EFFECT OF BIOCHEMICAL POLYMORPHISMS ON PERFORMANCE TRAITS IN INDIGENOUS CHICKEN GENOTYPES

BY

Hassan MUHAMMAD

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA

JULY, 2015

EFFECT OF BIOCHEMICAL POLYMORPHISMS ON PERFORMANCE TRAITS IN INDIGENOUS CHICKEN GENOTYPES

BY

HassanMUHAMMAD
M.Sc./AGRIC/07884/2010-2011
B. AGRICULTURE (ANIMAL SCIENCE), ABU, 2009.

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA

JULY, 2015

DECLARATION

I hereby declare that the work in this thesis entitled "effect of biochemical polymorphisms on performance traits in indigenous chicken genotypes" was carried out by me in the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State Nigeria. The information derived from relevant literature is duly acknowledged in the text and a list of reference provided. No part of this thesis was previously presented for another degree or diploma in this or any other institution.

_____ _____

MUHAMMAD Hassan Date

Name of Student

CERTIFICATION

This thesis entitled "EFFECT OF BIOCHEMICAL POLYMORPHISMS ON PERFORMANCE TRAITS IN INDIGENOUS CHICKEN GENOTYPES" by Hassan MUHAMMAD meets the regulations governing the award of degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

_____	_____
Professor B.I. Nwagu Chairman, Supervisory Committee	Date
_____	_____
Dr. M. Orunmuyi Member, Supervisory Committee	Date
_____	_____
Professor S. Duru Head of Department	Date
_____	_____
Professor A. Z. Hassan Dean, School of Postgraduate Studies	Date

DEDICATION

This thesis is dedicated to Islam, then to those who care for me; helping me realize my heart desire and to my twin children (Muhsin and Muhsina).

ACKNOWLEDGEMENTS

All praises and thanks are due to Allah, the Lord Whose Will becomes the inevitable, The Most Merciful, Whose mercy showers over all creatures. The Most Compassionate; Who cares and Most kind to all creatures.

I thank the Chairman of my supervisory committee; Professor B.I. Nwagu, who was always soft spoken whenever I went to him for any advice. I am grateful to my supervisor, Dr. (Mrs.) M. Orunmuyi, who was always with me through out this experiment.

I must register my gratitude to my parents, my beloved wife, and the rest members of my family who cared for me especially brother Yahya Bello, Muhammad Isah, Ali Muhammad, Ya'qub Abdulhamid Umar, Nana Hauwau and Rahima Muhammad.

I wish to thank my friends (Abubakar Ibrahim, Ismail Adamu, Mall. Mustafa Ojonuba, Mall. Abdullahi Abdulkareem, Mall. Abdurahman Sani, Adamu Shuaibu, Badmus Qasim, Muhammad Jamiu, Musa Abduraheem Arome, Athony Kayode Olutunmogun) and many more friends whom due to lack of space cannot be mentioned. I must not forget brother Ayoola Shoyombo, who helped me with the reagents for the biochemical analysis. I wish to mention Dr. Akinyemi of Department of Animal Science, University of Ibadan, together with her students who helped me during the biochemical analysis in the laboratory.

May Allah reward the Muslim Forum of Ahmadu Bello University and especially the Area F Muslim Forum, whichhas never relented in any way in helping me.To all others not mentioned here, I say thank you. I hereby register my gratitude to Mall M.K Lawal and his family provided me accommodation during my study period.

ABSTRACT

This research investigated the effect of biochemical polymorphisms on performance traits in Nigerian indigenous chicken genotypes. The chickens were obtained from pedigree mating of Normal feathered, Frizzle feathered and Naked Neck cocks to Normal feathered, Frizzle feathered and Naked Neck hens respectively to produce F_1 offspring. One hundred and fifty five chicks (37 Frizzle, 79 Normal and 39 Naked Neck) were measured for body weight (g), breast girth (cm) and tibia length (cm). At 20weeks, 5ml of blood was collected from wing vein of each chicken into heparinized tubes labeled according to its tag number for electrophoresis. Each bird was scored as either fast (AA), midway (AB) or slow (BB) according to the mobility on the cellulose-acetate paper for each of transferrin, haemoglobin and carbonic anhydrase. Data obtained were subjected to general linear model procedure of statistical analysis system (SAS, 2002)and significant means were separated using tukey honestly significant difference. Hardy Weinberg's equation was used to calculate genotypic and allelic frequencies and tested using chi-square (χ^2). Each of the three biochemical markers distinguished into three polymorphic forms viz; AA, AB and BB. The Frizzle feathered had significant higher ($P<0.05$) weight (338.54g) than both the Normal feathered (319.59g) and Naked Neck (295.51g) from day old to 8weeks, with no significant differences ($P>0.05$) from 12 to 20 weeks with no consistent trend for tibia length and breast girth. The effect of sexual dimorphism was significant ($P<0.05$) with males having significantly higher body weight (1168.79g) than females (937.06g), breast girth, males (25.74cm) and females (24.24cm) and tibia length, males (9.59cm) and females (8.96cm). The genotypic frequencies of Transferrin (Tf^{AA}, Tf^{AB} and Tf^{BB}) had 8, 140 and 7 respectively, haemgolobin (Hb^{AA}, Hb^{AB} and Hb^{BB}), had 49, 56 and 50 respectively and carbonic anhydrase (Ca^{AA}, Ca^{AB} and Ca^{BB}) had 63, 79 and 13 respectively. The effect of the polymorphic forms on body weight (g), breast girth (cm), tibia length (cm) showed that the AA had significant higher ($P<0.05$) body weight (g) than AB and BB for; transferrin (1434.75g, 1047.11g, 1047.43g respectively) and haemoglobin (1296.43g, 1029.59g, and 884.46g respectively). The AA was also higher ($P<0.05$) than the AB and BB for breast girth (cm) and tibia length (cm) in the case of transferrin and haemoglobin. The carbonic anhydrase showed no consistent significant differences ($P>0.05$) between the different genotypes for body weight (g), breast girth (cm) and tibia length (cm). It could be concluded that body weight of the genotypes indicated Frizzle feather may be suitable for meat production. The effect of sexual dimorphism showed that the parameters were sex influenced. The high level of heterozygosity indicates that more of the heterozygotes adapted and survived better than the homozygotes. The effect of the polymorphic forms of the biochemical markers on body weight (g), breast girth (cm), and tibia length (cm) showed that transferrin and haemoglobin could be used for body weight selection, while carbonic anhydrase may not be used for selection of the measured parameters.

TABLE OF CONTENT

TITLE PAGE i

DECLARATION ii

CERTIFICATION iii

DEDICATION iv

ACKNOWLEDGMENT. v

ABSTRACT vi

TABLE OF CONTENT. vii

LIST OF TABLES viii

LIST OF PLATES xii

CHAPTER ONE

1.0 INTRODUCTION. 1

1.1 Justification 3

1.2 Hypotheses 5

1.3 Objectives 5

CHAPTER TWO

2.0 LITERATURE REVIEW. 6

2.1 Origin and Domestication of chicken 6

2.2 The use of Chicken in Research and Development 6

2.3 Tropical Indigenous Animal Genetic Resources (TIAnGR) 7

2.4 Management System and Distribution of Indigenous Chicken in Nigeria 8

2.5 Growth of Indigenous Chicken 9

2.6 Comparison between indigenous (Unimproved) and exotic (Improved) chickens. .10

2.7 Traits of Economic Importance in Chicken. 11

2.8 Linear Body Measurement in Chicken. 12

2.9 Biotechnology in Animal Production. 13

2.10 Electrophoresis 14

2.11 Polymorphism of Transferrin in Poultry. 16

2.12 Polymorphism of Haemoglobin in Poultry 18

2.13 Polymorphism of Carbonic Anhydrase in Poultry 20

2.14 Sexual Dimorphism in Chicken 21

CHAPTER THREE

3.0 MATERIALS AND METHODS. 23

3.1 Location of the Experiment. 23

3.2 Source of Experimental Animal, Breeding and Management 23

3.3 Feeding 23

3.4 Mating Procedure 26

3.5 Egg Collection 26

3.6 Incubation of Eggs and Management of Chicks 26

3.7 Data Collection 28

3.7.1 Growth parameters or traits. 28

3.7.2 Blood collection. 28

3.8 Preparation of Buffer and Other Solutions. 28

3.9 Electrophoresisof Blood Samples. 30

3.10 Statistical Analysis 31

CHAPTER FOUR

4.0 RESULTS. 33

4.1 Body Weight and Body Linear Measurement 33

4.2 Effect of Sex on the Body Weight(g), Breast Girth(cm) and Tibia Length(cm) of the whole Population of the Indigenous Chickens. 35

4.3 Transferrin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria 37

4.4 Haemoglobin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chickens of Nigeria. 40

4.5 Carbonic Anhydrase Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chickens of Nigeria 43

4.6 Effect of Transferrin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of the Indigenous Chickens. 47

4.7 Effect of Transferrin Genotypes on Body Weight(g), Breast Girth(cm) and Tibia Length(cm) within the Frizzle Indigenous Chicken Population 49

4.8 Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)within the Normal Indigenous Chicken Population 51

4.9 Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)within the Naked Neck Indigenous Chicken Population 52

4.10 Effect of Haemoglobin Genotype on the Body Weight (g), Breast Girth (cm)and Tibia Length (cm)of the wholePopulation of Indigenous Chicken. 55

4.11 Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)withinthe Frizzle Indigenous Chicken Population 57

4.12 Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)withinthe Normal Indigenous Chicken Population 59

4.13 Effect of Haemoglobin Genotypes on Body Weight(g), Breast Girth(cm) and Tibia Length withinthe Naked Neck Indigenous Chicken Population 61

4.14 Effect of Carbonic anhydrase Genotype on the Body Weight(g), Breast Girth(cm) and Tibia Length(cm) of the whole Population of the Indigenous Chickens. 63

4.15 Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)withinthe Frizzle Indigenous Chicken Population 65

4.16 Effect of Carbonic Anhydrase Genotype on Body Weight(g), Breast Girth(cm) and Tibia Length(cm) withinthe Normal Indigenous Chicken Population 67

4.17 Effect of Carbonic Anhydrase Genotype on Body Weight(g), Breast Girth(cm) and Tibia Length(cm) withinthe Naked Neck Indigenous Chicken Population 69

CHAPTER FIVE

5.0 DISCUSSION. 71

5.1 Body Weight and Body LinearMeasurement 71

5.2 Effect of Sex on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) on the whole Population of the Experimental Indigenous Chickens 72

5.3 Transferrin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria 73

5.4 Haemoglobin Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria 75

5.5 Carbonic Anhydrase Genotype, Genotypic and Allelic Frequency of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria 76

5.6 Effect of Transferrin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of indigenous chicken and within the individual populations of Frizzle, Normal and Naked Neck. 76

5.7 Effect of Haemoglobin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of indigenous chicken and within the individual populations of Frizzle, Normal and Naked Neck 78

5.8 Effect of Carbonic Anhydrase Genotype on the Body Weight, Breast Girth and Tibia Length of the whole population of indigenous chicken and within the individual populations of Frizzle, Normal and Naked Neck 79

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS. 80

6.1 Summary 80

6.2 Conclusion 80

6.3 Recommendations 82

REFERENCES. 83

LIST OF TABLES

Table 3.1 Experimental chick, grower, layer and breeder rations 25

Table 3.2 Vaccination/Medication schedules from chicks to breeders stage 27

Table 4.1 The least square means and coefficient of variation for body weight(g), breast girth(cm) and tibia length(cm) of Frizzle, Normal and Naked Neck Indigenous Chickens from Day-old to 20 weeks of age 34

Table 4.2 Effect of Sex on Body Weight(g), Breast Girth(cm) and Tibia Length(cm) of the whole Population Indigenous Chickens. 36

Table 4.3 Transferrin Genotype, Genotypic and Allelic Frequencies of the Indigenous Frizzle, Normal and Naked Neck Chicken of Nigeria 39

Table 4.4 Haemoglobin Genotype, Genotypic and Allelic Frequencies of theFrizzle, Normal and Naked NeckIndigenous Chickens of Nigeria 42

Table 4.5 Carbonic Anhydrase Genotype, Genotypic and Allelic Frequency of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria 46

Table 4.6 Effect of Transferrin Genotype on the BodyWeight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of the Indigenous Chickens. 48

Table 4.7 Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population 50

Table 4.8 Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)within the Normal Indigenous Chicken Population 52

Table 4.9 Effect of Transferrin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)within the Naked Neck Indigenous Chicken Population 54

Table 4.10 Effect of Haemoglobin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of theIndigenous Chickens 56

Table 4.11 Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population 58

Table 4.12 Effect of Haemoglobin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population 60

Table 4.13 Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)within the Naked Neck Indigenous Chicken Population 62

Table 4.14 Effect of Carbonic Anhydrase Genotype on the Body Weight(g), Breast Girth(cm) and Tibia Length(cm) of the whole Population of the Experimental Indigenous Chickens 64

Table 4.15 Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm)within the Frizzle Indigenous Chicken Population 66

Table 4.16 Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population 68

Table 4.17 Effect of Carbonic Anhydrase Genotype on Body Weight(g), Breast Girth(cm) and Tibia Length(cm) within the Naked Neck Indigenous Chicken Population. . . .70

LIST OF PLATE

Plate 1: Sample electropherogram of the electrophoresis 30

CHAPTER ONE

1.0 INTRODUCTION

The local breeds of chicken also referred to as indigenous chickens are genetically adapted to harsh environment facing limited resources and severe challenges from climatic conditions, pathogens and predators (Mwacharo *et al.*, 2005; Sorenson, 2009). They are often utilized for several purposes simultaneously (Sorenson, 2009; Adeleke *et al.*, 2011a), and possess both superior levels of genetic diversity/variation relative to commercial breeds (which have been selected for a particular performance traits) and they have unique traits of valuable local adaptations (Sorenson, 2009). Some local chickens have special characteristics of potential interest to commercial breeders. Therefore, indigenous chickens could be genetic source for future breeding strategies (Horst, 1999).

Genetic or protein polymorphism results from variations in the proteins or specifically in the amino acids for which the same genes code in different individuals, strains, breeds (Rege and Okeyo, 2006; Kwaga, 2006). This is the occurrence of two or more discontinuous forms of protein in a species/population in such a proportion that the rarest phenotype which has a frequency of more than 0.1 percent cannot be maintained merely by recurrent mutation (Das and Deb, 2008). Protein polymorphism can be used to map (locate) genes such as those causing a disease, for economic traits, selection of superior animals for breeding purposes (Akpa *et al.*, 2011) and they can help match two samples of deoxyribonucleic acid (DNA) to determine if they come from the same source. In general, this variation in proteins can be used for the study of genetic diversity within a population's gene pool by applying two approaches viz; protein electrophoresis and protein

immunology, bearing in mind that the basic principle behind electrophoretic mobility of enzymes as well as other proteins is mobility across gels, which denotes differences in allelic groups responsible for amino acid variations in the protein (Rege and Okeyo, 2006).

Transferrin is a polymorphic blood protein found in the serum and in milk of animals (Steppa *et al*., 2009), it is synthesized at high levels in an egg laying bird and is secreted as a major component of the egg white gene (Lee *et al.*, 1980). Transferrin is characterized by the highest heterogeneity among all polymorphic blood proteins (Steppa *et al.*, 2009). Das and Deb (2008) reported that three types of alleles viz Tf^A, Tf^B and Tf^C were observed in chicken on the gel electrophoresis separation. The chickens with type 'Tf^B' have an advantage in egg production over the chickens with Tf^A. The effect of heterozygous transferrin (Tf^{BC}) appears to have significant variability in the fertility, hatchability and egg production (at least 90 days' production) and chicken with Tf^A have delayed sexual maturity while the chicken with the Tf^B has earlier age at sexual maturity.

Haemoglobin is an erythrocyte pigment, conjugated globins-prosthetic group, and also a polymorphic protein (Das and Deb, 2008). It carries oxygen and carbon dioxide (Das and Deb, 2008; Steppa *et al.*, 2009) and participates in maintenance of proper blood reaction (Steppa *et al*., 2009). Das and Deb (2008), reported three haemoglobin polymorphic forms, controlled by two autosomal alleles A_1 and A_2 with genotypic frequencies as 0.96 : 0.04 for White Leghorn, 1.00 : 0.00 for local fowl, 1.00 : 0.00 for Guinea fowl and 0.85 : 0.15 for Japanese quail. Haemoglobin polymorphism affects growth rate, hatchability and susceptibility of chicken to Marek's disease (Das and Deb, 2008). Steppa *et al*. (2009), however, reported that there were two codominant autosomal alleles, found in the beta-haemoglobin chain in sheep.

Carbonic anhydrase was not directly reported to affect weight of chicken, but, it was recognized to affect the transportation and utilization of haemoglobin in the body of chickens (Das and Deb, 2008), while haemoglobin is known to affect growth rate in chickens. The effect of the carbonic anhydrase on heamoglobin could therefore indirectly translate into effect on the growth rate of chickens.

1.1 Justification

In order to measure genetic diversity within and between breeds/strains, the field of molecular biology, particularly the application of molecular markers to study genetic diversity, has evolved very rapidly since the mid-1960s. The dominance of protein electrophoretic approaches to population genetics and evolutionary biology was, in the late 1970s, replaced by DNA analysis, primarily through the use of restriction enzymes, and in the 1980s by mitochondrial DNA analyses and DNA fingerprinting approaches (Rege and Okeyo, 2006). More recently, the introduction of PCR-mediated (polymerase chain reaction-mediated) DNA genotyping/sequencing has provided the first rapid and easy access to the ultimate genetic data (Miao *et al.*, 2013). Although DNA based technologies are now the methods of choice, it would be a mistake to conclude that DNA markers provide the ultimate solution. Several alternative assays, such as protein/allozyme polymorphisms (biochemical), remain tremendously useful, especially in developing countries, because of their utility, ease, cost and amount of genetic information accessed or simplicity of data interpretation (Rege and Okeyo, 2006).

To date, characterization of quantitative traits in livestock, especially in Nigeria has been based majorly on phenotype or on estimated breeding values (EBV) derived from

phenotype without proper knowledge on how many genes are actually playing effective role on the trait or knowing the specific effect of the individual genes, and thus the genetic foundation of traits is usually treated as "hidden actor" (Naqvi, 2007).

Transferrin could be obtained in blood serum, plasma and eggs of poultry (Frelinger, 1972; Jaayid *et al.,* 2011) and the polymorphic forms of it affects sexual maturity, while sexual maturity of an animal is a function of its growth, and it therefore has implication to detect performance in terms of weight gain. Haemoglobin polymorphism on the other hand has been directly linked to affect the growth rate and hatchability of chickens. The polymorphic nature of both transferrin and haemoglobin is said to be responsible for the differences observed in performances of the birds and could serve for evaluation and selection for improvement in genetic performance (Das and Deb, 2008). Carbonic anhydrase participate in the regulation of ion, water and acid-base balance, while some members of carbonic anhydrase gene family have been suggested to promote cell proliferation and act as trophic/growth factor (Karhuma, 2002). Therefore, by applying different biochemical – genetic markers like transferrin, haemoglobin, carbonic anhydrase; the individual animal and the population as a whole could be genetically well characterized in relation to their performance (Jaayid *et al.,* 2011).

