ANALYSIS OF EARLY GROWTH AND MORPHOSTRUCTURE OF FULANI ECOTYPE, BOVANS NERA CHICKEN AND THEIR CROSSBREDS

BY

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ABSTRACT

One of the thrusts of Nigeria Agriculture Promotion Policy is the expansion of the chicken genetic pool. Crossing of indigenous chickens, such as Fulani Ecotype (FE), with exotic types which possess desirable potentials could achieve targeted genetic improvement. However, information on hybrid chickens from such crosses and their morphological evaluation have not been adequately documented. Therefore, early growth and morphostructure of the FE, Bovans Nera (BN) and their crossbreds were evaluated.

Fifteen hens and three cocks each of matured FE and BN constituted the base breeder chicken population. The FE breeders were sourced from Fulani kraals around Kisi, Oyo State and Isundunrin, Osun State and BN from a reputable farm in Ibadan. One hundred and fifteen chicks comprising 25 Bovans x Fulani (BF), 33 Fulani x Bovans (FB), 39 pure Bovans x Bovans (BB) and 18 pure Fulani x Fulani (FF) were generated using artificial insemination technique. The Body Weight-BW (g) of the genotypes were monitored for eight weeks and Average Weekly Growth Rate-AWGR (g) was derived. Seventy-eight chicks (aged eight weeks) comprising 20 each: BB, FB and BF and 18 FF were randomly selected. Shank Length (SL), Shank Diameter (SD), Body Circumference (BC), Body Length (BL), Keel Length (KL), Wing Length (WL) and Neck Length (NL) were measured (cm). Morphostructural indices such as massiveness, compactness and long-leggedness were calculated. The effects of genotype, sex and genotype by sex interactions on growth and genetic effect on morphostructure were investigated. Data were analysed using analysis of variance and the discriminant function at $\alpha_{0.05}$.

The BW of BF (328.2±8.6) was significantly higher than FB (302.2±8.6), BB (269.3±8.6) and FF (241.6±8.6). The male chicks (317±4.4) were heavier than females (253.5±7.4). The female BF (307.7±14.8) were significantly heavier than BB female (240.8±14.8) but similar to FB female (274±14.8). Females of other genotypes were heavier than FF female which weighed 190.6±14.9. Among males, the BW of BF (348.8±8.6) was significantly higher than 329.7±8.6 (FB), 297.7±8.6 (BB) and 292.6±9.3 (FF). Genotype by sex effect on growth was not significant. The highest growth rate of 79.2±4.4 (BF) was followed by 65.5±4.4 (FB), 57.9±4.4 (BB) and 52.2±3.2 (FF). The BF and FB had similar BC (23.5, 23.1), BL (18.0, 17.1), KL (8.6, 8.4), WL (17.4, 16.9) and NL (8.4 and 8.3, respectively) which were significantly higher than those of BB and FF. Massiveness was similar across the genotypes; while compactness of BF (97.5) was significantly higher than those of FF (91.2) and BB (89.3) but similar to FB (93.8). Long-leggedness of BF (32.0) and FB (31.6) were similar but significantly higher than BB (29.5) and FF (28.7). The most discriminant function accounting for 91% of total variation was dominated by BC (-0.01), BL (0.19), WL (1.00) and BW (0.71).

Bovans X Fulani and Fulani X Bovans were superior to Bovans X Bovans and Fulani X Fulani in body weight, growth rate, and long leggedness but were similarly massive. Bovans x Fulani crossbred was most compact. Body circumference, body weight, wing and body lengths differentiated the genotypes.

Keywords: Genetic improvement, Fulani ecotype, Bovans Nera, Morphological evaluation.

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DEDICATION

My dedication is to Almighty God who decreed that this dream comes true.

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CERTIFICATION

I certify that this work was carried out by Mr. A.K. Tiamiyu in the Department of Animal Science, University of Ibadan, Nigeria.

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DEFINITIONS

Ecotype: A sub- species that has stabilised to particular habitat or ecosystem

Dominance: A phenomenon whereby one allelic form of a gene is expressed to the exclusion of the other

Epistasis: The interaction between genes of different loci.

Exotic: Originating in or characteristic of a distant foreign country.

Genotype: The genetic constitution of an individual organism as passed from parents to an individual

Heterozygosity: A condition in which alleles of a particular gene are different.

Heavy ecotype: This is a classification of indigenous chicken with comparatively high body weight

Hybrids: Crosses of different breeds, species or varieties.

Light ecotype: This is a classification of indigenous chicken with comparatively low body weight.

Function: This indicates the utility of the animal.

Morphostructure: This is the body dimensions and the relationships between them.

Morphological index: This is a ratio of morphological traits indicating relative productive capacity.

ABBREVIATIONS

HDP	Hen Day Production
YE	Yoruba Ecotype
FE	Fulani Ecotype
GL	Gold Link egg laying strain
LC	Local Chicken
DB	Dominant Black egg laying strain
FF	Fulani x Fulani chicken
BF	Bovans Nera x Fulani chicken
FB	Fulani x Bovans Nera chicken
BB	Bovans Nera x Bovans Nera chicken
SL	Shank Length
SD	Shank Diameter
BC	Body Circumference
BL	Body Length
KL	Keel Length
WL	Wing Length
NL	Neck Length
BW	Body Weight

CHAPTER ONE

INTRODUCTION

Interventions to reduce poverty will go a long way in improving access to food. A report by GAP (2016) noted that about two billion people of the world are of poor health and also underfed, with 800 million having no access to food. By 2050, over 50 percent of the global population which is expected to rise from 7.3 billion to 9.7 billion will be Africans (UN, 2015). Meat and dairy intakes is also expected to rise by 73% and 58% over 2010 levels respectively (FAO, 2011).

Sub-Saharan Africa (SSA) of which Nigeria is inclusive is averagely dependent on agriculture and natural resources for food needs and earnings. To be food secure, they need to improve their agriculture, maintain low population growth and reduce environmental degradation.

Poultry especially chicken are readily found around rural households. They are usually reared together with other livestock and in some cases with fish. In rural third world countries, local poultry are about 80 and 99 percent of the poultry that are reared (Adedokun and Sonaiya, 2002). Only a few hens (5 to 20) usually are kept by women. The production system provides extra earnings for the indigent and the landless. Smallholder poultry production is anticipated to be relevant because of the security they provide for their owners (Adebambo *et al*., 1999).

Chicken crosses like ‘Vanaraja’ and ‘Gramapriya’ developed for backyard farming are popular in countries like India where farmers generate supplementary income through increased egg production, enhanced meat from cockerels and hardiness. Development of high performing and adaptable germplasm suitable for backyard farming is highly essential to improve the production system.

Nigeria indigenous chickens like other local chickens are important in the economic, social and cultural life of their rearers. They are resilient as they are able to produce under difficult production conditions. Some ecotypes were identified such as Yoruba ecotype and Fulani ecotype (Olori, 1992) based on the identity of their keepers while some were classified on the basis of relative sizes of the birds (Momoh *et al.,* 2010). Several efforts were undertaken to upgrade the genetic potential of Nigeria indigenous chickens ranging from cock exchange programmes to crossbreeding studies carried out by Nigeria breeders (Akinokun and Dettmers, 1977; Nwosu and Omeje, 1985; Sola-Ojo *et al.*, 2012).

The Fulani ecotype chicken is traditionally linked with the Fulani cattle rearers who due to their migratory nature took it to different sections of Nigeria. The chicken constitution is largely maintained because the Fulanis usually live in isolation from other human settlements. Ogundipe (1990) and Tiamiyu (1999) suggested that the Fulani ecotype chicken may likely be a crossbred between indigenous fowls and Rhode Island Red Chickens from previous cockerel exchange programs.

Fulani ecotype chicken was reported to be heavier than other ecotypes within Nigeria (Atteh, 1990; Olori, 1992 and Adedokun and Sonaiya, 2002). Osaiyuwu *et al*. (2009) indicated that Fulani ecotype chicks had significantly better body weights from week 1-12 (32.30 ± 3.74 - 461.50 ± 102.06g) for females and 34.00 ± 3.73 - 552.43 ± 104.98g for males while the Yoruba ecotype chicks had lower body weights (24.27 ± 1.55 - 394.46 ± 29.86g) for females and 24.09 ± 1.48- 395.92 ± 17.85g for males respectively. Sola-Ojo *et al*. (2013) reported that the mean egg weight, total egg number, hen house production in Fulani ecotype chicken were 44.11g, 128 and 53.16% and significantly higher than 42.44g, 98, 45.5% obtained for Yoruba ecotype. They further stated that external and internal quality traits of eggs from both ecotypes were similar except shell thickness that was significantly better in Yoruba ecotype chicken and yolk height that was significantly higher in Fulani ecotype chicken. However, Fayeye *et al.* (2005) stated that mean values for Fulani ecotype egg parameters were 40.73g, 73.43 percent, and 0.58 for egg weight, Haugh unit, and shell thickness respectively.

Sola-Ojo and Ayorinde (2011) reported that a crossbred from Fulani ecotype and Dominant Black strain showed appreciable production and adaptability. Bovans Nera chicken and Dominant black strains have similar production potential (breeder layer type) therefore the need to complement this with the reported superior body weight in the Fulani ecotype chicken.

Exploring the performance of livestock at a younger age for information on its potentials at maturity is desirable as it saves time in making critical decision on keeping the productive ones. Morphological traits are usually used as indicators of productive potentials in poultry. Moreover, morphological indices of newly generated livestock could be associated with various productive and adaptive characteristics of the same, hence the conduct of this study to assess the early growth and morphostructure of Fulani ecotype, Bovans Nera chickens and their crossbreds.

1.1 Justification

There is high repeatability of early growth traits in assessing type in poultry. Presently, there are few improved indigenous hybrid chickens in Nigeria and smallholder poultry producers contribute a sizable supply of poultry products. Poultry Commodity Development Plan under Agricultural Transformation Agenda (ATA) proposes development of new breeder stock into poultry industry. Moreover, the Agriculture Promotion Policy of the present administration, building on the policy thrust of Agricultural Transformation Agenda emphasizes conduct of research to enhance livestock productivity (FMARD, 2016).

Consequently, the following hypotheses are put forward:

Ho: There are no significant differences in morphological structures of Bovans Nera, Fulani Ecotype and their main and reciprocal crosses.

1.2.0 General Objective

The general goal of this study is to document growth and morphostructure of Bovans Nera, Fulani ecotype and their crosses for possible type assessment.

1.2.1 Specific Objectives

i. To generate hybrid chickens from Fulani ecotype and Bovans Nera chickens.

ii. Assess the hybrid chickens generated (Fulani x Bovans Nera and Bovans Nera x Fulani) for growth and morphometric characteristics.

iii. Determine the morphometric characteristics that best discriminate between the Fulani ecotype, Bovans Nera and crossbreds.

CHAPTER TWO

LITERATURE REVIEW

2.1 Nigeria Indigenous Chickens

Indigenous breeds of chickens are economically important to the suburban life of third world countries. Smallholders benefited mostly through income generation and provision of nutritious food (egg and meat) for their consumption.

Nigeria indigenous chickens like others are largely reared under smallholder production systems that are typified by little or no inputs with concomitant small production of meat and eggs (Dessie *et al*., 2011).

The phenotypic diversity of Nigerian local chicken has been documented (Ige *et al.,* 2012). Based on the characterization of major genes controlling feather pattern, Nigerian local chickens have been sub-divided into frizzle feathered, Naked Neck and Normal feathered chickens (Ikeobi *et al.,* 1996). Other phenotypic varieties such as short winged or flightless (*Opipi*) and dwarf chickens have also been documented; most of which occur in small population sizes and are generally selected against due to religious beliefs and/or economic reasons.

The indigenous chicken numbers was put at 104 million (RIM, 1992) which indicates that they constitute an extensive genetic pool. In 2010, FAOSTAT estimated that they contributed about 285,977 metric tonnes of meat.

The indigenous chicken's eggs are small and the birds are usually not fast growers. Despite the harsh conditions under which they were reared, they still manage to produce. They are source of quality foods to their owners and are used to fulfill financial obligations as well as important socio-cultural requirements.

Oluyemi (1990) reported that the birds breed naturally and are believed to be hardy which may partially be expressed in disease tolerance and better adaptation to the environment.

2.1.1 Description and Distribution of Nigeria Indigenous Chickens

Dessie *et al.,* 2011 reported that indigenous chickens characterization are usually on the basis of major gene(s) they carry, utility, region or habitat they are found. Nigeria indigenous chickens are also described based on the identity of the rearers, physical attributes such as feather morphology or body size .Distances are also responsible for the heterogeneity observed among local chicken population. Chickens from the same region or niche tend to be similar than others . The ecotypes are usually named after the region of production or local market (e.g. ecotypes of Horro and Tepi in Ethopia) or as the case may be the identity of its keepers (Yoruba and Fulani ecotypes in Nigeria) (Olori, 1992). Moreover, feather morphology (e.g. the naked neck and frizzle feathers) are also used in identifying the ecotypes. Nwosu (1979) evaluated the distribution and characterization of local chicken in South-Eastern Nigeria. He identified three main ecotypes namely; Nsukka, Owerri and Agwu types at the South-Eastern States of Nigeria. These chicken types are found to be multi-coloured with several feather variations and no single dominant colour. The colour mixtures were brown, black, red, orange, grey, white in various grades and shades.

