EVALUATION OF YORUBA ECOTYPE CHICKEN AND CROSSES WITH THREE EXOTIC STRAINS FOR PERFORMANCE AND EGG PRODUCTION IN NIGERIA

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CERTIFICATION

This is to certify that this research work was carried out and presented by **OGUNDERE, ABIMBOLA ALICE** of the Department of Animal Production, University of Ilorin. The report of the research work has been read and approved for the award of Doctor of Philosophy (Ph.D) having met the requirements of the department of Animal Production, Faculty of Agriculture and the Post Graduate School, University of Ilorin, Ilorin, Kwara State, Nigeria.

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DEDICATION

This work is dedicated to the Almighty God, My Alpha and Omega, The all Sufficient God, You have made it Beautiful in Your Own Time and to my Father Late Barrister, Jonathan Adebisi Ogundere.

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LIST OF ACRONYMS

YEC – Yoruba Ecotype Chicken

MM - Marshall Broiler

SS - Sussex Chicken

GG - Goliath Chicken

ANOVA – Analysis of Variance.

MIVQUE – Minimum Variance quadratic Unbiased Estimation

TES - Total Egg Set

FES – Fertile Egg Set

FCR – Feed Conversion Ratio

GxS – Genotype and Sex interaction

PCA – Principal Component Analysis

PC - Principal component

FAO – Food and Agriculture Organisation

HDP – Hen Day Production

NCDV- New Castle Disease Virus

NCDK –New Castle Disease Komorov

Na – Sodium

Cl – Chlorine

ME – Metabolisable Energy

AFE - Age at First Egg

HBW - Hen Body Weight

EW - Egg Weight

EN - Egg Number

EM -Egg Mass

HDP - Hen Day Production

FDE - Feed Per Dozen Egg

EL - Egg length

EWD - Egg width

EI - Egg index

SW - Shell Weight

ST - Shell Thickness

AW - Albumin weight

YW - Yolk weight

AHT - Albumin height
YH - Yolk height
AWD - Albumin width
YWD - Yolk width
YI - Yolk index
HU - Haugh unit
SAS – Statistical Analysis Software

SPSS – Statistical Package for Social Sciences

ABSTRACT

Yoruba Ecotype Chicken (YEC) is characterized by hardiness, and better adaptation to prevailing tropical environment. However, its small body size and egg weight has hindered its utilization for commercial meat and egg production. Crossbreeding is a major tool used in improving desired traits in animals. The objectives of the study were to: (i) evaluate fertility, hatchability, growth performance and survivability in Marshall (MM), Goliath (GG), Sussex (SS) and their crossbred with YEC; (ii) evaluate egg production and quality characteristics in YEC and its crosses with GG and SS; and (iii) estimate genetic parameters, predictive models for growth and egg production traits in YEC and its crosses.

Two experiments were conducted. Experiment 1 examined fertility, hatchability, early and late growth performance and survivability using a total of 529 chicks obtained from 971 eggs `that were collected from purebred chickens and their crosses (MMxMM, GGxGG, SSxSS, YECxYEC, YECxMM, YECxGG, YECxSS, MMxYEC, GGxYEC and SSxYEC). Experiment 2 investigated egg production and egg quality characteristics using 120 sixteen-week old YEC and its crosses. Data obtained from experiments 1 and 2 estimated heterosis, heritability, repeatability, correlation, predictive equations, principal component and genetic relatedness for body weight and egg parameters. Data on growth and reproductive parameters were subjected to analysis of variance.

The findings of the study were that:

i. MMxYEC had the highest fertility (97.50%) compared to other crosses. Hatchability was highest in MMxYEC and GGxYEC (89.74% in both);
ii. MMxMM and MMxYEC had significantly ($p<0.05$) higher feed intake, weight gain and feed conversion ratio than other crosses. YECxYEC had 91.20% survivability. Survivability was highest in YECxGG (100%) at early and late growth phases;
iii. egg parameters were significantly higher ($p<0.05$) and maturity occurred earlier (154 days) in YECxSS than in YECxYEC (146 days) and other YEC crosses. Crosses between YEC cock and exotic hens exhibited positive heterosis for body weight and egg parameters;
iv. heritability for body weight was higher in YECxGG (0.38 to 0.63) and GGxYEC (0.59 to 1.00) than in YECxYEC. Repeatability estimates were generally low in YECxYEC and its crosses;
v. body weight was best predicted by cubic and quadratic equations in most crosses, Principal component 1 accounted for the highest variance in weekly body weight with the low variation existing in SSxSS, YECxGG, YECxMM and MMxYEC. Crosses of SSxSS, YECxGG and YECxSS were best described by egg external quality traits while GGxGG, GGxYEC and SSxYEC were described by external and internal quality traits ; and
vi. Dendogram showed that body weight of YECxYEC was more closely related with SSxSS and GGxGG than MMxMM. Similarity existed between egg number of YECxYEC and GGxGG while the egg weight of the two strains were far apart in the dendogram.

The study concluded that cross breeding improved body weight and egg production of YEC. Crossbred YECxMM or YECxGG is therefore recommended for body weight and YEC x SS for egg production in Nigeria.

CHAPTER ONE

1.0 GENERAL INTRODUCTION

Poultry production is one area of animal enterprise with significant contribution to human food production. The request for poultry meat is higher because of its alleged superiority in health aspects when compared to red meat. The comparable low fat and cholesterol contents of poultry meat and its perceived superior gustatory qualities made it more acceptable by people. The relatively low price, the typically convenient portion and lack of religious restriction made poultry producers and consumers to focus on the poultry carcass yield, composition and quality (Jaturashita, 2004).

The Indigenous chickens in Africa are in general hardy, adaptive to rural environments, live on little or no inputs and adjust to fluctuations in feed availability. Also, they represent valuable resources for livestock development because their extensive genetic diversity allow for rearing under varied environmental conditions (Ajayi. 2010). Also, indigenous chickens have small matured live and carcass weight and produce few eggs per year. Growth rate along with feed conversion and degree of muscling are among the most important criteria in genetic improvement or selection programmes of desired traits. Growth generally relates to the increase in body cells and volume. It is a multifarious process, which is guarded by both genetic and non-genetic factors (Kor *et al*., 2006).

In Nigeria, local chicken constitute 80% of the 120 million poultry type raised in the rural areas (Ajayi, 2010) found mostly in the rural areas, they are good scavengers as well as foragers. They have good maternal qualities, hard when compared to the exotic breeds and have high survival rates with minimal care and attention (Salako and Ige, 2006). Local chickens have been adjudged to be genetically poor producer of meat and eggs (Gueye, 1998; Tadelle *et al*., 2000). They

display high genetic variance in their performance and as a result have great potential for genetic improvement through cross breeding and or selection in breeding and improvement programmes. (Omeje and Nwosu, 1983; Nwosu *et al*., 1985; Ikeobi *et al*., 1996; Adebambo *et al*., 1999, 2009; Peters, 2000; Adedeji *et al*., 2008). The Nigeria local chicken (NLC) exhibits higher fertility and hatchability under natural incubation and better adaptation to the prevailing diseases, physical conditions and local management practices than the exotic chickens. Reports by Gueye (1998) and Tadelle *et al*. (2000) however, showed that local chickens are genetically poor producer of meat and eggs, as they take longer time to reach maturity.

With the high demand of chicken and its product in Nigeria, there is the need to explore the potentials of the other exotic strains to boost the genetic base of chicken for meat and egg production since exotic pure breeds of chicken could be bred with native chicken but adaptability may become problematic, to utilize the good adaptive characteristics of the indigenous chicken and possibly exploit the phenomenon of heterosis, Oluyemi and Roberts (1979) proposed that crossbreeding programmes including upgrading local chicken with suitable exotic stocks would be more appreciable.

In Genetic improvement of the indigenous chicken, the selection for growth rate, feed conversion efficiency and degree of muscling has been the focus primarily. Most of these efforts have been limited by the required funding needed for a long term selection programme. However, there are a number of factors that can be used to improve the low genetic potential of the indigenous chicken like cross breeding program with the exotic. The Exotic breeds have been used to improve the productivity of the Indigenous birds by mating them with the improved cocks. However, Permin (2008) reported that such schemes do fail to work due to problem of adaptation of the introduced breed to hot climate, low feeding and extensive management. Thus,

it is very important to consider the breeds or strain that combine fast growth with adaptability to the tropical environment. The goal will then be to get a new breed or hybrid that is resistant to harsh tropical conditions and at the same time produces appreciable amount of egg and meat (Mekki *et al.*, 2005).

Animal genetics allows farmers to select stocks or develop new breeds in response to environmental change, threat of disease, new knowledge of human nutrition requirements, changing market conditions and societal need FAO (2000). However, Sola-Ojo and Ayorinde (2011) reported that improved exotic chickens produce higher number of eggs and more meat but tropical climate possed a great challenge. Adaptation is the ability of an animal to survive and reproduce within a defined environment or the degree to which it can remain or become adapted to wide range of environment by physiological or genetic means (Barker, 2009). It is only the development of adapted poultry species that can quickly bridge way to the available protein gap in developing countries (Mirkenal *et al*., 2010). Survival is a general measure of an animal's fitness. In commercial poultry production, mortality can result from a range of conditions (disease, physiological stress, environmental condition and aggressive behaviour). Birds survival recorded as a binary trait (i.e. either dead or alive at a given time) is a potential indicator for many underlying health traits that could be improved simultaneously.

Marshall, Goliath and Sussex are some of the exotic Strains of chickens that can be found in the country. Sussex strain was created over a century ago in the country of Sussex in England; they are dual purpose type of chicken that is popularly known as backyard chicken in many countries because they are good foragers. Also, they are good producers of large size eggs (240-260 / year) which are cream to light brown in colour especially the light Sussex (Citrus Country Skill- A-Thon, 2010). Goliath strains were developed in 1886 by William Cook. They are large birds

from the English class of chickens and were bred as a dual purpose breed, famously known for their good carcass qualities, moderate early maturity and good laying capacity (110 to 160 large eggs/year). They lay eggs that are light brown to tinted white which range from small to large depending on the heredity of the breed. The hens tend to go broody more than other heavy eggs breeds occasionally. (Wikipedia, 2014). Goliath has capacity for faster growth and higher matured body weight compared to local chicken populations while, Marshall are generally raised for meat production because they grow faster with high mature body weight.

Cross breeding is important because of the greater performance that is expected from the crossbred compared to the average of the parent. This superiority is termed positive heterosis or hybrid vigor Ibe (1998). The cross bred animals exhibit heterosis and combines the strength of the breeds used to form the cross. Heterosis is the occurrence of a superior offspring from mixing the genetic contributions of its parents (Aly *et al.*, 2005). Positive or economically desirable traits can be as a result of dominant genes whereby the offspring will have large numbers of positive and dominant genes from both parents. Genetic effects had been employed to determine the extent of improvement in a cross breeding programme and which according to Amin (2014) are crossing effects (heterosis, direct and maternal additive effect). In cross breeding programmes, both parents (Sire and Dam) contribute genes and these genes together with their interaction with the environment determine the traits observed in the resulting offspring. Aly *et al*., (2005) reported the superiority of cross bred over the pure bred in terms of reproductive performance and other economic traits. It is therefore, important to determine the extent of contribution to parent on performance of the offspring. However, breeding methods depend on heritability and genetic correlation for desirable traits. Some traits are genetically correlated which may be positive or negative; complementary or antagonistic. Generally, there is preference for chickens that have high body weight and appreciable egg production capacity however, the genetic potential of the

indigenous chicken could be improved by crossing them with selected but still robust exotic breeds (Guéye, 1998).

Additionally, there is need to conserve and preserve the potentiality of these indigenious stocks before they go into extinction as they can form gene banks for infusion into present commercial stock in other to bring about more improvement particularly if granted improved breeding and husbandary techniques.The aim of the present study is to evaluate fertility, hatchability, survivability and early growth performance, egg production, quality and genetic estimates of Yoruba ecotype, Marshall, Sussex and Goliath chickens and their crossbreds in Nigeria.

1.1 JUSTIFICATION

The genetic potential of the Yoruba ecotype chicken is well spelt out in its hardiness, high fertility, hatchability and better adaptability to prevailing tropical environmental conditions. However, its small body size and egg weight coupled with its slow growth rate has hindered its utilization for commercial egg and meat production in Nigeria even though its juiciness and flavour has been established and have therefore been replaced by exotic strains with higher productivity but are less adapted to the prevailing environmental condition . Crossbreeding is one of the major tools used in improving desired traits in animals. It utilizes the good adaptive characteristics of the indigenous animals and possibly exploit the phenomenon of heterosis resulting in the greater performance of the crossbred compared with the average of the parent.

Previous attempt aimed at improving the productivity of the indigenous chickens have been made through crossbreeding with improved exotic cocks. However, adaptation of the introduced breed to hot tropical climate has always been a challenge. There is however little or no studies on the adaptability and genetic evaluation of Sussex, Goliath and Marshall and their crossbred with the Yoruba Ecotype Chicken in the warm humid climate of Nigeria for growth traits and egg

production. It is therefore important to evaluate these strains for their adaptation and crossbreeding potentials as this could lead to the production of hybrid that is resistant to harsh tropical conditions and at the same time produce a reasonable amount of egg with faster growth rate.

1.2 OBJECTIVES

Main objective:

To evaluate growth and egg production potentials of Yoruba Ecotype Chicken, Marshall, Sussex, Goliath and their crossbred progenies.

Specific objectives:

- To determine the fertility, hatchability and growth performance and survivability of Yoruba Ecotype Chicken, Marshall, Sussex, Goliath and their crossbred progenies under Nigeria Humid tropical climate.
- To compare the egg production and egg quality characteristics of Yoruba, Sussex and Goliath chickens and their crossbred progenies under humid tropical climate.
- To measure genetic parameters (heterosis, reciprocal effects, heritability and repeatability) for growth and egg production traits in Yoruba ecotype chicken and its crosses with Marshall, Sussex, Goliath strains of chicken in Nigeria humid tropics.
- To develop predictive models (curvilinear, linear and principal component analysis) for adult body weight and egg production in YEC, Sussex and Goliath chickens and their crossbred progenies in Nigeria humid tropics.
- To determine the genetic relatedness among YEC, Sussex and Goliath chickens and their crossbred progenies for body weight and egg production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin of Chicken

The domesticated fowl (chicken) is believed to have descended from the Wild Indian Jungle fowl and the South East Asia Red Jungle fowl (Mason, 1983). Chicken is the most common and under spread domestic animals with a population of more than 24 billion in 2003 and kept primarily as a source of food for their meat and eggs (Mason, 1983) Domestic fowl or chickens referred to as *Gallus domesticus* occur throughout the world and according to Mason (1983), they are the most utilized species and the most popular of poultry kept in rural conditions.

Generally, there are four wild chicken species available on the Indian sub-continent viz; red jungle fowl (*Gallus gallus*), gray jungle fowl (*Gallus sonnerati*), Ceylon fowl (*Gallus lafayettii*) and green jungle fowl (*Gallus rarius*), indigenous chicken locally known as Deshi (*Gallus domesticus*) are reported to be derived from *Gallus gallus* whereas *Gallus bankiva* is believed to be the major contributor to the development of modern commercial breeds. However, after generations of genetic selection, chicken now come in many different shapes and sizes. Chicken are listed under several classes such as American, Asiatic, English, Mediterranean, Continental, Bortamas and Games (Adebambo *et al.*, 2011). The most popular type of chicken for commercial egg production is the white leghorn. This is a breed that originated from Italy spawned many sub-varieties in America, Denmark and England. They are noted for their prolific egg production of white shelled eggs. They are light weight birds with weight range of 1.2 to 1.5 kg for the females at maturity.

The Asiatic breeds were developed in 1904 from a cross of Red Maley game, leghorn and Asiatic stock. They are known as dual purpose birds and are bred for their high egg production and their potential for meat production. They are popular brown egg producers; their females can

attain 2.5 to 2.9kg at maturity while male weighs 3.2 to 3.6kg. English breeds which are characterized by their dual purpose, these include Sussex, Goliath, Austrolorp and Cornish.

2.2 Genetic Diversity of Chickens.

Genetic diversity makes farmers to select stocks or develop new breeds in response to the change in environment, discover of new human nutrition requirement, changing market conditions, threat to disease and the level of demand in the society FAO (2000). Efforts have been made in characterizing Nigerian Indigenous chickens; Sonaya and Olori (1990) classified based on ecotypes, Ebozoje and Ikeobi, 1995; Ikeobi *et al*., 1996 classified based on plumage and shank colour, Ibe, 1999; Ebozoje and Ikeobi, 1995; Peters *et al*., 2002, 2005, 2007, 2008 classified based on possession of major genes of feather distribution and structure of feather. Additionally, Adeleke *et al*. (2011) classified using molecular characterization while the effect of major genes on growth, fertility, hatchability and quality of semen and characteristics were reported by Peters *et al*., 2002, 2005, 2008. There are different methods for measuring or quantifying genetic diversity which include the use of phenotypic characters, biochemical traits and molecular markers. Modern molecular tools have been widely used by Groene *et al*. (1998) in assessing genetic variation between different chicken breeds. Adeleke *et al*. (2011) used blood protein analysis collected from three strains of Nigerian Local Chicken (normal, frizzle feathered and naked neck) and one exotic strain (Anak Titan).

2.3 Population of Chickens

The Indigenous chickens are the most abundant species of poultry that are kept by the rural dwellers and their reported number vary from one country to another. They are widely distributed than other livestock. Gueye (1998) reported that they represent about 98% of the total poultry numbers kept in Africa. In Nigeria 80% of 120 million poultry birds (Fayeye *et al*, 2005).

2.4 Improvement of Indigenous Chickens

A number of approaches aimed at increasing the productivity and improving the economic production profile for poultry farmers have been conducted in some part of Africa and elsewhere in the world. The genetic improvement program in a number of African countries did not achieve sustainable result and this has been attributed to various factors. These include operational and financial problems of state-owned farms or station maintaining the parent stocks which resulted in failure to deliver the pullets as planned However, some of the failures experienced for improving productivity are related to breeds unsuitability to the environment, disease challenges, bad management, lack of supplementary feeding and predator problems.

2.5 Characteristics, Growth and Performance of Local Chickens

The local chicken constitute 80% of the 120 million poultry types (Fayeye *et al.*, 2005) 86% of which are found in the Northern part of the country. The Nigerian local chicken is a light breed often with single comb and black and brown plumage laced with various colours and mottling are common. They exhibit large variation in body shape, feather contours with different combinations of plumage colours.

According to FAOSTAT (2011), local poultry represents the main avian genetic resources in West Africa with about 80% of total poultry production grown mainly for meat production and secondarily for egg production. Local chicken are to resistant to adverse weather conditions when compared with their exotic counterpart as a result of some unique adaptive features developed over a long period of random mating in their natural ecosystem. As listed by Egahi *et al.* (2010), the features include their relative small adult body size, nature of flight, relatively thick egg shells, different colour pattern and the presence of some major genes affecting their feather structure and feather distribution. These features are key to their adaptation and survival in prevailing conditions in rural environments. Importantly, indigenous chickens have high

genetic variance in their performance, hardiness, disease resistance (Apuno *et al*., 2011). Environmental stress factors such as excessive heat, poor management (feeding and housing, disease and parasite) are known to combine with poor genetic profile to result in the overall low performance in this population. However, they possess the potential to fast at early stages of life and this makes them suitable for use as parent in a broiler chicken development. Akinokun, (1990) reported that their body weight ranges between 0.9 and 1.8kg which shows sex differences at 8 and 20 weeks of age.

Investigation on growth performance of normal feathered, frizzled and naked necked indigenous chicken of Nigeria was carried out by Ibe (1993). He reported that the frizzled and naked neck birds mature earlier than the normal feathered birds in a tropical environment. Also, it was reported that the significantly better performance of adult live weight, shank length and back bone length may be as a result of the increased ability of frizzled chicken for heat regulation leading to increased fitness in a hot, humid environment as found in South Western Nigeria (Ikeobi *et al.,* 1996).

Akunokun, (1990) reported that age at sexual maturity and average egg weight were 169.50 days and 43.50g. Their productive ability was reported to be in the range of 40 to 80 eggs while their genetic potential for egg production is about 125 eggs (Nwosu and Omeye, 1985). The Nigerian Local chicken lays both brown and white eggs (Olori, 1992). These makes them suitable for development as a layer strain for the tropical environment because of the heat tolerance and adaptation to the tropics.

2.6 Body Weight Gain in Chicken

The body weight of the newly-hatched chick is about 66-68% of the incubated egg weight having had about 12% weight loss due to water loss during incubation. However, once the chick

is hatched the layer chicks increases in hatching weight about 10 times within the first six weeks of life (Ayorinde *et al.,* 1999). He also reported a body weight increase from 32.88gm to 1445.45gm between day old and 20 weeks of age. Weight at first egg in Fayoumi chicken was reported as 1253.53gm at 163.63 days (Kor *et al.,* 2006), while the laying test of German Democratic Republic (1986) for commercial hybrids put the body weight of white egg layers as 1.33kg, brown egg layers as 1.59kg and others as 1.32kg at 19 weeks of age. Chineke (2005) recommended that the maintenance of an optimum body weight range of 1.72 to 1.80kg for optimum egg traits performance in Olympia black pullets. He also reported that the association between body weight and selected egg traits (egg length, egg breadth, egg index, egg weight, albumen weight, yolk weight, shell weight, shell thickness, hen-day production) was non-linear. In a related study of phenotypic characteristics of Nigerian local chicken by Ajayi and Ejiorfor (2009), it was reported that the mean mature body weight was 1504 and 1289m for cocks and hens respectively. Similarly, the average body weight of the Fulani ecotype chicken in Nigeria was reported as 1099.28±196gm at 20 weeks and mean day-old weight of 30.45±1.24gm/chick by Sola-Ojo and Ayorinde (2009). The village chicken in Tanzania with highest body weight gain (120.85gm) between 16 and 18 weeks was reported with mean body weight of 1948gm/cock and 1348gm/hen by Goromella *et al.* (2009). Dana *et al.* (2011) reported mean body weight from hatch to 16 weeks as (25g to 701g) in male and from (25g to 573g) in female homo chicken.

2.7 Feeding and Feed Utilization

The role of feeding and nutrition cannot be over emphasized in poultry production. Food is an essential part of life, animals use the portion of feed called nutrient that are released by digestion and then absorbed into the body fluids and tissues for maintenance and production. Some of the

failures experienced for improving productivity are related to breeds unsuitability to the environment, disease challenges, bad management, lack of supplementary feeding and predator problems.

Rose (1997) reported that poultry eat feed approximately 5% of their body weight daily. However, offering pelletized feed may increase intake to 8% of body weight. Marks (1993) observed that selection for body weight improves feed utilization and that the increase in total feed intake was due to the nutritional need for maintenance requirements of a large body size in Japanese quail. Feed restriction is not practiced in rearing of layer chickens while ad-libitum feeding is practiced in the first week of life before gap-feeding is established. Sometimes full-feeding is practiced till production phase where daily gap-feeding (40/60%) is commercially favoured here because chickens feed mostly in the cool hours of the day (early morning and late evening) in the tropics and it ensures that adequate amount of feed is available for birds at night when egg formation is taking place and it is used to encourage proper uptake of micro-nutrients that are in the feed. Also, it reduces feed wastage and the empty troughs in the afternoon stimulate hunger for feed at the late evening hours. Phase feeding is practiced to adjust the decreasing nutrient requirement of the hen body, with increasing age and decreasing production levels for optimum production.

Water is important for feed metabolism in the body. It is related to temperature and feed consumption. Feed consumption (calorie intake) is also related to temperature. In a normal temperature range of birds, comfortable birds drink twice as much water as the feed intake but the ratio changes as temperature rises as birds eat less and consume more water to cool itself.

2.8 Sexual Maturity

The age at which a hen drops her first egg signifies early sexual maturity age while the age at peak production signifies full sexual maturity age. Early maturity could be achieved at 16 weeks or 122 days (Mussawar *et al.*, 2004). Ayorinde *et al., (*1999) reported 132 and 210 days (30 weeks) for Shika brown commercial strain reared in deep litter. Khan *et al.* (2006) reported early maturity at 163.63± 11.17 days in Fayoumi chicken with average body weight of 1253.53±16.43gm and first egg weighing 45.79gm under intensive management. Akanni *et al.* (2008) report indicate that Black Nora pullets achieved sexual maturity at 188 days with a body weight of 1421.59gm/bird while improved local B-Alpha pullets matured sexually at 199 days with a body weight of 1315gm/bird. Dana *et al.* (2011) reported that hens attained sexual maturity at an average of 190 days. He also stated that 16% of hens started laying between 21 and 24 weeks of age.

Horst and Peterson (1981) reported that the introduction of dwarf genes into chicken is capable of reducing both the body weight by 29.3 – 31.7% and increasing age-at-sexual maturity by 12.6 – 17.2% in hot environment. Ayorinde and Oke (1995) also reported that birds with lower body weight mature late by a week as against those with higher body weight, while those on ad-libitum feeding mature sexually 3 weeks before those on restricted feeding.

2.9 Survivability of Birds

Survival is a general measure of an animal's fitness. In commercial poultry production, mortality can result from a range of conditions (disease, physiological stress, environmental condition and aggressive behavior. Bird's survival recorded as a binary traits i.e either dead or alive at a given time is a potential indicator for many underlying health traits that could be improved simultaneously. Flock *et al.,* 2005 and Havensten *et al*., 2007 stated that selection for general survival has been applied largely in chickens and turkey but with little success.

2.10 Characteristics and Performance of the Experimental Parent Stock

2.10.1 Yoruba Ecotype Chicken (YEC)

Yoruba ecotype chicken (YEC) are mostly found at the backyards of poultry keepers in south west villages and town they are classified as a light breed of chicken with their mature body weight ranging 0.68-1.50kg (Momoh *et al*., 2007). Several authors have reported on the unique adaptation features of the Nigerian local chicken (Adebambo *et al*., 1999; Ibe, 1993). These include their relatively small adult size, generally flighty nature, relatively thick eggshell, high tolerance to some tropical diseases and parasites.

They lay more eggs than Fulani ecotype chicken (Fayeye *et al*., 2006; Momoh *et al*., 2007) studies relating to the development of the local chicken as a potential layer have shown appreciable improvement in egg production traits of the birds under improved management system the following authors (Nwosu *et al.*, 1985, Omeje, 1983). Nwosu and Omeje (1985) further noted that the local chicken has a genetic potential of producing 128 eggs /bird/year.



Plate 1: Yoruba Ecotype Chickens (YEC)

2.10.2 Marshall Broiler

Broiler chickens are gallinaceous domesticated fowl, breed and raised specifically for meat production, they are a hybrid of egg-laying chicken, both being a sub species of red jungle fowl (*Gallus gallus*). Typically, broilers have white feather and yellow skin they lay fewer eggs than other breed usually about 140 per year (Wikipedia, 2014).

2.10.3 Goliath

Goliath was developed in 1886 by William Cook. It is also referred to as Orpington. He crossed many different breeds of chickens, chiefly Minorcas, Langshans and Plymouth rocks to create the new hybrid bird. Goliath is a large bird from the English class of chicken, it was bred as a dual purpose breed famously known for good laying capacity (110 to 160 eggs /year even through winter), moderately early maturity and good carcass qualities [Citrus County Poultry Skill-A-Thon (2010)].



Plate 2: Goliath hen



Plate 3: Goliath Cock

2.10.4 Sussex

The Sussex chicken was created over a century ago in the country of Sussex, England. Sussex is dual purpose type of chicken, good forager and is regarded as a popular backyard chicken in many countries. They are good producers of large eggs (240 to 260/year) especially the light Sussex [Citrus Country Poultry Skill-A-Thon (2010)].



Plate 4: Sussex hen



Plate 5: Sussex Cock

2.11 Methods of Improvement of Local Stocks.

2.11.1 Development of Local Stock through Pure Breeding.

Indigenous breeds have been reported to be highly productive. In most poorly developed nations, the above breeding strategy would be quite appropriate, which means efforts need to be directed to the introduction and development of selection within local breeds. This strategy of developing the local stock is sustainable because the introduction of the exotic breeds or strains into small farming systems demands a high level of management and expensive feed. The challenge posed by this strategy is that selection within breed under extensive conditions will be extremely difficult due to lack of any genetic estimates of growth and reproductive parameters.

2.11.2 Gradual Replacement of Local Males

Genetically improved males of locally adapted exotic stocks should be released by breeding farms to small holder systems for village poultry development. Nwosu (1990) have found that less productive local breeds can be of commercial and breeding utility if crossed with improved breeds or strains. Their result showed that the body size and feed conversion efficiency of F_1 crosses [local X Gold link]could be as high as the imported Gold-link chickens and the back cross progeny [F_1 X Gold-link] showed a higher growth performance and feed conversion efficiency without significant reduction traits. This strategy also suggests that a continuous upgrading scheme either through backcrossing or line breeding is possible to obtain a synthetic breed genetically close to the exotic breed.

2.11.3 Uses of Local Genomes and Major Genes

High temperature and harsh nutritional and climatic conditions are the bone to successful commercial livestock production in the tropics, despite the numerical strength and the adaptation

of these animals to the different ecological niches. Meanwhile, major genes that make up for the adaptive qualities have been found to be present in these indigenous breeds at a high frequency especially in poultry of the utmost importance among chicken breeds are the frizzling and the naked neck genes.

A study by Fayeye *et al.* (2006) revealed that birds that possessed thermo-regulatory genes (Na and F) had a higher adult body weight than their normally feathered counterparts. According to Kitalyi (1998), slow feathering (K), Fayoumi (Fa), Frizzle (F), silky (H) and fibro-melanosi (Fm). Once the phenotypic effects of these genes on physiological and anatomical traits are characterized, it would be easy to incorporate these genes into crossbreeding programmes by establishing paternal breeding lines with dominant and or sex-linked major genes. Apart from the major genes identified, Kitalyi (1998) also found other morphological traits that allow better heat dissipation. These include large combs, large wattles and long legs. Gene coding for these traits which are not major genes but the result of multiple genes and their interactions could also be considered for incorporation into the development of high performing local birds for the tropics.

2.11.4 Development by Crossbreeding

Crossbreeding certainly is one elementary technique that can be used to improve productivity. It has its justification in the improvement of farm animal productivity under tropical conditions. The outcome of cross breeding is the phenomenon of heterosis which is expressed in the performance of the hybrids because heterosis is almost exclusively the aggregate of all single locus dominance effects and because these are usually positive or negative. Heterosis can be expected to be usually in the positive direction (Kitalyi, 1998). Hence, in the face of these problems, it therefore becomes imperative to explore interventions that may increase productivity through increased number of clutches per year and reduction of losses due to

predation. The interventions to improve the productivity were mostly made through cockerel exchange and egg distribution to rural farmers. Past attempts at improving livestock productivity in developing countries have focused largely on importation of exotic breeds which was aimed at achieving increase in production of meat and egg in the shortest time possible with limited success in the communal areas.

However, Gueye (1998) suggested that there is a need to protect and conserve the indigenous chickens because they represent an important gene reservoir. Indigenous chickens constitute a variable genetic reservoir that make them well adapted to the extensive management system.

2.12 Principles of Cross Breeding

Cross breeding offers two primary advantages relative to the use of one breed. The cross bred animals exhibit heterosis or hybrid vigour and the cross bred animals also combine the strength of these various breed used to form the cross. The goal of a well design, systematic crossbreeding program is to optimize the advantages of heterosis and breed complementarities simultaneously. Heterosis is primarily expressed by improvement in fitness, such as adaptation, resistance viability, survival, fertility and performance to mention few. Heterosis is normally observed in the F1 only and is about half in the F2 due to segregation, it is usually higher in traits with low heritability estimates such as growth rate, litter size, conception rate etc. Fayeye (2014). The mechanism of heterosis can be explained using various theories but the major theory is the assumption that the positive or economically desirable traits are dominant. Which means that the hybrid progeny will contain a large number of different dominant and positive genes from both parents. Dominant applies to gene interaction with the same pair. The other theories include:

The Stimulation Theory which states that heterozygosity stimulate hybrid vigor.

Theory of Dominance- linkage which state that dominant genes may be linked and transmitted, this is an extension of the dominance theory.

The Overdominance Theory states that hybrid individuals surpass both homozygotes. This is based on gene action at allelic level and overdominance can be due to allelic interaction.

The allelic interaction theory is a further extension of the overdominance theory to an allelic series in which more than two pairs of alleles determine a character (a given gene may have different phenotypic effects which are related to its location on the chromosome and such changes in the effect of gene due to changes in its location on the chromosome is referred to as position effect)

The Epistasis Theory- this is an explanation that heterosis results on the basis of interaction of positive non-allelic genes in the parents.

2.13 Crossbreeding and Its Effects on Poultry Performance.

In poultry production, crossbreeding refers to the mating of birds of different strains or breeds. It is an improvement strategy to find optimum combination of breeds for pre-specified breeding program by mating of unrelated stocks. Crossbreeding can be used as a tool that allows for manipulation of genetic variation to change the population in an attempt to optimize desired phenotype. The main purpose of crossing is to produce superior crosses to improve performance of local chickens and to combine different traits or characteristics. (Aly *et al*., 2005; Amin, 2007 and 2008; Saadey *et al.*, 2008; Lalev *et al*., 2014).

Crossbreeding offers two primary advantages relative to the use of one breed. Also, the crossbred animals exhibit heterosis or hybrid vigour and the crossbred animals combine the strengths of the various breeds used to form the cross. The goal of a well designed, systematic crossbreeding program is to optimize the advantages of heterosis and breed complementarity simultaneously.

Heterosis or hybrid vigour refers to the superiority of the crossbred animal compared to the average of the straight bred parents. However, hybrid vigour is the additional performance shown by the crossbred progeny above the mean performance of the two parents. The amount of heterosis for a particular character varies considerably depending on the degree of genetic diversity of the two parents that were crossed. Improved body weight at point of lay which influence egg size and post lay meat yield was recorded for 20th week body weight indicating the egg production potential of the local chicken. Also, high and positive heterosis percentage for body weight at different ages among cross bred and reciprocal cross breds were obtained in chickens (Atallah, 1989; Farghaly, 1989; Madour *et al*., 1992 and 1996; El- Gendy, 2000; Iraqi, 2008 and Amin, 2007). In addition, William *et al*. (2002) and Al- Shaheen and Razuki (2011) reported that the heterosis estimates for body weight of crossbred chickens at different ages were higher and associated with positive heterotic effects for growth trait. Hans *et al*. (2016) reported that chicken resulting from local lines grow slower than those resulting from mating between their males with Isa brown females and differences in percentages of heterosis calculated for body weights of chicks resulting from local male and Isa brown females and their reciprocal. Siwendu *et al*. (2013) reported highest heterotic effect for body weight in the cross between the Venda sires and Ross 308 dams and Venda sire and Naked neck dams. He concluded that it is important to consider the estimates of heterotic effects, genetic combining ability and specific combining ability of the breed of birds before embarking on a crossbreeding program.