This study therefore, was conducted to investigate the effect of biochemical polymorphisms on performance traits in indigenous chicken genotypes in order to know the basic genetic activities which contribute to the differences observed in terms of weight in the performance of Nigerian local chicken genotypes especially as research of this kind is limited in the country.

1.2 Hypotheses: This study was carried out to investigate the following null and alternative hypotheses:

H_0: Biochemical Polymorphic form of transferrin, haemoglobin and carbonic anhydrase in Nigerian local chickens of Normal feathered, Frizzle feathered and Naked Neck have no effect on performance traits.

H_A: Biochemical Polymorphic form of transferrin, haemoglobin and carbonic anhydrase in Nigerian local chickens of Normal feathered, Frizzle feathered and Naked Neck have effect on performance traits.

1.3 Objectives

This study was designed to address the following:

i. To examine the differences in weight between and within the Nigerian local chicken Normal feathered, Frizzle feathered and Naked Neck.
ii. To calculate the genotypic and allelic frequencies of transferrin, haemoglobin and/or carbonic anhydrase of the different genetic groups and of the whole population combined.
iii. To determine the effect of the polymorphic forms of transferrin, haemoglobin and carbonic anhydrase on growth performance of Normal feathered, Frizzle feathered and Naked neck Nigerian indigenous chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Domestication of Chicken

Chickens (*Gallus gallus domesticus*) were domesticated from red jungle fowl in Southeast Asia long before sixth millennium BC and only became established in China by < 6000BC. The domestic chicken were taken to Japan from China through Korea at about 3000BC – 3000AD. At 2000BC, domestic chickens were found in India either as a result of independent domestication activity or by influx from South-East Asia. While the iron age witnessed the spread of chicken throughout Europe, they were already noticed in some places during the Neolithic and early Bronze ages (West and Zhou, 1988). All domesticated animals fulfill one or another purpose to mankind. Chicken (*Gallus gallus domesticus*) as a domesticated animal and most widely distributed of the poultries plays lots of vital roles ranging from source of food, wealth, ornament to source of entertainment (Moiseyeva *et al*., 2003; Zeder, 2012; Miao *et al*., 2013).

2.2 The use of Chicken in Research and Development

The number of the domesticated animals is amazingly increasing in response to general human needs and demands. Chickens have found different uses in the area of general agriculture, religion, research, industrialization and many more fields - in general agriculture, it is believed that more than 50 billion chickens are reared annually as a source of food in terms of their meat and eggs (Johnson, 2012).

Chickens have long been partnered by man in the area of research, health (diseases, medicines and drugs), the discovery of blood circulation and transmission of diseases, the variation of animals under domestication, the realization of the chicken genome project and eventual detection and prediction of quantitative trait loci (QTL) which has led to the manifestation of many research ideas which were hitherto impossible. There has been great achievement in the mapping of QTL for susceptibility to Marek's diseases and also growth traits (Burt, 2007).

2.3 Tropical Indigenous Animal Genetic Resources (Tiangr)

Animal Genetic Resource (AnGR) is defined as all animal species, breed and strains (whether local or exotic, genetically improved or unimproved) that are of economic, scientific, and cultural interest to human kind in term of food and agricultural production for the present or the future (Rege and Okeyo, 2006). Several adverse production, environmental and cultural factors have tethered the ability of the tropical indigenous animal genetic resources from being competitively appreciated vis-à-vis their exotic counterparts. Without any argument, it is clear that the tropical animal genetic resources is rich and diverse, since most of the tropical animals serve dual purposes like meat and draft bulls, egg and meat chicken – no specialized production interest/use. In fact, the tropical indigenous poultry species symbolizes packs of genetic resources for livestock development due to the embedded extensive genetic diversity which allow for production of poultry under the tropical environmental conditions (which is naturally not very suited for the exotic poultry) providing many/different products and functions (Ajayi, 2010).

2.4 Management System and Distribution of Indigenous Chicken in Nigeria

It is really very difficult to state a correct figure of the number and distribution of indigenous chicken available in Nigeria. However, Adene and Oguntade (2008) reported that the poultry population as at 2002 was estimated to be 137, 679, 000 of which 115,880,864 (84%) constituted backyard indigenous chicken.

Many authors have used different words and phrases to describe two (2) major systems of indigenous chicken production namely, extensive (Abubakar *et al*., 2007; Petrus *et al.*, 2011; Hassan *et al*., 2012; Ochieng *et al.*, 2012) and semi-intensive (Mwalusanya *et al.*, 2002). Kperegbeyi *et al*., (2009) however, has on the contrary reported three management methods namely rural, the free range low input, backyard and semi-intensive husbandry system – to this last classification, it is good to understand that the "rural" is not a way of defining a system of indigenous chicken production, it is rather a description of where the indigenous chicken is found, just as well as the semi-intensive is located at backyard of the household. Consequently, there are presently two major methods of indigenous chicken production as stated earlier – the extensive and semi-intensive methods.

The extensive is a free range system characterized by low input and low output (Ochieng *et al.*, 2012) where the birds scavenge during the day. In a serious extensive management, housing may not be provided (Abubakar *et al*., 2007) and the birds are seen perching on trees, walls or at other corners of houses and tree roots (Hassan *et al*., 2012). There is little or no health management (Mwalusanya *et al.*, 2002, Abubakar *et al*., 2007, Hassan *et al.*, 2012; Ochieng *et al*., 2012). Some farmers may provide supplementary feed from home grown grains and household left over. In the semi-intensive system there is little provision

of health services, housing and better feeding regime – birds are treated with local herbs, or veterinary drugs or with human medicine when sick or show clinical signs of sickness (though no dosage for local herbs, which causes issue of concern, but the use of local herbs have been reported to have positive effect in production when compared to the farmer who do not use it or any other means of healthcare management (Petrus *et al.*, 2011). Housing is provided at the house backyard, some use thatched/mud houses which provides better protection for the birds against predators, harsh weather situation and theft. A better feeding/nutrition condition is provided in the semi-intensive method. Here, birds are always given grains as their houses are opened in the morning after which they go out for scavenging. There is also provision of watering points in or around their houses.

2.5 Growth of Indigenous Chicken

Most rapid rate of growth or weight gain is when the chick is young, and as it attains older ages, it grows or gains weight at a slower rate. The heavier the day-old chick, the heavier the pullet at 12 to 18 weeks, but the correlation is less at older ages and at 20 to 21 weeks of age, factors other than initial chick weight show their effect on body weight and variations in body weight cannot be associated with day-old weight (Mignon-Grasteau *et al.*, 1998; Nthimo, 2004).

Understanding the above issue therefore necessitates effort to model the growth curve in order to provide information which can be usefully employed for visualizing growth processes over time, and hence, the equation thereby formulated could be theoretically used to predict the expected weight of a group of animals at a particular age especially, since it is possible to make selection based on the shape of the curve (Nthimo, 2004; Norris *et al.*,

2007), bearing strongly in mind that growth parameters have been known to be highly heritable in nature and also have been successfully used in selection studies (Sengul and Kiraz, 2005; Norris *et al.*, 2007). It is unarguably believed that growth curve is a sigmoidal pattern by plotting live weight against age time (t) from conception (hatch) of animal till maturity and the sigmoidal curved shape can be influenced by many factors such as nutrition, environment, health, gender and genotype. When all these factors are optimum and homogenous, then the shape of the growth will only tell the hidden genetic potential for growth (Nthimo, 2004).

2.6 Comparison Between Indigenous (Unimproved) and Exotic (Improved) Chickens

Most farmers will compare the local indigenous animal with the improved exotic ones in terms of production ability. Obviously, the result of such direct comparison will be prejudice humiliation of the local indigenous animals in terms of their productive ability vis-à-vis the exotic animals. On the other hand, an objective comparison between these local indigenous and the improved exotic breeds will allow good understanding and to better appreciate the genetic potential of the local indigenous breeds as well as help to engineer better innovative ideas of developing and improving genetic make up of the local indigenous animals. In every sense of the words, there is nothing equitable between improved and unimproved, hence between indigenous and exotic chickens. The genetic improvement achieved today in the exotic chickens as broilers (meat type) and layers (egg types) started its selection journey as long as more than 50 years (Leeson and Summers, 2000). This process has even been perfected that genetic potential specificity into meat, egg production has been identified. In the case of the indigenous chicken, this has not been the

same. There has been little or no effort made to genetically select the best available chickens according to the needs of the people (meat, egg producer chickens) except what is selected and made available by nature (Rege and Okeyo, 2006; Sorenson, 2009; Adeleke *et al.*, 2011b; Worku *et al.*, 2012) which may not really produce to satisfy the need of the people.

Notwithstanding, based on environment, it was found out that the indigenous chicken has been technically favoured over the exotic, though when both are reared and practically assessed, the exotic physically will produce higher than the indigenous but the indigenous is said to demand less in terms of input at any level of assessment of both type of chickens. Furthermore, the indigenous is a multi-purpose producer, unlike the exotic (specialized producer), therefore, when we also assess the individual chicken as a multi-purpose producer, then will we obtain a satisfactorily fair comparison between the exotic and indigenous chicken types (Rege and Okeyo, 2006).

2.7 Traits of Economic Importance in Chicken

Economic trait was defined by (Dhakal *et al.*, 2011) as those traits which have monetary value in livestock and poultry production most of which can be said to be governed by many pairs of genes i.e polygenic traits or quantitative traits. Economic traits can be said therefore, to be traits for which selection programme is designed and maximized. In the 1960s, most selection programme capitalized on live weight but in modern times, it has been recognized (through complex physiological studies of the avian system and also due to new trend of demand from consumers) that, other factors which were not considered could contribute to an economic trait for example, feed conversion ability for live weight gain,

skeletal integration could help in weight build up for broilers or egg laying ability for layers and so on.

Rural poultry has been commended by many authors with its contribution to alleviate poverty, create job, and improve the nutrition of the poor famers (Zaman *et al*., 1991; Adene and Oguntade, 2008; Worku *et al.*, 2012; Johnson, 2012; Hassan *et al.*, 2012). Together with these attributes, indigenous chicken does not still rate very high in the mainstream national economy because of lack of quantitative record of its contribution to macro-economic indices such as gross domestic product (GDP), especially due to the fact that there is multiple function of indigenous chicken. However, the indigenous chickens are able to achieve the contributions due to their inherent trait which we termed traits of economic importance.

2.8 Linear Body Measurement in Chicken

There is correlation between some morphological traits of chicken which can be used to predict body weight from their orthogonal body shape (Yakubu *et al*., 2009) system. Morphometric measurement could be employed in differentiating individual animal size (Latshaw and Bishop, 2001; Ajayi *et al.*, 2008; Yakubu *et al*., 2009; Ogah, 2011). Traits such as body size and conformation are used extensively in assessing live market broilers. Therefore, a quantitative measure of conformation will for sure give access to genetic parameter for the trait to be estimated, at the same time make it possible to include selection for body conformation in breeding programme. Linear body measurement has also been reportedly used to predict live weight in poultry (Ogah, 2011).

Adeleke *et al.* (2011a) reported phenotypic correlation between body weight and linear body measurement even at day-old, though low, which increased to highest at 20 weeks, implying that the heritabilities are low for body weight and linear body measurement in the early period of growth in the Nigerian indigenous chickens.

2.9 Biotechnology in Animal Production

For about 10,000 years, farmers have been improving wild plants and animals through the selection and breeding of desirable characteristics. This breeding has resulted in the domesticated plants and animals that are commonly used in crop and livestock agriculture. In the twentieth century, breeding became more sophisticated, as the traits that breeders select for include increased yield, disease and pest resistance, drought resistance and enhanced flavour. Recently, scientists have learned enough to begin to identify and work with the genes (DNA) that are responsible for traits. Agricultural biotechnology is a collection of scientific techniques used to improve plants, animals and microorganisms. Based on an understanding of DNA, scientists have developed solutions to increase agricultural productivity. Starting from the ability to identify genes that may confer advantages on certain animals/crops, and the ability to work with such characteristics very precisely. Biotechnology enhances breeders' ability to make improvements in crops and livestock and it also enables improvements that are not possible with traditional crossing of related species alone (King'ori, 2011).

The existence of indicator traits and genetic markers as biotechnology tools in animal breeding and genetics is of relevance to the present study. Indicator traits are characteristics which are genetically correlated to traits of economic importance and are easier to measure

than the latter. Such traits are usually not the target of genetic improvements but provide an indirect means of improving a targeted trait. Indicator traits can improve genetic response by increasing accuracy of selection and reducing generation interval. Another simple technique is packed cell volume (PCV), an indication of the extent of anaemia, which is widely used as an indicator trait for pathological conditions associated with anaemia. For example, PCV is currently used at ILRAD and ILCA (International Livestock Centre for Africa) as an indicator of the effect of trypanosomiasis and hence of trypanotolerance, and at ILCA as an indicator of effect of the endoparasite *Haemonchus contortus* and hence as an indicator of resistance to the parasite (Rege and Okeyo, 2006).

A genetic marker for a trait on the other hand is a DNA segment which is associated with, and hence segregates in a predictable pattern as the trait. Genetic markers facilitate the "tagging" of individual genes or small chromosome segments containing genes which influence the trait of interest. Availability of large numbers of such markers has enhanced the likelihood of detection of major genes influencing quantitative traits. The method involves screening the genome for genes with a large effect on traits of economic importance through a procedure known as linkage analysis with the fact that, the chances of major genes existing for most traits of interest, and of finding them are considered to be high (Rege and Okeyo, 2006).

2.10 Electrophoresis

Electrophoresis is an electrochemical separation process in which molecules, such as protein or RNA/DNA fragments, are made to migrate through a specific substrate, such as a polyacrylamide gel, under the influence of an electric current. The technique has a wide

range of applications, in DNA sequencing and in studying variation in the identity and amount of proteins obtained from different sources. Techniques of image analysis and pattern recognition can be used to extract qualitative as well as quantitative information (Ye *et al*., 1999).

Animal breeders generally understand the need to identify differences among population or individuals and to monitor genetic changes. Hence, there is need to recognize the link between phenotypic differences, protein variation, and genetic variation inherited in a Mendelian manner (Aebersold *et al.*, 1987).

Five of the 20 common amino acids which make up proteins are charged; the charges of lysine, arginine, and histidine are positive, while those of aspartic acid and glutamic acid are negative. Thus, different proteins tend to exhibit different net electrical charges. Electrophoresis uses this physical-chemical property of proteins to separate mixtures of proteins on the basis of charge. If allelic differences (i.e. different forms of a gene) occur at a protein coding locus, the net charge of the protein often changes. Gel electrophoresis makes it possible to identify such allelic differences. The basic procedures of cellulose acetate electrophoresis includes a cellulose acetate paper in which introduced solutions of proteins are separated by passage of a direct electrical current through the paper carefully placed over a buffer solution. The rate of migration is determined by the absolute charge of the protein. A dye solution is added to the sample to mark the progress of electrophoresis. The final result of the electrophoretic procedure is bands, which identify the locations of the various forms of a single type of protein on the paper. The banding pattern of an individual contains information on that individual's genotype with respect to the locus (loci) coding for that particular protein (Utter *et al.*, 1987).

2.11 Polymorphism of Transferrin in Poultry

There have been reports of some research works that have been carried out with regards to transferrin polymorphism either with exotic, local or cross breeds of chickens. Ige and Salako (2013) reported that transferrin has six phenotypes (Tf^{AA}, Tf^{AB}, Tf^{BB}, Tf^{AC}, Tf^{BC} and Tf^{CC}) genetically controlled by three codominant alleles (Tf^{A}, Tf^{B} and Tf^{C}). Gene frequencies of Tf^{A}, Tf^{B} and Tf^{C} were 0.35, 0.2 and 0.43 in Yoruba ecotype chickens (YEC) and 0.21, 0.32 and 0.44 in Fulani ecotype chickens (FEC). While Genotype frequencies were 12.5%, 10%, 75%, 35%, 17.5% and 15% for Yoruba ecotype chickens (YEC) and 11.19%, 2.5%, 16.6%, 22.2% and 27.7% for Fulani ecotype chickens (FEC). Main clusters observed from the dendogram indicated 72% genetic similarity within Fulani ecotype chickens (FEC), 58% genetic similarity within Yoruba ecotype chickens (YEC) and 70% genetic similarity between Fulani ecotype chickens (FEC) and Yoruba ecotype chickens (YEC). They however reported that no genetic relationship existed between transferrin and phenotypic traits (sex, plumage colour and comb type).

Rashid (1982) reported that there was no regular correlation found between transferrin genotypes and age at maturity, egg number and egg weight, but the transferrin locus had an additive effect on body weight where the Tf^{B} allele was associated with a body weight superior to that of Tf^{A} allele at all ages. Zaman *et al*. (1991), who worked on transferrin polymorphism and growth rate up to 12 weeks in Rhode Island Red, Crossbred and Native chickens, categorized the transferrin forms into two types Tf^{BB} which was observed in all the samples and Tf^{BC}, which occurred only in crossbred and native chickens. This is to say that Rhode Island Red had only Tf^{BB} genes but not Tf^{CC} genes, while Tf^{BB} and Tf^{CC} genes were found in the crossbreds and natives. The gene frequency in Rhode Island Red was

Tf^{BB} = 1.00 and Tf^{CC} = 0.00, while the gene frequencies in the crossbreds and natives for Tf^{BB} genes were; 0.8854 and 0.783 and for Tf^{CC} genes were; 0.115 and 0.217 respectively. They however noted that frequency of Tf^{BB} was the highest in all types and that the difference between the correlated weight of the crossbreds Tf^{BB} and Tf^{BC} as affected by their genotypes was significant ($P<0.05$). Zaman *et al.* (1991) compared Tf^{BB} and Tf^{BC} genotypes within the crossbred at week 8, and reported that Tf^{BB} averagely weighed 265g while Tf^{BC} weighed 236g and at week 12, Tf^{BB} weighed 536g while the Tf^{BC} weighed 431g. The difference in weight clearly demonstrated the effect of transferrin genotype possessed by each group. Essa *et al.* (2014), reported no significant genetic variation between Arabic, Arabic Cross, Arabic-Lingnan and Kedu crossbred and equally in the local chicken crossbred (Abubakar *et al.,* 2014) with regards to transferrin locus. However, they reported that the transferrin locus was occupied by two codominant alleles with three genotypes. The gene frequency reported in Kedu (20 in number) were Tf^{AA} (0.45) and B (0.55) while the genotype frequencies were Tf^{AA} (1), Tf^{AB} (16) and Tf^{BB} (3). The gene and genotypic frequencies in Arabic cross (15) were Tf^{AA} (0.57) and Tf^{BB} (0.43) while the genotypic frequencies were Tf^{AA} (5), Tf^{AB} (7) and Tf^{BB} (3) and finally, for the Lingman (5), gene frequencies were Tf^{AA} (0.40) and Tf^{BB} (0.60) while the genotypic frequencies were Tf^{AA} (0), Tf^{AB} (4) and Tf^{BB} (1). Abubakar *et al.* (2014) reported that transferrin locus had two alleles Tf^{A} and Tf^{B} and 3 genotypes with most of the samples being heterozygotes.