A survey of poultry breeds of South Western Nigeria showed variations in feather type, feather colour, shank, beak and ear lobe colours, comb type and performance characteristics (Adebambo, *et al.,* 1999). These differential feather colours assist them to escape from predators as they hatch and brood their chicks themselves.

They have small body size which is generally ubiquitous of indigenous chickens. This is likely a survival trait as the maintenance requirement will be minimal to be met by the low input production system they are reared.

2.1.2 Potentials of Nigeria Indigenous Chickens

Olori (2009) stated that indigenous chicken production and utilization is essential in preserving the unique genetic diversity they possess. In an evaluation of Nigerian indigenous chickens with Rhode Island Red, Amao (2017) reported that naked neck chicken type was heavier than frizzled feathered, Fulani ecotype and normal feathered type. He suggested that this could partly be attributed to the thermal stress tolerance of this strain.

Adedokun and Sonaiya (2001) reported that the growth performance of female local chickens from derived Savannah was 23±1.6, 104±14.5, 262±4.8, 605±7.5, 765±103.4 and 948±130.6g for 0, 4, 8, 12, 16 and 20 weeks body weight respectively. The corresponding values for male were 29±1.0, 124±9.2, 311±36.4, 702±55.3, 914±65.4 and 1096±84.1g. However, growth of birds from the rain forest agro-ecology were not significantly different from those of the derived savannah.

Nwosu (1979) also stated that local chickens laid 128 eggs/year when raised on deep litter system, a figure much higher than 60 – 80 eggs reportedly produced by local birds on free range (Hill and Modebe, 1961). Under intensive management, Oluyemi (1974) reported that indigenous fowls grow significantly faster than the White Leghorn from 4 to 14 weeks of age, although they were lighter than the Rhode Island Red or White Rocks.

Oluyemi and Oyenuga (1971) suggested that a particular variety of Nigeria native chickens may actually or potentially belong to either of the light or heavy breeds. Nwosu *et al.,* (1985) studied the conformation of the native chickens and reported an average body weight of 1.14kg and 1.27kg at point of lay and end of lay respectively. Atteh (1990) stated that each indigenous hen laid and incubates about 11 eggs, hatching in most cases 100% of the eggs laid. Approximately 1.84 broods of chicks are produced by each mother hen per year. There is no artificial brooding of chicks and depending on the season of the year that the chicks were hatched, survivability varied between 10-80%. On the average 58% of the hatched chicks reach the objective for which they are produced. The percentage of the households that artificially weaned the chicks was 30.8 while 69.2 allowed the mother hen to do the weaning. Although in general, age at weaning is not definite, the Fulanis, whose main objective for chicken production is for income, wean chicks for sale at 4 or 6 weeks of age. In this group, the hens produce about 3 broods of chicks per year.

The average time between hatching and ultimate use (sales or consumption) varies between eight months to one and half years although the phrase "when old enough to eat" was more common than a target body weights. Random weighing of what were considered as matured hen and cocks outside cattle kraals showed an average live body weight of 1.29kg (0.98 – 1.42 kg) and 1.76 kg (1.46 – 2.21 kg) respectively. Corresponding averages for hens and cocks on cattle kraals were 1.62 kg and 2.39 kg respectively. The mean bodyweight of birds in households was comparable to those reported by Nwosu *et al.,* (1985) though the average for birds raised on cattle kraals was significantly higher. Momoh *et al.,* (2008) conceptually categorized Nigeria indigenous chicken on the basis of body weight and body size into “heavy” and “light” ecotypes for egg production under improved management conditions. They reported a mean hen-day percentage production of 38.0 and 40.11 for the “heavy” and “light” ecotypes, respectively. Total number of eggs layed in a year, mean egg weight and cumulative egg mass for “heavy” ecotype was 135.69 eggs, 40.34 g and 5740.85 g, respectively. The corresponding values for the “light” ecotype were 144.19 eggs, 37.32 g and 5008.21 g. Hen-day production, egg number and egg mass except egg weight was observed to be similar, with the “heavy” ecotype producing significantly heavier eggs.

Agu *et al*. (2012) reported that the hen day percentage production (HDP) of Nigerian heavy ecotype chickens ranged from 51.69 to 61.74% and age at first egg was 162.23 ± 1.22 days. Moreover, Oleforuh-Okoleh (2011) reported that age at first egg among the Nigerian light ecotype chickens was 159.47 ± 1.97 to 168.47 ± 1.90 days.

The weight of first egg of heavy ecotype chicken (34.29 ± 0.67 g) was heavier than 25.97g and 30.62 g that was reported by Omeje and Nwosu (1984) and Oleforuh-Okoleh (2011) in light native chickens but lower than 38.06 g reported by Momoh (2005) for light local ecotype. The Mean Egg Weight of heavy ecotype of the Nigerian local chicken of 41.47 ± 0.57 g was comparable to the values reported by Msoffe *et al.* (2001) for Tanzanian local chicken ecotypes. Agu *et al*., (2012) suggested that the short-term egg number of 71.50 ± 3.77 eggs expressed by the heavy ecotype of hens showed that it has egg laying potential which could be exploited.

2.2 Fulani Ecotype chicken

2.2.1 Origin and Distribution

The origin of Fulani ecotype chicken is uncertain, what is known is that this chicken type is usually associated with cattle rearers from the northern part of Nigeria. Due to the nomadic nature of the Fulani herdsmen, the chicken ecotype is found in cattle kraals scattered all over the country. Towns like Eruwa, Kishi and Igbeti in Oyo state; Isundunrin, Iwo and Iree in Osun state and Ogoja town in Cross Rivers state harbor pockets of this chicken ecotype. Momoh *et al.,* (2010) conceptually categorized the Nigerian indigenous chicken on basis of body weight and bat the Fulani ecotype chicken might be a crossbred between Rhode Island Red and indigenous fowls evolved as a result of previous cockerel exchange programmes, retained and maintained by the Fulanis or they might have been the lost *Riyom* breed developedody size into “heavy and light ecotypes” instead of acknowledging the distinctiveness of Fulani ecotype aside from other indigenous chicken ecotypes. However, Tiamiyu (1999) while studying the conformational and carcass features of Fulani ecotype chickens suggested th in Jos in the early sixties. Adedokun and Sonaiya (2002) suggested the existence of two strains of Fulani ecotype chickens mainly the normal and the dwarf type.

2.2.2 Description of Fulani Ecotype Chicken

The mongrel nature of the Fulani ecotype chicken was in agreement with the works of (Oluyemi, 1974, Nwosu *et al.*, 1985) who also noted several variations in the colours of Nigeria indigenous chickens. Tiamiyu (1999) reported that normal feather morphology and distribution appeared most common among Fulani ecotype chickens accounting for 99.5% and 72.4% respectively. Frizzled feathered, naked neck, silky feathered and flightless birds were not noticed but the proportion of frayed feathered and crested were 0.5% a piece. Fayeye and Oketoyin (2006) also reported 0.05 and 0.03 for the gene frequencies of frizzled (F) and Naked neck (Na) among Fulani ecotype chicken population, indicating that the alleles for these traits were almost obsolete within the population.

Variable plumage patterns and colours were found among the Fulani ecotype chicken (Tiamiyu, 1999) but a highly significant proportion (27.3%) had Colombian pattern (a well-defined plumage pattern), with red/brown and black feathers accounting for 29.1 % and 41.25 % respectively. Barred plumage pattern was 3.5 % while lacing and mottling were 10.7 % and 17.5 % respectively. Percentages of non-descript self-white, self-black were 30.2 %, 7.6 % and 2.7 % respectively. Among the Fulani ecotype chickens he sampled, 54.1 % were yellow shanked, 99.0 % single combed, 1 % rose combed with 75.3

% exhibiting red comb colour and 41.1 % having dark brown beaks. The birds were mostly 4- toed (74.6 %) but (25.4 %) displayed 5-toed condition.

Olawunmi *et al.* (2008) reported that Fulani ecotype chickens were usually larger sized than Yoruba ecotype. The body length of adult Fulani ecotype is longer 30.1 ± 2.5 cm against 24.00 ± 1.8 cm for the Yoruba ecotype. Shank and thigh lengths of the Fulani type are longer than those for the Yoruba type. The highest contributor to the variation in body weight of Fulani ecotype cocks was breast length while drum stick was the least (Yunusa and Adeoti, 2014). Small, medium and large wattle sizes were observed in Fulani and Yoruba ecotypes by Ige *et al.* (2012).

2.2.3 Potentials of Fulani Ecotype Chicken

Jesuyon and Salako (2013) reported that the mature bodyweight ranges of Fulani ecotype chickens cocks and hens were (2.28kg to 2.40kg and 1.40kg to 1.50 kg) respectively. These figures were higher than 1.47 to 1.77 and 0.85 to 1.44 kg reported by Nwosu *et al*. (1985) for Nsukka cocks and hens, respectively. Body weight of Bayelsan chicken (1.50 and 1.23 kg; Ajayi and Agaviezor, 2009) and Tanzanian chickens (1.95 and 1.35 kg; Goromela *et al*., 2009) were lower.

In a study on the evaluation of Fulani and Yoruba ecotypes chickens raised intensively, Olori (1992) opined that the Nigeria indigenous chickens many consist of distinct populations of chickens with differentiation in body weight characteristics and potential for meat production. He reported that the Fulani ecotype was heavier by about 27% than the Yoruba ecotypes at all ages. It grew faster by 1.4g daily and had heavier body weight at day 70 (454g) than Yoruba ecotype (369g)

The coefficients of variations for body weight were 25.4 % for the Yoruba ecotype and 17.8% for the Fulani ecotype which signifies the possibility of improvement through selection. Hen housed egg production was 31.2 % for the Fulani ecotype and 32.9 % for the Yoruba ecotype. The mean egg weight was 37.6 g with no difference between the ecotypes in the second month of production. The egg traits such as shell thickness (0.38 mm), egg shape index (0.74) were comparable between the ecotypes. The Yoruba ecotype eggs had more yolk (14.8 g vs.13.5 g) and less albumen (18.2 g vs. 21.1 g) than the Fulani ecotype. Sola-Ojo *et al.,* 2013 observed that the Yoruba ecotype chickens matured earlier than Fulani ecotype chickens with its first egg being layed at 20.56 weeks relative to 26.73 weeks for Fulani ecotype. Body weight at first egg, (BFE) was significantly higher in Fulani ecotype 1437.5 g than in Yoruba ecotype 1314.60 g. The mean egg weight and total egg number in Fulani ecotype (44.11 g and 128, respectively) were higher than 42.44 g and 98 obtained for Yoruba ecotype. Clutch size (CS) of 2- 6 eggs observed for Yoruba ecotype was lower than 3-9 eggs in Fulani ecotype but the pause length (PL) displayed a reverse trend of 1- 6 days and 1-3 days respectively. However, the egg quality characteristics were similar for the two ecotypes although Yoruba ecotype chickens' egg shell was thicker than those of the Fulani ecotype. In contrast the yolk height of the Fulani ecotype was higher than those of the Yoruba ecotype chickens' egg. Fayeye *et al*. (2005) asserted that the egg quality and growth performance of Fulani-ecotype chicken was appreciable and could be useful in chicken improvement.

Sola-Ojo and Ayorinde (2009) reported that Fulani ecotype had highest body weight gain from 14 to 18 weeks of age 663.98 ± 122.20 g to 977.2 ± 187.16 g and this agreed with the fact that local chicken usually grow fastest from the age of 10 – 14 weeks (Oluyemi and Oyenuga, 1974) which reduces at the beginning of sexual maturity (Nwosu, 1979).

The mean body weight increase rapidly at early stage from 0 – 4 weeks, then at a slower rate from 6 weeks to 20 weeks of age, while the mean body girth and wing length shows rapid development between 0 and 6 weeks of age. Other body parts such as thigh, keel and shank length increase at a faster rate from 0 week to 6 weeks of age, then at a slower rate from 8 to 12 weeks. Sola-Ojo and Ayorinde (2009) further stated that the feed conversion ratios in Fulani ecotype chickens were 1.12, 1.17, 1.63, 1.77, and 2. 14 between 0 – 4 weeks of age, 5 – 8 weeks, 9 – 12 weeks, 13 – 16 weeks and 17 – 20 weeks of age respectively.

They concluded that Fulani ecotype chickens could be selected for growth traits between the ages of 13 – 16 weeks when they have better feed efficiency and their weight gain is almost doubled.

