

**COMPARATIVE EVALUATION OF THREE COMMERCIAL STRAINS OF BROILER
TYPE CHICKEN RAISED IN THE SEMI-ARID ZONE OF NIGERIA**

BY

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DECLARATION

I declare that the work in this Thesis entitled “**COMPARATIVE EVALUATION OF THREE COMMERCIAL STRAINS OF BROILER TYPE CHICKEN RAISED IN THE SEMI-ARID ZONE OF NIGERIA**” has been carried out by me in the Department of Animal Science. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

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(Name of Student)

Signature

Date

CERTIFICATION

This thesis report entitled “**COMPARATIVE EVALUATION OF THREE COMMERCIAL STRAINS OF BROILER TYPE CHICKEN RAISED IN THE SEMI-ARID ZONE OF NIGERIA**” by ILYASU ABDULLAHI AHMED meets the regulations governing the award of the degree of Master of Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my late uncle, Alhaji Abdullahi Nadada who nursed me and my brothers after the death of our biological father; my late parents, Malam Ilyasu and Madam Zulaiha (May their souls rest in perfect peace), AMEEN, as well as the entire members of my family especially my beloved wife, Hajia Bintu (Batulu) Abdullahi and all our children.

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ABSTRACT

The study was undertaken to compare and evaluate growth performance, conformation and morphological traits of three commercial strains of broiler chicken. A total of 315 day old chicks of three broiler strains (105 from each strain) consisting of NAPRI-X, Marshall and Ross strains, respectively were used in this experiment. Computed indices comprising of Daily feed intake (DFI), weekly weight gain, percentage mortality (MTLY) and feed conversion ratio (FCR) as growth traits; whereas the conformation traits which include Neck length (NEL), back length (BKL), thigh length (THL), shank length (SHL), breast width (BRW), body length (BDL) and wing length (WNL) were obtained. Traits consisting of ocular length (OCL), ocular width (OCW), comb length (CBL), comb width (CBW), beak length (BEL), ear lobe length (ELL), ear lobe width (ELW), wattle length (WTL) and wattle width (WTW) were the morphological traits. Descriptive statistics, correlation, regression and principal component analyses (PCA) were carried out. Results for comparative growth performance, conformation and morphological traits among the three strains at 4 and 8 weeks of age showed that Marshall strain had significantly ($P < 0.05$) higher mean values, except for WTL and WTH in which NAPRI-X breed had the highest values at 8 weeks. However, no significant ($P > 0.05$) differences were observed among the three strains for MTLTY, FCR, BDL, WNL, ELL and ELW, respectively, at 8 week and also MTLTY at 4 week. Correlations among growth traits revealed positive and perfect correlations between FBW, DWG, TWG, DFI and TFI in all the three strains at 4 weeks of age. At 8 week of age, positive and highly significant ($P < 0.01$) correlations were observed between IBW and FBW in Ross strain and also between FBW, DWG and TWG in all the three strains. In addition, positive and perfect correlations existed between DWG and TWG in the three strains as well as between DFI and TFI in NAPRI-X and Marshall strains. The prediction equations for conformation traits revealed that NEL and BKL were the most significant predictors of body

weight among the three strains. For morphological traits WTL was observed to be the most significant predictor of body weight among the three broiler strains. The PCA for conformation and morphological traits depicts highest eigen values in PC1 for both conformation and morphological traits. The percentage total variance of 84.40%, 73.54% and 88.50% for NAPRI-X, Marshall and Ross strains were adequate for conformation traits. Similarly, adequate percentage total variance of 45.57%, 90.53% and 57.56% were also obtained in morphological traits. In conclusion, it has been observed that Marshall strain was superior for growth, conformation and morphological traits at 4th and 8th weeks of age followed by NAPRI-X and Ross strains. Further study should be carried out to map the genes that make Marshall the best strain in growth, conformation and morphological traits.

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LIST OF ABBREVIATIONS

- A.B.U. = Ahmadu Bello University
- ANOVA = Analysis of Variance
- BDL = Body Length
- BEL = Beak Length
- BKL = Back Length
- BRW = Breast Width
- CBL = Comb Length
- CBW = Comb Width
- cm = Centimeter
- CP = Crude Protein
- CRD = Completely Randomized Design
- DFI = Daily Feed Intake
- DWG = Daily Weight Gain
- EE = Ether Extract
- ELL = Ear Lobe Length
- ELW = Ear Lobe Width
- FAO = Food and Agriculture Organization
- FBW = Final Body Weight
- FCR = Feed Conversion Ratio
- G.P.S. = Geographical Positioning System
- g = Grams
- H_a = Alternative hypothesis

H₀ = Null hypothesis

IBW = Initial Body Weight

IFPRI = International Food Policy Research Institute

Kg/bird = Kilogram per bird

KNARDA = Kano State Agricultural and Rural Development Authority

LOS = Level of Significance

MEKcal/kg = Metabolizable Energy Kilocalories per Kilogram

MPLY = Percentage Mortality

NAPRI-X Strain = a synthetic broiler strain bred from Hubbard and Anak broiler breeds by National Animal Production Research Institute (NAPRI), Shika A.B.U., Zaria-Nigeria.

NEL = Neck Length

NFE = Nitrogen Free Extract

NRC = National Research Council

NS = Not Significant

OCL = Ocular Length

OCW = Ocular Width

PBAUM = Peace and blessings of Allah be upon his Messenger

% = Percentage

PCA = Principal Component Analysis

PC1 = Principal Component 1

PC2 = Principal Component 2

PC3 = Principal Component 3

R² = Coefficient of Determination

SAS = Statistical Analysis System

SEM = Standard Error of Mean

SHL = Shank Length

SPSS = Statistical Package for Social Science

TFI = Total Feed Intake

THL = Thigh Length

TWG = Total Weight Gain

WNL = Wing Length

WTL = Wattle Length

WTW = Wattle Width

Y = Dependent Variable (Live Body Weight)

* = Significant

** = Highly Significant

*** = Very Highly Significant.

CHAPTER ONE

1.0 INTRODUCTION

The contribution of poultry to animal protein supply in Nigeria cannot be overemphasized. FAO (2008) estimated that, the poultry population at 137,679,000 out of this number, 115,880,864 representing 84% is backyard poultry, while 21,798,079 representing 16% are exotic poultry. Ojedapo *et al.* (2010) highlighted that, poultry contributed immensely as major source of animal protein for human consumption in Nigeria as they contributed about 10% of the total national livestock production. Poultry meat and egg production account for more than 30% of available animal protein (Permin and Pedersen, 2000). The International Food Policy Research Institute (IFPRI, 2000) estimated that by the year 2015, poultry will account for 40% of animal protein; however, this might be difficult to attain in Nigeria.

FAO (1997) recommended 56g of animal protein intake for growing and developing individuals per day. Christopher *et al.* (1997) reported that Nigerians consume only 15g of animal protein per day. There has been a call for substantial increase in the intake of protein of animal origin in developing countries like Nigeria. This can be achieved through the production of animals that are prolific and have short generation interval (Abeke *et al.*, 2003). Poultry is among the animal species with short generation interval and they are highly prolific.

Among the fastest growing livestock industries in Nigeria, poultry sub-sector was ranked first (Akanni *et al.*, 2010). Poultry have been widely reported to possess high degree of efficiency of feed utilization with little or no socio-religious taboo in their consumption (Akanni *et al.*, 2010). Preference for poultry production by man has also been attributed to the short growing cycle of poultry (Global plan, 1992).

Unfortunately, poultry production is affected by several factors among which include temperature, humidity, nutrition and genetic makeup. The productivity of poultry under high temperature and humidity is low and accompanied by heavy mortality. It is of importance to develop and test poultry breeds that compete with the original breeds under these climatic conditions. However, the development of suitable strains of broiler chickens for the tropical environment is a research interest which has engaged the attention of a number of poultry geneticists and breeders for the past two decades (Ndri *et al.*, 2007).

On the other hand, human population was believed to be increasing rapidly especially in the developing countries like Nigeria. In this regard, food production and supply are found to be lower than the rate at which population is growing especially in the developing countries. As such, breeders have done good job through continuous selection that helped to reduce the age at marketing in the last four decades; as a result, body weight of 1.5 kg in broilers which was possible at 12 weeks of age in the past can now be achieved at 6-7 weeks (Kabir *et al.*, 2006). Genetically improved strains of poultry have been a major contribution to the success of the poultry industry, which is a major source of animal protein for human population in most countries of the world (McKay, 2009). Furthermore, improvement in health, nutrition and environmental management has also contributed to improved performance, but the majority of the changes have been attributed to genetic improvement McKay (2009). Havenstein *et al.* (2003 a,b) estimated that at least 85% of the improvement in performance is attributed to genetic changes. Yakubu and Salako (2009) hinted that growth is a complex and dynamic physiological process that exists from conception until maturity. Growth in any organism is a result of

the genetic potential of the individual and genetic x environment interaction (Kor *et al.*, 2006). Body growth in livestock may be evaluated with body components such as live weight and linear body measurements (Wolanski *et al.*, 2006; Saatci and Tilki, 2007). Poultry breeders need some techniques to select animals for breeding purposes. Linear body measurements otherwise called conformation traits are important parameters in predicting body weight and this has been observed by commercial breeders and producers. Breeders, therefore, breed desirable sizes of chickens which also have the desirable production traits particularly body weight (Ojedapo *et al.*, 2010).

Apart from weight, a number of conformation traits are known to be good indicators of body growth and market value of broiler (Ibe, 1989). Amao *et al.* (2012) reported that most of the linear body measurements reflect primarily the long bones of the animals. Such conformation traits include shank length, breast width, keel length, wing span, chicken height, body length, thigh length, and head circumference (Ojo *et al.*, 2010a). There are other traits that are less significant nutritionally than conformation traits; these are called morphological traits otherwise called head measurements. They include comb length and height, ocular length and width, beak length, wattle length and width, ear lobes length and width. Yakubu and Salako (2009) reported that comb length, beak length, and neck length did not significantly influence body weight. The relationships between body weight and conformation traits have been found to have important implications in the production of broilers with desirable body conformation (Ibe and Nwakalor, 1987). Okon *et al.* (1996) highlighted that the relationships between body weight and conformation traits are direct and positive. As such knowledge of this relationship would help breeders organize their program in order to achieve optimum

combination of body weight and conformation for maximum economic returns (Adeniji and Ayorinde, 1990). The knowledge of interrelationships among body measurements can be applied in selection and breeding (Monsi 1992). Chambers and Fortin (1984) reported that the importance of evaluating interrelationships and conformation traits in poultry lies in their usefulness as predictors of characteristics like body weight. Such applications could speed up the assessment of traits through the involvement of simple measurement tools like ruler or tape, as such simple linear measurements that can predict body weight without necessitating bird slaughter will be particularly desirable.

However, body weight and body conformations are the two important parameters for measuring growth in the domestic chickens. The mechanism involved in the control of growth in chickens are too complex to be explained only under univariate analysis because all related traits are biologically correlated due to pleiotropic effect of gene and linkage of loci (Rosario *et al.*, 2008). Principal components analysis is a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables known as principal components which are ordered so that the first few retain most of the variation present in the original variables (Jolliffe, 2002). Use of principal component analysis to examine the relationship between measurement of size and shape in poultry has been reported in chicken (Ibe, 1989; Yakubu *et al.*, 2009a), and duck (Shahin, 1996; Mc Cracken *et al.*, 2000; Ogah *et al.*, 2009).

1.1 JUSTIFICATION FOR THE STUDY

Poultry production is an important universal enterprise. Many poultry breeds or strains were found to survive and produce in the humid, sub-humid and semi-arid zones of the

world; but one of the major constrains in the semi-arid zone is heat. Patra *et al.* (2002) reported that most of the layer and broiler breeds have originated and been developed under temperate climate, so they are more prone to tropical climatic stress as found in Nigeria. The result is decrease in feed consumption; feed efficiency accompanied with heavy mortality during summer. Broilers especially suffer more in dissipating the body heat due to their faster metabolism. Adeosun (2012) stated that, the heat stress begins at about 32⁰C which depresses voluntary feed intake. In this context, effort is been made to develop and test breeds or strains that are tolerant to tropical environment.

There are numerous breeds and strains for both meat and egg production and most of them were developed in temperate regions. In the semi-arid zone, Marshall, Ross, Hubbard and Anak have been accepted as commercial broiler chickens and so development of strains from these breeds would perhaps perform better than any of the breeds in the region.

1.2 RESEARCH HYPOTHESIS:

NULL HYPOTHESIS (H₀): There is no difference in growth, body conformation and morphological traits among NAPRI-X, Marshall and Ross broiler strains.

ALTERNATIVE HYPOTHESIS (H_a): There is difference in growth, body conformation and morphological traits among NAPRI-X, Marshall and Ross broiler strains.

1.3 OBJECTIVES OF THE RESEARCH

1. To determine variations in growth performance traits of NAPRI-X, Marshall and Ross broiler strains at 4 and 8 weeks of age;

2. To evaluate the relationships that exist between body weight, conformation and morphological traits of NAPRI-X, Marshall and Ross broiler strains at 4 and 8 weeks of age;
3. To ascertain the extent to which conformation and morphological traits could be used to predict eight weeks body weight of NAPRI-X, Marshall and Ross broiler strains.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 COMMERCIAL BROILER BREEDERS

Breeding companies have the responsibility to manage their genetic resources to deliver stock of predictable performance at high health standards (McKay, 2009). It was reported that, the population sizes must be sufficient to avoid inbreeding and ensure that the genetic variation is maintained to sustain long-term selection response (McKay 2009). The most important developments in genetics since the late 1980s have been in the ability of breeding programs to deliver predictable and coordinated changes in multiple traits. Thus, selection for improved skeletal quality, heart and lung function has allowed simultaneous improvements in growth, feed efficiency and decreasing incidences of skeletal defects and ascites.

Major investments are now being made to further improve the relevance and accuracy of the measurements made. This will allow more efficient and accurate selection to make further progress in many traits (McKay, 2009).

Genetic improvement in pigs and poultry is now almost wholly in the hands of specialized breeding companies whose business is the art of genetic improvement and the supply of improved breeding stock (Olori, 2009). The evolution of this process has taken decades and in the case of broiler chickens, it is now that, the number of primary poultry breeding companies globally has reduced to less than ten (10) through the process of mergers and acquisition (Aho, 2002, Laughlin, 2007). Presently, three (3) companies supply over 90% of the global parent stock requirement (Laughlin, 2007). Breeding broilers for over half of the world puts a lot of responsibilities on the shoulder of any one company. The global leaders include:

1. Aviagen®

Aviagen group is the world's leading poultry breeding company, developing products to meet the needs of the commercial broiler and turkey industries (Penn 2013). Formed in 1999, the company now combines poultry breeding resources and expertise across its brand portfolio, which include Ross, Arbor Acre, Lohman Indian River, CWT farms and Nicholas (Penn 2013).

2. Hubbard

From the small flock of chickens, Ira and Oliver Hubbard began the business in 1921 (Penn 2013). Hubbard has grown to be one of the major international broiler breeding companies in the world (Penn 2013). The poultry industry has seen remarkable changes during the past 90 years, with dramatic results for the benefit of humankind. It provides solutions that focus on the economic performance, health and well-being of breeding stock (Penn 2013). Hubbard specializes in state-of-the art selection programs to improve the performance of pure lines, and offers a range of products that respond to current and future needs of the broiler industry. It has a longstanding experience in breeding, developing and marketing breeding stock for both conventional and alternative markets (Penn 2013).

Hubbard operates its selection programs in three (3) different centers in North America, Europe, along with its own production sites in America, Europe and Brazil (Kelly, 2007). However, ultra-yield's genetic potential is maximized at the heavier weight (2.8 - 4.0 kg) where the highest meat yield can be harvested by the processors looking for the maximum value de-boned chicken meat from each carcass.

3. Marshall – The founders of Marshall, brothers Elias and Richard D’Souza, started their career in the poultry industry with modest beginning in 1961 in Nasik, India (Marshall Breeders 2013). A small of 200-birds backyard farm was the first step in learning about raising and farming poultry for meat and eggs (Marshall Breeders 2013). In the years and decades that followed, the founders went on to play a pivotal role in the development of the poultry industry in India (Marshall Breeders 2013).

Marshall is one of the very few basic poultry breeding companies in Asia. In a short period of time, Marshall broiler breeds have firmly established themselves as leaders in efficient chicken meat production taking intensive commercial broiler growing to a whole new level of productivity (Marshall Breeders 2013). Marshall breeding program includes a good mix of classical population genetic and tools available through the advances in molecular genetics and collaborative research with universities (Marshall Breeders 2013).

4. Research Institutes – In Nigeria, the only Federal Government Research Institute on Animal production is the National Animal Production Research Institute (NAPRI) located in Shika, Zaria, Kaduna State. The institute was formerly known as Stock-farm. It was transformed and renamed National Animal Production Research Institute (NAPRI) in 1976. NAPRI is one of the three agricultural research institutes of the renowned Ahmadu Bello University, Zaria. NAPRI has research programs among which include poultry research programme.

Some objectives of the poultry research program include:

- Improvement of genetic and reproductive capacity of poultry species including local and exotic chickens, guinea fowls and turkeys.
- Improvement of management practices of poultry production.

- Determination of the nutritional needs of all classes of poultry
- Research into the utilization of conventional and non-conventional feed ingredients
- To ensure standardization and quality of poultry feeds.

Some of the research highlights under poultry research program include:

- Development of layer breed of chicken for Nigeria the ShikaBrown[®] layer.
- The use of unconventional feed resources for poultry diets
- Comparative performances of naked neck broiler and imported Ross or Anak breed.
- Study on the seasonality of reproduction in guinea fowl.
- Characterization of local chickens.
- The use of ShikaBrown[®] breeding cocks for upgrading local birds.

Development of Broiler strains

Poultry breeding companies generally have a pyramid structure (FAO, 2007). A general structure for broiler breeders is shown below. What differs is the efficiency of the primary breeder at the top of the pyramid in setting relevant breeding goals and achieving the targets that result in the development of suitable products for their clients (Olori, 2009).

BROILER INDUSTRY STRUCTURE

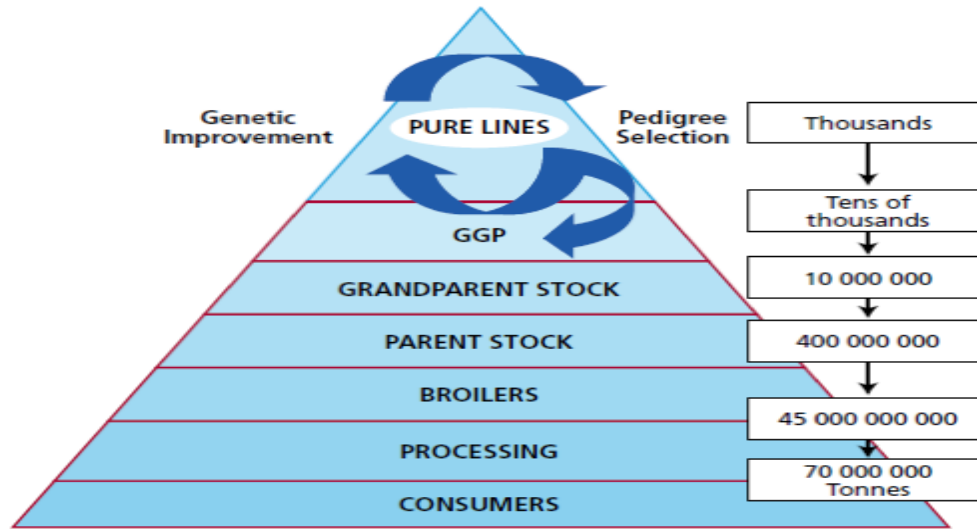


Figure 1 Broiler industry structure. *Source:* McKay, 2008

2.2 GROWTH PERFORMANCE TRAITS.

In Nigeria, there are many reports on the genetic parameter estimates for broiler growth traits. The reports of Amao *et al.* (2009), Ojedapo *et al.* (2008) and Oluyemi and Roberts, (2000) all suggested the need to generate these estimates as baseline data for any future improvement efforts. Carborg *et al.* (2003) obtained significant strain differences on broiler birds' weight, feed intake and feed efficiency. There is evidence that there are genetic differences in growth rate between strains and the changes in weight ranking may be critical in the age ranged eight (8) to twelve (12) weeks (Deeb and Lamont 2000). The development of suitable strains of broiler chickens for the tropical environment is a research interest which has engaged the attention of a number of poultry geneticists and breeders for the past two decades (Nargish, 2010).