The anticipated dominant effect is high for egg production traits, (Fairfull and Gowe, 1990 and Abou El- Ghar *et al*., 2003) some researchers affirm that the additive effect is markedly higher than the dominant effect. Mohamed *et al*., 2005; Aly *et al*., 2005; Amin, (2007) reported high estimates of non-additive gene effect for native breeds. Some reports showed that general

combining ability (additive genetic effect) was high and important as specific combining ability (non- additive effect) that involves dominance and epistalsis. Ledur *et al*. (2000) opined that crossbred hens increasingly exceeded egg production of their parental lines at later stages in the laying cycle in an experiment involving crossing of three strains of white leghorn and two commercial line. Sato *et al*. (1989) investigated heterosis for egg characteristics in reciprocal crosses between highly inbred lines of Japanese quail the crossbreds were superior to the parent lines in egg weight, albumen weight, shell weight, egg length, specific gravity, shell thickness, shell strength and yolk colour.

However, breeders can obtain adequate improvement due to the crossing and reciprocal crossing by different estimates of heterosis (i.e. direct and individual heterosis). Maternal and direct additive effect is important for body weight at different ages. Lalev *et al*., 2014, Abou El-Ghar *et al*., 2012. Reciprocal effects are deviations between the crosses of two parental strains or breeds in their roles as male or female parent are interchanged. Al- Shahen and Razuki (2011) reported important reciprocal effects for body weight in crosses between the local Iraqi chicken breed and two adapted exotic breeds. Fairbairn and Roff (2006) indicate that reciprocal effects can be attributed to sex linkage. Alewi *et al.* (2013) reported that reciprocal effects were influenced by age in an experiment involving local chickens crossed with Rhode Island Red and Fayoumi breed of chicken.

2.14 Egg Traits in Poultry

Egg traits in poultry can be classified into external and internal traits which are described by Fayeye and Adeshiyan (2005) and Ojedepo *et al.* (2008) as egg number, egg weight, egg length, egg width, egg index, shell weight, shell thickness, age at sexual maturity for external traits

while internal egg quality include albumen weight, albumen height, Yolk colour, yolk weight, yolk diameter, yolk height, yolk index and haugh unit.

Essien (1989) reported that maximum rate of egg production occurred in shaver in the first 12 weeks of production, then declined gradually after 12 weeks and markedly decreased during 25 – 48 weeks of lay. Dana *et al.* (2011) reported that peak egg production was achieved at the fourth month of laying which started to drop in the 5th month. They also stated that HDP increased from 2.5% in the first month to 32% in the fourth month of laying and decline afterwards. Also, Rose (1997) and Oluyemi and Roberts (2000) reported that the egg production curve of the domestic chicken can be divided into 3 main phase which are:

Phase 1: Time from the first egg laid to the time when nearly all birds in a flock are laying continuously (peak production). This is very short because individuals are exposed to same environmental and nutritional regime. This phase ends in peak production.

Phase 2: It is the main laying period with a continuous but gradual decline in HDP due to lengthening egg formation time. There is also slow and continuous reduction in the rate of egg-yolk deposition as birds get older. This period last for various lengths of time depending on species, strain, environment and management.

Phase 3: Incidence of interval laying increases sharply. This condition is due to a number of factors such as broodiness, moulting, changes in nutrient intake, changes in body composition, stress factors such as sharp noise, regular disturbances and fright, all these conditions accelerate end of lay and onset of moulting.

2.15 Egg Production in Chicken

Egg production of 70.06, 67.43 and 54.06% at 33 – 46, 47 – 59 and 60 – 72 weeks as reported for Shika brown while Rhode Island Red (RIR) chicken reared under intensive system had egg

production of 55.8% with 133 eggs during 16 – 50 weeks (Sazzad, 1992). Although egg production of 240 eggs/hen/year was reported in a strain of RIR chicken, however, a bird laying 180 – 200 eggs/year in the tropics is considered a good layer (Atteh, 2004).

Jesuyon (2010) reported that Bovine Nera did not experirnce deperession before week 25 and after week 55 while Isa Brown experienced depression in egg production almost throughout their life time. Essien (1989) reported that maximum rate of egg production occurred in shaver fowls during the first 12 weeks of production. Khan *et al.* (2006) investigated effect of season on egg production of chicken among local chicken among local chicken in Bangladesh. They reported highest egg production in winter season (52.78%), followed by summer, spring and late autumn respectively.

2.16 Factors that Affect Egg Production in Poultry

2.16.1 Body Weight

The Variation in body weight within a flock can be attributed to genetic variation and environmental factors that impinge on individuals (Ayorinde and Oke, 1995). The poultry producer wants birds of minimum possible size and weights that will maximize production of standard sized eggs at an economic rate and still maintain its marketable carcass value at the end of the production period (Oke *et al.,* 2004). Jesuyon (2010) concluded that Bovan hens used more energy during growth making them to have higher body weight while Isa Brown hens conserved their energy for egg laying during Production period. Body weight in poultry is known to be moderate to highly heritable. Though various factors are known to affect egg production, there are conflicting reports on the effect of body weight on egg production. Fairfull and Gowe (1990), reported that dwarf broiler females lay as well as normal broiler females. Various findings using broiler birds in egg production experiment tend to suggest the possibility

that the lower egg production of dwarf chickens may be due to close linkage of the dwarfing gene and genes determining egg production on the sex chromosome. For the development of egg production strains within the local chicken, it is necessary to establish the nature of the relationship existing between body weights of the local chicken and egg production parameters.

2.16.2 Age

The age at which a hen begins to lay eggs affects the total egg production in its life cycle. Selection of laying hens is normally based on partial records; improvement in production occurs largely in the first part of the laying cycle. Khalil *et al.* (2004) found that selection of hens with lower age at first egg leads to improvement of performance of egg production. Nwagu *et al.* (2001) obtained a positive response in a female line population which they attributed to reduced age at sexual maturity. Age influences egg production especially within the first laying cycle and over the subsequent laying cycles (Fairfull and Gowe, 1980) in each laying cycle, egg production (per hen housed or per live hen) quickly rises to a peak and declines slowly thereafter to the end of the cycle, usually terminating with a natural or induced molt. Thus, within egg production cycles, egg production declines with increasing age while its variation increases.

2.16.3 Disease

Disease affects egg production through mortality and morbidity (sub-clinical and clinical disease, inadequate nutrition, toxic elements, etc.). Mortality reduces the number of layers available to lay eggs, and morbidity reduces the laying ability of affected hens (Fairfull and Gowe, 1990). However the effects of morbidity and mortality on egg production records depend upon the age of the hens when affected, however, infection or conditions of instability in hens before or about their peak period of egg production would greatly affect the overall egg production records.

2.17 Persistency in Egg Production

Laying performance of some exotic breeds Rhode Island Red are excellent egg producers (Wikipedia, 2014). Although they can be stubborn sometimes, they can end up producing 250 to 300 large, light brown eggs per year. Goad langshons hen lay 140 – 150 eggs a year which are brown with a plum-coloured bloor are excellent sitters and mothers (Wikipedia, 2014). The Sussex hen approximately 240 – 260 eggs a year which is large and cream to light brown in colour, although the light and white varieties are the best layers (Wikipedpia, 2014). Also, Goliath lay between 110 and 160 eggs a year, they also lay in winter, the eggs are small to large depending on the heredity of the breed and are light brown to tinted white in colour. The hens occasionally tend to go broody more than other heavy egg breeds (Wikipedia, 2014).

2.18 Effect of Strain on Sex

Ajayi and Ejiofor (2009) reported significant strain X sex effect on live weight and linear measurements in broiler breed. Also, Benyi *et al.* (2015) reported significant strain X sex interaction on body weight, feed intake and mortality rate in Coob and Ross stains of broiler chicken. Ojedepo *et al.*, (2008) observed that there is no significant stain X sex interaction on carcass traits of broiler chicken.

2.19 Effect of Strain and Environment on Egg Production and Quality

Breeds has some effect on carcass characteristics, high body weight found in male and female exotic breed is probably mainly due to breed complementarily. According to Tadelle (2000), chicken breed has led to the introduction of different exotic breeds white leghorn, brown leghorn, New Hampshire, light Sussex, Barred Rock, Rhode Island Red, and Fayoumi etc. The genetic composition of any fowl always interacts with the environmental factors resulting in the phenotypic expression manifested in the offspring in terms of reproductive performance. Peter (2000) suggested that the performance of any given chicken at a point is a function of strain and

environment interaction. Many researchers have reported improvement in production of crossbred chickens, Zaman *et al.* (2004) reported improved egg production in crossing indigenous naked male with an exotic laying strain female, Islam *et al.* (2001) recorded significant egg weight and quality traits for indigenous naked neck and Indigenous full feathered chicken. Sola-Ojo and Ayorinde (2011) who obtained high egg production in crossbred FE x DB chicken, Fletcher *et al.* (1981), Olawumi and Ogunlade (2009) who reported significant breed effect for egg quality traits in some exotic breeds of chicken.

2.19.1 Fertility and Hatchability of Eggs

Fertility and hatchability of eggs are both functions of breed and environment. Peters *et al.* (2004) describe fertile eggs as eggs that are capable of hatching. Peters (2000) observed that the effect of strain and breed differences do affect fertility of eggs. Hatching to a large extent is a derivative of fertility except for the presence of major genes and strain or breed differences that affect embryonic liveability (Peters *et al.*, 2005, 2008) confirmed that the strain of the dam had prominent effect on fertility and hatchability of eggs. The superior fertility demonstrated by local chickens is influenced by sire strain effect which may be due to the quality of their semen which had higher sperm concentration, mobility and liveability.

2.19.2 Effect of Egg Weight on Fertility and Hatchability

Asuquo and Okon (1993) established that egg size has a marked effect on hatchability. They also reported that hatchability is at a maximum when eggs of medium size are set for hatching and the also opined that there was a significant difference between medium and large size eggs, with average percentage of 88.24% and 84.79% respectively. They claimed that this difference was probably due to embryonic mortality. Sinclair *et al.* (1990) and Pinchasov (1991) indicated that

there is a decline in the magnitude of correlation between egg weight and chick body weight with the advancement of age of the chick. Also, Sola- Ojo and Ayorinde (2011) opined that insufficient egg nutrient, storage duration and conditions will contribute to the failure of fertile eggs to hatch. Physiology, egg size, plane of nutrition, strain and possession of major genes in chicken influenced hatchability (Peters *et al*., 2004) while King'Ori (2011) reported other factors which include; health, nutrition and age of the hen and egg size.

2.20 Heritability and Repeatability Estimates and their Effect on Crossbreeding.

Heritability estimates provide an insight on the additive genetic influence on a given traits, additive genetic effect is the part of the genetic component that is passed on from both parents to their offspring. Heritability indicates what proportion of the total phenotypic variation is due to genetic variation among individuals. High heritability values indicate that the traits are highly heritable and can be transfer from parents to offspring. Heritability estimates for traits are usually categorized into three category viz Low, Moderate and high with their values in most cases ranging from 0.1 to 1.0. Low heritability (0-0.19), moderate heritability (0.2-0.39) while high (0.4 and above). Low heritability is an indication that variability due to additive gene action is probably small or the non-additive gene action such as dominance, overdominance and epistalsis may be important than additive and environmental factors.

Repeatability estimates reveal the fraction of differences between single records of individuals that are likely to repeat in the future performance (Toye *et al.,* 2012). The direction of repeatability estimates indicates the extent to which selection methods adopt at any stage will affect subsequent flock performance Ibe, 1995. It is the correlation between two or more measurement on each individual in a given population, when repeatability estimates is high,

culling poor performers on the basis of a single record will be effective in improving flock performance when the measurement is repeated.

The estimated heritability and repeatability is always specific for a trait, but also for a particular population in a particular environment this is because the influence of environment will depend on that environment and genetic variation for a trait which may vary between population.

2.21 Estimation of Heritability

2.21.1 Negative Variance Components Estimates

The variance component should be positive always because it is assumed to represent the variance of a random variable, but some methods like ANOVA and MIVQUE do result to negative estimates. This could be as a result of the following reasons:

The variability in the data set may be large enough to produce a negative estimate even when the true value of the variance component is positive.

Data may contain outliers which exhibit unusual large variability.

A different model can be used to interpret the data because under some model a negative estimate is an indication that observations are negatively correlated Rao *et al*. (2014).

2.22 Correlation.

There are components of correlations which include genetic, phenotypic and environmental correlation.

2.22.1 Genetic Correlation

Genetic correlation can be defined as the proportion of the heritability shared between two traits divided by the square root of the product of each trait.

Also, genetic correlation occur when single gene affect two traits. It can either be positive or negative and ranged between +1 to -1, if it is zero it indicates that there is no genetic correlation. If genetic correlation is +1 the traits always occur together but if -1 it means that an increase in one leads to a decrease in the other traits, the consequence of breeding practically is that selection for one trait will carry along any positive correlated traits even though there is no deliberate selection for them but when traits have a negative genetic correlation, selecting the traits together will be difficult Albert, 2018.

2.22.1.1 Causes of Genetic Correlation include;

Pleiotropy which implies a situation when a single gene is having multiple unrelated biological effects or shared regulation of multiple genes Fayeye, (2014). Secondly, linkage disequilibrium this occurs when two neighbouring genes tend to be inherited together, each affecting a different trait.

2.22.2 Phenotypic and Environmental Correlation

Phenotypic correlation between two characters is the correlation between their observed values. It arises from correlations between genetic and environmental effects affecting the two characters Ibe, 1998. Also, phenotypic correlation measures the degree to which two traits co-vary among individuals in the population.

Environmental correlation can be defined as the correlation between environmental deviations, including all non-additive genetic deviations influencing two characters. It estimates the degree to which two traits respond to variation in the same environmental factors (Conner, 2002).

The genetic and environmental correlations among traits are important when selecting for net merit involving several traits.

2.23 Prediction of Body Weight, Egg Weight and Egg Number in Chicken.

It is of interest to determine how changes of values of some variables influence the change of values of other variables. Regression analysis includes a procedures designed to study statistical relationships among variables in a way by which one variable is defined as dependent upon others defined as independent variables. In using regression analysis, the cause and consequence relationship between independent variable and dependent variables can be determined. Linear regression could be done using stepwise regression which requires two significant levels with one adding and the other for removing variables. Forward selection is a method used to provide an initial screening of the individual variable when a large group of variable s exist while backward selection will select values that are not really necessary in the model. Also, when the change of the dependent variable is described with just one independent variable and the relationship between them is linear then this relationship is termed simple linear regression .while multiple regression procedures are utilized when the change of a dependent variable is explained by changes of two or more independent variables. But in some situations the influence of an independent variable on a dependent variable is not linear. The simple linear regression model is not suitable for such problems, hence curvilinear relationship can be used in order to predict accurately and making the assumptions satisfied. Regression analysis as two main applications which include estimation of a function of dependency between variables and prediction of future measurements of the independent variable(s).

Prediction of body weight have been widely reported by several authors using body measurements as predictors for body weight Sanda *et al.* (2014) reported that body weight of broilers can be predicted from any of the linear body measurements in an experiment involving three strains of broilers. Jesuyon (2010) reported that age of birds gave the best prediction of body weight eventhough correlation indices was higher in cocks than hen in an experiment

involving Bovan Nera and Isa Brown Chickens. Chineke (2001) also reported a significant quadratic relationship between total hen-day production and body weight at sexual maturity in white leghorn layers. Relationships between body weight and linear body measurements are important for predicting body weight and can also be applied speedily in selection and breeding programmes. In addition, Oni *et al.* (2001) studied egg production in a strain of Rhode Island breeder hens using six mathematical models namely exponential, parabolic exponential, woods gamma, modified gamma, inverse polynomial and linear model. They fitted 28-day periodic egg production data to models starting from first-egg. Comparison between these functions indicated that the modified gamma model by McNally (1971) gave the best fit to data but they concluded that one model may not necessarily be best in all circumstances or with all data; and suggested that properties of models and data should be examined before choosing an appropriate model.

Also, the use of body measurements to predict body weight of different animal species (e.g. cattle, sheep and goat) have been done by some authors (e.g. Attah *et al*., 2004; Sowande and Sobola, 2007; Goe, 2007). The regression models can be used to make fast or early evaluation of the market body weight of an animal (Amao *et al.*, 2010; Ojo, 2010), thereby enhancing the rate of progress in selection programmes. The use of linear equation is common in the prediction of body weight in poultry (Raji *et al*., 2009) and other species (Silva *et al.*, 2015; Zergaw *et al*., 2016). Another report by Semakula *et al.* (2011) showed that prediction using quadratic regression was more reliable than simple linear regression and polynomial. Yakubu *et al.* (2009) stated that cubic function predicted carcass weight of broiler chickens more accurately than quadratic and linear functions. In a comparison of four functional forms, Fayeye and Ayorinde (2007) reported that the linear function gave the best fits for the regression of egg weight on egg quality traits.

2.24 Principal Component Analysis

Principal component analysis is a Multivariate technique that analyzes a data set in which observations are described by several inter-correlated quantitative dependent variable Abdi *et al*. (2010). Also, according to (Jolliffe, 2002) principal component analysis is a mathematical procedure that transforms a number of possible correlated variables known as principal components which are ordered so that the first few retains most of the variation present in the original variables. It simultaneously consider a group of attributes which may be interesting for selection purposes and each of the principal components explains a percentage of the total variance with the first principal component explaining the highest percentage of this variance. Salako (2006) reported that principal component 1 (PC1) could be used to describe the generalized form of broilers, Yakubu *et al*. (2009) also opined that the first principal component accounted for the largest variance in the morphological traits of three Nigerian Chicken strains Pinto *et al*. (2006) opined that in animal genetics and improvement, principal component simultaneously consider a group of attributes which may be of importance in selection, he used Principal component analysis to analyse performance and carcass traits in chicken and reported that the first five components explained 93.30% of the total variation with the first component explaining 66%.

2.25 Cluster Analysis

Cluster analysis refers to a class of data reduction methods used for sorting cases, observations and variables of a given dataset into homogeneous groups that differs from each other, they analyses group differences based on independent and dependent variables. The purpose of cluster analysis are to discover a system of organizing observations where members of the group share specific properties in common, it also classifies cases into groups that are relatively homogeneous within themselves and relatively heterogeneous between each other. Sangwon *et*

al. (2014) opined that clustering individuals into population groups based on their strain data will allow the interpretation of relatedness without having prior knowledge about the breed. Hierarchical clustering is an example of cluster analysis used to separate each case into its own individual cluster in the first step so that the initial number of cluster equals the total number of cases a successive steps, similar clusters are merged together until every case is grouped into one single cluster and this produce a sequence of clustering assignments, visualized by a dendogram. Ikpene *et al.* (2016) who used three strains of chicken reported that the result revealed that the chicken strains are related to their morphology and Adekoya *et al.* (2013) who also reported that five indigenous chicken types are also related to their morphology. Also, Adeleke *et al*. (2011) reported that both frizzle and normal feathered chicken are genetically close to Anak Titan while these three are genetically far from Naked neck chickens.

CHAPTER THREE

EXPERIMENT ONE

FERTILITY, HATCHABILITY, GROWTH PERFORMANCE AND SURVIVABILITY OF YORUBA ECOTYPE CHICKEN, MARSHALL, SUSSEX, GOLIATH AND THEIR CROSSBRED PROGENIES UNDER NIGERIA HUMID TROPICAL CLIMATE

3.1. Introduction

Fertility, hatchability, growth rate and survivability are important traits in poultry production system; these are major factors that influence day-old chicks demand. Fertility is an important aspect in chicken production and encompasses the actual reproductive capacity of males and females expressed when mature together to produce offspring. Fertility refers to the percentage of incubated eggs that is fertile. Maizi *et al*. (2012) explained that an egg is said to be infertile when it fails to shows an evidence of developing embryo. Variations in percentage fertility has been reported by some authors, El- Gengy, 2000; Hanafi and Iraqi, 2001; Dessie and Ogle (2001) reported high fertility in native breeds and Ethiopian local purebred while, Sola-Ojo and Ayorinde (2011) reported low fertility for Fulani ecotype. Hatchability can be define as the percentage of fertile eggs that hatch (Wondmeneh *et al*., 2006; King'Ori, 2011). Tarek, 1992 defined hatchability as the ability of embryo to successfully escape from the egg shell. Hatchability is influenced by some factors such as egg weight, rate of turning eggs during incubation, storage, humidity, shell strength, egg size and genetic factors. Fayeye *et al*., 2005; Alaba, 1990; Atteh, 1990 reported high hatchability for the Fulani ecotype chicken under natural incubation. Chickens need adequate amount of feeds and water for them to grow, they absorb the nutrient that are released from the feed through digestion into the body fluid and tissue for their

maintenance and production. Growth involves physiological changes that starts when the zygote is formed during fertilization and this process continued until maturity Oleforue –Okoleh *et al.*, (2017). Also, Kor *et al.* (2006) viewed growth in animal as a complex process that is controlled by the genetic and non-genetic factors. The rate of growth in chicken depend solely on some factors which include; the quality of feed, health status, strain and environmental conditions. Additionally, Oleforuh-Okoleh *et al.*, (2017) opined that growth performance of an animal can be attributed to phenotypic factors that are influenced by the environment to a large extent and it is a manifestation of the genetic constitution of the animal. Hence, growth performance is an important parameter in assessing the potential of genetic improvement and development of livestock strains.

Survivability refers to the rate at which an animal survive and reproduce within a define environment (Barker, 2009), the rate of survival of chicken could result from conditions like poor feeding, disease condition, physiological stress and response to environmental conditions. The aim of the work is to evaluate YEC, SS, GG, MM and crossbred with YEC for fertility, hatchability, growth performance and survivability.

3.2 Objectives

- To determine the fertility, hatchability of pure and cross-bred chickens.
- To determine the early and late growth performance of pure and cross-bred chicken.
- To measure survivability for the early and late growth performance of pure and cross-bred chicken.
- To estimate the mean Heterosis, % heterosis, direct and maternal additive effect for body weight in crossbred chickens.

3.3 MATERIALS AND METHODS

3.4. Preliminary Study

3.4.1 Experimental Birds and Management.

A total of 450 eggs collected from three strains which include 277 Yoruba ecotype chicken eggs obtained from rural farmers in Oyo town, 110 eggs of Sussex and 63 eggs of Goliath from a private farm in Benin-Republic were sent to a commercial hatchery for incubation in Ibadan. A total of 329 chicks were hatched (comprising of 195 YEC, 86 Sussex and 48 Goliath day-old chicks) and 100 day old purebred Marshall Chicks obtained from a commercial hatchery were used to form the base population. Birds were raised separately according to their strain on deep litter, water and feed were given ad-libitum from day-old to maturity.

3.4.2. Semen Collection, Insemination, Egg Collection and Incubation.

Matured chickens of Goliath, Sussex and Marshall were crossed between themselves and crossbred with YEC sire and dam .Semen was collected by double hand stimulation of the cocks in each strain and the released semen is collected through a suction tube into a cylindrical container blood stains and contaminated semen was avoided. The insemination kit (pap set) was used to deposit the semen in the uterus through cloaca opening by stimulation of the hens, fertile eggs were collected four days after insemination and eggs laid were picked daily from each genotypic group. A total of 971 eggs collected from Yoruba ecotype, Goliath, Sussex, Marshall and six crossbred chickens were used to evaluate fertility and hatchability of eggs. The eggs collected were set into commercial incubator for 21-days. Eggs were candled at day 5 to determine the number of fertile eggs, Hatched chicks were collected, counted, weighed and wing-banded according to strains.

A total of 529 chicks which belong to four purebred (Yoruba ecotype, Sussex, Goliath and Marshall) and six crossbred strains (Table 3.1) obtained from hatchability experiments were used for the evaluation of early growth performance of the 10 chicken strains. Also, a total of 457 eight-weeks old chickens were used to evaluate weekly bodyweight performance of grower chicken. Birds were raised in deep litter floored pens at a poultry facility located at Oyan (Osun state, South-West Nigeria). The coordinates of the experimental site is latitude 8.05 and longitude 4.77 and an elevation of 422 meters above sea level. All birds were given unrestricted access to water, and were fed the same diet *ad-libitum*. The time (days) for individuals within each strain to die (mortality) was recorded and plotted against the cumulative probability of survival. The composition of experimental diet is shown in Table 3.2. Routine vaccination was carried out to prevent endemic diseases (Table 3.3).

Table 3.1: Matting Pattern of the experimental birds

Strains
♂ **x** ♀
YEC x YEC
GG x GG
SS x SS
MM x MM
YEC x GG
YEC x SS
YEC x MM
GG x YEC
SS x YEC
MM x YEC

♂ and ♀ represent male and female

Table 3.2: Nutrient Composition of Starter (Broiler starter), Grower and Layer Mash Fed to Pure and Crossbred Chickens

Ingredients	**% Composition (starter)**	**Grower**	**Layer**
Calcium%	1.00	1.00	3.50
Available phosphorus%	0.45	0.45	0.54
Na%	0.38	0.38	0.36
Cl % (min)	0.55	0.30	0.50
Methionine digest% (min)	0.50	0.46	0.77
Cystine digest% (min)	0.38	0.30	0.36
Lysine digest% (min)	1.20	0.90	1.74
Threoinine digest% (min)	0.89	0.70	0.71
Crude fibre% (max)	5.00	7.00	5.00
Crude fat% (min)	4.00	5.00	1.40
Crude Protein %	22.00	16.00	18.40
ME Kcal/kg	2900.00	2450.00	2760.40

Na, Cl, ME, %, min, max, kcal/kg represent: sodium, chlorine, metabolizable energy, percentage, minimum, maximum, kilocalorie per kilogram.

Table 3.3: Vaccination Program

Weeks	**Vaccines**	**Methods/route**
Day-old	New castle	Ocular
2	Gumboro (1st short)	Drinking water
3	NCDV (Lasota)	Drinking water
4	Gumboro (2nd short/booster)	Drinking water
6	Fowl pox	Wing web
8	Komorov	Intral muscular (i.m)
12	NCDK (booster)	Drinking water

Other medication of antibiotics (such as Doxygen) and vitamins (such as Vitalite) were given when necessary.

3.5 Data Collection

Records of bodyweight of chicks (in grammes) were taken for a period of 8 weeks (early growth phase) and for a period of 12 weeks, until the birds were 20 weeks of age. Feed intake was recorded as the difference between the quantity of feed supplied and left-over for the week. Mortality was recorded as the number of birds dead per strain per week. Feed efficiency was calculated as the ratio of feed intake to weight gain for the week.

Fertility and hatchability of total eggs and hatchability of fertile eggs were estimated as follows:

$$\text{Fertility \%} = \frac{Number\ of\ fertile\ eggs}{Total\ number\ of\ egg\ set} \times 100$$

$$\text{Hatchability\% (TES)} = \frac{Number\ of\ chicks\ hatched}{Number\ of\ egg\ set} \times 100$$

$$\text{Hatchability}_{\%}\ \text{(FES)} = \frac{Number\ of\ chicks\ hatched}{No\ of\ fertile\ eggs} \times 100$$

3.6 Statistical Analysis.

Data on fertility and hatchability of eggs were subjected to descriptive statistics (percentages of total). Data on weekly bodyweight were subjected to a two-way Analysis of Variance (ANOVA) suitable for a 10x2 factorial design to evaluate the fixed effects of strains, sex and their interaction, using SAS statistical package. Mean genotypic values were separated using Duncan multiple range test.

Data for survivability was obtained for all the genotypic records from day-old to 8 weeks of age (early growth phase) and 9 weeks to 20 week (late growth phase). The incidence of death (mortality) was recorded per day per bird while mortality was scored 1 throughout the experimental period. Data was compiled and analysed using SPSS version 21 by using the methods of Kapler mier survivability test. The cumulative probability percentage of survivability was calculated for each breed and the survival function was obtained from the record of mortality and plotted against the cumulative probability of survival. Also, the log rank test was used to test the probability of equality in survival among all the breeds.

The mathematical model of ANOVA used is as follows:

$Y_{ijk} = \mu + G_i + S_j + GS_{ij} + e_{ijk}$

Where:

Y_{ijk} is the phenotypic value obtained for k^{th} animal which belong to the ith strains and j^{th} sex.

Gi, Sj, represent the fixed effects of strains and sex, respectively.

GSij represents the interaction between strains and sex.

μ and e_{ijk} represent overall mean and error residual, respectively.

The mean heterosis was calculated by subtracting the average weight of cross bred from the average weight of pure bred while percentage heterosis was generated by the proportion of

heterosis value to the average weight of the pure bred multiplied by 100. Maternal and direct additive effects was generated by subtracting the average weight of purebred from average weight of the cross bred for straight and reciprocal cross.

Estimation of direct heterosis was obtained as follow: (Dickerson, 1992)

(1). H' (YEC×MM) = {(YEC ×MM +MM ×YEC) - (YEC ×YEC +MM×MM)}/2

(2). H' (YEC×SS) = {(YEC×SS + SS × YEC) - (YEC × YEC +SS ×SS)}/2

(3). H' (YEC ×GG) = (YEC× GG+GG×YEC) - (YEC×YEC +GG×GG)} 2

%Heterosis was calculated as follows:$= \frac{H'(units)}{Means\ of\ purebreds} \times 100$

MAE = (YEC x GG – GG x YEC)

DAE = (YEC x YEC +YEC x GG) – (GG x GG + GG x YEC)

Where,

H' = Estimation of direct heterosis in units,

%H = Heterosis percentage

MAE = Maternal Additive Effect

DAE = Direct Additive Effect

YEC = Yoruba Ecotype Chicken

GG = Pure bred Goliath chicken

SS = Pure bred Sussex chicken

MM = Marshall Broiler Chicken

3.7 Results

3.7.1 Fertility and Hatchability of Eggs of Yoruba Ecotype, Goliath and Sussex and Crossbred Chickens

Table 3.4 shows the result of fertility and hatchability of eggs of pure and crossbred chickens. Mean %Fertility of egg, %Hatchability of egg set and %Hatchability of fertile egg for the 10 strains were 74.01%, 61.35% and 82.32%, respectively. Sussex and Goliath hens used in pure-breeding produced eggs that were higher in fertility and hatchability than Yoruba ecotype. Generally, crossbreeding improved the %Fertility of egg, %Hatchability of egg set and %Hatchability of fertile egg. Crossbreeding (reciprocal) between Yoruba ecotype and either Marshall or Goliath chicken gave better fertility and hatchability than the cross between Yoruba ecotype and Sussex chicken. Reciprocal effects on fertility and hatchability generally favour the use of male Yoruba ecotype and female exotic chicken.

3.7.2 Feed Intake, Weight Gain and FCR of Pure and Cross Bred Chicken

Table 3.5 shows the effect of strain and age of birds on feed intake, feed conversion ratio and their weight gain. There was a significant ($P<0.05$) difference among all the strains in all the traits observed. Pure bred GG and cross bred YEC x GG consumed significantly ($P<0.05$) more feed than their pure bred and cross bred counterparts at day –old to week 4 of age, while getting to week 5 pure bred MM consumed significantly ($P<0.05$) more feed than their purebred and cross bred counterparts up to 20weeks of age. However, pure bred YEC chickens consumed significantly ($P<0.05$) less feed than other strains up to16 weeks of age while GG x YEC and

Table 3.4 Total Egg Set, Fertile Eggs, Hatched Chicks, Percentage Fertility and Hatchability in YEC, Goliath, Sussex and Marshall Broiler and their Crossbred Chickens

Strains	**No of eggs set**	**Fertile eggs**	**Total hatched**	**%Fertility of egg**	**% Hatchability of egg set**	**% Hatchability of fertile egg**
YEC x YEC	363	206	148	56.75	40.77	71.85
GG x GG	100	75	61	75.00	61.00	81.33
SS x SS	119	90	79	75.63	66.39	87.78
MM x MM	76	54	46	71.05	60.05	85.19
YEC x GG	61	50	40	81.97	65.57	80.00
YEC x SS	64	40	30	62.50	46.89	75.00
YEC x MM	30	25	20	83.33	66.70	80.00
GG x YEC	58	39	35	67.24	60.35	89.74
SS x YEC	60	42	35	70.00	58.33	83.33
MM x YEC	40	39	35	97.50	87.50	89.74

YEC, GG, SS, MM , represent: Yoruba Ecotype Chicken, Goliath, Sussex, Marshall Broiler, Male and female respectively.

Table 3.5: Feed Intake, Weight Gain and FCR of Pure and Cross Bred Chicken

PARAMETER	**AGE**				**STRAIN**						
	(WKS)	**YECxYEC**	**GGxGG**	**SSxSS**	**MMxMM**	**YECxGG**	**YECxSS**	**YECxMM**	**GGxYEC**	**SSxYEC**	**MMxYEC**
FI(g/day)	0-4	9.51±`1.1^{d}	22.98±1.9^{a}	15.47±0.3^{cd}	20.07±0.3^{ab}	23.19±2.6^{a}	12.39±1.2^{cd}	19.10±2.4^{ab}	13.29±2.6^{cd}	19.50±1.4^{ab}	14.91±1.3^{cd}
	5-8	23.34±1.3^{d}	60.79±5.7^{ab}	38.22±0.5^{cd}	85.58±12.7^{a}	54.30±4.0^{bc}	29.91±1.2^{cd}	47.49±4.6^{bc}	34.10±4.6^{cd}	61.20±6.2^{ab}	37.44±3.0^{cd}
	9-12	29.36±2.1^{d}	67.18±6.4^{b}	49.21±1.6^{c}	108.00±6.0^{a}	55.24±4.1^{bc}	40.95±1.7^{cd}	38.28±2.3^{c}	38.29±2.3^{cd}	68.77±8.6^{b}	55.24±2.7^{bc}
	13-16	44.66±4.6^{d}	96.69±7.3^{b}	75.51±2.0^{bc}	146.84±9.1^{a}	78.11± 2.7^{bc}	63.77±2.7^{cd}	45.03±1.0^{c}	45.03±1.0^{c}	95.87±8.6^{b}	50.98±4.3^{d}
	17-20	59.06±6.3^{de}	116.31±9.5^{b}	99.74±1.7^{bc}	177.4±11.9^{a}	106.87±1.3^{bc}	84.89±1.7^{cd}	53.04±2.0^{bc}	53.04±2.0^{d}	123.62±6.7^{b}	54.75±5.5^{e}
WG(g)	0-4	7.65±0.7^{d}	20.49±0.9^{a}	15.06±0.5^{bc}	16.16±1.5^{b}	19.23±1.6^{ab}	11.52±1.1^{cd}	18.87±1.6^{ab}	11.80±0.9^{c}	12.17±1.1^{c}	11.34±1.0^{cd}
	5-8	13.98 ±0.9^{d}	31.46±2.14^{ab}	21.90±1.3^{cd}	37.85±4.14^{a}	24.66±2.0^{bc}	26.01±2.1^{bc}	31.49±2.9^{ab}	18.14±1.4^{d}	11.71±0.9^{ab}	18.78±1.2^{d}
	9-12	12.94±0.9^{e}	32.09±3.0^{bc}	22.22±0.7^{cd}	42.31±5.7^{a}	24.61±2.4^{cd}	25.40±0.9^{cd}	33.32±3.0^{ab}	16.40±1.0^{bc}	25.56±2.5^{cd}	18.09±0.9^{de}
	13-16	15.69±1.3^{c}	39.29±3.0^{b}	32.89±0.8^{b}	53.97±6.8^{a}	32.70±2.3^{b}	33.16±2.3^{b}	42.87±3.0^{b}	20.45±2.0^{ed}	31.71±4.5^{b}	20.76±0.8^{cd}
	17-20	20.61±2.3^{d}	45.76±3.5^{ab}	41.45±0.7^{bc}	58.03±4.8^{a}	33.16±1.7^{b}	18.18±3.7^{bc}	50.76±1.4^{ab}	24.23±2.0^{d}	37.26±5.2^{c}	23.93±1.6^{d}
FCR	0-4	1.24±0.05^{bc}	1.12±0.04^{bc}	1.03±0.01^{c}	1.30±0.16^{bc}	1.21±0.04^{bc}	1.08±0.04^{bc}	1.01±0.01^{c}	1.12±0.09^{bc}	1.64±0.20^{a}	1.32±0.05^{b}
	5-8	1.71±0.13^{ab}	1.95±0.09^{ab}	1.79±0.09^{ab}	2.30±0.47^{a}	2.21±0.08^{a}	1.15±0.05^{b}	1.56±0.42^{ab}	2.02±0.39^{a}	1.73±0.03^{ab}	1.99±0.25^{a}
	9-12	2.28±0.07^{ab}	2.09±0.07^{bc}	2.21±0.05^{ab}	2.66±0.27^{a}	2.26±0.08^{ab}	1.64±0.12^{c}	1.63±0.53^{c}	2.39±0.26^{ab}	2.68±0.06^{a}	2.59±0.02^{ab}
	13-16	2.81±0.12^{ab}	2.46±0.05^{bc}	2.30±0.07^{bc}	2.81±0.23^{ab}	2.41±0.18^{bc}	1.92±0.05^{cd}	1.74±0.43^{d}	2.23±0.16^{cd}	3.05±0.18^{a}	2.45±0.22^{bc}
	17-20	2.91±0.21^{ab}	2.54±0.06^{cd}	2.41±0.03^{cd}	3.15±0.26^{ab}	2.67±0.07^{b}	2.32±0.16^{cd}	1.98±0.29^{d}	2.31±0.23^{d}	3.36±0.31^{a}	2.31±0.39^{cd}

WG =weight gain, FI= feed intake, FCR= feed conversion ratio, Wks= Weeks. YEC, GG, SS, MM, ±S.E represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler and standard error.