Sola-Ojo *et al.,* 2011 also reported that male Fulani ecotype chickens were similar to females in body weight, length and girth, wing, keel, and drumstick lengths from day old to 4th week of age, but significantly better from 6th to 20th week. Their thigh lengths were also similar from day old to 6th week, 14th and 20th weeks, but significantly different at other ages. Shank length and diameter were also comparable from day old to 4th week with shank length being significantly different at other ages though shank diameter was similar in at weeks 10, 14 and 16.

Their findings revealed sexual dimorphism in Fulani ecotype chickens with respect to bodyweight and morphological traits at 8 weeks which showed those traits could be used in grouping them at this age.

Carcass characteristics of male Fulani ecotype chicken was also reported to be better than that of female, though relative to the body weight ,female FE had higher but not significant slaughtered and feathered weight than the male FE. Carcass yield and meat composition values were in agreement with the results of Joseph *et al*. (1992) where the carcass yield of the male local chicken was significantly higher than that of the female but their percentage water and fat content were similar.

2.3 Bovans Nera Chicken

2.3.1 Description/ Origin

These are hybrid layers produced from Rhode Island Red and barred Plymouth Rock originally sourced from Belgium(Hendrix Genetics, 2009).They were initially developed in the 50's by four breeder farms (Bovans Organisatie) in Netherlands which later became competitive in different parts of the world. The Bovans gene pool prior to its acquisition by Hendrix Genetics in 1991 was improved and traded worldwide by Hypeco poultry Breeders.

Several years of genetic improvement produced these layers noted for their hardiness and production of large number of eggs with exceptional quality (ISA B.V, 2009). It is one of the highly vigorous birds. Non flighty behaviour and good appetite contribute to its ability to survive production pressures with heavier body weight than other strains (ISA B.V., 2013). Age at 50 percent production was estimated to averagely occur at 146 days, with peak production of 94 percent and mean egg weight of 63.0g.

Breeding method employed in its improvement initially was recurrent selection tests which was carried out in the sixties ahead of other poultry breeding companies such as Dekalb and Hisex. Some Recurrent Reciprocal Selection was later incorporated which graduated to the new genomic selection technique (ISA Breeding Programme, 2011). The genetic origin and breeding programme details of these genotypes were kept secret by top technical management partners of these breeding concerns and never divulged to the public to guide against competition from rivals. Bovans Nera as well as ISA Brown are popularly distributed in Nigeria by CHI (Ajanla) Farms Limited, Ibadan among others (TGI, 2019)

2.3.2 Potentials of Bovans Nera

It was claimed by Hendrix Genetics that the laying period for BovansNera hens was 18 to 90 weeks .Peak egg production percentage was 94% and age at 50% production 146 days. Average egg weight, average feed consumption per day and livability 62.3g, 122gand 94.2% respectively (ISA B.V. 2013).

Olawumi and Dudusola (2011) in a study assessing the long term production traits of Bovans Nera and two other exotic commercial layers, namely Isa Brown and Dominant Black reported that the strain of bird had a profound effect on egg production and ability to utilize feed but no effect on mortality rate. Bovans Nera recorded 5.41 ± 0.08 eggs/bird/week while Isa Brown recorded 5.37±0.07 eggs/bird/week. The values for the two strains were similar and superior to that of Dominant Black 4.94eggs/bird/week for the 58 week study period. The findings contradicted that of Duduyemi (2005) who reported no significant strain effect on egg production. With regards to feed efficiency, Bovans Nera and Isa Brown recorded higher values which were similar but superior to that of Dominant Black. The results was in conformity with that of Adebambo *et al*., 2009 which stated that there are significant strain differences in feed efficiency. This implies that Bovans Nera and Isa Brown produced more eggs than Dominant Black strain on less feed. On liveability, it was reported that Bovans Nera recorded 0.14±0.06 mortality per week during the 58 week egg production trial. This value was similar to what obtained with Isa Brown of 0.14± 0.07 and Dominant Black of 0.21. This indicated that Bovans Nera as well as the other commercial strains were only tolerable to the tropical environment because their liveabilities under tropical field conditions were lower than expected liveabilities in their production manuals (ISA B.V. 2013).

The tolerance of Bovans Nera was also confirmed by Duduyemi and Oseni (2012) who reported that Bovans Nera had lower mortality per month of lay of 14.46±1.25 when compared to Isa Brown of 24.19±1.25. Their egg productions were however, below the optimum due to heat stress and the fact that they were bred and selected under temperate climates. The least heat stress that could be endured by the birds and the concomitant egg productions were similar. Bovans Nera recorded lower rate of egg production decline of 0.32 eggs per temperature humidity index (THI) as against Isa Brown 0.37 eggs/THI. They reported that the mean weekly egg production per bird for Isa Brown of 4.98±0.21 was significantly different from 5.20±0.21 for Bovans Nera.

2.4. Genetic Improvement Strategies of Local Chickens

2.4.1 Crossbreeding

2.4.1.1 Genetic Basis of Heterosis

Crossbreeding could be through additive and non-additive effects. The sformer is that which is caused by the mean potentials of the parents, reflected from their proportional genetic contributions in the offspring (Swan and Kinghorn, 1992). This could be displayed in the offspring based on what it inherited and or moderation of its performance adduced to the genotype of its dam (Maurer and Gregory, 1990). The maternal advantage can be before and after birth.

Hybrid vigour is the non – additive effect of crossbreeding. It is improvement in performance of the crossbreds in comparison to the parents (Swan and Kinghorn, 1992). It can be classified into individual and maternal heterosis. Individual heterosis is the deviation in performance in the offspring relative to the mean value of the parents, excluding the effect of the dam while the maternal heterosis is that advantage linked to using crossbred dams possessing hybrid vigour instead of purebred dam.

2.4.1.2 Dominance The degree of gene pair dissimilarity is expected to increase when the parents are genetically different. Parents with different genotypic frequencies contribute offspring genes. Crossbreeding leads to an increase of the frequency of heterozygous loci, which improves fitness traits. It is normally expected that dominance and the level of heterozygosity increases concurrently (Dickerson, 1973). Dominance is therefore assumed to be favorable.

2.4.1.3 Epistasis

Harmony of genes actions is necessary for favorable outcome. Selection over generations in purebred animals leads to stability. During crossbreeding, interactions among genes may lead to moderation of gene actions at some loci from those at other loci. This instability of genes interactions usually resulted in new genes subduing other genes making epistasis to lead to reduction in performance. A sharp drop in performance in some crossbred generations was supposed to be due to recombination loss caused by degradation of advantageous epistatic gene interactions (Dickerson, 1973).

2.4.1.4 Previous crossbreeding trials of indigenous chickens in Nigeria

Earlier attempts at the improvement of the performance of the local chickens of Nigeria started in the late 1930s (Otchere *et. al*., 1990), with the introduction of village poultry improvement scheme based on cockerel exchange, using the imported dual purpose Rhode Island Red, Light Sussex and the Australorp to upgrade the local fowl. No lasting genetic response was achieved because there were no proper articulation and involvement of animal breeders (Nwosu, 1990).

Nigeria indigenous chicken was improved through crossing with foreign breeds, which largely had egg laying potentials. Adedokun and Sonaiya(2002) used Dahlem Red, a dual purpose breed to cross normal and dwarf Fulani ecotype as well as Yoruba ecotype chickens. Akinokun and Dettmers (1977) reported that Apollo breed and "Indigenous Ife Collection" egg production performance were different. The indigenous laid smaller eggs which was comparatively lighter by 14g at the beginning of lay and about 16g by twenty weeks of production. Nwosu (1990) suggested that the observed improvement in body weight of cross-bred chicken after 12th week of age was likely due to the effect of paternal exotic cock while Omeje and Nwosu (1984)also implied that the ability to lay early by crossbred chicken was likely transmitted by indigenous cock to crossbred females when crossed with exotic hens.

Nwachukwu *et al*., (2006) in a growth assessment of crosses of normal feathered local (NL), naked neck (Na) and frizzle (F) chickens with Arbor Acre broiler (E) breeder stock reported that the body weight of the main cross (E x NL, E x Na and E x E) chicks at day old were similar and ranged between 26.00 to 26.80g. However, they were lighter than their reciprocal crosses (NL x E, Na x E and F x E) whose body weights at day old ranged within 30.10 to 30.50 g. The mean day old weights recorded for the main cross progenies fall within the range reported for indigenous chicks (Omeje and Nwosu, 1984; Ibe, 1993). They observed that the main cross F_1 chicks appeared to be more like their local chicken dams than their exotic broiler breeder sires. The mean day old weights recorded for both main and reciprocal crossbreds showed strong evidence of maternal effects. The main cross birds maintained their small body size till 18 weeks, finishing with body weight range of 866 to 941.00 g. The reciprocal cross individuals on the other hand maintained their superiority in body weight with NL x E and F x E attaining more than 1.5 kg at 18 weeks of age. Feed intakes were significantly higher for the reciprocal crossbreds than the main crossbreds at week 6, 12, and 18. This observation was expected as heavier birds consume more feed than lighter ones. However, reciprocal crossbreds had lower feed conversion ratios indicating better or more efficient feed utilization due to the fact that fast growing birds are more feed efficient than slow growing ones. Among all the genetic groups, the F x E (frizzled crossbred individuals was the best with significantly heaviest body weight (2150.00 g), lower feed conversion ratio, though they consumed significantly more feed. Nwosu and Omeje (1985) showed that local and exotic F_1 crossbred progeny pullets, housed singly in 2- tier standard cages from the point of lay to 500 days of age exhibited tremendous improvements on the local fowl egg performance due to crossing alone. The local hen (LC) had survivor egg number (SEN) of 146 eggs per hen per year, the Gold-Link x Local F_1 hen laid 213 eggs/hen/year; the Local x Gold-Link reciprocal crossbred hen laid 189 eggs/hen/year whereas the Gold-Link hen laid 227 eggs/hen/year. The main cross (GL x LC) was statistically equal to the Gold-Link in survivor egg number in a year. Nwosu *et al*. (1984), when comparing the post- natal growth of three ecotypes of the Local Chicken with Starcross 579 under deep- litter system of management, established that a wide genetic gap existed between the three local ecotypes on one hand and the F_1Starcross on the other hand from day old to 50 weeks of age. In an analysis of self –accelerating phase of growth, Nwosu *et al.* (1984) reported that growth rate of local chickens from day-old to point of inflection (13 to 14 weeks) was rapid and did not differ from that of an imported stock. They further opined that Local chickens possess the potential to grow fast at the early stages of life and, therefore, fitted for use as a parent in broiler chicken development in Nigeria.

Sola-Ojo and Ayorinde (2011) also reported on the crossbreds of exotic Dominant Black (DB) and Fulani ecotype chicken (FE). The DB x FE and FE x DB crosses eggs were bigger though not significant than the pure line progenies during early egg production (51.45 g and 51.35 g). DB x DB eggs were also observed to be similar in weight to those of FE x FE. The genetic constitution was noted to effect the age at first egg.

DB x DB started laying earlier than the other genotypes. Age at first egg differentials compared to the DB x DB were 5 days for DB x FE, 8 days for FE x DB and 18 days for FE x FE. The results showed that the crossbreds age at first egg was close to that of DB x DB.

Adedokun and Sonaiya (2002) showed that Dahlem Red (DR),Nigeria Indigenous(NI) and their crosses average egg weights over 10 months production were 55.7, 36.8 and 42.9 g respectively. The DR x Fu produced 148 eggs within 10 months production and this was significantly better than that of DR x Y, Fu x DR and FuD x DRD . The average body weights reported at 10 months of age were 1537±72.5 g and 1320±41.9 g respectively. These were noted to be lower than 1620 g for matured Fulani ecotype though higher than 1290 g for Yoruba ecotype (Atteh, 1990). Moreover, DR x Y with a body weight of 1306±41.9 g at 10 months of age was heavier than non Fulani ecotype hen. The average body weight of indigenous hen at 20 weeks of age as reported by Akinokun (1990) was 908.7±26.6 g. Crossbred chickens from this study were noted to be heavier when compared to this performance and this was suggested to be due to the genetic potentials of the exotic parent . The crosses, except DRD x Y, had higher average body weight than the indigenous NI at 20 and 40 weeks of age and this was likely attributed to dwarfness in Dahlem Red cock. The growth rate per day of the crosses between the DR and NI chicken increased from 3.8 g/day (week 8) to 16 g/day (week 20). Female offspring of FuD cock and DRD hen had least growth rate. Moreover, sexual dimorphism was reported in the growth rate of cocks and hens with cocks being heavier except for the crossed hens which gained 0.6 g daily more than that of the cock.