The growth traits of concern as per this research are:

- Feed intake
- Body weight
- Feed Conversion Ratio (FCR)

2.2.1 Feed Intake

Broiler feeds are high energy, high protein-concentrate feeds designed to promote rapid growth (Dafwang, 2002). He further added that, there are two (2) types of broiler feeds available commercially. The broiler starter, which should be fed for from day old to 5 weeks of age and the broiler finisher, from 5 weeks to 8 weeks of age. Although, both feeds can have the same energy level (3000 MEKcal/kg of diet) (Dafwang, 2002); the broiler starter should have a higher protein (22-24%) than the finisher (20%).

However, the use of artificial light stimulates feeding day and can increase feed intake and promote a more rapid growth rate. Dafwang (2002) further reported that, consumption of starter mash should be between 1.5 - 2.0 kg/bird from 0-5 weeks while the amount of broiler finisher should be 3 – 4 kg/bird depending on several factors such as breed type, weather, quality of feed etc.

Amao *et al.* (2011) in their research conducted at the derived savannah environment of Nigeria on ‘growth performance traits in strains of broiler chicken’ reported that Ross broiler strain significantly consumed higher feed than other strains (Anak and Marshall). They added that the propensity with which Ross strain consumed feed to put on higher body weight could be attributed to its genetic makeup over the other strains.

However, Mammo and Sultan (2010) reported that Hubbard strain significantly had average range of daily feed intake of 31.8 - 34.2 g/bird/day of broiler starter, and 102.7 - 109.9 g of finisher feed, respectively.

Ncube *et al.* (2012) highlighted the mean feed intake of Ross broiler strain at 4 weeks as 400g and at 7 weeks as 550g. Afolayan *et al.* (2012) reported 2,050.68; 1,921.33; 1,853.88; 1,859.11; 1,802.23; 1,808.46 and 633.78 g/bird as feed intake of Ross broiler strains from 0 to 5 weeks at various levels of substituting maize with sweet potato meal at (0, 10, 20, 30, 40, 50 and 60%). respectively. Afolayan *et al.* (2012) also reported 3,135.72; 3,110.31; 3,011.91; 2,888.10; 2,915.64; 2,809.76 and 2,873.80g/bird as total feed intake of Ross at finisher phase respectively.

Afolayan *et al.* (2012) also observed 73.24, 68.62, 66.21, 66.40, 64.37, 64.59 and 58.35g as the feed consumed per day for Ross broilers at starter level for the various levels of

substituting maize with sweet potato meal at (0, 10, 20, 30, 40, 50 and 60%). They also, recorded 149.32, 148.11, 143.42, 137.53, 138.84, 133.80 and 136.85g as the feed intake per broiler per day at finisher level.

2.2.2 Body Weight

Amao *et al.* (2011) obtained final body weight of Ross, Anak and Marshall broiler chickens as 2,445.32±60.02, 2,340.75±39.04, and 2,100.21±61.23g respectively. Also Adeyinka *et al.* (2006) recorded body weight of naked necked broiler chicken at day old, 2, 4, 6, and 8 weeks as 37.22±0.32, 210.46±1.97, 744.33±4.31, 1,351.3±7.91 and 2,428.1±14.61g respectively.

Kwari *et al.* (2011) recorded means final body weight of unspecified broiler breed as 2,375; 2,055; 2,040; 1,900 and 2,070g at eight weeks for the total replacement of maize grain with different cultivars of sorghum (Ajagama, Bulwana, Chakalare, Kafimoro and Tumbuna varieties) in broiler finisher diets. Mammo and Sultan (2010) obtained the average live weight of Hubbard strain as 1,554.0±94.8 at 45 days old.

However, Jiya *et al.* (2013) observed the initial body weight of Marshall broiler strain as 33.33±0.00, 33.30±0.00, 33.30±0.00, 33.23±0.00 and 33.33±0.00g respectively for 0% activated charcoal supplementation, 0.5% activated charcoal supplementation, 1% activated charcoal supplementation, 1.5% activated charcoal supplementation and 2% activated charcoal supplementation. Jiya *et al.* (2013) also recorded the final body weight for Marshall broiler strain at 4 weeks as 889.88±32.82, 880.78±27.73, 834.35±28.97, 880.37±12.91 and 903.97±85.12g respectively and finally, obtained the final body weight at 8 weeks as 2,324.70±120.5; 2,378.50±50.67; 2,284.90±93.67; 2,131.40±65.42 and 2,034.60±44.56g respectively. Again, Afolayan *et al.* (2012) observed the initial body

weight of Ross strain at first week as 92.00, 91.56, 91.56, 92.00, 91.56 and 92.00g respectively for the 0, 10, 20, 30, 40, 50 and 60% sweet potato meal (SPM) substituted for maize.

However, Afolayan *et al.* (2012) recorded the final body weight from 0 to 5 weeks of age as 1,067.96; 1,009.16; 978.67; 909.56; 850.89; 791.60 and 670.45g/bird respectively and the daily weight gain per bird as 34.86, 32.76, 30.97, 29.21, 27.10, 25.00 and 20.66g respectively.

Afolayan *et al.* (2012) also recorded daily weight gain of Ross from 6 to 9 weeks for the different levels of substituting maize with sweet potato meal at (0, 10, 20, 30, 40, 50 and 60%) as 52.83, 53.23, 45.69, 38.97, 37.34, 31.07 and 28.34 g/bird/day respectively. They also reported final weight for Ross strain from 6 to 9 weeks as 2,310.01; 2,308.81; 2,160.01; 2,016.43; 1,984.64; 1,852.86 and 1,795.71 g/bird for the respective levels of substitutions.

Okon *et al.* (1996) obtained the mean body weights of 265 ± 6.32 , 616.88 ± 16.52 , $1,492.13\pm 30.59$ and $2,550.00\pm 43.08$ g at 3, 6, 9 and 12 weeks of age in broilers respectively. They also reported that live body increments at 28 days (4 weeks) were 6.21 and 6.09 times their 7 day old value for the Lohman Brown and Anak strains, respectively and added that chick doubles its weight 3 to 5 times before 6 weeks of age. Udeh and Ogbu (2011) recorded average body weight for Arbor Acre and Ross as 1,880g and 1,801g respectively which were superior to Marshall (1,650g) at 8 weeks of age.

2.2.3 Feed Conversion Ratio (FCR)

Afolayan *et al.* (2012) recorded the FCR of Ross at starter phase (0-5 weeks) as 2.10, 2.09, 2.14, 2.27, 2.37, 2.58 and 2.82 respectively for the various levels of substituting maize with sweet potato meal at (0, 10, 20, 30, 40, 50 and 60%).

However, Afolayan *et al.* (2012) obtained FCR of Ross at finisher phase (from 6-9 weeks) as 2.83, 2.79, 3.14, 3.53, 3.72, 4.31 and 4.83 for the different levels of substituting maize with sweet potato meal at (0, 10, 20, 30, 40, 50 and 60%).

Ncube *et al.* (2012) highlighted on the average FCR of Ross strain at 4 weeks as 2.25 and 2.4 at seven weeks. Jiya *et al.* (2013) recorded FCR for Marshall Strain at starter phase as 1.76 ± 0.06 , 1.82 ± 0.05 , 1.82 ± 0.02 , 1.84 ± 0.04 and 1.92 ± 0.13 for 0% activated charcoal supplementation, 0.5% activated charcoal supplementation, 1% activated charcoal supplementation, 1.5% activated charcoal supplementation and 2% activated charcoal supplementation, respectively. Jiya *et al.* (2013) also obtained 2.92 ± 0.19 , 2.32 ± 0.28 , 2.74 ± 0.14 , 2.96 ± 0.16 and 3.75 ± 0.19 as FCR at finisher phase for 0% activated charcoal supplementation, 0.5% activated charcoal supplementation, 1% activated charcoal supplementation, 1.5% activated charcoal supplementation and 2% activated charcoal supplementation. Mommo and Sultan (2010) recorded FCR for Hubbard as 2.17 ± 0.11 , 2.19 ± 0.00 , 2.18 ± 0.11 , 2.21 ± 1.15 at starter phase and 1.88 ± 1.00 , 1.9 ± 0.00 , 1.8 ± 0.11 and 2.0 ± 0.00 respectively at finisher phase for three broiler starter, grower/finisher-1 and finisher-11 diets. Kwari *et al.* (2011) reported FCR of unspecified broiler breed at finisher phase as 3.39, 3.68, 3.04, 3.09, 3.20 and 3.43 for the total replacement of maize grain with different cultivars of sorghum (Ajagama, Bulwana, Chakalare, Kafimoro and Tumbuna varieties) in broiler finisher diets respectively. Amao *et al.* (2011) reported

FCR of Ross, Anak and Marshall Strains of broilers at finisher phase as 2.32 ± 0.01 , 3.50 ± 0.08 , 3.65 ± 0.03 respectively.

2.2.4 Mortality

Afolayan *et al.* (2012) reported 2.20, 2.20, 0.00, 2.20, 0.00, 2.20 and 0.00 as percentage mortality of Ross broiler breed at different levels of substituting maize with sweet potato meal at (0, 10, 20, 30, 40, 50 and 60%) at starter phase (0-5 weeks). They also reported 0.00 as percentage mortality of Ross at finisher level. Kwari *et al.* (2011) reported 0 percent mortality of chickens at finisher level for the different 6 sorghum varieties as replacements for maize.

2.3 LIVE BODY MEASUREMENTS/BODY CONFORMATION TRAITS

Body weight and conformation traits are the two important traits for measuring growth in the domestic chicken (Udeh and Ogbu, 2011). Reports on body weight and linear body measurements (conformation traits) had been documented and were found useful in quantifying body size and shape (Ibe, 1989; Ibe and Ezekwe, 1994). Linear body measurements have been used to predict live weights in poultry (Chhabra *et al.*, 1972; Monsi, 1992; Okon *et al.*, 1997; Gueye *et al.*, 1998), rabbit (Ekanno and Ibe, 2006), goat (Hassan and Ciroma, 1992; Ozoje and Herbert, 1987), sheep (Kandasame and Gupta, 1983) and cattle (Orheruata and Olutogun, 1994).

However, body growth in livestock may be evaluated with body components such as live weight and body measurements (Wolanski *et al.*, 2006; Saatci and Tilki, 2007). Examining relationships between live weight and linear body measurements of birds especially in rural communities where weighing scales may not readily be available can assist in the selection of animals. The relationship between body weight and

conformation traits has been found to have important implications in the production of broilers with desirable body conformation (Ibe, 1989). The relationship existing among linear body traits provides useful information on performance, productivity and carcass characteristics of animals (Amao *et al.*, 2012). They added that most of the linear body measurements reflect primarily the length of long bones of the animals (Amao *et al.*, 2012). The animal linear body measurement analyses had been used to predict live weight gain, examine relationship among economic characteristic, reproduction performance and to study the relationships between heredity and environments and such studies had found application in selection and breeding (Owojori *et al.*, 2007). Also, poultry breeders have tried to establish the relationship that exist between body weight and body conformation traits such as shank length, back length, and thigh length as this information reflects on the growth and development of the broiler birds (Adenowo and Omoniyi, 2004).

Ibe (1989) reported that apart from body weight, a number of conformation traits are known to be good indicators of body growth and market value of broilers. He further highlighted such conformation traits to include shank length, breast width, keel length, wing spin, chicken height, body length, thigh length, and head circumference.

Linear measurements are divided into two groups, which include skeletal and tissue measurements. Skeletal measurements include all the height and length measurements, while tissue measurements include heart girth, chest depth, punch girth and width of hips. Amao *et al.* (2012) reported that most of the linear body measurements reflect primarily the length of long bones of the animals.

2.3.1 Neck Length

Kabir *et al.* (2008) stated the neck length of Anak2000 broiler strain as 3.43 ± 0.014 cm, 4.60 ± 0.037 cm, 6.68 ± 0.018 cm, 8.71 ± 0.027 respectively at 2, 4, 6 and 8 weeks of age. However, Adewumi (2000) reported a neck length of 9.83 ± 0.0163 cm for broiler (strain unspecified) at 8 weeks of age. In another development, Ogah (2011) recorded mean neck length for male and female turkey as 25.52 ± 0.61 and 20.28 ± 0.35 cm respectively. Yakubu and Salako (2009) recorded neck length in male and female indigenous chicken as 8.90 ± 0.24 and 7.81 ± 0.12 cm respectively.

2.3.2 Back Length

Ojo *et al.* (2010b) recorded back length for Anak broiler strain as 20.2 ± 0.18 cm, 26.4 ± 0.27 cm, 34.4 ± 0.39 cm and 40.8 ± 0.43 cm at 2, 4, 6 and 8 weeks of age respectively. Kabir *et al.* (2008) observed back length of Anak2000 strain as 4.54 ± 0.07 cm, 8.22 ± 0.06 cm, 14.85 ± 0.050 cm and 19.89 ± 0.047 respectively at 2, 4, 6 and 8 weeks of age. However, Adewumi (2000) and Kadri (2000) reported back lengths of 14.70 ± 0.33 cm and 18.32 ± 0.61 cm at 8 weeks for broilers. They added that the high back length reported could be due to differences in breeds/strains used. Kabir *et al.* (2010) reported the back length for Hubbard as 1.65 ± 0.03 cm, 4.37 ± 0.02 cm, 8.12 ± 0.05 cm, 13.22 ± 0.02 cm and 18.21 ± 0.08 cm respectively at 0, 2, 4, 6 and 8 weeks of age. Ojo *et al.* (2010b) reported back length of Hubbard strain as 20.2 ± 0.18 cm, 26.4 ± 0.27 cm, 34.4 ± 0.39 cm and 40.8 ± 0.43 cm respectively at 2, 4, 6 and 8 weeks of age.

2.3.3 Shank Length

Kabir *et al.* (2006) obtained values for mean shank length for female breeder line of Rhode Island Red as 9.7 ± 0.190 cm at 20 weeks and 12.50 ± 0.117 cm at 40 weeks of age

respectively. Udeh and Ogbu (2011) reported mean shank length of $7.80\pm 0.05\text{cm}$, $7.64\pm 0.06\text{cm}$ and $7.54\pm 0.06\text{cm}$ respectively for Arbor Acre, Marshall and Ross breeds of broilers. Ogah (2011) recorded mean shank length of $12.52\pm 0.35\text{cm}$ and $9.14\pm 0.35\text{cm}$ for the male and female turkeys. Yakubu and Salako (2009) indicated mean shank length of $6.65\pm 0.12\text{cm}$ and $6.25\pm 0.05\text{cm}$ in male and female indigenous chicken of Nigeria.

Kabir *et al.* (2008) recorded shank length of Anak broiler strain as $2.93\pm 0.039\text{cm}$, $4.21\pm 0.035\text{cm}$, $6.13\pm 0.021\text{cm}$ and $8.03\pm 0.029\text{cm}$ at weeks 2, 4, 6 and 8 respectively. Essien and Adeyemi (1999) reported shank length of $4.34\pm 0.09\text{cm}$, $6.20\pm 0.09\text{cm}$, $8.10\pm 0.11\text{cm}$ and $9.92\pm 0.13\text{cm}$ for Lohman Brown broiler strain and $4.38\pm 0.08\text{cm}$, $6.14\pm 0.60\text{cm}$, $8.89\pm 0.09\text{cm}$ and $10.03\pm 0.07\text{cm}$ for Anak broiler strains at 2, 4, 6 and 8 weeks of age respectively. Ubani *et al.* (2010) recorded mean values for shank length of naked neck broiler chicken at 8 weeks as 3.09cm . Ojo *et al.* (2010b) reported shank length in Hubbard as $4.7\pm 0.05\text{cm}$, $6.4\pm 0.08\text{cm}$, $7.9\pm 0.10\text{cm}$ and $10.8\pm 0.39\text{cm}$ at 2, 4, 6 and 8 weeks respectively.

However, Okon and Ogundu (2006) observed that shank length differed between sexes in turkeys and they recorded higher shank length for males than females. This was also true for local chickens of Edo State as reported by Okpeku *et al.* (2003) with males measuring $9.52\pm 0.32\text{cm}$ and females, $8.99\pm 0.64\text{cm}$. Essien and Adeyemi (1999) reported that shank length increased with age and differed among broiler strains. This agreed with earlier report of Okon *et al.* (1997).

In another development Kabir *et al.* (2010) reported mean shank length in Anak and Hubbard across all ages as $1.62\pm 0.03\text{cm}$, $2.90\pm 0.01\text{cm}$, $4.76\pm 0.02\text{cm}$, $6.68\pm 0.02\text{cm}$, $8.90\pm 0.03\text{cm}$ at 0, 2, 4, 6 and 8 weeks of age for Anak and $1.25\pm 0.01\text{cm}$, $2.97\pm 0.01\text{cm}$,

4.61±0.06cm, 6.62±0.02cm and 8.65±0.37cm at 0, 2, 4, 6 and 8 weeks of age respectively for Hubbard. Nwosu *et al.* (1985) reported 7.54±0.09cm for mean shank length in the chicken. Malik *et al.* (1997) obtained 7.08±0.27cm and 6.89±0.15cm for feathered neck and naked neck broiler birds respectively.

2.3.4 Thigh Length

Essien and Adeyemi (1999) observed that thigh length increased with age and differed between strains of broilers. Okon and Ogundu (2006) however, reported that thigh length differed between sexes in turkeys and males had higher thigh length than females. They also obtained breed differences in thigh length. Ogah (2011) reported 9.62±0.27cm and 8.13±0.14cm as the thigh length of male and female turkeys. Kabir *et al.* (2010) recorded thigh length of Anak2000 and Hubbard strains of broilers as 1.81±0.02cm, 3.61±0.01cm, 5.80±0.05cm, 8.60±0.02cm and 9.97±0.03cm at 0, 2, 4, 6 and 8 weeks for Anak strain. They also reported thigh length of Hubbard as 1.68±0.01cm, 3.48±0.01cm, 5.44±0.03cm, 8.23±0.02cm and 9.43±0.05cm respectively at 0, 2, 4, 6 and 8 weeks of age for Hubbard strain. Udeh and Ogbu (2011) stated the mean thigh length in Arbor Acre, Marshall and Ross broiler strains as 17.16±0.06cm, 17.39±0.08cm and 15.25±0.04cm at 8 weeks of age respectively.

2.3.5 Breast Width

The breast width is measured in centimeter across the keel bones from one side of the armpit to the other armpit. Kadri (2000) reported a breast width of 14.51±0.37cm from his experiment on naked neck broiler strain. However, Udeh and Ogbu (2011) reported mean breast width of Arbor Acre, Marshall and Ross broiler strains at 8 weeks of age as 10.53±0.05cm, 12.93±0.05cm, and 9.60±0.06cm respectively. Kabir *et al.* (2010)

obtained mean breast width of (Nu-breed Abeokuta) as $5.04\pm 0.051\text{cm}$, $8.53\pm 0.048\text{cm}$, $12.84\pm 0.032\text{cm}$ and $14.18\pm 0.026\text{cm}$ at 2, 4, 6 and 8 weeks of age. Ubani *et al.* (2010) highlighted the mean breast width in naked neck broiler strain as 2.28cm. Kabir, *et al.* (2010) obtained breast width of Anak and Hubbard broiler strains across all ages as $2.46\pm 0.02\text{cm}$, $5.95\pm 0.01\text{cm}$, $8.92\pm 0.06\text{cm}$, 12.93 ± 0.01 and $16.32\pm 0.01\text{cm}$ at 0, 2, 4, 6, and 8 weeks of age for Anak; and 2.31 ± 0.02 , 5.92 ± 0.01 , $8.75\pm 0.03\text{cm}$, $12.71\pm 0.02\text{cm}$ and 15.10 ± 0.01 at 0, 2, 4, 6 and 8 week of age for Hubbard respectively.

