ukwu *et al.*, (2014) who reported a positive correlation between back length and feed intake. They alluded this outcome to the increased muscle mass, growth potential, and feed consumption associated with chickens having higher back length. This outcome could also be due to the fact that longer back lengths are linked to greater abdominal capacity, allowing for increased feed storage and processing (Yakubu and Salako, 2009). The relationship between back length and feed intake has been observed in other species as well, including Guinea fowls and cattle (Dzungwe *et al.*, 2018; Godara *et al.*, 2015). This demonstrates the level of exploration as well as the significant milestone in assessing the effectiveness of phenotypic markers as a selection tool. Some studies have reported findings which do not support this current result outcome, including no significant correlation between back length and feed intake (Yakubu *et al.*, 2009; Semakula *et al.*, 2011). This difference in result could be attributed to the differences in breeds used in their research as well as environmental differences. Despite these contradictions, the most of studies suggest that back length is a crucial factor in determining feed intake in Ross broiler chickens, with longer back lengths generally associated with increased feed consumption and growth potential.

5.1.1c: Effect of head circumference as a phenotypic marker on feed intake in Ross broiler chickens

The relatively higher performance for feed intake by Ross broiler chickens with higher head circumference is in line with the report that birds with larger head circumferences

exhibit enhanced feed consumption capabilities, outperforming those with medium and smaller head circumferences (Malomane *et al.*, 2014; and Momoh and Kershima, 2008). This outcome could be attributed to the possession of desirable traits by Ross broiler chickens with higher head circumference such as faster growth rates and improved feed efficiency which triggers the consumption of higher volumes of feed (Yakubu and Salako, 2009). The magnitude of difference in head circumference among chickens directly impacts the variation in feed intake, highlighting the importance of this trait.

Interestingly, this significant correlation between head circumference and feed intake is not unique to Ross broiler chickens, as similar findings have been reported in other species, such as cattle (Mekonnen, and Biruk, 2004) and pigs (Machebe, and Ezekwe, 2010). Some studies have yielded conflicting results, spelling out no significant correlation between head circumference and feed intake (Ikeh, and Okwesili, 2021; Adeniji, and Ayorinde, 1990). This contradictory result finding could be due to the differences in breeds as well as sex and age. It is reported that the relationship between head circumference and feed intake could be influenced by factors such as age (Petrus *et al.*, 2019) and sex (Mir *et al.*, 2017), with varying degrees of correlation observed across different studies (Ajayi *et al.*, 2008; and Egena *et al.*, 2014).

In the light of these inconsistencies, the prevailing evidence suggests that head circumference is a vital marker in determining feed intake in Ross broiler chickens, with larger head circumferences generally associated with increased feed consumption.

5.1.1d: Effect of day-old body weight (DOBW) on feed intake in Ross broiler chickens

A significant body of research has established a strong link between day-old body weight and feed intake in demonstrating. The superior feed consumption capabilities ascribed to Ross broiler chickens possessing higher initial day-old body weights corroborates with the findings of a significant body of research outcomes (Michalczuk *et al.*, 2011; and Wolanski *et al.*, 2006). These studies indicated a positive correlation between feed intake and day-old body weight noting that Ross broiler chickens with higher day-old body weights exhibited efficient nutrient uptake and utilization potentials allowing them to consume higher quantities of feed.

This phenomenon is not unique to Ross broiler chickens, as similar findings have been reported in other species, such as Leghorn chickens (Oke *et al.*, 2004) and quails (Ojo *et al.*, 2014). Despite the prevailing evidence, some studies have yielded contradictory results, including no significant correlation between day-old body weight and feed intake (Jiang and Yang, 2007; and Suk, 2004). They associated these negative outcomes to the possession of unabsorbed fat along the abdominal region at early stages of life which might have accounted for the increase in body weight realised. Overall, the evidence suggests that, day-old body weight is a critical marker influencing feed intake in Ross broiler chickens, with higher initial body weights generally associated with increased feed consumption

5.1.2 Effect of phenotypic markers on body weight (BW) in Ross broiler Chickens

5.1.2a: Effect of breast length (BRL) as a phenotypic marker on body weight in Ross broiler Chickens

The outstanding performance for body weight by ROBROC with higher breast length followed by ROBROC with medium breast length compared to ROBROC with lower breast length agrees with the finding from Adeyinka *et al.*, (2006) and Oke *et al.*, (2004) who confirmed the reliability of using phenotypic markers as an effective tool for selecting body weight as a trait of interest. They stated that chickens with superior performance for body weight in relation to these linear body measurements are associated with efficient foraging capabilities which makes them exploit food sources more effectively leading to increased body weight. They further attributed this outcome to their distinctive developed digestive systems which enable them to extract and utilize nutrients more efficiently, resulting in increased body weight. The superiority in performance of Ross broiler chickens having higher breast lengths over those with medium and lower ones for body weight could also be due to their enhanced feed consumption capabilities as well as increased muscle mass which facilitates efficient feed utilization that affects overall body weight. Abdel-Lattif (2019) also confirmed the reliability of predicting body weight using breast circumference as a marker attributing this positive milestone to consistency of performance. Ukwu *et al.*, (2014) also confirmed the reliability of using breast circumference as a superior and faster method of selection which is also in support of the previous findings. The assertion agrees with the finding of Willemsen *et al.*, (2008) who showed that moderate and high body weight hens had greater proportions of carcass protein and ash than low body weight hens. The positive result outcome associated with Ross broiler chickens having higher breast length as compared to those with medium and smaller ones could be attributed to the former having a more efficient metabolism, allowing them to convert

feed into energy and body weight more rapidly and effectively. This evidence has been observed in other poultry species, such as Wadi Ross meat type chicken (Amao *et al.*, 2011) and Isa brown chickens (Fayeye *et al.*, 2014).

Nevertheless, some studies have reported contradictory findings. For instance, a study by Ojo *et al.*, (2014) found no significant correlation between breast length and body weight in quails. Another study by Adeleke *et al.*, (2004) reported a negative correlation between breast length and body weight in chickens, suggesting that longer breast length may actually be associated with lower body weight. The difference in these result findings could be attributed to differences in genetic background, breed, as well as analytical procedures and tools. Moreover, a study by Latshaw and Bishop (2001) found that the relationship between breast length and body weight is also influenced by the chicken's genetic background which confirms this current suggestion.