Fowle *et al.* (1967), reported that transferrin genotypes in cows are under the influence of genetic control/and genotypic difference. This may influence or be related to milk production and fertility in cows. Naevdal and Haraldsvik (1966) reported that serum transferrin identified had a greater anodic movement than haemoglobin but less than any of

the other serum proteins and that two transferrin bands were commonly found designated as Tf^{AA} and Tf^{BB}.

It has been reported that not all cells/locus respond similarly to metabolic stimulation with respect to the biochemical enzyme concerned (de-Jong, 1993). In this regard, locus with large and significant correlations with growth rate synthesizes enzyme which function in protein catabolism better than the one which do not. The transferrin biochemical structure of individual animal of the same species (or different species) generally have fairly similar amino acid compositions (Guérin *et al.*, 1976; Ching-ming, 1984), as well as those of other biochemical enzymes e.g haemoglobin and carbonic anhydrase. However, the minor differences manifested in their amino acid compositions coupled with the variation in carbohydrate contents is the basis for differences in electrophoretic mobility (Ching-ming, 1984) and hence, the reason for polymorphism. Moreover, the basis for the association of weight to genotype is derived from individual differences in net energy status, particularly energetic costs of whole-body protein turnover, which thereafter indicates the phenotypic effects for example variation in growth rate (Richard *et al.*, 1988).

2.12 Polymorphism of Haemoglobin in Poultry

Ige *et al*. (2013b) reported that haemoglobin (Hb) had three genotypes: Hb^{AA}, Hb^{AB} and Hb^{BB} which were genetically controlled by two co-dominant alleles Hb^{A} and Hb^{B}. Allele frequencies of Hb^{A} and Hb^{B} in Yoruba ecotype chicken were 0.34 and 0.66, while those of Fulani ecotype were 0.28 and 0.72, respectively. The genotype frequencies of 12.5, 42.5 and 45% were recorded for Hb^{AA}, Hb^{AB}, Hb^{BB} respectively, for Yoruba ecotype chickens while Fulani ecotype chickens had 16.67, 22.2 and 61.11%, respectively. Hb^{AA} was lower

than Hb^{BB} in the two populations. Genetic similarity within ecotype indicated 60% in Fulani, 80% in Yoruba and 40% between Yoruba and Fulani at Hb locus. Genetic distance between the two Ecotypes was $2.1x10^{-2}$. He concluded that, the two populations were genetically related. Yakubu and Aya (2012) also reported two haemoglobin alleles Hb^{A} and Hb^{B} of distinctly different mobilities were observed. From the pattern of the bands, three genotypes (homozygous Hb^{AA}, Hb^{BB} and heterozygous Hb^{AB}) were observed. The genotype frequencies of Hb^{AA}, Hb^{AB} and Hb^{BB} were 0.59, 0.29 and 0.12; 0.61, 0.17 and 0.22; 0.67, 0.20 and 0.13 for cocks and 0.52, 0.27 and 0.21; 0.53, 0.40 and 0.07; 0.59, 0.30 and 0.11 for hens of normal feathered, naked neck and Fulani-ecotype chickens respectively. When the data of both sexes were pooled, the respective genotype frequencies were 0.54, 0.28 and 0.18; 0.58, 0.27 and 0.15; 0.62, 0.26 and 0.12 for Normal feathered, Naked Neck and Fulani-ecotype birds. The distribution of allele A appeared to be higher in the three chicken populations sampled. He reported Heterogeneity estimates to be 0.44, 0.41 and 0.38 for Normal feathered, Naked Neck and Fulani-ecotype chickens. However, the average amount of heterozygosity at haemoglobin locus was 0.41. Heterozygosity is a measure of genetic variation or gene diversity. Biological diversity, he said is exhibited both at the intrapopulation and interpopulation levels (Yakubu and Aya, 2012). Ajayi *et al.* (2013) however, put forward their findings that, out of the 15 Frizzle indigenous chickens sampled, 1 was Hb^{AA}, 3 Hb^{AB} and 11 Hb^{BB}. 20 Normal indigenous chicken sampled had 6 Hb^{AA}, 8 Hb^{AB} and 6 Hb^{BB} and 19 Naked Neck sampled recorded 4 Hb^{AA}, 5 Hb^{AB} and 10 Hb^{BB}. The Hb^{BB} was the most occurring genotype in all the groups of Normal, Naked Neck and Frizzle while Hb^{AB} was higher among Naked Neck. The pooled analysis showed that BB had the highest value of 50% followed by Hb^{AB} (23.32%) and then Hb^{AA} (20.37%). In terms of gene frequency, the Frizzle feathered chickens Hb^{BB} had a higher gene frequency of 0.83

compared to Hb^{AA} (0.17). The frequency for Hb^{AA} and Hb^{BB} in the Normal feathered chicken was 50:50, but Hb^{BB} was higher again in the Naked Neck (0.66) and 0.34 respectively. The authors further explained that the indigenous chickens in the Niger Delta are characterized into distinct group of Frizzled, Naked Neck and Normal feathered indigenous chickens. The population they said was in Hardy Weinberg equilibrium.

It was believed that genetic polymorphisms at two aminopeptidase loci have direct influences on protein metabolism, including associated influences on energy flux and animal condition. Energy costs associated with protein turnover play a clear role in determining the physiological and evolutionary consequences of genetic polymorphism. Reduced whole-body protein turnover consistently underlies lower energy expenditure and higher growth efficiencies (net energy balance per unit of energy absorbed). In turn, slower protein turnover, lower energy expenditure and/or higher growth efficiencies have been shown to represent the metabolic basis of positive associations between growth and polymorphic locus (Hawkins and Day,1999).

2.13 Polymorphism of Carbonic Anhydrase in Poultry

For the distribution of allele and allelic frequencies of Carbonic Anhydrase (CA), Ige *et al.* (2013) reported that it was comparable to those obtained with Hb and it was also interpreted into three phenotypes (CA^{FF}, CA^{FS} and CA^{SS}) which are genetically controlled by two co-dominant alleles CA^{F} and CA^{S}; their respective allele frequencies were 0.33 and 0.67 in Yoruba ecotype chicken and 0.24 and 0.76 in Fulani ecotype chicken. Genotype frequencies were 15, 35 and 50% in Yoruba ecotype and 8.33, 30.55 and 61.11% in Fulani ecotype for CA^{FF}, CA^{FS} and CA^{SS}, respectively. Generally, allelic frequency of CA^{F} allele

was low in the two populations studied compared to CA^S loci allele. Genetic similarity within ecotype indicated 60% in Fulani, 80% in Yoruba and 40% between Yoruba and Fulani at Hb locus while at CA locus, genetic similarity was 69% in Fulani ecotype, 50% in Yoruba ecotype and 42% between Yoruba and Fulani ecotype.

Ohwojakpor *et al.* (2012) reported that the averages of observed heterozygosity among loci were 0.5068, 0.5236 and 0.5755 for Naked Neck (NN), Normal Feathered (N) and Frizzle Feathered (F) chicken populations, respectively and the genetic distance estimates showed Normal and Frizzle chicken populations being closely related with genetic distance value of 0.5183. Genetic distance value (0.6177) intermediate and (0.6306) farthest were obtained for Normal vs. Naked Neck, and Frizzle vs. Naked Neck respectively. Their study however, revealed the existence of moderate genetic diversity in chicken populations studied.

2.14 Sexual Dimorphism in Chicken

Sexual dimorphism is a natural phenomenon in all growing animals, with a characteristic manifestation of visible differences in traits of growth between males and females of the same species (Laseinde and Oluyemi, 1996). Dimorphism is more evident in the near adults or fully matured adult animals (Frayer and Wolpoff, 1985; Badyaev, 2002). This is because many of the conduit organs of sexual dimorphism are normally triggered by sex hormones which take their full effect at puberty. It has been recorded that generally, males are more pronounced in any shared traits of interest than their female counterparts, that is to say; males grow larger and bigger. Laseinde and Oluyemi (1996) reported that male broilers had significantly higher body weight gains than the females especially at the finisher phase, adding that in local chicken, sexual dimorphism is observed in terms of body weight gains,

size, shape and behaviour. In addition, they explained the effect of sex on hatched body weight that it allows the males to possess heavier weight compared to the females. Ogah (2011) also testified that variation was noted between males and females turkey, in favour of the males as an expression of sexual dimorphism for all traits with the major difference being accounted for by the size. Alabi *et al.* (2012), who worked on body weight and linear body measurement in indigenous chicken in South Africa noted that the males were statistically heavier, had longer body, better body girth, wing length, shank thickness, and shank length than the female counterparts, Mignon-Grasteau *et al.* (1998) also reported the same result.

Ajayi *et al.* (2012) reported effect of sexual dimorphism on weight in turkeys with values ranging from 0.445 to 0.821 in toms and 0.053–0.660 in hens, respectively. Sola-Ojo *et al.* (2011) however, report that sex had no significant differences in body weight and body parts for both males and females chicken from day old to 4 weeks of age, but only at 8 weeks, with male chicken having higher values for body weight (452.81g) compared to that of female (331.18g), with body length 29.88cm versus (vs). 27.70cm, body girth (18.34cm vs. 15.58cm), wing length (16.66cm, vs. 15.04cm), drumstick length (9.58cm vs.8.74cm), keel length (7.56 cm vs. 6.16cm) thigh length (7.17cm vs. 6.77cm), shank length (7.08cm vs. 6.25cm) and shank diameter (0.49cm vs. 0.27cm).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Experiment

The research was conducted at the Poultry Unit, Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Samaru – Zaria, Kaduna State, which lies between latitude $11^{\circ}\ 09^{1}\ 06^{11}$ N and $7^{\circ}\ 38^{1}\ 55^{11}$E, at an altitude of 706m above sea level. (Ovimaps, 2012).

3.2 Source of Experimental Animal, Breeding and Management

Growing birds which served as the parent stock were sourced from Kogis State (Anyigba and Okene), Kaduna State (Shika and Sabon Gari markets) and Katsina State (Funtua). The birds were identified with individual wing tags. These birds were housed separately according to genotype on deep litter floor and treated against worms and lice. They were also vaccinated against Newcastle diseases. The birds were acclimatized to the environment for three weeks. Each genotype consisted a total of 30 hens and 6 cocks which were mated in the ratio of 1 cock to 5 hens.

Eggs were collected, pedigreed and hatched from the mating of Normal feathered, Frizzle feathered and Naked Neck of these growing Nigerian local cocks to their Normal feathered, Frizzle feathered and Naked Neck hens respectively to produce F_1 offspring.

3.3 Feeding

Feed was compounded to meet the nutrient requirements of the birds at all phases of growth and production. Growers diet was compounded for the foundation stock during the growing

phase. This diet was changed to layer (breeder) mash for the laying period. The hatched chicks were fed on chick mash for the chick stage and growers mash during the growers stage (Table 3.1). Feeds and water were given *ad libitum*.

Table 3.1: Experimental chick, grower, layer and breeder rations

Ingredients	Chick mash	Grower mash	Breeder mash
Maize %	45.00	34.45	43.45
Maize Offal %	10.00	10.00	10.00
Groundnut Cake %	13.05	10.00	13.50
Soya bean cake %	20.90	10.50	13.00
Wheat offal %	6.00	15.00	9.00
Rice offal %	0.00	15.00	0.00
Bone meal %	3.00	3.00	3.00
Limestone %	1.50	1.50	7.50
salt %	0.30	0.30	0.30
Premix %	0.25	0.25	0.25
Total	100.00	100.00	100.00
Calculated analysis			
M.E (Kcal/ kg DM)	2652.45	2400.18	2520.08
CP%	20.99	16.08	18.05
CF	5.97	10.82	5.74
EE	3.40	3.81	3.50
Ca	1.42	1.72	3.56
P	0.55	0.56	0.60
Lysine	0.90	0.70	0.80
Methionine	0.36	0.24	0.35

M.E- Metabolizable Energy; CP- Crude Protein; CF- Crude Fibre; EE- Ether Extract; Ca- Calcium; P- Phosphorus, DM = Dry Matter,

3.4 Mating Procedure

The mating was a pure mating in which males of Frizzle were mated to their female Frizzles, males of Normal feathered birds to females of Normal and males of Naked Neck mated to females of Naked Neck. There were 30 females in each group where there were 5 males. The mating ratio was 1male to 5females

3.5 Egg Collection

Laying nests were prepared, kept clean for the laying hens. Eggs were collected three times daily. This was to prevent cracking of the eggs. Eggs were collected separately according to the mating group. Each egg collected was identified according to breeding groups.

3.6 Incubation of Eggs and Management of Chicks

Eggs were incubated artificially in an automated electric incubator at the optimum temperature 37^0C, relative humidity of 60 – 65% and were turned hourly. Cracked and soiled eggs were removed. Eggs were fumigated in order to prevent microorganisms from invading the eggs during period of storage. Candling of the set eggs was done at day 18, in order to remove clear eggs without blood or tissue formation and dead embryo. Hatched chicks were collected separately according to genotype, counted, wing banded and weighed to the nearest 1g using Citizen weighing digital scale to determine the chick hatched weight on day "0". The birds were vaccinated against Newcastle, Gumboro and fowl-pox. Other routine medication and management operations that were carried out included anti-coccidial medication, deworming and delousing as shown on Table 3.2 below. Mortality was recorded. The birds were weighed on a weekly basis.

Table 3.2: Vaccination/Medication schedules from chicks to breeders stage

Age of bird	Vaccination/medication
Day 1 – 15	Anti stress
Day 10	IBDV – First dose
Day 24	IBDV – Second dose
Week 3	Coccidiostat
Week 4	NDI (L)
Week 6	Coccidiostat
Week 7	NDV (K) First dose + FPV
Week 8	Dewormer
Week 9 (for 5 days)	Coccidiostat
Week 12	Coccidiostat
Week 16	NDV (K) Second dose
Week 17 (for 1 day)	Dewormer

NDV (L) - Newcastle disease vaccine (Lasota); NDV (K) - Newcastle disease vaccine (Komorov); IBV – Infectious Bursal disease vaccine (Gumboro); FPV – Fowl pox vaccine

3.7 Data Collection

3.7.1 Growth parameters or traits

Data were collected on body weight, breast girth and tibia length and body weight gain was calculated.

3.7.2 Blood collection

At the age of 20weeks, a 5ml syringe was used to collect blood from the wing vein of each chicken into heparinized tubes each labeled according to the tag number of each bird. The tubes were kept inside cooler with ice packs. The bloods samples were taken to the biotechnology centre at University of Ibadan for electrophoretic analysis. The journey was made at night in order to lessen the effect of heat on the packs. On arrival, the blood samples were first centrifuged at 2,500 – 3,000 revolution per minute (rpm) for 10 minutes at 4^0C to separate the blood cells from the serum. The plasma obtained was stored at -80^0C till use. The blood cells were used for the electrophoretic analysis of haemoglobin, carbonic anhydrase while blood serum was used for the electrophoretic analysis of transferrin bands (RIKEN, 2006).

3.8 Preparation of Buffer and Other Solutions

Each of the biochemical markers has its specific buffer composition and concentration. This is outlined according to the standard procedure below (RIKEN, 2006).

Trasnferrin Buffer materials and condition

- Tris : 3.00g
- Glycine : 14.40g
- pH : 8.5

- Time (mins) : 15

Haemoglobin Buffer materials and condition

- Tris : 10.91g
- EDTA : 0.60g
- Boric acid : 3.10g
- pH : 8.4
- Time(mins) : 40

Carbonic Anhydrase Buffer materials and condition

- Sodium acetate trihydrate : 17.0g
- EDTA : 2.48g
- pH : 5.6
- Time(mins) : 45

Other general materials used were as listed below

- Filter paper
- Cellulose acetate paper
- Gloves
- Saline water
- Ponceau S
- Petri dishes
- Tissue roll
- Detergent

- Electrophoretic tank
- Fridge
- Pipette
- EDTA tubes

3.9 Electrophoresis of Blood Samples

About 0.6µl undiluted blood constituent was taken for centrifugation. After centrifugation, the blood serum was decanted from the cells. The prepared buffer was used as indicated for each of the biochemical markers and at their respective pH for the gel preparation. Each biochemical marker had its specific buffer chemicals and temperature range. These different chemicals have been shown above. Cellulose acetate membrane was used as a supporting media. The electrophoresis was carried out at a voltage of 150V for about 50minutes at a temperature of 4^0C. The migration of the genotype was from Cathode (-) to anode (+) as shown in plate 1 below.

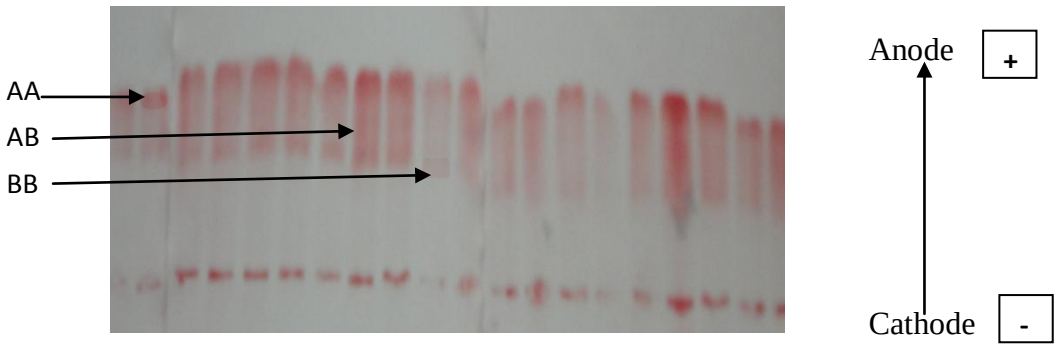


Plate 1: Sample electropherogram of the electrophoresis

The direct gene counting method as explained by Christensen, (2003) was then used to score the bands based on the separation of the electrophoretic mobility as follows:

- Fast moving band (homozygous, AA gene)

- Slow moving band (homozygous, BB gene)
- Any of a mixture midway between fast and slow (heterozygotes, AB gene)

After the electrophoresis was completed, each of the experimental bird was scored according to its band for each of the biochemical markers of transferrin, haemoglobin and carbonic anhydrase either fast (AA), midway (AB) or slow (BB).