2.3.6 Body Length

Adedeji *et al.* (2008) observed that body length differed with sex as seen in pure and cross bred progeny of chicken in a derived savannah environment with males being higher in length than females. However, Okon *et al.* (1996) observed that body length increased with age and recorded a range of $10.23\pm 0.12\text{cm}$ to $25.0\pm 0.21\text{cm}$ from 3-12 weeks of age in Lohman Brown broiler chicken and 51.7% increase (over 3-6 weeks), 26.93% (over 6-9 weeks) and 26.90% (over 9-12 weeks). Essien and Adeyemi (1999) also indicated that body length increased from $16.01\pm 0.11\text{cm}$ to $40.26\pm 0.47\text{cm}$ in Lohman Brown while in Anak broiler strain a range of $16.10\pm 0.12\text{cm}$ to $41.08\pm 0.37\text{cm}$ from 1 week to 7 week of age was obtained. Okpeku *et al.* (2003) recorded body length of $34.16\pm 2.82\text{cm}$ and $34.11\pm 2.72\text{cm}$ for males and females respectively in matured local chicken of Edo State.

Ogah (2011) also reported that male turkey is higher in body length than female turkey; he reported mean values for body weight in indigenous male and female turkeys as $35.05\pm 0.17\text{cm}$, and $31.86\pm 0.33\text{cm}$ respectively. Similarly, differences in body lengths

were observed by Sola-Ojo *et al.* (2008) between ages 6-20 weeks. They also reported that body length showed no significant difference between male and female of Fulani ecotype chicken between 2-6 weeks which agrees with earlier report by Okpeku *et al.* (2003) on local chicken of Edo State. They also reported that males had longer bodies than females and added that rapid gains in body length were made when the chicken were young and decreased as they grew older. This is also applicable on the turkeys as quoted above by Ogah (2011) who reported that male turkeys are heavier than females. Yakubu and Salako (2009) reported the mean body length of indigenous chicken as 28.67 ± 0.40 cm, and 26.56 ± 0.17 cm for males and females.

Udeh and Ogbu (2011) observed mean body length of 32.79 ± 0.15 cm, 31.30 ± 0.16 cm and 37.12 ± 0.07 cm for Arbor Acre, Marshall and Ross broiler strains at 8 weeks of age. Ojo *et al.* (2010a) observed mean body length in Hubbard broiler strain as 20.2 ± 0.18 cm, 26.4 ± 0.27 cm, 34.4 ± 0.39 , and 40.8 ± 0.43 cm at 2, 4, 6 and 8 weeks of age respectively.

2.3.7 Wing Length

Udeh and Ogbu (2011) indicated the mean wing length of some broiler strains at 8 weeks of age as 18.98 ± 0.07 cm, 17.95 ± 0.06 cm, and 18.57 ± 0.05 cm for Arbor Acre, Marshall and Ross broiler strains. Ojo *et al.* (2010b) obtained mean wing length of Hubbard broiler strain across all ages as 11.2 ± 0.15 cm, 14.3 ± 0.16 cm, 17.8 ± 0.18 cm, and 20.8 ± 0.13 cm at 2, 4, 6 and 8 weeks of age respectively. Ogah (2011) reported mean wing length of turkey as 26.85 ± 0.40 cm, and 24.57 ± 0.49 cm for male and female turkeys respectively. Males were reported to have longer wings in Fulani ecotype chicken than the females for all

ages except at fourth week and all the covariances were closely related (Sola-Ojo *et al.*, 2008).

2.3.8 Correlation between Body Weight and Live Body Measurements

Yakubu and Salako (2009) reported that phenotypic correlations between linear type traits and body weight of Nigeria indigenous chicken ranged from moderate to high values in both males and females sexes. They added that, in male chicken, path analysis revealed that thigh circumference had the highest direct effect on body weight, followed by comb height and body length, respectively. The direct effects of comb length, beak length, and shank length and chest circumference were non-significant, as they were influenced greatly by thigh circumference. They added that in female chicken, the direct effects of comb height, thigh circumference, body length, and chest circumference and shank length on body weight were positive and significant. The effects of comb length and beak length were however, negative and non-significant while neck length negatively and significantly impacted on body weight.

Ojo *et al.* (2010b) reported high and positive coefficients of genetic correlation at 2 weeks between body weight and back length, shank length, and chicken height. This implies that an increase in back length would result in body weight. Similarly, improvement in chicken height can be achieved through selection for increased shank length.

Okon and Ogundu (2006) obtained high and positive phenotypic correlations between body weight and other body parameters namely: thigh length, chest circumference, breast width, keel length and shank length. They suggested that these parameters may be good indicators of body weight. Similarly, Okpeku *et al.* (2003) reported that body weight was

positively correlated with body length, chest circumference, femur and crust but obtained negative and low correlation between body weight and tarso-metatarsus (shank length) among local chicken of Edo State of Nigeria. Okon *et al.* (1996) stated the interrelationships of live body measurements in broiler chicken at 3, 6, 9 and 12 weeks of age. They observed that the correlation coefficient at 3 weeks were generally weak and non-significant with some traits showing negative relationships. Body weight was observed to be only positively correlated with shank width at 3 weeks of age, whereas body girth at 3 weeks was positively correlated with length. From these findings, shank width was the highest estimator of body weight at 3 weeks. Shank width was also positively correlated with body weight at 3, 6, 9, and 12 weeks. At 6 and 9 weeks, body weight was reported to be positively correlated with body girth, body length, keel length, shank length and width.

However, at 12 weeks body weight was positively correlated with only three of the parameters namely: body girth, keel length, and shank length. These results suggest that body weight in broiler chicken can be rapidly predicted from these live body measurements at 6, 9, and 12 weeks of age. This agrees with similar observation by Monsi (1992) with Cob broiler strain. Okon and Ogundu (2006) observed that shank length had significant and positive correlation with thigh length, thigh circumference, breast width and keel length. Whereas, low but significant correlation was observed between shank length and body weight in turkey breeds of south eastern Nigeria. They also reported that thigh length had high and significant correlations with body weight, thigh circumference, breast width, keel length and shank length. They also obtained

highly significant correlations between chest circumferences (breast width) with body weight, thigh length and thigh circumference.

Chhabra *et al.* (1972) reported positive correlation (0.86) for live body weight and shank length at 20 weeks of age. Clayton and Robertson (1966) reported highly and positive genetic correlation (0.84) between body weight and live body measurements at 12 and 20 weeks of age. Oni *et al.* (1991) also reported a highly positive genetic correlation (0.88 and 0.98) between juvenile body weight (16 and 20 weeks of age) in two strains of Rhode Island birds. Similarly, Sani *et al.* (1991) reported low correlation coefficient of 0.09 between body weight at 18 weeks and body weight at 32 weeks respectively.

Udeh and Ogbu (2011) reported coefficient of correlations of body weight and body measurements of three strains of broiler chicken as ranged -0.05 to 0.76, -0.02 to 0.56 and -0.28 to 0.60 in Arbor Acre, Marshall and Ross strains respectively. They also reported that relationships between body weight and most of the body measurements were positive and non significant ($p>0.05$) in the three strains of broilers.

However, a significant ($p<0.01$) and positive correlations were recorded for shank length and breast width (0.62), thigh length and breast width (0.66), thigh length and wing length (0.64) and breast width and wing length (0.76) in Arbor Acre broiler.

In Marshall, significant ($P<0.05$) and positive relations were obtained for shank length and body width (0.56), shank length and wing length (0.50), and body width and wing length (0.47).

Similarly, in Ross strain, significant ($p < 0.05$) and positive relations were observed for thigh length and wing length (0.54), shank length and wing length (0.55) and body width and breast width (0.50).

2.3.9 Eigen Values and Percentage of Total Variance Along with the Rotated Component Matrix and Communalities of the Body Measurements.

Udeh and Ogbu (2011) reported that two principal components were extracted from Abor Acre broilers with eigen values of 2.841 for the first principal component (PC1) and 1.707 for the second principal component (PC2). The two PCs accounted for 65% of the total variance present in the seven original variables. PC1 had high loadings (correlations between the components and the variables) on breast width (0.930), wing length (0.897) and thigh length (0.789). PC2 was orthogonal to PC1 and loaded heavily on drumstick length (0.852). In Marshall, three PCs were extracted with eigen values of 2.677, 1.549 and 1.007 for PC1, PC2 and PC3 respectively. The three PCs accounted for 74.76% of the total variance present in the original variables. PC1 had high positive loadings on shank length (0.885), wing length (0.766) and a negative loading on drumstick length (-0.735) implying that an increase in shank length and or wing length will result to correlated decrease in drumstick length of Marshall Broiler.

A similar situation was obtained in PC2 which loaded heavily on breast width (0.899) and thigh length (-0.736), thus implying that an increase in breast width will result to decrease in thigh length. PC3 was most highly correlated with body length (0.939). In Ross broiler, three PCs were extracted after varimax rotation accounting for 70% of the total variance in the original variable with eigen values of 2.733, 2.079, and 1.155 for PC1, PC2 and PC3 respectively. PC1 was most highly correlated with breast width

(0.913), body width (0.748) and body length (-0.878) implying high relationship among the three variables. PC2 has high positive loadings on wing length (0.863) and thigh length (0.824) while PC3 was most highly correlated with drumstick length (0.935).

2.4 MORPHOLOGICAL TRAITS: AN OVER VIEW

Many livestock scientists apply methodology for morphological characterization with the aim of comparing their various breeds (Francesch *et al.*, 2011). They reported that in fowls, not many measurements have been taken from live birds; few studies have been done in wild (undomesticated) fowls. Some measurements reported include: length or ornithological measurement, wingspan, beak length, comb length (Ceballos *et al.*, 1989), apparent size and folded wing length (Ceballos *et al.*, 1989); (Ralph *et al.*, 1993); (SEO, 2000), tarsus length; (Ceballos *et al.*, 1989; SEO, 2000).

2.4.1 Ocular Length and Width

Nääs *et al.* (2008) indicated ocular length of Cob-500 broilers for the left and right sides at 28 days old as 12.85 and 12.66mm; at 35 days 13.02 and 13.07mm; and at 42 days old as 14.50 and 14.95mm respectively. Francesch *et al.* (2011) reported significant differences between ocular length, ear lobes length, neck length, thigh length, tarsus diameter (shank diameter) and central toes length. They further observed the ocular length of 14.32 ± 0.21 mm and 14.20 ± 0.21 mm in Partridge penedesenca and Blond Empordanesa strains of chicken at 30 weeks old. On the other hand, Francesch *et al.* (2011) observed the mean ocular width of the Partridge penedesenca and Blond Empordanesa strains of chicken as 11.35 ± 0.19 mm and 11.16 ± 0.19 mm at 30 weeks of age, respectively.

2.4.2 Comb Height and Length

Joseph *et al.* (2003) highlighted comb height in Cob-500 broiler breeder pullets as 1.07, 1.09, 1.24, 1.44, 1.39, 1.52, 1.56, 1.64, 1.81, 1.93, 2.00, 2.00 and 1.98 cm at 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24 days old respectively.

Francesch *et al.* (2011) reported that the comb height of Partridge penedesenca and Blond Empordanesa are 35.41 ± 1.59 mm and 39.56 ± 1.59 mm at 30 weeks old, respectively.

Yakubu and Salako (2009) observed mean comb height in male and female indigenous chickens as 2.17 ± 0.12 and 1.32 ± 0.06 cm respectively. In addition, Joseph *et al.* (2003) reported comb length of Cob-500 broiler breed as 3.72, 3.56, 3.52, 3.66, 3.78, 4.10, 4.02, 4.25, 4.30, 4.14, 4.50, 4.47 and 4.48cm respectively at 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24 days old.

Francesch *et al.* (2011) reported that comb length, wattle length and width and ear lobes length measures were higher in Blond Empordanesa strain. They further highlighted that folding wing length and tarsus diameter were higher in the Blond Empordanesa strain compared with the Partridge penedesenca strain, whereas Partridge penedesenca strain had a longer length of the keel and greater breast angle. Yakubu and Salako (2009) observed comb length in male and female indigenous chicken as 3.97 ± 0.22 and 2.70 ± 0.10 cm respectively.

2.4.3 Beak Length

Yakubu and Salako (2009) reported beak length in male and female indigenous chicken as 2.12 ± 0.04 and 1.95 ± 0.02 cm respectively. Francesch *et al.* (2011) observed that beak length (20.16 ± 0.30 mm), earlobes length (14.57 ± 0.54 mm) for Partridge penedesenca strain and 19.00 ± 0.30 mm and 16.26 ± 0.54 mm for Blond Empordanesa strain at 30 weeks

of age, respectively. Ogah (2011) reported the beak length in male and female turkeys as 5.02 ± 0.10 cm and 4.20 ± 0.09 cm respectively.

2.4.4 Ear Lobes Length and Width

Francesch *et al.* (2011) reported ear lobes length for the Partridge penedesenca and Blond Empordanesa strains of chicken as 14.57 ± 0.54 mm and 16.26 ± 0.54 mm at 30 week old respectively. In addition, Francesch *et al.* (2011) observed ear lobes width for the Partridge penedesenca and Blond Empordanesa strains of chicken as 12.42 ± 0.36 mm and 14.67 ± 0.36 mm at 30 weeks old, respectively.

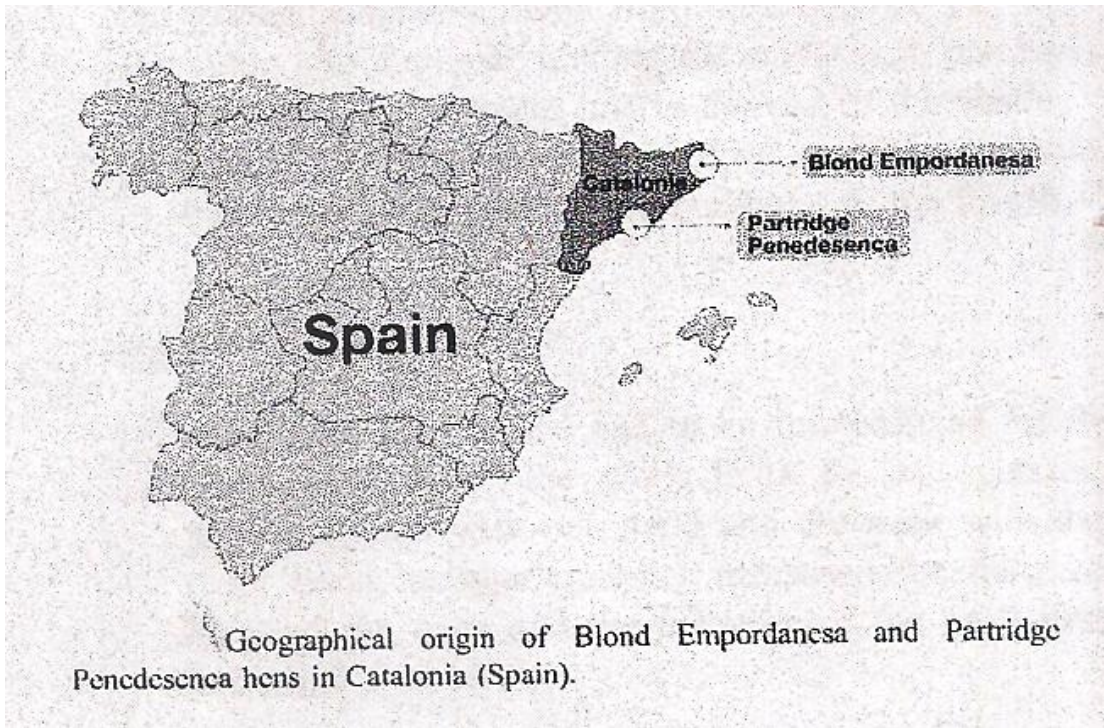
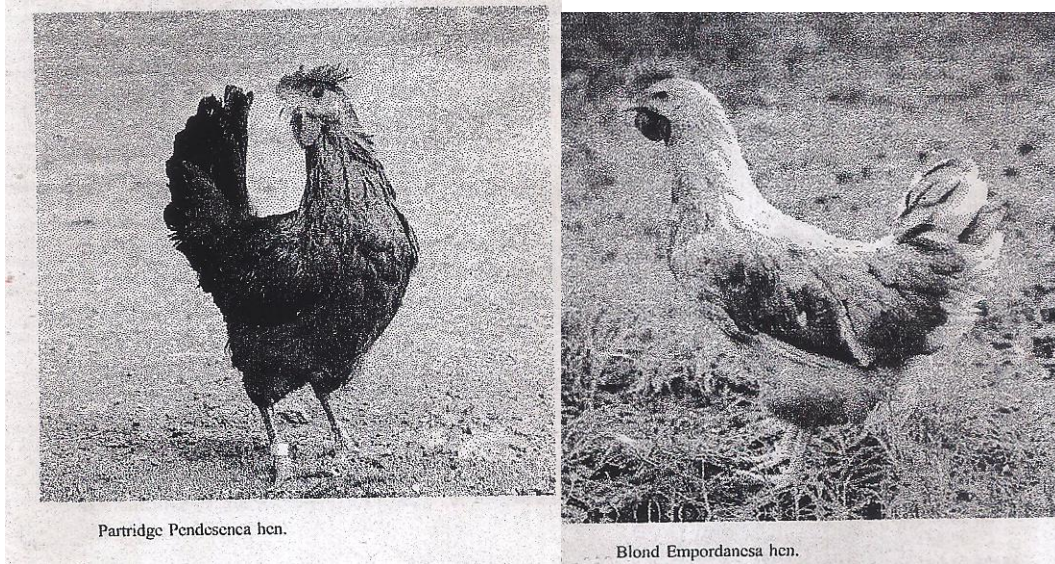


Figure 2 Photograph of Partridge Penedesenca and Blond Empordanesa strains of fowl in Catalonia (Spain) and Map of Spain showing the origin of these strains. *Source : Francesch et al 2011*

2.4.5 Wattle Length and Width

Nääs *et al.* (2008) reported 23.73 and 23.30mm as wattle width of Cob-500 broiler for the left and right sides at 28 days respectively; 28.24 and 25.43mm were reported at 35 days. At 42 days old 32.25 and 31.60mm were recorded respectively. However, Francesch *et al.* (2011) highlighted that head variables as wattles length and width, ear lobes length and comb length, measures were higher in Blond Empordanesa strain. They reported wattle length in the two strains as 27.16 ± 1.22 and 39.38 ± 1.22 mm at 30 weeks of age, respectively. Moreover, Francesch *et al.* (2011) observed wattle width as 21.44 ± 0.86 and 29.64 ± 0.86 mm at 30 weeks old, respectively for the Partridge penedesenca and Blond Empordanesa strains.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The research was conducted at the Poultry Unit of Teaching and Research Farm of the Department of Animal Health and Husbandry, Audu Bako College of Agriculture, Dambatta, Kano State, situated at 35 km along Kano-Daura Road. The College is located at the Northern part of Kano metropolis and positioned on latitude 12° 20.260' N and longitude 8° 31.567' E (G. P. S., 2012). The College possesses a tropical climate with mean annual rainfall of 600mm which last for four months (between May and September) and the mean annual temperature is 38°C with highest temperature occurring in April (41°C) and lowest in January (30°C) (Abdulrashid *et al.*, 2012). The relative humidity ranged from 22 to 52% as recorded by (KNARDA, 2011).