5.1.2b: Effect of back length (BL) as a phenotypic marker on body weight in Ross broiler Chickens

The superior performance for body weight by ROBROC with higher back length aligns with the result from Alimi *et al.*, (2012) and Sadick *et al.*, (2020). They confirmed the reliability of predicting body weight using phenotypic markers as a selection tool. They stated a significant correlation between body weight and phenotypic markers. This milestone of significant performance could be attributed to the possession of better body conformation by chickens with higher back length in comparison with those having medium and lower back lengths which signals a more desirable body shape, with a more even and balanced conformation leading to increased body weight. The higher body weight performance attributed to Ross broiler chickens with higher back length could also be attributed to their superior feed consumption and utilization

endowments as compared to those with medium and lower back lengths. This phenomenon has been observed in other species, such as dairy cattle (Lukuyu *et al.*, 2016) and Nigerian local chickens (Momoh and Kershima, 2008).

Additionally, some studies have reported contradictory findings. For instance, a study by Ojedapo *et al.*, (2012) found no significant positive relationship between back length and body weight in chickens. Another study by Ajayi *et al.*, (2008) reported a no significant correlation between back length and body weight in Ross broiler chickens, suggesting that longer back length may actually be associated with lower body weight. The variation in result outcome could be due to differences in the breeds used, sex, as well as differences in methodological approaches. Remarkably, a study by Obike *et al.*, (2019) discovered that the relationship between back length and body weight varies depending on the chicken's sex. In males, longer back length was associated with higher body weight, while in females, the relationship was positive but weaker. This finding aligns with my suggested remark in relation to the variation of result outcome.

5.1.2c: Effect of head circumference (CH) as a phenotypic marker on body weight in Ross broiler Chickens

Ross broiler chickens with larger head circumference exhibition of superior body weight performance, compared to those with medium and smaller head circumference is in line with the positive correlation effect of head measurements on body weight reported by (Latshaw, and Bishop, 2001; Gwaza and Haruna, 2018). They indicated further that the correlation effect was outstanding and thus an effective tool for selecting body weight as a trait at an early stage of the animal's life. The impact of this result outcome could be due to the possession of higher nutrient uptake and utilization capabilities, higher growth rates as well as superior genetic endowments by Ross broiler

chickens with higher head circumference as compared to those with medium and smaller ones.

This phenomenon is not unique to Ross broiler chickens, as similar findings have been reported in other poultry species, such as Nigerian indigenous chicken (Ukwu *et al.*, 2014), coloured broiler chickens (Patbandha, *et al.*, 2017) and French broiler Guinea fowls (Gwaza and Haruna, 2018). Some studies have reported conflicting findings in relation to the effect of head measurements on body weight. Yahaya *et al.*, (2012) reported no significant positive correlation between head measurements and body weight. The variation in these outcomes could as well be attributed to the differences in strain of broiler chickens used as well as methodological and environmental differences.

5.1.2d: Effect of day-old body weight (DOBW) on body weight in Ross broiler chickens

The highly remarkable performance for body weight shown by ROBROC with higher day-old body weight as compared to those with medium and lower day-old body weight resonates with the findings of (Willemsen *et al.*, 2008 and Michalczuk *et al.*, 2011) that there was a positive relationship between day old body weight and final body weight and thus the marker could be used to predict final body weight at an early stage in the life of a bird. They further added that, the superiority in performance of the higher weight groups in contrast to the medium and lower weight groups were attributed to their superior genetic potentials as well as nutrient utilization capabilities. The superiority of performance could also be associated with their improved feed consumption efficiency potential, higher nutrient reserves, improved organ

development as well as higher genetic potentials in comparison with their counterparts having medium and lower day-old body weights.

This phenomenon is also observed in other poultry species, such as quality meat type chickens (Jiang and Yang, 2007) and Nigerian local chickens (Fayeye *et al.*, 2006). On the other hand, some studies have reported contradictory findings. For instance, a study by Molenaar *et al.*, (2008) found no significant correlation between day-old body weight and body weight in Ross broiler chickens. Another study by Jiang and Yang (2007) reported a negative significant correlation between day-old body weight and body weight in Ross broiler chickens, suggesting that higher day-old body weight may actually be associated with lower body weight. They attributed the difference in the result outcome to the presence of unabsorbed residual yolk in the abdomen among the larger chicken groups.

However, Michalczuk *et al.*, (2011) reported that Ross 308 chicks with higher initial body weight had better growth rates till market age which contradicts the findings by the two reports. Patbandha *et al.*, (2017) also reported that final body weight was similar for high, medium and lower initial chick weight groups of coloured broiler chickens. Suk (2004) as well also reported that initial chick weight did not have an effect on post hatch weight from 1st week to 5th week except for day one when using Ross broiler chickens. The level of contrast attributed to these result outcomes could be linked to variation in environment, feeding regimes as well as procedural differences.

5.1.3 Effect of phenotypic markers on body weight gain (BWG) in Ross broiler chickens

5.1.3a: Effect of breast length (BRL) as a phenotypic marker on body weight gain in Ross broiler chickens

The revelation that Ross broiler chickens with longer breast length tend to exhibit superior body weight gain performance, outperforming those with medium and smaller breast length corroborates with previous findings (Abdel-Latif, 2019; Momoh and Kershima, 2008) disclosing that there was a positive correlation between breast measurements and gain in body weight. This was attributed to the possession of a longer breast bone by Ross broiler chickens with higher breast length compared to those with medium and smaller ones which provides a more extensive skeletal framework allowing for increased muscle mass attachment and growth. This finding is also supported by the significant linear association between chest girth and body weight reported by Yakubu and Salako (2009). The sterling performance outcome could also be due to the higher feed consumption capabilities, as well as feed utilization capabilities associated with Ross broiler chickens with longer breast length as compared to those with medium and smaller breast length.

Similar findings have been observed in other species, such as Greybreasted Helmeted Guinea fowls (Variedades, 2010), coloured broiler chickens (Patbandha *et al.*, 2017) and rabbits (Chineke, 2005). Some studies have reported conflicting findings, including no significant correlation between breast length and body weight gain (Saikhom *et al.*, 2018; Tegua, *et al.*, 2008). These contradictory reports could be attributed to the differences in the strain of animals used as well as different environmental impacts.