3.10 Statistical Analysis

Data obtained were subjected to general linear model procedure of statistical analysis system (SAS, 2002) and significant means were separated using tukey honestly significant difference. Gene and genotypic frequencies were calculated using the Hardy Weinberg's equation by the expansion of the binomial equation below.

$$(p+q)^2 = p^2 + 2pq + q^2$$

Where p stands for the fast alleles and q for the slow types and pq is the midway (heterozygotes). Mendelian inheritance ratio for band (genotype) inheritance was tested using chi-square (χ^2) formula below.

$$\text{Chi-square } (\chi^2) = \frac{(Observed\ \ genotypefrequency\ \ -Expected\ \ Mendelian\ \ genotype\ \ frequency\ )^2}{Expected\ \ Mendelian\ \ genotype\ \ frequency}$$

The statistical model used for the association of blood polymorphic types with each traits was;

$$y_{ij} = \mu + b_i + e_{ij}$$

Where;

y_{ij} = Result of the observation

μ = The overall mean

b_i = Effect of particular biochemical genotype (either of transferrin, haemoglobin and or carbonic anhydrase)

e_{ij} = Residual error

The assumptions of this model is that

e_{ij} – NIID (0, σ^2) i. e it is normally independently and identically distributed, and

- There is no environmental effect or modification

CHAPTER FOUR

4.0 RESULTS

4.1 Body Weight and Body Linear Measurement

Table 4.1 shows least square means and coefficient of variation for body weight (g), body linear measurements (cm) of Frizzle, Normal and Naked Neck indigenous chicken from day old to 20 weeks of age. Significant differences ($P<0.05$) were observed in body weight among the genotype groups (Frizzle, Normal and Naked Neck) with Frizzle having the highest value from day-old to 8 weeks, closely followed by Normal and Naked Neck respectively. At 8 weeks, Frizzle had body weights of 338.54g which was significantly higher ($P<0.05$) than Normal 319.59g and Naked Neck 295.51g. At 20 weeks there was no significant ($P>0.05$) difference in body weight between the different genotypes studied. Breast girth and tibia length were not measured at day old. At 4 weeks, breast girth (BG_4) was 9.81(cm) for Frizzle which was significantly higher ($P<0.05$) than the Normal (9.30cm) and the Naked Neck (9.04cm). At 12 to 20 weeks, Naked Neck had significantly higher ($P<0.05$) values than Frizzle and Normal.

There was no significant difference ($P>0.05$) in the tibia length of the Normal (3.14cm) and Frizzle (3.12cm) at 4 weeks but were significantly different ($P<0.05$) from the Naked Neck (2.93cm). At 12 to 20 weeks, Naked Neck had significantly higher ($P<0.05$) values than Frizzle and Normal indigenous chickens.

Table 4.1: The least square means and coefficient of variation for body weight (g), breast girth (cm) and tibia length (cm) of Frizzle, Normal and Naked Neck Indigenous Chickens from Day-old to 20 weeks of age

Parameters	GENETIC GROUP			CV (%)	SEM	LOS
	F (No. = 37)	N (No. = 79)	NN (No. = 39)			
Day-old	25.97[a]	25.37[b]	24.21[c]	12.29	0.25	*
WT_4	109.70[a]	97.24[b]	91.97[c]	20.97	1.67	*
WT_8	338.540[a]	319.59[b]	295.51[c]	20.46	5.23	*
WT_{12}	590.84	583.11	571.56	22.42	10.48	NS
WT_{16}	734.73	714.51	727.82	22.11	12.84	NS
WT_{20}	1050.51	1081.90	1052.97	20.82	17.85	NS
BG_4	9.81[a]	9.30[b]	9.04[c]	8.78	0.07	*
BG_8	12.69[a]	12.48[b]	12.80[a]	8.64	0.09	*
BG_{12}	17.28[b]	17.33[b]	17.87[a]	8.91	0.12	*
BG_{16}	22.54[b]	21.08[c]	23.28[a]	11.34	0.20	*
BG_{20}	22.62[c]	25.30[b]	27.00[a]	9.27	0.19	*
TL_4	3.14[a]	3.12[a]	2.93[b]	10.87	0.03	*
TL_8	4.66	4.59	4.57	10.51	0.04	NS
TL_{12}	6.93[b]	6.96[b]	7.14[a]	11.31	0.06	*
TL_{16}	8.58[ab]	8.38[b]	8.67[a]	19.58	0.13	*
TL_{20}	9.27[b]	9.18[b]	9.62[a]	10.65	0.08	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. F = Frizzle Indigenous chicken, N = Normal, NN = Naked Neck, NS = Not significant, CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, WT = Weight, BG = Breast girth, TL = Tibia length

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.2 Effect of Sex on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole Population of the Indigenous Chickens.

Table 4.2 shows the effect of sex on the body weight (g), breast girth (cm) and tibia length (cm) of the combined population of the indigenous chickens. Sexual dimorphism really played a very strong role in body weight (WT), breast girth (BG) and tibia length (TL) measured. From day old to 20 weeks, it was evident that males had significantly higher values ($P<0.05$) than the females.

Table 4.2: Effect of Sex on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole Population of Indigenous Chickens.

Parameters	SEX		CV (%)	SEM	LOS
	MALE (No = 87)	FEMALE (No = 68)			
Day-old	26.72[a]	23.29[b]	10.50	0.21	*
WT_4	108.44[a]	86.68[b]	18.95	1.50	*
WT_8	347.66[a]	280.19[b]	18.08	4.62	*
WT_{12}	645.38[a]	501.03[b]	18.64	8.71	*
WT_{16}	800.82[a]	622.72[b]	18.33	10.64	*
WT_{20}	1168.79[a]	937.06[b]	17.75	15.21	*
BG_4	9.65[a]	8.98[b]	8.53	0.06	*
BG_8	12.95[a]	12.18[b]	8.14	0.08	*
BG_{12}	17.90[a]	16.89[b]	8.51	0.12	*
BG_{16}	22.31[a]	21.57[b]	12.00	0.21	*
BG_{20}	25.74[a]	24.24[b]	10.71	0.22	*
TL_4	3.19[a]	2.93[b]	10.32	0.08	*
TL_8	4.75[a]	4.41[b]	9.82	0.04	*
TL_{12}	7.25[a]	6.68[b]	10.60	0.06	*
TL_{16}	8.86[a]	8.04[b]	18.97	0.13	*
TL_{20}	9.59[a]	8.96[b]	10.26	0.08	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. F = Frizzle Indigenous chicken, N = Normal, NA = Naked Neck, NS = Not significant, CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, WT = Weight, BG = Breast girth, TL = Tibia length

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.3 Transferrin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria

Table 4.3 shows the transferrin genotype, genotypic and allelic frequency of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria. There existed three (3) genotypes viz; Tf^{AA}, Tf^{AB}, Tf^{BB}.

There were 37 Frizzle birds with 20 males and 17 females. The males had 1(Tf^{AA}), 19(Tf^{AB}) and 0(Tf^{BB}) genotypes, corresponding to a genotypic and allelic frequencies of 0.05, 0.95, 0.00 and 0.52, 0.48 respectively. The females had 1(Tf^{AA}), 14(Tf^{AB}), 2(Tf^{BB}) genotypes with genotypic and allelic frequencies of 0.06, 0.82, 0.12 and 0.47, 0.53 respectively. Overall frequencies of Frizzle birds were 2(Tf^{AA}), 33 (Tf^{AB}) and 2 (Tf^{BB}) with genotypic and allelic frequencies of 0.05, 0.90, 0.05 and 0.50, 0.50 respectively.

The Normal birds had a total of 79 birds, among which there were 43 males with 4(Tf^{AA}), 36(Tf^{AB}) and 3(Tf^{BB}) with genotypic frequencies of 0.09, 0.84 and 0.07 respectively while the allelic frequencies for Tf^{A} and Tf^{B} were 0.51 and 0.49 respectively. The females on the other hand were 36 with; 0(Tf^{AA}), 33(Tf^{AB}) and 0(Tf^{BB}) genotypes, genotypic frequencies 0.00, 1.00 and 0.00 respectively, and allelic frequencies for Tf^{A} and Tf^{B} were 0.50 and 0.50 respectively. The over all observed genotype for Normal feathered local chickens were 4(Tf^{AA}), 72(Tf^{AB}) and 3(Tf^{BB}), genotypic frequencies of 0.05, 0.91 and 0.04 for Tf^{AA}, Tf^{AB} and BB respectively and allelic frequencies for Tf^{A} and Tf^{B} as 0.51 and 0.49 respectively.

The Naked Neck however, had 39 birds with 24 males with an array of genotype as 2(Tf^{AA}), 21(Tf^{AB}) and 1(Tf^{BB}), genotypic frequencies of 0.08, 0.88 and 0.04 and allelic frequencies for Tf^{A} and B as 0.52 and 0.48 correspondingly. There were 15 female Naked necks on the other hand, with 0(Tf^{AA}), 14(Tf^{AB}) and 1(Tf^{BB}) genotypes with corresponding

genotypic frequencies as 0.00, 0.93 and 0.07 and the allelic frequencies for Tf^{A} and Tf^{B} were 0.47 and 0.53 respectively. Total observed genotypes for Naked Neck were 2(Tf^{AA}), 35(Tf^{AB}) and 2(Tf^{BB}) having genotypic frequencies of 0.05, 0.90 and 0.05 with allelic frequencies for Tf^{A} and B as 0.50 and 0.50 correspondingly.

The genotype, genotypic and allelic distribution could be described in terms of male and female composition of the population. A total of 87 males were present, with the following array of transferrin genotypes having 7(Tf^{AA}), 74(Tf^{AB}) and 4(Tf^{BB}), genotypic frequency as 0.08, 0.87 and 0.05 respectively while the corresponding allelic frequency for Tf^{A} and Tf^{B} wais 0.52 and 0.48. The total female population was 68 with transferrin genotype having 1(Tf^{AA}), 64(AB) and 3(Tf^{BB}) with genotypic frequency of 0.02, 0.94 and 0.04 respectively, while the allelic frequency for Tf^{A} and B was 0.49 and 0.51 respectively. The total population of males and females of the three groups (Frizzle, Normal and Naked Neck) indigenous chickens was 155 displaying Tf^{AA}, Tf^{AB} and Tf^{BB} to be 8, 140 and 7 respectively and corresponding genotypic frequency of 0.05, 0.90 and 0.05 while the allelic frequency for Tf^{A} and Tf^{B} was 0.50 each. Chi-square value of 5.99 at 2 degrees of freedom was the expected limit for which the calculated (observed) chi-square can be discriminated. The calculated chi-square value for the Frizzle population was 22.73, while that of Normal was 53.52, Naked Neck was 24.64 and the entire population was 98.78.

Table 4.3: Transferrin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria

Group	Sex	No.	Observed number of genotypes			Allelic frq(gene) = 1		Observed genotypic frq = 1			Chi-square (χ^2)
			Tf^{AA}	Tf^{AB}	Tf^{BB}	p	q	p^2	2pq	q^2	
Frizzle	Male	20	1	19	0	0.52	0.48	0.05	0.95	0.00	16.37
	Female	17	1	14	2	0.47	0.53	0.06	0.82	0.12	7.24
	Total	37	2	33	2	0.50	0.50	0.05	0.90	0.05	22.73
Normal	Male	43	4	36	3	0.51	0.49	0.09	0.84	0.07	19.61
	Female	36	0	36	0	0.50	0.50	0.00	1.00	0.00	36.00
	Total	79	4	72	3	0.51	0.49	0.05	0.91	0.04	53.52
Naked	Male	24	2	21	1	0.52	0.48	0.08	0.88	0.04	13.61
Neck	Female	15	0	14	1	0.47	0.53	0.00	0.93	0.07	11.48
	Total	39	2	35	2	0.50	0.50	0.05	0.90	0.05	24.64
Total Male		87	7	76	4	0.52	0.48	0.08	0.87	0.05	48.83
Total Female		68	1	64	3	0.49	0.51	0.02	0.94	0.04	53.14
Population Total		155	8	140	7	0.50	0.50	0.05	0.90	0.05	98.78

fre = Frequency

4.4: Haemoglobin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chickens of Nigeria.

Table 4.4 shows the haemoglobin genotype, genotypic and allelic frequencies of the Frizzle, Normal and Naked Neck Indigenous Chickens of Nigeria. There were three forms of genotypes for the haemoglobin polymorphism as Hb^{AA}, Hb^{AB} and Hb^{BB}. A total of thirty seven (37) Frizzled feathered indigenous chickens were used for the study. Twenty were males while seventeen (17) were females. The genotype distribution of the males were 11(Hb^{AA}), 9(Hb^{AB}) and 0(Hb^{BB}) with genotypic frequencies of 0.55, 0.45 and 0.00 respectively, while the allelic frequency for Hb^{A} and Hb^{B} were 0.78 and 0.22 respectively. Females (16) on the other hand had 0(Hb^{AA}), 9(Hb^{AB}) and 8(Hb^{BB}) genotype and the associated genotypic frequencies were 0.00, 0.53 and 0.47 respectively, while the allelic frequency for Hb^{A} and B were 0.26 and 0.74 respectively. The total genotype for the Frizzle chickens were 11(Hb^{AA}), 18(Hb^{AB}) and 8(Hb^{BB}) with associated genotypic frequencies of 0.30, 0.49 and 0.22, while the allelic frequency for Hb^{A} and Hb^{B} were 0.54 and 0.46 respectively.

The Normal feathered birds used for the analysis were 79 with 43 males and 36 females. The genotype distribution of the males were 16(Hb^{AA}), 15(Hb^{AB}) and 12(Hb^{BB}) with corresponding frequencies of 0.37, 0.35 and 0.28 while the allelic frequencies for Hb^{A} and Hb^{B} were 0.55 and 0.45. The female however had genotype distribution of 1(Hb^{AA}), 8(Hb^{AB}) and 27(Hb^{BB}) having genotypic frequencies of 0.03, 0.22 and 0.75 respectively. The total of 79 Normal birds recorded a genotype distribution of 17(Hb^{AA}), 23(Hb^{AB}) and 39(Hb^{BB}) with their registered genotypic frequencies as 0.22, 0.29 and 0.49 respectively. The allelic frequencies for Hb^{A} and Hb^{B} were 0.36 and 0.64.

Thirty-nine (39) Naked Neck (24 males and 15 females) formed the population for the study. The males had a genotype distribution of 16(Hb^{AA}), 7(Hb^{AB}) and 1(Hb^{BB}) with corresponding genotypic frequencies of 0.67, 0.29 and 0.04. The allelic frequencies however, were for Hb^{A} (0.81) and Hb^{B} (0.19). The female on the other hand had a genotype of 5(Hb^{AA}), 8(Hb^{AB}) and 2(Hb^{BB}) with genotypic distribution of 0.33, 0.53 and 0.13 correspondingly. The allelic frequencies for Hb^{A} and Hb^{B} were 0.60 and 0.40 respectively. Considering the entire population of Naked Neck, 21(Hb^{AA}), 15(Hb^{AB}) and 3(Hb^{BB}) and 0.54, 0.38 and 0.08 were reported as the genotype and genotypic frequencies respectively. The allelic frequencies for Hb^{A} and B were 0.73 and 0.27.

The number of males in the entire population were 87 having genotype of 43(Hb^{AA}), 31(Hb^{AB}) and 13(Hb^{BB}) with associated genotypic frequencies of 0.49, 0.36 and 0.15 respectively. The allelic frequency for Hb^{A} and B were 0.67 and 0.33 respectively. In the same way, the number of females were 68 with the genotype distribution of 6(Hb^{AA}), 25(Hb^{AB}) and 37(Hb^{BB}) and genotypic frequencies of 0.09, 0.37 and 0.54 respectively. The allelic frequencies for Hb^{A} and Hb^{B} were 0.27 and 0.73 respectively.

The haemoglobin polymorphism for the whole population were 155 with a genotype array of 49(Hb^{AA}), 56(Hb^{AB}) and 50(Hb^{BB}) having an associated genotypic frequencies of 0.32, 0.36 and 0.32 respectively while the allelic frequencies were 0.50 for both Hb^{A} and Hb^{B}.

The chi-square value of 5.99 at 2 degrees of freedom was the expected limit for which the calculated (observed) chi-square can be compared. The calculated chi-square value for the Frizzle population was 0.02, while that of Normal was 10.74, Naked Neck was 0.02 and the entire population was 11.93.

Table 4.4: Haemoglobin Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chickens of Nigeria

Group	Sex	No.	Observed number of genotype			Allelic frq(gene) = 1		Observed genotypic frq = 1			Chi-square (χ^2)
			Hb^{AA}	Hb^{AB}	Hb^{BB}	p	q	p^2	2pq	q^2	
Frizzle	Male	20	11	9	0	0.78	0.23	0.55	0.45	0.00	1.69
	Female	17	0	9	8	0.26	0.74	0.00	0.53	0.47	2.20
	Total	37	11	18	8	0.54	0.46	0.30	0.49	0.22	0.02
Normal	Male	43	16	15	12	0.55	0.45	0.37	0.35	0.28	3.77
	Female	36	1	8	27	0.14	0.86	0.03	0.22	0.75	0.18
	Total	79	17	23	39	0.36	0.64	0.22	0.29	0.49	10.74
Naked Neck	Male	24	16	7	1	0.81	0.19	0.67	0.29	0.04	0.04
	Female	15	5	8	2	0.60	0.40	0.33	0.53	0.13	0.19
	Total	39	21	15	3	0.73	0.27	0.54	0.38	0.08	0.02
Total Male		87	43	31	13	0.67	0.33	0.49	0.36	0.15	3.18
Total Female		68	6	25	37	0.27	0.73	0.09	0.37	0.54	0.35
Population Total		155	49	56	50	0.50	0.50	0.32	0.36	0.32	11.93

fre = Frequency

4.5: Carbonic Anhydrase Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chickens of Nigeria

Table 4.5 shows the genotype, genotypic and allelic distribution of all the different genotypes in respect to Carbonic Anhydrase. There were three polymorphic forms of Carbonic Anhydrase as CA^{AA}, CA^{AB} and CA^{BB}. The Frizzle chickens had a population of 37 with 20 males and 17 females. The males had genotypes distribution of 7(CA^{AA}), 12(CA^{AB}) and 1(CA^{BB}) with associated genotypic frequencies of 0.35, 0.60 and 0.05 while the allelic frequencies for CA^{A} and B were 0.65 and 0.35 respectively. The genotype of the 17 females on the other hand had 10(CA^{AA}), 6(CA^{AB}) and 1(CA^{BB}) with genotypic frequencies of 0.59, 0.35 and 0.06 respectively while the allelic frequencies for CA^{A} and CA^{B} were 0.76 and 0.24 accordingly. The Frizzled chicken population (37) had genotype distribution of 17(CA^{AA}), 18(CA^{AB}) and 2(CA^{BB}) corresponding to genotypic frequencies of 0.46, 0.49 and 0.05 while the allelic frequency for CA^{A} and CA^{B} were 0.70 and 0.30 respectively.