3.2 Source of Experimental Birds

Marshall and Ross broiler breeds were purchased from Obasanjo Farms in Abeokuta, Ogun State while NAPRI-X broiler breed was obtained from National Animal Production Research Institute (NAPRI), Shika, A. B. U., Zaria.

3.3 Experimental Birds and Management.

A total of three hundred and fifteen (315) day old broiler chick strains comprising NAPRI-X, Marshall and Ross breeds (105 each) were used to compare growth performance, conformation and morphological traits in the semi-arid zone of Nigeria. Each strain was identified by wing tag, randomized and allotted to pens in a brooder house with floor covered using wood shavings which was kept dry throughout the experimental period by replacing the litter regularly. The birds were brooded with the aid

of kerosene stoves and charcoal as heat source and reared on deep litter from day-old to 8 weeks of age. All the chicks were fed *ad libitum* with a broiler starter feed containing 23.75% Crude Protein (CP) and 3,038.64 MEKcal/kg up to 4 weeks of age. Thereafter the birds were given broiler finisher diet containing 19.95% CP and 3,102.00 MEKcal/kg up to 8 weeks in accordance with NRC (1994) nutrient standard for broiler birds. Fresh, cool drinking water was also given *ad libitum*. Vaccination and other routine medication were carried out as at and when due.

3.4 Experimental Design:

The experiment was conducted in a Completely Randomized Design (CRD). Each breed serves as a treatment. Treatments were replicated seven (7) times with fifteen (15) birds per pen.

3.5 Growth Traits Measured:

3.5.1 Feed Intake (FI):

Daily feed intake was measured from day-old to eight (8) weeks of age and feed intake was obtained by getting the difference between feed offered and leftover.

3.5.2 Body weight (BW):

The birds were wing tagged for easy identification. Body weight was measured in grams from day old to 8 weeks using a digital electronic scale (with maximum calibration of 3,000g). The birds were individually weighed after which the mean body weight for all the birds was computed and used in the subsequent calculations. The body measurements were carried out early in the morning before feed is provided.

3.5.3 Feed Conversion Ratio (FCR):

This was computed using the following formula: $FCR = \frac{FC \text{ (in grams)}}{WG \text{ (in grams)}}$

Where FC = Feed consumed in gram, WG = Weight gained in grams.

3.5.4 Percentage Mortality:

Percentage mortality was evaluated as the number of birds that died / Total number of birds started with at the initial stage of the experiment multiply by 100.

3.6 CONFORMATION TRAITS MEASURED

The neck was gently straightened out and the length was measured with a tape rule as neck length (NEL). Back length (BKL) was measured from the base of the neck to the uropygial gland at the base of the tail, including the cape and saddle parts. Thigh length (THL) was taken from the hock joint to the hinge joint. The tarso-metatarsus (shank length) (SHL) was obtained by measuring from the hock joint to the base of the three toes. Breast width (BRW) was measured across the keel bones from the left armpit to the right armpit. Body length (BDL) was measured as the distance between the base of the neck to the cloaca. Wing length (WNL) was measured from the shoulder joint to the extremity of terminal phalanx. To ensure accuracy, each measurement was taken twice. All the measurements were taken by the same person using tape rule calibrated in centimeters (cm). These conformation traits were measured every week up to eight weeks.

3.7 MORPHOLOGICAL TRAITS MEASURED

The morphological traits were measured at fourth and eighth weeks of age. The traits include: ocular length (OCL) measured from the lateral canthus of the eye to the medial

canthus and ocular width (OCW) measured from the proximal surface of the eye socket to the distal surface of the eye socket. Comb width (CBW) was measured from its base at the crest of the head to the tip of the tallest cusp on the comb; comb length (CBL) measured from the horizontal distance from the beginning to the end of the comb; beak length (BEL) taken as distance from the rectal aperture to the maxillary nail; ear lobes length (ELL) measured from the proximal surface of the temporal bone to the distal surface of the temporal bone; ear lobes width (ELW) taken from the cranial to the caudal surface of the temporal bone; wattle height (WTH) measured from the base to the apex of the wattle; wattle width (WTW) taken from the cranial to the caudal borders of the wattle. All these traits were measured using tape rule calibrated in (cm).

3.8 STATISTICAL ANALYSIS

3.8.1 Analysis of Variance:

The data generated from growth performance, conformation and morphological traits were subjected to General Linear Model (GLM) procedure of analysis of variance (ANOVA) using Statistical Package for Social Science SPSS (2011) version 20. Significant differences among means were separated using Duncan's Multiple Range Test procedure (Duncan, 1955).

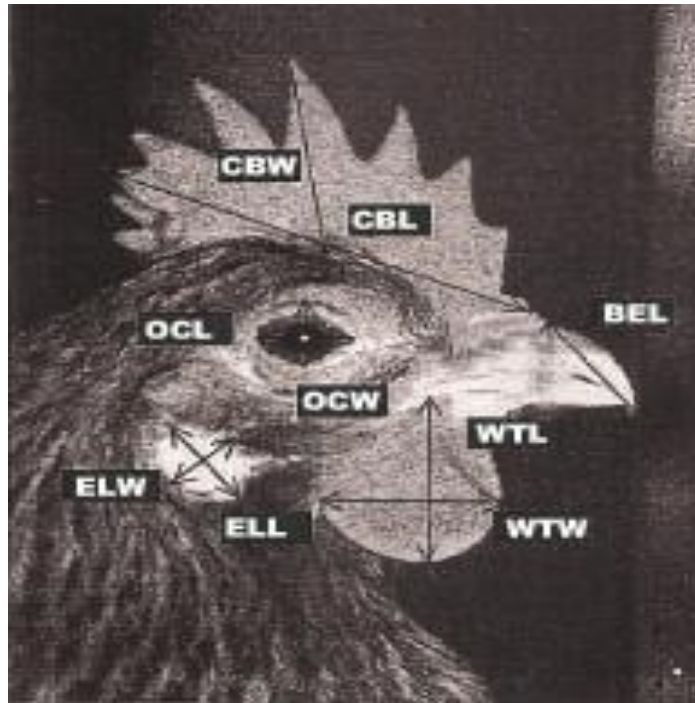


Figure 3: Details of a Partridge Penedesenca hen head with its corresponding measures. CBW = Comb width, CBL = Comb length, OCL = Ocular length, OCW = Ocular width, BEL = Beak length, WTL = Wattle length, WTW = Wattle width, ELL = Ear lobe length and ELW = Ear lobe width. *Source: Francesch et al 2011*

3.8.2 Correlation Analysis:

The coefficient of relationship between growth performance, conformation and morphological traits in each of the strain was carried out using Pearson Moment correlation of Predictive Analytical Software for Windows PASW (2011) formerly known as Statistical Package for Social Sciences SPSS (2011) version 20.

3.8.3 Regression Analysis:

Similarly, measurements of conformation and morphological traits at 8 weeks were regressed against body weight using simple linear regression analysis procedure of SAS (2008) version 9.0.

Univariate regression procedure was used to obtain model for predicting body weight from body conformation and morphological traits.

$$Y = a + b_X (X_1 \dots \dots \dots X_i)$$

Where:

Y = the dependent variable (live body weight)

a = the intercept of regression curve on y-axis and was the value of the dependent variable Y when all independent variables were zero.

b = partial regression coefficient associated with respective independent variable X_1

x = independent variables (body measurements).

The regression assumed that: Independent variables have no measurement error

The errors about the regression line were equal.

3.8.4 Principal Component Analysis procedure:

In order to have precise and more reliable estimates, principal component analysis was also used. The correlation coefficients of body weight, conformation and morphological traits measurements at eight (8) weeks were also determined. From the correlation matrix, data for the principal component factor analysis were generated which was the primary data required for PCA. Bartlett's test of sphericity was used to test if the correlation matrix was an identity matrix (each variable correlated with itself) or a correlation matrix is full of zero. The suitability of the data set to PCA was further tested by Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This tested whether the partial correlation among variables were small. A KMO measure of 0.60 and above is considered adequate (Eyduran *et al.*, 2010).

Everitt *et al.* (2001) defined principal component analysis as a method of transforming variables in a multivariate data set, x_1, x_2, \dots, x_p into new uncorrelated variables y_1, y_2, \dots, y_p which account for decreasing proportions of the total variance in the original variables defined as

$$y_1 = a_{11}x_1 + a_{12}x_2 + \dots + a_{1p}x_p$$

$$y_2 = a_{21}x_1 + a_{22}x_2 + \dots + a_{2p}x_p$$

$$y_p = a_{p1}x_1 + a_{p2}x_2 + \dots + a_{pp}x_p$$

The principal components y_1, y_2, \dots, y_p account for decreasing proportions of the total variance in the original variables x_1, x_2, \dots, x_p . Variance maximizing orthogonal rotation was used in the linear transformation of the factor pattern matrix in order to make the interpretation of the extracted principal components easier. The principal components analysis was performed using the PROCPRINCOMP of SAS (2008) version 9.0.

Model for strain evaluation:

$$Y_{ij} = \mu + C_i + e_{ij}$$

Where Y_{ij} = Observation

μ = overall population mean

C_i = the effect of i^{th} strain ($i=1, 2$ and 3)

e_{ij} = random error term

CHAPTER FOUR

4.0 RESULTS

4.1 GROWTH PERFORMANCE CHARACTERIZATION

4.1.1 Comparative growth performance of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Table 4.1.1 shows comparative growth performance of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age.

The results showed that the three strains differed significantly ($P < 0.001 - 0.05$) in terms of IBW, FBW, DWG, TWG, DFI, TFI and FCR but not in MTLTY ($P > 0.05$). The results indicated that the mean values of Marshall strain was higher in all the traits than NAPRI-X and Ross strains, except in FCR in which Ross breed was higher than NAPRI-X and Marshall which were statistically the same; indicating that Marshall strain was superior than the other strains.

4.1.2 Correlated phenotypic relationship between growth performance of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Table 4.1.2 presents the correlated relationship between growth performance of NAPRI-X, Marshall and Ross strains at 4 weeks of age. The results demonstrate that positive and perfect correlations were found between FBW, DWG and TWG ($r = 1.00$; $P < 0.01$) in NAPRI-X, Marshall and Ross strains, indicating that DWG is a function of TWG; with higher DWG leading to higher FWG.

Table 4.1.1: Comparative growth performance of broiler strains at 4 weeks of age

Traits	Treatments			SEM	LOS
	NAPRI-X	Marshall	Ross		
Initial Body Weight (g/bird)	45.35 ^b	46.48 ^a	45.26 ^b	0.16	***
Final Body Weight (g/bird)	446.28 ^b	548.01 ^a	472.13 ^b	12.26	***
Daily Weight Gain (g/bird)	14.32 ^b	17.91 ^a	15.24 ^b	0.43	***
Total Weight Gain (g/bird)	401.08 ^b	501.53 ^a	426.87 ^b	12.13	***
Daily Feed Intake (g/bird)	28.12 ^b	30.74 ^a	30.62 ^a	0.52	*
Total Feed Intake (g/bird)	787.36 ^b	860.68 ^a	857.48 ^a	14.50	*
Feed Conversion Ratio	1.97 ^{ab}	1.73 ^a	2.03 ^b	0.56	*
Mortality (%)	3.00	1.86	2.57	0.26	NS

(g) = grams, LOS = Level of significance, SEM = Standard error of mean, *** = very highly significant (P = <0.001), * = significant (P = <0.05), NS = Not significant.

Table 4.1.2: Correlated relationship between growth performance (g) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Traits	IBW	FBW	DWG	TWG	DFI	TFI	FCR
NAPRI-X							
FBW	0.19	-					
DWG	0.18	1.00**	-				
TWG	0.18	1.00**	1.00**	-			
DFI	-0.26	-0.09	-0.08	-0.08	-		
TFI	-0.26	-0.09	-0.08	-0.08	1.00**	-	
FCR	-0.27	-0.70	-0.69	-0.69	0.77*	0.77*	-
MTLY	0.53	-0.04	-0.04	-0.04	-0.19	-0.19	-0.11
MARSHALL							
FBW	0.68	-					
DWG	0.67	1.00**	-				
TWG	0.68	1.00**	1.00**	-			
DFI	0.26	0.24	0.24	0.24	-		
TFI	0.26	0.24	0.24	0.24	1.00**	-	
FCR	-0.56	-0.91**	-0.92**	-0.92**	0.77	0.17	-
MTLY	-0.14	0.26	0.26	0.26	0.12	0.12	-0.26
ROSS							
FBW	0.42	-					
DWG	0.41	1.00**	-				
TWG	0.41	1.00**	1.00**	-			
DFI	0.15	-0.31	-0.31	-0.31	-		
TFI	0.15	-0.31	-0.31	-0.31	1.00**	-	
FCR	-0.23	-0.85*	-0.86*	-0.86*	0.76*	0.76*	-
MTLY	0.39	0.01	0.00	0.00	-0.03	-0.03	0.00

IBW = Initial body weight, FBW = Final body weight, DWG = Daily weight gain, TWG = Total weight gain, DFI = Daily feed intake, TFI = Total feed intake, FCR = Feed conversion ratio, MTLY = Mortality, * = significant (P<0.05), ** = highly significant (P<0.01), (g) = grams

Similarly, negative and highly significant correlations of FBW and FCR were observed ($r = -0.91$; $P < 0.01$) and ($r = -0.85$; $P < 0.05$) in Marshall and Ross strains, respectively; indicating that as FBW increases, FCR decreases, portraying inverse relationships. Moreover, positive and perfect correlation was found between DWG and TWG ($r = 1.00$; $P < 0.01$) in all the three strains, depicting that DWG contributes substantially to TWG. In addition, negative and highly significant correlations were observed between DWG and FCR ($r = -0.92$; $P < 0.01$) and ($r = -0.86$; $P < 0.05$) as well as between TWG and FCR ($r = -0.92$; $P < 0.01$) and ($r = -0.86$; $P < 0.05$) in Marshall and Ross strains, portraying that as DWG and TWG increase, the better the FCR becomes.

In another relationship, DFI and TFI were positive and perfectly correlated ($r = 1.00$, $P < 0.01$) in the three strains, demonstrating that TFI is a direct function of the DFI. Also, positive and highly significant correlations were observed between DFI and FCR ($r = 0.77$; $P < 0.05$) and ($r = 0.76$; $P < 0.05$) in NAPRI-X and Ross strains, respectively, demonstrating that poor FCR would lead to increase in DFI. Meanwhile, positive and highly significant correlations were observed between TFI and FCR ($r = 0.77$, $P < 0.05$) and ($r = 0.76$, $P < 0.05$) in NAPRI-X and Ross strains, indicating that the FCR of these birds was poor leading to higher feed intake to meet up with their nutrient need.

4.1.3 Comparative growth performance of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

The results for comparative growth performance of NAPRI-X, Marshall and Ross strains at 8 weeks of age are presented in Table 4.1.3. The results showed a significant ($P < 0.001$) breed differences in the growth performance of the birds with Marshall strain having

better performance in IBW, FBW, DWG, TWG, DFI and TFI. However, no significant ($P>0.05$) differences were observed between the strains in FCR and mortality (MTLTY). The findings revealed that Marshall strain was superior when compared with NAPRI-X and Ross strains.

4.1.4 Correlated phenotypic relationship between growth performance traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Table 4.1.4 shows correlated relationship between growth performance traits of NAPRI-X, Marshall and Ross strains at 8 weeks. The results showed positive and highly significant correlations between IBW and FBW ($r = 0.76 - 0.90$; $P<0.01$) in NAPRI-X, Marshall and Ross strains, respectively, revealing that IBW influences FBW. In addition, positive and highly significant correlations occurred between IBW, DWG and TWG ($r = 0.85$; $P<0.05$) in Ross strain, indicating that IBW influences DWG and TWG. Similarly, a positive and highly significant correlations were observed between FBW, DWG and TWG ($r = 0.96 - 0.99$; $P<0.01$) in NAPRI-X, Marshall and Ross strains, respectively, indicating that DWG influences FBW and TWG in all the three strains.

However, a negative but highly significant correlation between FBW and FCR was observed ($r = -0.85$; $P<0.05$) in NAPRI-X and ($r = -0.95$; $P<0.01$) Ross strains. This shows that FBW negatively influences FCR.

Table 4.1.3: Comparative growth performance of broiler strains at 8 weeks of age

Traits	Treatments				
	NAPRI-X	Marshall	Ross	SEM	LOS
Initial Body Weight (g/bird)	446.28 ^b	548.01 ^a	472.13 ^b	12.26	***
Final Body Weight (g/bird)	1530.58 ^b	1870.69 ^a	1588.69 ^b	45.87	**
Daily Weight Gain (g/bird)	38.72 ^b	47.24 ^a	39.88 ^b	1.25	**
Total Weight Gain (g/bird)	1084.29 ^b	1322.69 ^a	1116.56 ^b	35.07	**
Daily Feed Intake (g/bird)	109.96 ^c	125.85 ^a	116.86 ^b	1.91	***
Total Feed Intake (g/bird)	3078.92 ^b	3523.67 ^a	3229.18 ^b	52.35	***
Feed Conversion Ratio	2.89	2.67	3.01	0.08	NS
Mortality (%)	3.00	2.57	2.86	0.24	NS

(g) = grams, LOS = Level of significance, SEM = Standard error of mean, *** = very highly significant ($P < 0.001$), ** = highly significant ($P < 0.01$), NS = Not significant.

Table 4.1.4: Correlated relationship between growth performance (g) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Traits	IBW	FBW	DWG	TWG	DFI	TFI	FCR	MTLY
NAPRI-X								
FBW	0.76 *	-						
DWG	0.63	0.98**	-					
TWG	0.64	0.98**	1.00**	-				
DFI	0.18	0.32	0.34	0.34	-			
TFI	0.18	0.32	0.34	0.33	1.00**	-		
FCR	-0.48	-0.85*	-0.88**	-0.88**	0.08	0.08	-	
MTLY	-0.04	-0.26	-0.29	-0.29	0.05	0.05	0.32	-
MARSHALL								
FBW	0.82*	-						
DWG	0.62	0.96**	-					
TWG	0.62	0.96**	1.00**	-				
DFI	0.47	0.57	0.54	0.54	-			
TFI	0.47	0.57	0.54	0.54	1.00**	-		
FCR	-0.34	-0.59	-0.65	-0.65	0.27	0.27	-	
MTLY	-0.19	0.12	0.07	0.07	-0.40	-0.40	-0.53	-
ROSS								
FBW	0.900**	-						
DWG	0.853*	0.99**	-					
TWG	0.853*	0.99**	1.00**	-				
DFI	0.351	0.25	0.22	0.22	-			
TFI	0.173	0.21	0.21	0.21	0.81	-		
FCR	-0.789*	-0.95**	-0.96**	-0.96**	0.04	-0.01	-	
MTLY	-0.281	-0.25	-0.23	-0.23	-0.47	-0.82	0.15	-

IBW = Initial body weight, FBW = Final body weight, TWG = Total weight gain, DWG = Daily weight gain, DFI = Daily feed intake, MTLY = Mortality, * = significant (P<0.05), ** = highly significant (P<0.01), (g) = grams.

Moreover, positive and perfect correlation between DWG and TWG was observed in the three strains ($r = 1.000$; $P < 0.01$), which indicates that DWG influences TWG in all the three strains. In the same vein, negative and highly significant correlations between DWG and FCR were found ($r = -0.88$; $P < 0.01$) in NAPRI-X and ($r = -0.96$; $P < 0.01$) in Ross strain. The results depict that DWG negatively influences FCR. Furthermore, negative and highly significant correlations were observed between TWG and FCR in NAPRI-X ($r = -0.88$; $P < 0.01$) and Ross ($r = -0.96$; $p < 0.01$) strains. The results demonstrate that TWG negatively influences FCR. The results also showed positive and perfect correlation between DFI and TFI ($r = 1.000$; $P < 0.01$) in NAPRI-X and Marshall strains. The findings showed that DFI influences TFI.