The disparity in the egg production of DR x Fu cross and its reciprocal cross (148 eggs vs 119 eggs) was likely attributed to the genotype of the cocks. Improved egg production was suggested to be passed on by the exotic cock. Among the hens of the crosses the Fu x DR hens laid first. This trait was suggested to be due to the indigenous Fulani cock used as sire. Omeje and Nwosu (1984) supposed that indigenous cock transmits genes for early age at first egg and noted that genetic groups with indigenous paternal cocks mature earlier. This trend was not however obtained with FuD x DRD whose age at first egg was higher. The FuD x DRD also had the least average body weight at first egg among the crosses. The differential in potentials of the exotics used in the different studies was implied in the results .The egg production of the Dahlem Red at most of the ages was the best followed by the crosses while the least was the indigenous. The crosses were superior to the indigenous chickens in terms of egg production performance. Stress was adduced to the drop in production of the crosses at this period. The DR egg production was 47 % and 15 % better than the NI and the crosses, respectively, while the crossbreds produced 27% more than the NI. The DR egg was heavier than both the indigenous and their crosses. Akinokun and Dettmers (1977) also reported that the egg of the exotic they used was statistically heavier than those of the indigenous.

Among the crosses, FuD x DRD skin test result appeared highest indicating ability to withstand diseases. Horst (1988) suggested that small body size lowered metabolism and dwarfness genes likely promote fitness and hardiness. The indigenous with the highest value of 0.50mm had the propensity of being more resistant than the pure Dahlem Red with the value of 0.33mm to infection.

2.4.2 Selection

This is a procedure of choosing parents of next generation. It could be natural or artificial. Natural selection is usually aimed at adaptive traits which allowed the best to survive and individuals that are fit will produce more offspring and survive better. Selection increases the frequencies of genes that accentuates the traits to be improved over those that are less helpful.

Ogundipe (1990) stated that the first set of Nigerian agricultural extension officers in the former Northern Region Government verbally reported an attempt by the expatriate staff of the Ministry of Agriculture to develop the local chicken through a selection process. The work was carried out at one of the old agricultural centres located in Riyom in Plateau state. It was reported that after some years of selection, those expatriate staff were able to develop a type of breed which they called "Riyom breed". This bird was said to be almost as good as the exotic Rhode Island Red in terms of egg production and growth rate. He further stated the report did not indicate whether there was an initial crossbreeding done between the exotic and the indigenous fowls in this process of breed development. With the creation of the ten northern states in 1967 and the major reorganization of the staff structure and reposting of staff, Ogundipe (1990) also reported that this breed development work was abandoned and unfortunately the stock that was being developed disappeared.

Oluyemi and Oyenuga (1971) reported that the heritability estimate of the local fowl for 12 weeks body weight, determined by sib analysis to be $h^2_s = 0.321 \pm 0.004$; $h^2_d = 0.293 \pm 0.008$ and $h^2_{(s+d)} = 0.307 \pm 0.007$, indicating that only a moderate improvement by mass selection can be made in the broiler weight of the local fowls.

Research on layer poultry breeding started in 1985 at the NAPRI and after over 15 years of active breeding and selection work by scientists at NAPRI on exotic parent stock a brown egg layer strain named Shikabrown® was developed. It is claimed to produce eggs of excellent weight, shell quality, good production rate, persistency, livability and feed conversion (NAERLS, 2014)

Ogbu (2010) reported significant increases in all the traits selected among Nigeria heavy local chicken ecotype. Selection intensity values for mass selection in males were 2.11, 1.75 and 1.16 for G0, G1 and G2 generations, respectively. Mean selection intensity values for total egg number, average egg weight and body weight at first egg were 0.729, 0.106 and -0.277, respectively. For index values, selection differentials were equally positive across the three generations and selection intensity remained relatively stable viz. 0.703, 0.989 and 0.890 for G0, G1 and G2 generations, respectively. Direct selection responses namely, expected, predicted and realized genetic gains were mostly positive for all traits selected. Expected average direct genetic gain per generation for egg number, egg weight and BWFE were 12.58 eggs, 2.98g and 25.04g, respectively. For gain in index traits due to selection on index score, a mean value of 1.705 eggs was obtained for total egg number, 0.949 g for average egg weight and 43.93 g for BWFE. The ratio of realized to expected genetic gain were positive across the three generations. Specifically, a mean ratio of 0.61 was obtained for 39 weeks body weight in males, 1.58 for BWFE, 1.70 for average egg weight and 1.75 for total egg number, for females. The estimate of additive genetic heritability (h2) ranged from 0.12 to 0.24 for egg number, 0.34 to 0.43 for egg weight and 0.57 to 0.70 for body weight. Estimates of genetic correlation in whole populations across the three generations ranged from -0.01 to 0.01 for EN-EW, -0.06 to 0.01 for EN-BWFE, and 0.002 to 0.02 for EW-BWFE. For phenotypic correlation, a range of -0.12 to 0.09, -0.04 to 0.08, and 0.21 to 0.23 were obtained for EN-EW, EN-BWFE, and EW-BWFE, respectively whereas, for environmental correlation, a range of 0.55 to 1.31, 0.52 to 0.69, and 0.38 to 0.85 were obtained, respectively for the same pairs of traits.

He concluded that mass selection for body weight at 39 weeks of age in the male line was effective on the 39^{th} week body weight as well as the body weights within the accelerating phase of growth (0 – 20 weeks). Greater improvement will however be expected if in future selection for body weight improvement in the Nigerian heavy local chicken ecotype is based on 8, 12 or 20 weeks body weight as recommended.

He also deduced that the multiple trait selection indexes employed for the simultaneous selection of total egg number, mean egg weight and body weight at first egg brought about improvement in these traits and the efficiency factors reported in this study were positive and high. Body weight at first egg was not, however, a good selection criterion for improvement in the growth performance of hens within the accelerating phase of growth (0 – 20 weeks). The selection pressure applied brought about modest improvement in the traits concerned and significant genetic variation was still present to ensure positive selection responses in subsequent generations. The relative economic weights determined for the traits in this study appropriately weighted the traits according to their relatively contribution to the economic worth of the Nigeria heavy local chicken ecotype. While the values for egg number and egg weight ensured that individuals with good performances in these traits were selected in each generation, the negative weighting of body weight at first egg ensured that hens with high body weight values without corresponding high values in egg number and/or egg weight were rejected as it costs much more to maintain local chickens of high body weights than would be realized from sale of local chicken carcass.

The final mean phenotypic values of 79.38 eggs in 16 weeks (112 days) for unselected population (expected annual mean, 258.69 eggs) and 88.91 eggs for the same period for selected population (expected annual mean, 289.75 eggs) is quite impressive. Commercial flocks (exotic breeds) commonly average 200 to 250 eggs per year within the tropics. The performance of the Nigerian heavy local chicken ecotype in egg production as obtained in this study hence compares favourably with any exotic breed in Nigeria. This in addition to attaining a body weight of above 1kg at sexual maturity makes the Nigerian heavy local chicken ecotype a potential dual purpose bird.

2.5 Morphological Characterization of Chickens

Morphometrics is the quantitative study of morphology, and differences among groups of individuals are usually explored using information on their morphology (Madsen, 1977). Apart from their importance in explaining genetic variabilities and peculiars attributes, qualitative morphological traits have important economic value in chickens (Jiang, 1999).

Ige *et al.,* (2012) stated that methodology for morphological characterization was applied to many livestock species with the objective of assessing them. Previous reports (Olawunmi *et al.,* 2008) compared the morphological characteristics of Nigeria indigenous chickens.

Mulyono *et al*., (2009) have applied morphological information in grouping indigenous from exotic chickens and associations among various genetic groups was described by Yakubu *et al*. (2009). Quantitative morphological traits reflect the size and dimensions of animals body parts, which are related to production traits (FAO, 2012). Due to the fact that they are continuously expressed, they are moderated by several genes unlike qualitative traits and can be accurately estimated for particular collection of livestock.

The age of the animal as well as the production system moderate most quantitative traits unlike many qualitative traits. Morphological traits such as body weight, body length and height at withers are used as indicators of the production traits due to their strong associations.

Biometrical traits largely impart lifecycle production of livestock. Investigations on body weights and linear body measurements had been reported in poultry (Kabir *et al*., 2010). Results from such have been used to depict morphological structure and carcass traits; assess breed potentials and examine associations between conformational traits.

In poultry, few biometrical traits were examined on live birds and those in the wild. Such include: length or ornithological measurement, wingspan, beak length, comb length (Ceballos *et al*., 1989).

To viably preserve and exploit specific collection of livestock, its characteristics must be determined (FAO, 2007).

Adekoya *et al*., (2013) stated that morphological analysis of chicken types in Nigeria revealed some divergence among the types. According to them Wild type (normal feathered) was the most divergent from the others (frizzled, naked neck, frayed feathered) followed by rose comb. Wild type had the highest body weight, back length, toe to back length, beak to comb length and beak length. Rose comb had the highest shank length and higher body weight and back length, when compared to frizzle feather, naked neck and featherless wing. Frizzle feather and naked neck had very similar values for body weight, back length, shank length, toe to back length and beak length. Frayed feathered also had similar values with frizzle feather and naked neck for body weight, back length and shank length. The similar values of morphological characters recorded for frizzle feather, naked neck and featherless wing was explained by their similarity in reduction in feather coverage. This also explained the overlap of frizzle feather with naked neck and featherless wing with naked as presented in their study. The greater overlap between the naked neck and frizzle feather, as compared to that between naked neck and featherless wing, was attributed to the fact that the reduction in feather coverage is on the body for both naked neck and frizzle feather which likely allowed greater internal heat loss compared to the feather loss on the wings for the featherless wing.

Principal component analysis revealed that morphometric differentiation between types was largely from the beak length, toe to back length, back length, shank length, body weight and beak to comb length. The normally feathered chickens had longer beak, toe to back, back, shank, and beak to comb lengths as well as higher body weight. Such differences between the types maybe related to environmental adaptation and growth rate. The longer shanks, beak to comb (which relates to the head and comb size), beak, and toe to back (which accounts for both the shank length and back length) lengths in normally feathered birds should give room for dissipation of heat. Those areas, that is, the beak, comb, face and shank, are not normally covered with feather and therefore allowed heat loss. The proportion of individuals correctly classified into their original group was highest in the wild type (78.6 %) and high in the naked neck (63.6 %) and featherless wing (60.0 %). This means that the wild type chickens can be more easily distinguished from others, followed by naked neck and featherless wing. The overall percentage of correctly classified cases is 56.0 %. Shanks of roosters and hens in the southern region were relatively longer than the shanks of the roosters and hens from the central and northern regions, though the difference was insignificant.

Hens and roosters in the southern region have larger chest circumference than those in the central and northern regions ($P<0.05$). This could indicate the possible infusion of Paraoakan bloodlines and genetic potentials among the local chickens in the southern region. The body measurements of the hens were generally smaller than that of the roosters. They suggested that the body frames of roosters are suited for muscle building while that of the hen is built for reproduction. Association between body size and egg production was reported to be negative. The results of their study showed that there were variations in the morphological characteristics of the native chicken in Palawan.

Agu *et al*., (2012) reported variability in most of the biometric traits studied in heavy Nigerian ecotype chicken. Differences were observed for thigh length, back length and neck length at weeks 4, 16 and 20. The thigh length increased from 5.12 cm to 13.18 cm from weeks 4 to 20 while the neck length improved from 4.34 cm to 12.06 within the period. Hill (1954) suggested that compactness could be associated with meatiness and this could be linked to the broad back of the native chicken. Appreciable back width likely indicates carcass potential. Agu *et al*. (2012) posited that this chicken ecotype could be developed into a meat type by improving its back width through selection.

They further suggested that mass selection could improve body length of heavy ecotype and that genetic improvement of morphological traits should be initiated at the week 8 and 12 as estimates of heritability were highest at those stages. Heritability estimates of the body measurements were reported as being low or moderate indicating that responses could be rapid. Moreover, interrelationships among the traits were positive. The degree ranged between 0.81 and 0.86 suggesting likely joint improvement.

2.6 Effect of crossbreeding on morphological traits.

Greiner (2009) stated that crossbreeding confers an edge on the crossbred animal through hybrid vigour or heterosis generally caused by synergy of traits of the parents through aggregating their desirable traits and suppressing some of deleterious ones. Heterosis is a degree of superiority of the crossbred with regard to the mean performance of the parents.

Chacon *et al.* (2011) in a comparative study of Cuban creole goat and their crossbred with Anglo-Nubian goats reported that crossbreds were heavier than purebreds. The two groups were horned, but the purebred had straight ears and variable coat colour while the crossbred had curly ears and less variable coat colour. In all the linear body measurement were better than the purebred. The degree of variability of the morphological indices was also lower in purebred compared to the crossbred which they suggested could probably be caused by disorganised crossing.

Onasanya *et al.*, 2017 reported that crossbreeding moderated the body weight and morphological traits of rabbits at various ages. At 12 weeks of age, cross between California with New Zealand Red was bigger and had higher value for breast girth, height at withers over purebred California. However the New Zealand Red purebred outperformed the cross in terms of body weight, breast girth, trotter and body lengths indicating partial dominance.