5.1.3b: Effect of back length (BL) as a phenotypic marker on body weight gain in Ross broiler chickens

The much higher and better body weight gain values attributed to Ross broiler chickens with higher back length over those with medium and lower back length and this resonates with previous findings (Adeleke *et al.*, 2011; Yakubu and Ari, 2018). They explained that chickens with higher back measurements had increased muscle mass, better feed consumption values as well as faster growth rates compared to those with medium and lower back lengths. It is reported by Ikeh and Okwesili (2021) also that the linear relationship between back length and final body weight was remarkable such that the linear body measurement affected gain in body weight extensively.

This phenomenon has been observed in other poultry species, such as Dagu male chickens (Tyasi *et al.*, 2018) and Nigerian indigenous chickens (Ukwu *et al.*, 2014). Similarly, some studies have reported inconsistencies in relation to these positive relationships. For instance, a study by Ajayi *et al.*, (2008) found no significant correlation between back length and body weight gain in Ross broiler chickens. Another study by Alabi *et al.*, (2012) reported a negative significant correlation between back length and body weight gain in Ross broiler chickens. The difference in these result outcomes could be due to variation in methodology, environmental factors, as well as data analysis and statistical methods.

5.1.3c: Effect of head circumference (CH) as a phenotypic marker on body weight gain in Ross broiler chickens

The outstanding significant body weight gain performance associated with Ross broiler chickens endowed with higher head circumference in comparison with those having medium and lower head circumference echoes with the discovery by (Tyasi *et al.*, 2017;

Tyasi *et al.*, 2018) that head measurements were an effective and reliable tool for determining body weight of Chinese indigenous Dagu male chickens. The confirmation of our result outcome by these researchers could be linked to the superior feed consumption capabilities, improved feed efficiency as well as higher body density and structural integrity tied to Ross broiler chickens having higher head circumference in comparison with their medium and lower counterparts. The positive correlation between head circumference and body weight gain is also supported by the report from Ukwu *et al.*, (2014), which highlights the impact of body conformation traits, including head circumference, on body weight gain in chickens.

Similar findings have been observed in other poultry species, such as Isa brown chickens (Fayeye *et al.*, 2014). Notwithstanding these positive reports, Malomane *et al.*, (2014) and Obike *et al.*, (2019) found no substantial connections between head measurements and gain in body weight. However, the conflicting results from various studies underscore the need for further research to elucidate the underlying mechanisms driving this relationship.

5.1.3d: Effect of day-old body weight (DOBW) on body weight gain in Ross broiler chickens

Michalczuk *et al.*, (2011); and Willemsen *et al.*, (2008), reported a positive correlation between higher day-old body weight and body weight gain which aligns with our scientific verdict. They relate this outstanding attribute to the relatively superior feed consumption potentials as well as extensively increased muscle mass associated with Ross broiler chickens with higher initial day-old body weight as compared to those with medium and lower initial day-old body weight. This remarkable alignment of results between previous and the current study, could also be due to the higher crop volume,

enhanced digestive capacity and genetic advantage the Ross broiler chickens with higher initial day-old body weight have over their counterparts. The significant positive correlation between day-old body weight and body weight gain is also supported by the report from Wolanski *et al.*, (2006), which highlights the impact of initial body weight on market-age body weight.

Similar findings have been observed in other species, such as French broiler guinea fowls (Gwaza and Haruna, 2018) and Nigerian Nsukka ecotype local hens (Ikeh and Okwesili, 2021). Notwithstanding this significant milestone, other researchers have found no significant correlation between Initial day-old body weight as a marker on gain in body weight (Molenaar *et al.*, 2008). This finding as well is contradicted by Jiang and Yang (2007), who reported a significant effect of initial chick weight on early growth, but a diminishing effect as the birds approached maturity. This negative relationship was attributed to the presence of unabsorbed fat along the abdominal region which affects subsequent body weight gain.

5.1.4 Effect of phenotypic markers on feed conversion ratio (FCR) in Ross broiler chickens

5.1.4a. Effect of breast length (BRL) as a phenotypic marker on feed conversion ratio in Ross broiler chickens (ROBROC)

The FCR values obtained by ROBROC with longer breast lengths were smaller than those with medium and shorter breast lengths and this resonates with Quisenberry *et al.*, (1971) and Yakubu *et al.*, (2009) who reported a significant relationship between longer breast length and feed conversion efficiency (FCE). Their reports suggested that linear body measurements were an effective tool in assessing the feed conversion potentials of birds and thus recommended the use of body markers as an effective

selection tool. The positive correlation between breast length and FCR is also supported by the report from Patbandha *et al.*, (2017), which highlights the impact of initial body length on FCR performance. This remarkable performance could be attributed to the higher feed consumption as well as body weight associated with Ross broiler chickens having higher breast length as compared to those with medium and lower breast lengths.

Similar findings have been observed in other species, such as rock partridge (Caglayan *et al.*, 2011) and helmeted French broiler guinea fowl (Gwaza and Haruna, 2018). Contrary to these reports, other findings have reported no significant correlation between these morphological markers and feed conversion efficiency (Obike *et al.*, 2019). The difference in these findings in relation to the findings that support this current outcome could be attributed to differences in the breeds used, maturity ages of the animals considered as well as the sex. The variability in findings highlight the importance of considering multiple factors and methodologies to accurately determine the relationship between breast length and FCR. Furthermore, the conflicting results from various studies emphasize the need for a comprehensive understanding of the complex interactions between breast length, FCR, and other factors influencing poultry performance.

5.1.4b: Effect of back length (BL) as a phenotypic marker on feed conversion ratio in Ross broiler chickens (ROBROC)

The superior FCR performance exhibited by Ross broiler chickens with higher back length compared to those with medium and lower ranges is supported by the reports from (Abdel- Latiff, 2019; and Egena *et al.*, 2014). They concluded that phenotypic markers were effective in determining the effective utilization of feed consumed by birds. This milestone they attributed to the superior genetic endowments in relation to

digestion and body muscle accumulation associated with chickens having higher back length in comparison with those having medium and lower back lengths.

Similar findings have been observed in other poultry species, such as Anak commercial broiler (Ojedapo *et al.*, 2010) and Namibian Boschveld chicken (Petrus *et al.*, 2019). However, contradictory findings have also been reported, highlighting the complexity of the relationship. For instance, some studies have found no significant correlation between back length and FCR (Sadick *et al.*, 2020 and Semakula *et al.*, 2011). The disconnection could be aligned to differences in the breeds used as well as methodological differences.