4.2 MEASUREMENT OF BODY WEIGHT (g) AND CONFORMATION TRAITS (cm).

4.2.1 Comparative conformation traits of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Table 4.2.1 shows the results for comparative conformation traits of NAPRI-X, Marshall and Ross strains at 4 weeks of age. Marshall strain had significantly ($P < 0.01 - 0.001$) higher conformation traits when compared with NAPRI-X and Ross strains. Even though NAPRI-X strain had higher mean values for conformation traits when compared with Ross breed, there is no significant difference between them statistically.

4.2.2 Correlated phenotypic relationship between conformation traits of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Table 4.2.2 presents results of correlated relationship between conformation traits of NAPRI-X, Marshall and Ross at 4 weeks of age. The results showed positive and highly significant correlation between FBW and BRW ($r = 0.78$; $P < 0.05$) in NAPRI-X strain

illustrating that BRW influences FBW in NAPRI-X breed. In addition, a negative and highly significant correlation was observed in NAPRI-X breed between FBW and BDL ($r = -0.88$; $P < 0.01$), indicating that as FBW increases BDL decreases. Similarly, a positive and highly significant correlation was obtained between NEL and BKL ($r = 0.76$; $P < 0.05$) in NAPRI-X breed. The findings reveal that NEL has influence on BKL in NAPRI-X strain. Furthermore, a positive and highly significant correlation was obtained between THL and WNL ($r = 0.79$; $P < 0.05$) in Ross strain, revealing that THL influences WNL. Meanwhile, negative and highly significant correlation was observed between SHL and BDL ($r = -0.78$, $P < 0.05$) in Marshall strain, revealing that as BDL increases SHL decreases in Marshall strain.

Table 4.2.1: Comparative conformation traits (cm) of broiler strains at 4 weeks of age

Traits	Treatments			SEM	LOS
	NAPRI-X	Marshall	Ross		
Initial Body Weight (g)	45.35 ^b	46.48 ^a	45.26 ^b	0.16	***
Final Body Weight (g)	446.28 ^b	548.01 ^a	472.13 ^b	12.26	***
Neck Length	3.68 ^b	4.89 ^a	3.37 ^b	0.17	***
Back Length	6.80 ^b	8.22 ^a	6.62 ^b	0.18	***
Thigh Length	3.84 ^b	5.51 ^a	3.50 ^b	0.21	***
Shank Length	3.93 ^a	4.41 ^a	3.44 ^b	0.13	**
Breast Width	6.67 ^b	8.36 ^a	6.00 ^c	0.25	***
Body Length	7.89 ^b	9.35 ^a	7.41 ^b	0.21	***
Wing Length	12.57 ^b	14.19 ^a	11.44 ^c	0.30	***

(g) = grams, (cm) = centimeter, LOS = Level of significance, SEM = Standard error of mean, *** = very highly significant (P = <0.001), ** = highly significant (P = <0.01).

Table 4.2.2: Correlated relationship between conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Traits	IBW	FBW	NEL	BKL	THL	SHL	BRW	BDL	WNL
NAPRI-X									
FBW(g)	0.19	-							
NEL	0.24	-0.48	-						
BKL	-0.22	-0.71	0.76*	-					
THL	-0.06	-0.20	0.72	0.58	-				
SHL	-0.11	0.45	0.32	0.05	0.43	-			
BRW	0.40	0.78*	0.04	-0.34	0.39	0.50	-		
BDL	-0.14	-0.88**	0.71	0.88	0.52	-0.28	-0.46	-	
WNL	0.13	0.20	0.23	-0.43	0.11	-0.38	0.38	-0.06	-
MARSHLL									
FBW(g)	0.68	-							
NEL	-0.75	-0.29	-						
BKL	-0.03	-0.13	0.08	-					
THL	-0.13	-0.10	-0.25	-0.68	-				
SHL	0.12	0.08	0.02	0.57	-0.48	-			
BRW	-0.12	0.10	-0.05	-0.28	0.58	0.17	-		
BDL	-0.24	-0.06	-0.57	0.53	-0.71	-0.78*	0.06	-	
WNL	-0.57	-0.43	-0.74	-0.36	-0.12	-0.46	-0.40	0.07	-
ROSS									
FBW(g)	0.42	-							
NEL	-0.16	-0.51	-						
BKL	0.61	0.53	0.09	-					
THL	-0.18	0.24	-0.56	0.00	-				
SHL	-0.09	0.60	-0.19	0.01	-0.47	-			
BRW	-0.46	0.52	-0.73	0.47	0.20	0.15	-		
BDL	-0.10	0.27	-0.42	-0.12	0.01	0.24	0.24	-	
WNL	0.17	0.15	-0.12	-0.05	0.79*	-0.45	-0.30	0.11	-

IBW = Initial body weight, FBW = Final body weight, NEL = Neck length, BKL = Back length, THL = Thigh length, SHL = Shank length, BRW = Breast width, BDL = Body length, WNL = Wing length, * = Significant (P<0.05), ** = highly significant (P<0.01) (g) = grams, (cm) = centimeters.

4.2.3 Comparative conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Table 4.2.3 indicates comparative conformation traits of NAPRI-X, Marshall and Ross strains at 8 weeks of age. The findings showed that significant ($P < 0.001 - 0.01$) differences existed among the three strains in IBW, FBW, NEL, BKL, THL, SHL, and BRW with Marshall having the highest mean values in all the traits mentioned above. Although, NAPRI-X breed had numerically higher values of conformation traits when compared with Ross strain, the differences were not significant ($P > 0.05$). However, no significant ($P > 0.05$) differences were observed among the three strains in BDL and WNL, respectively.

Table 4.2.3: Comparative conformation traits (cm) of broiler strains at 8 weeks of age

Traits	Treatments				
	NAPRI-X	Marshall	Ross	SEM	LOS
Initial Body Weight (g)	446.28 ^b	548.01 ^a	472.13 ^b	12.26	***
Final Body Weight (g)	1530.58 ^b	1870.69 ^a	1588.69 ^b	45.87	**
Neck Length	7.54 ^b	8.59 ^a	7.28 ^b	0.15	***
Back Length	18.04 ^b	19.89 ^a	17.45 ^b	0.26	***
Thigh Length	8.05 ^b	9.13 ^a	7.92 ^b	0.15	***
Shank Length	7.45 ^b	8.40 ^a	6.95 ^c	0.16	***
Breast Width	13.14 ^b	14.49 ^a	12.40 ^c	0.21	***
Body Length	23.11	23.79	23.44	0.26	NS
Wing Length	18.83	18.90	18.39	0.13	NS

(g) = gram, (cm) = centimeter, LOS = Level of Significance, SEM = Standard error of mean, *** = very highly significant (P = <0.001), ** = highly significant (P = <0.01), NS = Not significant.

4.2.4 Correlated phenotypic relationship between conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Table 4.2.4 indicates the results of correlated relationship between conformation traits of NAPRI-X, Marshall and Ross strains at 8 weeks. Positive and highly significant correlation was observed between IBW and FBW in NAPRI-X ($r = 0.76$; $P < 0.05$), Marshall ($r = 0.82$; $P < 0.05$) and Ross ($r = 0.82$; $P < 0.05$). The findings indicated that IBW influences FBW. Similarly, positive and highly significant correlation was observed in NAPRI-X strain between IBW and NEL ($r = 0.95$; $P < 0.01$), indicating that IBW contributes to NEL. Moreover, negative and highly significant correlation was found between BKL and WNL in Ross strain ($r = -0.92$; $P < 0.01$), depicting that BKL increases with decreasing level of WNL.

In addition, a positive and highly significant correlation existed between THL and SHL in Ross strain ($r = 0.81$; $P < 0.05$), indicating that THL has an influence on SHL.

Meanwhile, positive and highly significant correlation was observed between BDL and WNL in Ross strain ($r = 0.78$, $P < 0.05$), demonstrating that BDL influences WNL.

Table 4.2.4: Correlated relationship between conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Traits	IBW	FBW	NEL	BKL	THL	SHL	BRW	BDL	WNL
NAPRI-X									
FBW(g)	0.76*	-							
NEL	0.95**	0.72	-						
BKL	-0.63	-0.17	-0.54	-					
THL	-0.07	-0.49	-0.06	-0.23	-				
SHL	-0.05	-0.16	0.26	-0.01	0.16	-			
BRW	0.58	0.21	0.62	-0.27	0.56	0.22	-		
BDL	0.08	0.57	0.09	0.08	-0.24	-0.02	-0.21	-	
WNL	0.23	0.71	0.23	0.21	-0.52	-0.08	0.03	0.73	-
MARSHLL									
FBW(g)	0.82*	-							
NEL	-0.15	-0.54	-						
BKL	0.42	-0.09	0.46	-					
THL	-0.39	-0.29	-0.49	-0.01	-				
SHL	-0.35	0.04	-0.54	-0.47	0.42	-			
BRW	0.05	-0.04	0.66	0.11	-0.57	0.00	-		
BDL	0.70	0.72	-0.32	-0.20	-0.29	-0.25	0.01	-	
WNL	0.20	-0.07	0.45	-0.04	-0.57	-0.61	0.28	0.54	-
ROSS									
FBW(g)	0.90**	-							
NEL	0.46	0.47	-						
BKL	-0.24	-0.34	-0.68	-					
THL	0.16	0.48	0.22	-0.56	-				
SHL	-0.18	0.09	0.40	-0.59	0.81*	-			
BRW	-0.17	-0.04	-0.34	-0.34	0.41	0.08	-		
BDL	0.64	0.68	0.63	-0.67	0.29	0.18	-0.15	-	
WNL	0.38	0.59	0.60	-0.92**	0.73	0.58	0.33	0.78*	-

IBW = Initial body weight, FBW = Final body weight, NEL = Neck length, BKL = Back length, THL = Thigh length, SHL = Shank length, BRW = Breast width, BDL = Body length, WNL = Wing length, * = Significant (P<0.05), ** = highly significant (P<0.01) (g) = grams, (cm) = centimeters.

4.3 MEASUREMENT OF BODY WEIGHT (g) AND MORPHOLOGICAL TRAITS (cm)

4.3.1 Comparative morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Table 4.3.1 showed comparative morphological traits of NAPRI-X, Marshall and Ross at 4 weeks of age. The results revealed that the three strains differed significant ($P < 0.001 - 0.01$) in IBW, FBW, CBL, CBW, OCL, OCW, BEL, ELL and ELW with Marshall strain having the highest mean values followed by NAPRI-X and Ross strains. Even though NAPRI-X strain had higher values in morphological traits (IBW, CBL, OCL and OCW) when compared with Ross strain, the differences are not significant ($P > 0.05$). NAPRI-X was significantly higher ($P < 0.001$) in beak length and ear lobes than Ross. There was no growth of wattle (WT) at this period among the three strains.

Table 4.3.1: Comparative morphological traits (cm) of broiler strains at 4 weeks of age

Traits	Treatments				
	NAPRI-X	Marshall	Ross	SEM	LOS
Initial Body Weight (g)	45.35 ^b	46.48 ^a	45.26 ^b	0.16	***
Final Body Weight (g)	446.28 ^b	548.01 ^a	472.13 ^b	12.26	***
Comb Length	0.88 ^b	1.94 ^a	0.78 ^b	0.12	***
Comb Width	0.30 ^b	0.55 ^a	0.28 ^b	0.03	***
Ocular Length	0.82 ^b	1.17 ^a	0.69 ^b	0.06	**
Ocular Width	0.51 ^b	0.87 ^a	0.48 ^b	0.04	***
Beak Length	1.32 ^b	2.12 ^a	0.83 ^c	0.13	***
Ear Lobes	0.52 ^b	0.80 ^a	0.30 ^c	0.06	***
Ear Width	0.46 ^b	0.78 ^a	0.45 ^b	0.04	***
Wattle Length	-	-	-	-	-
Wattle Height	-	-	-	-	-

(g) = grams, (cm) = centimeter, LOS = Level of Significance, SEM = Standard error of mean, *** = very highly significant (P = <0.001), ** = highly significant (P = <0.01).

4.3.2 Correlated phenotypic relationship between morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Table 4.3.2 shows correlated relationship between morphological traits of NAPRI-X, Marshall and Ross strains at 4 weeks of age. A positive and highly significant correlation between FBW and OCW ($r = 0.78$; $P < 0.05$) was observed in NAPRI-X strain, indicating that FBW influences OCW in NAPRI-X.

Similarly, negative and highly significant correlation was found between FBW and BEL ($r = -0.82$; $P < 0.05$) in NAPRI-X, demonstrating an inverse relationship that FBW negatively influences BEL in NAPRI-X. In addition, a positive and highly significant correlation between CBL, CBW and OCL was obtained ($r = 0.85 - 0.95$; $P < 0.01$) Marshall strain. The results showed that CBL influences CBW and OCL, whereas, in Ross strain positive and highly significant correlation was also found between CBL and OCW ($r = 0.87$; $P < 0.05$), revealing that CBL has influence on OCW in Ross strain.

Moreover, a positive and highly significant correlation between CBW and OCL was found ($r = 0.88$; $P < 0.01$) in Marshall strain indicating that CBW contribute to CBL in Marshall strain.

Furthermore, positive and highly significant correlations were found between OCL and ELW ($r = 0.87$; $P < 0.05$) and ($r = 0.83$; $P < 0.05$) in Marshall and Ross strains, respectively, demonstrating that OCL influences ELW. Similarly, positive but highly significant correlation was found between OCW and BEL ($r = 0.91$; $P < 0.01$) in Marshall strain, depicting that strain with high OCW tend to have long BEL.

Table 4.3.2: Correlated relationship between morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

Traits	IBW	FBW	CBL	CBW	OCL	OCW	BEL	ELL	ELW	WTL	WTH
NAPRI-X											
FBW(g)	0.19	-									
CBL	-0.66	-0.48	-								
CBW	0.12	0.45	-0.15	-							
OCL	0.14	-0.03	-0.32	0.64	-						
OCW	0.28	0.78*	-0.34	0.28	0.07	-					
BEL	-0.22	-0.82*	0.33	-0.69	-0.24	0.50	-				
ELL	-0.36	0.04	0.19	-0.27	0.03	0.09	-0.19	-			
ELW	0.45	0.50	0.66	0.59	0.44	0.06	-0.76*	-0.04	-		
WTL	-	-	-	-	-	-	-	-	-	-	-
WTH	-	-	-	-	-	-	-	-	-	-	-
MARSHALL											
FBW(g)	0.68	-									
CBL	0.44	0.28	-								
CBW	0.47	0.14	0.95**	-							
OCL	0.59	0.32	0.85*	0.88**	-						
OCW	0.16	0.45	0.56	0.29	0.21	-					
BEL	0.27	0.58	0.39	0.11	0.03	0.90**	-				
ELL	0.06	-0.31	0.62	0.72	0.72	-0.17	-0.33	-			
ELW	0.32	0.09	0.63	0.68	0.87*	-0.08	-0.22	0.88**	-		
WTL	-	-	-	-	-	-	-	-	-	-	-
WTH	-	-	-	-	-	-	-	-	-	-	-
ROSS											
FBW(g)	0.42	-									
CBL	-0.18	-0.11	-								
CBW	-0.16	-0.09	0.21	-							
OCL	-0.26	0.71	0.18	-0.15	-						
OCW	-0.61	-0.27	0.87*	0.21	0.25	-					
BEL	0.21	-0.32	-0.63	0.36	-0.66	-0.66	-				
ELL	0.10	-0.57	-0.49	-0.42	-0.69	-0.38	0.33	-			
ELW	-0.16	0.54	-0.10	-0.41	0.83*	-0.05	-0.51	-0.29	-		
WTL	-	-	-	-	-	-	-	-	-	-	-
WTH	-	-	-	-	-	-	-	-	-	-	-

IBW = Initial body weight, FBW = Final body weight, CBL = Comb length, CBW = Comb width, OCL = Ocular length, OCW = Ocular width, BEL = Beak length, ELL = Ear lobes length, ELW = Ear lobes width, WTL = Wattle length, WTH = Wattle height, * = significant (P<0.05), ** = highly significant (P<0.01), (g) = grams, (cm) = centimeters.

Conversely, negative and highly significant correlation between BEL and ELW was found ($r = -0.76$; $P < 0.05$) in NAPRI-X, illustrating that breed with long BEL tend to have lower ELW.

Finally, a positive and highly significant correlation was observed between ELL and ELW ($r = 0.88$; $P < 0.01$) in NAPRI-X strain, portraying that breed with long ELL tend to have large ELW.

4.3.3 Comparative morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Table 4.3.3 shows comparative morphological traits of NAPRI-X, Marshall and Ross strains at 8 weeks of age. The results showed that significant ($P < 0.001 - 0.05$) differences were observed among the three breeds in IBW, FBW, CBL, CBW, OCL, OCW, BEL, ELL, ELW, WTL and WTH. The results demonstrated that the mean values for Marshall strain were higher in the body weights and morphological traits mentioned above except in WTL and WTH in which NAPRI-X strain was significantly ($P < 0.01 - 0.05$) higher than Marshall and Ross strains, respectively. Moreover, no significant ($P > 0.05$) differences were observed in ELL and ELW among the three strains.

Table 4.3.3: Comparative morphological traits (cm) of broiler strains at 8 Weeks of age
Treatments

Traits	NAPRI-X	Marshall	Ross	SEM	LOS
Initial Body Weight (g)	446.28 ^b	548.01 ^a	472.13 ^b	12.26	***
Final Body Weight (g)	1530.58 ^b	1870.62 ^a	1588.69 ^b	45.86	**
Comb Length	2.30 ^b	3.67 ^a	2.03 ^b	0.17	***
Comb Width	0.94 ^b	1.36 ^a	0.77 ^b	0.07	***
Ocular Length	1.23 ^b	1.92 ^a	1.24 ^b	0.10	***
Ocular Width	1.06 ^b	1.45 ^a	1.18 ^b	0.05	**
Beak Length	2.30 ^b	3.12 ^a	2.19 ^b	0.13	**
Ear Lobes Length	1.17	1.34	1.39	0.06	NS
Ear Lobes Width	1.27	1.28	1.15	0.06	NS
Wattle Length	2.38 ^a	2.14 ^{ab}	1.93 ^b	0.07	*
Wattle Height	1.71 ^a	1.44 ^b	1.16 ^c	0.07	**

(g) = gram, (cm) = centimeter, LOS = Level of Significance, SEM = Standard error of mean, *** = very highly significant (P = <0.001), ** = highly significant (P = <0.01), * = significant (P = <0.05), NS = Not significant.

4.3.4 Correlated phenotypic relationship between morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Table 4.3.4 presents correlated relationship between morphological traits of NAPRI-X, Marshall and Ross strains at 8 weeks of age. The results showed that positive and highly significant correlation between IBW and FBW was found in NAPRI-X, Marshall and Ross strains ($r = 0.76$; $P < 0.05$), ($r = 0.82$; $P < 0.05$) and ($r = 0.90$; $P < 0.01$) respectively, illustrating that strain with high IBW tend to have high FBW. In addition, in Ross strain, a positive and highly significant correlation was observed between IBW and OCL ($r = 0.80$, $P < 0.05$) as well as BEL ($r = 0.76$, $P < 0.05$), depicting that breed with high IBW tend to have long OCL and BEL.

However, negative and highly significant correlation between FBW and CBL was found ($r = -0.87$, $P < 0.05$) in NAPRI-X strain. The results illustrated that strain with high FBW tend to have less CBL. In addition, positive and highly significant correlation was found in Ross strain between FBW and WTL ($r = 0.84$, $P > 0.05$). The findings indicated that strains with long WTL tend to have more FBW.