MM x YEC less than purebred YEC at week 17 to 20. Other strains were intermediate between cross bred YEC x GG and pure bred YEC.

The effect of strain on body weight gain showed a significant difference ($P<0.05$) between all the strains with pure bred GG having the highest body weight gain at day old up to week 4 of age but getting to week 5 pure bred MM gained highest weight up to 20 weeks of the feeding trial, while pure bred YEC had the lowest body weight gain from day old up to the end of the feeding trial. However, all the other strains had values that were intermediate between pure bred GG, MM and YEC. There was a significant difference among all the strains with YEC x MM having the best (lowest) feed conversion ratio while others had values that were intermediate between pure bred YEC, GG and MM. However, cross bred SS x YEC and pure bred MM both have the highest feed conversion ratio from day old up to 20 weeks of age.

Table 3.6 showed the effects of strain and sex on bodyweight of local, exotic and crossbred chickens. Between zero and 8 weeks of age the three exotic chickens were significantly higher ($p<0.05$) in weekly body weights than the local Yoruba ecotype chickens. Marshall Chicks had Significantly heavier ($p<0.05$) weekly body weights than other strains from the $5^{th}$to the 8th week of age. Reciprocal crossbred chicks were significantly higher ($p<0.05$) in weekly body weights than the local Yoruba ecotype chickens. Generally, the body weights of crossbred chicks were intermediate between the body weights of purebred exotic and local chickens. Crossbred chicks from Marshall male and Yoruba ecotype female were significantly heavier ($p<0.05$) in weekly body weights than other crossbred chicks from 5th to 8^{th}week of age. Male chicks were significantly higher ($p<0.05$) in weekly body weights than female chicks. Interaction between strains and sex on early body weights of chicks was significant ($p<0.05$).

Table 3.7 showed the interaction between strains and sex on body weight of chicks from hatch to 8 weeks of age. Interaction between strains and sex was significant ($p<0.05$) on weekly body weight from hatch to 8 weeks of age. Purebred male Goliath and Sussex chicks were significantly higher ($p<0.05$) in hatch weight compared with other strains while the best hatch weight among the female chicks was obtained in Purebred Marshall. YEC x MM male chicks was significantly higher ($p<0.05$) in 8 weeks body weight compared with other strains while purebred Marshall had the best 8-week body weight among the female chicks.

Mean body weight of Yoruba ecotype, exotic and crossbred grower chickens are shown in Table 3.8. The three exotic chickens were significantly heavier ($p<0.05$) in weekly body weights than the local chickens from 9 to 20 weeks of age. Marshall Grower chickens were significantly heavier ($p<0.05$) in weekly body weights than Sussex, Goliath and the six crossbred chicken strains throughout the study. All the crossbred chicks were significantly heavier ($p<0.05$) in

Weekly body weights than Yoruba ecotype chicken, except MM x YEC. Crossbred chicks that were produced from Marshall Cocks and Yoruba ecotype hens were numerically heavier in weekly body weights than other crossbred chicks. The male chicks were significantly higher ($p<0.05$) in weekly body weights than female chicks from 9 to 20 weeks of age (Table 3.8).

Table 3.9, shows the interaction between strains and sex on body weight of chickens from 9 weeks to 20 weeks of age. There was significant ($p<0.05$) interaction between strain and sex on body weights of crossbred chickens. YEC x MM male chicks were significantly ($p<0.05$) heavier than other strains at week 9, whereas the heaviest female chicken at week 9 was the MM x MM chickens. There was no significant difference between GG x YEC and SS x YEC male chickens at weeks 15 to 20. However, the female GG x YEC chickens were significantly ($p<0.05$) heavier within the same period. The YEC x GG male chicks were consistently superior ($p<0.05$) to YEC x SS male chicks at weeks 10, 11, 12, and 13, while there was no significant difference between female chickens of the two strains during the same period. Reciprocal effect on body weight was significant ($p<0.05$) in all the crossbred groups. Reciprocal effect favoured chicks that were born to purebred cocks and Yoruba ecotype hens.

Table 3.6: Effects of strain and sex on early bodyweights of local, exotic and crossbred chickens

	Weeks								
Strain	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
YEC x YEC	23.61±0.22^{e}	45.82±0.68^{e}	74.13±1.41^{f}	100.11±2.97^{h}	129.85±3.26^{f}	170.62±3.87^{f}	234.77±4.56^{f}	317.48±5.33^{h}	382.26±5.73^{h}
GG x GG	32.66±0.31^{a}	79.40±0.96^{a}	135.90±1.98^{b}	218.46±3.48^{b}	322.82±4.59^{a}	437.69±5.45^{b}	570.83±6.41^{b}	702.47±7.49^{c}	804.95±8.06^{c}
SS x SS	32.58±0.29^{a}	77.79±0.87^{a}	124.73±1.80^{c}	194.99±3.16^{c}	286.52±4.18^{b}	384.06±4.95^{c}	465.10±5.83^{c}	568.93±6.82^{d}	674.96±7.33^{d}
MM x MM	31.61±0.31^{b}	60.07±0.96^{c}	108.29±2.90^{e}	166.38±3.47^{e}	270.91±4.59^{c}	515.63±5.44^{a}	704.67±6.40^{a}	908.03±7.49^{a}	1025.41±8.06^{a}
YEC x GG	30.52±0.46^{c}	72.21±1.27^{b}	155.46±2.62^{a}	254.38±4.61^{a}	328.85±6.08^{a}	394.73±7.21^{c}	475.48±8.49^{c}	544.67±9.93^{e}	627.13±10.68^{e}
YEC x SS	24.76±0.42^{d}	60.43±1.41^{c}	101.38±2.9^{e}	157.90±5.10^{f}	224.15±6.74^{d}	293.92±7.99^{d}	366.01±9.39^{d}	435.63±10.99^{f}	533.34±11.83^{f}
YEC x MM	22.88±0.43^{ef}	63.34±1.76^{c}	136.38±3.66^{b}	182.14±6.42^{cd}	257.49±8.48^{c}	424.33±10.06^{b}	570.75±11.83^{b}	737.57±13.84^{b}	913.21±14.88^{b}
GG x YEC	24.76±0.42^{d}	52.86±1.28^{d}	93.96±2.64^{e}	137.84±4.64^{g}	187.86±6.13^{e}	252.47±7.27^{e}	316.30±8.55^{e}	384.87±10.00^{g}	442.90±10.76^{g}
SS x YEC	22.88±0.43^{ef}	60.40±1.32^{c}	121.82±2.72^{c}	179.98±4.78^{d}	235.13±6.31^{d}	287.49±7.48^{d}	346.46±8.79^{d}	396.84±10.29^{g}	435.47±11.07^{g}
MM x YEC	22.88±0.43^{ef}	52.87±1.36^{d}	110.64±2.80^{d}	176.41±4.93^{de}	234.36±6.52^{d}	293.65±7.73^{d}	342.56±9.09^{d}	394.44±10.64^{g}	437.79±11.44^{g}
Sex effect									
Male	30.46±0.19^{a}	69.48±0.59^{a}	128.66±1.22^{a}	200.55±2.15^{a}	285.61±2.84^{a}	399.68±3.36^{a}	507.71±3.96^{a}	626.46±4.63^{a}	726.36±4.98^{a}
Female	26.06±0.16^{b}	55.56±0.50^{b}	103.88±1.03^{b}	153.17±1.81^{b}	209.98±2.39^{b}	291.84±2.84^{b}	370.87±3.34^{b}	451.73±3.91^{b}	529.13±4.21^{b}
Interaction(BxS)	*	*	*	*	*	*	*	*	*

YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, respectively. ^{a,b,c,d,e,f,g}*Means with different superscripts for the same week are significantly different,(p< 0.05),* indicates significant interaction*

Table 3.7: Details of interaction between strain and sex on weekly body weights in Yoruba ecotype, Goliath, Sussex, Marshal and their crossbred chicks (Hatch to 8weeks)

		STRAINS									
Weeks	**Sex**	**YECxYEC**	**GGxGG**	**SSxSS**	**MMxMM**	**YECxGG**	**YECxSS**	**YECxMM**	**GGxYEC**	**SSxYEC**	**MMxYEC**
0	M	24.11±0.31^{h}	36.32±0.47^{a}	36.46±0.44^{a}	33.05±0.54^{b}	34.08±0.68^{b}	32.91±0.71^{b}	32.20±0.74^{b}	25.77±0.65^{fg}	24.55±0.71^{gh}	25.18±0.71^{ghi}
	F	23.11±0.32^{i}	29.00±0.42^{d}	28.70±0.36^{d}	30.17±0.32^{c}	26.96±0.48^{ef}	29.06±0.59^{cd}	28.71±0.89^{cd}	23.75±0.53^{hi}	21.22±0.49^{j}	19.95±0.54^{j}
1	M	47.43±0.96^{i}	92.08±1.44^{a}	92.07±1.36^{a}	61.16±1.99^{ef}	80.75±2.07^{b}	63.73±2.17^{de}	71.40±2.28^{c}	60.46±1.99^{ef}	62.36±2.17^{de}	63.36±2.17^{de}
	F	44.22±0.97^{j}	66.72±1.27^{cd}	63.51±1.09^{de}	58.98±0.98^{gh}	63.67±1.47^{de}	57.13±1.80^{gh}	55.29±2.72^{h}	45.25±1.61^{i}	58.43±1.50^{gh}	42.37±1.65^{j}
2	M	76.32±1.98^{i}	153.96±2.97^{b}	152.07±2.80^{b}	115.26±3.40^{de}	177.00±4.28^{a}	106.82±4.47^{ef}	151.90±4.69^{b}	102.46±4.11^{fg}	124.64±4.47^{cd}	126.18±4.47^{cd}
	F	71.95±2.00^{i}	117.84±2.62^{d}	97.39±2.26^{fg}	101.31±2.02^{fg}	133.92±3.03^{c}	95.94±3.71^{fg}	120.86±5.61^{de}	85.45±3.32^{h}	119.00±3.09^{d}	95.11±3.45^{g}
3	M	102.32±3.48^{k}	239.60±5.21^{b}	243.21±4.92^{b}	184.47±5.98^{cd}	320.92±7.52^{a}	183.18±7.85^{cd}	195.00±8.24^{c}	153.23±7.23^{gh}	192.09±7.85^{cd}	191.45±7.85^{cd}
	F	97.89±3.51^{k}	197.31±4.61^{c}	146.77±3.97^{hi}	184.47±5.98^{cd}	187.83±5.32^{cd}	132.6±6.51^{ij}	169.29±9.85^{de}	122.45±5.83^{j}	167.87±5.43^{ef}	161.37±5.98^{fg}
4	M	133.70±4.59^{k}	349.96±6.88^{b}	349.39±6.51^{b}	296.11±7.89^{c}	418.33±9.94^{a}	272.55±10.38^{cd}	301.40±10.89^{c}	214.08±9.55^{hi}	254.18±10.38^{de}	266.45±10.38^{cd}
	F	126.00±4.64^{k}	295.69±6.08^{c}	223.65±5.25^{gh}	245.72±4.68^{ef}	239.37±7.03^{fg}	175.75±8.61^{j}	213.57±13.01^{hi}	161.65±7.69^{j}	216.09±7.18^{hi}	202.26±7.89^{i}
5	M	176.11±5.45^{l}	488.88±8.16^{b}	454.54±7.71^{c}	583.16±9.36^{a}	489.25±11.78^{b}	360.09±12.30^{de}	515.80±12.90^{b}	223.23±9.12^{k}	306.21±8.33^{gh}	340.73±12.30^{ef}
	F	165.13±5.50^{l}	386.50±7.21^{d}	313.58±6.22^{g}	448.11±5.55^{c}	306.21±8.33^{gh}	227.75±10.20^{k}	332.86±15.42^{ef}	223.23±9.12^{k}	268.43±8.51^{ij}	246.58±9.36^{jk}
6	M	250.55±6.41^{m}	654.32±9.59^{c}	538.50±9.07^{e}	766.47±11.01^{a}	580.17±13.86^{d}	446.27±14.47^{g}	716.50±15.18^{b}	279.45±10.73^{l}	375.27±14.47^{ij}	395.91±14.47^{hi}
	F	218.98±6.47^{n}	487.34±8.49^{f}	391.70±7.32^{hi}	642.87±6.53^{c}	370.79±9.79^{ij}	285.75±11.99^{l}	425.00±18.14^{gh}	353.15±13.31^{j}	317.65±10.01^{k}	289.21±11.01^{kl}
7	M	345.84±7.50^{hi}	822.40±11.23^{c}	676.25±10.61^{d}	984.16±12.88^{a}	653.08±16.21^{d}	530.45±16.92^{f}	919.00±17.76^{b}	444.38±15.57^{g}	430.64±16.93^{g}	458.36±16.93^{g}
	F	289.13±7.57^{j}	582.53±9.93^{e}	461.60±8.56^{g}	831.91±7.64^{c}	436.25±11.46^{g}	340.81±14.04^{hi}	556.14±21.22^{ef}	325.35±12.55^{i}	363.04±11.71^{h}	330.53±12.88^{hi}
8	M	416.46±8.07^{jk}	944.68±12.08^{b}	814.21±11.42^{c}	1099.47±13.86^{a}	752.08±17.44^{d}	627.18±18.21^{f}	1115.00±19.10^{a}	509.85±16.75^{gh}	479.64±18.21^{hi}	505.00±18.21^{gh}
	F	348.05±8.15^{m}	665.22±10.68^{ef}	535.70±9.21^{g}	951.35±8.22^{b}	502.17±12.33^{h}	439.50±15.10^{ij}	771.43±22.83^{de}	375.95±13.51^{lm}	391.30±12.59^{kl}	370.58±13.86^{lm}

M, F represent male and female chicks, respectively. YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, respectively. $^{a\text{-}m}$*Means with different superscripts between row for the same week are significantly different,(p< 0.05),*

Table 3.8: Effects of strains and sex on body weight of pure bred and cross bred grower chickens

Strain	**Week9**	**Week 10**	**Week 11**	**Week 12**	**Week 13**	**Week 14**	**Week 15**	**Week 16**	**Week 17**	**Week 18**	**Week 19**	**week20**
YECxYEC	459±7^{h}	513±8^{h}	559±8^{h}	617±9^{g}	677±8^{g}	789±28^{e}	798±90^{h}	887±10^{g}	1026±12^{g}	1103±14^{g}	1183±14^{g}	1248±14^{g}
GGx GG	917±9^{c}	1038±11^{c}	1157±12^{c}	1272±12^{c}	1431±72^{c}	1583±40^{c}	1756±13^{c}	1852±14^{c}	1952±17^{c}	2024±19^{c}	2093±20^{c}	2161±20^{c}
SS x SS	776±8^{d}	865±10^{d}	977±11^{d}	1066±11^{d}	1157±10^{d}	1254±36^{d}	1353±12^{e}	1458±13^{e}	1556±15^{e}	1644±17^{e}	1744±18^{e}	1836±18^{e}
MMx MM	1151±9^{a}	1324±11^{a}	1595±12^{a}	1891±12^{a}	2065±11^{a}	2202±40^{a}	2458±13^{a}	2674±14^{a}	2925±17^{a}	3130±19^{a}	3381±20^{a}	3621±20^{a}
YECx GG	706±12^{e}	790±14^{e}	920±16^{e}	1047±16^{d}	1168±15^{d}	1284±53^{d}	1407±17^{d}	1521±18^{d}	1642±22^{d}	1766±25^{d}	1903±26^{d}	2025±26^{d}
YECxSS	613±14^{f}	716±16^{f}	813±17^{f}	949±18^{e}	1058±17^{e}	1145±58^{d}	1227±19^{f}	1306±20^{f}	1394±25^{f}	1476±28^{f}	1546±29^{f}	1602±29^{f}
YECxMM	1101±17^{b}	1277±20^{b}	1455±22^{b}	1628±22^{b}	1809±22^{b}	1979±73^{b}	2164±23^{b}	2324±26^{b}	2470±31^{b}	2626±35^{b}	2778±36^{b}	2932±36^{b}
GGxYEC	495±12^{g}	551±14^{g}	602±16^{g}	660±16^{f}	721±16^{f}	780±53^{e}	836±17^{g}	896±19^{g}	963±23^{h}	1039±25^{h}	1093±26^{h}	1145±26^{h}
SSxYEC	490±13^{g}	539±15^{gh}	584±16^{gh}	635±17^{fg}	685±16^{fg}	741±55^{e}	797±17^{gh}	870±19^{g}	931±23^{h}	987±27^{h}	1036±27^{h}	1083±27^{h}
MMxYEC	491±13^{g}	543±15^{gh}	590±17^{gh}	643±17^{fg}	692±17^{fg}	743±56^{e}	800±18^{gh}	855±20^{g}	915±24^{h}	987±27^{h}	1058±28^{h}	1126±28^{h}
Sex												
Male	835±6^{a}	943±7^{a}	1075±7^{a}	1210±8^{a}	1339±7^{a}	1453±24.5^{a}	1586±8^{a}	1702±9^{a}	1829±10^{a}	1944±12^{a}	2060±12^{a}	2161±12^{a}
Female	605±5^{b}	689±6^{b}	775±6^{b}	872±6^{b}	954±6^{b}	1047±21^{b}	1132±7^{b}	1227±7^{b}	1326±9^{b}	1412±10^{b}	1504±10^{b}	1595±10^{b}
GxS	*	*	*	*	*	*	*	*	*	*	*	*

YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, respectively. ^{a,b,c,d,e,f,g,h}*Means with different superscripts among the strains are significantly different,(p< 0.05), * indicates significant interaction(*GxS)

Table 3.9: Details of Interaction between strain and sex on weekly body weights in Yoruba ecotype, Goliath, Sussex, Marshal and their crossbred chicks

		STRAIN									
Week	**Sex**	**YECxYEC**	**GGxGG**	**SSxSS**	**MMxML**	**YECxGG**	**YECxSS**	**YECxMM**	**GGxYEC**	**SSxYEC**	**MMxYEC**
9	M	500 ± 9^{j}	1093 ± 14^{c}	939 ± 13^{e}	1246 ± 16^{b}	847 ± 20^{f}	729 ± 21^{g}	1322 ± 22^{a}	565 ± 19^{i}	533 ± 21^{ij}	571 ± 21^{hi}
	F	417 ± 9^{k}	741 ± 12^{g}	612 ± 11^{h}	1055 ± 9^{d}	564 ± 14^{i}	496 ± 17^{j}	880 ± 26^{f}	424 ± 16^{k}	447 ± 14^{k}	411 ± 16^{k}
10	M	561 ± 11^{i}	1255 ± 16^{c}	1031 ± 15^{d}	1425 ± 18^{b}	944 ± 23^{e}	838 ± 24^{f}	1529 ± 25^{d}	625 ± 22^{h}	591 ± 24^{hi}	631 ± 24^{h}
	F	465 ± 11^{j}	822 ± 14^{f}	700 ± 12^{g}	1222 ± 11^{c}	636 ± 16^{h}	595 ± 20^{hi}	1026 ± 30^{d}	477 ± 18^{j}	488 ± 17^{j}	456 ± 18^{j}
11	M	612 ± 12^{h}	1413 ± 18^{b}	1184 ± 17^{c}	1754 ± 20^{a}	1125 ± 26^{c}	945 ± 27^{d}	1714 ± 28^{a}	674 ± 25^{fg}	642 ± 27^{gh}	686 ± 27^{fg}
	F	506 ± 12^{i}	902 ± 16^{d}	771 ± 14^{e}	1435 ± 12^{b}	714 ± 18^{f}	680 ± 22^{fg}	1196 ± 33^{c}	529 ± 20^{i}	525 ± 18^{i}	494 ± 20^{i}
12	M	671 ± 12^{k}	1573 ± 18^{d}	1287 ± 17^{e}	2061 ± 21^{a}	1283 ± 26^{e}	1128 ± 27^{f}	1904 ± 29^{b}	737 ± 25^{j}	707 ± 27^{jk}	745 ± 27^{j}
	F	562 ± 12^{l}	971 ± 16^{g}	844 ± 14^{h}	1720 ± 12^{c}	811 ± 19^{hi}	770 ± 23^{ij}	1353 ± 34^{e}	583 ± 20^{l}	564 ± 19^{l}	505 ± 21^{l}
13	M	731 ± 12^{m}	1771 ± 18^{d}	1407 ± 17^{f}	2301 ± 20^{a}	1434 ± 25^{f}	1269 ± 27^{g}	2097 ± 28^{b}	811 ± 24^{kl}	769 ± 27^{g}	799 ± 27^{kl}
	F	623 ± 12^{n}	1091 ± 16^{h}	908 ± 13^{i}	1830 ± 12^{c}	902 ± 18^{ij}	846 ± 22^{jk}	1523 ± 33^{e}	632 ± 20^{n}	602 ± 18^{n}	586 ± 20^{n}
14	M	792 ± 40^{gh}	1956 ± 59^{b}	1508 ± 56^{cd}	2475 ± 68^{a}	1571 ± 86^{cd}	1384 ± 90^{de}	2280 ± 94^{a}	872 ± 82^{fg}	837 ± 90^{fg}	856 ± 90^{fg}
	F	786 ± 40^{gh}	1209 ± 53^{e}	1000 ± 45^{f}	1929 ± 40^{b}	997 ± 61^{f}	906 ± 74^{fg}	1679 ± 112^{c}	688 ± 67^{hi}	644 ± 62^{ij}	631 ± 68^{j}
15	M	860 ± 13^{l}	2198 ± 19^{c}	1589 ± 18^{g}	2789 ± 22^{a}	1713 ± 27^{f}	1473 ± 29^{h}	2481 ± 30^{b}	928 ± 26^{k}	914 ± 29^{kl}	919 ± 28^{kl}
	F	735 ± 13^{m}	1314 ± 17^{i}	1117 ± 14^{j}	2126 ± 13^{d}	1102 ± 19^{j}	982 ± 24^{k}	1847 ± 36^{e}	744 ± 21^{m}	681 ± 20^{n}	680 ± 22^{n}
16	M	972 ± 14^{l}	2313 ± 21^{d}	1698 ± 20^{g}	2974 ± 24^{a}	1840 ± 30^{f}	1557 ± 32^{h}	2665 ± 33^{b}	995 ± 29^{kl}	1021 ± 32^{kl}	982 ± 32^{kl}
	F	802 ± 14^{m}	1390 ± 18^{i}	1219 ± 18^{j}	2374 ± 14^{c}	1202 ± 21^{j}	1055 ± 26^{k}	1983 ± 39^{e}	797 ± 23^{m}	719 ± 22^{n}	729 ± 24^{n}
17	M	1189 ± 17^{k}	2437 ± 25^{d}	1805 ± 24^{g}	3203 ± 29^{a}	1976 ± 37^{f}	1635 ± 38^{h}	2822 ± 40^{b}	1070 ± 35^{lm}	1107 ± 38^{kl}	1048 ± 38^{m}
	F	862 ± 17^{n}	1467 ± 22^{j}	1308 ± 19^{j}	2648 ± 17^{c}	1309 ± 26^{j}	1153 ± 32^{kl}	2117 ± 48^{e}	857 ± 28no	756 ± 26^{p}	782 ± 29^{op}
18	M	1312 ± 19^{k}	2538 ± 28^{d}	1909 ± 27^{g}	3401 ± 33^{a}	2130 ± 41^{f}	1705 ± 43^{h}	2981 ± 45^{b}	1156 ± 39^{lm}	1169 ± 43^{lm}	136 ± 43^{m}
	F	894 ± 19^{n}	1512 ± 25^{i}	1379 ± 22^{j}	2859 ± 19^{c}	1402 ± 29^{j}	1248 ± 36^{kl}	2271 ± 54^{e}	922 ± 32^{n}	795 ± 30^{o}	838 ± 33no
19	M	1407 ± 20^{i}	2633 ± 29^{c}	2034 ± 28^{e}	3612 ± 34^{a}	2316 ± 42^{d}	1770 ± 44^{f}	3148 ± 46^{b}	1215 ± 41^{k}	1236 ± 44^{jk}	1226 ± 44^{jk}
	F	959 ± 20^{l}	1553 ± 26^{g}	1454 ± 22^{hi}	3150 ± 20^{b}	1490 ± 30^{gh}	1322 ± 37^{j}	2409 ± 55^{d}	970 ± 33^{l}	836 ± 31^{m}	891 ± 34^{lm}
20	M	1488 ± 20^{j}	2723 ± 29^{d}	2148 ± 28^{f}	3811 ± 34^{a}	2476 ± 42^{e}	1829 ± 44^{g}	3283 ± 46^{c}	1269 ± 41^{k}	1288 ± 44^{k}	1300 ± 44^{k}
	F	1008 ± 20^{l}	1600 ± 26^{h}	1524 ± 22^{ij}	3431 ± 20^{b}	1575 ± 30^{h}	1375 ± 37^{k}	2581 ± 56^{e}	1022 ± 33^{l}	878 ± 31^{m}	952 ± 34^{lm}

M, F represent male and female chicks, respectively, YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, respectively.$^{a-h}$ Means with different superscripts for the same week are significantly different,($p< 0.05$)

3.7.3 Survivability of Pure and Cross Bred Chickens at Early and Late Growth Phase

3.7.3.1 Survivability in Early Growth Phase

Figure 3.1, shows the Kaplan-Meier survival distribution of early growth phase in pure and cross bred chickens. The birds were monitored for the period of 8weeks (early growth phase) It was noted that about 9% of YEC, 13 % of GG, 11% of SS, 11% of MM, 25 % of YEC x GG, 15% of YEC x SS, 20% of YEC x MM, 17% of GG x YEC, 14 % of SS x YEC and 20% of MM x YEC reached the event (mortality) at different days during the early growth phase.

The Log rank test of equality of survival distribution (Table 3.10) for different breeds was significant (x^2 = 12.08, d.f = 9, $p<0.05$). Pure bred YEC had the highest percentage survival (91.2%) while cross bred YEC x GG recorded the lowest percentage survival (75.0 %). Other breeds had percentage survival values that were intermediate between these two values at the same growth phase.

3.7.3.2 Survivability in Late Growth Phase

The Kaplan meier survival plot for late growth phase is shown in Fig 3.2. Most of the birds in each strain survived better at this phase. Aproximately 5% of YEC, 6 % of GG, 4% of SS, 17% of MM ,0% of YEC x GG, 8% of YEC x SS , 12.5% of YEC x MM, 7% of GG x YEC, 3% of SS x YEC and 4% of MM x YEC reached the event (mortality) in this growth phase. The log rank test of equality of survival distribution (Table 3.11) for different strains was significant at this stage (x^2 =25.41, d.f= 9, $p<0.05$). This explained inequality in probability of survival among all the breeds in this growth phase with cross bred YEC x GG recording the highest (100%) while cross bred YEC x MM had the lowest (87.5 %).

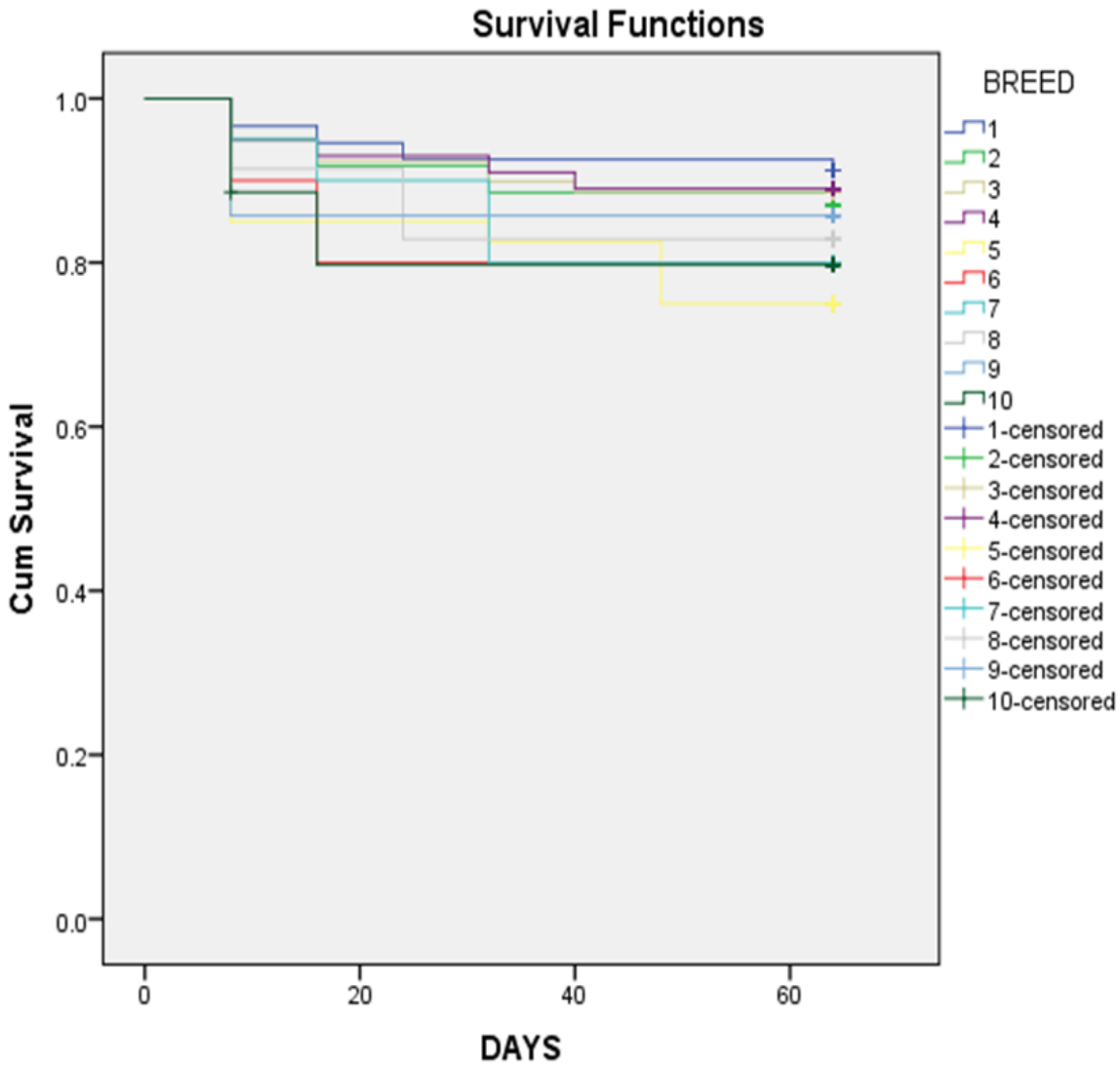


Figure 3.1: Survival function for early growth phase

Breed 1= YEC, 2= GG, 3 = SS, 4 = MM, 5= YEC x GG, 6 = YEC x SS, 7 = YEC x MM, 8= GG x YEC, 9 = SS x YEC and 10 = MM x YEC.

Table 3.10: Survival Distribution of Early Growth Phase (Day Old - wk8) in Pure and Crossbred Chickens

Strain	**Number**	**Survival**	**Percentage Survival**
YEC x YEC	148	135	91.2%
GG x GG	61	54	86.9%
SS x SS	79	70	88.6%
MM x MM	46	41	89.0%
YEC x GG	40	30	75.0%
YEC x SS	30	24	80.0%
YEC x MM	20	16	80.0%
GG x YEC	35	29	82.9%
SS x YEC	35	30	85.7%
MM x YEC	35	28	80.0%
Overall	529	457	86.4%

LogRank(x^2 =12.08,$p<0.05$)

YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, respectively

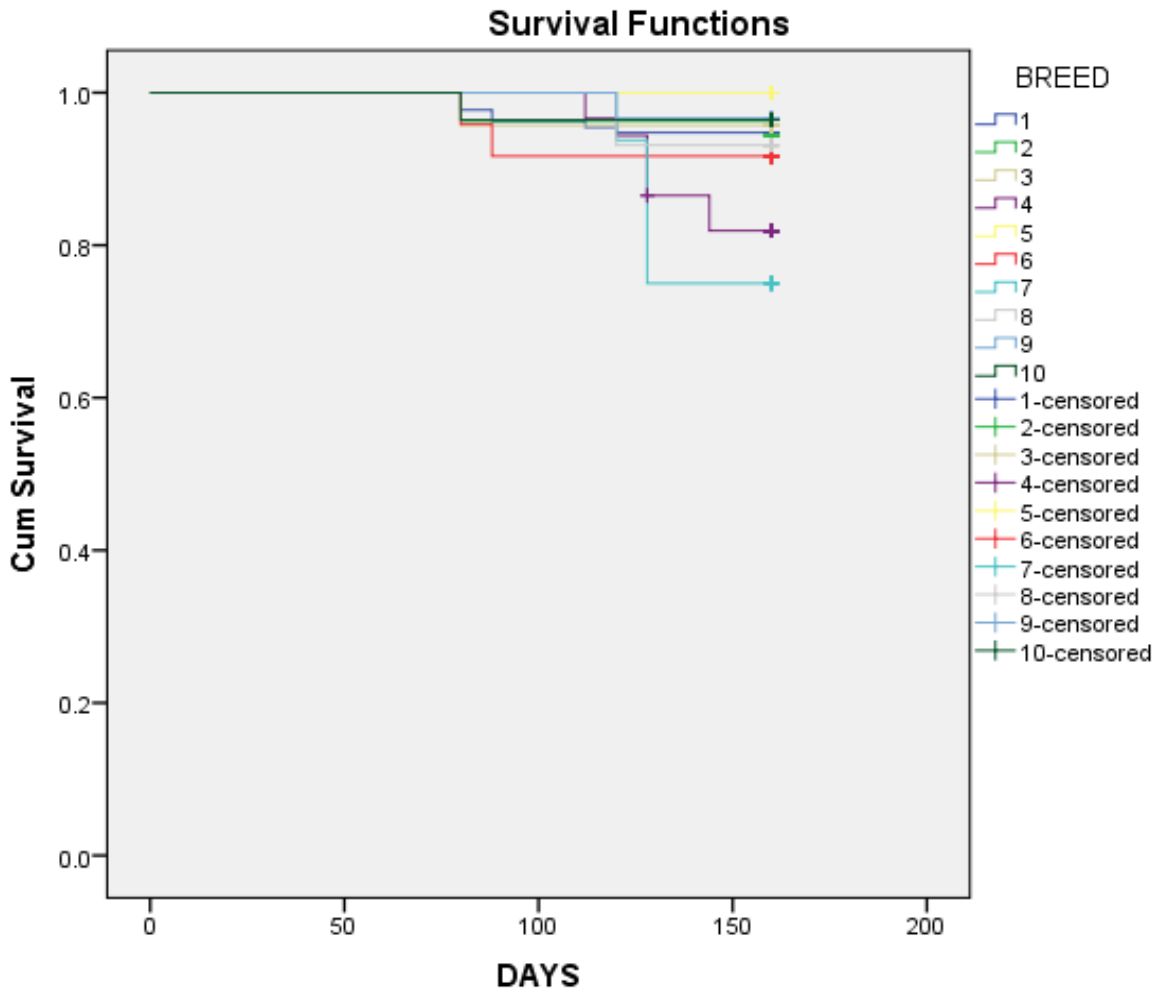


Figure 3.2: Survival function for late growth phase

Breed 1= YEC, 2= GG, 3 = SS, 4 = MM, 5= YEC x GG, 6 = YEC x SS, 7 = YEC x MM, 8= GG x YEC, 9 = SS x YEC and 10 = MM x YEC.