5.1.4c: Effect of head circumference (CH) as a phenotypic marker on feed conversion ratio in Ross broiler chickens

The superior feed conversion efficiency demonstrated by Ross broiler chickens with larger head circumference compared to their counterparts with medium and smaller head circumference has also been reported by (Obike *et al.*, 2019; and Patbandha *et al.*, 2017). This positive assertion they associated with higher feed consumption potentials as well as higher nutrient uptake and utilization. This phenomenon has also been observed in other species, such as rabbits (Chineke, 2005) and pigs (Machebe and Ezekwe 2010).

Notwithstanding these positive assertions, other studies have reported contradictory findings of no significant relationship (Gueye *et al.*, 1998; and Gwaza and Haruna 2018). The discrepancy in these result outcomes could also be attributed to differences in breeds used as well as methodological differences.

5.1.4d: Effect of day-old body weight (DOBW) on feed conversion ratio in Ross broiler chickens

The outstanding feed conversion efficiency exhibited by Ross broiler chickens with higher day-old body weight compared to their counterparts with medium and smaller day-old body weight resonates with previous findings (Petek *et al.*, 2010; and Michalczuk *et al.*, 2011) reporting a positive significant correlation between phenotypic markers and feed conversion efficiency. The scientific linkage associated with this positive milestone was associated with the possession of superior feed consumption traits as well as prominent increased muscle attachment and growth potentials of chickens with higher initial day-old body weight compared to their counterparts.

This phenomenon is not unique to Ross broiler chickens, as similar findings have been observed in other species, such as Anak broilers (Ojedapo *et al.*, 2010) and Japanese quails (Ojo *et al.*, 2014). However, contradictory findings have also emerged, highlighting the complexity of the relationship. Some studies have reported no significant correlation between day-old body weight and FCR (Suk, 2004), while others have found a negative correlation (Mukhtar *et al.*, 2013). These contradictions could be linked to the differences in strains of chicken used as well as differences in data analysis and statistical tools.

5.2 Effect of phenotypic markers on production traits in Southern Ecotype Chickens

5.2.1 Effect of phenotypic markers on feed intake in Southern Ecotype Chickens (SEC)

5.2.1.a: Effect of breast length (BRL) as a phenotypic marker on feed intake in Southern ecotype chickens (SEC)

The research revealed that local chickens with longer breast lengths exhibited superior feed intake capabilities compared to their counterparts with medium and smaller breast lengths which is in tandem with the findings of (Sadick *et al.*, (2020); and Obike *et al.*, (2019). They associated this significant milestone to the larger muscle mass of Southern ecotype chickens with larger breast length as compared to those with medium and lower breast length. It has also been reported by Rashid *et al.*, (2016) that, the length of the breast influences how much feed a chicken consumes to a larger extent. They adduced further that, increase in the length and size of phenotypic markers such as height at wither, chest girth and loin girth have been associated with the amount of feed consumed and processed.

This phenomenon is also observed in other species, such as goats (Adebayo *et al.*, 2012) and cattle (Lukuyu *et al.*, 2016). However, some studies have reported contradictory findings. For instance, a study by Ojedapo *et al.*, (2010) found no significant correlation between breast length and feed intake in Ghanaian local chickens. They attributed the differences in these result outcomes to the differences in the breed of chickens used as well as environmental differences. The difference in these result outcomes could also be attributed to the ages of the chickens used as well as the differences in methodology.

5.2.1b: Effect of back length (BL) as a phenotypic marker on feed intake in Southern ecotype chickens

The exceptional performance of Southern ecotype chickens with longer back lengths in terms of feed intake, compared to those with medium and shorter back lengths, has been the notable phenomenon in this study as it has been reported in the affirmative by

renowned researchers (Ikeh, and Okwesili, 2021; and Abdul- Latiff, 2019). They adduced that indigenous chickens with longer back lengths possess superior feed intake capabilities, likely due to their increased metabolic rate as well as muscle. The initial body length of chicks has also been found to influence feed consumption potentials, with longer chicks exhibiting higher feed intake (Mukhtar *et al.*, 2013). This outstanding performance could also be attributed to the increased gut rate associated with chicks having higher gut rate as compared to their counterparts enabling them to consume and process more feed efficiently. This trend is not unique to Southern ecotype chickens, as similar findings have been observed in other species, such as (Pesmen and Yardimci, 2008) and Kenyan local chickens (Amao *et al.*, 2011).

Contradictory findings have also emerged, suggesting that the relationship between them is complex and influenced by multiple factors other than phenotypic markers, including sex and genetic background. For instance, male chickens with longer back lengths tend to exhibit higher feed intake, while females exhibit a non-significant correlation (Assan, 2015). Additionally, chickens with a fast-growth genetic background tend to have higher feed intake with longer back lengths, while those with a slow-growth genetic background exhibit a non-significant correlation (Atansuyi *et al.*, 2017).

5.2.1c: Effect of head circumference (CH) as a phenotypic marker on feed intake in Southern ecotype chickens

The notable outstanding significant association between higher feed consumption and larger head circumference in Southern ecotype chickens has been corroborated by several researchers (Patbandha *et al.*, 2017; Michalczuk *et al.*, 2011). They adduced from their empirical evidence that indigenous chickens with larger head circumference

tend to exhibit enhanced feed intake capabilities, likely due to their increased cranial capacity, improved nutrient uptake, and efficient feed conversion capabilities. The impact of linear body traits, including head circumference, on feed consumption is significant, with higher values resulting in increased feed intake (Yakubu and Salako, 2009). This significant empirical evidence could also be attributed to the improved nutrient partitioning potentials associated with chickens having higher head circumference which requires that they consume more feed to be able to direct more energy towards growth.

Similar findings have been observed in other species, such as cattle (Rashid *et al.*, 2016) and West African Dwarf goats (Idorenyin *et al.*, 2016). However, contradictory findings have also emerged, suggesting that the relationship is not influenced by phenotypic markers alone but by a complex combination of factors including sex and age. For instance, younger chickens with larger head circumference tend to exhibit higher feed intake, while older chickens exhibit a weaker positive correlation (Mir *et al.*, 2017). Additionally, male chickens with larger head circumference tend to have higher feed intake, while females exhibit a weaker positive correlation (Adeniji, and Ayorinde, 1990).