Moreover, positive and highly significant correlation between CBL and WTL ($r = 0.78$, $P < 0.05$) was obtained in NAPRI-X strain, demonstrating that breed with long CBL tends to have long WTL. Similarly, in Marshall strain, a high, positive and significant correlation was observed between CBL and CBW ($r = 0.89$, $P < 0.05$), depicting that CBL influences CBW.

Besides that, positive but highly significant correlation was found between CBW and ELW ($r = 0.89$, $P < 0.01$) in Ross strain, indicating that breed with large CBW tend to have large ELW

Table 4.3.4: Correlated relationship between morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Traits	IBW	FBW	CBL	CBW	OCL	OCW	BEL	ELL	ELW	WTL	WTH
NAPRI-X											
FBW(g)	0.76*	-									
CBL	0.61	-0.87*	-								
CBW	-0.03	-0.34	-0.07	-							
OCL	0.00	-0.32	0.44	0.29	-						
OCW	0.01	0.12	-0.08	0.03	0.11	-					
BEL	-0.33	-0.05	-0.18	0.27	-0.15	0.80*	-				
ELL	-0.42	-0.59	0.61	0.14	0.37	-0.29	-0.38	-			
ELW	-0.32	-0.35	0.38	-0.26	-0.59	-0.13	-0.11	0.32	-		
WTL	-0.17	-0.60	0.78*	0.12	0.83*	-0.21	-0.47	0.63	-0.11	-	
WTH	-0.26	-0.15	0.10	0.30	0.09	-0.67	-0.54	0.73	0.04	-0.25	-
MARSHALL											
FBW(g)	0.82*	-									
CBL	0.45	0.56	-								
CBW	0.25	0.45	0.89**	-							
OCL	-0.01	-0.05	0.62	0.44	-						
OCW	-0.47	-0.45	-0.15	0.02	0.24	-					
BEL	0.40	0.43	0.17	0.08	0.29	0.38	-				
ELL	-0.29	-0.29	0.37	0.35	0.71	-0.15	-0.26	-			
ELW	0.05	-0.06	0.66	0.67	0.70	-0.14	-0.24	0.83*	-		
WTL	-0.18	0.06	0.66	0.75	0.75	0.40	0.31	0.60	0.62	-	
WTH	0.11	0.17	0.87	0.72	-0.90**	0.04	0.09	0.68	0.82*	-0.78*	-
ROSS											
FBW(g)	0.90**	-									
CBL	0.03	-0.28	-								
CBW	-0.28	-0.33	-0.44	-							
OCL	0.80*	0.65	0.39	-0.30	-						
OCW	0.88	-0.08	0.67	-0.54	0.20	-					
BEL	0.76*	-0.64	-0.20	0.43	-0.41	-0.26	-				
ELL	0.35	0.42	-0.13	-0.66	0.06	0.10	-0.34	-			
ELW	-0.28	-0.41	-0.11	0.90**	-0.14	-0.15	0.44	-0.81*	-		
WTL	0.68	0.84*	-0.27	-0.10	0.67	-0.29	-0.31	-0.01	-0.16	-	
WTH	0.54	0.73	-0.33	-0.42	0.49	-0.13	-0.08	0.64	-0.52	0.63	-

IBW = Initial body weight, FBW = Final body weight, CBL = Comb length, CBW = Comb width, OCL = Ocular length, OCW = Ocular width, BEL = Beak length, ELL = Ear lobes length, ELW = Ear lobes width, WTL = Wattle length, WTH = Wattle height, * = Significant (P<0.05), ** = highly significant (P<0.01), (g) = grams, (cm) = centimeters.

Similarly, positive and highly significant correlation existed between OCL and WTL ($r = 0.83, P < 0.05$) in NAPRI-X strain, demonstrating that OCL influences WTL in NAPRI-X strain. Similarly, negative and highly significant correlation existed between OCL and WTH ($r = -0.90, P < 0.01$) in Marshall strain, revealing that strain with long OCL tend to have low WTH. However, positive but highly significant correlation was found between OCW and BEL ($r = 0.80, P < 0.05$) in NAPRI-X strain, indicating that strain with large OCW tend to have long BEL. Conversely, a positive and highly significant correlation between ELL and ELW ($r = 0.83, P < 0.05$) was found in Marshall strain, illustrating that ELL influences ELW. In Ross strain, negative but highly significant correlation was observed ($r = -0.81, P < 0.05$), depicting that strain with long ELL tend to have small ELW.

In addition, positive and highly significant correlation was also recorded between ELW and WTH ($r = 0.82, P < 0.05$) in Marshall strain, indicating that ELW influences WTH. Finally, a negative and highly significant correlation was obtained between WTL and WTH ($r = -0.78, P < 0.05$), in Marshall strain, depicting that breed with long WTL tend to have low WTH.

4.4 PREDICTION EQUATIONS FOR 8 WEEKS BODY WEIGHT USING CONFORMATION AND MORPHOLOGICAL TRAITS.

4.4.1 Prediction equations for 8 weeks body weight of NAPRI-X, Marshall and Ross broiler strains using conformation traits.

Table 4.4.1 shows simple linear regression analysis to determine how body conformation traits influenced precision of live weight predictions at 8 weeks for NAPRI-X, Marshall and Ross strains. It was observed that NEL, SHL, BDL, BKL, WNL, BRW, and THL were highly significant ($P < 0.001$) and are very good estimators ($R^2 = 0.95, 0.91,$

Table 4.4.1: Prediction equations for 8 weeks body weight (g) of NAPRI-X, Marshall and Ross broiler strains using conformation traits (cm)

Breed	Traits	Prediction equation	R ²	Significance
NAPRI-X				
	NEL	Y = 4.50+0.18NEL	0.95	***
	BKL	Y = 9.20+0.28BKL	0.91	***
	THL	Y = 5.36+0.48THL	0.70	***
	SHL	Y = 3.57+0.19SHL	0.91	***
	BRW	Y = 7.58+0.31BRW	0.88	***
	BDL	Y = 10.85+0.32BDL	0.91	***
	WNL	Y = 7.55+0.30WNL	0.91	***
MARSHAL				
	NEL	Y = 4.89+0.18NEL	0.95	***
	BKL	Y = 9.62+0.27BKL	0.91	***
	THL	Y = 5.26+0.23THL	0.91	***
	SHL	Y = 3.60+0.17SHL	0.92	***
	BRW	Y = 8.31+0.30BRW	0.88	***
	BDL	Y = 10.66+0.26BDL	0.95	***
	WNL	Y = 8.05+0.31WNL	0.90	***
ROSS				
	NEL	Y = 4.74+0.34NEL	0.84	***
	BKL	Y = 9.77+0.26BKL	0.91	***
	THL	Y = 5.57+0.27THL	0.85	***
	SHL	Y = 3.85+0.22SHL	0.87	***
	BRW	Y = 8.21+0.40BRW	0.76	***
	BDL	Y = 10.97+0.34BDL	0.89	***
	WNL	Y = 7.86+0.31WNL	0.88	***

NEL = Neck length, BKL = Back length, THL = Thigh length, SHL = Shank length, BRW = Breast width, BDL = Body length, WNL = Wing length, Y = Final body weight, *** = very highly significant (P<0.001), (g) = grams, (cm) = centimeter, R² = Coefficient of determination.

0.91, 0.91, 0.91, 0.88 and 0.70, respectively) of body weight in NPRI-X strain, though NEL was observed to be the best predictor ($R^2 = 0.95$) of body weight at 8 weeks.

For Marshall strain, it was found that NEL, BDL, SHL, BKL, THL, WNL and BRW were highly significant ($P < 0.001$) and are very good estimators ($R^2 = 0.95, 0.95, 0.92, 0.91, 0.91, 0.90$ and 0.88 , respectively) of body weight, though NEL was also showed to be the best predictor ($R^2 = 0.95$) of body weight at 8 weeks.

For Ross strain, it was observed that BKL, BDL, WNL, SHL, THL, NEL and BRW were also highly significant ($P < 0.001$) and are very good estimators ($R^2 = 0.91, 0.89, 0.88, 0.87, 0.85, 0.84$ and 0.76 , respectively) of body weight, though BKL was considered to be the best predictor ($R^2 = 0.91$) of body weight at 8 weeks.

4.4.2 Prediction equations for 8 weeks body weight of NAPRI-X, Marshall and Ross broiler strains using 8 weeks morphological traits.

Table 4.4.2 presents simple linear regression analysis to determine how morphological traits influence precision of live weight predictions at 8 weeks for NAPRI-X, Marshall and Ross strains. It was observed that WTL, WTH, CBL, BEL, OCL and OCW were highly significant ($P < 0.001 - 0.05$) and are very good estimators ($R^2 = 0.98, 0.95, 0.89, 0.87, 0.82$ and 0.79 , respectively) of body weight in NAPRI-X strain, even though WTL was found to be the best predictor ($R^2 = 0.98$) of body weight at 8 weeks.

At 8 weeks, moderate but highly significant coefficient of determinations were obtained for CBW, ELL and ELW in NAPRI-X strain which is an indicator that these characters are moderate estimators ($R^2 = 0.67, 0.46$ and 0.41 , respectively) of body weight at 8

Table 4.4.2: Prediction equations for 8 weeks body weight (g) of NAPRI-X, Marshall and Ross broiler strains using morphological traits (cm)

Breed	Traits	Prediction equations	R ²	Significance
NAPRI-X				
	CBL	Y = 1.21+0.17CBL	0.89	***
	CBW	Y = 0.23+0.19CBW	0.67	***
	OCL	Y = 0.94+0.08OCL	0.82	***
	OCW	Y = 0.63+0.09OCW	0.79	***
	BEL	Y = 1.62+0.12BEL	0.87	***
	ELL	Y = 0.49+0.25ELL	0.46	**
	ELW	Y = 0.64+0.16ELW	0.41	*
	WTL	Y = 0.82+0.10WTL	0.98	***
	WTH	Y = -0.56+0.10WTH	0.95	***
MARSHAL				
	CBL	Y = 1.21+0.12CBL	0.95	***
	CBW	Y = 0.21+0.10CBW	0.87	***
	OCL	Y = 0.87+0.09OCL	0.85	***
	OCW	Y = 0.66+0.08OCW	0.80	***
	BEL	Y = 1.70+0.11BEL	0.89	***
	ELL	Y = 0.69+0.10ELL	0.66	***
	ELW	Y = 0.57+0.11ELW	0.66	***
	WTL	Y = -0.86+0.09WTL	0.98	***
	WTH	Y = -0.58+0.07WTH	0.98	***
ROSS				
	CBL	Y = 1.18+0.12CBL	0.94	***
	CBW	Y = 0.15+0.10CBW	0.87	***
	OCL	Y = 0.85+0.10OCL	0.83	***
	OCW	Y = 0.64+0.07OCW	0.83	***
	BEL	Y = 1.64+0.13BEL	0.84	***
	ELL	Y = 0.63+0.11ELL	0.55	**
	ELW	Y = 0.52+0.12ELW	0.53	**
	WTL	Y = -0.81+0.09WTL	0.98	***
	WTH	Y = -0.48+0.07WTH	0.96	***

CBL = Comb length, CBW = Comb width, OCL = Ocular length, OCW = Ocular width, BEL = Beak length, ELL = Ear lobes length, ELW = Ear lobes width, WTL = Wattle length, WTH = Wattle height, Y = Final body weight, * = significant (P<0.05), ** = (P<0.01), *** = very highly significant (P<0.001), (g) = grams, (cm) = centimeter, R² = Coefficient of determination.

weeks, even though CBW was observed to be the best predictor ($R^2 = 0.67$) of body weight at 8 weeks.

For Marshall strain, WTL, WTH, CBL, BEL, CBW OCL and OCW were highly significant ($P < 0.001$) and are very good estimators ($R^2 = 0.98, 0.98, 0.89, 0.87$ and 0.85 , respectively) of body weight, even though WTL was found to be the best predictor ($R^2 = 0.98$) of body weight at 8 weeks. Moderate but highly significant coefficient of determinations were observed for ELL and ELW which is an indicator that these traits are moderate estimator ($R^2 = 0.66$ and 0.66 , respectively) of body weight at 8 weeks, even though ELL was shown to be the best predictor ($R^2 = 0.66$) of body weight at 8 weeks.

For Ross strain, it was realized that WTL, WTH, CBL, CBW, BEL, OCL and OCW were found to be highly significant ($P < 0.001 - 0.01$) and are very good estimators ($R^2 = 0.98, 0.96, 0.94, 0.84, 0.83, 0.83$, respectively) of body weight, even though WTL was observed to be the best predictor ($R^2 = 0.98$) of body weight at 8 weeks. However, moderate but high significant was observed for ELL and ELW which is an indication that these traits are moderate estimators ($R^2 = 0.55$ and 0.53) of body weight at 8 weeks.

4.5 PRINCIPAL COMPONENT ANALYSIS.

4.5.1 Eigen values and share of total variance along with factor loading and communalities of conformation traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age.

Table 4.5.1 shows the eigen values and percentage of the total variance along with the rotated component matrix and communalities of conformation traits of the three strains of

Table 4.5.1: Eigen values and share of total variance along with factor loadings and communalities of body conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Traits	PC1	PC2	PC3	Communalities
NAPRI-X				
NEL	0.82	0.40	0.10	0.99
BKL	0.28	0.29	0.23	0.68
THL	1.17	0.16	0.12	0.99
SHL	0.05	0.09	0.05	0.53
BRW	0.13	0.06	0.21	0.99
BDL	0.25	0.00	0.24	0.82
WNL	0.13	0.99	0.14	0.93
Eigen values	2.82	1.99	1.09	
% of total variance	40.33	15.54	28.53	
MARSHALL				
NEL	0.73	0.02	0.03	0.88
BKL	0.94	0.00	0.65	0.92
THL	0.85	0.22	0.17	0.63
SHL	0.82	0.24	0.06	0.97
BRW	0.78	0.34	0.03	0.92
BDL	0.81	0.52	0.01	0.94
WNL	0.79	0.01	0.11	0.93
Eigen values	2.75	1.34	1.06	
% of total variance	39.25	19.14	15.15	
ROSS				
NEL	0.90	0.08	0.13	0.79
BKL	0.69	0.30	0.01	0.66
THL	0.50	0.32	0.14	0.91
SHL	0.60	0.05	0.12	0.70
BRW	0.11	0.02	0.14	0.86
BDL	0.21	0.56	0.29	0.80
WNL	0.70	0.02	0.32	0.65
Eigen values	3.70	1.35	1.14	
% of total variance	52.87	19.33	16.30	

PC1 = Principal component 1, PC2 = Principal component 2, PC3 = Principal component 3.

broiler chickens. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy computed for NAPRI-X, Marshall and Ross breeds were 0.55, 0.67 and 0.60 respectively which were within the recommended value of 0.60 (Eyduran *et al.*, 2010). These values revealed the pattern of correlation among the variables. Even though the values were low due to low sample size of the data, but the values indicated that the sample sizes were adequate to apply PCA (Kaiser, 1960). The results of the Bartlett test of sphericity for body conformation traits of NAPRI-X (Chi-square 21.19 at $P < 0.05$), Marshall (Chi-square 548.22 at $P < 0.01$) and Ross (Chi-square 11.39 at $P < 0.01$) were significant. This implied that PCA was applicable to the data set. The communalities represent estimates of the variance in each variable accounted for by the components. It ranges 0.53 – 0.99, 0.63 – 0.97 and 0.65 – 0.91 for NAPRI-X, Marshall and Ross broilers respectively. The eigen values showed the amount of variance out of the total variance explained by each of the factors.

Three (3) Principal Components were extracted from NAPRI-X broilers with eigen values of 2.82 for the first principal component (PC1), 1.99 for the second principal component (PC2) and 1.09 for the third principal component (PC3). The three principal components accounted for 84.40% of the total variance present in the seven conformation traits. PC1 had high loadings (correlations between the components and the variables) on NEL (0.82). PC2 had high loadings on WNL (0.99). PC3 had low loadings (indicating low relationship between the components and the variables).

In Marshall strain, three components were extracted with eigen values of 2.75, 1.34 and 1.06 respectively. The three principal components accounted for 73.54% of the total variance present in the conformation traits. PC1 had high and positive loadings on BKL

(0.94), THL (0.85), SHL (0.82), BDL (0.81), WNL (0.79) and NEL (0.73) indicating high correlation among the variables. PC2 had medium and positive loadings on BDL (0.52). All other traits were low and positive. NEL (0.02), BKL (0.00), THL (0.22), SHL (0.24), BRW (0.34) and WNL (0.01) respectively, describing low relationship between the component and variables. PC3 had medium loadings on BKL (0.65) and low loadings on other traits NEL (0.03), THL (0.17), SHL (0.06), BRW (0.03), BDL (0.01) and WNL (0.11) indicating low relationship between the components and these variables.

In Ross breed, three principal components were extracted with eigen values of 3.70, 1.35 and 1.14 respectively. The three components accounted for 88.50% of the total variance present in the conformation traits. PC1 was most correlated with NEL (0.90), WNL (0.70) and BKL (0.69) respectively, implying high relationship among the three variables. Other traits had medium to low loadings THL (0.50), SHL (0.60), BKL (0.11) and BDL (0.210) respectively. PC2 had medium to low loadings on BDL (0.56), BKL (0.30), THL (0.32), SHL (0.05), WNL (0.02) and BRW (0.02) respectively. PC3 had low and positive loadings on BKL (0.01), SHL (0.12), NEL (0.13), THL (0.14), BRW (0.14), BDL (0.29) and WNL (0.32) respectively. This indicated low relationship between components and the variables.

4.5.2 Eigen values and share of total variance along with factor loading and communalities of morphological traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

Table 4.5.2 shows the eigen values and percentage of the total variance along with factor loading and communalities of morphological traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age. Kaiser-Meyer-Olkin (KMO) measure of sampling

Table 4.5.2: Eigen values and share of total variance along with factor loadings and communalities of morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

	PC1	PC2	PC3	Communalities
Traits				
NAPRI-X				
OCL	1.02	0.73	0.38	0.91
OCW	0.50	0.11	0.22	0.95
CBL	0.07	0.20	0.30	0.98
CBW	0.21	0.12	0.22	0.75
BEL	0.16	0.23	0.12	0.82
ELL	0.13	0.31	0.02	0.91
ELW	0.13	0.01	0.02	0.99
WTL	0.50	0.20	0.30	0.99
WTH	0.50	0.00	0.12	0.91
Eigen values	3.21	1.92	1.68	
% of total variance	35.70	1.27	8.60	
MARSHALL				
OCL	0.27	0.30	0.10	0.71
OCW	0.94	0.04	0.00	0.74
CBL	0.60	0.08	0.20	0.80
CBW	0.89	0.24	0.00	0.62
BEL	0.52	0.12	0.00	0.83
ELL	0.68	0.13	0.00	0.75
ELW	0.56	0.31	0.00	0.93
WTL	0.52	0.08	0.05	0.86
WTH	0.60	0.30	0.05	0.94
Eigen values	5.58	1.60	0.97	
% of total variance	61.95	17.81	10.77	
ROSS				
OCL	0.24	0.35	0.50	0.85
OCW	0.25	0.20	0.16	0.94
CBL	0.52	0.20	0.20	0.83
CBW	0.62	0.10	0.11	0.93
BEL	0.61	1.25	0.10	0.83
ELL	1.37	0.20	0.01	0.79
ELW	1.42	0.11	0.00	0.92
WTL	0.02	0.10	0.27	0.91
WTH	0.61	0.13	0.27	0.91
Eigen values	4.53	2.30	1.09	
% of total variance	50.33	5.58	1.65	

PC1 = Principal component 1, PC2 = Principal component 2, PC3 = Principal component 3.

adequacy calculated for NAPRI-X, Marshall and Ross strains were 0.65, 0.69 and 0.83 respectively which corresponded with the recommended value of 0.60. The values indicated that the sample sizes were adequate to apply PCA (Kaiser, 1960). The results of the Bartlett test of sphericity for morphological traits of NAPRI-X (Chi-square 1123.15 at $P < 0.05$), Marshall (Chi-square 1018.02 at $P < 0.001$) and Ross (Chi-square 1807.00 at $P < 0.01$) were significant. This showed that PCA was applicable to the data sets. The communalities ranged 0.75 – 0.99, 0.62 – 0.94 and 0.79 – 0.94 in NAPRI-X, Marshall and Ross broilers.