Buchanan and Northcut (1999) stated that genetic divergence among breeds produces higher heterozygosity leading to more heterosis. Dominance is present if the performance of the crossbred is not exactly intermediate between the two parents and could be of three types, over dominance, complete dominance or partial dominance. They also noted that epistasis which is the interaction between different loci may also play a part in heterosis.

2.7 Effect of Crossbreeding on the morphostructure of chicken.

Ekka *et al. (*2016) reported that the body weight of crossbred chickens was higher than that of indigenous but lower than the improved throughout the stages evaluated. The longest body length was observed in the improved parent at 8 weeks followed by the crossbred and the least was the indigenous. This trend was observed with body girth, shank width, keel bone length and weights of the chicks. They posited that since many performance characteristics and biometrical traits of the crossbred (Hansli x CSML) coincide with the average of the two parents (Hansli and CSML), they suggested that the characters could probably be governed by additive gene action and suspected absence of dominance of heterosis. The indigenous chicken used in the study was also reported to be heavier than most of the reputed indigenous chicken in India. However, the general result they obtained could be probably be due to the less divergence between the indigenous Hansli chicken they used compared to the improved line CSML. As the genetic similarity of the lines used in crossbreeding increases, the level of heterozygosity of the crossbred will be minimal and hence little or no heterosis.

However, Yang (1998) noted that body weights and shank lengths of the crossbreds he obtained from divergent lines were better than for both parental lines indicating over dominance. He also reported positive relationships of shank length and weight with body weight. Moreover, Nigerian local chicken and their crossbreds have been reported to had low heritability estimates for body weight and conformational traits in their early growth period.

2.8 Morphological indices and Morphostructure

Animal morphostructure indicates the body dimensions and their relationships as represented by morphological indices (Bravo and Sepulveda, 2010). The body shape of an animal population determines ranges of biological functionality and productive use. Biometrical measurements provide appreciable knowledge on morphological structure and development ability of animal and are the most influential factors determining animals that are appropriate for the derived efficiency (Yakubu, 2010). They are highly associated with body weights; hence they are affected when body weight is genetically improved. This informed the use of some breeds in terminal crossbreeding in order to produce offsprings with desired carcass characteristics (Cardoso *et al.*, 2013).

Several morphological indices were composed from body measurements. Kokosyznski *et al.* (2017) on a study on broiler chicken morphology,calculated indices to indicate massiveness, compactness, and long-leggedness. Massiveness was composed as percentage ratio of body weight in kilogram to trunk length, in centimetres, compactness as percentage ratio of chest circumference to trunk length, in centimetres, long-leggedness as percentage ratio of shank length to body length, in centimetres. From this study, Hubbard Flex chicken strain at 6 weeks of age was more massive (11.3) and long-legged (34.9) than Ross 308 and Hubbard F15. However, Ross 308 was the most compact of the broiler type (158.0) followed by Hubbard Flex (153.1) and the least was Hubbard F15.

2.9 Morphological indices and Type and Function.

Simon and Buchenauer, (1993) stated that wither height had been traditionally used as a choice indicator of type in beef cattle because it indicates long bone growth. However, rump height at times was preferred to wither height. Salako (2006) also noted that both height at withers and rumps have been considered limited in their values as indicators of type and function. Aside from body weights, type and function have been valuable in indicating the utility of animals. The usefulness of weight will be enhanced with associated information of body measurements.

Alderson (1999) reported that morphological indices are probably better than single linear measurement due to the moderating effect of husbandry system on the characters, though they could be useful within the herd on the farm.

Olawunmi *et al.* (2008) reported that Fulani ecotype chickens had longer bodies and breast width over Yoruba ecotype which tends to confirm the superiority of the former in terms of bodyweight (Atteh, 1990). These attributes associated with muscling and meatiness confers advantage on the former. However, the relatively smaller stature of the latter seemed likely to be adaptive in reducing maintenance feed requirement and increase in feed efficiency.

Oladejo *et al*. (2013) in a study of morphological differentiation of the Nigerian indigenous chickens using morphological indices and discriminant analysis indicated that the males of Yoruba (YEC) and Fulani (FEC) ecotypes chickens had higher massiveness(MAS), stockiness (STK), long-leggedness (LLN) and condition indices than their respective females. They defined massiveness (MAS) as a ratio of live body weight to body length expressed as percentage; stockiness (STK) as percentage ratio of breast circumference to body length; long-leggedness (LLN) as percentage ratio of total leg length(shank length plus thigh length to body length and condition index (CND) as percentage ratio of live body weight to wing length.

Massiveness in YEC and FEC were 2.12 and 2.19 versus 2.04 and 1.99 for males and females respectively. Comparing the Yoruba ecotype chickens with Fulani ecotype chickens using morphological indices, they observed that FEC had higher body indices than the YEC except for the massiveness of the female FEC (1.99) which was lower than that of YEC (2.04).The discriminant analyses revealed that high discriminating powers of body weight, body girth, shank length, shank circumference, toe length and comb length were sufficiently robust in distinguishing the two chicken ecotypes on the field. They further reported that body weight was the most discriminating variable between the ecotypes thus indicating its importance in differentiating the two chicken ecotypes.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Location

This research was conducted at the Bora Poultry Farm, Poultry Research Unit of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan Nigeria. The area lies within latitude $07^{o}\ 27^{1}$North and longitude $03^{o}\ 25^{1}$ East respectively. Annual average rainfall is about 1250mm. The natural day length is 12 – 13 hours and average minimum and maximum daily temperatures are $30^{o}C$ and $35^{o}C$, respectively. Relative humidity ranges from 76% to 84% (IART, 2016). Ibadan belongs to the humid transition forest of the South – western agro-ecology of Nigeria.

3.2 Foundation Stock

The base breeder chicken population that was used to generate the two hybrid crosses and two pure lines were the Fulani ecotype chickens and exotic Bovans Nera parent stock breeder. The indigenous chickens were sourced from Fulani kraals in Kishi villages, Irepo Local Government Area of Oyo State and Isundunrin villages in Ejigbo Local Government Area of Osun State; however the exotic was purchased from Ajanla Poultry breeder farm in Ibadan.

The breeder flock consisted of 15 hens and 3 cocks each of Fulani ecotype and Bovans Nera (sex ratio 5: 1).

Figure 3.1. Male Fulani Ecotype parent

Figure 3.2. Female Fulani Ecotype parent

Figure 3.3**.** Male Bovans Nera Parent

Figure 3.4**.** Female Bovans Nera Parent

3.3 Mating Design

The mating system used to generate the F_1chicks involved main and reciprocal crossbreeding. The main cross (BF) was generated by mating the Bovans Nera cocks to Fulani ecotype hens while the reciprocal cross FB, was produced by mating Fulani ecotype cocks to Bovans Nera hens. Fulani ecotype cocks mated to Fulani ecotype hens produced FF chicks while BB chicks were generated from crosses of Bovans Nera cocks to Bovans Nera hens. Mating was carried out using artificial insemination technique by a trained technician as described by Lake and Stewart (1978) and Bakst and Long (2010)

Fertile labeled eggs of the four genetic groups were collected daily and taken to a commercial hatchery for incubation after seven days storage period. A total of 115 day old chicks comprising 39 BB, 33 FB, 25 BF and 18 FF were generated.

Figure 3.5. Artificial insemination technique (Semen collection)

Figure 3.6. Artificial Insemination technique(Semen Deposition)

Figure 3.7. Bovans x Fulani (BF) chicks


Figure 3.8. Fulani x Bovans (FB) chicks


Figure 3.9. Fulani x Fulani (FF) chicks

Figure 3.10. Bovans x Bovans (BB) chicks

3.4 Management of the Birds

Each day old chick was individually identified using neck tags. They were weighed and allotted to different deep litter pens according to their genetic group. The genotypes were reared concurrently on deep litter using standard management procedure. Heat was provided to the birds throughout the 3 weeks brooding period by means of electric bulbs and charcoal stoves when necessary. The experimental period was from day–old to 8 weeks. The chicks were fed starter diet containing 18% crude protein and 2800 Kcal/kg of Metabolisable Energy. Feed and water were provided *ad libitum*. Regular medication and routine vaccination against prevalent poultry diseases were employed to ensure good health, optimal performance and reduced mortality in the flocks.

3.5 Data Collection

Body weight data were collected from 115 chicks from day-old to 8 weeks. Body weights were measured weekly by means of a sensitive 5000 grams capacity CAMRY® digital balance (EK5055) with a sensitivity of 1gram. Weight records of chicks were taken with associated genotype and sex.

At 8 weeks of age, 78 chicks were randomly selected due to the initial unequal sample size across the genotypes. This comprised 20 chicks each of BB, FB and BF extraction and 18 FF chicks. Seven morphological traits of the birds such as shank length (SL), shank diameter (SD), body circumference (BC), body length (BL), keel length (KL), wing length (WL) and neck length (NL) were measured. Previous works (Olawumi *et al.,* 2008; Oladejo *et al.,* 2013) had established the importance of these body parameters in the morphological differentiation of chickens. Biometrical measurements were taken using a measuring tape graduated in centimeters and a ELITE®digitalVernier caliper. The records were taken by one person to prevent bias.

The reference points and procedure for body measurements were as follows:

Shank length (SL): measured as the length of the lefttarso-metatarsus from the hock joint to the metatarsal pad.

Shank diameter (SD): measured as the diameter of the lefttarso-metatarsus just below the spur.

Body circumference (BC), measured as the circumference of the breast region taken at the tip of the pectus.

Body length(BL): Length from insertion of the neck into the body to the base of the tail.

Keel length (KL): Distance between both vertices of the sternum (processuscarinae and processusxiphoideus) leaning the bird on its back.

Wing length (WL): measured as the length of the left wing from the scapula joints to the last digit of the wing .

Neck length (NL): The bird had to be restrained on its left-hand side on a flat surface by an individual, stretching legs with one hand and the neck with the other hand, another individual record the distance between the nape and the insertion of the neck into the body.

Morphological Indices: These were calculated from the above body measurements and body weight to indicate morphostructure.

(a) Massiveness: Percentage ratio of body weight in kilogram (kg) to body length plus neck length in centimetre (cm)

(b) Compactness: Percentage ratio of body circumference (cm) to body length plus neck length (cm)

(c) Long-leggedness: Percentage ratio of shank length (cm) to body length plus neck length (cm)

3.6. Experimental Design and Statistical Analysis

3.6.1 Experimental Design

The experiment was a Randomised Complete Block Design with chicken genotypic group as treatment and different sexes as block. The genotypic group had four levels – Bovans X Bovans (BB), Bovans X Fulani (BF), Fulani X Bovans (FB), Fulani X Fulani (FF) and sex two levels (male and female). The model used was of the type:

$Y_{ijk} = \mu + G_i + S_j + (GS)_{ij} + e_{ijk}$

Where, Y_{ijkl} = Individual observation ,μ = Overall mean ,G_i= Effect of genotype ,S_j = Effect of sex , $(GS)_{ij}$= Interaction effect of genotype and sex , e_{ijk}= Residual error

Assumption $e_{ijk} \sim NID(0,\sigma^2)$

The dependent variables measured were body weight (BW), shank length (SL), shank diameter (SD), body circumference (BC), body length (BL), keel length (KL), wing length (WL), and neck length (NL).

3.6.2 Statistical Analysis

3.6.2.1 Repeated Measures Analysis

Repeated measures analysis was performed on body weight measurements of the chicken genotypes between day old to eighth week of age using PROC MIXED of SAS (2004) (SAS Institute Inc., Cary; Version 9.1). Covariance structure used was compound symmetry. Least square means and standard errors of body weights and their differences as well as tests and solutions for fixed effects of genotype, sex, week and their interactions were computed using the program.

3.6.2.2 t- test

T –statistics procedure (PROC T Test) of SAS (2004) was used to detect the significance difference between the morphological traits for the sexes of the chicken genotypes at eight weeks. Comparative analysis of the morphological traits across the chicken genotypes at eighth week of age was carried out using the General Linear Model procedure of SAS (2004) and means were separated with Duncan Multiple Range Test.

3.6.2.3 Discriminant Analysis

Canonical discriminant analysis was used to select the combination of morphometric variables that can be used to group the chicken genotypes.

The linear combination for a discriminant analysis, also known as the discriminant function, is derived from an equation that takes the following form:

$Z_{ik} = b_{0i} + b_{1i} X_{1k} + \ldots b_{ji}X_{jk}$

Z_{ik}= discriminant score of a discriminant function i for object k, i=1,….,G−1

X_{jk}= independent variable j for object k, j=1,2,…..,J

b_{ji} = discriminant weight for independent variable j and discriminant function i

b_{0i} = constant of discriminant function

CHAPTER FOUR

4.0 RESULTS

4.1. Body weights of Fulani ecotype, Bovans Nera and their crosses

The least square means and standard errors of body weights of Fulani ecotype chickens, Bovans Nera and their crosses is indicated in table 4.1a. Bovan X Fulani chicken cross (BF) had the highest least square body weight mean, followed by Fulani X Bovans chicken cross (FB)while the least was Fulani X Fulani chicken cross (FF). The two hybrid crosses (BF and FB) had higher body weight least square means over Bovans X Bovans chicken cross (BB).