5.2.1d: Effect of day-old body weight (DOBW) on feed intake in Southern ecotype chickens

The outstanding performance of Southern ecotype chickens with the highest initial day-old body weight followed by those with medium day -old body weight compared to the ones with lower day-old body weight in terms of feed intake is in line with the findings of (Ojo *et al.*, 2010; Udeh and Ogbu ,2011). They reported that phenotypic markers affected feed intake significantly with those having higher morphological markers

eliciting better feed intake performance compared to their analogous with medium and smaller body weights. They added further that chickens with higher initial body weight were associated with higher physiological rates including feed passage and digestibility. The outstanding feed intake for Southern ecotype chickens with higher day-old body weight may be ascribed to the higher physiological rate coupled with the higher crop volumes which enable them to store and process more food compared to the other weight groups. This phenomenon is also observed in other poultry species, such as Nigerian indigenous chickens (Yakubu and Salako, 2009) and Naked neck broiler chickens (Ubani *et al.*, 2010).

Meanwhile, some studies have reported contradictory findings. For instance, a study by Suk (2004) found no significant correlation between day-old body weight and feed intake in broiler chickens. Another study by Momoh and Kershima (2008) reported a significant negative correlation between day-old body weight and feed intake in Nigerian indigenous chickens. The indifference in these result outcomes could be attributed to differences in breeds as well as variation in environmental endowments.

5.2.2 Effect of phenotypic markers on body weight in Southern ecotype chickens

5.2.2a: Effect of breast length (BRL) as a phenotypic marker on body weight in Southern ecotype chickens

The superior performance of Southern ecotype chickens with the highest breast length over their counterparts in terms of body weight resonates with the findings from (Egena *et al.*, (2014); and Gueye *et al.*, (1998). This sterling performance was attributed to the possession of higher skeletal muscle development on the part of chickens with higher breast length which ultimately translates into greater overall muscle mass and body weight. This outcome resonates with the report from Alabi *et al.*, (2012) that linear

body measurements (shank length, wing length, body girth, thigh length and back length) had a stronger relationship with body weight when they used Venda chickens of South Africa. It is also in line with the findings of Yahaya *et al.*, (2012) who also drew the same conclusion on the significant positive relationship between linear body measurements and body weight using Hubbard and Arbor acre broiler strains. This superiority in performance could also be attributed to the higher success rate associated with Southern ecotype chickens having higher breast length in terms of feed consumption and genetic endowment as compared to those with medium and lower breast lengths.

This phenomenon is also observed in other indigenous chickens (Mancha *et al.*, 2008) and Japanese quails (Ojo *et al.*, 2014). Conversely, some studies have reported contradictory findings. For instance, a study by Tyasi *et al.*, (2017) found no significant correlation between breast length and body weight in indigenous Chinese Dagu chickens. The disparity in this result outcome could be associated with differences in the strain of chickens used as well as differences in methodology and statistical procedure.

5.2.2b: Effect of back length (BL) as a phenotypic marker on body weight in Southern ecotype chickens

The outstanding performance for body weight associated with Southern ecotype chickens with higher back length in comparison with the other groups is in line with previous findings (Yang *et al.*, 2006). They associated this significant milestone to the increased gut capacity on the part of chickens with higher back length which affects overall feed consumption leading to better body weight attainment. This report agrees with the finding of Ahmed *et al.*, (2017) that back length had a stronger relationship

with body weight using Ross broiler chickens. It also affirms the report of Momoh and Kershima (2008) who also reported a stronger relationship between body weight and back length using Nigerian local chickens. This positive significant milestone could also be attributed to the higher crop volume attributed to Southern ecotype chickens with higher back length which affect feed consumptions and subsequently translating into higher muscle mass acquisition.

This evidence has also been observed in other species, such as finishing gilts (Machebe and Ezekwe, 2010) and Senegalese indigenous chickens (Gueye *et al.*, 1998). Additionally, some studies have reported contradictory findings. For instance, a study by Ajayi *et al.*, (2008) found no significant correlation between back length and body weight in commercial meat type chickens. This scientific outcome could be linked to differences in the breeds used as well as statistical procedure and methodological differences.

5.2.2c: Effect of head circumference (CH) as a phenotypic marker on body weight in Southern ecotype chickens

The superior result outcome in relation to body weight exhibited by Southern ecotype chickens with higher head circumference in comparison with the other measurement groups associated with head circumference is in line with previous research findings (Alabi *et al.*, 2012; Sowande and Sobola, 2007). This success was linked to the improved bone density associated with the larger head circumference group as compared to the other groupings which provides a stronger framework for muscle growth and body weight. This outcome also affirms the report by Sadick *et al.*, (2020) and Gwaza and Haruna (2018) that, there was a high remarkable relationship between

body weight and head length when they worked with Cobb broiler and French broiler Guinea fowls respectively.

This report is also observed in other poultry species, such as Nigerian indigenous chickens (Yahaya *et al.*, 2012) and South African indigenous chickens (Petrus *et al.*, 2019). Nonetheless, some studies have reported contradictory findings. For instance, a study by Michalczuk *et al.*, (2011) found no significant correlation between head circumference and body weight in Ross 308 chickens. Another study by Petek *et al.*, (2010) reported a negative significant correlation between head circumference and body weight in broiler chickens. They attributed this effect to factors not limited to only phenotypic markers such as head circumference. The difference in the result outcome could be due to differences in age and sex of the breeds, the breeds used as well as data processing management.

5.2.2d: Effect of day-old body weight (DOBW) on body weight in Southern ecotype chickens

The higher body weight scores obtained by Southern ecotype chickens with higher day-old body weight followed by Southern ecotype chickens with medium day-old body weight compared to those with lower day-old body weight is in support of the findings from (Amao *et al.*, 2011; and Assan, 2015). It is reported by Willemsen *et al.*, (2008) that higher initial chick weight affected body weight up to market age which as well is in support of the current finding. This sterling outcome was attributed to the higher muscle mass associated with chickens with higher initial day-old body weight compared to the other groupings. This positive outcome of genetic superiority is also observed in other species, such as Sudanese Kenana cattle (Musa *et al.*, 2011) and Sahel goats (Mohammed and Amin, 1997).

However, this finding contradicts that of Jiang and Yang (2007) and Molenaar (2008) that initial chick weight affected body weight at early age and suddenly declined during market age in studies involving the use of quality meat type broilers suggesting that higher day-old body weight may actually be associated with the presence of unknown quantity of residual yolk in the abdominal region. The variation in these findings could be due to differences in the breeds used as well as environmental provisions.