Three (3) principal components were extracted from NAPRI-X broilers with eigen values of 3.21 for first principal component (PC1), 1.92 for the second principal component (PC2) and 1.68 for the third principal component (PC3). The three principal components accounted for 45.60% of the total variance present in the nine morphological traits. PC2 loaded heavily on OCL (0.73) implying high relationship with this variable. PC2 also had low loadings on other morphological traits (0.00 – 0.31). This shows low relationship among the variables. PC3 was positive with low loadings on all morphological traits (ELL, ELW, BEL, WTH, CBW, OCW, CBL, WTL and OCL) 0.02 – 0.38 respectively. This indicated low relationship between these variables.

In Marshall strain, three principal components were extracted with eigen values of 5.58, 1.60 and 0.97, accounting for 90.53% of the total variance in the morphological traits.

PC1 was most highly correlated with OCW (0.94), CBW (0.89) implying high relationship among the two variables. PC2 had low and positive loadings on the morphological traits (OCW, WTL, CBL, ELL, BEL, CBW, OCL, WTH and ELW) 0.04

– 0.31, meaning that there is low relationship among these variables. PC3 had low and positive loadings on all the morphological traits (BEL, ELL, ELW, OCW, CBW, WTL, WTH, OCL and CBL) 0.00 – 0.20 respectively, implying low relationship amongst the morphological traits.

In Ross strain, three principal components were derived with eigen values of 4.53, 2.30 and 1.09 respectively. The three principal components accounted for 57.56% of the total variance present in the morphological traits. PC1 had medium to low loadings on CBW (0.62), BEL (0.61), WTH (0.61), CBL (0.52), ELW (0.42), ELL (0.37), OCW (0.25), OCL (0.24) and WTL (0.02) meaning that there were medium to low relationship among these traits. PC2 had positive and low loadings on all morphological traits (CBW, WTL, ELW, WTH, ELL, OCW, CBL, BEL and OCL) 0.10 – 0.35 respectively, implying low relationship among the morphological traits. PC3 also had positive and low loadings on all the morphological traits (ELW, ELL, BEL, CBW, OCW, CBL, WTL and WTH) 0.00 – 0.27 with the except OCL (0.50) with medium loading indicating medium relationship between PC and this trait.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Growth Performance Characterization

5.1.1 Comparative growth performance of NAPRI-X, Marshall and Ross broiler strains at 4 week of age

The results for comparative growth performance of NAPRI-X, Marshall and Ross broiler strains at four weeks showed that the strains were different in IBW, FBW, DWG, TWG, DFI, TFI and FCR. The initial body weight of NAPRI-X and Ross agreed with the report of Kabir *et al.* (2010) who recorded 45.55g and 45.00g as the initial body weights of Anak and Hubbard broiler strains. The findings depict that the breeds are almost similar in terms of IBW though they are different breeds. However, the initial body weights of Marshall as recorded by Ibe (2013) ranges from 42.60g to 42.69g and are lower than the initial body weight of Marshall in this experiment.

Similarly, FBW at the end of 4 weeks ranges from 446.28g to 580.01g for the three breeds with Marshall having the highest mean values. This is higher than the final body weight at 4 weeks reported by Kabir *et al.* (2010) for Anak and Hubbard (450.91g and 450.63g), respectively. This could be attributed to differences in genetic make-up of the strains and or possibly environment. The findings reveal that DWG, TWG, DFI and TFI were significantly ($P < 0.001 - 0.05$) higher in Marshall strain than in NAPRI-X and Ross strains, indicating that Marshall and Ross consume significantly ($P < 0.05$) higher feed than NAPRI-X strain. The finding is contrary with the findings of Udeh *et al.* (2011) who reported that Abor Acre was significantly ($P < 0.05$) higher in TWG and TFI than Anak, Ross and Marshall strains in Asaba, Delta State of Nigeria. The propensity with which Marshall and Ross strains consumed feeds to put on higher body weight could be

attributed to their genetic make-up over NAPRI-X breed as well as environmental variation. Moreover, a better ($P < 0.05$) feed conversion ratio (FCR) was observed in Marshall than NAPRI-X and Ross strains indicating better utilization of feed by Marshall strain as they had the least feed conversion ratio, since the lower the feed conversion ratio the better the diet and this is in line with the report of Amao *et al.* (2009). Similarly, Doma, (1998) reported that the lower the feed conversion ratio the better the diet in monogastric animals.

5.1.2 Correlated phenotypic relationship between growth performance of NAPRI-X, Marshall and Ross broiler strains at 4 week of age

The high positive and non significant ($P > 0.05$) correlations between various traits observed in this work was synonymous with the report of Ogah (2011) who recorded negative highly and non significant ($P > 0.05$) correlations between keel length (KL) and chest circumference (CC) ($r = -0.72$; $p > 0.05$), wing length (WN) and chest circumference (CC) ($r = -0.52$; $P > 0.05$), neck length (NL) and chest circumference (CC) ($r = -0.54$; $P > 0.05$), keel length (KL) and neck length (NL) ($r = -0.43$; $P > 0.05$) in male and female turkeys. The findings show that FBW was positively and perfectly correlated with DWG and TWG in the three strains. The finding is similar to the report of Amao *et al.* (2011), who discovered that body weight is positively and significantly correlated to DWG. In the same vein, Amao *et al.* (2011) reported that daily gain, feed intake and feed conversion ratio showed high, significant ($P < 0.01$) and positive correlation against body weight. However, negative and significant ($P < 0.05$) correlations were obtained between FBW and FCR in Marshall and Ross strains, respectively. The findings is contrary to the report of Amao *et al.* (2011) who recorded that body weight was high, significantly

($P < 0.01$) and positively correlated with feed conversion ratio in Ross, Anak and Marshall strains.

Similarly, DWG and TWG were positively and perfectly ($P < 0.01$) correlated in NAPRI-X, Ross and Marshall strains. This agreed with the findings of Amao *et al.*, (2011) who reported very highly, significant ($P < 0.01$) and positive correlations between body weight and daily gain, feed intake and feed conversion ratio (FCR). In addition, high, negative and significant ($P < 0.01 - 0.05$) correlation was observed between DWG and FCR in Marshall and Ross strains, respectively. The finding is contrary to the findings of Ajayi and Ayorinde (2000) who revealed that phenotypic correlations coefficient were very high for feed conversion ratio over other growth traits measured. Moreover, the correlation of TWG and FCR was high, negative and significantly correlated in Marshall and Ross strain respectively.

However, positive and perfect correlation between DFI and TFI was observed in NAPRI-X, Marshall and Ross strains. Besides that, a high, positive and significant ($P < 0.05$) correlation was observed between DFI and FCR respectively in NAPRI-X and Ross strains. This was contrary to the report of Amao *et al.* (2011) who reported that FCR against FI were positively and significantly highly correlated.

In the same vein, significant ($P < 0.05$) correlations was found between TFI and FCR respectively in NAPRI-X and Marshall strains. The findings is consistent with the results of Amao *et al.* (2011) who reported feed intake against daily gain and feed conversion ratio were high ($P < 0.01$) and positively correlated.

5.1.3 Comparative growth performance of broiler strains at 8 weeks of age

The results also show significant ($P<0.01$) differences in the initial body weight (IBW) of the three strains. Marshall strain was significantly ($P<0.01$) heavier than Ross and NAPRI-X strain. This might be due to high genetic make-up of Marshall over NAPRI-X and Marshall strains.

Besides that, the average final body weight (FBW) for Marshall, Ross and NAPRI-X strains were 1870.69g, 1588.69g and 1530.58g respectively at 8 weeks of age and were in line with the report of Akanno *et al.* (2007) who reported that broiler birds attain market weight of 1300 to 2000g at 8 to 10 weeks at age. Similarly, Abdullahi *et al.* (2010) reported an average body weight of 1801.00g for Ross broilers at 7th weeks of age.

The significant ($P<0.01$) higher values for body weights (initial and final) for Marshall over NAPRI-X and Ross strains were not in agreement with the findings of Amao *et al.* (2011) who reported that body weight of Ross showed significantly ($P<0.05$) higher values than Anak and Marshall strains. These differences in body weights and other growth traits in this experiment could be attributed to the genetic merit of Marshall over other strains in the semi-arid zone of Nigeria.

Moreover, daily weight gain, total weight gain, daily feed intake and total feed intake were significantly ($P<0.05$) different among the three strains. The ability with which Marshall strain consumed higher feed at this phase to put higher body weight and other growth traits could be attributed to its higher genetic make-up over other breeds in the semi-arid zone of Nigeria. The findings are inconsistent with the results of Amao *et al.* (2011) who revealed that feed intake and weight gain were significantly ($P<0.05$) higher

in Ross strain than Anak and Marshall strains in the derived savanna environment of Nigeria.

However, Marshall strain has the least FCR than NAPRI-X and Ross strains, respectively. This indicates better utilization of feed by Marshall as they had the least FCR, since the lower the feed conversion ratio (FCR) the better the diet. This was in line with the report of Amao *et al.* (2009). Doma, (1998) reported that the lower the FCR the better the diet in monogastric animals.

In the present study, better FCR was recorded for Marshall strain while Amao *et al.* (2011) recorded better FCR in Ross strain. These differences could be due to differences genetics and or environmental factors.

5.1.4 Correlated phenotypic relationship between growth performance of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

The positive, highly and non significant correlations existed in this work agreed with the results of Yakubu and Ayoade (2009) who reported positive, highly and non significant correlations between body length (BL) and body weight (BW) ($r = 0.74$; $P > 0.05$), heart girth (HG) and body weight (BW) ($r = 0.91$; $P > 0.05$). Also the negative, non significant correlations found in this work agreed with the findings of Ogah (2011) who reported negative, high and non significant correlations between shank length (SL) and chest circumference (CC) ($r = -0.53$; $P > 0.05$), beak length (BKL) and chest circumference (CC) ($r = -0.50$; $P > 0.05$), respectively. The high and positive correlations between IBW and body measurements in all the strains suggest high predictability between traits in all the three strains. However, the negative and significant ($r = -0.789$; $P < 0.05$) correlation between IBW and FCR ($r = -0.79$, $P < 0.05$) in Ross strain indicating an inverse relationship between IBW with FCR. Besides that, the finding indicates that FBW was

very highly, positively and significantly ($r = 0.98$ to 0.99 ; $P < 0.01$) correlated with DWG and TWG in all the three strains but high, negatively and significantly ($r = -0.95$ to -0.85 ; $P < 0.01$) correlated with FCR. The findings are consistent with the report of Amao *et al.* (2011) who reported that positive and significant correlation between final body weight (FBW) and daily weight gain (DWG) in Ross, Anak and Marshall broiler strains. The negative and significant correlation with FCR is contrary with the findings of Amao *et al.* (2011) who reported that FBW was positively and significantly correlated with FCR. This variation could be attributed to genetic and location/ or environment. This trend of results was contrary to the report of Ajayi and Ayorinde (2000) who revealed that the phenotypic correlation coefficient was very high for FCR over other growth traits measured.

Moreover, the findings also revealed that DWG was very high and perfectly correlated with TWG ($r = 1.000$, $P < 0.01$); and negatively correlated with FCR ($r = -0.88$, $P < 0.01$) and ($r = -0.96$, $P < 0.01$) in NAPRI-X and Ross strains, respectively. Amao *et al.* (2011) reported that daily gain (DG), feed intake (FI) and feed conversion ratio (FCR) showed high, significant ($P < 0.05$) and positive correlation with body weight (BDW) in Ross, Anak and Marshall strains with highest values obtained for feed intake (FI) against body weight by Ross strain; they further reported that it was confirmed by Zerehdaran *et al.* (2004) who reported feed intake, FCR against daily gain were also high, positively and significantly ($P < 0.01$) correlated.

TWG and FCR were very high, negatively and significantly correlated in NAPRI-X ($r = -0.88$, $P < 0.01$) and Ross ($r = -0.96$; $P < 0.01$). Furthermore, the findings depict positive and perfect correlation between DFI and TFI in NAPRI-X and Marshall strains.

5.2 MEASUREMENTS OF BODY WEIGHT (g) AND CONFORMATION TRAITS (cm) AT STARTER PHASE.

5.2.1 Comparative conformation traits (cm) of broiler strains at 4 week of age

The IBW for NAPRI-X (45.35g) and Ross (45.26g) strains were in agreement with the report of Kabir *et al.* (2010) who reported 45g as the IBW of both Anak and Hubbard broiler strains. Binda *et al.* (2012) also recorded IBW of Hubbard and Hybro broiler strains as 39.76g and 37.85g respectively. This could be attributed to differences in breeds used.

There were significant ($P < 0.05$) differences in final body weights of NAPRI-X, Marshall and Ross strains at 4 weeks with Marshall having the highest body weight then followed by NAPRI-X and Ross strains. The values for body weight of Ross and NAPRI-X strains were lower in the study reported of Binda *et al.* (2012) who reported body weights of Hubbard (497.37g) and Hybro (516.25). The differences in results of body weight could be attributed to the differences in the breeds used and or environmental factors (Okon *et al.* 1997).

However, the findings also revealed that significant ($P < 0.05$) differences existed in all other conformation traits measured: NEL, BKL, THL, SHL, BRW, BDL and WNL in NAPRI-X; Marshall and Ross strains. The findings were in agreement with the findings of Kabir *et al.* (2010) who reported significant ($P < 0.05$) differences in conformation traits measured in Anak and Hubbard broiler strains at 4 weeks of age.

5.2.2 Correlated phenotypic relationship between conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks

The positive, highly and non significant correlations existed in this research work tallied with the work of Yakubu and Ayoade (2009) who indicated positive, high and non significant correlations between thigh circumference (TC) and body weight (BW) ($r = 0.84$; $P > 0.05$), thigh circumference (TC) and body length (BL) ($r = 0.77$; $P > 0.05$), thigh circumference and heart girth (HG) ($r = 0.82$; $P > 0.05$) in domestic rabbits. The correlated relationship between conformation traits of NAPRI-X, Marshall and Ross broiler strains at 4 weeks demonstrate high, positive and significant correlations between FBW and BRW ($r = 0.78$, $P < 0.05$) and negatively correlated with BDL ($r = -0.88$, $P < 0.01$) as well as between NEL and BKL ($r = 0.76$, $P < 0.05$) in NAPRI-X strain. The high, positive and significant correlation between FBW and BRW ($r = 0.78$, $P < 0.05$) imply that improvement in FBW would result in corresponding improvement in BRW; as such selection for increased FBW would have a positive effect on the genetic merit of the BRW. The results agreed with the findings of Okon and Ogundu (2006) and Singh (2008). Moreover, selection for the improvement of lowly correlated traits will lead to little or no progress while for the negatively correlated traits; selection for the improvement of one trait may lead to progress if reduction in the other trait is so desired.

Similarly, a high, positive and significant correlation was found between THL and WNL ($p < 0.05$, $r = 0.79$) in Ross strain. The finding is in line with the report of Udeh and Ogbu (2011) who reported positive and significant ($P < 0.05$) correlation between THL and WNL in Arbor Acre and Ross broiler strains in Asaba, Delta State. Moreover, a high, negative and significant correlation was found between SHL and BDL ($r = -0.78$, $p = 0.05$) in Marshall strain and the finding is inconsistent with the findings of Udeh and

Ogbu (2011) who reported positive but no significant ($P>0.05$) correlation between SHL and BDL in Marshall and Arbor Acre strains but negative but no significant in Ross broiler strain.

5.2.3 Comparative conformation traits (cm) of broiler strains at 8 week of age

The results for comparative conformation traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks are discussed. The findings for body weight showed significant ($P<0.05$) differences in IBW and FBW with Marshall strain having the highest values. The findings for IBW in Marshall, Ross and NAPRI-X were lower than the report of Binda *et al.* (2012) who reported 516.25g and 497.37g as the initial body weight of Hybro and Hubbard broiler strains at 8 weeks of age. Also, Kabir *et al.* (2010) highlighted 450.91g and 450.63g as the initial body weights of Anak and Hubbard broiler strains at 8 weeks of age which were lower than the values obtained in this experiment. Jiya *et al.* (2013) recorded initial body weight of Marshall strain at 8 weeks of age which ranged from 834.35g to 903.97g for the various treatments. Kwari *et al.* (2011) reported initial weight of undefined broiler breed at 8 weeks which ranged from 540.85g to 541.05g. These differences could be attributed to differences in breeds used, management and environmental factors. Similarly, the FBW reported in this experiment attained by Marshall, Ross and NAPRI-X strains at 8 weeks of age were in line with the report of Akanno *et al.* (2007) who reported that broiler birds attain a market weight of 1300 to 2000g at 8 to 10 weeks of age. Abdullahi *et al.* (2010) reported an average body weight of 1801g for Ross broiler at 7 weeks of age. The results of FBW obtained in this experiment were higher than the report of Kabir *et al.* (2010) who reported 1304.43g and 1250.49g as FBW of Anak and Hubbard at 8 weeks of age. Udeh and Ogbu (2011)

recorded 1880g, 1650g and 1810g as the FBWs of Arbor Acre, Marshall and Ross broiler strains at 8 weeks of age. The differences in body weight could be due to differences in breed used, management and or environmental factors.

Besides that, the findings involving conformation traits showed that the three breeds differed significantly ($P < 0.05$) with Marshall having the highest values of NEL, BKL, THL, SHL, BRW, BDL and WNL.

The findings are consistent with the report of Ojo *et al.* (2010b) who reported that significant differences exist among body weight and conformation traits measured in Hubbard broiler strain. Kabir *et al.* (2010) recorded that significant differences existed between Anak and Hubbard with respect to body conformation traits at 8 weeks of age. Kabir *et al.* (2008) also recorded that significant differences occurred among conformation traits in Anak2000 strain of broiler in the Northern guinea savanna zone of Nigeria. Also, Udeh and Ogbu (2011) reported significant differences among the body measurements between Arbor Acre, Marshall and Ross broiler strains. These differences in body weight and conformation traits measured could be due to breed differences, management and environmental factors.

However, the findings involving BDL and WNL indicate that no significant ($P > 0.05$) differences existed among the three strains in BDL and WNL, respectively.

5.2.4 Correlated phenotypic relationship between conformation traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

The correlated relationship between conformation traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks is presented in table 8. High, Positive and significant correlations were observed between IBW and FBW ($r = 0.76$, $P < 0.05$) and NEL ($r = 0.95$,

P<0.01) in NAPRI-X, ($r = 0.82$, $P<0.05$) in Marshall and ($r = 0.90$, $P<0.01$) in Ross breed. The findings indicate high predictability among the variables (Pundir *et al.*, 2011). However, the high and positive relationship between body weight and most of the body measurements showed that body weight can be predicted from body measurements. A similar observation was reported by Ajayi *et al.* (2008). These variations in body weight and conformation traits could be due to differences in genetic, environment and management.

Besides that, a high, negative and significant correlation was found in Ross strain between BKL and WNL ($r = -0.92$, $P<0.01$). Similarly, a high, positive and significant correlation was observed between THL and SHL ($r = 0.81$, $P<0.05$) as well as BDL and WNL ($r = 0.78$, $P<0.05$) in Ross strain. This was inconsistent with the findings of Udeh and Ogbu (2011) who reported low, positive but non significant correlation between SHL and THL ($r = 0.31$, $P>0.05$, $r = 0.31$, $P>0.05$ and $r = 0.22$, $P>0.05$) in Arbor Acre, Marshall and Ross strains in the Asaba, Delta State.