The Normal feathered chickens (79) consisting of 43 males had genotype distribution of 19(CA^{AA}), 20(CA^{AB}) and 4(CA^{BB}) with associated genotypic frequencies of 0.44, 0.47 and 0.09 accordingly and the allelic frequencies of 0.67(CA^{A}) and 0.33(CA^{B}), while the females (36) had genotype distribution of 10(CA^{AA}), 20(CA^{AB}) and 6(CA^{BB}) with associated genotypic frequencies of 0.28, 0.56 and 0.17 while the allelic frequencies for CA^{A} and CA^{B} were 0.56 and 0.44 respectively. The total population of the Normal feathered indigenous chickens had genotype distribution of 29(CA^{AA}), 40(CA^{AB}) and 10(CA^{BB}) with genotypic frequency of 0.37, 0.50 and 0.13 while the allelic frequency for CA^{A} and CA^{B} was 0.62 and 0.38 respectively.

The Naked Neck had total of 39 indigenous chickens with 24 males, with genotypes distribution of 10(CA^{AA}), 13(CA^{AB}) and 1(CA^{BB}) with associated genotypic frequencies of 0.42, 0.54 and 0.04 respectively while the allelic frequencies for CA^{A} and CA^{B} were 0.69 and 0.31 respectively. The females were 15 with genotype distribution as follow; 7(CA^{AA}), 8(CA^{AB}) and 0(CA^{BB}) with corresponding genotypic frequencies of 0.47, 0.53 and 0.00, while the allelic frequencies recorded 0.73 for CA^{A} and 0.27 for CA^{B}. The total population of Naked Neck (39) showed the following genotype distribution: 17(CA^{AA}), 21(CA^{AB}) and 1(CA^{BB}) with genotypic frequencies of 0.44, 0.54 and 0.02. The allelic frequencies for CA^{A} and CA^{B} were 0.71 and 0.29 respectively.

Observation on the carbonic anhydrase in terms of male and female constitution revealed that there were 87 males with genotype distribution of 36(CA^{AA}), 45(CA^{AB}) and 6(CA^{BB}) and associated genotypic frequency of 0.41, 0.52 and 0.07 respectively. The allelic frequencies recorded for CA^{A} and CA^{B} were 0.67 and 0.33 respectively. The total female population was 68, which had genotype distribution of 27(CA^{AA}), 34(CA^{AB}) and 7(CA^{BB}) with associated genotypic frequencies of 0.40, 0.50 and 0.10 respectively, while the allelic frequencies were 0.66 for CA^{A} and 0.34 for CA^{B}.

The grand total of the different groups was 155 which had genotype distribution of 63(CA^{AA}), 79(CA^{AB}) and 13(CA^{BB}) and genotypic frequencies of 0.41, 0.51 and 0.08 respectively. The allelic frequencies for CA^{A} and CA^{B} was 0.66 and 0.34 respectively.

Chi-square value of 5.99 at 2 degrees of freedom was the expected limit for which the calculated (observed) chi-square can be compared. The calculated chi-square value for the

Frizzle population was 1.00, while that of Normal was 0.44, Naked Neck was 3.39 and the entire population was 2.94.

Table 4.5: Carbonic Anhydrase Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria

Group	Sex	No	Observed number of genotype			Allelic Frq(Gene) = 1		Observed Genotypic Frq = 1			Chi-square (χ^2)
			CA^{AA}	CA^{AB}	CA^{BB}	p	Q	p^2	2pq	q^2	
F	Male	20	7	12	1	0.65	0.35	0.35	0.60	0.05	2.03
	Female	17	10	6	1	0.76	0.24	0.59	0.35	0.06	0.01
	Total	37	17	18	2	0.70	0.30	0.46	0.49	0.05	1.00
N	Male	43	19	20	4	0.67	0.33	0.44	0.47	0.09	0.15
	Female	36	10	20	6	0.56	0.44	0.28	0.56	0.17	0.56
	Total	79	29	40	10	0.62	0.38	0.37	0.50	0.13	0.44
NA	Male	24	10	13	1	0.69	0.31	0.42	0.54	0.04	1.63
	Female	15	7	8	0	0.73	0.27	0.47	0.53	0.00	1.98
	Total	39	17	21	1	0.71	0.29	0.44	0.54	0.02	3.39
Total Male		87	36	45	6	0.67	0.33	0.41	0.52	0.07	2.64
Total Female		68	27	34	7	0.65	0.35	0.40	0.50	0.10	0.61
Population Total		155	63	79	13	0.66	0.34	0.41	0.51	0.08	2.94

fre = frequency

4.6: Effect of Transferrin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of the Indigenous Chickens.

Table 4.6 shows the effect of transferrin genotype on body weight (g), breast girth (cm) and tibia length (cm) on the whole population of the Indigenous Chickens. Three polymorphic forms of transferrin were recognized via Tf^{AA}, Tf^{AB} and Tf^{BB} with two allelic types: Tf^{A} and Tf^{B}. The Tf^{AA} genotype performed significantly highest ($P<0.05$) than the Tf^{AB} and Tf^{BB} for day old body weight in the following order Tf^{AA} (31.36g), Tf^{AB} (24.92g), and Tf^{BB} (24.14g). The same trend was observed for 4 weeks body weight Tf^{AA} (135.63g), Tf^{AB} (96.98g) and BB (95.14g); 8 weeks body weight for Tf^{AA} (423.25g), Tf^{AB} (312.71g) and Tf^{BB} (304.71g); 12 weeks body weight for Tf^{AA} (791.00g), Tf^{AB} (572.32g) and Tf^{BB} (537.86g); 16 weeks body weight for Tf^{AA} (996.38g), Tf^{AB} (709.31g) and Tf^{BB} (677.29g) and finally, for 20 week body weight, Tf^{AA} (1434.75g), Tf^{AB} (1047.11g) and Tf^{BB} (1047.43g).

Significant differences ($P<0.05$) were observed in breast girth (BG) and tibia length (TL) among the transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) from 4 to 20 weeks with Tf^{AA} having the highest values closely followed by Tf^{AB} and Tf^{BB} respectively.

Table 4.6: Effect of Transferrin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of the Indigenous Chickens.

Parameter	TRANSFERRIN GENOTYPES			CV (%)	SEM	LOS
	Tf^{AA}	Tf^{AB}	Tf^{BB}			
Day-old	31.36^{a}	24.92^{b}	24.14^{c}	11.14	0.23	*
WT_4	135.63^{a}	96.98^{b}	95.14^{b}	20.15	1.60	*
WT_8	423.25^{a}	312.71^{b}	304.71^{b}	19.52	4.99	*
WT_{12}	791.00^{a}	572.32^{b}	537.86^{c}	20.76	9.71	*
WT_{16}	996.38^{a}	709.31^{b}	677.29^{c}	20.25	11.75	*
WT_{20}	1434.75^{a}	1047.11^{b}	1047.43^{b}	19.23	16.48	*
BG_4	10.28^{a}	9.31^{b}	9.32^{b}	8.98	0.07	*
BG_8	13.46^{a}	12.57^{b}	12.35^{c}	8.56	0.09	*
BG_{12}	18.63^{a}	17.41^{b}	17.07^{c}	8.87	0.12	*
BG_{16}	22.61^{a}	22.03^{c}	20.31^{b}	12.02	0.21	*
BG_{20}	26.34^{a}	25.04^{b}	24.43^{c}	11.08	0.22	*
TL_4	3.25^{a}	3.07^{b}	3.00^{c}	11.11	0.03	*
TL_8	4.94^{a}	4.59^{b}	4.51^{b}	10.39	0.04	*
TL_{12}	7.56^{a}	6.98^{b}	6.73^{c}	11.19	0.06	*
TL_{16}	9.51^{a}	8.46^{b}	8.19^{c}	19.42	0.13	*
TL_{20}	10.06^{a}	9.23^{b}	9.16^{b}	10.66	0.08	*

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

$WT_{4\text{-}20}$ = body weight for week 4, 8, 12, 16 and 20 weeks respectively

$BG_{4\text{-}20}$ = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

$TL_{4\text{-}20}$ = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.7: Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population

Table 4.7 shows effect of transferrin genotypes on body weight (g), breast girth (cm) and tibia length (cm) of the Frizzle indigenous chicken population. From 4 to 20 weeks of the experiment, there were significant differences ($P<0.05$) in body weight observed among the Frizzle transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) with Tf^{AA} having the highest values closely followed by Tf^{AB} and then Tf^{BB}.

Significant differences ($P<0.05$) were also observed in breast girth and tibia length among the transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) with Tf^{AA} having the highest values closely followed by Tf^{AB} and lastly by Tf^{BB}.

Table 4.7: Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population

Parameter	TRANSFERRIN GENOTYPES			CV (%)	SEM	LOS
	Tf^{AA}	Tf^{AB}	Tf^{BB}			
Day-old	31.00[a]	26.00[b]	20.50[c]	12.95	0.55	*
WT_4	119.00[a]	111.27[b]	74.50[c]	14.25	2.57	*
WT_8	367.50[a]	342.82[b]	239.00[c]	13.04	7.26	*
WT_{12}	704.50[a]	600.79[b]	313.00[c]	20.81	20.21	*
WT_{16}	901.50[a]	744.42[b]	408.00[c]	24.16	29.19	*
WT_{20}	1235.00[a]	1059.24[b]	722.00[c]	17.63	30.44	*
BG_4	10.40[a]	9.82[b]	9.15[c]	6.94	0.11	*
BG_8	12.65[a]	12.77[a]	11.48[b]	6.58	0.14	*
BG_{12}	18.25[a]	17.40[b]	14.40[c]	8.65	0.25	*
BG_{16}	23.90[a]	22.68[b]	18.90[c]	14.14	0.52	*
BG_{20}	24.00[a]	22.69[b]	20.05[c]	11.59	0.43	*
TL_4	3.20[a]	3.16[a]	2.65[b]	8.79	0.05	*
TL_8	4.85[a]	4.67[b]	4.25[c]	8.78	0.07	*
TL_{12}	7.70[a]	6.99[b]	5.60[c]	12.29	0.14	*
TL_{16}	9.70[a]	8.62[b]	6.70±2.14[c]	35.25	0.50	*
TL_{20}	10.45[a]	9.24[b]	8.55±0.78[c]	11.83	0.18	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different (P<0.05) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.8: Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population

Table 4.8 shows the effect of Transferrin Genotypes on Body Weight, Breast Girth and Tibia Length within the Normal Indigenous Chicken Population. There were significant differences ($P<0.05$) in weight among the transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) from day old to 20 weeks with Tf^{AA} having the highest values closely followed by Tf^{BB} and lastly by Tf^{AB}.

Breast girth for 4 and 8 weeks revealed that Tf^{AA} (10.45cm, 13.63cm) and Tf^{BB} (10.40cm, 13.67cm) were similar ($P>0.05$) but significantly different ($P<0.05$) from Tf^{AB} (9.19cm, 12.36cm). At 16 and 20 weeks, significant differences ($P<0.05$) were observed in the breast girth among the Normal transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) with Tf^{AA} having the highest values while the Tf^{AB} and Tf^{BB} have no definite pattern of differences in values. At 20 weeks Tf^{BB} showed significant difference ($P<0.05$) from Tf^{AB} and Tf^{BB} which were similar ($P>0.05$). Significant differences ($P<0.05$) were observed in the tibia length among the Normal transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) with Tf^{BB} having the highest values closely followed by Tf^{AA} and lastly by Tf^{AB}.

Table 4.8: Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population

	TRANSFERRIN GENOTYPES					
Parameter	**Tf^{AA}**	**Tf^{AB}**	**Tf^{BB}**	**CV (%)**	**SEM**	**LOS**
Day-old	32.00^{a}	24.82^{c}	29.67^{b}	9.43	0.27	*
WT_4	143.00^{a}	93.19^{c}	133.33^{b}	17.71	1.94	*
WT_8	449.50^{a}	307.75^{c}	430.67^{b}	18.44	6.63	*
WT_{12}	837.50^{a}	560.74^{c}	781.00^{b}	19.37	12.71	*
WT_{16}	1031.25^{a}	685.61^{c}	985.67^{b}	16.63	13.37	*
WT_{20}	1545.25^{a}	1041.21^{c}	1440.67^{b}	19.50	23.74	*
BG_4	10.45^{a}	9.19^{b}	10.40^{a}	8.86	0.09	*
BG_8	13.63^{a}	12.36^{b}	13.67^{a}	8.78	0.12	*
BG_{12}	19.65^{a}	17.17^{c}	18.20^{b}	8.76	0.17	*
BG_{16}	22.18^{a}	21.07^{b}	19.93^{c}	11.53	0.27	*
BG_{20}	25.58^{b}	25.18^{b}	27.80^{a}	9.20	0.26	*
TL_4	3.20^{b}	3.10^{c}	3.47^{a}	10.98	0.04	*
TL_8	4.83^{b}	4.56^{c}	4.97^{a}	10.20	0.05	*
TL_{12}	7.23^{b}	6.90^{c}	7.97^{a}	10.12	0.08	*
TL_{16}	9.30^{a}	8.28^{b}	9.47^{a}	10.79	0.10	*
TL_{20}	9.43^{a}	9.15^{b}	9.53^{a}	10.59	0.11	*

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.9: Effect of Transferrin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Naked Neck Indigenous Chicken Population

Table 4.9 shows the effect of transferrin genotypes on body weight, breast girth and tibia length within the Naked Neck indigenous chicken population. From day old to 20 weeks, Tf^{AA} ranged from 30.50g to 1413.50g, while Tf^{AB} ranged from 24.11g to 1047.80g and Tf^{BB} from 19.50g to 783.00g. Significant differences ($P<0.05$) were observed in body weight among the transferrin genotypes (Tf^{AA}, Tf^{AB} and Tf^{BB}) with Tf^{AA} having the highest value closely followed by Tf^{AB} and lastly by Tf^{BB}.

The breast girth ranged from 9.80cm to 30.20cm for Tf^{AA}, 9.06cm to 26.98cm for Tf^{AB} and 7.90cm to 23.75cm for Tf^{BB}. The breast girth showed significant differences ($P<0.05$) at 4 and 8 weeks, with Tf^{AA} having the highest values closely followed by Tf^{AB} and then Tf^{BB}, while at 12 weeks, the Tf^{AB} and Tf^{BB} were similar ($P>0.05$) but were significantly different ($P<0.05$) from Tf^{AA}. There was no significant difference ($P>0.05$) in breast girth among the transferrin (Tf^{AA}, Tf^{AB} and Tf^{BB}) genotypes at 16 weeks while at 20 weeks, Tf^{AA} was again significantly different ($P>0.05$) from Tf^{AB} and Tf^{BB}.

There were significant differences ($P<0.05$) observed in tibia length among the transferrin genotype of Naked Neck (Tf^{AA}, Tf^{AB} and Tf^{BB}) from 4 to 20 weeks with Tf^{AA} having the highest values closely followed by Tf^{AB} and lastly by Tf^{BB}.

Table 4.9: Effect of Transferrin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Naked Neck Indigenous Chicken Population

Parameter	TRANSFERRIN GENOTYPES			CV (%)	SEM	LOS
	Tf^{AA}	Tf^{AB}	Tf^{BB}			
Day-old	30.50^{a}	24.11^{b}	19.50^{c}	8.50	0.33	*
WT_4	137.50^{a}	91.29^{b}	58.50^{c}	19.79	2.92	*
WT_8	426.50^{a}	294.54^{b}	181.50^{c}	19.26	9.11	*
WT_{12}	784.50^{a}	569.31^{b}	398.00^{c}	17.46	15.98	*
WT_{16}	1021.50^{a}	724.97^{b}	484.00^{c}	16.06	18.72	*
WT_{20}	1413.50^{a}	1047.80^{b}	783.00^{c}	14.99	25.27	*
BG_4	9.80^{a}	9.06^{b}	7.90^{c}	8.27	0.12	*
BG_8	13.95^{a}	12.83^{b}	11.25^{c}	8.66	0.18	NS
BG_{12}	16.95^{b}	17.91^{a}	18.05^{a}	7.80	0.22	NS
BG_{16}	22.20	22.40	22.30	7.34	0.27	NS
BG_{20}	30.20^{a}	26.98^{b}	23.75^{c}	6.10	0.26	*
TL_4	3.40^{a}	2.92^{b}	2.65^{c}	11.32	0.05	NS
TL_8	5.25^{a}	4.56^{b}	4.10^{c}	11.95	0.09	NS
TL_{12}	8.10^{a}	7.15^{b}	6.00^{c}	10.48	0.12	*
TL_{16}	9.75^{a}	8.67^{b}	7.75^{c}	9.95	0.14	NS
TL_{20}	10.95^{a}	9.57^{b}	9.20^{c}	9.21	0.14	NS

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.10: Effect of Haemoglobin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole Population of Indigenous Chicken.

Table 4.10 shows the effect of haemoglobin genotype on the body weight, breast girth and tibia length of the combined population of indigenous chicken. At day old, Hb^{AA} group with average body weight of (28.18g) was significantly higher ($P<0.05$) than Hb^{AB} (24.73g) and Hb^{BB} (22.86g). This trend of significant differences ($P<0.05$) observed in body weight among haemoglobin genotype (Hb^{AA}, Hb^{AB} and Hb^{BB}) continued till the end of the experiment with Hb^{AA} having the highest values closely followed by Hb^{AB} and lastly by Hb^{BB}. Significant differences ($P<0.05$) were observed in breast girth (BG) and tibia length among the haemoglobin genotype with Hb^{AA} having the highest values followed by Hb^{AB} and lastly followed by Hb^{BB}.

Table 4.10: Effect of Haemoglobin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole Population of Indigenous Chicken

	HAEMOGLOBIN GENOTYPES					
Parameters	**Hb^{AA}**	**Hb^{AB}**	**Hb^{BB}**	**CV (%)**	**SEM**	**LOS**
Day-old	28.18^{a}	24.73^{b}	22.86^{c}	9.10	0.18	*
WT_4	119.49^{a}	96.29^{b}	81.62^{c}	15.50	1.23	*
WT_8	381.88^{a}	308.23^{b}	266.52^{c}	14.91	3.81	*
WT_{12}	717.14^{a}	567.13^{b}	466.38^{c}	14.08	6.58	*
WT_{16}	897.37^{a}	696.02^{b}	581.36^{c}	13.09	7.60	*
WT_{20}	1296.43^{a}	1029.59^{b}	884.46^{c}	13.63	11.68	*
BG_4	9.86^{a}	9.38^{b}	8.84^{c}	8.16	0.06	*
BG_8	13.48^{a}	12.43^{b}	11.96^{c}	7.15	0.07	*
BG_{12}	18.61^{a}	17.28^{b}	16.52^{c}	7.57	0.11	*
BG_{16}	23.51^{a}	21.83^{b}	20.67^{c}	10.97	0.19	*
BG_{20}	26.75^{a}	24.61^{b}	23.98^{c}	10.13	0.20	*
TL_4	3.23^{a}	3.09^{b}	2.90^{c}	10.34	0.03	*
TL_8	4.93^{a}	4.52^{b}	4.37^{c}	9.23	0.03	*
TL_{12}	7.56^{a}	6.95^{b}	6.50^{c}	9.59	0.05	*
TL_{16}	9.04^{a}	8.63^{b}	7.82^{c}	18.73	0.13	*
TL_{20}	9.95^{a}	9.20^{b}	8.81^{c}	9.60	0.07	*

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

$WT_{4\text{-}20}$ = body weight for week 4, 8, 12, 16 and 20 weeks respectively

$BG_{4\text{-}20}$ = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

$TL_{4\text{-}20}$ = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.11: Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population

Table 4.11 shows the effect of haemoglobin genotypes on body weight (g), breast girth (cm) and tibia length (cm) within the Frizzle indigenous chicken population. From day old to 20 weeks, Hb^{AA} had values ranging from (30.18g to 1292.91g), Hb^{AB} (25.17g to 1014.17g) and Hb^{BB} (22.00g to 799.00g). Significant differences ($P<0.05$) were observed in body weight among the haemoglobin genotypes (Hb^{AA}, Hb^{AB} and Hb^{BB}) with Hb^{AA} having the highest values closely followed by Hb^{AB} and lastly by Hb^{BB}.