5.2.3 Effect of phenotypic markers on body weight gain in Southern ecotype chickens

5.2.3a: Effect of breast length (BRL) as a phenotypic marker on body weight gain in Southern ecotype chickens

The stronger and better values obtained for body weight gain by Southern ecotype chickens with higher breast length over those with medium and lower breast morphology resonates with the scientific outcomes of (Mwacharo *et al.*, 2006; and Ojedapo *et al.*, 2012). Their attribution had to do with the higher feed conversion capabilities as well as faster growth rates associated with the chickens having higher breast length in comparison with those with medium and lower breast length. It could also be due to the higher genetic potential for growth associated with Southern ecotype chickens having higher breast length over those with medium and lower breast length. This occurrence is also observed in other species such as dairy cows (Yan *et al.*, 2009) and Jinghai yellow chicken. (Yang *et al.*, 2006).

On the contrary, some studies have reported findings which do not support these evidences. For instance, a study by Ojo *et al.*, (2010) found no significant correlation between breast length and body weight gain in Hubbard broiler breeder chickens. Another study by Malomane *et al.*, (2014) reported a negative significant correlation

between breast length and body weight gain in local chickens. The difference in these findings could be due to the variation in breeds used for the studies as well as differences in environmental provisions.

5.2.3b: Effect of back length (BL) as a phenotypic marker on body weight gain in Southern ecotype chickens

The significantly higher, better and superior body weight gain values realized by Southern ecotype chickens having higher back length followed by Southern ecotype chickens with medium back length compared to those with lower back length is in support of the results from (Ige *et al.*, 2006; Ikeh and Okwesili, 2021). . It was also recorded by Momoh and Kershima (2008) that a strong linear relationship was established between back length and body weight using Nigerian local chickens. They adduced this significant milestone to the reduced maintenance energy rate associated with chickens having higher back length which allows more energy to be directed towards growth and weight gain. It could also be associated with the higher feed conversion efficiency aligned with Southern ecotype chickens having higher back length over those with medium and lower back length.

These factual experiences have also been observed in other species, such as dairy cattle (Lukuyu *et al.*, 2016) and Brown and Ilorin ecotype chickens (Fayeye *et al.*, 2014). Notwithstanding, some studies have reported findings not in the affirmative to this current report. For instance, a study by Gueye *et al.*, (1998) found no significant correlation between back length and body weight gain in mature indigenous chickens in Senegal. This negative association could be due to differences in the strain of chickens used for the experiments as well as the data analysis procedures.

5.2.3c: Effect of head circumference (CH) as a phenotypic marker on body weight gain in Southern ecotype chickens

The higher and better values for body weight gain associated with Southern ecotype chickens with higher head circumference as compared to their counterparts with medium and lower head circumference connects with the findings of (Peter *et al.*, 2006; and Egena *et al.*, 2014). They associated this sterling performance to the superiority of chickens with higher head circumference in converting feed efficiently into energy and protein leading to increased body weight gain as compared to their peers with medium and lower head circumference. This reason is remarked and referenced from the superior feed conversion ratios associated with Southern ecotype chickens having higher head circumference compared to those with medium and lower head circumference.

These scientific outcomes have been observed in other poultry species, such as ducks (Raji *et al.*, 2009) and goats (Islam *et al.*, 1991). However, a study by Lukuyu *et al.*, (2016) found no significant correlation between head measurements and body weight gain in cattle. The difference in these result outcomes could be due to differences in breeds used as well as variability in measurement techniques.

5.2.3d: Effect of day-old body weight (DOBW) on body weight gain in Southern ecotype chickens

The higher and superior values for body weight gain elicited by Southern ecotype chickens with higher initial day-old body weight over those with medium and lower weight groups harmonizes with the findings of (Sadick *et al.*, 2020; Mancha *et al.*, 2008). This positive outcome is in support of findings from renowned researchers. For instance, Patbandha *et al.*, (2017) reported that Chick weight and morphometric traits

like chick body length and shank length have great influence on growth performance of broiler as these parameters positively affect slaughter yield at market age. They adduced this positive response to the better skeletal development potential tied to chickens with higher initial body weight compared to their counterparts which support greater muscle growth and body weight gain. It could also be attributed to the higher feed conversion efficiency associated with Southern ecotype chickens having higher initial body weight compared to their counterparts with medium and lower initial day-old body weight.

This scientific outcome is also observed in other species, such as Sudanese Kenana cattle (Musa *et al.*, 2011) and Nguni-type cattle (Nesamvuni, *et al.*, 2000). The finding however contradicts the report from Mukhtar *et al.*, (2013) who reported no significant correlation between initial day-old body weight and body weight gain. They adduced further in explanation that initial chick weight as a predictor of growth performance is not remarkable due to the presence of unabsorbed residual yolk in the abdomen. The difference in the result outcome could also be due to differences in the strain of chickens used as well as environmental variability.

5.2.4 Effect of phenotypic markers on feed conversion ratio in Southern ecotype chickens

5.2.4a: Effect of breast length (BRL) as a phenotypic marker on feed conversion ratio in Southern ecotype chickens

The exceptional performance of Southern ecotype chickens with longer breast length morphology in terms of feed conversion efficiency corroborates the findings of (Abdel-Latif, 2019; and Abrar *et al.*, 2021). The finding as well is in line with the report from Ajayi *et al.*, (2008) who found a positive correlation between breast length and FCR in

commercial meat-type chickens. This significant performance was attributed to the increased muscle mass and efficient feed utilization linked to chickens with higher breast length over the ones with medium and lower breast length. It could as well be associated with the higher genetic potential for body weight due the Southern ecotype chickens with higher breast length as compared to their medium and smaller counterparts.

This phenomenon is not unique to Southern ecotype chickens, as similar findings have been observed in other poultry species, such as crossbred egg- type chickens (Adeleke *et al.*, 2004) and rock partridge (Caglayan *et al.*, 2011). Interestingly, some studies have reported conflicting results, suggesting that breast length was not a significant predictor of FCR in Japanese quails (Ojo *et al.*, 2014). The difference in these scientific outcomes could be due to differences in the breeds used as well as the environmental provisions for the research works and differences in data analysis procedures.