5.3 MEASUREMENT OF BODY WEIGHT (g) AND MORPHOLOGICAL TRAITS (cm)

5.3.1 Comparative morphological traits (cm) of broiler strains at 4 weeks of age

The findings for comparative morphological traits of NAPRI-X, Marshall and Ross broiler strains at 4 weeks revealed that Marshall strain was significantly ($P < 0.05$) heavier at initial body weight (IBW) and final body weight (FBW) then followed by NAPRI-X and Ross strain. The findings of initial body weight at 4 weeks of this experiment for the NAPRI-X and Ross were in agreement with the report of Kabir *et al.* (2010) who reported 45.55g and 45.00g for Anak and Hubbard broiler strains; whereas that of Marshall (46.48g) which was higher. In addition, the findings for FBW of this experiment indicate that the results for Marshall and Ross were higher than the report of Kabir *et al.* (2010) who recorded 450.91g and 450.63g for Anak and Hubbard strains.

On the other hand, the morphological traits measured differed significantly ($P < 0.05$) among the three strains. The findings are consistent with the results of Francesch *et al.* (2011) who reported that CBL and ELL were significantly ($p < 0.05$) higher in Blond emphordanesa breed followed by Partridge penedesenca breed. The findings depict that the values for morphological traits were higher in Marshall than in NAPRI-X and Ross strains. However, there were no growth of WTL and WTH observed in all the breeds at four weeks of age.

5.3.2 Correlated phenotypic relationship between morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age

The findings of correlated relationship between morphological traits of NAPRI-X, Marshall and Ross broiler strains at 4 weeks of age demonstrate significantly ($P < 0.01$) high and positive association between FBW and OCW ($r = 0.78$, $p < 0.05$) and also

highly, negatively and significantly correlated with BEL ($r = -0.82$, $P < 0.05$) in NAPRI-X strain. The high, negative and significant correlation observed between FBW and BEL in NAPRI-X strain differs from the findings of Ogah (2011) who reported high, positive and significant ($r = 0.89$, $P < 0.001$) correlation between body weight and beak length (BEL) in female turkeys. In addition high, negative and significant correlation was found between BEL and ELW ($r = -0.76$, $P < 0.05$) in NAPRI-X strain. The finding is consistent with the report of Kabir *et al.* (2010) reported that for negatively correlated traits, selection for the improvement of one trait may lead to progress if reduction in the other trait is so desired. Generally, most of the morphological traits investigated were positively and highly correlated among themselves. This agreed with the report of Kabir *et al.* (2010) who compared growth and linear body measurements in Anak and Hubbard broiler strains in the guinea savanna zone of Nigeria.

Similarly, a very high, positive and significant correlations were observed between CBL and CBW ($r = 0.95$, $P < 0.001$); CBL and OCL ($r = 0.85$, $P < 0.05$); CBW and OCL ($r = 0.88$, $P < 0.01$); OCL and ELW ($r = 0.87$, $P < 0.05$); OCW and BEL ($r = 0.90$, $P < 0.01$) and ELL and ELW ($r = 0.88$, $P < 0.01$) in Marshall strain. The findings however are in line with the report of Yakubu and Salako (2009) who reported high, positive and significant ($P < 0.01$) correlations between CBL and CBW, CBW and CBL in Nigerian indigenous chicken. The high, positive and significant correlations obtained imply that there are strong relationships among the traits concerned. This means that selection for the improvement of any trait will lead to a corresponding improvement in the other traits on which selection has not been directly applied. Meanwhile, positive and significant

correlation was also found between OCL and ELW ($r = 0.83$, $P < 0.05$) as well as CBL and OCW ($r = 0.87$, $P < 0.05$) in Ross strain.

5.3.3 Comparative morphological traits (cm) of broiler strains at 8 weeks of age

The findings for comparative morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks revealed that the three breeds differed significantly with Marshall strain significantly ($P < 0.05$) heavier for IBW and FBW. The IBW for Marshall and Ross strains were higher than the report of Kabir *et al.* (2010) who reported body weight of Anak and Hubbard broiler strains at 4 weeks as 450.91g and 450.63g respectively. Similarly, for FBW, the findings were higher than the weights of Anak (1304.43g) and Hubbard (1250.49g) at 8 weeks of age as reported by (Kabir *et al.* 2010). Also Udeh and Ogbu (2011) reported 1880g, 1650g and 1810g as the final body weights of Arbor Acre, Marshall and Ross broiler strains at 8 weeks of age. The differences in the body weights could be attributed to the differences in strains used and or environmental factors.

The results revealed significant ($P < 0.05$) differences exist in the morphological traits (CBL, CBW, OCL, OCW, BEL, WTL and WTH) in NAPRI-X, Marshall and Ross strains except in ELL and ELW with Marshall having the highest values accepts in WTH. The findings are in line with the report of Francesh *et al.* (2011) who reported that WTL, WTW, ELL and CBL measured were higher in Blond Empordanesa than in Partridge Penedesenca strains of Catalonia. The CBL reported in this experiment for NAPRI-X, Marshall and Ross strains correlated with the results of Joseph *et al.* (2003) who reported 3.52 to 3.78cm for different treatment. The variations in body weight and morphological

traits could be attributed by differences in genetic make-up of the strains used and or environmental factors.

5.3.4 Correlated phenotypic relationship between morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

The findings for correlate relationship between morphological traits of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age indicate that IBW was high, positive and significantly ($r = 0.76, P < 0.05$; $r = 0.82, P < 0.05$ and $r = 0.90, P < 0.01$) correlated with FBW in all the NAPRI-X, Marshall and Ross strains. However, IBW was high, positive and significantly correlated with OCL ($r = 0.80, P < 0.05$) and BEL ($r = 0.76, p < 0.05$) in Ross strain. The findings indicate high, negative and significant correlation between FBW and CBL ($r -0.87, P < 0.05$) in NAPRI-X strain. The finding is inconsistent with the report of Yakubu and Salako (2009) who reported that final body weight (FBW) was highly, positively and significantly correlated with CBL in the male and female Nigerian native chickens respectively. However, FBW was also highly, positively and significantly correlated with WTL ($r = 0.84, P < 0.05$) in Ross broiler strain.

Similarly, high, positive and significant correlation exist between CBL and WTL ($r = 0.78, P < 0.05$); OCL and WTL ($r = 0.83, P < 0.05$); OCW and BEL ($r = 0.80, P < 0.05$) in NAPRI-X strain. Meanwhile CBL was highly, positively and significantly correlated with CBW ($r = 0.89, P < 0.01$); ELL and ELW ($r = 0.83, P < 0.05$); ELW and WTH ($r = 0.82, P < 0.05$) as well as negative correlation between OCL and WTH ($r = -0.90, P < 0.01$); WTL and WTH ($r = -0.78$) in Marshall strains. Finally, high, positive and significant correlation was observed between CBW and ELW ($r = 0.89, P < 0.01$) as well as negative correlation between ELL and ELW ($r = -0.81, p < 0.05$).

5.4 PREDICTION EQUATIONS FOR 8 WEEKS BODY WEIGHT OF NAPRI-X, MARSHALL AND ROSS BROILER STRAINS USING 8 WEEKS CONFORMATION AND MORPHOLOGICAL TRAITS.

5.4.1 Prediction equations for 8 weeks body weight (g) of NAPRI-X, Marshall and Ross broiler strains using conformation traits (cm)

It was observed that the regression analysis was very highly significant ($P < 0.001$) in all the three strains and the coefficient of determination (R^2) are more than 50%. This suggests that the body conformation traits are very good predictors for body weight in broilers, even though it was observed that NEL was the best predictor of weight at 8 weeks in NAPRI-X and Marshall strains whereas, BKL was the best predictor in Ross strain. This agreed with the report of Udeh *et al.* (2011) who indicated that the regression analysis were highly significant ($P < 0.001$) in Anak, Arbor Acre, Ross and Marshall strains and the R^2 (coefficient of determination) values were more than 50% in most of the groups. Ojo *et al.* (2010a) reported that chest circumference, chicken height and back length were all highly significant ($p < 0.01$) and very good estimators ($R^2 = 0.78, 0.85$ and 0.85 , respectively) of body weight. In addition, the R^2 values showed the contribution of each trait to the body weight development.

Moreover, the findings indicate that conformation traits are very good predictors for body weight in broilers. Therefore, in the rural area where scale is not available, any of these body conformation traits could be used to predict body weight of broiler chicken especially (NEL and BKL). A similar observation was reported by Akanno *et al.* (2007).

5.4.2 Prediction equations for 8 weeks body weight (g) of NAPRI-X, Marshall and Ross broiler strains using morphological traits (cm)

It was observed that the regression analysis was very highly significant ($P < 0.001$) in all the three strains and the coefficient of determination (R^2) are more than 50% in the majority of the traits. This suggests that the morphological traits are very good predictors for body weight in broilers. It was observed that WTL was the best predictor of body weight at 8 weeks and CBW, ELL and ELW are the moderate estimators in NAPRI-X strain. It was also found that in Marshall strain, WTL was the best predictor whereas, ELL and ELW are the moderate estimators of body weight. In Ross strain, WTL was also found to be the best predictor of body weight at 8 weeks with ELL and ELW as the moderate estimators of body weight at 8 weeks.

5.5 PRINCIPAL COMPONENT ANALYSIS

5.5.1 Eigen values and share of total variance along with factor loading and communalities of conformation traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age

The values of communalities computed for the three strains of chicken confirmed that PCA was appropriate for the data set. Yakubu *et al.* (2009b) reported high range of communalities (0.76 to 0.99) for body measurements of Arbor Acre broilers. Mendes (2011) highlighted a communality range of (0.79 to 0.99) for body measurements of Ross broilers which was similar to what was obtained in this study. Udeh and Ogbu (2011) recorded communalities range of (0.59 to 0.89) for body measurements of Marshall broilers. Medium communalities were observed for SHL (0.53), THL (0.63) and WNL (0.65) in NAPRI-X, Marshall and Ross strains imply that the SHL, THL and WNL were moderate in explaining the total variation in the body measurements of NAPRI-X, Marshall and Ross broiler strains.

Generally, in the three breeds of chicken, PC1 had the largest share of the total variance and correlated highly with NEL, BKL, THL, SHL and BDL. PC1 could be described as the generalized form of broilers (Salako, 2006). Udeh and Ogbu (2011) reported that PC1 had the largest share of the total variance and correlated with BRW, THL, and SHL. In a principal component analysis of body measurements of broilers, Yakubu *et al.* (2009b) reported that PC1 had high positive loadings on body weight, breast circumference, and thigh length of Arbor Acre and termed PC1 “form factor”. Similarly, Mendes (2011) revealed that PC1 had the highest correlation with shank length, breast circumference and body weight of Ross 308 broilers. Ogah *et al.* (2009) presented data that showed PC1 accounting for the largest variance in the body measurements of ducks with high positive loadings on body width, shank length, body length, head length and neck length. Pinto *et al.* (2006) used PCA to analyze performance and carcass traits measured in a population of *Gallus gallus*. The authors reported that the five first principal components explained 93.30% of the total variance and the first component explained 66%. They called the first component generalized weight because the largest eigen vectors were associated with body weight at 35 and 42 days of age. According to Mendes (2009), PC1 provides an adequate summary of the data in most cases.

In conclusion, Debut *et al.* (2003) affirmed that the principal component obtained for the three breeds can be an important tool for development of selection index for improvement purposes.

5.5.2 Eigen values and share of total variance along with factor loading and communalities of morphological traits (cm) of NAPRI-X, Marshall and Ross broiler strains at 8 weeks of age.

The values of communalities computed for the three strains of chicken confirmed that PCA was appropriate and adequate for the data set. Ogah (2011) reported high range of communalities (0.85 to 0.99) and (0.86 to 0.99) for morphometric measurements of male and female turkeys; which was similar to what was obtained in this experiment (0.75 to 0.99), (0.62 to 0.94) and (0.79 to 0.94) for NAPRI-X, Marshall and Ross broiler strains respectively. The high communalities for almost all the morphological traits found in the three strains illustrated that they were high in explaining the total variation in morphological traits of the three strains.

Generally, in the three strains of chicken, PC1 had the largest share of the total variance and correlated highly with OCW and CBW respectively. Yakubu *et al.* (2009a) indicated that the first principal component (PC1) accounted for the largest variance in the morphological traits of three Nigerian chicken genotypes.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

The purpose of the study was to assess and compare traits comprising of growth performance, conformation and morphological traits of NAPRI-X, Marshall and Ross broiler strains at 4 and 8 weeks of age as well as to determine the extent to which 8 weeks conformation and morphological traits could predict body weight at 8 weeks.

315 Day-old chicks of the three breeds were raised in the teaching and research poultry farm of Audu Bako College of Agriculture, Dambatta, Kano State. Data on growth performance, conformation and morphological traits were measured at 4 and 8 weeks of age. Data were analyzed using the correlation matrix and general linear model procedures of Statistical Package for Social Sciences SPSS (2011) version 20. The data was also subjected to simple linear regression analysis and PCA using SAS (2008) version 9.0.

Growth performance traits at 4 and 8 weeks of age for the NAPRI-X, Marshall and Ross strains were observed and indicated that Marshall strain was significantly ($P < 0.05$) superior at both ages in initial body weight (IBW), final body weight (FBW), daily weight gain (DWG), total weight gain (TWG), daily feed intake (DFI), total feed intake (TFI) and feed conversion ratio (FCR) as well as low % mortality rate followed by NAPRI-X and Ross broiler strains. Non significant ($P > 0.05$) differences were observed for feed conversion ratio (FCR) and percentage mortality rate at 8 weeks.

Positive, negative and perfect relationships were observed among the studied traits at 4 and 8 week of age for all the three strains.

The results of comparative conformation traits of NAPRI-X, Marshall and Ross broiler strains at 4 and 8 weeks of age, indicated that the strains differed significantly ($P < 0.01$)

in all the studied traits with the Marshall strain being the most superior with the exception of BDL and WNL. Positive, negative and high associations were observed among the studied conformational traits at 4 and 8 weeks of age for all the three strains.

Morphological traits of NAPRI-X, Marshall and Ross broiler strains at 4 and 8 weeks of age showed that significant ($P < 0.01$) differences were observed among the traits with Marshall having the highest average mean values. ELL and ELW had no significant ($P > 0.05$) influence on morphological traits. Positive, negative and highly significant associations were observed among the studied morphological traits at 4 and 8 weeks of age for all the three strains.

The results of prediction equations for 8 week body weight of NAPRI-X, Marshall and Ross broiler strains using conformation traits revealed that NEL, BKL, THL, SHL, BRW, BDL and WNL were all significant ($P < 0.001$) and are very good estimators of body weight in the three broiler strains. NEL was observed to be the best predictor of body weight at 8th weeks in NAPRI-X; NEL, BRW and BDL were the best predictors in Marshall strain whereas, BKL and BDL were the best predictors of body weight in Ross strain. The prediction equations for 8 week body weight of NAPRI-X, Marshall and Ross broiler strains using 8th weeks morphological traits indicated that WTL, WTH, CBL, CBW, BEL, OCL and OCW were found to be significantly ($P < 0.001$) and are very good estimators of body weight. WTL was the best predictor of body weight at 8th weeks in NAPRI-X, CBL and WTL in Ross strain.

The principal component analysis for conformation traits at 8 week showed that 3 principal components were extracted in the three strains. The 3 principal components accounted for 84.40%, 73.54% and 88.50% of the total variances present in the seven

conformation traits for the three strains. It was observed that, PC1, PC2 and PC3 for the three strains had high, positive loadings on NEL, BKL, THL, SHL, BDL, and WNL respectively.

The principal component analysis for morphological traits at 8 week revealed that 3 principal components were also extracted in each of the three strains. The 3 principal components accounted for 45.57%, 90.53% and 57.56% of the total variances present in the nine morphological traits. PC1, PC2 and PC3 had high loadings on OCW, CBW OCL respectively.

6.2 CONCLUSION

The three strains used for this study showed significant variations for growth, conformation and morphological traits and thus these traits can be used as basis for selection to develop direct lines for (rapid growth and or early maturing) these traits and other correlated traits.

Low to high positive and negative correlations were observed among the three studied breeds at 4 and 8 weeks of age which is an indication of pleiotropic effect, reflecting the effect of some set of genes for the traits.

Both regression and principal component analyses models are good tools for predicting body weight.

The principal component obtained for the three strains can be used as an important tool for development of selection index for improvement purpose.

6.3 RECOMMENDATIONS

- It is recommended that traits that were significantly correlated (IBW, FBW, DWG, TWG, DFI, TFI, FCR, NEL, BKL, THL, BDL, WNL, SHL, CBL, CBW, OCL, OCW, BEL, CBW, ELL, ELW) should be given priority in selection due to their high tendency of influencing body weight of the breeds.
- Principal component analysis should be used as an added tool in prediction of body weight.

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APPENDICES

APPENDIX A: VACCINATION/MEDICATION SCHEDULE

Age of bird	Vaccination/Medication	Route of admin.
Day 1	Hitchner B-1 (i/o) and Marek's Vaccine	Intra ocular
Day 1-5	Neoterramycin and Vitalyte	In Water
Week 1	Gumboro: (IBDV 1 st dose)	In Water
Day 7-10	Vitalyte for 3 days	In Water
Week 3	Gumboro: (IBDV 2 nd dose)	In Water
Day 21-23	Vitalyte for 3 days	In Water
Week 4	NDV- Lasota In Water	In Water
Day 28-30	Vitalyte for 3 days	In Water

IBDV = Infectious Bursal Disease Vaccine, NDV = Newcastle Disease Vaccine,
i/o = intraocular

APPENDIX B: COMPOSITION OF BROILER STARTER AND FINISHER DIETS

Ingredients	Broiler Starter Diet (%)	Broiler Finisher Diet (%)
Maize	45.00	58.00
Full fat soya bean	30.00	24.00
Groundnut cake	19.10	12.10
Limestone	2.00	2.00
Bone meal	3.00	3.00
Lysine	0.15	0.15
Methionine	0.15	0.15
Table salt	0.35	0.35
Vitamin-premix	0.25	0.25
Total	100.00	100.00
Calculated Values		
Me (Kcal/Kg)	3038.64	3102.00
Crude protein (%)	23.75	19.95
Crude fibre (%)	3.51	3.09
Ether extract (%)	8.35	7.37
Calcium (%)	1.87	1.84
Avail. phosp. (%)	0.62	0.58
Lysine (%)	1.41	1.16
Methionine (%)	0.52	0.47

Vitamin-premix used in this research supplied the following per kilogram diet: vit. A: 10,000 IU, vit. D3: 2000 IU, vit. E: 51 IU, vit. K: 2.34mg, Riboflavin: 5.5g, Calcium pantothonate: 10mg, Niacin: 25mg, Choline chloride: 25mg, Folic acid: 1mg, Manganese: 56mg, Zinc: 50mg, Cpper: 10mg, Iron: 20mg, Cobalt: 1.25mg, Amprolium: 125mg, Tetracycline: 100mg, Selenium: 0.2mg and Antioxidant: 1.25mg. Me (Kcal/kg) = Metabolizable energy kilocalories per kilogram of diet.

APPENDIX C: Proximate Composition of Broiler Starter and Finisher Diets

Nutrients	Broiler Starter Diet (%)	Broiler Finisher Diet (%)
Dry Matter (%)	93.18	94.26
Metabolizable energy (Kcal/Kg)	24.31	20.91
Crude protein (%)	3237.11	3246.90
Crude fibre (%)	9.37	8.69
Ether extract (%)	6.08	5.38
Total Ash (%)	7.66	6.93

Metabolizable energy values were calculated from the proximate composition data using the formula as described by Ponzenga (1985): $Me = 37 X \% CP + 81.8 X \% EE + 35 X \% NFE$.