Significant differences ($P<0.05$) were also observed in breast girth and tibia length among the Frizzle haamoglobin genotypes (Hb^{AA}, Hb^{AB} and Hb^{BB}) with Hb^{AA} having the highest values closely followed by Hb^{AB} and lastly by Hb^{BB} throughout the period of the experiment.

Table 4.11: Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population

	HAEMOGLOBIN GENOTYPES					
Parameters	**Hb^{AA}**	**Hb^{AB}**	**Hb^{BB}**	**CV (%)**	**SEM**	**LOS**
Day-old	30.18^{a}	25.17^{b}	22.00^{c}	8.41	0.36	*
WT_4	130.27^{a}	107.78^{b}	85.75^{c}	6.51	1.17	*
WT_8	398.73^{a}	329.17^{b}	276.88^{c}	6.51	3.63	*
WT_{12}	738.27^{a}	596.33^{b}	375.75^{c}	8.60	8.35	*
WT_{16}	960.18^{a}	711.44^{b}	477.123^{c}	11.53	13.93	*
WT_{20}	1292.91^{a}	1014.17^{b}	799.00^{c}	8.58	14.81	*
BG_4	10.30^{a}	9.84^{b}	9.08^{c}	5.62	0.09	*
BG_8	13.39^{a}	12.49^{b}	12.18^{c}	5.84	0.12	*
BG_{12}	18.68^{a}	17.32^{b}	15.26^{c}	6.33	0.18	*
BG_{16}	25.13^{a}	22.03^{b}	20.13^{c}	12.06	0.45	*
BG_{20}	25.11^{a}	22.42^{b}	19.65^{c}	8.00	0.30	*
TL_4	3.34^{a}	3.13^{b}	2.88^{c}	7.92	0.04	*
TL_8	4.86^{a}	4.62^{b}	4.46^{c}	8.48	0.06	*
TL_{12}	7.44^{a}	7.13^{b}	5.79^{c}	9.72	0.11	*
TL_{16}	9.05^{a}	9.06^{a}	6.84^{b}	34.02	0.48	*
TL_{20}	9.92^{a}	9.29^{b}	8.34^{c}	10.65	0.16	*

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.12: Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population

Table 4.12 shows the effect of haemoglobin genotypes on body weight (g), breast girth (cm) and tibia length (cm) within the Normal indigenous chicken population. From the day old weight (WT_0) till the end of the experiment at 20 weeks (WT_{20}), the Hb^{AA} performed significantly higher ($P<0.05$) with values (29.59g, 127.35g, 420.06g, 773.24g, 940.00g and 1432.12g), than Hb^{AB} (25.78g, 100.17g, 328.74g, 600.48g, 726.96g and 1116.17g) and Hb^{BB} (23.28g, 82.38g, 270.41g, 490.00g, 608.87g, and 909.03g).

For the breast girth, Hb^{AA} was significantly higher ($P<0.05$) than Hb^{AB} and Hb^{BB} at 4, 8 and 12 weeks. At 16 and 20 weeks, Hb^{AA} and Hb^{AB} genotypes were similar ($P>0.05$) but both significantly different ($P<0.05$) from Hb^{BB}.

Significant differences ($P<0.05$) were observed in tibia length among the Normal haemoglobin genotypes (Hb^{AA}, Hb^{AB} and Hb^{BB}) with Hb^{AA} having the highest values closely followed by Hb^{AB} and lastly by Hb^{BB}.

Table 4.12: Effect of Haemoglobin Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population

Parameters	HAEMOGLOBIN GENOTYPES			CV (%)	SEM	LOS
	Hb^{AA}	Hb^{AB}	Hb^{BB}			
Day-old	29.59^{a}	25.78^{b}	23.28^{c}	6.58	0.19	*
WT_4	127.35^{a}	100.17^{b}	82.38^{c}	12.80	1.40	*
WT_8	420.06^{a}	328.74^{b}	270.41^{c}	11.94	4.29	*
WT_{12}	773.24^{a}	600.48^{b}	490.00^{c}	12.78	8.38	*
WT_{16}	940.00^{a}	726.96^{b}	608.87^{c}	10.79	8.68	*
WT_{20}	1432.12^{a}	1116.17^{b}	909.03^{c}	12.85	15.65	*
BG_4	10.12^{a}	9.42^{b}	8.88^{c}	8.06	0.08	*
BG_8	13.52^{a}	12.53^{b}	11.9^{c}	7.89	0.11	*
BG_{12}	18.85^{a}	17.36^{b}	16.65^{c}	7.39	0.15	*
BG_{16}	21.70^{a}	21.36^{a}	20.65^{b}	11.45	0.27	NS
BG_{20}	25.98^{a}	25.52^{a}	24.87^{b}	9.24	0.26	NS
TL_4	3.35^{a}	3.26^{b}	2.93^{b}	9.50	0.03	*
TL_8	5.02^{a}	4.63^{b}	4.38^{c}	8.82	0.05	*
TL_{12}	7.64^{a}	6.97^{b}	6.66^{c}	9.10	0.07	*
TL_{16}	9.02^{a}	8.52^{b}	8.02^{c}	10.36	0.10	*
TL_{20}	9.85^{a}	9.12^{b}	8.92^{b}	9.85	0.10	*

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.13: Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Naked Neck Indigenous Chicken Population

Table 4.13 shows the effect of haemoglobin genotypes on body weight (g), breast girth (cm) and tibia length (cm) within the Naked Neck indigenous chicken population. The chickens with Hb^{AA} was significantly different ($P<0.05$) from Hb^{AB} and Hb^{BB} throughout the experiment. However, Hb^{AB} was significantly different ($P<0.05$) from Hb^{BB} for day old, 4 and 16 weeks body weights while there was no significant difference ($P>0.05$) between Hb^{AB} and Hb^{BB} for 8, 12 and 20 weeks body weights.

Significant differences ($P<0.05$) were observed in breast girth and tibia length among the Naked Neck haemoglobin genotypes (Hb^{AA}, Hb^{AB} and Hb^{BB}) with Hb^{AA} having the highest values closely followed by Hb^{AB} and lastly by Hb^{BB} throughout the experiment except at 12 weeks, when Hb^{AA} breast girth was similar ($P>0.05$) to BB and significantly different ($P<0.05$) from Hb^{AB} which was the least.

Table 4.13: Effect of Haemoglobin Genotypes on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within Naked Neck Indigenous Chicken Population.

Parameters	HAEMOGLOBIN GENOTYPES			CV (%)	SEM	LOS
	Hb^{AA}	Hb^{AB}	Hb^{BB}			
Day-old	26.00^{a}	22.60^{b}	19.67^{c}	7.16	0.28	*
WT_4	107.48^{a}	76.53^{b}	60.67^{c}	14.91	2.20	*
WT_8	342.14^{a}	251.67^{b}	188.33^{b}	14.71	6.96	*
WT_{12}	660.67^{a}	480.93^{b}	401.00^{b}	10.61	9.71	*
WT_{16}	829.95^{a}	630.07^{b}	501.67^{c}	11.85	13.81	*
WT_{20}	1188.43^{a}	915.33^{b}	793.00^{b}	10.39	17.51	*
BG_4	9.42^{a}	8.77^{b}	7.73^{c}	7.03	0.10	*
BG_8	13.48^{a}	12.21^{b}	11.00^{c}	6.77	0.14	*
BG_{12}	18.38^{a}	17.10^{b}	18.13^{a}	7.06	0.20	*
BG_{16}	24.12^{a}	22.30^{b}	22.30^{b}	6.31	0.24	*
BG_{20}	28.22^{a}	25.84^{b}	23.97^{c}	4.78	0.21	*
TL_4	3.08^{a}	2.79^{b}	2.60^{c}	10.60	0.05	*
TL_8	4.90^{a}	4.22^{b}	4.03^{c}	9.78	0.07	*
TL_{12}	7.56^{a}	6.72^{b}	6.33^{c}	9.42	0.11	*
TL_{16}	9.07^{a}	8.27^{b}	7.97^{c}	9.34	0.13	*
TL_{20}	10.05^{a}	9.21^{b}	8.70^{c}	8.34	0.13	*

^{a,b,c} = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.14: Effect of Carbonic anhydrase Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole Population of the Indigenous Chickens.

Table 4.14 shows the effect of carbonic anhydrase genotype on the body weight (g), breast girth (cm) and tibia length (cm) on the whole population of the indigenous chickens. The carbonic anhydrase genotype CA^{AB} and CA^{BB} maintained similar ($P>0.05$) values in body weight from day old to 20 weeks of the experiment, and were significantly higher ($P<0.05$) in weight than carbonic anhydrase genotype CA^{AA}. CA^{AB} and CA^{BB} showed a definite pattern of significant differences ($P<0.05$) in breast girth with CA^{AB} genotype having higher values than the CA^{BB} genotypes except at 20 weeks when CA^{BB} was higher than the CA^{AB}. The CA^{AA} however, showed no definite pattern of growth difference from CA^{AB} and CA^{BB}. Significant differences ($P<0.05$) in tibia length were also observed between CA^{AB} and CA^{BB} genotypes with CA^{AB} having the higher values than CA^{BB} except at 8 weeks when there was no significant difference ($P>0.05$) between them. The CA^{AA} genotype also did not show a consistent patter of tibia length growth difference between CA^{AB} and CA^{BB} genotypes.

Table 4.14: Effect of Carbonic Anhydrase Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole Population of the Indigenous Chickens.

Parameters	CARBONIC ANHYDRASE GENOTYPES			CV (%)	SEM	LOS
	CA^{AA}	CA^{AB}	CA^{BB}			
Day-old	24.63[b]	25.58[a]	25.85[a]	12.40	0.25	*
WT_4	95.41[b]	101.46[a]	100.15[a]	21.78	1.73	*
WT_8	306.79[b]	326.78[a]	319.62[a]	20.80	5.31	*
WT_{12}	561.00[b]	598.78[a]	582.38[a]	22.24	10.40	*
WT_{16}	691.11[b]	745.92[a]	734.46[a]	21.84	12.68	*
WT_{20}	1024.33[b]	1099.91[a]	1075.31[a]	20.59	17.65	*
BG_4	9.29[b]	9.44[a]	9.18[b]	9.22	0.07	*
BG_8	12.55[a]	12.70[a]	12.32[b]	8.66	0.09	*
BG_{12}	17.29[b]	17.65[a]	17.06[b]	8.93	0.13	*
BG_{16}	22.05[a]	22.00[a]	21.57[b]	12.14	0.21	*
BG_{20}	24.90[b]	25.09[b]	25.87[a]	11.11	0.22	*
TL_4	3.04[b]	3.11[a]	3.03[b]	11.13	0.03	*
TL_8	4.57	4.63	4.56	10.51	0.04	NS
TL_{12}	7.02[a]	7.02[a]	6.77[b]	11.33	0.06	*
TL_{16}	8.23[b]	8.76[a]	8.20[b]	1.65	0.13	*
TL_{20}	9.33[a]	9.35[a]	9.01[b]	10.79	0.08	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.15: Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population

Table 4.15 shows the effect of carbonic anhydrase genotype on body weight, breast girth and tibia length within the Frizzle indigenous chicken population. Significant differences ($P<0.05$) were observed in body weight among the carbonic anhydrase genotype of Frizzle (CA^{AA}, CA^{AB} and CA^{BB}) for body weight, breast girth and tibia length. The carbonic anydrase genotype CA^{BB} showed highest body weight values from day old to 20 weeks, closely followed by CA^{AB} while CA^{AA} however did not show a definite pattern of growth. There was also no definite pattern of significant growth difference observed for breast girth and tibia length among the carbonic anhydrase genotypes forms.

Table 4.15: Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Frizzle Indigenous Chicken Population

Parameters	CARBONIC ANHYDRASE GENOTYPES			CV (%)	SEM	LOS
	CA^{AA}	CA^{AB}	CA^{BB}			
Day-old	25.29[b]	26.17[b]	30.00[a]	14.07	0.60	*
WT_4	105.71[c]	111.67[b]	126.00[a]	15.77	2.84	*
WT_8	328.00[b]	343.39[b]	384.50[a]	14.49	8.07	*
WT_{12}	567.53[b]	600.50[b]	702.00[a]	23.61	22.94	*
WT_{16}	685.94[c]	759.94[b]	922.50[a]	25.80	31.16	*
WT_{20}	1001.41[c]	1075.56[b]	1242.50[a]	18.80	32.47	*
BG_4	9.75[a]	9.95[a]	9.15[b]	7.00	0.11	*
BG_8	12.46[b]	12.86[a]	13.10[a]	6.77	0.14	*
BG_{12}	16.91[b]	17.68[a]	16.90[b]	9.38	0.27	*
BG_{16}	22.45[b]	22.37[b]	24.85[a]	14.53	0.54	*
BG_{20}	22.08[b]	22.89[b]	24.75[a]	11.63	0.43	*
TL_4	3.15[b]	3.10[b]	3.35[a]	9.42	0.05	*
TL_8	4.66[a]	4.69[a]	4.30[b]	8.88	0.07	*
TL_{12}	7.01[b]	6.81[b]	7.40[a]	13.24	0.15	*
TL_{16}	7.81[b]	9.22[a]	9.35[a]	34.73	0.49	*
TL_{20}	9.36[ab]	9.17[b]	9.45[a]	12.32	0.19	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different ($P<0.05$) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.16: Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population

Table 4.16 shows the effect of carbonic anhydrase genotype on body weight (g), breast girth (cm) and tibia length (cm) within the Normal indigenous chicken population. Significant differences ($P<0.05$) were observed among the carbonic genotypes (CA^{AA}, CA^{AB} and CA^{BB}) of Normal indigenous chicken population of the experimental birds. The CA^{AB} genotype showed a superior ($P<0.05$) weight, breast girth and tibia length performance than the CA^{AA} and CA^{BB} genotypes throughout the period of the experiment except at breast girth at 16 weeks when there was no significant difference ($P<0.05$) among the various carbonic anhydrase genotypes and at 20 weeks, the BB genotype was significantly higher ($P<0.05$) than CA^{AB}.

Table 4.16: Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Normal Indigenous Chicken Population

Parameters	CARBONIC ANHYDRASE GENOTYPES			CV (%)	SEM	LOS
	CA^{AA}	CA^{AB}	CA^{BB}			
Day-old	24.62[c]	28.88[a]	25.50[b]	11.63	0.33	*
WT_4	91.83[b]	100.95[a]	98.10[a]	21.94	2.40	*
WT_8	302.66[b]	332.60[a]	316.70[ab]	21.63	7.78	*
WT_{12}	553.93[b]	606.60[a]	573.80[b]	22.72	14.91	*
WT_{16}	676.14[b]	742.95[a]	712.00[a]	20.81	16.73	*
WT_{20}	1027.00[b]	1126.40[a]	1063.10[b]	22.68	28.62	*
BG_4	9.13[b]	9.43[a]	9.28[ab]	9.53	0.10	*
BG_8	12.51[a]	12.56[a]	12.02[b]	9.16	0.13	*
BG_{12}	17.14[b]	17.54[a]	17.06[b]	9.30	0.18	*
BG_{16}	20.97	21.19	21.01	11.63	0.28	NS
BG_{20}	25.46[b]	24.94[b]	26.28[a]	9.25	0.26	*
TL_4	3.08[b]	3.17[a]	3.01[b]	11.07	0.04	*
TL_8	4.53[b]	4.63[a]	4.62[a]	10.36	0.05	*
TL_{12}	6.90[b]	7.09[a]	6.61[c]	10.32	0.08	*
TL_{16}	8.22[b]	8.57[a]	8.05[b]	11.16	0.11	*
TL_{20}	9.18[ab]	9.23[a]	8.98[b]	10.31	0.11	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different (P<0.05) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

4.17: Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Naked Neck Indigenous Chicken Population

Table 4.17 shows the effect of carbonic anhydrase genotype on body weight (g), breast girth (cm) and tibia length (cm) within the Naked Neck indigenous chicken population. The carbonic anhydrase genotype CA^{AA} and CA^{AB} were similar ($P>0.05$) in body weight and breast girth from day old to 20 weeks of the experiment, though, they were significantly higher ($P<0.05$) than genotype CA^{BB}, except in the breast girth at 8 weeks, when CA^{BB} was significantly different ($P<0.05$) from CA^{AA} and CA^{AB}. Significant differences ($P<0.05$) were observed in breast girth at 4, 16 and 20 among the Naked Neck carbonic anhydrase genotypes (CA^{AA}, CA^{AB} and CA^{BB}) with CA^{AB} having the highest values closely followed by CA^{AA} and lastly by CA^{BB}. There were no significant differences ($P>0.05$) observed at 8 and 12 weeks between the genotypes.