5.2.4b: Effect of back length (BL) as a phenotypic marker on feed conversion ratio in Southern ecotype chickens

The revelation from this research remarking the significant performance for feed conversion efficiency (FCR) for the local chickens with longer back length over those with medium and lower back length agrees with the findings of (Fayeye *et al.*, 2014; and Momoh and Kershima, 2008). They adduced that this significant milestone could be attributed to the sterling performance for feed consumption as well as the remarkable body weight aligned to chickens with higher back length in comparison with their counterparts having medium and lower back lengths. This milestone as well could also be due to the efficient genetic potential for feed utilization associated with Southern

ecotype chickens having higher back length as compared to those with medium and lower back lengths.

This assertion is also observed in other species, such as Tharparkar cattle (Godara *et al.*, 2015) and Ross 308 chickens (Michalczuk, *et al.*, 2011). Furthermore, some studies have reported contradictory findings. For instance, a study by Sanpha *et al.*, (2022) found no significant correlation between back length and FCR in local chickens. Another study by Semakula *et al.*, (2011) also reported a negative correlation between back length and FCR in local chickens. These inconsistencies in result outcomes could be as well attributed to differences in the breeds used as well as

5.2.4c: Effect of head circumference (CH) as a phenotypic marker on feed conversion ratio in Southern ecotype chickens

The superior feed conversion efficiency (FCE) attributed to Southern ecotype chickens with higher head circumference compared to their counterparts with medium and smaller head circumference aligns with the scientific report from (Raji *et al.*, 2009; and Sadick *et al.*, 2020). They linked this significant performance for FCE to the enhanced nutrient transport and utilization potential due the chickens with higher head measurements as compared to the ones with medium and lower head measurements. It could also be linked to the enlarged gut, crop volume as well as the enhanced skeletal muscle development tied to the chickens having higher head circumference over their peers which translates into higher feed consumption and subsequently efficient feed conversion potentialities.

These events have also been observed in other poultry species, such as Haringhata black chickens (Saikhom *et al.*, 2018) and African Muscovy duck (Teguia *et al.*, 2008). Additionally, some studies have reported contradictory findings. For instance, a study

by Dzungwe *et al.*, (2018) found no significant correlation between head circumference and FCR in French broiler guinea fowls. Another study by Tsegaye *et al.*, (2013) reported a negative significant correlation between head circumference and FCR in Hararghe highland goats. The difference in these scientific reports could be due to differences in animals as well as breeds used for the research.

5.2.4d: Effect of day-old body weight (DOBW) on feed conversion ratio in Southern ecotype chickens

The exceptional feed conversion efficiency (FCE) for Southern ecotype chickens with higher day-old body weight, compared to those with lower and medium day-old body weight is in line with the scientific outcomes from (Tyasi *et al.*, 2017; and Wolanski *et al.*, 2006). This outstanding performance was associated with the increased muscle mass, efficient feed utilization, and faster growth rates associated with chickens belonging to the higher weight groups over those in the medium and lower weight groups. It could as well be due to the higher energy requirement for body growth and development as well as efficient digestive systems linked to chickens with higher initial body weight compared to those with medium and lower initial body weight which ultimately triggers the consumption of higher volumes of feed to meet this demand.

This phenomenon is not unique to Southern ecotype chickens, as similar findings have been observed in other species, such as Nguni-type cattle (Nesamvuni *et al.*, 2000) and West african dwarf goats (Idorenyin *et al.*, 2016). Jiang and Yang (2007) and Molenaar *et al.*, (2008) reported conflicting results, suggesting that day-old body weight was not a significant predictor of FCR. They attributed these scientific lapses to the presence of an amount of unabsorbed fat along the abdominal region which had an effect on the growth characteristics of the chickens used for the research. This could also be linked

to differences in strain of chickens used, environmental provisions as well as analytical procedures.

5.3 Correlation between phenotypic markers on body weight gain in Ross broilers and Southern ecotype chickens

5.3a: Correlation between phenotypic markers on body weight gain in Ross broiler chickens

The high positive significant correlation shown between breast length and back length for body weight gain marked by a correlation coefficient (r) of 0.94 confirms the finding of Ukwu *et al.*, (2014) who described the high predictive association between live body weight and body measurements. This signifies a strong degree of relationship between the two phenotypic markers for body weight gain on Ross broiler chickens. It also justifies the reliability of using the two phenotypic markers to predict body weight gain. The high positive correlation between Breast length and head circumference for body weight gain characterized by a correlation coefficient value of 0.97 justifies clearly the stronger degree of relationship between the two phenotypic markers for body weight gain.

It is also worth to note that, it is much more reliable to predict body weight gain using breast length or head circumference as a marker or indicator. This finding is in line with that of Alimi (2012) who reported a high, positive and significant relationship between linear body measurements and body weight. The correlation coefficient of 0.94 attributed to breast length and day-old body weight as phenotypic markers affirms the high degree of relationship between breast length and day-old body weight for body weight gain. Considering all two phenotypic markers, body weight gain was highest at their highest level of measurement. This clearly indicates that, phenotypic markers at higher ranges influence body weight gain better than phenotypic markers at medium

and lower ranges. The higher positive correlation exhibited between Back length and head circumference proves that, there was a stronger degree of relationship between back length and head circumference as phenotypic markers on influencing body weight gain.

The extremely higher positive correlation coefficient of 0.99 shown between back length and day-old body weight on the influence of body weight gain as a parameter signals a stronger degree of association between the two phenotypic markers on body weight gain. Head circumference and day - old body weight also had 0.89 as a correlation coefficient for body weight gain. It also signifies a high degree of association between the two phenotypic markers for body weight gain. It is justifiable from these findings that all four phenotypic markers at high levels of measurement could influence body weight gain. This report affirms the findings of Ikeh and Okwesili, (2021) that linear body measurement traits of Nigerian heavy ecotype local hens were strongly and positively correlated.

5.3b: Correlation between phenotypic markers on body weight gain in Southern ecotype chickens

The high positive correlation marked by a correlation coefficient of 0.93 between breast length and back length corroborates the reports from Yahaya *et al.*, (2012), and Alabi *et al.*, (2012) that high positive correlation exists between body weight and linear body measurements in broilers and naked neck. This signals a high degree of relationship between the two phenotypic markers on body weight gain. The stronger positive correlation also marked by a correlation coefficient of 0.86 between breast length and head circumference is a clear signal of the high degree of association between the two phenotypic markers on body weight gain. The highly remarkable

correlation coefficient value of 0.91 associated with breast length and day-old body weight indicates a stronger degree of relationship between breast length and day-old body weight on body weight gain of Southern ecotype chickens.