Least square mean differences (table 4.1b) showed that there were significant differences ($p<0.05$) between FB and BF as well as between BB and FF. Moreover, there were differences ($P<0.001$) between the hybrid crosses and the commercial BB and indigenous FF.

4.2 Body weight of the chicken genotypes within sexes.

The least square means and standard error of the chickens within sexes is as presented in table 4.2a showed. The male had higher least square body weight mean over the female. The differential of the least square means showed that males were significantly ($p<0.01$) heavier than females (table 4.2b).

4.3 Body weights of Fulani ecotype chickens, Bovans Nera and their crosses for genotype by sex

Least square means and their tests for significance of body weights of Fulani ecotype chicken, Bovans Nera and their crosses for genotype by sex is presented in tables 4.3a and 4.3b. Among males across genotypes, BF hybrid cross male seemed to have the highest least square body weight mean followed by FB males with the indigenous FF males being the least. However, BB male was slightly heavier than FF male.

Table 4.1a. Least Squares means (g) and standard errors of Body weights of BB, BF, FB, and FF chicken genotypes

Gen	**Standard Estimate**	**Error**	**DF**	**Tvalue**	**Pr>|t|**
FB	302.24	8.56	70	35.30	<0.0001
BF	328.21	8.57	70	38.31	<0.0001
BB	269.26	8.58	70	31.39	<0.0001
FF	241.61	8.81	70	34.12	<0.0001

FB = Fulani × Bovans Nera

BF = Bovans Nera × Fulani

BB = Bovans Nera × Bovans Nera

FF = Fulani × Fulani

Table 4.1b: Least squares means differences (g) and standard errors of body weights among BB, BF, FB, FF chicken genotypes

Gen	Gen	Standard Estimate	Error	DF	Tvalue	Pr>|t|
FB	BF	-25.97	12.11	70	-2.14	0.0355
FB	BB	32.98	12.12	70	2.72	0.0082
FB	FF	60.63	12.28	70	4.94	<0.0001
BF	BB	58.95	12.12	70	4.86	<0.0001
BF	FF	86.60	12.29	70	7.05	<0.0001
BB	FF	27.65	12.30	70	2.25	0.0277

FB = Fulani × Bovans Nera

BF = Bovans Nera × Fulani

BB = Bovans Nera × Bovans Nera

FF = Fulani × Fulani

This trend was maintained among females across genotypes though the margin between least square mean bodyweight of FF female and the remaining females was wider.

The least square means bodyweight of BF male and FB male were similar. This was similarly displayed between BB male and FF male.

However, there were highly significant differences ($p<0.01$) between the hybrid (BF and FB) males and BB and FF males.

Among females, there were no significant differences ($p>0.05$) between the BF female and FB female as well as between the FB female and BB female, though BF female was highly significantly ($p<0.01$) heavier than BB female. The FF female was highly significantly ($p<0.01$) lighter than the remaining females.

Within each genotype, males were highly significantly heavier than the females ($p<0.01$). A striking trend was observed indicating that the female BF was not significantly ($p>0.05$) different in terms of body weight compared to the males of other genotypes except its own.

4.4 Test of fixed effects of genotype, sex, week and their interactions

The effects of genotype, sex, week and their interactions were indicated in table 4.4. The interactive effects of Week x Genotype x Sex and Genotype x Sex were not significantly different ($p>0.05$) but that of Week x Genotype and Week x Sex were highly significantly different ($p<0.001$). All the main effects of genotype, week and sex were highly significantly different ($p<0.001$).

4.5 Solution vector for fixed effect of genotype

The solution vector for the fixed effects of genotype is presented in Table 4.5. The estimate of the Genotype 4 (FF) intercept is -23.00 while that of genotypes 1 (FB), 2 (BF) and 3 (BB) are 7.14, -16.1 and 3.95 respectively.

Similarly, the estimate for the genotype 4 (FF) slope is 52.23 while that for the genotypes 1 (FB), 2 (BF) and 3 (BB) are 65.45, 79.17 and 57.92 respectively.

Table 4.2a: Least squares means (g) and standard errors of body weights of the chickens within sexes

Sex	**Standard Estimate**	**Error**	**DF**	**Tvalue**	**Pr>|t|**
Male	317.18	4.39	70	72.24	<0.0001
Female	253.47	7.43	70	34.12	<0.0001

Table 4.2b: Least squares means difference (g) and standard error of body weights of the chickens within sexes

Effect	Sex	Sex	Standard Estimate	Error	DF	Tvalue	Pr>|t|
Sex	Male	Female	63.71	8.63	70	7.38	<0.0001

Table 4.3a: Least squares means (g) and standard errors of body weights of BB, BF, FB, and FF chicken genotypes by sex.

Gen	**Sex**	**Standard Estimate**	**DF**	**Error**	**Tvalue**	**Pr>|t|**
FB	Male	329.66	70	8.56	38.50	<0.0001
FB	Female	274.81	70	14.83	18.53	<0.0001
BF	Male	348.76	70	8.58	40.65	<0.0001
BF	Female	307.66	70	14.83	20.75	<0.0001
BB	Male	297.69	70	8.63	34.51	<0.0001
BB	Female	240.83	70	14.83	16.24	<0.0001
FF	Male	292.61	70	9.33	31.35	<0.0001
FF	Female	190.61	70	14.94	12.76	<0.0001

FB = Fulani × Bovans Nera

BF = Bovans Nera × Fulani

BB = Bovans Nera × Bovans Nera

FF = Fulani × Fulani

Table 4.3b: Least squares means differences (g) and standard errors of body weights of BB, BF, FB, and FF chicken genotypes by sex.

Gen	Gen	Standard Estimate	Errors	DF	tvalue	Pr>|t|
FB (male)	BF (male)	-19.09	12.12	70	-1.58	0.1197
FB (male)	BB (male)	31.97	12.15	70	2.63	0.0105
FB (male)	FF (male)	37.05	12.67	70	2.93	0.0046
BF (male)	BB (male)	51.06	12.17	70	4.20	<0.0001
BF (male)	FF (male)	56.14	12.68	70	4.43	<0.0001
BB (male)	FF (male)	5.08	12.71	70	0.40	0.6907
FB (female)	BF (female)	-32.85	20.97	70	-1.57	0.1218
FB (female)	BB (female)	33.98	20.97	70	1.62	0.1096
FB (female)	FF (female)	84.20	21.05	70	4.00	0.0002
BF (female)	BB (female)	66.83	20.97	70	3.19	0.0022
BF (female)	FF (female)	117.05	21.05	70	5.56	<0.0001
BB (female)	FF (female)	50.22	21.05	70	2.39	0.0198
FB (male)	FB (female)	54.85	17.12	70	3.20	0.0020
BF (male)	BF (female)	41.10	17.13	70	2.40	0.0191
BB (male)	BB (female)	56.87	17.16	70	3.31	0.0015
FF (male)	FF (female)	102.01	17.62	70	5.79	<0.0001
FB (male)	BF (female)	22.00	17.12	70	1.28	0.2030
BF (female)	BB (male)	9.97	17.16	70	0.58	0.5631
BF (female)	FF (male)	15.05	17.52	70	0.86	0.3935

FB = Fulani × Bovans Nera
BF = Bovans Nera × Fulani
BB = Bovans Nera × Bovans Nera
FF = Fulani × Fulani

4.6 Solution vector for fixed effect of Sex

The fixed effect of sex solution vector is shown in table 4.6. The estimate of the Sex 2 (female) intercept is -23.00 while that of sex 1 (male) is -42.85.

The estimate for the female slope is 52.23 while that of the male is 82.03.

4.7 Solution vector for fixed effect of genotype by sex

The output for the solution for effect of genotype by sex is presented in Table 4.7.

The estimate of the starting point of FB, BF and BB females were similar to that of FF male and female of -23.00. The intercepts for the FB, BF and BB males were -38.75 , -33.27 and -36.01 respectively.

The slopes of the males of the other chicken genotypes except that of FF were smaller than that of the female.

4.8 Morphological traits of Fulani x Bovans chicken cross(FB) at 8 weeks

Morphological traits of the Fulani x Bovans chicken cross (FB) as affected by sex at 8 weeks is indicated in table 4.8. Generally, FB male had higher morphological traits values than female. There were significant differences ($p<0.05$) between male and female birds within the genotype with respect to shank length, shank diameter, body circumference and keel length. However, no significant differences ($p>0.05$) were noticed in their body lengths, wing and neck lengths.

4.9 Morphological traits of Fulani x Fulani chicken (FF) at 8 weeks

Biometrical traits of Fulani x Fulani chicken (FF) at 8 weeks are presented in table 4.9. Fulani x Fulani chicken (FF) male were significantly ($p<0.05$) superior to their female in terms of the morphological traits considered- shank length, body length, keel, wing, and neck lengths, as well as shank diameter and body circumference.

Table 4.4: Tests of fixed effects of genotype, sex, week and their interactions.

Type 1 Tests of Fixed Effect				
Effect	Num DF	Den DF	F value	Pr>F
Genotype	3	70	12.67	<0.0001
Week	1	596	10514.2	<0.0001
Sex	1	70	51.96	<0.0001
Genotype x Sex	3	70	2.60	0.0589
Week x Genotype	3	596	30.86	<0.0001
Week x Sex	1	596	159.74	<0.0001
Week x Genotype x Sex	3	596	1.95	0.1204

Table 4.5: Solution for fixed effects of Genotype

Effect	Genotype	Standard Estimate	Error	DF	t value	Pr>|t|
Intercept		-23.00	20.03	70	-1.15	0.25
Genotype	FB	30.14	27.69	70	1.09	0.28
Genotype	BF	6.90	27.69	70	0.25	0.80
Genotype	BB	26.95	27.69	70	0.97	0.33
Genotype	FF	0				
Week		52.23	3.18	596	16.4	<0.0001
Week x Genotype	FB	13.22	4.39	596	3.01	0.0027
Week x Genotype	BF	26.94	4.39	596	6.14	<0.0001
Week x Genotype	BB	5.69	4.39	596	1.34	0.1954
Week x Genotype	FF	0				

FB = Fulani × Bovans Nera

BF = Bovans Nera × Fulani

BB = Bovans Nera × Bovans Nera

FF = Fulani × Fulani

Table 4.6: Solution for fixed effect of sex

Effect	**Sex**	**Standard Estimate**	**Error**	**DF**	**t value**	**Pr>|t|**
Intercept		-23.00	20.03	70	-1.15	0.25
Sex	Male	-19.85	23.76	70	-0.84	0.41
Sex	Female	0				
Week		52.23	3.18	596	16.4	<0.0001
Week x Sex	Male	29.80	3.79	596	7.86	<0.0001
Week x Sex	Female	0				

Table 4.7: Solution for fixed effect of Genotype by Sex

Effect	Genotype	Sex	Standard Estimate	Error	DF	t value	Pr>|t|
Intercept			-23.00	20.03	70	-1.15	0.25
	FB	Male	-15.75	32.44	70	-0.49	0.63
	FB	Female	0				
	BF	Male	-10.27	32.50	70	-0.32	0.75
	BF	Female	0				
	BB	Male	-13.01	32.62	70	-0.40	0.69
	BB	Female	0				
	FF	Male	0				
	FF	Female	0				
Week			52.23	3.18	596	16.4	<0.0001
	FB	Male	-7.68	5.15	596	-1.49	0.14
	FB	Female	0				
	BF	Male	-12.38	5.16	596	-2.40	0.02
	BF	Female	0				
	BB	Male	-7.86	5.18	596	-1.52	0.13
	BB	Female	0				
	FF	Male	0				
	FF	Female	0				

FB = Fulani × Bovans Nera BF = Bovans Nera × Fulani

BB = Bovans Nera × Bovans Nera FF = Fulani × Fulani

4.10 Morphological traits of Bovans x Fulani chicken cross(BF) at 8 weeks.

Table 4.10 shows the morphological traits of Bovans x Fulani chicken cross (BF) as affected by sex. There were significant ($p<0.05$) superiority of BF males over females with regards to shank length, shank diameter and body circumference. No significant difference ($p>0.05$) was observed between the sexes with respect to body, keel, wing and neck lengths.

4.11 Morphological traits of Bovans x Bovans chicken (BB) at 8 weeks.

The effect of sex on the morphological traits of Bovans x Bovans chicken cross (BB) is as presented in table 4.11.

Except for shank diameter which was not significantly different ($p>0.05$) between the BB sexes, males were significantly ($p<0.05$) better than females on all other morphological traits.

4.12 Comparative morphological traits of Fulani ecotype, Bovans Nera and their crosses at 8 weeks

Table 4.12 indicated the comparative biometrical traits of BF, FB, BB and FF chicken crosses at 8 weeks. The genotype by sex interactive effects were found to be insignificant ($p>0.05$).