Table 4.17: Effect of Carbonic Anhydrase Genotype on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) within the Naked Neck Indigenous Chicken Population

Parameters	CARBONIC ANHYDRASE GENOTYPES			CV (%)	SEM	LOS
	CA^{AA}	CA^{AB}	CA^{BB}			
Day-old	24.00[a]	24.52[a]	21.00[b]	11.17	0.43	*
WT_4	91.24[a]	93.67[a]	69.00[b]	24.12	3.55	*
WT_8	292.65[a]	301.48[a]	219.00[b]	23.27	11.01	*
WT_{12}	566.53[a]	582.43[a]	429.00[b]	20.34	18.61	*
WT_{16}	721.82[a]	739.57[a]	583.00[b]	19.95	23.25	*
WT_{20}	1042.71[a]	1070.33[a]	863.00[b]	17.76	29.95	*
BG_4	9.10[a]	9.03[a]	8.20[b]	8.87	0.13	*
BG_8	12.70[b]	12.84[b]	13.82[a]	9.25	0.19	*
BG_{12}	17.91[a]	17.85[ab]	17.40[b]	7.89	0.23	*
BG_{16}	23.49[a]	23.24[a]	20.60[b]	7.22	0.27	*
BG_{20}	26.78[a]	27.28[a]	24.00[b]	6.98	0.30	*
TL_4	2.86[b]	3.00[a]	2.60[c]	11.74	0.06	*
TL_8	4.55	4.59	4.54	12.68	0.09	NS
TL_{12}	7.24	7.07	7.10	11.51	0.13	NS
TL_{16}	8.68[a]	8.73[a]	7.40[b]	10.37	0.14	*
TL_{20}	9.55[a]	9.74[a]	8.40[b]	9.54	0.15	*

[a,b,c] = Means with the same superscript within the same row for a particular parameter are not significantly different (P<0.05) different. CV = Coefficient of variation, SEM = Standard Error of Means, LOS = Level of Significance, NS = Not significant

WT_{4-20} = body weight for week 4, 8, 12, 16 and 20 weeks respectively

BG_{4-20} = breast girth for week 4, 8, 12, 16 and 20 weeks respectively

TL_{4-20} = tibia length for week 4, 8, 12, 16 and 20 weeks respectively

CHAPTER FIVE

5.0 DISCUSSION

5.1 Body Weight and Body Linear Measurement

The significant effect of genetic group on body weight from day old to 8 weeks could be due to differences in genetic groups studied, because there is indication that there are differences in the rate of attainment of a particular stage of growth by the different genetic group as reported by (Norris *et al.*, 2007). The superior weight performance attained by Frizzle birds from day old till 8 weeks could be associated with its possession of a major gene (the frizzle gene) which aids in feed utilization. Though, Garcês *et al.* (2001) had reported that the major genes of Naked Neck or Frizzle feather had no effect on feed efficiency, Nthimo (2004) registered that as with any growing pullet, feed conversion is best when the hens are young and then gradually decreases with age. Perhaps, the frizzle gene helped the Frizzle from day old to 8 weeks. In other words, according to the report of Ngeno *et al*. (2011) who observed that over the growth period, a particular ecotype was the heaviest from week 2 till week 12, after which no significant differences in body weight were observed between the ecotypes. This pattern of growth observed in the present study was also reported by Sola-Ojo and Ayorinde (2009) in the dominant black strain and the Fulani ecotype chickens. Norris *et al*. (2007) reported that the Venda chicken matured late but heavier at maturity while the Naked Neck had a higher growth rate, reached maturity earlier though, attained lighter matured weight.

The final weight of each ecotype at 20 week was within the range of 1038 – 1257g obtained in indigenous chickens in Ethiopia by Halima *et al.* (2006). In the report of Norris *et al*.

(2007) the Naked Neck had physiological fast growth and attained early maturity but had lighter weight when compared to the Venda (Normal birds) in Nigeria.

There was no consistent trend in the difference between the three genetic groups in terms of breast girth and tibia length of the birds. This could be because the local chickens have not been selected for a particular trait for which some of this correlated indicator traits would have been positively selected too. This is why there is a large amount of genetic diversity for virtually every gene examined between and within the different groups of the indigenous breeds compared to selected exotic group where indicator traits like breast girth, drum stick size will have positive correlation with the body weight or rate of growth. Alabi *et al.* (2012) reported that linear measurements of body length, shank thickness, body girth, wing length and shank length in correlation with body weight scored best for Naked Neck, when it was compared with Venda and Potchefstroom Koe-Koek except shank length in which no differences was observed. One would have assumed that if these traits were all-readily selected as correlates with body weight, then shank length would not have been different. The report of Alabi *et al.* (2012) then shows that it is possible for one or more different parameters of body linear measurements to correlate with or without body weight in indigenous chickens. At the end of the experiment, Naked Neck showed the best size of the breast girth. This could however, be due to the fact that, Naked Neck grew faster but with less body weight as earlier noted.

5.2 Effect of Sex on Body Weight (g), Breast Girth (cm) and Tibia Length (cm) on the whole Population of the Experimental Indigenous Chickens.

Sexual dimorphism really played a very strong role in body weight (WT), breast girth (BG) and tibia length (TL). From day old (WT_0) to 20 weeks (WT_{20}), it was significantly evident that males were better ($P<0.05$) than the females. Studies showed that the rapid evolution of

sex-specific developmental regulators and modifiers, though, of specific development of the sexes would have been the cause of sexual size dimorphism while maintaining the integrity of the developmental program that is shared between males and females (Badyaev, 2002). Hence, what is frequently found in developmental physiology studies of sex size dimorphism which is mistakenly nearly universally overlooked in quantitative and population genetics models of sex size dimorphism is that the sex-biased expression of size-related traits whose genetic determination is not sex limited (most traits) is accomplished by sex-specific regulators of development (Badyaev, 2002) which in most cases favours male sex.

Sola-Ojo *et al.* (2011) reported no significant difference (P>0.05) in dominant black strain and the Fulani ecotype chickens from day old to week 4 but the significant difference was recorded after week 4 till week 20 which was in agreement with the present work. Most literatures consulted reported this sexual dimorphism effect to be seen in some traits namely wing length, neck length, shank length, thigh length, body length, beak length, head length, keel length and chest circumference measured (Badyaev, 2002; Sola-Ojo *et al*., 2011; Ogah, 2011; Ajayi *et al*., 2012), which is also in support of superiority of males over females for all traits considered in the present study. In quails however, there was a report that sexual dimorphism for weight tends to favour the females than the males (Onyewuchi *et al*., 2013).

5.3: Transferrin Genotype, Genotypic and Allelic Frequency of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria

The existence of three genotypes of the transferrin which were being controlled by two co-dominant alleles, the Tf^A and Tf^B was in agreement with the claim of Essa *et al.* (2014), Abubakar *et al*. (2014) and Naevdal and Haraldsvik (1966) also reported that the transferrin locus has

two co-dominant alleles and three genotypes. Ige and Salako (2013) however, reported six genotypes as (Tf^{AA}, Tf^{AB}, Tf^{BB}, Tf^{AC}, Tf^{BC} and Tf^{CC}) which are controlled by three co-dominant alleles (Tf^{A}, Tf^{B} and Tf^{C}). The differences in the number of available genotypes reported by each of these authors may be due to differences in the sizes of the populations covered by each of the researchers, since the more the population size; the more the possibility of variation.

The high heterozygotes transferrin forms over the homozygotes at the transferrin locus in the Frizzle, Normal and Naked Neck local chickens suggests availability of huge genetic diversity among the indigenous chickens at this locus. Heterozygosity is a measure of biological diversity which is said to be exhibited both at the intra-population and inter-population levels (Yakubu and Aya, 2012). More so, this also suggests that many of the homozygotes do not adapt well to survive as the heterozygotes do. This clearly indicates that the heterozygotes are more hardy and adapted to the harsh environmental conditions.

There is also an indication that the transferrin locus within and between the groups of indigenous chickens remains undiluted and highly heterozygous. The high observed chi-square values for the Frizzle population (22.73), Normal (53.52), Naked Neck (24.64) and the entire population (98.78) were all above the expected 5.99 at 2 degrees of freedom. Therefore, the Frizzle, Normal, Naked Neck as well as the entire population can thus, be said not to be in Hardy Weinberg's equilibrium. This could be due to the process of the assigning of mating partners used for breeding the offspring, in any case which is a form of selection, an activity which normally hinders the attainment of Hardy Weinberg's equilibrium; secondly, many of the homozygotes might not have adapted well to survive the

environmental conditions, which means that most of the genes got lost due to mortality and finally, there might have been no opportunity for random mating.

5.4: Haemoglobin Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria

The three genotypes of the haemoglobin obtained were controlled by two co-dominant alleles, the Hb^A and Hb^B. Yakubu and Aya (2012), Ajayi *et al.* (2013), and Ige *et al.* (2013a) agreed that the haemoglobin locus is being controlled by two codominant alleles and had three genotypes.

The higher number of homozygotes than the heterozygotes at the haemoglobin locus for Frizzle, Normal and Naked Neck is in sharp contrast to what was obtained for transferrin loci, as noted earlier. The report of Ajayi *et al*. (2013) favoured the Hb^{BB} genotypes while the present research however favoured the Hb^{AA} genotypes.

The observed chi-square values for the Frizzle population (0.02), Normal (10.74), Naked Neck (0.02) and the entire population (11.93) showed that Frizzle and Naked Neck population were both in Hardy Weinberg's equilibrium while the Normal and entire population were not, considering the expected 5.99 at 2 degrees of freedom. A similar report has also been noted by Yakubu and Aya (2012) who worked on haemoglobin polymorphism between indigenous Fulani, Normal and Naked Neck chickens of Nigeria, and reported that Fulani and Naked Neck were in Hardy Weinberg's equilibrium but the Normal was not.

The whole population was not in Hardy Weinberg's equilibrium at haemoglobin locus and the chi-square value was 11.93. This may be due to the fact that, there was no equal survival (availability) of each genotype and gene frequency was not the same in each sex.

Hardy Weinberg's equilibrium can only be attained when there is random mating, no selection occurred, no migration, no mutation and genetic drift (Kinghorn and Van-der-Werf, 2000).

5.5: Carbonic Anhydrase Genotype, Genotypic and Allelic Frequencies of the Frizzle, Normal and Naked Neck Indigenous Chicken of Nigeria

Three genotypes of the carbonic anhydrase found were being controlled by two co-dominant alleles, this was also reported by Ige *et al.* (2013a). Das and Deb, (2008) however, reported six genotypes, controlled by three codominant alleles. The differences in the number of recognized genotypes may be due to differences in the size of the population size used by each researcher.

There were more of heterozygotes than the homozygotes at the carbonic anhydrase locus for Frizzle, Normal and Naked Neck. Thus, the genotypic and allelic frequencies for gene CA^{A} and CA^{B} differ highly. This indicates a form of genetic diversity among the local chickens, and heterozygosity is said to indicate the measure of genetic diversity while genetic diversity on the other hand is observed at both the intrapopulation and interpopulation levels (Yakubu and Aya, 2012). This also suggests that many of the homozygotes do not adapt well to survive as the heterozygotes did adapted and survived. The low chi-square values for Frizzle (1.00), Normal (0.44), Naked Neck (3.39) and the entire population (2.94) was in consistence with Hardy Weinberg's equilibrium.

5.6: Effect of Transferrin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of indigenous chicken and within the individual populations of Frizzle, Normal and Naked Neck.

The significant ($P<0.05$) higher body weight and breast girth attained by birds with the transferrin polymorphic form Tf^{AA} over the other two (Tf^{AB} and Tf^{BB}) may be due to the

different genetic effect of transferrin polymorphs on growth. This may be explained by the fact that not all the transferrin polymorphs respond equally to metabolic stimulation as noted by de-Jong (1993). In this regard, metabolic activity of the cells with large and significant correlations with growth rate synthesizes enzyme which function in protein catabolism. Also, it could be because the biochemical structure of each transferrin genotype might have minor differences in amino acid and carbohydrate compositions as noted by Ching-ming (1984) and Guérin *et al.* (1976), resulting in individual differences in net energy status, particularly energetic costs of whole-body protein turnover, manifesting into the differences in the variation in growth rate and weight as observed in the present study. The present study indicates clear polarization of weight and breast girth of the birds to favour the transferrin polymorphic form of Tf^{AA}. Zaman *et al.* (1991), also reported a similar study that the difference between the associated weight of Tf^{BB} and Tf^{BC} of crossbred between Rhode island red and native chickens as affected by their genotypes was significant ($P<0.05$). Rashid (1982) however reported that, for body weight, the transferrin locus had an additive effect, the Tf^{B} allele being associated with a body weight significantly higher ($P<0.05$) to that associated with the Tf^{A} allele at all ages. The author added that there was no regular correlation found between transferrin genotypes and age at maturity, egg number and egg weight. This difference in weight could be employed in selection for weight and breast meat. The significant difference in the tibia length on the other hand could be due to the effect of correlated traits which have been developed too. Ige (2013c) reported significant and positive correlation between body weight and linear body parameters in Yoruba and Fulani ecotype chickens. Mukherjee and Yap (1979) reported that there was no significant variation ($P > 0.05$) between the effects of different transferrin

genotypes observed on any of the body weight or body conformation trait in crossbred cattle between Zebu and temperate cattle.

5.7: Effect of Haemoglobin Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of indigenous chicken and within the individual populations of Frizzle, Normal and Naked Neck.

The high significant differences ($P<0.05$) in weight, breast girth and tibia length along the different haemoglobin genotypes available (Hb^{AA}, Hb^{AB} and Hb^{BB}) may be due to differences in polymorphic forms which might have resulted from their amino acid and carbohydrate compositions. It is believed that genetic polymorphisms at an aminopeptidase locus have direct influences on protein metabolism, including associated influences on energy flux and animal condition. Energy costs associated with protein turnover play a clear role in determining the physiological and evolutionary consequences of genetic polymorphism. Reduced whole-body protein turnover consistently underlies lower energy expenditure and higher growth efficiencies (net energy balance per unit of energy absorbed). In turn, slower protein turnover, lower energy expenditure and/or higher growth efficiencies have been shown to represent the metabolic basis of positive associations between growth and polymorphic locus (Hawkins and Day,1999).

The result of the present study confirms the report of Das and Deb (2008), which stated that haemoglobin polymorphism/polymorphic forms affect growth rate and hatchability. The authors indicated that hatchability was highest in Hb^{AA} followed by Hb^{AB} and lowest in Hb^{BB}. The present study showed that the haemoglobin genotype forms serve as a better biochemical discriminator of weight, breast girth and tibia length for selection than the transferrin genotypes, a phenomenon which suggests that some of the biochemical enzymes have more powerful biological interactions with physiological growth of the body than

others, just as some do not even indicate growth but are recorders of other traits. Das and Deb (2008) reported series of biochemical/biological enzymes and the activities of each of them namely; serum alkaline phosphate, carbonic anhydrase, plasma albumin variant, pre-albumin variant, egg albumin variants and many others.

5.8: Effect of Carbonic Anhydrase Genotype on the Body Weight (g), Breast Girth (cm) and Tibia Length (cm) of the whole population of indigenous chicken and within the individual populations of Frizzle, Normal and Naked Neck.

The significant difference in the body weight, breast girth and tibia length of the birds in association to the type of carbonic anhydrase genotype showed that carbonic anhydrase has a trophic effect which is polymorphic on the growth of the indigenous chickens. Karhuma (2002) reported that carbonic anhydrase participate in the regulation of ion, water and acid-base balance, promote cell proliferation and act as trophic/growth factor. The present research has contradicted the report by Das and Deb (2008) that carbonic anhydrase polymorphism has no significant effect on economic traits of chickens except on egg shell thickness only. Carbonic anhydrase polymorphic effect on growth of the indigenous chickens was however not as much consistent as those of transferrin and haemoglobin. The lack of persistent correlation of the breast girth and tibia length to body weight showed that some of the correlated indicator traits of body weight may sometimes not behave in an expected manner of body linear parameters – body weight correlated trait, especially in indigenous chickens. This could be due to the fact that most of the indigenous chickens were adapted to multipurpose uses and have not been selected for any particular use, so that these correlated traits have not been developed too. Adeyinka *et al.* (2006) reported negative genetic correlations between weight and some linear body parameters in Naked Neck broilers at NAPRI.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The present research work examined the possible effect of biochemical polymorphisms on performance traits in indigenous chicken genotypes in order to know the basic genetic activities which contribute to the differences observed in terms of body weight (g), breast girth (cm) and tibia length (cm), among the Nigerian indigenous chicken genotypes (Frizzle, Normal and Naked Neck) using transferrin, haemoglobin and carbonic anhydrase polymorphisms. It was observed that there were significant ($P<0.05$) differences between the different groups (Frizzle, Normal and Naked Neck). There were also differences ($P<0.05$) among the various biochemical genotypic categorization of transferrin, haemoglobin, and carbonic anhydrase in terms of body weight (g), breast girth (cm) and tibia length (cm).

6.2 Conclusion

It could be concluded that the biochemical genetic studies of the different groups of the indigenous chickens of Nigeria has led to the following discoveries:

1. From day old to 8weeks of age, the Frizzle feathered had significantly highest ($P<0.05$) average body weight (338.54g) than the Normal feathered (319.59g) and Naked Neck (295.51g) indigenous chickens of Nigeria. Therefore, for the production of meat/broiler type indigenous chicken, the Frizzle feathered could be considered.
2. The effect of sexual dimorphism was significant ($P<0.05$) in favour of the males against the females from day old till 20weeks, for body weights: males (1168.79g) and females (937.06g), breast girth: males (25.74cm) and females (24.24cm) and

tibia length: males (9.59cm) and females (8.96cm). This implied that these traits are sex influenced.

3. All of the three biochemical markers were distinct into three polymorphic genotypic forms viz; AA, AB and BB. The birds were more of heterozygotes (AB) than either of the homozygotes (AA or BB) for the three loci considered. Transferrin (Tf^{AA}, Tf^{AB} and Tf^{BB} had 8, 140 and 7 respectively), haemgolobin (Hb^{AA}, Hb^{AB} and Hb^{BB} had 49, 56 and 50 respectively) and carbonic anhydrase (CA^{AA}, CA^{AB} and CA^{BB} had 63, 79 and 13 respectively). This means more of the heterozygotes adapted and survived better than the homozygotes. The total population was not in Hardy Weinberg's equilibrium with respect to transferrin and haemoglobin loci but was however in Hardy Weinberg's equilibrium in the case of carbonic anhydrase locus.
4. The relationship between body weight(g), breast girth(cm), tibia length(cm) and the polymorphic forms of the biochemical markers showed that the AA genotype had a significant ($P<0.05$) weight than the AB and BB for; transferrin (1434.75g, 1047.11g, 1047.43g respectively) and haemoglobin (1296.43g, 1029.59g, and 884.46g respectively). This means that there is additive genetic superiority of the different polymorphic forms and therefore, they could be used for selection criteria. In the case of carbonic anhydrase however, there was no consistent pattern of a particular polymorphic form exhibiting significant difference neither between the separate indigenous chicken groups nor within the total population. This shows that carbonic anhydrase polymorphic form does not suitably serve for body weight (g), breast girth (cm) and tibia length (cm) selection in indigenous chickens.

6.3 Recommendations

1) Haemoglobin and Tranferrin polymorphic forms can be used for selection for body weight and related parameters in the indigenous chicken.
2) More research is recommended on the effect of the polymorphic forms of blood biochemical parameters on the reproductive traits of the indigenous chickens.
3) There should be more advance studies into the genetic resources of all the indigenous chicken species of the country; with the aim of improving their reproduction, production and general uses to mankind.

REFERENCES

Abubakar, E., Suprijatna, E. and Sutopo, E. (2014). Genotype distribution of local chicken crossbred in Poultry Breeding Centre Temanggung-Central Java. *International Refereed Journal of Engineering and Science*, 3(3): 1-14.

Abubakar, M. B., Ambali, A. G. and Tamjdo, T. (2007). Rural chicken production: effects of gender on ownership, and management responsibilities in some parts of Nigeria and Cameroon. *International Journal of Poultry Science,* 6(6): 413-416.

Adeleke, M. A., Peters, S. O., Ozoje, M. O., Ikoebi, C. O. N., Adebambo, A. O., Olowofeso, O., Bambgose, A. and Adebambo O. A. (2011b). Preliminary screening of genetic lineage of Nigerian local chickens based on blood protein polymorphisms. *Animal Genetic Resource*, 48: 23–28.