Table 3.11: Survival (%) in Pure and Crossbred Chickens during the Late Growth Phase (wk9 – wk20)

Strain	**Number**	**Survival**	**Percentage Survival**
YEC x YEC	135	126	94.7%
GG x GG	54	51	94.4%
SS x SS	70	67	95.7%
MM x MM	41	37	90.0%
YEC x GG	30	30	100.0%
YEC x SS	24	22	91.7%
YEC x MM	16	14	87.5%
GG x YEC	29	27	93.1%
SS x YEC	30	29	96.7%
MMx YEC	28	27	96.4%
Overall	457	430	94.1%

LogRank (x^2 =25.41,$p<0.05$) YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, respectively.

3.7.4 Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for Body Weight in Cross Bred Chickens.

Table 3.12 showed the results of direct heterosis, percentage heterosis, maternal and direct additive effect for body weight in cross bred chickens. In strain YEC x GG, direct heterosis for body weight was positive and increased as the bird progress in age within the weeks with values ranging from 3.30g to 320.50g while percentage heterosis had similar trend with direct heterosis ranging from 4.50% to 18.00%, Maternal and direct additive effect also had values that increased with age of the animals with values ranging from 19.35g to 880g and 33.96g to 1793g. Strain YEC x SS had negative values for direct and percentage heterosis at week 1 (-1.36g, 13.75%) and positive values for direct heterosis ranging from 4.73g to 133.50g while percentage heterosis ranged from 0.89% to 12.77% from weeks 4 to 20. Maternal additive effect had positive influence at weeks 1, 8, 12, 16 and 20 but was negative at week 4. However, direct additive effect increased with respect to age of the animal with values ranging from 32g to 1107g. Strain YEC x MM had direct and percentage heterosis that were positive across the weeks with the values ranging from 10.39g to 543.5g and (19.63% -30.52%) while ,maternal and direct additive effect had similar trend with the formal having their values ranged from 10.49g to1806g and 24.72g to 4179g respectively. In the reciprocal cross bred GG x YEC all the heterotic effects for body weight were negative with direct heterosis having values that ranged from -9.75g to -559.50g, percentage heterosis ranged form -15.57% to 34.57%, MAE ranged from -19.35g to -880g and DAE ranged from -52.93g to -1793g . Strain SS x YEC also had negative values for these traits across the week except for week 4 which had direct heterosis (26.95g), percentage heterosis (12.94%),maternal and direct additive effect (10.98g and 56.31g) .Similarly, strain MM x YEC had values that were negative for direct heterosis and percentage heterosis at weeks

1,8 , 12, 16 and 20 but positive at 4th week , MAE and DAE had negative values across the weeks for the trial period, the values ranged -10.47 to -1806 and -24.72 to - 4179g .Generally , from the above result cross breeding favoured the crosses made with YEC sire and dam by exotic chickens (Goliath, Sussex and Marshall broiler) in body weight even as they progressed in age more than their reciprocal cross bred.

Table 3.12: Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for Body Weight in Cross Bred Chickens

Strain	**Effect**	**Weeks**					
		1	**4**	**8**	**12**	**16**	**20**
YEC x GG	H	3.30	102.50	33.58	102.5	151.5	320.50
	% H	5.74	4.50	5.64	10.85	11.06	18.00
	MAE	19.35	140.99	184.23	387.00	625.00	880.00
	DAE	33.96	333.96	609.92	1042.00	1590.00	1793.00
YEC x SS	H	-1.36	15.97	4.73	107.5	133.50	60.00
	%H	-1.375	7.67	0.89	12.77	11.38	3.89
	MAE	0.03	-10.98	97.87	314.00	436.00	519.00
	DAE	32.00	145.69	390.57	763.00	1007.00	1107.00
YEC x MM	H	10.39	57.11	209.38	374.00	543.5.00	497.50
	%H	19.63	28.50	29.75	29.82	30.52.00	20.44
	MAE	10.49	23.13	475.92	985.00	1469.00	1806.00
	DAE	24.72	164.19	1118.57	2253.00	3256.00	4179.00
GG x YEC	H	-9.75	-38.48	-150.71	-284.5	-473.50	-559.50
	%H	-15.57	-16.99	-25.38	-30.12	-34.57	-32.82
	MAE	-19.35	-140.99	-184.23	-387.00	-625.00	-880.00
	DAE	-52.93	-333.96	-613.08	-1042.00	-150.00	-1793.00
SS x YEC	H	-1.40	26.95	-93.14	-206.50	-302.50	-459.00
	%H	-2.27	12.94	-17.61	-24.54	-25.81	-29.77
	MAE	-0.03	10.98	-97.87	-314.00	-436.00	-519.00
	DAE	-32.00	56.31	-390.57	-763.00	-1007.00	-1107.00
MM x YEC	H	-0.075	33.98	-90.82	-611.00	-925.5.00	-1308.50
	%H	-0.14	16.96	-17.18	-48.72.00	-51.98.00	-53.75
	MAE	-10.47	-23.13	-475.42	-985.00	-1469.00	-1806.00
	DAE	-24.72	-163.28	1118.57	-2259.00	-3256.00	-4179.00

H,%H, MAE,DAE , (g)represents direct heterosis , heterosis percentage, Maternal effect, Direct additive effect, grams and YEC,GG,SS,MM means Yoruba ecotype, Goliath, Sussex and Marshall chickens

3.8 Discussion

The genotypic difference in the fertility and hatchability of eggs observed in this study show that strains have effect on fertility and hatchability of eggs , this agrees with Peters *et al.* (2004, 2008) who reported that the strains of the dam have prominent effects on fertility and hatchability of eggs. The high percentage fertility obtained could be as a result of good sperm characteristics in MM cocks which agrees with the reports of Alaba (1990) who opined that high body weight of cocks could lead to high genital contents which allow good insemination in chicken. Sola-Ojo and Ayorinde (2011) also reported high fertility in the crosses involving dominant black strain cocks while in a recent study, Ahmedin and Mangistu (2016) also reported significant difference between strains in the hatchability of fertile egg and hatchability of total egg set. The lower fertility and hatchability obtained for YEC in this study is at variance with earlier reports on the fertility and hatchability of local and exotic chickens by Ahmedin and Mangistu, (2016) who observed that hatchability of fertile eggs and total eggs were significantly higher for indeginous chicken than exotic chicken and Islam and Nishibori, (2009) who reported that crossbred of indigenious naked neck with exotic chicken can perform better in reproductive traits. Also, Sola-Ojo and Ayorinde (2011) reported low percentage fertility in Fulani ecotype chicken. The low fertility, hatchability of the purebred YEC eggs could be attributed to pre-incubation handling of the eggs while the superior fertility and hatchability of YEC x MM and MM x YEC crossbred chickens over other crossbred groups suggest higher breed complementarity.

There was an increase in feed intake of pure bred GG, MM and cross bred YEC x GG as they progressed in age in this study which can be attributed to the response of metabolic demand for increased calorie, amino acids and other nutrients. This is in accordance with Ilori *et al.*, (2010)

who recorded highest feed intake in crossbred turkey and attributed it to metabolic demand and effect of combine genetic make-up of both indigenous and exotic turkey in term of feed intake. From the result the propensity at which GG and MM consumed feeds to put on high body weight could be attributed to their genetic makeup over other breed as well as environmental variation. Also, the significant difference in feed intake between strains implies that the birds were utilizing the feed based on their genetic makeup. This observation is similar to the reports of Benyi *et al*., (2015) who noted that strain have significant effect on feed intake, weight gain and FCR in Cobb and Ross broiler strains.

Doma (1998) reported that the lower the feed conversion ratio the better the diet in monogastric animals. The results obtained for Sussex, Marshall and SS x YEC revealed that they had the least feed conversion ratio. This result support the report of Amao *et al*. (2014) who recorded better FCR in Ross broilers than Marshall and Anak broilers. Also, better FCR was recorded for Marshall Broiler by Ahmed (2014). The variation in feed utilization among chickens of different strains in this study underscores the need for further studies to evaluate the physiologic basis for feed utilization in chicken strains. Earlier McCarthy and Siegel (1983) had noted that there is substantial evidence that increased growth rate of selected lines of chicken is mainly associated with increased appetite.The result of weight gain in this study showed that pure bred Marshall and Goliath chicken gained weight than their other pure and cross bred counterparts which is in contrast with the report of Santos *et al*. (2005) who reported no significant difference in weight gain of Paraiso Pedns and ISA label birds. Also, the results obtained for growth rate in this study were consistent with the submission of Deeb and Lamont (2000) that there exist differences in growth pattern of animals belonging to the same species.

The higher hatch weights and weekly body weights of exotic (Goliath and Sussex) strains suggests their genetic superiority over the local Yoruba ecotype chickens. Mmereole and Udeh (2009) reported significant effect of strain on body weight in their study involving local chicken and its crosses with barred Plymouth Rock. The bigger size of eggs (67g and 64g) obtained from Goliath and Sussex chickens may account for their higher hatch weights than chicks from Yoruba ecotype chicken. An earlier report by Farooq *et al.* (2001) showed that a positive correlation exists between egg weight and hatching chick weight in Rhode Island Red and local Desi Fayoumi chicken in Pakistan. The higher body weight of Marshall Chicks at 8 weeks of age suggests that it is a superior meat strain, which according to Adebambo *et al*., (2009) is expected in chickens that have been previously selected for meat production.

Significant reciprocal effect was observed for growth and conformation traits between exotic chicken sires and YEC dam.This agrees with the reports of Adebambo *et al.* (2011) who opined that sire and dam strains had significant effects on growth rate of chicken. However, reciprocal effect is a maternal effect and may also be due to possible difference in the combining abilities between sires and dams of the local and exotic breeds. Previous reports on chickens have shown that reciprocal effects could be an important factor in crossbreeding programmes (Hanafi and Iraqi, 2001).

The sexual dimorphism observed in the present study was similar to previous reports of Singh *et al*., (1982) who attributed the male biased sexual dimorphism observed in many avian species to effective male growth hormones compared with female hormones. There was male biased sexual dimorphism in this study for all the genotypic groups which can be attributed to the effectiveness of their male growth hormone since; male chicks have more androgen hormones responsible for muscle anabolism, which results in higher growth rates than female chicks. This

observation is similar to the reports of Gonzales and Sartori (2002) who opined that the muscle development in meat type birds occurs through the interaction of several factors, among which sex and hormonal factors have significant influence. Similar, Fayeye *et al.,* 2005 reported male biased sexual dimorphism in Fulani ecotype chicken. Kgwatalala *et al*., 2012 reported significantly higher body weight in male than female grower chicks of naked and normal strains of indigenous Tswana chicken that were raised from 14 to 20 weeks of age. Also, Benyi *et al.* (2015) opined that male chicks consumed more feed, utilized the feed more efficiently, and gained more body weight than their female counterparts but had a higher mortality rate in Cobb and Ross broiler strain. Ricklefs (1985) opined that the rapid changes between males and females could partially result from differences in physiological ages between males and females at the same chronological age. However, the heavier body weight observed in male chicks compared with their female counterparts may possibly be due to better feed conversion.

The strain *x* sex interaction on body weight of crossbred grower chicks suggests a complex interplay between the two fixed effects on bodyweights of chicks at different ages and variation in the growth pattern of male and female chicks of different strains at the same chronological age. Del Castilho *et al*. (2013) observed no strain *x* sex interaction in their evaluation of six strains of free ranged broiler chickens that were raised for 91 days. The present results showed that the highest body weight through crossbreeding would be achieved by crossing YEC Cocks with Marshall Hens. Sexual dimorphism in body weight of chicks which is in favour of male chicks in this study is consistent with previous reports (Adebambo *et al.,* 2009).

The variation in probability of survival between early growth rates could be attributed to genetic makeup of the birds because pure bred YEC had been known for their hardiness in the tropics (Egahi *et al.* 2010). The high survival rates in the introduced strains (i.e. SS and GG) gave an

understanding that they adapt well in the tropics though this was more positive during the late growth phase while the cross bred also survived better at this growth phase. This implies that the probability of survival was not equal among all the examined breeds. It can be generally explained that survival can display variability depending on differential strain expression, environmental stressor, non-additive genetic factors and environmental factors. Merila and Sheldon, 1999; Ellen *et al*. (2008, 2010) opined that antagonistic relationship and social interactions can also be a reason for survivability in chickens. However, Quinton *et al*. (2011) reported that early survival and late survival were not genetically correlated, this indicate that this traits are independent of each other.

The heterosis for body weight observed in this study could be attributed to the differences in body weight between parental lines involved. The positive heterotic effect for body weight observed for crossbred chickens sired by YEC cock at different ages showed that indigenous breeds exhibit higher non-additive genetic variance. This is in accordance with the findings of Iraq *et al*. (2002) and Alewi and Melesse, (2013) who reported similar results in local Kei chickens and their F_1 cross with Rhode Island Red and Fayoumi chicken.While, GG cock had negative heterotic effect for body weight throughout the experimental period (20 weeks).

The positive and negative values obtained in the study showed that YEC cock and GG cock have superior ability for weekly body weight over others. This is similar to the result obtained by Williams *et al*. (2002) and Razuki and Al-Shahea (2011), who found that the heterosis estimates for body weight at different ages differ in magnitude and may be positive or negative.

The positive and high result obtained for direct and maternal additive effect for body weight revealed that using strains GG, SS and MM as dam was better than using YEC as dam for these traits. The negative and high values obtained show that using meat line as sire will give more

positive result than egg line for body weight. The latter was similar to the report of Aly and Abou El- Ella (2005) who reported that crossing between Bandara and Gimmizah strain gave negative estimates of direct additive effect at all growth phase. Also ,the result of present study is similar with that of Amin *et al*. (2013) who noted that positive heterotic values for GR0-4, GR4-8, and GR0-8 may lead to the use of meat line as dam better than egg line for body weight in crosses between two Alexandria chickens (egg line and meat line).

CHAPTER FOUR

EXPERIMENT TWO

EGG PRODUCTION AND EGG QUALITY CHARACTERISTICS OF YORUBA, MARSHALL, SUSSEX AND GOLIATH CHICKENS AND THEIR CROSSBRED PROGENIES UNDER HUMID TROPICAL CLIMATE

4.1 Introduction

Poultry eggs constitute one of the cheap and major valuable sources of animal protein recommended for human consumption. The Nigerian Indigenous chickens are suitable for the development of layer strain for the tropical environment (Ayorinde, 1986). Birds with good production can result from the combining ability of best performing exotic and indigenous chicken line, laying performance of Nigerian indigenous chickens have been reported. Nwosu and Omeje (1985) reported egg number of 146 /year under battery cage system, 80 to 112 per year under semi-intensive system by Sonaya *et al.* (1998) and Momoh *et al.* (2010) obtained 144 and 136 egg per year for light and heavy ecotypes of Nigeria local chicken. Also, Fulani Ecotypes are known to produce 78 to 144 eggs per year while Yoruba ecotypes are known to produce 58 to 128 eggs per year Sola-Ojo *et al*. (2013). However, laying performance of some exotic breeds have also been reported, Rhode Island Red are known to be excellent egg producers (Wikipedia, 2014) they can produce 250 to 300 large light brown eggs per year. While, Croadlang Shan hen lay 140-150 eggs per year and they are characterised as excellent sitters and mothers (Wikipedia, 2014). Broiler chickens are bred and raised for meat production but there are some hybrids of egg-laying chicken, they lay fewer eggs than other breeds usually about 140 eggs per year. (Wikipedia, 2014) Also, Sussex hen lay approximately 240-260 eggs per year which are large and cream to light brown in colour [Citrus County Poultry Skill-A-

Thon(2010)] while, Goliath lay between 110 and 160 eggs per Year [Citrus County Poultry Skill-A-Thon (2010)]. Among the most important productive traits in poultry are live body weight and egg weight. Egg quality is important for consumer acceptance and the economic success of egg producer is directly proportional to the total number of eggs sold. Silverside *et al.*, 2006 reported that the quality of eggs has a genetic basis and this quality varies between strains of hens. Egg quality encompasses egg weight, egg length, egg width, shell weight, shell thickness (external quality) and albumen weight, albumen height, haugh unit and yolk weight (internal quality).These external qualities represent one of the important phenotypic traits that influence egg quality and reproductive fitness of chicken parent (Islam and Dulta, 2010).The relationship between external and internal egg quality traits had contributed to increase egg weight with the age of hen and reaching an apex by the end of laying cycle (Danilov, 2000). The aim of the work is to evaluate egg production traits, egg quality traits in pure and cross bred hens.

4.2 Objectives

- To determine the egg production and egg quality (external and internal) characteristics of pure and cross bred hens.
- To estimate the mean Heterosis, % heterosis, direct and maternal additive effect for egg production and egg quality characteristics in crossbred chickens.

4.3 Materials and Methods.

4.3.1 Location of the Study.

The study was carried out in a private farm located at Oyan (Osun state, South-West, Nigeria). The coordinates of the experimental site is latitude 8.05 and longitude 4.77 and an elevation of 422 meters above sea level.

4.3.2 Experimental Animals.

A total of 120 sixteen weeks old point of lay comprising of 7 strains were randomly selected from birds established in experiment 1. The selected birds comprises of 30 pure breed YEC, 20 pure bred GG, 20 pure bred SS, 15 cross bred (YEC x GG), 15 cross bred (YEC x SS), 10 cross bred (GG x YEC) and 10 cross bred (SS x YEC) pullets were transferred to individual battery cage. Egg production and egg quality traits measured were recorded for a period of 24 weeks.

4.4 Data Collection

4.4.1 Laying Performance

Age at First Egg (AFE): This was the age at which each hen start laying and was recorded for each hen.

Body Weight at first egg (HBW): This was obtained by weighing the individual hen using a 10kg camry measuring scale to record the hen body weight at first egg.

Egg Weight (EW): The egg laid by each hen was weighed on a daily basis.

Egg Number (EN): This was recorded as the total number of eggs laid by each hen per strain over a period of 24 weeks.

Egg Mass (EM): This was obtained as the product of average weight and egg number.

Hen Day Production (HDP %): This was taken for each strain as the number of eggs laid in a week per bird alive at end of the week (Fairful and Gowe, 1990)

Feed per Dozen Egg (FDE): Amount of feed consumed divided by dozens of egg produced.

4.4.2 Egg External Quality Traits

Two eggs samples were selected weekly per genetic group to estimate external egg quality traits. The external egg quality traits considered in this study include:

Egg length (EL): This was measured as the distance between the tip of narrow and broad ends of an egg with the aid of a pair of vernier calliper (calibrated in mm)

Egg width (EWD): Measured with a pair of vernier calliper (calibrated in mm)

Egg index (EI): This was taken as the ratio of egg length and egg width.

Shell Weight (SW): This was taken as the weight of shell after the content has been removed. The shell is rinsed in warm water and air dried for 48hrs before taking the weight with a digital scale (value obtained was recorded in % of EW).

Egg Shell Thickness (ST): This was determined as the average of measurements of selected egg shells taken at the broad end, middle portion and narrow end of the shell using a micrometer screw gauge (calibrated in mm) after removing the egg membrane.

4.4.3 Egg Internal Quality Traits.

On weekly basis, two eggs were randomly chosen from each genetic group, weighed, broken and the content poured into a petri dish to determine the egg internal quality traits.

The internal egg quality traits considered in this study include:

- Albumen weight (AW) and Yolk weight (YW): Albumen and yolk were carefully detached with the aid of a spatula and kept separately for weighing with digital scale.
- Albumen height (AH) and Yolk height (YH): These were measured using spherometer.
- Albumen width (AWD) and Yolk width (YWD): This was measured with the aid of vernier calliper.
- Yolk index (YI): Yolk index is a measure of the standing- up quality of the yolk this was taken as the ratio of yolk height to yolk width.
- Haugh unit (HU): Values were obtained using the formular

$HU = 100Log (H+ 7.57-1.7W^{0.37})$ (Card *et al.*, 1979).

Where;

HU= Haugh Unit

H= Height of thick albumen (mm)

W= weight of eggs in grams

Mean of the data obtained were evaluated to represent the average performance of the population for a period of 24 weeks.

4.5 Statistical Analysis

Data collected were subjected to one way analysis of variance, using the general linear model (GLM) procedure of the statistical analysis system (SAS 2009). Duncan multiple range tests was used to separate significant means .The statistical model used to fix the effect of strain on egg production and egg quality characteristics is as follows:

$Yij = \mu + gi + eij$

Where,

Yij = performance of jth individual of ith strain.

μ = the overall mean for each of the egg production and egg quality traits.

gi = Fixed effect of ith strain.($i= 1,2,...10$)

eij = Residual error.

The mean heterosis was calculated by subtracting the average egg production traits(individual traits) of cross bred from the average egg production traits (for individual traits) of pure bred while percentage heterosis was generated by the proportion of heterosis value to the average of the pure bred multiplied by 100, Maternal and direct additive effects was generated by

subtracting the average egg production traits(individual traits) of purebred from average of the cross bred for straight and reciprocal cross.

Estimation of direct heterosis was obtained as follow :(Dickerson, 1992)

(1). H' (YEC×SS) = {(YEC×SS + SS × YEC) - (YEC × YEC +SS ×SS)}/2

(2).H' (YEC ×GG) = (YEC× GG+GG×YEC) - (YEC×YEC +GG×GG)} 2

%Heterosis was calculated as follows:$= \frac{H'(units)}{Means\ of\ purebreds} \times 100$

MAE = (YEC x GG – GG x YEC)

DAE = (YEC x YEC +YEC x GG) – (GG x GG + GG x YEC)

Where,

H' = Estimation of direct heterosis in units,

%H = Heterosis percentage

MAE = Maternal Additive Effect

DAE = Direct Additive Effect

YEC = Yoruba Ecotype Chicken

GG = Pure bred Goliath chicken

SS = Pure bred Sussex chicken

4.6 Results

4.6.1 Egg Production Traits

The egg production traits in YEC, Goliath, Sussex and their cross bred are presented in Table 4.1. There was a significant difference ($p<0.05$) among strain in egg number with purebred SS and cross bred YEC x SS having the highest, while crossbred GG x YEC had the lowest.

AFE was significantly ($p<0.05$) influenced by strain, with GG and SS reaching sexual maturity earlier than others the difference in AFE compared to the exotic GG were 10days for YEC x GG, 35 days for GG x YEC and with exotic SS was 8 days for YEC x SS and 23 days for SS x YEC while, the difference compared to YEC were 11 days for GG x YEC and one day for SS x YEC. The result implies that cross breeding with YEC extends sexual maturity in exotic hens. Hen body weight at first egg differed significantly ($p<0.05$) in all the genotypic groups with YEC x GG having the highest value (1715g) and YEC had the least (1310g) with a difference of (405g). Egg mass were significant ($p<0.05$) in all the strain with values ranging (5882g- 2040g) for SS and GG x YEC. Also, significant difference ($p<0.05$) exist between all the strains in HDP with purebred SS having the highest (25.19%) while cross bred GG x YEC had the least(14.39%). There was significant difference($p>0.05$) between all the strains generally for feed per dozen eggs with purebred GG having the highest while crossbred SS x YEC recorded the least value.

4.6.2 Effect of Strain on Egg Quality Traits

The result of external egg quality traits in YEC, Goliath, Sussex and their crossbreds are presented in Table 4.2 while that of internal egg quality traits are shown in Table 4.3. There were significant differences ($p<0.05$) among the strains for egg weight (EW) except purebred GG, SS and YEC, GG x YEC and SS x YEC that did not differ significantly from each other. Significantly ($p<0.05$) bigger eggs (64.89g and 64.85g) were obtained in purebred GG and SS

while the eggs laid by purebred YEC, GG x YEC and SS x YEC (39.12 to 39.38) were small ($p<0.05$) in weight.

Also, there were significant differences ($p<0.05$) among strains in egg length and egg width. Purebred SS had the highest value while YEC had the least. Significantly higher ($p<0.05$) EI values were obtained for YEC, GG x YEC and SS x YEC while, YEC x SS recorded the least value. There were significant differences ($p<0.05$) in all the strains for SW with YEC having the highest (13.13%) and SS recording the lowest (8.65%). Shell thickness was significantly higher in YEC (0.61mm) and lower in SS (0.37mm) for this trait.

Strains differed significantly ($p<0.05$) in albumen weight, albumen height, albumen width, yolk weight, yolk height, yolk width, yolk index and H.U. The crossbred YEC x SS had significantly higher ($p<0.05$) values for albumen weight, albumen height, albumen width while purebred YEC x YEC had the lowest value for these traits.

Also, purebred GG x YEC had significantly higher value ($p<0.05$) for relative yolk weight and crossbred YEC x GG had the lowest while purebred GG, SS, YEC x GG had high values but which were not significanly different for yolk height. However, crossbred SS x YEC had the lowest value for this trait. Significantly higher ($p<0.05$) values for yolk width and yolk index were obtained in purebred GG while crossbred YEC x SS recorded lowest value for yolk width and crossbred SS x YEC for yolk index respectively. Significant differences ($p<0.05$) also exist among the strains for Haug Unit except for purebred YEC, GG and crossbred GG x YEC SS x YEC that were not significantly different from each other. Highest values were obtained for crossbred GG x YEC while crossbred YEC x SS had the lowest value for these traits.

Table 4.1: Egg Production Traits in Pure and Cross Bred Hens

TRAITS	YEC	GG	SS	YECxGG	YECxSS	GGxYEC	SSxYEC
EN	63.45 ± 1.34^{c}	68.70 ± 0.60^{b}	90.7 ± 0.49^{a}	60.00 ± 0.69^{d}	90.00 ± 0.61^{a}	51.8 ± 0.36^{e}	65.80 ± 052^{c}
AFE(days)	168 ± 0.503^{c}	147 ± 0.21^{f}	146 ± 0.29^{f}	157.90 ± 0.17^{d}	154.10 ± 0.23^{e}	182.07 ± 0.31^{a}	169.93 ± 0.15^{b}
HBW(g)	1310 ± 3.76^{f}	1662 ± 18.7^{b}	1575 ± 21.14^{c}	1715 ± 16.81^{a}	1499 ± 12.15^{d}	1377 ± 12.93^{e}	1056 ± 10.03^{g}
EM(g)	2482 ± 53.7^{f}	4458 ± 33.9^{c}	5882 ± 46.4^{a}	3521 ± 56.3^{d}	4954 ± 33.11^{b}	2040 ± 16.3^{g}	2576 ± 23.38^{e}
HDP%	17.63 ± 0.37^{de}	19.08 ± 0.15^{c}	25.19 ± 0.13^{a}	17.14 ± 0.19^{e}	22.5 ± 0.8^{b}	14.39 ± 0.10^{g}	18.23 ± 0.14^{d}
FPD(g/egg)	4.87 ± 0.11^{f}	7.57 ± 0.06^{a}	6.07 ± 0.03^{c}	7.34 ± 0.08^{b}	5.00 ± 0.33^{e}	5.84 ± 0.04^{cd}	4.71 ± 0.03^{e}

YEC,GG,SS,EN,AFE,HBW,EM,HDP,FPE,(g),%,g/egg, $\pm$, represents Yoruba ecotype, Goliath and Sussex chickens , egg number, age at first egg, hen body weight, egg mass, hen day production, feed per dozen egg, grams, percentage, gram per egg and ,standard error. $^{a-g}$*Means with different superscripts across the strain are significantly($p< 0.05$) different.*

Table 4.2: External Egg Quality Traits in Pure and Cross Bred Hens

TRAITS	YEC	GG	SS	YECxGG	YECxSS	GGxYEC	SSxYEC
EW(g)	39.12±0.07^{d}	64.89±0.26^{a}	64.85±0.25^{a}	58.67±0.41^{b}	55.04±0.01^{c}	39.38±0.08^{d}	39.15±0.09^{d}
EL(mm)	2.91±0.09^{f}	4.30±0.01^{b}	4.42±0.01^{a}	3.86±0.01^{c}	3.67±0.01^{d}	3.09±0.04^{e}	2.94±0.01^{f}
EWD(mm)	2.12±0.01^{e}	3.34±0.05^{b}	3.40±0.01^{a}	3.12±0.01^{c}	3.04±0.01^{d}	2.14±0.06^{e}	2.13±0.01^{e}
EI(%)	1.38±0.07^{a}	1.28±0.03^{b}	1.30±0.02^{b}	1.24±0.01^{c}	1.21±0.01^{d}	1.45±0.02^{a}	1.37±0.01^{a}
SW(%)	13.13±0.07^{a}	9.29±0.03^{e}	8.65±0.04^{f}	9.85±0.03^{d}	10.16±0.07^{d}	13.10±0.01^{b}	13.10±0.01^{b}
ST(mm)	0.61±0.03^{a}	0.38±0.01^{c}	0.37±0.01^{d}	0.35±0.01^{e}	0.37±0.06^{d}	0.52±0.01^{b}	0.52±0.01^{b}

YEC,GG,SS, EW,EL,EWD,EI,ST,ST, (g),(mm) , %, and ± represents Yoruba ecotype, Goliath and Sussex chickens, egg weight, egg length, egg width, egg index, shell weight, shell thickness, grams, millimetre, percentage, and± standard error. $^{a\text{-}f}$*Means with different superscripts across the strain are significantly($p< 0.05$) different.*

Table 4.3: Internal Egg Quality Traits in Pure and Cross Bred Hens

TRAITS	YEC	GG	SS	YECxGG	YECxSS	GGxYEC	SSxYEC
AW (%)	52.15 ± 0.07^{e}	65.53 ± 0.14^{b}	61.84 ± 0.05^{c}	65.91 ± 0.25^{b}	66.47 ± 0.07^{a}	53.50 ± 0.06^{d}	52.43 ± 0.08^{e}
AHT(mm)	6.31 ± 0.04^{f}	7.07 ± 0.03^{b}	7.13 ± 0.02^{a}	6.89 ± 0.019^{c}	6.53 ± 0.02^{d}	6.42 ± 0.04^{e}	6.37 ± 0.04^{f}
AWD(mm)	0.53 ± 0.05^{d}	0.65 ± 0.07^{a}	0.61 ± 0.06^{b}	0.63 ± 0.01^{b}	0.61 ± 0.01^{b}	0.56 ± 0.01^{c}	0.54 ± 0.01^{c}
YW (%)	28.09 ± 0.09^{b}	27.35 ± 0.14^{d}	26.68 ± 0.09^{e}	26.03 ± 0.15^{f}	26.42 ± 0.07^{e}	28.26 ± 0.01^{a}	27.84 ± 0.09^{c}
YH(mm)	15.98 ± 0.04^{c}	18.28 ± 0.03^{a}	18.25 ± 0.02^{a}	18.24 ± 0.27^{a}	15.99 ± 0.03^{c}	16.52 ± 0.02^{b}	15.90 ± 0.05^{c}
YWD(mm)	3.62 ± 0.01^{d}	3.75 ± 0.01^{a}	3.70 ± 0.08^{b}	3.61 ± 0.01^{d}	3.59 ± 0.011^{e}	3.66 ± 0.01^{c}	3.63 ± 0.01^{d}
YI (%)	4.40 ± 0.19^{e}	4.87 ± 0.02^{c}	4.93 ± 0.03^{b}	5.05 ± 0.015^{a}	4.50 ± 0.01^{d}	4.87 ± 0.06^{c}	4.39 ± 0.02^{e}
H.U	86.22 ± 0.22^{a}	82.47 ± 0.22^{cd}	82.56 ± 0.14^{bc}	83.23 ± 0.20^{b}	82.01 ± 0.13^{d}	86.76 ± 0.22^{a}	86.56 ± 0.21^{a}

YEC,GG,SS,AW,AHT,AWD,YW,YH,YWD,YI,HU,(mm) , % and $\pm$ represents: Yoruba ecotype, Goliath and Sussex chickens, albumen weight,albumen height,albumen width,yolkweight,yolk height,yolk width,yolk index,haugh unit ,millimetre, percentage and $\pm$ standard error. $^{a\text{-}f}$*Means with different superscripts among strains are significantly(p< 0.05) different.*

4.6.3 Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for Egg Production Traits in Cross Bred Hen

Table 4.4 shows direct heterosis, % heterosis, maternal and direct additive effect for egg production traits in cross bred hen. Strain YEC x GG had negative direct and percentage heterosis for egg number while maternal and direct additive effect were positive (8.20g and 2.95g). Age at first egg was positive for direct and percentage heterosis 0.40g and 0.25g but negative values exist for maternal and direct additive effect for these traits. The hen body weight and egg mass showed similar trend with direct, percentage heterosis and maternal additive effect having positive values (229g,15.45%,338g) and (50.87g,1.46% and 1481.32g) while direct additive effect were negative for both hen body weight and egg mass. Hen day production was positive for direct, percentage heterosis, maternal and direct additive effect (1.22, 6.65%, 2.75 and 1.34). Feed per dozen eggs was positive for direct heterosis, percentage heterosis, and maternal additive effect but direct additive effect was negative for this trait.

Positive values were obtained for egg number in strain YEC x SS within all the effects (12.93, 16.77 and 24.20) except in direct additive effect where the value was negative. Age at first egg had negative values for direct heterosis, percentage heterosis and maternal additive effect while direct additive effect had positive value (8.17) for this traits. Hen body weight had positive values for all the effects (56.50g, 3.92%, 442.33g and 177.33g). The direct heterosis, percentage heterosis and maternal additive effect for egg mass, hen day production, feed per dozen egg had similar trend with positive values (771.47g, 18.44% and 2377.52g), (1.09, 5.09% and 4.27) and (0.47, 8.59% and 0.29) while direct additive effect had negative values for all these traits.