With regards to body circumference, body, keel, wing and neck lengths, there were no significant differences($p>0.05$) between BF and FB, but both were significantly ($p<0.05$) better than BB and FF that similar values. Bovans x Fulani chicken cross (BF) was significantly ($p<0.05$) better than the remaining genotypes in terms of shank length, though no significant difference ($p>0.05$) was observed between FB , BB and FF . Shank diameter showed no significant difference ($p>0.05$) among all the genotypes.

Table 4.8: Effect of sex on morphological traits of the Fulani x Bovans chicken cross (FB) at 8 weeks

Parameter	**Male (Mean $\pm$s.e)**	**Female (Mean $\pm$s.e)**
Shank length (cm)	7.49 ± 0.08^a	6.59 ± 0.17^b
Shank diameter (cm)	1.07 ± 0.04^a	0.85 ± 0.02^b
Body circumference (cm)	23.37 ± 0.29^a	22.11 ± 0.46^b
Body length (cm)	17.44 ± 0.41^a	16.21 ± 0.51^a
Keel length (cm)	8.62 ± 0.17^a	7.70 ± 0.17^b
Wing length (cm)	17.11 ± 1.54^a	16.11 ± 0.44^a
Neck length (cm)	8.38 ± 0.22^a	7.95 ± 0.44^a

^{a,b}Means with different superscripts along the same row are significantly different ($P< 0.05$).

Table 4.9: Effect of sex on morphological traits of Fulani x Fulani chicken cross (FF) at 8 weeks

Parameter	**Male (Mean $\pm$s.e)**	**Female (Mean $\pm$s.e)**
Shank length (cm)	7.37 ± 0.16^{a}	5.98 ± 0.15^{b}
Shank diameter (cm)	1.15 ± 0.03^{a}	0.91 ± 0.05^{b}
Body circumference (cm)	21.62 ± 0.59^{a}	18.20 ± 0.75^{b}
Body length (cm)	15.70 ± 0.45^{a}	13.18 ± 0.65^{b}
Keel length (cm)	7.75 ± 0.15^{a}	6.58 ± 0.29^{b}
Wing length (cm)	15.86 ± 0.56^{a}	12.94 ± 0.57^{b}
Neck length (cm)	7.40 ± 0.16^{a}	6.33 ± 0.25^{b}

^{a,b}Means with different superscripts along the same row are significantly different ($P < 0.05$).

Table 4.10: Effect of sex on morphological traits of Bovans x Fulani chicken cross (BF) at 8 weeks

Parameter	**Male (Mean ±s.e)**	**Female (Mean ±s.e)**
Shank length (cm)	7.96 ± 0.13^{a}	7.13 ± 0.33^{b}
Shank diameter (cm)	1.32 ± 0.04^{a}	1.10 ± 0.06^{b}
Body circumference (cm)	23.78 ± 0.24^{a}	22.61 ± 0.58^{b}
Body length (cm)	18.03 ± 0.42^{a}	17.95 ± 0.24^{a}
Keel length (cm)	8.76 ± 0.15^{a}	8.21 ± 0.16^{a}
Wing length (cm)	17.54 ± 0.32^{a}	16.83 ± 0.42^{a}
Neck length (cm)	8.40 ± 0.16^{a}	8.43 ± 0.22^{a}

^{a,b}Means with different superscripts along the same row are significantly different (P< 0.05).

Table 4.11: Effect of sex on morphological traits of Bovans x Bovans chicken cross (BB) at 8 weeks

Parameter	**Male (Mean ±s.e)**	**Female (Mean ±s.e)**
Shank length (cm)	7.22 ± 0.12^{a}	6.38 ± 0.13^{b}
Shank diameter (cm)	1.73 ± 0.59^{a}	1.00 ± 0.03^{a}
Body circumference (cm)	22.29 ± 0.54^{a}	18.84 ± 0.27^{b}
Body length (cm)	15.54 ± 0.39^{a}	12.74 ± 0.27^{b}
Keel length (cm)	7.68 ± 0.17^{a}	6.64 ± 0.06^{b}
Wing length (cm)	15.01 ± 0.39^{a}	13.08 ± 0.75^{b}
Neck length (cm)	7.42 ± 0.16^{a}	6.47 ± 0.21^{b}

^{a,b}Means with different superscripts along the same row are significantly different ($P < 0.05$).

Table 4.12: Comparative morphological traits of BF, FB, BB and FF chicken genotypes at 8 weeks.

Parameter	**BF**	**FB**	**BB**	**FF**
Shank length (cm)	7.75^{a}	7.26^{b}	7.01^{b}	6.99^{b}
Shank diameter (cm)	1.55^{a}	1.27^{a}	1.08^{a}	1.02^{a}
Body circumference (cm)	23.48^{a}	23.05^{a}	21.43^{b}	20.67^{b}
Body length (cm)	18.01^{a}	17.13^{a}	14.99^{b}	14.84^{b}
Keel length (cm)	8.63^{a}	8.39^{a}	7.42^{b}	7.42^{b}
Wing length (cm)	17.36^{a}	16.86^{a}	15.05^{b}	14.53^{b}
Neck length (cm)	8.41^{a}	8.28^{a}	7.19^{b}	7.10^{b}

^{a,b,c}Means with different superscripts along the same row are significantly different ($P<0.05$)

Table 4.13: Morphological Indices of Fulani ecotype chicken, Bovans Nera and their crosses at 8 weeks of age

Parameters	**BB**	**BF**	**FB**	**FF**
Massiveness	2.88^{a}	2.75^{a}	2.66^{a}	2.68^{a}
Compactness	89.3^{b}	97.5^{a}	93.8^{ab}	91.2^{b}
Long leggedness	29.5^{b}	32.0^{a}	31.6^{a}	28.7^{b}

Table 4.14: Summary of stepwise regression of studied morphological traits

Variable entered	Partial R^2	F-value	P>F	Wilks' Lambda	Pr<Lambda	ASCC	Pr<ASCC
BC	0.08	17.38	<0.0001	0.07	<0.001	0.86	<0.0001
BL	0.60	4.55	<0.0001	1.29	<0.001	0.36	<0.0001
WL	0.94	1.19	0.3179	7.20	<0.001	0.06	<0.0001
BW	0.99	0.02	0.8921	6.57	<0.001	0.02	<0.0001

ASCC: Adjusted Square Canonical Correlation

BC = Body circumference

BL Body length

WL = Wing length

BW = Body weight

Table 4.15: Canonical correspondence analysis of chicken Discriminant Variables

Traits	**CAN1**	**CAN2**	**CAN3**	**CAN4**
BC	-0.007	0.330	-1.827	1.000
BL	0.185	0.860	1.000	-1.487
WL	1.000	0.721	0.107	1.425
BW	0.709	-1.621	0.910	-0.185
Adjusted canonical correlation	0.927	0.577	0.210	0.630
Eigen Value	6.565	0.571	0.067	0.003
Variance accounted for (%)	91.14	7.93	0.01	0.01
Cumulative Variance (%)	91.14	99.07	100	100

BC = Body circumference

BL Body length

WL = Wing length

BW = Body weight

4.13 Morphological indices of Fulani ecotype, Bovans Nera and their crosses at 8 weeks of age

Table 4.13 indicated the morphological indices of Fulani ecotype, Bovans Nera and their crosses. Massiveness was not significantly different($P>0.05$) across the genotypes and it ranged from 2.88 for BB to 2.66 for FB. The BF was significantly ($P< 0.05$) more compact than FF and BB but similar to FB. In terms of long-leggedness, BF and FB were similar but significantly ($P< 0.05$)more long-legged than BB and FF.

4.14 Discriminant analysis of morphological traits of Fulani ecotype, Bovans Nera and their crosses

Stepwise selection of morphological traits to separate Fulani ecotype, Bovans Nera and their crosses is shown in table 4.14. The discriminant analysis based on significant F-values indicated body circumference, body length, wing length and body weight as traits permitting discrimination between BF, FB, BB and FF chicken crosses. The Adjusted Squared Canonical Correlation (ASCC) was highest in body circumference followed by body length and least in body weight. Body circumference also had the largest F ratio with the body weight being the least. This trend was reversed with the Wilk's Lambda.

4.15 Canonical correspondence analysis of morphological traits of Fulani ecotype, Bovans Nera and their crosses

Table 4.15 presented linear combination of the morphological traits that best summarize the differences among the Fulani ecotype, Bovans Nera and their crosses.

The Canonical discriminant analysis identified four statically significant ($p<0.0001$) canonical valuables that accounted for 91%, 7.9%, 1% and 1% of the total variation. CAN 1 was dominated by body weight (BW) and wing length (WL). Body weights (BW), body length (BL) and wing length (WL) were highly correlated with CAN 2. BC and BW were highly correlated with CAN 3 while BL and WL were moderately correlated with CAN 4. The Eigen value of CAN 1 was the highest and relatively substantial compared to the values of other discriminating functions.

CHAPTER FIVE

DISCUSSION

5.1 Body weight of Fulani ecotype chicken, Bovans Nera and their crosses

The higher overall body weight least square means of the hybrid crosses (Bovans x Fulani and Fulani x Bovans) over the indigenous Fulani x Fulani and commercial Bovans x Bovans suggested positive heterotic effect on the body weight. The differential in body weights across genotypes was in agreement with the report of Amao (2017) in a study of Nigerian indigenous chickens and Rhode Island Red who stated that chicken breeds significantly affected body weights, feed intake, mean weight gain and feed conversion ratio. The fact that Bovans x Fulani (BF) chicken genotype had higher body weights over Fulani x Bovans (FB) could be due to the different genetic constitution of the exotic parental lines used in the crossing. The male BovansNera parental line in the Bovans x Fulani cross was of Rhode Island Red extraction while the female Bovans Nera parental line in the Fulani x Bovans cross was of Barred Plymouth Rock origin. The two exotic parental lines used in this study were actually hybrids themselves. This was in agreement with the findings of Adedokun and Sonaiya (2002) when they crossed Fulani ecotype chicken with Dahlem Red (an exotic chicken). At eight weeks, males of the cross between Dahlem Red and Fulani ecotype chicken with bodyweight of 508±25.0g was bigger than the pure Dahlem Red while the females of the cross had similar weight with the male and female Dahlem Red.

Hybrid vigour may be responsible and could result from the favourable genes for growth from each parental genotype being either dominant and/or the result of weak epistatic interactions. There could have been an increase in the frequency of allelic heterozygosity which likely translate to better body weight. Dickerson (1973) reported that a linear relationship was generally expected to exist between dominance and the degree of heterozygosity. Dominance is therefore expected to be favourable. Better body weights of the hybrids BF and FB could also result from their faster rate of skeleton growth and rapid rate of muscle fibre enlargement (Rehfeldt *et al*., 2004)

The higher least square means of the commercial Bovans x Bovans over the indigenous Fulani x Fulani is expected due to the fact that the latter has been genetically improved.

5.2 Body weight of the chicken genotypes by sex

Sexual dimorphism was clearly evident between the sexes of the chicken genotypes in terms of body weight. The male chickens had higher body weights than the female chickens. This trend is in consonance with what generally obtains within chickens (Olawumi *et al.,* 2008). They all suggested that sexual dimorphism in chickens is displayed in several biometrical traits and in most breeds. They infer that this effect could be due to sex hormones which may promote larger muscle development in males than in females.

5.3 Body weight of Fulani ecotype chicken, Bovans Nera and their crosses for genotype by sex

The superiority of the body weight of BF and FB male hybrids in terms of body weight over BB and FF males may be due to hybrid vigour. Swan and Kinghorn (1992) noted that hybrid vigour is the extent by which performance in crossbred deviates from the additive component which is generally linked to genetic interactions within loci (dominance) and interaction between loci (epistasis).

The closeness of the bodyweight of male Bovans x Bovans (BB) and male Fulani x Fulani (FF) may be due to the strain of Fulani ecotype chicken used as the indigenous parental line. Adedokun and Sonaiya (2002) reported that there are normal and dwarf strains of Fulani ecotype chickens. It seemed that the Fulani ecotype chicken used in this study tends to be the normal Fulani ecotype that was reported to have big body size and long shanks (Olawumi *et. al*., 2008 and Ige *et. al.*, 2012).

The outstanding bodyweight of the female BF in comparison to the FB, BB and FF males, though striking was corroborated by the findings of Adedokun and Sonaiya (2002) in the crossbreeding experiment of Dahlem Red (exotic) with Nigerian indigenous chickens. They reported that mean daily weight gain of males was generally higher than that of the females except for the Dahlem Red x 0.6g more than the cock between 8 and 15 weeks. This could be due to the gene interactions and the strain of the Fulani ecotype chicken used.

5.4 Fixed effects of genotype, sex, week and their interactions

The non-significance of Week x Gen x Sex indicated that the slopes of theFulani cross (DR X Fu) in which the female gained growth curves of male and female chicks within each genotype was similar. This could be as a result of the time period considered for this study. Growth at this period (0-8 weeks) in chickens is largely considered linear, hence this observation. This agreed with the report of Sola-Ojo and Ayorinde (2009).