The high positive correlation coefficient value of 0.94 between back length and head circumference is an indication that, the degree of relationship between back length and head circumference on body weight gain was strong. A correlation coefficient value of 0.93 associated with back length and day -old body weight on body weight gain signals the reliability of determining body weight trait at day old using the two markers. The significantly positive correlation between head circumference and day-old body weight on body weight gain with a correlation coefficient value of 0.91 confirms the significant degree of association between the two phenotypic markers on body weight gain of Southern ecotype chickens. The findings clearly indicate, the reliability of predicting body weight gain from all the four markers. The finding is in line with Pundir *et al.*, (2011) and Petrus *et al.*, (2019) who indicated a high positive relationship between body measurements and body weight. It also corroborates the report from Yahaya *et al.*, (2012) that correlations among the linear body measurements (shank length, wing length, body girth, thigh length and back length) were high, positive and highly significant ($P < 0.01$) using Hubbard and Arbor acre broiler strains.

5.4 Linear regression of phenotypic markers on body weight using simple linear regression models in Ross and Southern ecotype chickens

5.4a. Linear regression of phenotypic markers on body weight in Ross broiler chickens

The 71% coefficient of determination value attributed to breast length as a marker implies that, about 71% of the variation in body weight among the Ross broilers could

be attributed to breast length. Body weight could be determined using breast length as a marker with the prediction equation $BW = 1350.07 + 445.46BRL$. An R^2 of 92.60% was associated with breast width by Obike *et al.*, (2019) when they studied Arbor Acre chickens which were higher than the R^2 obtained from this present study. The difference in result outcomes may be due to differences in the breeds used as well as differences in environmental provisions as determined by geographical locations. Latshaw and Bishop (2001) also obtained an R^2 of 78% and 83% when they studied three and five phenotypic markers respectively with breast circumference included, which is also higher than the R^2 from this current study. Ukwu *et al.*, (2014) obtained an R^2 of 67% for breast circumference in mature local Nigerian chickens which was less than the R^2 from this study. With a coefficient of determination value of 68%, body weight could be predicted from back length using the predictive equation $BW = -970.80 + 845.51BL$. An R^2 of 68% indicates that only 32% of the variation in body weight among the Ross broilers is not attributed to the back length. Ukwu *et al.*, (2014) reported an R^2 of 79% which was higher than the R^2 obtained from the current study. The relationship between circumference of the head and body weight with an R^2 of 76% signals a higher predictive potential of the marker in relation to body weight. The predictive equation, $BW = -2994.46 + 1014.25CH$ generated from the relationship was strong and positive and could be used to predict body weight in relation to the marker accurately. Seventy six percent (76%) of the variation in the dependent variable (body weight) amongst the Ross broiler chickens is accounted for by the independent variable (circumference of the head). Sadick *et al.*, (2020) recorded a coefficient of determination of 63% for head length when they studied Cobb broilers which was lesser than that recorded for this study. The difference in these results outcomes could also be due to differences in the breeds used. An R^2 of 64% associated with day old body justifies that, about 64% of

the variation in body weight among the Ross broiler chickens could be attributed to DOBW as a morphological marker. The predictive equation $BW = 778.54 + 50.94DOBW$ obtained thereof is positive and resilient and could be used to predict body weight efficiently.

5.4b. Linear regression of phenotypic markers on body weight in Southern ecotype chickens

The coefficient of determination recorded for breast length in this study was 91%, indicating that breast length could be used to predict body weight efficiently from the prediction equation $BW = 272.37 + 284.52BRL$. This finding is in line with Obike *et al.*, (2019) who recorded an R^2 of 92% for breast width in a linear regression model when working with Noiler, Arbor Acre broiler and Yoruba ecotype cockerels. The R^2 obtained is also higher than 66% coefficient of determination for body girth obtained by Ukwu *et al.*, (2014). With a 91% coefficient of determination, it implies that only 9% of the variation in body weight is not accounted for by breast length. Back length also had a coefficient of determination value of 94%. This indicates that, the variation in body weight among the southern ecotype chickens is attributed to back length with a percentage margin of 94%.

With an R^2 of 94%, body weight could be predicted from the equation $BW = -402.29 + 279.50BL$. The R^2 value obtained in this research is higher than the 79% obtained by Ukwu *et al.*, (2014) when they studied Nigerian indigenous chickens. The difference in these result outcomes as well could be due to differences in the breeds used and the environmental conditions under which the studies were conducted. With a significant R^2 value of 81%, body weight could be predicted with the equation $BW = -770.88 + 333.19CH$ using circumference of the head as a marker. The R^2 obtained for head

circumference is relatively higher than 56% recorded for head length by Gwaza and Haruna (2018) when they studied French broiler Guinea fowls. The variation could be due to differences in breed, environmental provisions and the regression procedure used. The present study also recorded a coefficient of determination value of 95% for day old body weight as a marker. This presents day old body weight as a marker fit to predict body weight with the equation $BW = 139.55 + 32.83DOBW$. The four markers have proven to be more resilient and reliable in predicting body weight effectively and efficiently.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions were made from the findings of the study:

- ❖ Phenotypic markers taken at day-old affected feed intake, body weight, body weight gain and feed conversion ratio in Ross broiler chickens as well as Southern ecotype chickens.
- ❖ A significant positive correlation existed between the phenotypic markers with body weight gain in both Ross broiler and Southern ecotype chickens.
- ❖ There was a significant linear relationship between the phenotypic markers and body weight for both Ross broiler and Southern ecotype chickens.
- ❖ Predictive equations generated for determining chicken body weight using these phenotypic markers were applicably efficient.
- ❖ Farmers should select for birds that possess superior growth potentials using these phenotypic markers and body weight taken at day old at higher ranges.

6.2 Recommendations

- ❖ Farmers should select for body weight as a trait using these phenotypic markers taken at day old at higher ranges as an alternative to molecular selection.
- ❖ Further studies should be conducted on the effect of phenotypic markers taken at day old on egg quality characteristics of indigenous local chickens.
- ❖ Further studies should also be carried out on the effect of phenotypic markers taken at day old on semen quality characteristics in our indigenous chickens.
- ❖ This study should be carried out on other livestock and chicken breeds in Ghana to confirm the current finding.

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