In reciprocal cross bred GG x YEC, egg number had negative values for direct heterosis, percentage heterosis, and maternal additive effect while direct additive effect was positive

(13.45). Direct heterosis, percentage heterosis, maternal and direct additive heterosis were positive for age at first egg (24.57, 15.60%, 24.17, 45.17) respectively. Hen body weight, hen day production and feed per dozen egg had similar trend that were negative for all the effects. Egg mass had positive percentage heterosis (41.23%) while other effects were negative for these traits.

In strain SS x YEC, egg number was negative in all the effects while age at first egg was positive for direct heterosis, percentage heterosis and maternal additive effect (12.93, 8.24% and 15.83) while direct additive effect was negative. Hen body weight and egg mass were negative in all the effects. Hen day production had positive value for percentage heterosis (14.85%) but was negative for direct heterosis, maternal and direct additive effect. Feed per dozen eggs had positive values for direct and percentage heterosis (0.76, 13.89%) but maternal and direct additive effect was negative for these traits. Generally, strain GG x YEC had positive age at first egg, hen body weight was high in strain YEC x SS while, strain YEC x GG had positive heterotic effect for hen day production.

4.6.4 Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for External Egg Quality Traits in Cross Bred Hens

The direct heterosis, % heterosis, maternal and direct additive effect for external egg quality traits in cross bred hens is presented in Table 4.5. Positive values for egg and shell weight were obtained for strain YEC x GG in all the effects (7.67g, 14.72% , 19.29g) and (0.20g, 3.58%, 0.62g) except in direct additive effect which had negative values, egg length had positive values for direct heterosis, percentage heterosis, direct and maternal additive effect (0.25mm, 7.07%, 0.77mm and 0.62mm). Egg width had positive values for direct heterosis, percentage heterosis

and maternal additive effect (1.14mm, 41.91%, 0.98mm) but direct additive effect had Negative value. Shell thickness had positive value for percentage heterosis and direct additive effect (29.29%, 0.06mm) while negative values were obtained for mean heterosis and maternal additive effect. Strain YEC x SS had positive values for direct heterosis, percentage heterosis, maternal and direct additive effect which followed similar trend for egg weight, egg length, egg width and shell weight (3.06g, 5.87%, 15.89g), (0.01mm, 0.14%, 0.73mm), (0.29mm, 10.55%, 0.91mm) and (0.22g, 4.09%, 0.46g) while direct additive effect had Negative value for these traits. Also, egg index had positive value for percentage heterosis while other effects were Negative percentage heterosis and direct additive effect had positive values for shell thickness but direct heterosis and maternal additive effect values were not positive. In strain GG x YEC, direct heterosis, percentage heterosis , maternal and direct additive effect had similar trend with values that were positive in egg weight ,egg index and shell thickness (16.29g, 29.37%, 30.56g, 62.19g), (0.18%, 13.89%, 0.17%, 0.24%) and (0.05mm, 9.48%, 0.19mm, 0.44mm) while, egg length had positive values for direct heterosis, percentage heterosis and direct additive effect and negative for maternal additive effect. Egg width had values that were negative for direct heterosis, maternal and direct additive effect but positive value was obtained for percentage heterosis. However, shell weight was negative in all the effects for these traits.

Favourably, egg index and shell thickness had similar trend in strain SS x YEC, all the effect were positive while egg weight and width had percentage heterosis and direct additive effect that was positive but direct heterosis and maternal additive effect were negative. Also, egg length and shell weight had Negative values for all the heterotic effect.

Table 4.4: Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for Egg Production Traits in Cross Bred Hen

Strain	Effect	EN	AFE(days)	HBW(g)	EM(g)	HDP(%)	FPE(g/egg)
YEC x GG	XH	-6.03	0.40	229.00	50.87	1.22	1.98
	% H	-10.11	0.25	15.45	1.46	6.65	37.06
	ME	8.20	-24.19	338.00	1481.32	2.75	1.50
	DAE	2.95	-3.17	-12.00	-494.54	1.34	-1.20
YEC x SS	XH	12.93	-2.90	56.50	771.47	1.09	0.47
	%H	16.77	-1.84	3.92	18.44	5.09	8.59
	ME	24.2	-15.80	442.33	2377.52	4.27	0.29
	DAE	-3.05	8.17	177.33	-1022.12	-3.29	-0.91
GG x YEC	XH	-14.29	24.57	-109.00	-1430.52	-3.97	-0.38
	%H	-21.60	15.60	-7.34	41.23	-21.62	-6.10
	ME	-8.20	24.17	-338.00	-1481.58	-2.75	-1.50
	DAE	13.45	45.17	-690.00	-3457.32	-4.20	-4.20
SS x YEC	XH	-11.28	12.93	-385.83	-1806.24	-3.18	0.76
	%H	-14.63	8.24	-26.74	-43.18	14.85	13.89
	ME	-24.2	15.83	-442.33	-2378.04	-4.27	-0.89
	DAE	-51.45	-37.83	-923.33	-5777.31	-11.83	-1.49

YEC,GG,SS, H,%H, ME,DAE , EN,AFE,HBW,EM,HDP,FPE,(g),%,g/egg represents Yoruba ecotype, Goliath and Sussex chickens,direct heterosis , heterosis percentage, Maternal effect, Direct additive effect, egg number, age at first egg, hen body weight, egg mass, hen-day production, feed per dozen egg, grams, percentage, gram per egg.

Table 4.5: Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for External Egg Quality Traits in Cross Bred Hens

STRAIN	EFFECT	TRAITS					
		EW(g)	EL(mm)	EWD(mm)	EI (%)	SW (%)	ST(mm)
YEC x GG	XH	7.67	0.25	1.14	-0.09	0.20	-0.15
	%H	14.72	7.07	41.91	-6.77	3.58	29.29
	MAE	19.29	0.77	0.98	-0.21	0.62	-1.02
	DAE	-5.48	0.62	-0.36	-0.11	-0.28	0.06
YEC x SS	XH	3.06	0.01	0.29	-0.13	0.22	-0.12
	%H	5.87	0.14	10.55	9.70	4.09	24.48
	MAE	15.89	0.73	0.91	-0.17	0.46	-0.15
	DAE	-9.84	-0.78	-0.39	-0.09	-0.02	0.09
GG x YEC	XH	16.29	0.67	-0.65	0.18	-6.05	0.05
	%H	29.37	18.11	23.46	13.89	-54.06	9.48
	MAE	30.56	-1.1	-1.16	0.17	-0.65	0.19
	DAE	62.19	2.68	-2.50	0.24	-2.12	0.44
SS x YEC	XH	-12.84	-0.73	-3.37	0.03	-0.24	0.23
	%H	24.71	19.78	61.27	2.23	4.47	6.12
	MAE	-15.89	-0.73	-0.91	0.16	-0.49	0.16
	DAE	41.62	-2.24	2.21	0.24	-0.94	0.39

YEC,GG,SS,H,%H, ME,DAE EW,EL,EWD,EI,SW,ST, (g),(mm) , %represents Yoruba ecotype, Goliath and Sussex chicken, direct heterosis , heterosis percentage, Maternal effect, Direct additive effect ,egg weight ,egg length ,egg width ,egg index ,shell weight ,shell thickness, grams ,millimetre, percentage

4.6.5 Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for Internal Egg Quality Traits in Cross Bred Hens

The direct heterosis, % heterosis, maternal and direct additive effect for internal egg quality traits in cross bred hens is shown in Table 4.6. Albumen height and width, yolk height and index showed similar trend with values that were positive for direct heterosis, percentage heterosis, Maternal additive and direct additive effect.

Also, albumen and yolk weights followed the same pattern with direct heterosis, percentage heterosis and maternal additive effect all having positive values (7.11g, 22.53%, 17.60g) and (0.90g, 6.26%, 4.14g) while direct additive effect was negative for these traits. Haugh unit had direct heterosis, percentage heterosis and direct additive effect that were positive but value of direct additive effect were negative for this trait and for all the heterotic effects on yolk width. In Strain YEC x SS, direct heterosis, percentage heterosis and maternal additive effect were all positive in albumen weight, width, yolk weight, height and index while direct additive effect was negative for all these traits. Albumen height, yolk width and haugh unit followed the same trend with only maternal additive effect having positive value.

Heterotic values were negative for all the effects on albumen weight in strain GG x YEC. Also, albumen height, width, yolk weight and index had positive values for direct and percentage heterosis but the values obtained for maternal and direct additive effect were not positive.

Yolk height had positive value for percentage heterosis (3.52%) while other heterotic effects were negative. Yolk width had direct additive effect that was negative while other heterotic effect values were positive alongside with all the effects in haugh unit (2.42, 2.86%, 3.53, 7.28) respectively.

Furthermore, strain SS x YEC had negative heterotic values for albumen weight, width, yolk weight, and index. While haugh unit had positive heterotic values for all the effect, albumen height had direct and percentage heterosis that were positive with maternal and direct additive effect being negative. Yolk height had positive values for percentage and maternal additive effect (7.09%, 0.09) while in yolk width only maternal additive effect had positive value.

Table 4.6: Direct Heterosis, % Heterosis, Maternal and Direct Additive Effect for Internal Egg Quality Traits in Cross Bred Hens

STRAIN	EFFECT	TRAITS							
		AW (%)	AH(mm)	AWD(mm)	YW (%)	YH(mm)	YWD(mm)	YI (%)	HU
YEC x GG	XH	7.11	0.20	0.04	0.90	1.11	-0.75	0.42	1.12
	%H	22.53	2.99	6.78	6.26	6.47	-2.03	8.95	1.32
	MAE	17.60	0.49	0.07	4.14	17.00	-0.05	0.55	-3.35
	DAE	-4.92	0.29	0.05	-2.62	9.37	-0.18	0.08	0.22
YEC x SS	XH	6.34	-0.19	0.04	0.42	1.13	-0.07	0.21	-2.38
	%H	20.95	-2.83	7.02	2.96	6.57	-1.91	4.39	-2.82
	MAE	16.06	0.16	0.07	3.64	0.09	0.04	0.42	4.55
	DAE	-3.64	-0.60	-0.01	-2.67	-2.18	-0.12	-0.05	-0.89
GG x YEC	XH	-10.49	0.27	0.03	3.24	-0.61	0.03	0.23	2.42
	%H	-0.33	4.03	5.08	22.54	3.52	0.67	4.76	2.86
	MAE	-37.6	-0.47	-0.07	-4.14	-1.72	0.05	-0.75	3.53
	DAE	-39.96	-1.25	-0.19	-10.9	-4.02	-0.05	-1.02	7.28
SS x YEC	XH	-9.72	0.05	-0.03	-3.25	-1.22	-0.03	-0.275	2.17
	%H	-32.13	0.78	-5.26	-22.95	7.09	-0.82	-5.89	2.57
	MAE	-16.06	-0.16	-0.07	-3.64	0.09	0.04	-0.48	4.55
	DAE	-35.76	-0.98	-0.15	-9.95	-2.36	-0.04	-1.01	8.21

YEC,GG,SS,MM H,%H, ME,DAE,AW,AH,AWD,YW,YH,YWD,YI,HU, (g),(mm) , %represents Yoruba ecotype, Goliath, Sussex and Marshall chickens,direct heterosis , heterosis percentage, Maternal effect, Direct additive effect,albumen weight,albumen height,albumen width,yolkweight,yolk height,yolk width,yolk index,haug unit, grams ,millimetre, percentage.

4.7 Discussion

The result of this study showed significant difference among the strains for Age at first egg (AFE), Hen Body weight (HBW), Egg number (EN) and other egg production traits, this was in line with the report of Isidahomen *et al*. (2014), Amin (2008) and Harvenstein *et al.* (2007). The total number of eggs laid was higher in purebred SS and crossbred YEC x SS than their counterparts this corresponds with the findings of Sola –Ojo and Ayorinde (2011) who reported that cross bred FE x DB and DB x FE laid the highest number of eggs than their purebred during early egg production period while Omeje and Nwosu (1983) had earlier reported high egg production in GL x LC and their reciprocal cross LC x GL than the local chicken. Goliath and Sussex hens gained weight faster and the development of reproductive traits was early which contributed to their early attainment of age at first egg compared to YEC hen. The body weight at first egg obtained in this study for GG and SS were higher than that of Yoruba Ecotype hen (YEC). This corresponds with the findings of Singh *et al.* (1982) but higher than 140days reported by Sola-Ojo and Ayorinde (2011) for pure purebred Dominant black strain. However, the age obtained for YEC x GG and YEC x SS corroborate with 22 weeks reported for Local chicken by Oni *et al.* (1991), Fayeye *et al.* (2005), Yahaya (2008), Sola-Ojo and Ayorinde (2011, 2009) and Nwagu *et al.* (2001). The results of hen body weight at first egg in SS x YEC was lower to the findings of Khan *et al*. (2006) who reported weight at first egg in Fayoumi chicken with average body weight of 1253.53$\pm$16.43 gm and first egg weighing 45.79gm under intensive management. Meanwhile, Chineke (2001) reported that association between body weight and selected egg traits (egg length, egg breadth, egg index, egg weight, albumen weight, yolk weight, shell weight, shell thickness, hen-day production) was non-linear. He recommended maintenance of optimum body weight range of 1.72 to 1.80kg, which is in accordance with the report of

Akanni *et al*. (2008) on black nera pullet which attained sexual maturity at 188days and a body weight of 1421.59gm/bird. In this study, YEC x GG, YEC x SS, SS x YEC and YEC had age at first egg that was in close agreement with the report of Ayorinde and Oke (1995) who reported age at first egg in Black Olympian pullets to be between 151 and 175days, 132 days and 210 days for Shika brown commercial strain raised on deep litter (Ayorinde *et al*., 1999). The difference in body weight of Goliath and Sussex and their cross bred with YEC cock may be due to the adaptation of these exotic breeds in Nigeria humid tropical environment. However, the result obtained with respect to their reciprocal cross bred with YEC hen could be as a result of gene interaction between Goliath and Sussex cork and YEC hen involved in the study. Also, from this present study, the highest age at first egg and hen body weight obtained for crossbred GG x YEC was in accordance with the report of Akanni *et al*. (2008) on Black Nera pullet which attain sexual maturity at 188days and a body weight of 1421.59gm/bird.

Generally, light strains of poultry perform better than heavy strains in laying performance characteristics. Consequently, the higher egg number produced by SS and YEC x SS than others may be due to maternal effect of Sussex hens. Hence the superiority of purebred SS x SS and YEC x SS hen suggests that the use of Sussex or YEC as a terminal sire strain in crossbreeding program using Sussex hen will be beneficial for improving egg number.

Also, high feed per dozen eggs obtained for GG and YEC x GG suggest that they eat more to satisfy their desired appetite because heavy strain birds consume more feed which is used for muscle building other than egg production. The mean egg weight obtained in the present study for YEC and its reciprocal crossed breed are higher than values reported for Sudanese indigenous chicken type Mohammed *et al*., (2005) except for purebred YEC and GG x YEC and SS x YEC which had similar values. Also, result obtained in this study was in agreement with the report of

Olawumi and Ogunlade (2008) who reported significant effect for egg quality traits in some exotic breeds of chicken. The highest egg weight recorded by purebred GG, SS and lowest by YEC reveals that body weight of hen is directly proportional to egg weight. Also, the exotic strain had been known to attain high body weight under favourable environmental and feeding conditions and this will reflect on the egg quality.

Egg weight is directly proportional to the weight of albumen, yolk and shell that is contained in the egg and this varies significantly between strains of hen. YEC and its reciprocal cross bred had the lowest egg weight, the values fall within the range of values reported by Fayeye *et al*. (2005) for Fulani ecotype chicken and Yoruba ecotype chicken by (Peters *et al*., 2008). The egg length obtained in this present study was within the range of values reported by Fayeye *et al*. (2005) who opined that the Normal feather Nigeria local chicken had higher egg length than the Fulani ecotype chicken. The higher egg width for Sussex purebred chicken in this study could be attributed to genetic differences among the strains used in this study.

Egg index is a good indicator for external egg quality, the egg index obtained in this study were higher for purebred YEC and its crossbred (GG x YEC, SS x YEC) which implies good external quality of egg. The lower relative shell weight obtained for Goliath and Sussex breeds suggest that high proportion of the egg is made up of the internal content which explain their significance for high body weight in Nigeria humid tropical environment. The result for shell thickness in the present study showed that purebred YEC and its crossbred GG x YEC, SS x YEC, had the best shell thickness. Also, the values obtained for shell thickness was higher than the values recorded by Fayeye *et al*. (2005) for Fulani ecotype chickens. The high shell thickness obtained could be attributed to the cross breeding effects and the effect of feed supplied to the

chickens, since shell thickness is an important bio economic traits that breeder of egg should put into consideration to reduce egg shell breakage.

The mean Albumen characteristics (weight, height and width) were higher for Goliath and Sussex purebred chicken compared to YECand its crossbred. Also, the mean albumen weight obtained in this study showed the proportion of albumen that as contributed to the egg weight the result obtained for YEC and its reciprocal crossbred were similar to the reports of Sola-Ojo *et al*. (2011) who obtained 21.34 and 22.42g for Fulani and Yoruba ecotype chicken but higher than 19.86g reported by Oleforun- Okoteh, (2011) for South Eastern Nigeria Chicken.

The lower values obtained for purebred YEC for internal egg quality traits and its reciprocal crossbred were similar with the findings of Fayeye *et al*., (2005) for Fulani ecotype chicken. Purebred Goliath outperformed their other purebred counterparts in yolk weight, yolk index and haugh unit. These traits have been reported to be the best indicators of internal egg quality .The present study showed that yolk index was in favour of purebred YEC and crossbred with exotic cork (GG x YEC, SS x YEC). The haugh unit values obtained for the pure and crossbred were above 80% which gives an indication of good albumen quality .Hence, the present values obtained suggest that egg of purebred YEC and Crossbred GG x YEC and SS x YEC are of good quality because they combine favourably in the quality of eggs they produce.

Heterosis was greater for egg quality traits than for growth traits in this study which corroborate eaiier report of Fairfull (1990) who noted that heterosis was usually greater for reproductive traits than for growth traits .Percent heterosis for egg number was positive in cross bred (YEC x SS) and this supports the earlier reports of Khalil *et al.* (2004) who reported similar result for Egg number at day 90 in croses between Saudi chicken with white leghorn. However, negative values which were obtained for cross bred (YEC x GG, GG x YEC, SS x YEC) agree with the

reports of Udeh and Omeje (2005) as well as Santosh and Deepak (2006) who reported negative heterosis estimates for egg number in cross bred chickens. In this study, the values obtained for heterosis percentage for egg number was higher than those recorded by Amin (2014) for F, S and RIR sire (4.71%, 5.81% and 1.72%) and Saady *et al*. (2008) who reported highest heterosis percentage for egg number in cross bred F x S and its reciprocal S x F(12.49%, 18.12%). The positive and high heterotic effect recorded for egg weight in this study supports the findings of Saady *et al*. (2008) in cross bred F x S and S x RIR and their reciprocals

The positive maternal additive effect for egg number in cross bred chicks (YEC x GG, YEC x SS) was in support of the report of Amin (2014) who recorded positive values for direct and maternal additive effect in cross bred F x S, S x RIR. Additionally, the result found varied positive or negatively for the direct and maternal additive effect among the studied crosses for egg production is similar to the reports of Razuki and Al- Shahan (2011) who found varied positive and negative estimates for direct and maternal effect for body weight, egg production and egg weight among the crosses in laying chickens.

Generally, positive heterotic effect for body weight, egg number and other egg quality traits obtained in this present study for crossbred chickens sired by YEC cork revealed that the offspring are advantageous to the average of both parents, this can be further explained by the accumulation of dominant and positive genes for these traits from their parents thereby making the offspring to reflects superiority to that of their straight bred parent.

CHAPTER FIVE

EXPERIMENT THREE

ESTIMATION OF GENETIC PARAMETERS AND PREDICTIVE MODELS FOR GROWTH AND EGG PRODUCTION TRAITS IN YORUBA ECOTYPE CHICKEN AND ITS CROSSES WITH EXOTIC BREEDS OF CHICKEN IN NIGERIA HUMID TROPICS

5.1 Introduction

Breeding methods depend on heritability and genetic correlation for the desired traits. Heritability refers to the proportion of additive genetic variation to the total variation. Also, Heritability is the proportion of the difference between animals that is transmitted to the offspring .In other word it is a measure of degree to which offspring resemble their parents for a particular traits. It can also be regarded as a ratio of cause of variation between animals; it is the percentage of all differences between animals that is caused by the effect of gene transfer from generation to generation. Heritability is useful in planning breeding programs, predict response to selection, and determine management strategies and estimates breeding values of individual animals (Bennet Cassell, 2009). Theoretically, heritability estimates range between zero and one, the magnitude enables the breeder to decide on the type of selection that will lead to rapid genetic progress .If heritability is very close to zero selection for that trait will be totally ineffective but if high (0.4 and higher), useful progress can be made by selecting individuals on the records of their performance (Ibe, 1998).

Repeatability indicates the extent to which selection will influence future performance of individual. It measures the degree of association between records on the same animal for traits

expressed more than once in an animal's life. Also, repeatability estimates reveals the fraction of differences between single records of individual animal that are likely to repeat or occur in future performance (Toye *et al*., 2012). It is the correlation between two or more measurements on each individual in a given population and can be used to predict the most probable future production of an individual. The values can be negative if the present record will be exactly opposite the future or next production. When repeatability estimates is high, culling poor performers on the basis of a single record will be effective in improving flock performance when the measurement is repeated. The direction of repeatability estimates indicates the extent to which selection methods adopt at any stage will affect subsequent performance (Ibe, 1995). Repeatability values are useful to determine culling levels in selection as they have a predictive value for each trait.

Studies on heritability and repeatability of body weight, egg number and egg weight is of great importance in the establishment of poultry breeding programs. Information derived from heritability and repeatability estimates can help in culling the poor performers and retaining the good performers for the traits selected in a breeding program.

Genetic correlation occur when a single gene affect two traits, it can be positive or negative and ranged between +1 to -1,while zero (0) indicates that there is no genetic correlation. If genetic correlation is +1 it implies that the traits always occur together but if -1 it means that an increase in one lead to a decrease in the other traits. Studies on correlations between productive traits is of great importance in the establishment of poultry breeding programs (Silva *et al*., 2015). Information derived from correlation studies can help in selection of traits in breeding program with the aim of averting undesirable response in traits that are antagonistic.

Principal component analysis is a mathematical procedure used in transforming a number of possibly correlated variables known as Principal component (Jolliffe, 2002).These components

are ordered in such a way that the first few retains most of the variation present in the original variables. Principal component is a multivariate technique that analyzes a data set from which observations are described by many inter-correlated quantitative dependent variable (Abdi *et al*., 2010). Principal components simultaneously consider a group of attributes which may be interesting for selection purpose and each of these principal components explains a percentage of the total variance with the first principal component explaining the highest percentage of this variance. Communalities is the coefficient of determination of the variable predicted from the components, high communalities have been reported in Nigerian indigenous chicken by Yakubu *et al*. (2009), in breeds of broiler chickens (Mendes, 2011; Udeh and Ogbu, 2011; Ajayi *et al*., 2012). Ogah *et al.* (2011) also used Principal component analysis to describe the relationship between body weight and body size in Turkey. Furthemore, associations among the chicken egg quality traits have been reported (Abanikanda *et al*., 2007; Kabir *et al*., 2014). A major merit of principal component analysis is that it helps to resolve problems involving interpretation of relationship where large numbers of traits are considered by reducing the dimensionality of such data.

Indirect methods of assessing body weights in animals without recourse to the use of weighing scales do exist such as the use of body measurements to predict body weight. The regression coefficient is a measure of the relationship between a dependent variable or response and one or more explanatory or independent variables; it helps us to quantify the amount of change in the dependent variable for a unit change in the independent variable. Also, stepwise regression (forward selection) is a linear regression method used to provide an initial screening of the individual variables when a large group of variables exist, it selects variable that has the largest R^2. Forward stepwise regression is a good choice especially when multi co-linearity is a problem.

Body weight is the sum total of increases in size of different structural body components (Amao and Ojedapo, 2016) and it is a function of skeletal size, fleshing and condition (Tierce and Nordskog, 1985). Body weight plays important role in the determination of economically important traits and in determining market price of farm animals (Momoh and Kershima, 2008).

The regression models can be used to make fast or early evaluation of the market body weight of an animal (Amao *et al*., 2010; Ojo, 2010), thereby enhancing the rate of progress in selection programmes. The use of linear equation is common in the prediction of body weight in poultry (Raji *et al*., 2009) and other species (Silva *et al.*, 2015; Zergaw *et al*., 2016). Another report by Semakula *et al.* (2011) showed that prediction using quadratic regression was more reliable than simple linear regression and polynomial. Yakubu *et al.* (2009) stated that cubic function predicted carcass weight of broiler chickens more accurately than quadratic and linear functions. In a comparison of four functional forms, Fayeye and Ayorinde (2007) reported that the linear function gave the best fits for the regression of egg weight on egg quality trait. The disparities in the above reports necessitate the use of multiple curve estimation or regression models to ascertain the best for a particular breeding programme. Furthermore, there is no previous work known to the authors on the prediction of late body weight from early body weight in Sussex and Goliath and their cross bred chickens.

Cluster analysis refers to a class of data reduction methods used for sorting cases, observation or variables of a given data set into homogeneous groups that differ from each other. In cluster analysis cases will always be grouped into cluster regardless of the true nature of the data, an example of this cluster analysis is Hierarchical agglomerative clustering.

Hierarchical agglomerative clustering starts with all data set in their own group, and repeatedly merge groups based on linkage function and stops when points are in one group. Or it separates

each case into its own individual cluster in the first step so that the initial number of cluster equals the total number of cases. There are some linkages functions associated with hierarchical cluster this include single linkage which measures the least dissimilar pair between groups. Secondly, There is also the complete linkage which measures the most dissimilar pair and thirdly, average linkage which measures the average dissimilarity over all pairs. The hierarchical cluster produces a sequence of clustering assignments shown by a dendogram and this sequential and inflexible nature of hierarchical clustering makes the initial partitioning more influential than those at the latter point. Five underlying genetic clusters were reported by Seo *et al.* (2013) for five Korean native chicken breeds and they concluded that the Korean chicken breeds are without introgression of imported breeds. The aim of this study is to determine the heritability and repeatability estimates for body weight, egg number and egg weight in pure and cross bred chickens.

5.2 Objectives

- To estimate heritability and repeatability for body weight, egg number and egg weight in pure and cross bred chickens.
- To assess genetic and phenotypic correlations among body weight, egg production and egg quality traits in pure and cross bred hens
- To identify the components of early body weight that best define body weight at later age in pure and cross bred chicken strains.
- To identify the components of early egg quality traits that best describe the same trait in pure and cross bred chicken strains.
- To measure weeks 8, 12, 16 and 20 body weight from early body weight in pure and cross bred chickens using precitive equations that involve linear and curvilinear models.

- To determine weeks 8, 12, 16 and 20 egg weight and egg number from early egg weight and egg number in pure and cross bred chickens using precitive equations involving linear and curvilinear models.
- To determine similarities or genetic relatedness between the 10 genotypic groups in body weight, egg number and egg weight using their phenotypic records.

5.3 Materials and Methods

5.3.1 Location of the study

The study was carried out in a private farm located at Oyan (Osun state, South-West Nigeria). The coordinates of the experimental site is latitude 8.05 and longitude 4.77 and an elevation of 422 meters above sea level.

5.3.2 Experimental animals.

Records from 455 chickens used in experiments one and two were used to estimate from which 120 hens were used in estimating for egg production in all the strains used for this study.

5.3.3 Data collection

Genetic correlations between hen body weight and measurements of egg traits (Age at first egg, egg weight, egg number, egg mass, egg length, egg width, egg index, shell weight, and shell thickness) were assessed. Pearson correlations between hen body weight and external and internal egg quality traits were also assessed in the ten chicken strains using SAS (2009).

Heritability and repeatability for body weight, egg number and egg weight, predicting late body weight, egg weight and egg number from early parameters in pure and crossbred chickens, Mean values of data across the weeks within strains collected were used for Hierarchical cluster analysis.

5.4 Statistical Analysis.

The statistical model for heritability and repeatability used to fix the effect of strain on body weight, egg number and egg weight is as follows:

$Y_{ik} = \mu + g_i + e_{ik}$

Where,

Y_{ik}= performance of ith individual of kth strain.

μ = the overall mean for each of the traits.

g_i= Fixed effect of ith Strain (i= 1,2,...10)

e_{ik} = Residual error.

The variance components (i.e. δ_s^2 and δ_e^2 were obtained from ANOVA mean squares with the following assumptions:

Mean Square Error (in the ANOVA table) = Mean Square sire (in the ANOVA table) = $\delta_s^2 + k\delta_e^2$

Where k is number of progeny within sire

Heritability was computed from the sire variance components using the equation.

$h^2_s = \frac{4\delta_s^2}{\delta_s^2 + \delta_e^2}$

Where,

$h^2_s$is heritability estimates

$\delta_s^2$is Sire variance component

$\delta_e^2$is error variance component

The standard errors of heritability were estimated as described by Becker (1984).

$$S.E(h^2_s) = \sqrt[4]{\frac{2(1-t)^2\ [1+(k-1)t]^2}{k\ (k-1)(s-1)}}$$

Where,

t is intraclass correlation

k is number of progeny within sire

s is number of sire

Repeatability was estimated using the equation.

$$R=\frac{\delta_W^2}{\delta_W^2+\delta_e^2}$$

Where,

R is repeatability estimates

$\delta_w^2$is variance component between individuals

$\delta_e^2$is variance component within individuals

The standard errors of repeatability were estimated as described by Becker, 1984.

$$S.E(\ R\ ) = \sqrt{\frac{2(1-R)^2\ [1+(k-1)R]^2}{k(k-1)(N-1)}}$$

Where,

R is intraclass correlation

k is number of records taken per individual

N is number of individual.

Data collected were subjected to one way analysis of variance, using the general linear model

(GLM) procedure of MINITAB, 2014 Statistical package.

Genetic and Phenotypic correlation between hen body weight and measurement for egg traits, external and internal quality traits were assessed in seven chicken strains using PROC CORR procerdure of SAS 9.3 (SAS Institute, 2009).

In Principal component analysis, the transformation of the variables in the multivariate data set ,X_1,X_2,X_3,….X_n into new uncorrelated variables Y_1,Y_2,Y_3…..Y_p which account for decreasing proportions of the total variance in the original variables was done according to Everitt *et al.* (2001). The original variables were defined as follows:

$Y_1 = a_{11}X_1+a_{12}X_2+ ……..+a_{1p}X_p$

$Y_2 = a_{21}X_1+a_{22}X_2+ ……..+a_{1p}X_p$

$Y_p = a_{p1}X_1+a_{p2}X_2+ ……..+a_{1p}X_p$

The suitability of the data set obtained from weekly bodyweight and egg quality traits in experiment 1 and 2 was tested using Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sample adequacy. Factor loading was based on an Eigen value of 1.00 and above, the best descriptors were identify based on the communalities extraction factors closest to 1.00 and the varimax option of orthogonal rotation was used in the rotation of the factor matrix.

The principal component analysis was performed using the dimension reduction with factor analysis using SPSS statistical package version 21.

Predictive equations were developed by using linear regression models to predict the 8, 16 and 20-week body weight of pure and cross breed chickens from the early body weight using SPSS (version 21). Curvillinear regression models were also used in the prediction of 8, 12, 16 and 20 week body weight of chicks.(Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound,

Power, Sigmoid, Growth, Exponential and Logistics equation).

The linear regression model for body weight, egg weight and egg number is represented by:

$Y_{ijk} = a + bX + e_{ijk}$

Where: Y_{ijk} = 8th, 12th, 16th or 20th week body (grams)

a = Intercept or constant

b =regression coefficient

X =early weekly body weight of birds (or independent variable)

e_{ijk} = error term

The mathematical notations of the models for logarithmic, inverse, quadratic, cubic, power, compound, sigmoid, growth, exponential and logistic equations were as listed below.

Y =*a* + (b1 * X) -------- Linear

*Y = a + (b*1* log(X)). ---------Logarithmic

Y= a +(b1 / X) ---------- Inverse

Y = a + (b1 * X) + (b2*X**^{2}) ---------- Quadratic

Y = a+ (b1 * X) + (b2*X**^{2}) + (b3* X**^{3}) --------- Cubic

Y = a *(X**b1) or In(a) +(In(b1)* X) --------- Power

Y= a *(b1**X) or In(Y) = In (a) + (In (b1) *X) ----------Compound

Y= e**(a + (b1/ X)) or In (Y) = a+ (b1/ X) ------- Sigmoid curve

Y = e**(a + (b1 * X)) or In(Y) = a + (b1 * X) ---------- Growth

Y = a * (e ** (b1 * X)) or In (Y) = In(a) + (b1 * X) ---------- Exponential

Y = 1/ (1/u +(a * (b1 ** X))) or In (1/y-1/u) = In (a) + (In(b1) * X) -------- Logistic

From the above equations, Where Y is the dependent variable (body weight at week 8 or 20), X represent the independent variables,

b is the regression coefficient

a represent the same function associated with independent variable (or the intercept) which represent the estimate of dependent variable when the independent variable is zero.

u represent the upper boundary value. After selecting logistic specific the upper boundary value to use in the regression equation The value must be a positive number that is greater than the largest dependent variable value.

The regression models were fixed using SPSS statistical package version 21.

In addition, data used for hierarchical cluster analysis were analyzed by descriptive statistics after which they were subjected to hierarchical cluster analysis using average linkage with SPSS (version 21) statistical package to produce dendogram which indicates the relationship among the 10 genetic groups.

5.5 Results

5.5.1 Heritability.

5.5.1.1 Heritability estimates for body weight in pure and crossbred chickens.

Table 5.1 shows the heritability estimates for body weight derived from sire variance components in pure and crossbred chickens. Heritability estimates for body weight in strains SS, SS x YEC, MM x YEC were generally low at weeks 1, 8 and 12. YEC, GG, YEC x SS ,YEC x MM had low to moderate heritability estimates for body weights at weeks 1, 4, 16 and 20. Low to moderate heritability was recorded for strain YEC x GG (0.38 to 0.63). However, strain GG x YEC had moderate to high heritability estimates for all the weeks (0.59 to 1.0). Generally crossbreed GG x YEC had the highest and most consistent heritability estimate from week 1 up to week 20 but in absolute terms heritability estimate for body weight was generally low for all the strains when calculated from the pool of 20 weeks data.

5.5.1.2 Heritability estimates for egg number in pure and crossbred hens.

The heritability estimates for egg number derived from the sire variance component are represented in Table 5.2. The results of heritability varied between weeks and among the 7 genotypic groups. In YEC and YEC x GG, the heritability estimates for egg number at week 20 were 0.25 and 0.28 respectively. Heritability for egg number declined in the two strains from week 24 to week 44. Strains GG, SS x YEC and GG x YEC, had low to high heritability estimates of 0.20 to 0.66 at weeks 20 and 4; 0.27 to 1.04 obtained at weeks 20 and 32; 0.16 to 1.0 obtained at weeks 28 and 36, respectively. Strains SS and YEC x SS had moderate to high heritability estimates 0.55 to 1.0 obtained at weeks 40 and 32, 0.42 to 0.55 obtained for weeks 20 and 36, respectively. However, heritability estimate was generally low for egg weight when calculated from the pool of 24 weeks in lay data.