Adeleke, M. A., Peters, S. O., Ozoje, M. O., Ikoebi, C. O. N., Bamgbose, A. M and Adebambo, O. A. (2011a). Genetic parameter estimates for body weight and linear body measurements in pure and crossbred progenies of Nigerian indigenous chickens. *Livestock Resource for Rural Development,* 23 (01): 1-4.

Adene, D. F. and Oguntade, A. E. (2008). Poultry sector country review: Nigeria. *FAO Animal Production and Health Division*. Food and Agriculture Organisation, Animal Health and Production, Viale delle Terme di Caracalla, 00153 Rome, Italy, 1- 22

Adeyinka, I.A., Oni, O.O., Nwagu, B.I. and Adeyinka, F.D. (2006). Genetic parameter estimates of body weights of naked neck broiler chickens. *International Journal of Poultry Science*. 5 (6): 589-592.

Aebersold, P. B., Winans, G. A., Teel, D. J., Milner, G. B. and Utter, F. M. (1987). *Manual for Starch Gel Electrophoresis: A Method for the Detection of Genetic Variation*. National Oceanic and Atmospheric Administrative Technical Report NMFS (United States of America). Retrieved on www.nature.com/hdy/journal/v77/n4/abs/hdy1996162a.html 18/2/2013, Pp 2-26.

Ajayi, F. O. (2010). Nigerian indigenous chicken: a valuable genetic resource for meat and egg production. *Asian Journal of Poultry Science*, 4: 164-172.

Ajayi, F. O., Agaviezor, B. O. and Wihioka S. N. (2013). Haemoglobin genotypes in the Nigerian indigenous chicken in the Niger Delta region of Nigeria. *International Journal of Advanced Biological Research*, 3(1): 13-16.

Ajayi, F. O., Ejiofor, O. and Ironke, M. O.. (2008). Estimation of body weight from linear body measurements in two commercial meat-type chicken. *Global Journal of Agricultural Science*, 7: 57-59.

Ajayi, O. O., Yakubu, A., Jayeola, O. O., Imumorin, G. I., Takeet, M. I., Ozoje, M. O., Ikeobi, C. O. N. and Peters, S. O. (2012). Multivariate analysis of sexual size dimorphism in local turkeys (*Meleagris gallopavo*) in Nigeria. *Tropical Animal Health Production,* 44: 1089–1095.

Akpa, G. N., Ibrahim, O. A., Yakubu, H. and Kabir, M. (2011). Sexual dimorphism, haemoglobin polymorphism and body mensuration characteristics of red sokoto goats. In: Ado, S. G., Akpa, G. N., Dahiru, A. U., Mu'azu, S., Kabir, M., Adeyinka, I. A., Adamu, A. K. and Usman I. S. (Eds.), *Genetics in Food Security, Health and Environment*, pp 2-3. Proceedings of 35th Annual Conference of Genetics Society of Nigeria (GSN) held at Ahmadu Bello University, Zaria Kaduna State.

Alabi, O. J., Ng'ambi, J. W., Norris, D. and Egene, S. S. A. (2012). Comparative study of three indigenous chicken breeds of South Africa: body weight and linear body measurements. *Agricultural Journals*, 7(3): 220-225.

Badyaev, A. V. (2002). Male and female growth in sexually dimorphic species: harmony, conflict, or both? *Comments on Theoretical Biology*, 7: 11 – 33.

Burt, D. W. (2007). Emergence of the chicken as a model organism: implications for agriculture and biology. *Poultry Science Association*, 86:1460–1471.

Ching-ming, M. C. (1984). Structure and function of transferrin. *Biochemical Education.* 12(4):1984. Pp 146 – 154.

Christensen, K. (2003). Population genetics. Retrieved on www.ihh.kvl.dk/htm/kc/popgen/genetics/genetik.htm. 5/11/2014. P 1 – 20

Das, A. Kr. and Deb, R. (2008). Biochemical polymorphism and its relation with some traits of importance in poultry. *Veterinary World, Indian Veterinary Research Institute.* 1(7): 220 – 222.

de-Jong, G. (1993). *The physiological significance of transferrin microheterogeneity: An interpretation of the role of N-linked glycans in transferrin and iron metabolism*. Department of Chemical Pathology, Erasmus University, Rotterdam, the Netherlands.

Dhakal, S., Lamichhane, S., Gurung, S., Acharya, S., Subedi, S., Prakash, U. T. and Nepal, Y (2011). Economic Traits of Poultry and its implication in genetic improvement programmes. Retrieved on https://www.scribd.com/doc/48643480/**Economic-Traits-of-Poultry**. 25/8/2012.

Essa, A. A., Suprijatna, E. and Sutopo, E. (2014). Genetic variation of Arabic, Arabic cross, Lingnan and Kedu chicken in Poultry Breeding Center Temanggung Central Java. *International Refereed Journal of Engineering and Science,* 3(2): 76-86.

Fowle, K. E., Cline, J. H., Klosterman, E. W., and Parker, C. F. (1967). Transferrin genotypes and their relationship with blood constituents, fertility and cow productivity. *Journal of Animal Science*, 26: 1226-1231.

Frayer, D. W. and Wolpoff, M. H. (1985). Sexual dimorphism. *Annual Reviews Anthropology*, 14:429-73.

Frelinger, J. A. (1972). The maintenance of transferrin polymorphism in pigeons. *Proceedings of National Academy of Science. USA.* 69 (2): 326 – 329.

Garcês, A., Casey, N. H. and Horst, P. (2001). Productive performance of naked neck, frizzle and dwarf laying hens under various natural climates and two nutritional treatments. *South African Journal of Animal Science*. 31(3): 174 - 180

Guérin, G., Vreeman, H. and Nguyen, Y. C. (1976). Preparation and partial physico-chemical characterization of sheep-serum transferrin. *European Journal of Biochemistry*. 67(2):433-45.

Halima, H., Neser, F. W. C., de-Kock, A. and Van-Marle-Köster, E. (2006). Growth performance of indigenous chickens under intensive management conditions in Northwest Ethiopia. *South African Journal of Animal Science*. 36(5): 71-73

Hassan, D. I., Ogah, D. M., Yusuf, N. D., Musa-Azara, I. S., Ari, M. M. and Alaga, A. A. (2012). Village chicken flock ownership, management and constraints in Keana, Nasarawa State, Nigeria. *Egyptian Poultry Science*, 32(4): 809-817.

Hawkins, A J. S. and Day, A. J. (1999). Metabolic interrelations underlying the physiological and evolutionary advantages of genetic diversity. *American Zoology*, 39:401-411.

Horst, P. (1999). Evaluation of local poultry resources for creating genetic stock with improved adaptability, productivity and disease resistance in tropical environments. Summary reports of European Commission supported STD-3 projects (1992-1995). CTA. Wageningen-Netherlands. Pp 196 - 203

Ige, A. O. and Salako, A. E. (2013a). Transferrin genetic types in Fulani and Yoruba ecotype of Nigeria indigenous chickens. *Iranian Journal of Applied Animal Science*. 4(1): 191-196

Ige, A. O. (2013c). Estimation of genetic parameter in Yoruba and Fulani ecotype indigenous chickens of Nigeria. *Transnational Journal of Science and Technology*. 3(10): 1 – 16.

Ige, A. O., Salako, A. E.; Ojedapo, L. O. and Adedeji, T. A. (2013b). Biochemical characterization of indigenous Fulani and Yoruba ecotypes chicken of Nigeria. *African Journal of Biotechnology*. 12(50): 7002 – 7008.

Jaayid, T. A., Yousief, M. Y., Owaid, J. M, and Aziz, N. M. (2011). A study of biochemical polymorphism in Carp (*Cyprinus carpio*): new alleles in transferring. *Research Opinions in Animal and Veterinary Sciences,* 1(8): 521-524.

Johnson, R. J. (2012). Livestock, diary and poultry outlook. a report from the Economic Research Service, United States Department of Agriculture. Retrieved from www.ers.usda.gov, 22/5/2013.

Karhuma, P. (2002). Carbonic anhydrases in the reproductive system, with special emphasis on isoenzymes VI, IX, XII and a novel nuclear nonclassical form. Retrieved on http://herkules.oulu.fi/isbn9514266641/isbn9514266641.pdf, 17/5/2012

King'ori, A. M. (2011). Review of the factors that influence egg fertility and hatchability in poultry. *International Journal of Poultry Science,* 10(6): 483-492.

Kinghorn, B. and van-der-Werf, J. (2000). Indentifying and incorporating genetic markers and major genes in animal breeding programs. Retrieved on www.personal.une.edu.au/~jvanderw/Coursecover.PDF, 17/5/2012

Kperegbeyi, J. I., Meye, J. A. and Ogboi, E. (2009). Local chicken production: strategy of household poultry development in coastal regions of Niger Delta, Nigeria. *African Journal of General Agriculture,* 5(1): 17 – 20.

Kwaga, J. K. P. (2006). *Introduction to Biotechnology*. Zaria-Nigeria: Ahmadu Bello University Press Limited, Pp 1 – 7.

Laseinde, E. A. O. and Oluyemi, J. A. (1996). Sexual dimorphism in the growth patterns of broilers under different dietary and housing conditions. *Nigerian Journal of Animal Production,* 24(1): 1 - 6.

Latshaw, J. D. and Bishop, B. L. (2001). Estimating body weight and body composition of chickens by using noninvasive measurements. *Poultry Science,* 80: 868-873.

Lee, D. L., McKnight, S. G. and Palmiter, R. D. (1980). The chicken transferrin gene; restriction endonuclease analysis of gene sequences in liver and oviduct DNA. *The Journal of Biological Chemistry,* 225(4): 1442 – 1450.

Leeson, S. and Summers, J. D. (2000). *Broiler Breeder Production*. Nottingham-England: Nottingham University Press, Pp 1 – 21.

Miao, Y. W., Speng, M. S., Wu, G. S., Ouyang, Y. N., Yang, Z. Y., Yu, N., Liang, J. P. Pianchou, G., Beja-Pereira, A., Mitra, B., Palanichamy, M. G., Baig, M. K., Chaudhuri, T. K., Shen, Y. Y., Kong, Q. P., Murphy, R. W., Yao, Y. G. and Zhang, Y. P. (2013). Chicken domestication: an updated perspective based on mitochondrial genomes. *Heredity,* 110: 277–282.

Mignon-Grasteau, S., Beaumont, C., Piovey, J. and de-Rochambeau, H. (1998). Estimation of the genetic parameters of sexual dimorphism of body weight in label chicken and Muscovy ducks. *Genetic Selection Evolution*, 30: 481-491.

Moiseyeva, I. G., Romanov, M. N., Nikiforov, A. A., Sevastyanova, A. A. and Semyenova, S. K. (2003). Evolutionary relationships of red jungle fowl and chicken breeds. *Genetic Selection Evolution,* 35: 403-423.

Mukherjee, T. K. and Yap, T. N.(1979). Frequencies of the transferrin alleles and genotypes in crossbred cattle and their effect on growth traits. *Pertanika*, 2(1), 51-53.

Mwacharo, J. M., Otieno, C. J., and Okeyo A. M. (2005). Suitability of blood protein polymorphisms in assessing genetic diversity and relationships in population genetic studies. In: Makkar, H. P. S. and Viljoen, G. J. (eds). *Applications of gene-based technologies for improving animal production and health in developing countries*, Pp 585-591.

Mwalusanya, N. A., Katule, A. M., Mutayoba, S. K., Mtambo, M. M. A., Olsen, J. E. and Minga, U. M. (2002). Productivity of local chickens under village management conditions. *Tropical Animal Health and Production,* 34(5): 405-416.

Naevdal, G. and Haraldsvik, S. (1966). A preliminary report on electrophoretic studies on herring serum proteins. International Council for the Exploration of the Sea. Retrieved on http://www.brage.bibsys.no/xmlui/bitstream/handle/11250/101201/CM_1967_H_24.pdf?sequence=1, 1/1/2013

Naqvi, A.N. (2007). Application of molecular genetic technologies in livestock production: potentials for developing countries. *Advances in Biological Research*. 1 (3-4): 72-84.

Ngeno, K., Bebe, B. O. and Kahi, A. K. (2011). Estimation of growth parameters of indigenous chicken populations intensively reared in Kenya. Retrieved on www.ir-library.egerton.ac.ke/jspui/handle/123456789/59, 1/1/2013.

Norris, D., Ngambi, J. W., Benyi, K., Makgahlela, M. L., Shimelis, H. A. and Nesamvuni, E. A. (2007). Analysis of growth curves of indigenous male Venda and Naked Neck chickens, *South African Journal of Animal Science*, 37(1): 21 – 26.

Nthimo, A. M. (2004). The phenotypic characterization of native Lesotho chickens. Dissertation submitted to the Faculty of Natural and Agricultural Science, Department of Animal, Wildlife and Grassland Sciences, University of the Free State In partial fulfillment of the requirement for the degree of Magister of Agricultural Science. Pg 1 – 93. Retrieved on www.sasas.co.za/sites/sasas.co.za/files/NthimoGoudini06_0.pdf. 1/1/2013.

Ochieng, J., Owuour G. and Omedo, B. B. (2012). Determinants of adoption of management interventions in indigenous chicken production in Kenya. *African Journal of Agricultural Research,* 7(1): 39 – 50.

Ogah, D. M. (2011). Assessing size and conformation of the body of Nigerian indigenous turkey. *Slovakian Journal Animal Science,* 44 (1): 21-27.

Ohwojakpor, O., Olowofeso, O., Adebambo, O. A. and Onagbesan, O. M. (2012). Genetic diversity of chicken populations in south-south region of Nigeria using microsatellite markers. *Egyptian Poultry Science,* 32(2): 263-271.

Onyewuchi, U. U., Offor, I. R. and Okoli, C. F. (2013). Profitability of quail bird and egg production in Imo State. *Nigerian Journal of Agriculture, Food and Environment.* 9(1): 40-44.

Ovimaps, (2012). Ovilocation maps; ovi earth imaginary. Dated July, 2012.

Petrus, N. P., Mpofu, I. and Lutaaya, E. (2011). The care and management of indigenous chicken in Northern communal areas of Namibia. *Livestock Research for Rural Development*, 23(12): 1 - 3

Rashid, A. M. (1982). Ovotransferrin (conalbumin) polymorphism and economic characters in the domestic fowl. *British Poultry Science,* 23(6): 539-46).

Rege, J. E. O and Okeyo, A. M. (2006). Improving our knowledge of tropical indigenous animal genetic resources. *In:* Ojongo, J. M.; Malmfors, B. and Okeyo, A.M. (Eds)., *Animal Genetic Training Resource, version 2*. International Livestock Research Institute, Kenya, Nairobi and Swedish University of Agricultural Sciences, Uppsala, Sweden. Retrieved on www.agtr.ilri.cgiar.org/Documents/Modules/Improvingourknowledge.pdf, 1/1/2013.

Richard K. K., Walter J. D. and Timothy M. S. (1988). The differential contribution by individual enzymes of glycolysis and protein catabolism to the relationship between heterozygosity and growth rate in the coot clam, *mulinia lateralis. Genetics Society of America*. 118: 121-130.

RIKEN (2006). *Genetic Quality Monitoring by Biochemical Marker Isoenzymes.* Experimental Animal Division of RIKEN BioResource Center, Illinois, U.S.A. Pg 1 - 12. Retrieved on www.brc.riken.jp/lab/animal/en/quality.shtml, 1/1/2013

SAS, (2002). Statistical Analysis System, Users Guide, Statistical Analysis Institute Inc. Cary, North Carolina

Sengul, T. and Kiraz, S. (2005). Non-linear models of growth curves in large white turkeys. *Journal Veterinary Animal Science,* 29: 331-337.

Sola-Ojo, F. E., Ayorinde, K. L., Bolu, S. A. O., Toye, A. A., Kayode, R. M. O., Alli, O. I., Adeyemi, K. D. and Gomina, P. (2011). Sexual dimorphism in growth traits and carcass characteristics in the Nigerian Fulani ecotype chicken**.** *American-Eurasian Journal of Sustainable Agriculture*, 5(3): 371-377.

Sola-Ojo, F. E. and Ayorinde, K. L. (2009). Effect of genotype on body weight and egg production traits of the Dominant black strain and the Fulani ecotype chicken. In: Anonymous (eds), *Proceedings of 33rd Annual Conference of Genetics Society of Nigeria*. Pp 166 – 168. Retrieved on https://www.unilorin.edu.ng/publications/ayorinde/Evaluation%20of%20reproductive%20performance%20and%20egg%20quality%20traits%20in%20progenies.pdf, 1/1/2013.

Sorenson, P. (2009). Poultry genetic resources in the context of High Pathogenic Avian Influenza (HPAI). *Family Poultry*, 18 (1 and 2): 26.

Steppa, J., Wójtowski, J., Sylwia, B. and Maria K. (2009). Effect of transferrin and haemoglobin polymorphism on hygienic quality of milk in sheep. *Züchtungskunde,* 81(2): 125–132,

Utter, F., Aebersold, P. and Winans, G. (1987). Interpreting genetic variation detected by electrophoresis. In: Ryman, N. and Utter, F. (eds), *Population Genetics and Fishery Management*, 35 – 49. Retrieved on www.blackburnpress.com/pogeandfima.html, 1/1/2013.

West, B. and Zhou, B. (1988). Did chickens go North? New evidence for domestication. *Journal of Archaeological Science*, 15(5): 515–533.

Worku, Z., Melesse, A. and T-Giorgis, Y. (2012). Assessment of village local chicken production system and the performance of local chicken populations in West Amhara region of Ethiopia. *Journal Animal Production Advances,* 2(4): 199-207.

Yakubu, A. and Aya, V. E. (2012). Analysis of genetic variation in Normal Feathered, Naked Neck and Fulani-ecotype Nigerian indigenous chickens based on haemoglobin polymorphism. *Biotechnology in Animal Husbandry,* 28 (2): 377-384

Yakubu, A., Kuje, D. and Okpeku, M. (2009). Principal Components as Measures of Size and Shape in Nigerian Indigenous Chickens. *Thai Journal of Agricultural Science,* 42(3): 167-176.

Ye, X., Suen, C. Y., Cheriet, M., and Wang, E. (1999). A recent development in image analysis of electrophoresis gels. Vision Interface Canada '99, Trois-Rivières, Canada. Retrieved on http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.4.9386, 1/1/2013.

Zaman, S., Ali, A., Faruque, M.O. and Bhuiyan, A. K. F. H. (1991). Transferrin polymorphisms and growth rate in Rhode Island Red, Crossbred and Native chickens. *Asian Journal of Animal Science*, 4(3): 231 – 234.

Zeder, M. A. (2012). Pathways to animal domestication. In: Gepts, P., Famula, T. R., Bettinger, R. L. (eds), *Biodiversity in Agriculture: Domestication, Evolution, and Sustainability*. Cambridge: Cambridge University Press, Pp 227 – 259.