The Gen x Sex effect showed that male and female chicks within each chicken genotype had the same starting point. This may be due to the fact that they were hatched from eggs of similar weights.

The Week x Gen term showed that the growth rates of the chicken genotypes differed. This was expected since the four chicken genotypes: BF, FB, BB, and FF were of different genetic constitutions. This was in consonance with the work of Goto *et al.* (2010), who observed breed differences in growth curves of local chickens.

Week x Sex and Sex terms indicated that growth rates as well as the starting points of the male and female chicks in general differed. This was likely as a result of the different chicken genotypes that made up the sexes.

Since each chicken genotype chicks were produced from eggs of different weights, therefore their day old weights were expected to be dissimilar as indicated by the genotype term.

5.5 Growth slopes of the Fulani ecotype, Bovans Nera and their crosses

The intercepts of the growth curves of the chicken genotypes were different with genotype FB having the highest, followed by BB. This was in agreement with the findings of Nwachukwu *et al.,* 2006 who reported that the mean day old weights recorded for both main and reciprocal crossbreds showed strong evidence maternal effects. This observation could be attributed to the carry over effect of the size of the egg that hatched them. BB and FB were from Bovans Nera female parental line that laid big eggs while BF and FF were hatched from eggs of female indigenous Fulani ecotype chickens.

However, the growth rates of the two hybrids BF and FB were greater than that of BB and FF, and could likely be as a result of either dominance or weak epistatic interactions and the strain of the Fulani ecotype used as parent (Adedokun and Sonaiya, 2002; Amao, 2017).

5.6 Fixed effect of sex on growth slopes of Fulani ecotype, Bovans Nera and their crosses

The female chick had greater starting point estimates than that of the male chicks. This could be due to the different chicken genotypes that were pooled together to form the classification based on sex. However the growth rate of the male was over 60% greater than that of the female. This phenomenon of sexual dimorphism was well established in chicken (Olawunmi *et al*., 2008).

5.7 Growth slopes of the Fulani ecotype, Bovans Nera and their crosses for genotype by sex

Estimates of the starting points of all chicken genotypes based on sex were all negative, though the females seemed to have less negative values than that of the male except in the FF genotype where both male and female chicks had negative values. This agreed with the test on the fixed effect that showed that male and female chicks within the genotype had similar intercepts due probably to the fact that they were hatched from eggs of similar weights.

Moreover, the slopes of the growth curves of the female chicks were higher than that of the male, though the test of the fixed effect indicated that the slopes differentials were not significant.

5.8 Morphological traits of FB chicken cross at 8 weeks

The body weight of FB cross was better than what was reported for a cross of Dahlem Red and Fulani ecotype by Adedokun and Sonaiya (2002). This could be due to the strain of the Fulani ecotype used for their study as well as the exotic parental line. Male FB was heavier than the female and had longer shank length, shank diameter, body circumference and keel length. These could likely be attributed to sexual dimorphism. The better body circumference and keel length of the male FB over female FB corroborated the higher bodyweight of the former over the latter.

5.9 Morphological traits of the FF chicken genotype at 8 weeks

Sexual dimorphism was clearly observed between sexes of FF chicken genotype for body weight and other morphological traits with the males being evidently better. The body weight of the chicken genotype when pooled was about 38% higher than the value (387.77±99.95) reported by Sola-Ojo and Ayorinde, 2009 for Fulani ecotype chicken of the same age. The strain used for the study was also better in terms of keel length, body circumference, shank diameter, similar in shank length but slightly lower in wing length. The body lengths could not be compared due to different anatomical points used to estimate the parameter in the different studies. Moreover, the biometrical values of the FF chicken genotype observed suggested that it might be a heavier strain within the genotype.

The FF chicken genotype was also about 48 % heavier than the Nigerian ecotype of the same age evaluated by Ohagenyi, (2009). The shank length (5.81 cm) and body length (12.97 cm) of the Nigerian heavy ecotype at 8 weeks were lower than the FF values.

5.10 Morphological traits of the BF chicken genotype at 8 weeks

Except for bodyweight, shank length, shank diameter and body circumference on which male FB showed superiority over the female, they had similar values over all other traits.

It was in this genotype that the male and female had similar keel length that indicated meatiness. Similar observation was also reported by Adedokun and Sonaiya (2002). The female FB higher body length over other female chicken genotype also gives it a propensity for egg laying despite its appreciable keel length that indicates meatiness. Male FB had the highest body and keel length amongst male chicken genotypes indicating its meat potential.

5.11 Morphological traits of the BB chicken genotype at 8 weeks

Male BB was superior to the female BB on all the morphological traits except the shank diameter. The body weight of the female BB (479.20±20.47) was higher than the value (376.21±24.7) reported by Olawumi *et al.,* 2008 for 8-week Nera Black. Body length of 12.53cm was similar to the value observed, however the keel length was lower.

5.12 Comparative morphological traits of the chicken genotypes at 8 weeks

Better morphological traits of the hybrids BF and FB chicken genotypes over the BB and FF indicated positive heterotic effect. Their better values of body circumference, body length and keel length, showed their potentials for egg laying and meat yield. This was in agreement with the results of Sola-Ojo *et al.,* (2012) and Adedokun and Sonaiya (2002). The morphology of the Fulani ecotype used compared favourably with the BB chicken genotype, though largely driven by the impressive male FF morphological trait. This confirms the findings that some strain of Fulani ecotype chicken had appreciable body size and meat potential (Adedokun and Sonaiya, 2002). Remignon (1995) reported that skeleton develops earlier than those of muscles and feathers in chicks. Therefore, the differences in body weights of the chicken genotypes might be due to their different rates of growth of skeleton. The superiority of BF and FB in body weight could likely be linked to their improved morphological traits indicative of better skeleton. The rate of muscle fibre enlargement in the BF and FB might also be faster than those of BB and FF. A review by Rehfeldt *et al.,* (2004) reported that in mammals and birds, most authors stated that muscle fibre number has been reported to remain unchanged after birth. This is consistent with the theory that muscle growth is mostly due to the enlargement of muscle fibres. Higher body weights resulted from larger skeletons and more muscle mass.

5.13 Morphological Indices of the chicken genotypes

The chicken genotypes were similarly massive. This may be due to the fact that the index is a ratio and the differences among them were not large enough to differentiate them. The highest massiveness index was 2.88 for BB and the least was 2.66 for FB. These values were higher than those obtained by Oladejo *et al.* (2013) for indigenous chickens of Nigeria. The mean massiveness reported by them for Fulani ecotype chickens of 2.09 was lower for our own FF of 2.68. This may be due to due to strain effect as Fulani ecotype are known to have light strain among the heavy type. This effect was alluded to by Adedokun and Sonaiya (2002) when they described the light type as Fulani dwarf. For compactness, the index value of 97.5 for BF was higher than 89.3 for BB and 91.2 for FF to confer superiority. This may indicate enhanced carcass potential over other genotypes which are less compact. The BF and FB which were more compact also had higher keel lengths. These values were also better than those of Oladejo *et al.* (2013). However, the massiveness and compactness indices were lower to values obtained for 6 weeks broilers by Kokosyznski *et al.* (2017). This trend is not unusual as broilers are traditionally bred to be massive and compact. The hybrids used in this study are crosses of exotic egg type chicken by indigenous.

Long-leggedness enhances better locomotion and foraging ability. The better values for BF (32.1) and FB (31.6) showed that the hybrids may be better foragers than other genotypes when raised outdoors. These values compared to that of Kokosyznski *et al.* (2017) but were lower to that of Oladejo *et al.* (2013). This could be attributed to the fact that in the Oladejo *et al.* (2013) study, thigh length was added to the shank length as numerator in the calculation of the long-legged index whereas only shank length was used as the numerator in our study and that of Kokosyznski *et al.*(2017). Moreover, Oladejo *et al.* (2013) evaluated more matured birds compared to ours, which could also be a factor.

5.14 Discriminant morphological variables of the chicken genotypes

Body circumference, body length, wing length and body weight were effective in separating the chicken genotypes to groups. Body circumference with the least Wilks lambda indicated that it is the most discriminating variable among the chicken genotypes.

This was corroborated by it having the largest F ratio. Its Adjusted Squared Canonical Correlation (ASCC) was also the highest and this implied that most variance in the canonical variate was explained by it and 2% of the variance was accounted for by body weight though the ASCC values of the selected morphological traits were significant. This finding was in agreement with the result of Oladejo *et al.* (2013), who also reported that body weight, body girth, shank length, shank circumference, toe length and comb length were the six most important traits distinguishing Yoruba and Fulani ecotype chickens. Ogah (2013) also showed that body weight, body width and thigh length as important variables for discriminating among indigenous chicken genotypes.

5.15 Canonical discriminant variables of the chicken genotypes

The first canonical variable CAN 1 explained 91.4 % of total variation. This was quite substantial and it was loaded highly by body weight and wing length. The eigen value of CAN 1 was about 12 fold the value of that of CAN 2 and this indicated the relative explanatory power of CAN 1. By extension, CAN 1 accounted for about 1200 % more between group variance in the dependent categories than does the second discriminating function CAN 2.

Generally it was assumed that any variable with a loading of 0.30 (or higher) was considered to contribute significantly as discriminating variable, hence in CAN 1, the wing length and body weight were the most discriminating variables whereas in CAN 2 which accounted for 7.93 % of the total variation, all the four variables BC, BL, WL and BW were considered to contribute significantly. Ogah (2013) reported that body weight, body width and thigh length contributed significantly in discriminating among indigenous chicken genotypes. Among indigenous turkey colour variants, Adeyemi and Oseni (2018) showed that body weight, shank length and abdomen circumference were the most discriminating variables to separate them. Some of the discriminatory morphological variables were also reported by Yakubu *et al.,* (2009) when they found out that breast girth, shank circumference, body weight and thigh circumference as biometrical measures permitting discrimination among the Sasso, Kuroiler and Fulani chickens.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

BF and FB hybrids had significantly higher body weights over the parental lines offspring BB and FF indicating positive heterosis, although BF was better than FB in terms of body weight. Sexual dimorphism was observed with male chickens having better body weights than females. Amongst male chickens across genotype, BF males had the highest body weight though the bodyweights of BB male and FF male were similar. Among females there were no significant differences between the BF female and FB female as well as between FB females and BB females, though BF females were significantly heavier than BB females and FF females. The FF female was significantly lighter than all other females. A striking trend was observed indicating similarity in bodyweights between BF females and males of other genotypes except its own.

The genotype, sex and age significantly affect the growth curves of the chicken genotypes. Similarly, the interactive effects of genotype by age and sex by age also moderated the growth curves. However, genotype by sex and genotype by sex by age did not affect the growth curves. BF genotype was the fastest in growth followed by FB and the least was FF though the FB genotype had the highest intercept on the growth curve among genotypes. Growth rate of the male chicken was higher than that of the females.

BB males and FF males were morphologically better than their females, though FB females and BF males showed similarity to their males in body, keel, wing and neck lengths. Comparatively the BF and FB genotypes had better body weight, body circumference, body length, keel length, wing length , neck length, compactness and long-leggedness than BB and FF. This positive heterosis was desirable as their superiority were exhibited on useful morphological traits that may enhance better production in terms of carcass, egg laying and locomotion. Moreover, BF was exceptional as it was even better than FB in bodyweight and shank length.

Body circumference, body length, wing length and body weight were effective in separating the chicken genotypes to groups. The first canonical variable CAN 1 which explained about 91 percent of total variation was highly loaded by wing length and body weight, while the second canonical variable CAN 2 was loaded highly by body circumference, body length, wing length and body weight

6.2 Recommendation

BF and FB hybrids were better than BB and FF in terms of body weight, body circumference, body length, keel length, wing, neck lengths and compactness. This may confer better carcass value in adult stage and potential for egg laying on the hybrids. Moreover, BF and FB had similar long-leggedness which were higher than that of BB and FF this may indicate better locomotion and foraging ability .

To discriminate among the chicken genotypes, body circumference, body length, wing length and body weight were recommended.

6.3 Areas for further research

Since this study covered a period between day old and 8 weeks of age, there is need to extend the study to adult stage to estimate the carcass and egg potentials of the chicken genotypes.

6.4 Contributions to Knowledge

1. Main (Bovans X Fulani) and reciprocal (Fulani X Bovans) crossbred chickens were significantly heavier and grew faster than the pure lines (Bovans X Bovans and Fulani X Fulani) at early growth phase indicating overdominance gene action.

2. Male chicks were significantly heavier than the females exhibiting sexual dimorphism

3. The main (Bovans X Fulani) and reciprocal (Fulani X Bovans) crossbred chickens were morphologically more long-legged than the pure lines (Bovans X Bovans and Fulani X Fulani) but similarly massive.However, Bovans x Fulani crossbred was most compact.
4. The body circumference, body weight, body length and wing length were effective in classifying the crossbreds and the pure lines.

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