5.5.1.3 Heritability estimates for egg weight in pure and crossbred hens

The estimates of heritability for egg weight in pure and crossbred hens derived from the sire variance component are presented in Table 5.3. The heritability estimate varied among strains. Heritability for egg weight in YEC, GG, SS, GG x YEC, SS x YEC hens varied from low to high. Estimates of heritability increased with age in lay with week 1 having the lowest value. The highest heritability for egg weight (0.84) was obtained at week 36 in YEC, while GG x YEC and SS x YEC had the highest heritability for egg weight (0.68) at week 44.The estimates of heritability in YEC x GG varied from moderate to high. The highest heritability for egg weight was obtained at week 44 in GG, SS and YEC x SS. However heritability estimate was generally low for egg weight when calculated from the pool of 24 week in lay data.

Table 5.1: Heritability Estimates for Body Weight in Pure and Crossbred Chickens

	STRAINS									
	YEC	GG	SS	MM	YEC x GG	YEC xSS	YEC xMM	GG xYEC	SS xYEC	MM xYEC
	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E
Weeks										
1	0.07±0.05	-0.21±0.06	-0.03±0.11	1.04±0.01	0.38±0.10	0.35±0.10	0.26±0.097	0.59±0.09	0.05±0.07	0.18±0.09
4	0.09±0.06	0.35±0.096	-0.02±0.06	-0.04±0.06	0.40±0.10	0.11±0.08	0.11±0.08	0.96±0.01	-0.23±0.01	-0.37±0.04
8	0.16±0.06	-0.31±0.04	0.017±0.07	0.12±0.08	0.45±0.09	0.18±0.09	0.13±0.08	1.08±0.03	-0.31±0.02	-0.39±0.05
12	0.21±0.07	-0.09±0.05	0.23±0.09	-0.03±0.06	0.48±0.09	0.13±0.08	0.14±0.09	1.09±0.03	0.25±0.08	0.13±0.08
16	0.23±0.07	0.12±0.08	0.20±0.09	-0.008±0.06	0.58±0.09	0.10±0.08	0.30±0.10	1.06±0.01	-0.30±0.02	-0.38±0.05
20	0.35±0.07	-1.25±0.82	0.22±0.09	-0.055±0.05	0.63±0.08	0.12±0.08	0.36±0.10	1.04±0.01	-0.27±0.01	-0.33±0.03
0-20	0.0018±0.05	-0.002±0.1	0.08±0.08	0.006±0.07	0.037±0.07	0.045±0.07	0.09±0.07	0.05±0.07	0.04±0.07	0.007±0.07

YEC, GG, SS,h_S^2, ±S.E represent: Yoruba Ecotype Chicken, Goliath and Sussex ,Heritability estimate and Standard error respectively.Note:All negative estimates are assumed to be zero while estimates greater than 1 is assumed to be 1.

Table 5.2: Heritability Estimates for Egg Number in Pure and Crossbred Chickens

	STRAINS						
Age of hen (Weeks in lay)	YEC h_S^2±S.E	GG h_S^2±S.E	SS h_S^2±S.E	YEC x GG h_S^2±S.E	YEC Xss h_S^2±S.E	GG xYEC h_S^2±S.E	SS x YEC h_S^2±S.E
20	0.25±0.08	-0.48±0.12	-0.64±0.30	0.28±0.12	0.42±0.13	-0.32±0.08	0.27±0.12
24	-0.70±0.17	0.66±0.10	-0.88±0.51	-0.57±0.19	-0.80±0.31	0.30±0.12	0.56±0.12
28	-0.22±0.02	-0.08±0.31	-0.53±0.21	-0.48±0.17	-0.80±0.31	0.16±0.07	1.02±0.31
32	0.16±0.07	-0.64±0.30	1.04±0.31	-0.53±0.21	-0.80±0.31	1.03±0.31	1.04±0.31
36	-0.43±0.10	-0.80±0.05	-0.57±0.19	-0.80±0.31	0.55±0.12	1.04±0.31	0.56±0.12
40	-0.40±0.09	0.20±0.10	0.55±0.12	-0.81±0.31	-0.48±0.18	0.17±0.07	0.63±0.16
44	-0.28±0.09	-0.80±0.31	-0.48±0.12	-0.48±0.18	-0.48±0.18	-0.80±0.31	0.63±0.16
20-44	0.21±0.08	-0.02±0.05	-0.07±0.30	0.04±0.053	0.01±0.06	0.02±0.09	0.01±0.06

YEC, GG, SS, h_S^2, ± S.E represent: Yoruba Ecotype Chicken, Goliath and Sussex,Heritability estimate and Standard error respectively. Note:All negative estimates are assumed to be zero while estimates greater than 1 is assumed to be 1.

Table 5.3: Heritability Estimates for Egg Weight in Pure and Crossbred Chickens

	STRAINS						
Age of hen (weeks)	YEC	GG	SS	YEC x GG	YEC xSS	GG xYEC	SS x YEC
	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E	h_S^2±S.E
20	0.15±0.06	0.24±0.10	0.36±0.10	0.10±0.08	-0.05±0.05	0.09±0.07	0.05±0.07
24	0.24±0.08	0.33±0.10	0.47±0.09	-0.32±0.02	0.05±0.07	0.20±0.09	0.32±0.10
28	0.62±0.10	0.65±0.04	0.68±0.07	-0.39±0.05	0.42±0.10	0.49±0.09	0.35±0.10
32	0.72±0.03	0.68±0.24	0.69±0.07	0.30±0.08	0.50±0.09	0.66±0.07	0.44±0.10
36	0.84±0.02	0.72±0.03	0.68±0.07	0.32±0.10	0.92±0.02	0.68±0.07	0.54±0.09
40	0.72±0.03	0.88±0.03	0.85±0.08	0.68±0.07	0.95±0.07	0.50±0.09	0.58±0.09
44	0.60±0.06	1.03±0.01	1.01±0.003	0.98±0.006	1.01±0.003	0.51±0.09	0.68±0.07
20-44	0.01±0.05	0.06±0.07	0.06±0.05	0.002±0.06	0.009±0.07	0.01±0.06	0.013±0.06

YEC, GG, SS, h_S^2, ±S.E represent: Yoruba Ecotype Chicken, Goliath and Sussex, Heritability estimate and Standard error respectively. Note: All negative estimate is assumed to be zero while estimate greater than 1 is assumed to be 1.

5.5.2 Reapeatability

5.5.2.1 Repeatability estimates for body weight in pure and crossbred chickens

The repeatability estimates for body weight is presented in Table 5.4. Estimates for repeatability varied between weeks and among the genotypic groups used in this study. Repeatability estimates for weekly body weight in YEC were moderate at week 4 and 16 (0.31 and -0.43, respectively). GG had repeatability estimates of 0.22 and -0.23 at weeks1 and 16, respectively. SS, MM, YEC x GG, YEC x SS had low negative repeatability values for body weight for all weeks. Repeatability estimate for body weight was low for crossbred YEC x MM, GG x YEC and SS x YEC birds at weeks 1, 4, 12 and 16. Low to moderate repeatability estimates were recorded for strain MM x YEC at weeks 4 and 12 (0.20 to 0.40 respectively). MM x YEC had the best repeatability estimate for body weight with the highest estimate (0.40) obtained at week 12. Generally, repeatability estimate were low for body weight.

5.5.2.2 Repeatability estimates for egg number in pure and crossbred hens

The repeatability estimates for egg number is presented in Table 5.5. The repeatability estimates varied from one week to the other among all the genotypic groups. Strain YEC had low repeatability estimates (-0.34) at weeks 24 while low to moderate repeatability estimates was recorded for strain GG x YEC (0.06 to 0.35) obtained for weeks 20 and 28 respectively. Also, low to high estimates of repeatability was recorded for strains GG, SS, YEC x GG, YEC x SS and SS x YEC (-0.38 to 0.77) obtained at weeks 44 and 20, 0.27 to 0.80 obtained at weeks 28 and 20, (-0.60 to 0.60) obtained at weeks 20 and 28,(-0.60 to 0.72)obtained at weeks 20 and 28, (-0.31 to 0.74) obtained at weeks 44 and 28, (0.04 to 0.76) obtained at weeks 20 and 36

respectively. Strain SS had the highest repeatability estimate of 0.77 for egg number obtained at week 32.

5.5.2.3 Repeatability estimates for egg weight in pure and crossbred hens

The repeatability estimates for egg weight is presented in Table 5.6. Estimates of repeatability for egg weight varied between weeks. SS x YEC had repeatability estimate of -0.87 and 0.25 at weeks 28 and 36, respectively. Moderate repeatability estimates (-0.59 to 0.42) of egg weight were obtained for YEC, YEC x GG, YEC x SS and GG x YEC at weeks 20 and 32. Lower values were obtained at weeks 36 and 44. , GG and SS had low to high repeatability estimates with values ranging from -0.25 to 0.55 at weeks 20 and 44, -0.37 to 0.72 at weeks 20 and 40, 0.29 to 0.60 at weeks 20 and 44, 0.30 to 0.61 obtained at weeks 20 and 40, respectively. Purebred SS had the highest repeatability estimate at week 40.

Table 5.4: Repeatability Estimates for Body Weight in Pure and Crossbred Chickens

	STRAINS									
	YEC	GG	SS	MM	YEC x GG	YEC x SS	YECx MM	GG x YEC	SS x YEC	MMx YEC
WEEKS	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E
1	0.20±0.10	0.22±0.09	-0.19±0.01	-0.14±0.04	-0.18±0.02	-0.16±0.08	0.27±0.09	0.09±0.07	0.14±0.08	0.26±0.09
4	0.31±0.10	-0.09±0.05	-0.30±0.18	-0.02±0.06	-0.19±0.02	-0.06±0.05	0.29±0.10	0.26±0.09	0.22±0.09	0.20±0.09
8	-0.02±0.06	-0.13±0.04	-0.17±0.02	-0.47±0.14	-0.11±0.04	-0.13±0.04	0.13±0.08	0.25±0.09	0.21±0.09	0.21±0.09
12	-0.06±0.05	-0.18±0.02	-0.11±0.04	-0.31±0.02	-0.12±0.04	-0.10±0.06	0.09±0.07	0.13±0.08	0.19±0.09	0.40±0.10
16	-0.43±0.07	-0.23±0.01	-0.12±0.04	-0.19±0.02	-0.13±0.04	-0.13±0.04	0.23±0.09	0.13±0.08	0.27±0.10	0.39±0.10
20	-0.03±0.06	-0.22±0.01	-0.11±0.04	-0.33±0.18	-0.09±0.05	-0.15±0.02	0.16±0.08	0.12±0.08	0.26±0.09	0.38±0.10
0-20	-0.01±0.04	-0.24±0.06	-0.10±0.06	0.05±0.07	-0.002±0.06	0.04±0.07	0.11±0.08	0.06±0.07	0.018±0.11	0.06±0.07

YEC, GG, SS, MM, R, ±S.E represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler,Repeatability estimate and Standard error respectively.

Table 5.5: Repeatability Estimates for Egg Number in Pure and Crossbred Chickens

	STRAINS						
	YEC	GG	SS	YEC x GG	YEC x SS	GG x YEC	SS x YEC
Age of hens (weeks in lay)	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E
20	-0.02±0.06	0.77±0.08	0.36±0.16	-0.60±0.26	0.27±0.123	0.17±0.10	0.05±0.07
24	-0.34±0.09	0.66±0.08	0.80±0.07	0.07±0.05	-0.60±0.26	0.06±0.08	0.04±0.07
28	-0.03±0.12	0.27±0.12	0.27±0.12	0.60±0.12	0.72±0.10	0.35±0.15	0.28±0.12
32	-0.21±0.07	0.53±0.13	0.77±0.08	0.27±0.12	-0.59±0.26	0.16±0.11	0.66±0.10
36	0.15±0.10	0.27±0.12	0.53±0.13	0.27±0.12	0.09±0.10	0.14±0.08	0.76±0.09
40	0.09±0.09	-0.33±0.09	0.59±0.12	0.59±0.12	0.60±0.12	0.25±0.12	0.72±0.09
44	-0.23±0.03	-0.38±0.11	0.60±0.12	0.29±0.06	-0.33±0.07	0.25±0.12	0.77±0.08
20-44	-0.01±0.05	-0.001±0.06	-0.01±0.1	0.013±0.07	-0.02±0.06	-0.005±0.06	-0.01±0.06

YEC, GG, SS, R, ± S.E represent: Yoruba Ecotype Chicken, Goliath and Sussex ,Repeatability estimate and Standard error respectively

Table 5.6: Repeatability Estimates for Egg Weight in Pure and Crossbred Chickens

	STRAINS						
	YEC	GG	SS	YEC x GG	YEC x SS	GG x YEC	SS x YEC
Age of hens in lay(weeks)	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E	R ±S.E
20	-0.50±0.05	-0.25±0.03	-0.37±0.04	0.13±0.08	0.29±0.09	-0.29±0.01	-0.23±0.08
24	-0.59±0.07	0.24±0.09	0.28±0.09	0.20±0.09	0.49±0.10	-0.45±0.07	-0.38±0.04
28	0.41±0.09	0.025±0.10	0.26±0.09	0.33±0.10	0.30±0.10	0.36±0.10	-0.87±0.04
32	0.42±0.09	0.38±0.06	0.41±0.10	0.25±0.10	0.32±0.10	0.12±0.08	0.22±0.09
36	0.40±0.09	0.39±0.10	0.44±0.09	0.44±0.09	0.12±0.08	0.26±0.09	0.25±0.10
40	0.23±0.06	0.40±0.10	0.72±0.07	0.32±0.10	0.28±0.09	0.39±0.10	0.20±0.09
44	0.14±0.07	0.55±0.10	-0.28±0.09	-0.27±0.01	0.32±0.10	0.29±0.09	0.13±0.08
20-44	0.01±0.05	-0.06±0.07	-0.01±0.06	-0.11±0.03	-0.11±0.01	0.13±0.08	0.12±0.08

YEC, GG, SS R, ± S.E represent: Yoruba Ecotype Chicken, Goliath and Sussex, Broiler, Repeatability estimate and Standard error respectively.

5.5.3 Genetic and Phenotypic Correlation

5.5.3.1 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in Purebred YEC

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg external quality traits of purebred YEC are presented in Table 5.7. Significantly positive ($p<0.05$) and high genetic correlation existed between HBW and EM but HBW was negatively correlated with AFE which was not significant. Egg weight was significantly ($p<0.05$) and positively correlated with AFE, positively correlated with EM but negatively correlated with ST and SW. However, egg number was negative and highly correlated ($r= -0.68$) with AFE while there was no correlation between the trait and other egg biometric traits. Positive and negative but non-significant correlation existed between EM and SW, EM and AFE. Shell thickness did not correlate with shell weight.

Phenotypic correlation revealed significantly positive ($p<0.001$) and high correlation between EW and EN, M, ST, SW ($r= 0.83, -0.95$) while AFE were not correlated with egg weight. Egg number was positive and significantly ($p<0.001$) correlated with egg mass, shell thickness and shell weight while there was low relationship brtween egg number and AFE. Significant ($p<0.001$) and positive relationship was obtained between EM and ST, SW ($r= 083$ to 0.94). Shell thickness had significantly positive correlation with SW($r= 0.91$) while AFE did not statistically significant with all the egg biometric traits.

5.5.3.2 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in Purebred GG

Genetic (upper diagonal) and phenotypic (lower diagonal) correlation coefficient between hen body weight and egg external quality traits of purebred GG are presented in Table 5.8.

Significantly ($p<0.05$) low correlation existed between egg weight and egg mass ($r= 0.23$) while negative non-significant relationship existed between HBW and EN, SW and EW, SW and EN, ST and AFE. However, other egg biometric traits were not genetically correlated. Phenotypic correlation revealed that HBW did not statistically correlated with any of the biometric traits except with AFE that was significantly ($p<0.05$) low and positively correlated with HBW. Egg weight had positive and high significant ($p<0.001$) relationship with EN, EM, ST and SW ($r= 0.86$ -0.92) while, negligible insignificant correlation exist with AFE. Significant ($p<0.001$) relationship exist between egg number and EM, ST, SW ($r= 0.78$, -0.99) but negligible insignificant correlation exist with AFE. Also, egg mass had positive significantly ($p<0.001$) high correlation with ST and SW ($r= 0.83$) while AFE had negligible insignificant correlation. Significantly ($p<0.001$) positive and high relationship exist between ST and SW ($r= 0.79$).

5.5.3.3 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in Purebred SS

Genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg external quality traits of purebred SS are presented in Table 5.9. Significantly ($p<0.05$) high correlation existed between egg weight and age at first egg ($r= 1.00$). High positive and negative non-significant relationship existed between HBW and EM, EN and ST, EN and AFE. However, other egg biometric traits were not genetically correlated. Phenotypic correlation revealed that HBW did not statistically correlated with any of the biometric traits except AFE that was significantly ($p<0.01$) and negatively correlated with HBW.

Table 5.7: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Purebred YEC

	HBW	EW	EN	EM	ST	SW	AFE
HBW		0.00	0.00	1.00*	0.00	0.00	-1.00 ^{NS}
EW	0.36^{NS}		0.00	1.00^{NS}	-0.34^{NS}	-1.00^{NS}	0.64*
EN	0.25^{NS}	0.83***		0.00	0.04^{NS}	0.00	-0.68*
EM	0.015^{NS}	0.89***	0.98***		0.00	-1.00^{NS}	0.64^{NS}
ST	0.29^{NS}	0.91***	0.91***	0.94***		0.00	0.24^{NS}
SW	0.30^{NS}	0.95***	0.77***	0.83***	0.91***		0.00
AFE	0.21^{NS}	0.04^{NS-}	0.07^{NS}	0.01^{NS}	-0.01^{NS}	0.04^{NS}	

YEC , HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents Yoruba ecotype chicken , hen body weight, egg weight,egg number, eggmass , shell thickness, shell weight, age at first egg and ,standard error, **(p< 0.05),**(p<0.01),***(p<0.001).*

Table 5.8: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Purebred GG

	HBW	EW	EN	EM	ST	SW	AFE
HBW		0.00	-1.00^{NS}	0.00	0.00	0.00	0.00
EW	0.04^{NS}		0.00	0.23*	0.00	-0.89^{NS}	0.00
EN	-0.01^{NS}	0.86***		0.00	0.00	-0.06^{NS}	0.00
EM	-0.02^{NS}	0.91***	0.99***		0.00	0.00	0.00
ST	-0.03^{NS}	0.89***	0.78***	0.83***		0.00	-1.00^{NS}
SW	-0.03^{NS}	0.92***	0.92***	0.83***	0.79***		0.00
AFE	0.19*	0.08^{NS}	0.04^{NS}	0.06^{NS}	0.22^{NS}	-0.03^{NS}	

GG , HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents: Goliath chicken , hen body weight, egg weight, egg number, eggmass , shell thickness, shellweight, age at first egg and ,standard error, **(p< 0.05),**(p<0.01),***(p<0.001).*

Egg weight had positive significant ($p<0.001$) relationship with EN, EM, ST and SW (r= 0.87 - 0.97) while negligible correlation existed with AFE. Significant ($p<0.001$) relationship existed between egg number and EM, ST, SW (r= 0.85 -0.89) but low non-significant correlation existed with AFE. Also, egg mass had positive and significant ($p<0.001$) correlation with ST and SW (r= 0.89 to 0.95) while AFE had low relationship with shell thickness and shell weight. Significantly ($p<0.001$) positive and high relationship existed between ST and SW (r= 0.93) but negligible insignificant correlation occur with AFE. Similarly, shell weight had positive but low correlation with AFE which was not significant.

5.5.3.4 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in crossbred YEC x GG

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg external quality traits of crossbred YEC x GG are presented in Table 5.10. Significantly ($p<0.05$) positive correlation existed between HBW and EM, EW and AFE (r= 1.00). High negative non-significant relationship existed between EN and ST, EN and AFE. However, other egg biometric traits were not genetically correlated. Phenotypic correlation revealed that HBW were not statistically correlated with any of the biometric traits. Egg weight had positive and highly significant ($p<0.001$) relationship with EN, EM, ST and SW (r= 0.79, -0.96) while, negligible non-significant correlation existed with AFE. Significant ($p<0.001$) relationship existed between egg number and EM, ST, SW (r= 0.82, -0.99) but low negative non-significant correlation exist with AFE. Egg mass had positive significantly ($p<0.001$) high correlation with ST and SW (r= 0.83, -0.89) while it had low insignificant relationship with AFE. Also, significantly ($p<0.001$) positive and high relationship existed between ST and SW (r=

0.79) but negligible insignificant correlation occur with AFE. Similarly, shell weight had negative but negligible correlation with AFE which was not significant.

5.5.3.5 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in crossbred YEC x SS

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg external quality traits of crossbred YEC x SS are presented in Table 5.11. The result revealed that egg biometric traits were not genetically correlated in this strain. Phenotypic correlation also revealed that HBW were not statistically correlated with any of the biometric traits. Egg weight had positive and highly significant ($p<0.001$), relationship with EN, ST and ($p<0.01$) EM, SW ($r= 0.83$ -0.99) while, negligible correlation existed with AFE. Significant ($p<0.001$) relationship existed between egg number and EM, ST, SW ($r= 0.89$- 0.99) but low negative non-significant correlation exist with AFE. Egg mass had positive significantly ($p<0.001$) high correlation with ST and SW ($r= 0.89$) while it had negligible insignificant relationship with AFE. Also, positive and significant ($p<0.001$) relationship existed between ST and SW ($r= 0.86$) while its association with AFE was negligible. Similarly, shell weight had negative but negligible correlation with AFE which was not significant.

5.5.3.6 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in crossbred GG x YEC

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg external quality traits of cross bred GG x YEC are presented in Table 5.12. Significantly positive ($p<0.01$) genetic correlation existed between HBW and SW while negative relationship existed with HBW and EW, HBW and AFE. While EM and ST was negatively correlated with no significance. Egg weight was significantly ($p<0.01$) and positively

correlated with EM and AFE, but negatively correlated with SW with no significance. Egg number was not significantly correlated with AFE, while other egg biometric traits were not genetically correlated.

Phenotypic correlation between that HBW and any of the biometric traits was not significant. Egg weight had positive and highly significant ($p<0.001$) relationship with EN, ST and EM, SW ($r= 0.83$ to 0.95) while, non-significant correlation existed between the trait and AFE. Significant ($p<0.001$) relationship existed between egg number and EM, ST, SW ($r= 0.87$ to 0.99) but low positive non-significant correlation existed with AFE. Egg mass had positive significantly ($p<0.001$) high correlation with ST and SW ($r= 0.87$ to 0.88) while it had low non-significant relationship with AFE. Also, significantly ($p<0.001$) positive and high relationship existed between ST and SW ($r= 0.81$) but low insignificant correlation exist with AFE. Similarly, shell weight had positive but low correlation with AFE which was not significant.

5.5.3.7 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg External Quality Traits in Purebred SS x YEC

Genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg external quality traits of cross bred SS x YEC are presented in Table 5.13. Significantly positive ($p<0.01$) and high genetic correlation existed between HBW and AFE while EN was negatively correlated with no significance. Egg weight was significantly ($p<0.01$) and positively correlated with EM and AFE ($r= 0.15$ to 0.26), but negatively correlated with SW with no significance. Egg number was significantly ($p<0.01$) but negatively correlated ($r= -0.58$) with SW but negatively correlated with AFE with no significance. Also, egg mass had high significant ($p<0.01$) but negative relationship with SW ($r= -0.64$) while, the relationship with

AFE was not significant. However, significant ($p<0.01$) positive and high relationship exist between ST and AFE.

Phenotypic correlation between HBW and biometric traits were not significant. Egg weight had positive and moderate to highly significant ($p<0.001$) association with EN, ST and EM, SW ($r=$ 0.41 to 0.97) while, low non-significant correlation existed with AFE. Significant ($p<0.001$) correlation existed between egg number and EM, ST, SW ($r = 0.51- 0.96$) but low positive non-significant correlation existed with AFE. Egg mass had positively significant ($p<0.001$) but moderate to high correlation with ST and SW ($r = 0.45$ to 0.96) while it had low non-significant relationship with AFE. Also, significantly ($p<0.001$) positive and low relationship exist between ST and SW ($r= 0.38$) but low insignificant correlation exist with AFE. Similarly, shell weight had positive but low correlation with AFE which was not significant.

Table 5.9: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Purebred SS

	HBW	EW	EN	EM	ST	SW	AFE
HBW		0.00	0.00	1.00^{NS}	0.00	0.00	0.00
EW	-0.02^{NS}		0.00	0.00	0.00	0.00	1.00*
EN	-0.03^{NS}	0.89***		0.00	-1.00^{NS}	0.00	-1.00^{NS}
EM	-0.02^{NS}	0.95***	0.99***		0.00	0.00	0.00
ST	0.05^{NS}	0.87***	0.85***	0.89***		0.00	0.00
SW	-0.02^{NS}	0.97***	0.89***	0.95***	0.93***		0.00
AFE	-0.56**	0.09^{NS}	0.12^{NS}	0.11^{NS}	0.03^{NS}	0.12^{NS}	

SS , HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents: Sussex chicken , hen body weight, egg weight, egg number, egg mass , shell thickness, shell weight, age at first egg and ,standard error, **(p< 0.05),**(p<0.01),***(p<0.001).*

Table 5.10: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Crossbred YEC x GG

	HBW	EW	EN	EM	ST	SW	AFE
HBW		0.00	0.00	1.00*	0.00	0.00	0.00
EW	-0.01^{NS}		0.00	0.00	0.00	0.00	1.00*
EN	0.19^{NS}	0.93***		0.00	-1.00*	0.00	-1.00*
EM	0.17^{NS}	0.95***	0.99***		0.00	0.00	0.00
ST	-0.09^{NS}	0.96***	0.88***	0.89***		0.00	0.00
SW	0.10^{NS}	0.79***	0.82***	0.83***	0.79***		0.00
AFE	-0.40^{NS}	-0.04^{NS}	-0.12^{NS}	-0.12^{NS}	0.02^{NS}	-0.06^{NS}	

YEC ,GG , HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents Yoruba ecotype chicken , Goliath, hen body weight, egg weight,egg number, eggmass , shell thickness, shellweight, age at first egg and ,standard error, **($p< 0.05$),**($p<0.01$),***($p<0.001$).*

Table 5.11: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Crossbred YEC x SS

	HBW	EW	EN	EM	ST	SW	AFE
HBW		0.00	0.00	0.00	0.00	0.00	0.00
EW	0.04^{NS}		0.00	0.00	0.00	0.00	0.00
EN	0.04^{NS}	0.96***		0.00	0.00	0.00	0.00
EM	0.17^{NS}	0.99**	0.99***		0.00	0.00	0.00
ST	0.07^{NS}	0.86***	0.94***	0.89***		0.00	0.00
SW	0.03^{NS}	0.83**	0.89***	0.89***	0.86***		0.00
AFE	-0.40^{NS}	-0.05^{NS}	-0.01^{NS}	-0.03^{NS}	0.08^{NS}	0.01^{NS}	

YEC , HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents Yoruba ecotype chicken , hen body weight, egg weight,egg number, egg mass , shell thickness, shell weight, age at first egg and ,standard error, **(p< 0.05),**(p<0.01),***(p<0.001).*

Table 5.12: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Crossbred GG x YEC

	HBW	EW	EN	EM	ST	SW	AFE
HBW		-0.71**	0.00	-0.33^{NS}	-1.00^{NS}	0.87**	-1.00**
EW	-0.14^{NS}		0.00	1.00**	0.00	-1.00^{NS}	1.00**
EN	-0.033^{NS}	0.95***		0.00	0.00	0.00	1.00^{NS}
EM	0.04^{NS}	0.95***	0.99***		0.00	0.00	0.00
ST	0.07^{NS}	0.83***	0.87***	0.87***		0.00	0.00
SW	-0.06^{NS}	0.95***	0.88***	0.88***	0.81***		0.00
AFE	-0.03^{NS}	0.17^{NS}	0.23^{NS}	0.22^{NS}	0.12^{NS}	0.14^{NS}	

YEC , GG, HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents Yoruba ecotype chicken ,Goliath, hen body weight, egg weight, egg number, egg mass , shell thickness, shell weight, age at first egg and ,standard error, **(p< 0.05),**(p<0.01),***(p<0.001).*

Table 5.13: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg External Quality Traits in Crossbred SS x YEC

	HBW	EW	EN	EM	ST	SW	AFE
HBW		0.00	-1.00 ^{NS}	0.00	0.00	0.00	1.00**
EW	-0.19^{NS}		0.00	0.15**	0.00	-1.00 ^{NS}	0.26**
EN	-0.13^{NS}	0.96***		0.00	0.0	-0.58**	-1.00^{NS}
EM	0.04^{NS}	0.97***	0.99***		0.00	-0.64**	-1.00^{NS}
ST	-0.14^{NS}	0.41***	0.51**	0.45**		0.00	1.00**
SW	-0.15^{NS}	0.96***	0.96***	0.96***	0.38^{NS}		0.00
AFE	0.42^{NS}	-0.19^{NS}	-0.14^{NS}	-0.15^{NS}	-0.11^{NS}	-0.15^{NS}	

YEC ,SS, HBW, EW,EN,EM,ST,SW,AFE, $\pm$, represents Yoruba ecotype chicken ,Sussex, hen body weight, egg weight, egg number, egg mass , shell thickness, shell weight, age at first egg and ,standard error, **(p< 0.05),**(p<0.01),***(p<0.001).*

5.5.3.8 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg internal Quality Traits in Purebred YEC

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg internal quality traits of purebred YEC are presented in Table 5.14. Non-significant correlation exist between HBW and EW, significantly negative ($p<0.05$) and high genetic association exist between HBW and AW while positive non-significant relationship exist with HBW and YW, YWD, but negative with AH, YWD and H.U. Albumen weight was significantly ($p<0.05$) high and negatively correlated with AH and H.U. Yolk weight had significantly ($p<0.05$) negative and high correlation with H.U. ($r= -0.75$). Albumen height and yolk height were significantly ($p<0.05$) positive and highly correlated with H.U. Yolk width had highly negative non-significant relationship with H.U.

Phenotypic correlation revealed that HBW and EW did not correlated significantly with any of the egg internal biometric traits. Albumen weight had negative and low significant ($p<0.05$), relationship with Albumen height ($r = -0.41$) while other egg internal biometric traits were not significant with albumen weight. Significant ($p<0.01$) negative relationship exists between yolk weight and yolk height ($r = -0.54$) but negligible to low positive and negative non-significant correlation exist with other biometric traits. Albumen height had significantly ($p<0.001$) positive and high relationship with H.U. ($r = 0.99$) while, low positive and negative non-significant correlation exist with other egg internal biometric traits. Yolk height had low to high non-significant association with YWD, YI and H.U. Also, yolk width had positive low to high non-significant correlation with YI and H.U. Similarly, yolk index had positive but low non-significant association with H.U.

5.5.3.9 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg Internal Quality Traits in Purebred GG

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficients between hen body weight and egg internal quality traits of purebred GG are presented in Table 5.15. Significantly negative ($p<0.05$) but high genetic association existed between HBW and AH while positive but non-significant relationship existed between HBW and EW as well as H.U. Albumen weight and Yolk weight did not correlate significantly with any of the egg internal biometric traits. Albumen height had positive non-significant relationship with YI. Also, yolk height had positive non-significant association with H.U. However, yolk width, yolk index were not correlated with other egg internal biometric traits.

Phenotypic correlation between HBW and any of the egg internal biometric traits was not significant. Egg weight, albumen weight and yolk width had positive low non-significant relationship with egg internal biometric traits. Significant ($p<0.01$) positive and high relationship exist between albumen height and H.U. while YH, YWD and YI had positive but non-significant association with albumen height.Positive and significant ($p<0.05$) positively high relationship existed between yolk height and yolk index ($r= 0.71$) but low positive non-significant correlation exist with H.U. while, Yolk width had low to high negative non-significant correlation with other YI and H.U. Similarly, yolk index had positive but low non-significant association with H.U.

Table 5.14: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Purebred YEC

	HBW	EW	AW	YW	AH	YH	YWD	YI	H.U
HBW		0.40 ^{NS}	-0.99*	-1.00^{NS}	0.62^{NS}	0.00	-1.00^{NS}	0.00	0.32^{NS}
EW	0.32 ^{NS}		0.00	0.43 ^{NS}	0.22 ^{NS}	0.00	0.13 ^{NS}	0.00	-0.23 ^{NS}
AW	-0.37^{NS}	0.77^{NS}		0.32 ^{NS}	0.31^{NS}	-0.13 ^{NS}	0.00	0.00	-1.00*
YW	0.19^{NS}	-0.23^{NS}	-0.20^{NS}		0.00	0.00	0.00	0.00	-0.75*
AH	0.27^{NS}	0.32 ^{NS}	-0.41*	0.07^{NS}		0.00	0.00	0.00	1.00*
YH	-0.06^{NS}	0.31^{NS}	0.14^{NS}	-0.54**	0.21^{NS}		0.00	0.00	1.00*
YWD	-0.13^{NS}	-0.13 ^{NS}	0.11^{NS}	0.04^{NS}	-0.11^{NS}	-0.03 ^{NS}		0.00	-1.00 ^{NS}
YI	0.07^{NS}	0.23 ^{NS}	0.14^{NS}	-0.33^{NS}	0.22^{NS}	0.57^{NS}	0.83^{NS}		0.00
HU	0.31^{NS}	0.12 ^{NS}	-0.44^{NS}	-0.05^{NS}	0.99***	0.18^{NS}	0.10^{NS}	0.20^{NS}	

YEC HBW, EW, AW, YW, AH, YH, YWD, YI, HU. Represents: Yoruba ecotype chickens hen body weight, egg weight albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*, *(p< 0.05),* ** *(p<0.01),* *** *(p<0.001).*

Table 5.15: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Purebred GG

	HBW	EW	AW	YW	AH	YH	YWD	YI	HU
HBW		0.36 ^{NS}	0.00	0.00	-1.00*	0.00	0.00	0.00	1.00^{NS}
EW	-0.57 ^{NS}		0.00	-1.00*	0.00	0.00	0.00	0.00	0.00
AW	0.39^{NS}	0.39 ^{NS}		0.00	0.00	0.00	0.00	0.00	0.00
YW	-0.30^{NS}	-0.03 ^{NS}	-0.35^{NS}		0.00	0.00	0.00	0.00	0.00
AH	-0.06^{NS}	-0.06 ^{NS}	0.09^{NS}	-0.38^{NS}		0.00	0.00	1.00^{NS}	0.00
YH	0.22^{NS}	0.22 ^{NS}	-0.28^{NS}	0.35^{NS}	0.35^{NS}		0.00	0.00	1.00^{NS}
YWD	-0.03^{NS}	0.33 ^{NS}	-0.35^{NS}	0.41^{NS}	0.44^{NS}	-0.32^{NS}		0.00	0.00
YI	-0.35^{NS}	0.10 ^{NS}	0.02^{NS}	-0.15^{NS}	0.50^{NS}	0.71*	-0.88^{NS}		0.00
HU	0.16^{NS}	0.12 ^{NS}	0.28^{NS}	-0.56^{NS}	0.94***	0.22^{NS}	-0.45 ^{NS}	0.44^{NS}	

GG, HBW, EW, AW, YW, AH, YH, YWD, YI, HU. Represents: Goliath chicken, hen body weight, egg weight albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*, *(p< 0.05), ** (p<0.01), *** (p<0.001).*

5.5.3.10 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg Internal Quality Traits in Purebred SS

Genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg internal quality traits of purebred SS are presented in Table 5.16. Non-significant relationship exist between HBW and EW while, significantly positive ($p<0.05$) genetic association existed between HBW and AW. Positive non-significant relationship existed with HBW and AH, YWD and YI. Albumen weight was significantly ($p<0.05$) and negatively correlated with AH while, negative non-significant relationship exist with AH and YI. Yolk weight had non-significantly negative and high correlation with YI and YWD. Albumen height had positive non-significant correlation with YI. Yolk height, yolk width, yolk index and H.U. were not genetically correlated with other egg internal biometric traits.

Phenotypic correlation revealed that HBW did not significantly correlated with any of the egg internal biometric traits. Egg weight had significantly high ($p<0.05$) and positive correlation with AW, AH and YI ($r = 0.64, 0.62$ and 0.62) while non-significant relationship exist with YW, YH, YWD and H.U. Albumen weight had positively low non-significant relationship with other egg internal biometric traits. Yolk weight had positive non-significant correlation with AH, YI and negative non-significant correlation with YH, YWD, H.U. Albumen height had negligible to high non-significant relationship with YWD, YI and H.U. However, similar trend existed for YWD and YI.

5.5.3.11 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg Internal Quality Traits in crossbred YEC x GG.

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg internal quality traits of crossbred YEC x GG are presented in Table

5.17. Hen body weight had significantly ($p<0.05$) low and positive genetic correlation with egg weight while significantly negative ($p<0.05$) and high genetic association existed between HBW and YWD while positive non-significant relationship existed with AW and YWD. Yolk weights were not correlated with any of the egg internal biometric traits. Albumen height had highly positive non-significant relationship with YWD. Also, yolk height was not correlated with other egg internal biometric traits. Yolk width had positive non-significant association with H.U. However, yolk index were not correlated with H.U.

Phenotypic correlation revealed that HBW were not correlate significantly with any of the egg internal biometric traits. However, egg weight had significantly ($p<0.01$) positive association with AW and YW ($r = 0.78, 0.67$) but positive low non-significant relationship exist with AH, YH, YWD and YI. Albumen weight was significantly ($p<0.001$) negative and highly correlated with H.U while positive non-significant relationship exist with other egg internal biometric traits. Yolk weight had non-significant positive relationship with AH, YH, YWD, YI and H.U. Albumen height had significant ($p<0.001$) positively high relationship and H.U while, YH, YWD and YI had positive and negative non-significant association with albumen height. Significant ($p<0.01$) positively high relationship existed between yolk height and yolk index ($r = 0.76$) but low negative non-significant correlation exist with YWD and H.U. while, Yolk width had high negative non-significant correlation with other YI and H.U. Similarly, yolk index had positive but low non-significant association with H.U.

5.5.3.12 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg Internal Quality Traits in crossbred YEC x SS

Genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg internal quality traits of crossbred YEC x SS are presented in Table 5.18.

Significant ($p<0.05$) positive and low correlation existed between HBW and EW but positive non-significantly genetic association existed between AH and egg weight had significant ($p<0.05$) and positive genetic correlation with albumen weight while there was no genetic correlation between other egg internal biometric traits. Positive but non-significant relationship existed between yolk weight and YH and YWD. However, there but no genetic correlation between AH, YH, YWD, YI and H.U with all other egg internal biometric traits.

Phenotypic correlation revealed that HBW did not significantly correlate with any of the egg internal biometric traits. Egg weight had significant ($p<0.05$) but negative association with albumen weight while non-significant association existed between it and other egg internal biometric traits. Also, albumen weight had positive non-significant relationship with other egg internal biometric traits. Yolk weight had non-significant positive relationship with AH, YH, YWD, YI and H.U. Albumen height had significant ($p<0.001$) positively high relationship and H.U. ($r= 0.98$) while, YH, YWD and YI had negative non-significant association with other egg internal biometric traits.

Table 5.16: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Purebred SS

	HBW	EW	AW	YW	AH	YH	YWD	YI	HU
HBW		-0.23^{NS}	1.00*	0.00	-1.00^{NS}	0.00	1.00^{NS}	-1.00^{NS}	0.00
EW	-0.50^{NS}		1.00*	0.23*	0.00	0.00	-1.00^{NS}	0.00	0.00
AW	-0.14^{NS}	0.64*		0.00	-1.00^{NS}	0.00	1.00*	-1.00^{NS}	0.00
YW	-0.40^{NS}	0.14^{NS}	0.11^{NS}		0.00	-1.00^{NS}	-1.00^{NS}	0.00	0.00
AH	-0.39^{NS}	0.62*	-0.30^{NS}	0.42^{NS}		0.00	-1.00^{NS}	1.00^{NS}	0.00
YH	0.23^{NS}	0.43^{NS}	0.14^{NS}	-0.40^{NS}	0.32^{NS}		0.00	0.00	0.00
YWD	0.51^{NS}	0.48^{NS}	-0.4^{NS}	-0.45^{NS}	0.06^{NS}	0.43^{NS}		0.00	0.00
YI	-0.34^{NS}	0.62*	0.32^{NS}	0.22^{NS}	0.43^{NS}	-0.89^{NS}	0.40^{NS}		0.00
HU	-0.24^{NS}	0.27^{NS}	-0.46^{NS}	-0.22^{NS}	0.47^{NS}	-0.08^{NS}	0.30^{NS}	0.32^{NS}	

SS, HBW,EW ,AW,YW,AH,YH,YWD,YI, HU. Represents: Sussex chicken, hen body weight, egg weight albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*,*($p< 0.05$),**($p<0.01$),***($p<0.001$).*

Table 5.17: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Crossbred YEC x GG

	HBW	EW	AW	YW	AH	YH	YWD	YI	HU
HBW		0.23*	0.00	0.00	0.00	0.00	-1.00 *	0.00	0.00
EW	0.39 NS		0.21*	0.25*	0.00	0.00	0.00	0.00	0.00
AW	0.16NS	0.78**		0.00	0.00	0.00	-1.00NS	0.00	0.00
YW	0.07NS	0.67**	0.32NS		0.00	0.00	0.00	0.00	0.00
AH	-0.47NS	-0.32 NS	-0.50NS	0.32NS		0.00	1.00NS	0.00	0.00
YH	-0.03NS	0.07 NS	0.26NS	-0.37NS	-0.01NS		0.00	0.00	0.00
YWD	0.34NS	0.44 NS	0.32NS	0.08NS	-0.51NS	-0.38NS		0.00	1.00NS
YI	-0.91NS	0.34 NS	0.26NS	-0.29NS	0.34NS	0.76**	-0.85NS		0.00
HU	-0.55NS	-0.23 NS	-0.99***	-0.39NS	0.81***	-0.04NS	-0.59NS	0.38NS	

YEC, GG, HBW, EW, AW, YW, AH, YH, YWD, YI, HU. Represents: Yoruba ecotype chickens, Goliath, hen body weight, egg weight albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*, *(p< 0.05),* ** *(p<0.01),* *** *(p<0.001*

Table 5.18: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Crossbred YEC x SS

	HBW	EW	AW	YW	AH	YH	YWD	YI	HU
HBW		0.22*	0.00	0.00	1.00^{NS}	0.00	0.00	0.00	0.00
EW	0.34^{NS}		0.26*	0.00	0.00	0.00	0.00	0.00	0.00
AW	-0.36^{NS}	-0.37*		0.00	0.00	0.00	0.00	0.00	0.00
YW	-0.36^{NS}	0.19^{NS}	0.13^{NS}		0.00	1.00^{NS}	1.00^{NS}	0.00	0.00
AH	0.34^{NS}	0.36^{NS}	0.20^{NS}	-0.14^{NS}		0.00	0.00	0.00	0.00
YH	-0.26^{NS}	0.50^{NS}	-0.48^{NS}	0.27^{NS}	0.35^{NS}		0.00	0.00	0.00
YWD	-0.63^{NS}	0.28^{NS}	-0.43^{NS}	-0.29^{NS}	-0.11^{NS}	-0.13^{NS}		0.00	0.00
YI	-0.19^{NS}	0.31^{NS}	-0.16^{NS}	0.01^{NS}	0.17^{NS}	-0.34^{NS}	-0.38^{NS}		0.00
H.U	0.30^{NS}	0.19^{NS}	0.27^{NS}	-0.18^{NS}	0.98**	-0.15^{NS}	-0.25^{NS}	-0.23^{NS}	

YEC, SS, HBW, EW, AW, YW, AH, YH, YWD, YI, HU. Represents: Yoruba ecotype chickens, Sussex, hen body weight, Egg weight, albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*, *($p< 0.05$), ** ($p<0.01$), *** ($p<0.001$).*

5.5.3.13 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg Internal Quality Traits in Purebred GG x YEC

The genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg internal quality traits of crossbred GG x YEC are presented in Table 5.19. Significantly negative ($p<0.05$) and high genetic correlation existed between HBW and AH, H.U while positive non-significant relationship exist with HBW and EW, AW, YW, YH and YWD. Albumen weight had positive non-significant relationship with AH, YH, YWD and H.U. Yolk weight had non-significantly negative but high correlation with YH, YWD and H.U. Albumen height had negative non-significant correlation with YWD and H.U. Similarly, Yolk height had negative non-significant correlation with H.U. While, yolk width, yolk index and H.U were not genetically correlated with other egg internal biometric traits.

Phenotypic correlation revealed that HBW were significantly ($p<0.01$) and positively correlated with H.U ($r= 0.61$) while, non-significant correlation exists with other egg internal biometric traits. Egg weight and Albumen weight had positive non-significant relationship with other egg internal biometric traits. Yolk weight was significantly ($p<0.01$) negative and highly correlated with YH and significantly ($p<0.05$) correlated with H.U while positive non-significant relationship exists with other egg internal biometric traits. Albumen height had significantly ($p<0.001$) positive relationship and H.U. ($r= 0.99$) while, YH, YWD and YI had positive non-significant association with albumen height. Non-significant relationship existed between YH and other egg internal biometric traits. Significantly ($p<0.01$) but negative relationship exist between yolk width and yolk index($r= - 0.66$) but low negative non-significant correlation exist with YWD and H.U. However, Yolk width had negligible negative non-significant correlation with other YI and H.U.

5.5.3.14 Genetic (upper diagonal) and Phenotypic Correlation (lower diagonal) between Hen Body Weight and Egg Internal Quality Traits in crossbred SS x YEC

Genetic (upper diagonal) and phenotypic correlation (lower diagonal) coefficient between hen body weight and egg internal quality traits of crossbred SS x YEC are presented in Table 5.20. Non-significantly positive genetic correlation existed between HBW and AW, YW and YI. Egg weight had significantly ($p<0.05$) low and positive correlation ($r= 0.20$) with albumen weight while YW and AH had non-significant relationship with EW. Also, albumen weight had positive non-significant relationship with AH, YH, YWD and YI. Yolk weight had non-significantly negative correlation with YH, YWD and H.U. Albumen height had negative but non-significant correlation with YWD and H.U. Similarly, Yolk height had negative, non-significant correlation with YI, while, yolk width, yolk index and H.U were not genetically correlated with other egg internal biometric traits.

Phenotypic correlation between HBW and other egg internal biometric traits was not significant. Egg weight had significantly ($p<0.05$) high and positive correlation with albumen weight but not significantly correlated with other egg internal biometric traits. Albumen weight and yolk weight had positive non-significant relationship with other egg internal biometric traits. Albumen height had significant ($p<0.001$) positively high relationship with H.U. ($r= 0.98$) while, YH, YWD and YI had positive non-significant association with albumen height. Non-significant relationship existed between YH and YWD, H.U while significant ($p<0.01$) positively high association exist with YI ($r=0.93$). Non-significant positive correlation exists between YWD and YI, H.U. However, Yolk index had low negative non-significant correlation with H.U.

Table 5.19: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Crossbred GG x YEC.

	HBW	EW	AW	YW	AH	YH	YWD	YI	HU
HBW		0.35 ^{NS}	1.00^{NS}	0.90^{NS}	-1.00*	0.37^{NS}	0.54^{NS}	0.00	-1.00*
EW	-0.09 ^{NS}		0.34 ^{NS}	0.54 ^{NS}	0.34 ^{NS}	0.00	0.00	0.00	-0.65 ^{NS}
AW	-0.12^{NS}	-0.12^{NS}		0.00	-1.00^{NS}	0.24^{NS}	-0.94^{NS}	0.00	-1.00^{NS}
YW	0.15^{NS}	0.15 ^{NS}	0.14^{NS}		0.00	-0.84^{NS}	-1.00^{NS}	0.00	-0.85^{NS}
AH	0.61^{NS}	0.34 ^{NS}	-0.23^{NS}	-0.17^{NS}		0.00	-0.04^{NS}	0.00	-0.65^{NS}
YH	0.23^{NS}	0.34 ^{NS}	-0.06^{NS}	-0.61**	-0.11^{NS}		0.00	0.00	-0.19^{NS}
YWD	-0.13^{NS}	0.16 ^{NS}	0.38^{NS}	-0.23^{NS}	-0.18^{NS}	0.36^{NS}		0.00	0.00
YI	0.34^{NS}	0.14 ^{NS}	-0.41^{NS}	-0.26^{NS}	0.09^{NS}	0.44^{NS}	-0.66**		0.00
HU	0.61**	0.21 ^{NS}	-0.22^{NS}	-0.16*	0.99***	-0.16^{NS}	-0.21^{NS}	0.06^{NS}	

YEC ,GG,HBW,EW ,AW,YW,AH,YH,YWD,YI, HU. Represents: Yoruba ecotype chickens, Goliath, hen body weight, egg weight albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*, *(p< 0.05), ** (p<0.01), *** (p<0.001).*

Table 5.20: Genetic (Upper Diagonal) and Phenotypic Correlation (Lower Diagonal) Coefficient between Hen Body Weight and Egg Internal Quality Traits in Crossbred SS x YEC.

	HBW	EW	AW	YW	AH	YH	YWD	YI	HU
HBW		0.00	1.00^{NS}	-1.00^{NS}	0.00	0.00	0.00	-1.00^{NS}	0.00
EW	0.09^{NS}		0.20*	-0.08^{NS}	0.33^{NS}	0.00	0.00	0.00	0.00
AW	-0.05^{NS}	0.69*		0.00	-0.81^{NS}	-1.00^{NS}	1.00^{NS}	-0.71^{NS}	0.00
YW	-0.38^{NS}	-0.25^{NS}	0.19^{NS}		0.00	1.00^{NS}	1.00^{NS}	0.00	0.26^{NS}
AH	-0.36^{NS}	0.35^{NS}	-0.40^{NS}	0.91^{NS}		0.00	1.00^{NS}	0.00	0.99^{NS}
YH	-0.31^{NS}	0.19^{NS}	-0.28^{NS}	-0.33^{NS}	0.45^{NS}		0.00	-1.00^{NS}	0.00
YWD	-0.32^{NS}	-0.04^{NS}	-0.18^{NS}	0.02^{NS}	0.29^{NS}	-0.22^{NS}		0.00	1.00^{NS}
YI	-0.15^{NS}	0.20^{NS}	-0.16^{NS}	-0.31^{NS}	0.26^{NS}	0.93**	-0.56^{NS}		0.00
HU	-0.39^{NS}	0.20^{NS}	-0.41^{NS}	0.22^{NS}	0.98***	0.43^{NS}	0.31^{NS}	0.23^{NS}	

YEC, SS, HBW, EW, AW, YW, AH, YH, YWD, YI, HU. Represents: Yoruba ecotype chickens, Sussex, hen body weight, egg weight, albumen weight, yolk weight, albumen height, yolk height, yolk width, yolk index, haugh unit. NS- not significant,*, *(p< 0.05), ** (p<0.01), *** (p<0.001).*

5.5.4. Predictive Equations

5.5.4.1 Predictive Equations for late body weight from early measurements (8 weeks from 1- 4 week) in pure and crossbred chickens.

Table 5.21 shows the predictive equations for body weight at week 8 obtained from early body weight. In strain YEC x YEC predicting body weight at 8 weeks from 1-4 weeks gave rise to two models. Model 1 explained 17% variation in body weight obtained by including body weight at week 1; while an additional inclusion of body weight at week 4 in the latter model significantly improve the explained variance to 28%. In strain GG x GG three models were fitted with the models explaining 50.5%, 60% and 65% variation. In other words inclusion of body weight at week 4 to the first model yielded 11% increment while addition of week 3 to the latter had a 5% increment in predicting body weight at week 8. In Strain SS x SS, a single model with body weight at week 3 alone significantly explained 81% of the variation while strains MM x MM, YEC x GG, GG x YEC and SS x YEC also had a single model with body weight at week 4 alone explaining 79%, 88%, 68% and 90% respectively of the variation in body weight. The inclusion of other weeks in the models did not significantly improve the explained variance. In addition, strain YEC x SS had two models with body weight at weeks 1 and 2 explaining 64% and 69% variation while strains YEC x MM had two models explaining 91% and 85%with an increment of 6% from the first model resulting from the addition of week 1 to the existing week 4 as predictors of body weight at week 8 and MM x YEC also had two models explaining 96% and 97% for the two models obtained with weeks 3 and 4 being the predictors, respectively.

Table 5.21: Forward Stepwise Regression Analysis for 8th Week Body Weight Fitted from Body Weights at Weeks 1-4

Strain	Model	DV	Equations	R^2	S.E	Sig
YEC x YEC	1	WK8	$344.81 + 0.29 * BW_1$	0.17	46.03	*
	2		$368.90 + - 1.41 * BW_1 + 1.19 * BW_4$	0.28	43.39	*
GG x GG	1		$226.41 + 7.21 * BW_1$	0.51	125.46	*
	2		$-20.55 + 6.74 * BW_1 + 0.89 * BW_4$	0.60	113.53	*
	3		$-98.23 + 6.65 * BW_1 + -1.82 * BW_3 + 2.33 * BW_4$	0.65	107.40	*
SS x SS	1		$147.25 + 2.69 * BW_3$	0.81	68.89	*
MM x MM	1		$311.92 + 2.62 * BW_4$	0.79	32.47	*
YEC x GG	1		$180.06 + 1.36 * BW_4$	0.88	44.45	*
YEC x SS	1		$72.76 + 6.95 * BW_1$	0.64	44.41	*
	2		$-12.40 + 4.84 * BW_1 + 2.10 * BW_2$	0.69	42.04	*
YEC x MM	1		$158.93 + 1.66 * BW_4$	0.85	40.04	*
	2		$-332.05 + 9.98 * BW_1 + 1.17 * BW_4$	0.91	31.12	*
GG x YEC	1		$98.06 + 1.41 * BW_4$	0.68	36.54	*
SS x YEC	1		$-164.43 + 4.19 * BW_4$	0.90	79.21	*
MM x YEC	1		$-41.31 + 2.04 * BW_4$	0.96	14.37	*
	2		$-126.73 + 1.18 * BW_3 + 1.52 * BW_4$	0.97	12.80	*

YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, DV= Dependent variable, WK =weeks Y=predicted body weight, BW = body weight, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$) respectively.

5.5.4.2 Predictive Equations for late body weight from early measurements (week 16 from 1-4 weeks) in pure and crossbred chickens.

Table 5.22 shows the predictive equations for body weight at week 16 being predicted from week's 1-4 body weight. In strain YEC x YEC two models were fitted with the models which explained 50%, and 61% variation. Inclusion of body weight at week 4 to the first model obtained from week 2 yielded an 11% increment in predicting body weight at week 16. Strain GG x GG had two models which explained 59% and 67% of the variations respectively. Addition of body weight at week 2 gave an increment of 8% to the first model obtained from week 1. Similarly strains YEC x SS and YEC x MM had two models explaining 65% and 69% variation with an increment of 4% when of body weight at week 2 was added to model 1 while the latter explained 81% and 86% of the variation obtained by using week 4 and the addition of week 1 gave 5% increment. In strains SS x SS and YEC x GG, a single model with body weight at week 3 alone significantly explained 78% and 83% variation while, strains MM x MM, GG x YEC, SS x YEC and MM x YEC also had a single model with body weight at week 4 alone explaining 87%, 40%, 79% and 88% of the variation in body weight. The inclusion of other weeks in the models used for predicting body weight at week 16 did not significantly improve the explained variances in these strains.

5.5.4.3 Predictive Equations for late body weight from early measurements (week 20 from 1-4 weeks) in pure and crossbred chickens.

Table 5.23 shows the predictive equations for body weight at week 20 obtained from weeks 1-4 body weights. Strain GG x GG had two models with the first model explaining 58% of the variation in body weight at week 20 when the regression model is fitted at week 1, while an additional inclusion of body weight at week 4 in the former model significantly improved the explained variance by15% to give a higher value of 73%. In strain SS x SS, three models were

fitted with the models explaining 81%, 83% and 88% variation an addition of body weight at week 3 to the first model yielded a 2% increment while addition of week 4 to the latter had a 5% increment in predicting body weight at week 20. Strains YEC x SS and YEC x MM had two models explaining 62%, 68% and 92%, 93%, respectively. A 6% increment in body weight was recorded in the coefficient of determination for the equation fitted from body weight at week 4 for strain YEC x SS, while a 1% increment was recorded on addition of week1 to the first model in YEC x MM. Strain MM x MM had one model with body weight at week 4 significantly explained 81% of the variation. Strains GG x YEC and SS x YEC also had a single model with body weight at week 4 alone explaining 36% and 61% of the variation in body weight at week 20. Similarly, strains YEC x GG and MM x YEC had one model obtained from body weight at week 1 which explained 81% and 88% of the variation in body weight at week 20. The inclusion of other weeks in the models did not significantly improve the explained variance.

Table 5.22: Forward Stepwise Regression Analysis for 16th Week Body Weight Fitted from Body Weights at Weeks 1-4

Strain	Model	DV	Equations	R^2	S.E	Sig
YEC x YEC	1	WK16	978.63 +- 1.23 *BW_2	0.50	112.24	*
	2		964.88+ - 2.89*BW_2 + 11.06*BW_4	0.61	109.47	*
GG x GG	1		132.62+ 21.36 *BW_1	0.59	309.90	*
	2		-303.52+ 19.09*BW_1 +4.58 *BW_2	0.67	281.00	*
SS x SS	1		543.20 + 4.68*BW_3	0.78	127.42	*
MM x MM	1		-197.55+ 10.54*BW_4	0.87	94.50	*
YEC x GG	1		374.93 + 4.48*BW_3	0.83	133.94	*
YEC x SS	1		349.27 +10.25 *BW_1	0.65	63.77	*
	2		230.23+7.31*BW_1 +2.93*BW_2	0.69	60.59	*
YEC x MM	1		306.19 + 4.43 *BW_4	0.81	121.83	*
	2		-900.39 +24.53*BW_1 +3.22*BW_4	0.86	105.94	*
GG x YEC	1		153.65 + 2.90 *BW_4	0.40	136.18	*
SS x YEC	1		642.09 +6.57*BW_4	0.79	192.79	*
MM x YEC	1		-40.62 + 3.82 *BW_4	0.88	47.25	*

YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, DV= Dependent variable, WK= weeks, Y=predicted body weight, BW = body weight, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$) respectively.

Table 5.23: Forward Stepwise Regression Analysis for 20th Week Body Weight Fitted from Body Weights at Weeks 1-4

Strain	Model	DV	Equations	R^2	S.E	Sig
GG x GG	1	WK20	$68.62 + 25.99 * BW_1$	0.58	388.80	*
	2		$-744.12 + 18.8 * BW_1 + 3.18 * BW_4$	0.73	317.40	*
SS x SS	1		$223.98 + 4.19 * BW_4$	0.81	1.55.40	*
	2		$303.59 + 2.19 * BW_3 + 2.88 * BW_4$	0.83	148.47	*
	3		$266.25 + 4.55 * BW_1 + 3.95 * BW_3 + 4.72 * BW_4$	0.88	127.60	*
MM x MM	1		$1704.16 + 7.05 * BW_4$	0.73	104.57	*
YEC x GG	1		$409.27 + 6.31 * BW_3$	0.81	202.25	*
YEC x SS	1		$472.46 + 12.62 * BW_1$	0.62	84.54	*
	2		$354.87 + 7.53 * BW_1 + 1.54 * BW_4$	0.68	79.06	*
YEC x MM	1		$676.73 + 3.14 * BW_4$	0.92	69.83	*
	2		$120.30 + 11.40 * BW_1 + 2.69 * BW_4$	0.93	65.46	*
GG x YEC	1		$168.11 + 3.00 * BW_4$	0.36	174.67	*
SS x YEC	1		$1578.13 + 3.22 * BW_4$	0.68	245.60	*
MM x YEC	1		$252.39 + 16.52 * BW_1$	0.88	65.06	*

YEC, GG, SS, MM represent: Yoruba Ecotype Chicken, Goliath, Sussex, and Marshall Broiler, DV= Dependent variable, WK= weeksY=predicted body weight , BW = body weight , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$) respectively.

5.5.4.4 Predictive Equations for late egg number from early measurements (week 12 from 1-4 weeks) in pure and crossbred hens.

The predictive equations for egg number at week 12 being predicted from weeks 1-4 egg number is presented in Table 5.24. In strain GG x GG, two models were fitted with the models explaining 31%, and 63% of the variation. The addition of egg number at week 4 to the first model yielded a 25% increment in predicting egg number at week 12. Similarly, strain YEC x GG had two models which explained 67% and 80% of the variation. An addition of egg number at week 4 gave an increment of 13% to the first model that was obtained from week 1 alone. Strain SS x SS had a single model that were obtained from egg number at week 3, which significantly explained 34% of the variation in egg number at week 12, respectively. Strain YEC x SS also had a single model that was obtained from egg number at week 2 alone. This model explained 46% of the variation in egg number at week 12. The inclusion of other weekly egg number in the models did not significantly improve the explained variance.

5.5.4.5 Predictive Equations for late egg weight from early measurements (week 12 from 1-4 weeks) in pure and crossbred hens.

Table 5.25 shows the predictive equations for egg weight at week12 being predicted from weeks 1-4 egg weight. In strain SS x YEC two models were fitted with the models explaining 29%, and 50% significant variation, addition of egg weight at week 4 to the first model yielded a 21% increment in predicting egg weight at week 12. Strain GG x GG had a single model with egg weight at week 4 alone explaining 41% variation. Strain GG x YEC also had a single model with egg number at week 2 alone explaining 27% while inclusion of other weekly egg number in the models did not significantly improve the explained variance.

Table 5.24: Forward Stepwise Regression Analysis for 12th Week Egg Number Fitted from Egg Number at Weeks 1-4

Strain	Model	DV	Equations	R^2	S.E	Sig
GG x GG	1	WK12	$2.30 + 0.25\ EN_3$	0.31	0.37	NS
	2		$3.30 + 0.25*EN_3 + -0.50*EN_4$	0.63	0.29	*
SS x SS	1		$5.72 + -044\ *EN_3$	0.34	0.42	*
YEC x GG	1		$1.33 + 0.83*EN_1$	0.67	0.32	*
	2		$2.00 + 1.00*EN_1 + -0.50*EN_4$	0.80	0.27	*
YEC x SS	1		$3.10 + 0.38*EN_2$	0.46	0.25	*

YEC, GG, SS represent: Yoruba Ecotype Chicken, Goliath and Sussex DV= Dependent variable,WK= weeks Y=predicted egg number ,EN= egg number , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$) respectively.

Table 5.25: Forward stepwise regression analysis for 12th week egg weight fitted from egg weight at weeks 1-4

Strain	Model	DV	Equations	R^2	S.E	Sig
GG x GG	1	WK16	11.18 +0.89 EW_4	0.41	0.92	*
GG x YEC	1		64.61+-0.72 *EW_2	0.27	0.62	*
SS x YEC	1		53.02+ -0.38*EW_1	0.29	0.66	*
	2		40.89+ -0.52 *EW_1+ 0.48 *EW_4	0.50	0.57	*

YEC, GG, SS represent: Yoruba Ecotype Chicken, Goliath and Sussex DV= Dependent variable,WK=weeks Y=predicted egg weight , EW =egg weight , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$) respectively.

5.5.5 Curvilinear Regression Models Fitted for Late Body Weight from Early Body Weight in Pure and Cross Breed Chickens.

The models for predicting 8 weeks body weight from 4 weeks body weight in Yoruba Ecotype Chicken is presented in Table 5.26. The results showed that the 11 curvilinear (linear, logarithmic, inverse, quadratic, cubic, compound, power, sigmoid, growth, exponential and logistic) regression models significantly explained between 42.5% and 59.5% of variation with cubic explaining the highest variation. The cubic and quadratic models shows that the independent variable (wk4) contribute to more than 50% of change in body weight of purebred YEC at 8 weeks of age.

The models for predicting 8 weeks body weight from 4 weeks body weight in Goliath Chicken is presented in table 5.27. The result shows that the 11 curvilinear (linear, logarithmic, inverse, quadratic, cubic, compound, power, sigmoid, growth, exponential and logistic) regression models examined, explained a low proportion that ranged between 3.40% and 8.00 % of variation.

The models of predicting 8 weeks body weight from 4 weeks body weight in Sussex chicken is presented in Table 5.28. The results showed that the 11 curvilinear regression models explained between 28% and 44.7 % of the variations in 8 weeks body weight. Cubic function explained the highest variation of 44.7%.

Table 5.26: Curvilinear Predictive Equations in Strain YEC x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	278.51 + 0.55 * WK4.	0.507	24.296	*
Logarithmic			2.04 + 72.36 X*Ln(WK4.)	0.465	25.298	*
Inverse			426.58 + -8940.31 / WK4.	0.426	26.214	*
Quadratic			414.44 + -1.55 * WK4. + 0.01 * (WK4. X WK4.)	0.591	22.345	*
Cubic			343.38 + 0 * WK4. + 0 * (WK4.* WK4.) + 0 * (WK4. * WK4. * WK4.)	0.595	22.219	*
Compound			287.24 * 1 ^ WK4.	0.499	0.067	*
Power			135.81 * WK4. ^ 0.2	0.462	0.069	*
Sigmoid			e^(6.06 + (-24.27/ WK4.))	0.425	0.071	*
Growth			e^(5.66 + (0 * WK4.))	0.499	0.067	*
Exponential			287.24 * (e^(0 * WK4.))	0.499	0.067	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.499	0.067	*

YEC, represent: Yoruba Ecotype Chicken , DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$) respectively.

Table 5.27: Curvilinear Predictive Equations in Strain GG x GG

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	782.76 + 0.46 * WK4.	0.034	155.712	NS
Logarithmic			-146.36 + 186.72 * Ln(WK4.)	0.044	154.873	NS
Inverse			1157.08 + -72182.48 / WK4.	0.057	153.847	NS
Quadratic			-141.87 + 5.7 * WK4. + -0.01 * (WK4. * WK4.)	0.080	155.371	NS
Cubic			-141.87 + 5.7 * WK4. + -0.01 * (WK4. * WK4.) + 0 * (WK4.* WK4. * WK4.)	0.080	155.371	NS
Compound			758.77 * 1 ^ WK4.	0.043	0.174	NS
Power			237.81 * WK4. ^ 0.23	0.055	0.173	NS
Sigmoid			e^(7.1 + (-89.36/ WK4.))	0.069	0.172	NS
Growth			e^(6.63 + (0 * WK4.))	0.043	0.174	NS
Exponential			758.77 * (e^(0 * WK4.))	0.043	0.174	NS
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.043	0.174	NS

GG, represent: Goliath Chicken, DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$) NS: not significant respectively.

Table 5.28: Curvilinear Predictive Equations in Strain SS x SS.

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	350.34 + 0.83 * WK4.	0.361	38.346	*
Logarithmic			-555.84 + 202.12 * Ln(WK4.)	0.333	39.179	*
Inverse			752.63 + -47654.02 / WK4.	0.304	40.009	*
Quadratic			894.09 + -3.5 * WK4. + 0.01 * (WK4. * WK4.)	0.435	36.502	*
Cubic			619.09 + 0 * WK4. + -0.01 * (WK4. * WK4.) + 0 * (WK4. * WK4. *WK4.)	0.447	36.107	*
Compound			389.58 * 1 ^ WK4.	0.326	0.070	*
Power			82.96 * WK4. ^ 0.34	0.303	0.072	*
Sigmoid			e^(6.65 + (-81.66/ WK4.))	0.280	0.073	*
Growth			e^(5.97 + (0 * WK4.))	0.326	0.070	*
Exponential			389.58 * (e^(0 * WK4.))	0.326	0.070	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.326	0.070	*

SS, represent: Sussex Chicken, DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$) respectively.

The models for predicting 8 weeks body weight from 4 weeks body weight in Marshall Broiler Chicken is presented in Table 5.29. The result showed that the 11 curvilinear regression models was not important as it explained a low proportion that ranged between 8.2% and 21.5% of variation.

The results of predicting 8 weeks body weight from 4 weeks body weight in strain YEC x GG is presented in Table 5.30. The 11 curvilinear regression models significantly explained between 31.5% and 36.3% of variation in 8th week body weight, with quadratic equation explaining the highest variation.

The models for predicting 8 weeks body weight from 4 weeks body weight in strain YEC x SS is presented in Table 5.31. The result showed that the first five curvilinear (linear, logarithmic, inverse, quadratic, cubic) regression models was not enough in explaining the variation which implies that the independent variable (wk4) is not responsible for any amount of change in body weight at 8. However, compound, power, sigmoid, growth, exponential and logistic significantly explained a proportion that ranged between 19.5% and 20.4 % of variation in body weight at 8 weeks of age.

Table 5.29: Curvilinear Predictive Equations in Strain MM x MM

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	755.48 + 1.16 * WK4.	0.100	42.366	NS
Logarithmic			-755.32 + 325.98 * Ln(WK4.)	0.093	42.535	NS
Inverse			1407.02 + -90923.65 / WK4.	0.085	42.701	NS
Quadratic			6163.9 + -35.94 * WK4. + 0.06 * (WK4. * WK4.)	0.214	40.801	NS
Cubic			2694.87 + 0 * WK4. + -0.06 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.215	40.788	NS
Compound			806.24 * 1 ^ WK4.	0.096	0.039	NS
Power			207.39 * WK4. ^ 0.29	0.089	0.039	NS
Sigmoid			e^(7.28 + (-81.66/ WK4.))	0.082	0.039	NS
Growth			e^(6.69 + (0 * WK4.))	0.096	0.039	NS
Exponential			806.24 X (e^(0 * WK4.))	0.096	0.039	NS
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.096	0.039	NS

MM, represent: Marshall Broiler Chicken, DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$) NS: not significant respectively.

Table 5.30: Curvilinear Predictive Equations in Strain YEC x GG

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	254.68 + 1.03 *WK4.	0.336	53.147	*
Logarithmic			-792.44 + 236.81 * Ln(WK4.)	0.326	53.550	*
Inverse			730.69 + -53480.5 / WK4.	0.315	53.980	*
Quadratic			937.62 + -4.9 * WK4. + 0.01 * (WK4. * WK4.)	0.363	53.264	*
Cubic			674.93 + -1.72 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.361	53.349	*
Compound			305.01 * 1 ^ WK4.	0.339	0.105	*
Power			38.17 * WK4. ^ 0.47	0.329	0.105	*
Sigmoid			e^(6.67 + (-106.18/WK4.))	0.318	0.106	*
Growth			e^(5.72 + (0 * WK4.))	0.339	0.105	*
Exponential			305.01 X (e^(0 * WK4.))	0.339	0.105	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.339	0.105	*

YEC, GG represent: Yoruba Ecotype Chicken, Goliath chicken, DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$) respectively.

Table 5.31: Curvilinear Predictive Equations in Strain YEC x SS

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	303.29 + 0.45 * WK4.	0.174	22.700	NS
Logarithmic			55.89 + 63.07 * Ln(WK4.)	0.171	22.748	NS
Inverse			429.85 + -8504.09 / WK4.	0.163	22.851	NS
Quadratic			304.85 + 0.43 * WK4. + 0 * (WK4. * WK4.)	0.174	23.358	NS
Cubic			294.03 + 0.55 * WK4. + 0 *(WK4. * WK4.) + 0* (WK4. * WK4. * WK4.)	0.175	23.355	NS
Compound			299.6 * 1 ^ WK4.	0.204	0.064	*
Power			138.79 * WK4. ^ 0.2	0.202	0.064	*
Sigmoid			e^(6.1 + (-26.54/ WK4.))	0.195	0.064	*
Growth			e^(5.7 + (0 * WK4.))	0.204	0.064	*
Exponential			299.6 * (e^(0 * WK4.))	0.204	0.064	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.204	0.064	*

YEC, SS represent: Yoruba Ecotype Chicken, Sussex Chicken, and DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$), NS: not significant respectively.

The results of predicting 8 weeks body weight from 4 weeks body weight in strain YEC x MM is presented in Table 5.32. The result showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 69.2% and 74.5% of variation with quadratic and cubic equation explaining the highest variation.

In predicting 8 weeks body weight from 4 weeks body weight in strain GG x YEC the result is presented in Table 5.33 these significantly explained a proportion that ranged between 82.9% and 89.4% of variation with cubic equation explaining the highest variation, meaning that the independent variable (wk4) contributed to the amount of change recorded at 8 weeks body weight.

The result of predicting 8 weeks body weight from 4 weeks body weight in strain SS x YEC (Table 5.34). Showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 74.6% and 77.6% of variation with quadratic and cubic equation explaining the highest variation.

Predicting 8 weeks body weight from 4 weeks body weight in strain MM x YEC (Table 5.35). showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 84.7% and 86.3% of the variation with sigmoid equation explaining the highest variation this implies that the independent variable (wk4) contribute to any amount of change in body weight at 8 weeks of age.

Table 5.32: Curvilinear Predictive Equations in Strain YEC x MM

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	456.03 + 0.63 * WK4.	0.692	18.798	*
Logarithmic			-283.55 + 162.75 * Ln(WK4.)	0.707	18.305	*
Inverse			783.48 + -41547.92 / WK4.	0.721	17.864	*
Quadratic			-55.5 + 4.68 * WK4. + -0.01 * (WK4. * WK4.)	0.745	18.128	*
Cubic			-55.5 + 4.68 * WK4. + -0.01 *(WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.745	18.128	*
Compound			473.67 * 1 ^ WK4.	0.698	0.030	*
Power			141.52 * WK4. ^ 0.27	0.715	0.029	*
Sigmoid			e^(6.7 + (-67.87/ WK4.))	0.729	0.029	*
Growth			e^(6.16 + (0 * WK4.))	0.698	0.030	*
Exponential			473.67 * (e^(0 * WK4.))	0.698	0.030	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.698	0.030	*

YEC, MM represent: Yoruba Ecotype Chicken, Marshall broiler Chicken, DV: dependent variable, IV: independent variable ,WK=weeks,R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.33: Curvilinear Predictive Equations in Strain GG x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	90.81 + 1.53 * WK4.	0.855	24.580	*
Logarithmic			-1851.75 + 421.64 * Ln(WK4.)	0.878	22.499	*
Inverse			929.72 + -112493.39 / WK4.	0.887	21.632	*
Quadratic			-430.6 + 5.38 * WK4. + -0.01 * (WK4. * WK4.)	0.893	22.386	*
Cubic			-270.28 + 3.53 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.894	22.234	*
Compound			217.66 * 1 ^ WK4.	0.829	0.054	*
Power			4.26 * WK4. ^ 0.85	0.860	0.049	*
Sigmoid			e^(7.08 + (-228.6/ WK4.))	0.877	0.046	*
Growth			e^(5.38 + (0 * WK4.))	0.829	0.054	*
Exponential			217.66 * (e^(0 X WK4.))	0.829	0.054	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.829	0.054	*

YEC,GG represent: Yoruba Ecotype Chicken ,Goliath chicken, DV: dependent variable, IV: independent variable, WK=weeks , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$) respectively.

Table 5.34: Curvilinear Predictive Equations in Strain SS x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	80.65 + 3.43 * WK4.	0.773	85.830	*
Logarithmic			-4737.02 + 1026.84 * Ln(WK4.)	0.765	87.189	*
Inverse			2138.92 + -302870.46 / WK4.	0.754	89.216	*
Quadratic			824.16 + -1.55 * WK4. + 0.01 * (WK4. * WK4.)	0.776	90.988	*
Cubic			824.16 + -1.55 * WK4. + 0.01 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.776	90.988	*
Compound			432.84 * 1 ^ WK4.	0.756	0.081	*
Power			5.47 * WK4. ^ 0.93	0.753	0.082	*
Sigmoid			e^(7.94 + (-275.4/ WK4.))	0.746	0.083	*
Growth			e^(6.07 + (0 * WK4.))	0.756	0.081	*
Exponential			432.84 * (e^(0 * WK4.))	0.756	0.081	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.756	0.081	*

YEC, SS represent: Yoruba Ecotype Chicken ,Sussex Chicken, DV: dependent variable, IV: independent variable ,WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.35: Curvilinear Predictive Equations in Strain MM x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK8	WK4	138.76 + 1.37 * WK4.	0.847	9.669	*
Logarithmic			-1381.86 + 337.94 * Ln(WK4.)	0.849	9.599	*
Inverse			816.57 + -82710.16 / WK4.	0.851	9.547	*
Quadratic			-560.27 + 7.1 * WK4. + -0.01 * (WK4. * WK4.)	0.852	10.074	*
Cubic			-560.27 + 7.1 * WK4. + -0.01 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.852	10.074	*
Compound			233.7 * 1 ^ WK4.	0.859	0.019	*
Power			9.57 * WK4. ^ 0.71	0.861	0.019	*
Sigmoid			e^(6.88 + (-173.81/ WK4.))	0.863	0.019	*
Growth			e^(5.45 + (0 * WK4.))	0.859	0.019	*
Exponential			233.7 X (e^(0 * WK4.))	0.859	0.019	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.859	0.019	*

YEC, MM represent: Yoruba Ecotype Chicken, Marshall broiler Chicken, DV: dependent variable, IV: independent variable ,WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

The models for predicting 20 weeks body weight from 4 weeks body weight in strain YEC x YEC is presented in Table 5.36. The eleven curvilinear regression models significantly explained between 44.5% and 50.7% of variation in 20 weeks body weight of purebred YEC chickens, with Compound, Growth, and Exponential and Logistic equation explaining the highest variation in the 20 weeks body weight of purebred YEC chickens.

With respect to predicting 20 weeks body weight from 4 weeks body weight in strain GG x GG (Table 5.37) the model showed that the eleven curvilinear regression models significantly explained between 34% and 41.8% of variation in 20 weeks body weight of purebred GG chickens, with cubic equation explaining the highest variation in 20 weeks body weight of purebred GG chickens.

The models for predicting 20 weeks body weight from 4 weeks body weight in strain SS x SS is presented in table 5.38. The result shows that the 11 curvilinear regression models significantly explained a proportion that ranged from 24.9% to 35.5% of variation with cubic equation explaining the highest variation in body weight at 8 weeks of age.

In predicting 8 weeks body weight from 4 weeks body weight of Marshall broiler Chicken result (Table 5.39) showed that the curvilinear regression models was not significant in explaining a low proportion that ranged between 5.3% and 37.8% of the variation.

Table 5.36: Curvilinear Predictive Equations in Strain YEC x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	748.3 + 2.06 * WK4.	0.481	127.179	*
Logarithmic			-314.95 + 276.62 * Ln(WK4.)	0.464	125.009	*
Inverse			1315.4 + -35015.78 / WK4.	0.445	124.025	*
Quadratic			992.14 + -1.72 * WK4. + 0.01 * (WK4. * WK4.)	0.500	121.362	*
Cubic			930.21 + 0 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.505	120.537	*
Compound			790.1 X 1 ^ WK4.	0.507	0.089	*
Power			298.59 * WK4. ^ 0.25	0.493	0.087	*
Sigmoid			e^(7.19 + (-32.13/ WK4.))	0.477	0.086	*
Growth			e^(6.67 + (0 * WK4.))	0.507	0.089	*
Exponential			790.1 X (e^(0 * WK4.))	0.507	0.089	*
Logistic			1 / (1/max + (0 X (1 ^ WK4.)))	0.507	0.089	*

YEC, represent: Yoruba Ecotype Chicken, DV: dependent variable, IV: independent variable ,WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.37: Curvilinear Predictive Equations in Strain GG x GG

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	1794.82 + -2.3 * WK4.	0.340	40.674	*
Logarithmic			3168.68 + -346.04 * Ln(WK4.)	0.363	40.430	*
Inverse			1095.66 + 48821.08 / WK4.	0.373	40.175	*
Quadratic			2505.14 + -12.42 * WK4. + 0.03 * (WK4. * WK4.)	0.410	37.885	*
Cubic			2265.23 + -7.43 * WK4. + 0 * (WK4. * WK4.) + 0* (WK4. * WK4. * WK4.)	0.418	37.691	*
Compound			1834.42 X 1 ^ WK4.	0.343	0.026	*
Power			4808.58 * WK4. ^ -0.24	0.366	0.025	*
Sigmoid			e^(7.02 + (34.27/ WK4.))	0.377	0.025	*
Growth			e^(7.51 + (0 * WK4.))	0.343	0.026	*
Exponential			1834.42 * (e^(0 X WK4.))	0.343	0.026	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.343	0.026	*

YEC, MM represent: Yoruba Ecotype Chicken, Marshall broiler Chicken, DV: dependent variable, IV: independent variable ,WK=weeks Y=predicted body weight , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.38: Curvilinear Predictive Equations in Strain SS x SS

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	1371.95 + 0.68 * WK4.	0.254	291.885	*
Logarithmic			546 + 181.1 * Ln(WK4.)	0.279	290.491	*
Inverse			1734.57 + -46256.84 / WK4.	0.299	289.058	*
Quadratic			759.32 + 5.56 * WK4. + -0.01 * (WK4. * WK4.)	0.352	242.560	*
Cubic			952.92 + 3.21 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.355	241.215	*
Compound			1379.63 * 1 ^ WK4.	0.249	0.140	*
Power			805.51 * WK4. ^ 0.12	0.273	0.139	*
Sigmoid			e^(7.47 + (-30.14/ WK4.))	0.293	0.139	*
Growth			e^(7.23 + (0 * WK4.))	0.249	0.140	*
Exponential			1379.63 * (e^(0 * WK4.))	0.249	0.140	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.249	0.140	*

SS represent: Sussex Chicken, DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.39: Curvilinear Predictive Equations in Strain MM x MM

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	634.59 + 4.33 * WK4.	0.053	106.461	NS
Logarithmic			-7323.54 + 1617.67 * Ln(WK4.)	0.062	106.470	NS
Inverse			3858.77 + -596447.22 / WK4.	0.071	106.480	NS
Quadratic			-52366.42 + 311.15 * WK4. + -0.44 * (WK4. * WK4.)	0.371	106.451	NS
Cubic			-35033.13 + 159.17 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.378	107.238	NS
Compound			1012.44 * 1 ^ WK4.	0.055	0.031	NS
Power			20.58 * WK4. ^ 0.79	0.064	0.031	NS
Sigmod			e^(8.5 + (-291.57/ WK4.))	0.074	0.031	NS
Growth			e^(6.92 + (0 * WK4.))	0.055	0.031	NS
Exponential			1012.44 * (e^(0 * WK4.))	0.055	0.031	NS
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.055	0.031	NS

MM represent: Yoruba Ecotype Chicken, Marshall Broiler Chicken, and DV: dependent variable, IV: independent variable, WK=weeks, R^2 = coefficient of determination, S.E =standard error, Sig= significant ($p<0.05$), NS: not significant respectively.

Models for predicting 20 weeks body weight from 4 weeks body weight in strain YEC x GG is presented in Table 5.40. Result showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 42.6% and 46.7% of variation with quadratic and cubic equation explaining the highest variation in body weight at week 20.

With respect to predicting 20 weeks body weight from 4 weeks body weight in strain YEC x SS (Table 5.41) the model showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 12.5% and 16.8% of variation cubic equation explaining the highest variation. Similarly, models for predicting 20 weeks body weight from 4 weeks body weight in strain YEC x MM (Table 5.42) showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 38.9% snd 51.8% of variation cubic equation explaining the highest variation.

Table 5.40: Curvilinear Predictive Equations in Strain YEC x GG

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	2081.85 + 5.84 * WK4.	0.443	107.780	*
Logarithmic			-5780.07 + 1685.53 * Ln(WK4.)	0.435	107.803	*
Inverse			5448.62 + -484294.91 / WK4.	0.426	107.828	*
Quadratic			8061.54 + -35.18 * WK4. + 0.07 * (WK4. * WK4.)	0.467	110.082	*
Cubic			6031.28 + -14.48 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.467	110.134	*
Compound			2422.24 * 1 ^ WK4.	0.446	0.069	*
Power			308.82 * WK4. ^ 0.44	0.438	0.069	*
Sigmod			e^(8.67 + (-126.91/WK4.))	0.429	0.069	*
Growth			e^(7.79 + (0 * WK4.))	0.446	0.069	*
Exponential			2422.24 * (e^(0 * WK4.))	0.446	0.069	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.446	0.069	*

YEC , GG represent: Yoruba Ecotype Chicken, Goliath Chicken, DV: dependent variable, IV: independent variable ,WK=weeks , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.41: Curvilinear Predictive Equations in Strain YEC x SS

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	-1754.57 + 10.11 * WK4.	0.125	59.999	*
Logarithmic			-22945.47 + 4211.57 * Ln(WK4.)	0.127	60.020	*
Inverse			6667.06 + -1752570.48 / WK4.	0.129	59.923	*
Quadratic			-106580.81 + 516.8 * WK4. + -0.61 * (WK4. * WK4.)	0.167	48.587	*
Cubic			-71737.26 + 263.84 * WK4. + 0 X (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.168	48.001	*
Compound			365.32 * 1 ^ WK4.	0.142	0.057	*
Power			0.03 * WK4. ^ 1.9	0.144	0.057	*
Sigmod			e^(9.7 + (-790.02/ WK4.))	0.145	0.057	*
Growth			e^(5.9 + (0 * WK4.))	0.142	0.057	*
Exponential			365.32 * (e^(0 X WK4.))	0.142	0.057	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.142	0.057	*

YEC , SS represent: Yoruba Ecotype Chicken, Goliath Chicken, DV: dependent variable, IV: independent variable ,WK=weeks , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.42: Curvilinear Predictive Equations in Strain YEC x MM

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	1549.92 + -1.31 * WK4.	0.405	44.508	*
Logarithmic			2641.35 + -256.21 * Ln(WK4.)	0.433	44.999	*
Inverse			1039.85 + 48104.44 / WK4.	0.453	45.507	*
Quadratic			2329.94 + -9.65 * WK4. + 0.02 * (WK4. * WK4.)	0.509	40.723	*
Cubic			2096.26 + -5.71 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.518	40.721	*
Compound			1569.76 * 1 ^ WK4.	0.389	0.032	*
Power			3601.34 * WK4. ^ -0.19	0.417	0.032	*
Sigmod			e^(6.97 + (36.62/ WK4.))	0.436	0.033	*
Growth			e^(7.36 + (0 * WK4.))	0.389	0.032	*
Exponential			1569.76 * (e^(0 * WK4.))	0.389	0.032	*
Logistic			1 / (1/max + (0 X (1 ^ WK4.)))	0.389	0.032	*

YEC , MM represent: Yoruba Ecotype Chicken, Goliath Chicken, DV: dependent variable, IV: independent variable ,WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

The models for predicting 20 weeks body weight from 4 weeks body weight in strain GG x YEC is presented in Table 5.43. The result shows that the 11 curvilinear regression models significantly explained a proportion that ranged between 49.5% and 58.5% of variation cubic equation explaining the highest variation. With respect to Strain SS x YEC, the models for predicting 20 weeks body weight from 4 weeks body weight showed that the 11 curvilinear regression models significantly explained a proportion that ranged between 35.4% and 55.2% of variation cubic equation explaining the highest variation (Table 5.44).

Models for predicting 20 weeks body weight from 4 weeks body weight in strain MM x YEC is presented in table 5.45. The result shows that the 11 curvilinear regression models significantly explained a proportion that ranged between 54.8% and 58.1% of variation quadratic and cubic equation explaining the highest variation.

Table 5.43: Curvilinear Predictive Equations in Strain GG x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	1284.93 + 2 * WK4.	0.531	72.016	*
Logarithmic			-987.59 + 503.36 * Ln(WK4.)	0.514	71.257	*
Inverse			2298.56 + -124795.93 / WK4.	0.495	70.533	*
Quadratic			3147.56 + -12.76 * WK4. + 0.03 * (WK4. * WK4.)	0.585	70.570	*
Cubic			2424.78 + -4.83 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.578	70.570	*
Compound			1352.17 * 1 ^ WK4.	0.533	0.080	*
Power			386.43 * WK4. ^ 0.28	0.516	0.079	*
Sigmoid			e^(7.77 + (-68.73/ WK4.))	0.495	0.078	*
Growth			e^(7.21 + (0 * WK4.))	0.533	0.080	*
Exponential			1352.17 * (e^(0 * WK4.))	0.533	0.080	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.533	0.080	*

YEC ,GG represent: Yoruba Ecotype Chicken, Goliath Chicken, DV: dependent variable, IV: independent variable ,WK=weeks, R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.44: Curvilinear Predictive Equations in Strain SS x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	780.03 + 2 * WK4.	0.365	331.586	*
Logarithmic			-1879.02 + 572.81 * Ln(WK4.)	0.405	331.248	*
Inverse			1920.93 + -158150.24 / WK4.	0.438	330.901	*
Quadratic			-1480.7 + 18.67 * WK4. + -0.03 * (WK4. * WK4.)	0.544	358.738	*
Cubic			-788.29 + 10.71 * WK4. + 0 * (WK4. * WK4.) + 0 * (WK4. * WK4. * WK4.)	0.552	358.738	*
Compound			858.07 * 1 ^ WK4.	0.354	0.135	*
Power			104.76 * WK4. ^ 0.45	0.393	0.135	*
S			e^(7.66 + (-125.07/WK4.))	0.425	0.135	*
Growth			e^(6.75 + (0 * WK4.))	0.354	0.135	*
Exponential			858.07 X (e^(0 * WK4.))	0.354	0.135	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.354	0.135	*

YEC , SS represent: Yoruba Ecotype Chicken, Sussex Chicken, DV: dependent variable, IV: independent variable ,WK=weeks Y=predicted body weight , R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

Table 5.45: Curvilinear Predictive Equations in Strain MM x YEC

Equation	DV	IV	Model	R^2	S.E	Sig.
Linear	WK20	WK4	2438.82 + 2.8 * WK*.	0.569	56.990	*
Logarithmic			-1476.03 + 835.06 * Ln(WK4.)	0.559	57.044	*
Inverse			4112.86 + -245467.23 / WK4.	0.548	57.104	*
Quadratic			3696.44 + -5.63 * WK4. + 0.01 * (WK4. * WK4.)	0.581	56.940	*
Cubic			3278.68 + -1.44 * WK4. + 0 * (WK4. X WK4.) + 0 * (WK4. * WK4. * WK4.)	0.581	58.216	*
Compound			2543.4 * 1 ^ WK4.	0.575	0.059	*
Power			781.63 * WK4. ^ 0.25	0.566	0.059	*
Sigmoid			e^(8.35 + (-74.03/ WK4.))	0.555	0.059	*
Growth			e^(7.84 + (0 * WK4.))	0.575	0.059	*
Exponential			2543.4 * (e^(0 * WK4.))	0.575	0.059	*
Logistic			1 / (1/max + (0 * (1 ^ WK4.)))	0.575	0.059	*

YEC , MM represent: Yoruba Ecotype Chicken, Marshal broiler Chicken, DV: dependent variable, IV: independent variable ,WK=weeks R^2 = coefficient of determination ,S.E =standard error, Sig= significant ($p<0.05$), respectively.

5.5.6 Principal Component Analysis

5.5.6.1 Weekly body weight in 10 strains

The Eigen value of total variance, the rotated component matrix and communalities of weekly body weight are presented in Table 5.46. The anti-image matrices and Kaiser-Meyer-Olkin measure of sample adequacy (0.95) Bartlett's Test of sphericity ($p<.000$), chi square (3640.580), and the values of communalities gave an ample support for the authenticity of using PC for selecting principal components for 20 weeks bodyweight measurement in the 10 strains. The larger communality values 0.745 - 0.991 observed in the present study suggest that a large number of variance was shared among the input variables hence, they can be classified with PCA. 2 Principal components (PC) were extracted from the weeks used in description of these strains of chicken. The extracted PCs accounted for more than half of the total variance 94.899 after the varimax rotation of the component matrix. There were variations in the trend of loadings of the weekly body weight on each PC. The first principal component (PC1) which was characterized by week 8,11and 9 contributed the largest portion of 82.35% to the total variance. The PC2 was highly loaded with week 3 and 2 and contributed a lower portion of the total variance 12.55 %. The values of the loadings in PC1 ranged between 0.561 and 0.984 while PC2 ranged between -0.26 to 0.651. The scree Plot (Fig 5.1) showed the distribution pattern of the Eigen values with respect to the components. The first component was characterized with the highest value of 16.47 and had the longest and the most ascending curve followed by the second significant component, the curve flattens out, in a declining pattern after the second component.

Table 5.46: Explained Eigen Value, Percentage of Total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body Weight in 10 Strains of Chicken.

Weeks	PC1	PC2	COMMUNALITIES
1	0.590	0.627	0.745
2	0.564	0.769	0.910
3	0.561	0.790	0.938
4	0.722	0.651	0.946
5	0.934	0.264	0.942
6	0.972	0.82	0.951
7	0.984	-0.33	0.968
8	0.988	0.055	0.979
9	0.985	-0.072	0.975
10	0.983	-0.098	0.976
11	0.986	-0.115	0.985
12	0.981	-0.158	0.987
13	0.984	-0.140	0.987
14	0.884	-0.116	0.795
15	0.983	-0.140	0.986
16	0.980	-0.175	0.991
17	0.967	-0.233	0.989
18	0.959	-0.249	0.982
19	0.953	-0.266	0.979
20	0.947	-0.270	0.970
TOTALVARIANCE EXPLAINED			
EIGEN VALUE	16.470	2.509	
%TOTAL VARIANCE	82.350	12.547	
CUMULATIVE %	82.350	94.897	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2.

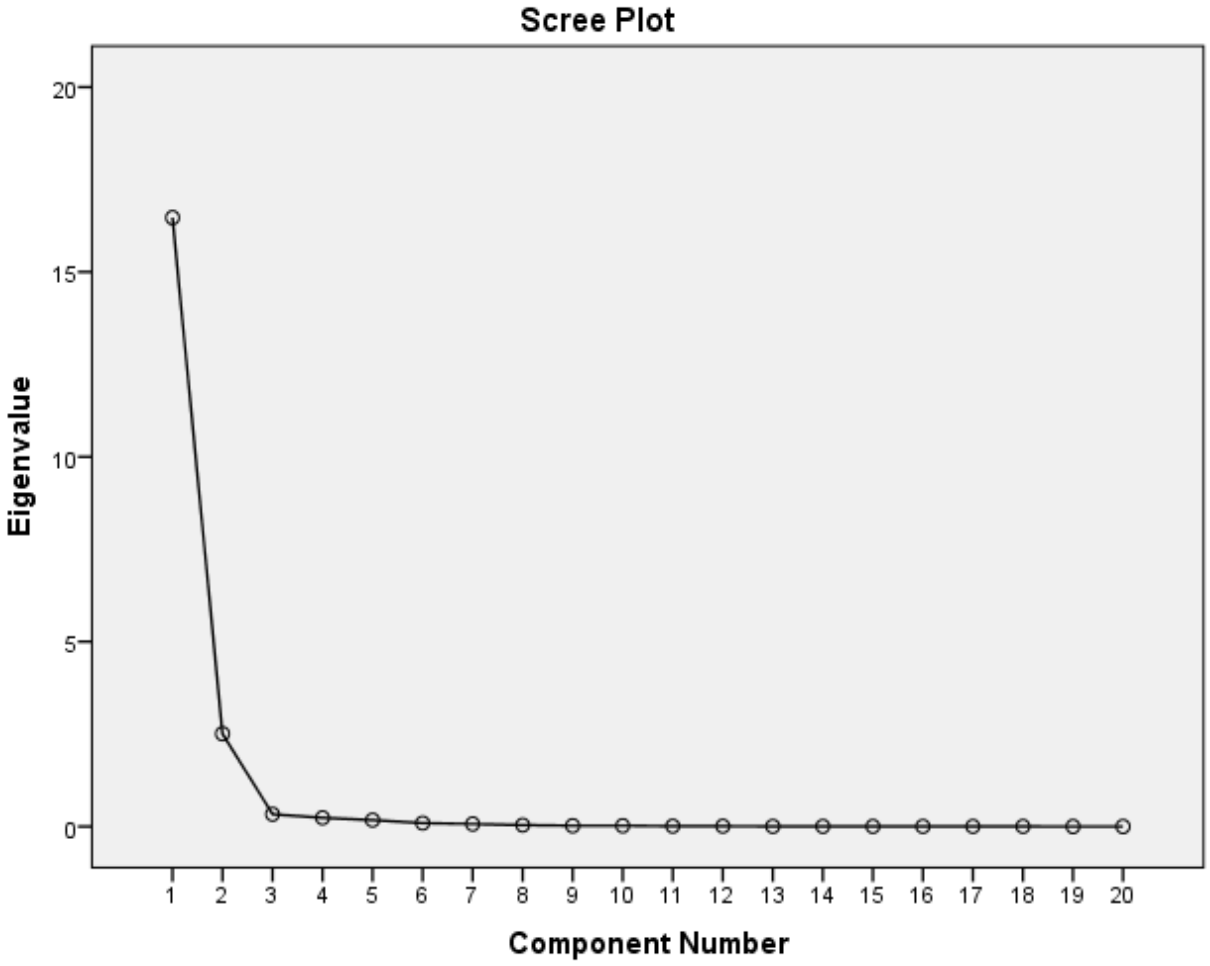


Figure 5.1: Body weight scree plot in 10 strains of chicken

5.5.6.2 Weekly Egg Weight in Pure and Crossbred Hens

A 24 weeks egg weight in pure and crossbred hens was selected for PCA, The Kaiser-Meyer-Olkin measurement of sample adequacy (0.966),Bartlett's test for sphericity ($p<0.000$), Chi-Square (16332.110) and the values of communality gave credence to the use of PCA for selecting for 24 weeks egg weight. The larger communality values (Table 5.47) of 0.972 to 0.997 observed in this present study suggests that a large number of variance has been shared among the variables imputed. Therefore, PCA can be used in classifying them. One principal Component (PC) was extracted from the weekly egg weight used in describing all the chicken strains. The extracted PC accounted for more than half of the total variance 98.608 after the varimax rotation of the component matrix. There were variations in the trend of loadings of the weekly egg weight on PC. In Principal Component 1 (PC1) weeks 11 and 12 contributed the largest portion of 98.68% to the total variance the values of the low loadings in PC1 ranged between 0.986 and 0.997. Figure 5.2, is the Scree plot showing the distribution pattern of Eigen values with respect to the components, the first component was characterized with the highest value of 23.666 with the longest and most ascending curve after which it declined and flattens out.

Table 5.47: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Egg Weight in 7 Strains of Chicken

WEEKS	PC1	COMMUNALITIES
1	0.986	0.972
2	0.989	0.978
3	0.991	0.982
4	0.991	0.982
5	0.993	0.986
6	0.991	0.983
7	0.992	0.984
8	0.992	0.984
9	0.995	0.990
10	0.997	0.993
11	**0.998**	0.995
12	**0.998**	0.997
13	0.997	0.994
14	0.997	0.994
15	0.996	0.993
16	0.995	0.991
17	0.995	0.991
18	0.994	0.989
19	0.992	0.984
20	0.992	0.983
21	0.992	0.983
22	0.991	0.982
23	0.990	0.981
24	0.988	0.976
TOTAL VARIANCE EXPLAINED		
EIGEN VALUE	23.666	
%TOTAL VARIANCE	98.608	
CUMULATIVE %	98.608	

Wk = Weeks, %= Percentage,PC1= Principal component 1.

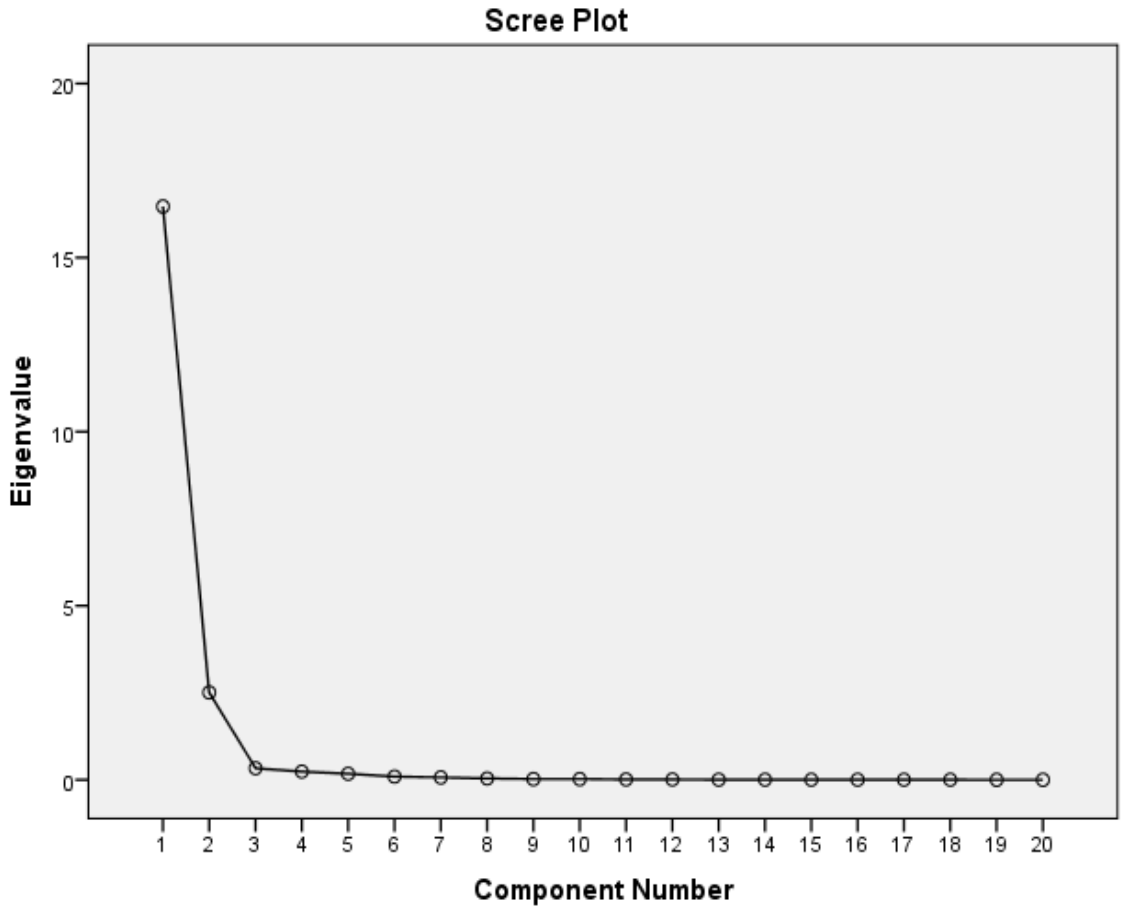


Figure 5.2: Egg weight scree plot in 7 strains of chicken

5.5.6.3 Weekly Egg Number in Pure and Crossbred Hens

In all the strains, 24 weeks egg number was selected for PCA, The Kaiser-Meyer- Olkin (0.95) measure of sample adequacy, Bartletts Test of sphericity ($p<0.000$), Chi square (2430.409) and the values of the communalities obtained gave credence to the use of PCA. 4 Principal components (PC) were extracted from weekly egg no used in the description of these genetic groups. The extracted PCs accounted for more than half of the total variance 66, 64% after the varimax rotation of the component matrix. There were variations in the trend of loadings of weekly body weight on each PC. PC1 was characterized by weeks 18, 16, 20 and 17 which together contributed the largest portion of 53.805% to the total variance. The PC2 was highly loaded with week 3 that contributed a lower portion of the total variance (7.436%), the third component PC3 contributed 5.400 to the total variance and loaded for week 6 while the last component PC4 contributed the least 4.692% to the total variance loaded for week 1. The values of the low loadings in PC1 ranged between 0.13 to 0.813 while PC2, PC3 and PC4 ranged values are -0.38 to 0.46, -0.299 to 0.448 and -0.27 to 0.162, respectively.

Figure 5.3 shows the scree plot for the distribution pattern of the Eigen values with respect to the first component. The first component which is characterized with the highest value 12.913 had the longest and most ascending curve followed by the other 3 significant components after which the curve flattens out in a declining form after the fourth component.

Table 5.48: Explained Eigen Value, Percentage of Total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Egg Number in 7 Strains of Chicken.

WEEKS	PC1	PC2	PC3	PC4	COMMUNALITIES
1	0.133	- 0.075	-0.035	0.900	0.834
2	0.384	0.025	0.448	-0.271	0.455
3	0.437	0.511	0.375	0.200	0.633
4	0.537	0.270	0.264	0.144	0.452
5	0.699	0.333	0.222	0.162	0.675
6	0.665	0.046	0.481	0.013	0.676
7	0.721	-0.080	0.409	-0.039	0.696
8	0.761	0.149	0.076	-0.175	0.638
9	0.755	0.336	-0.133	-0.265	0.771
10	0.721	0.310	-0.299	0.012	0.705
11	0.805	0.247	-0.269	-0.010	0.782
12	0.805	0.299	-0.204	-0.052	0.783
13	0.791	0.163	-0.313	0.067	0.755
14	0.774	0.323	-0.115	0.020	0.717
15	0.796	0.059	-0.146	0.082	0.666
16	0.833	-0.127	-0.069	-0.031	0.715
17	0.830	-0.115	-0.120	-0.073	0.722
18	0.871	-0.172	0.025	-0.069	0.794
19	0.816	-0.281	-0.032	0.001	0.747
20	0.833	-0.320	-0.066	0.081	0.806
21	0.813	-0.368	-0.158	-0.021	0.821
22	0.800	-0.382	0.024	-0.039	0.787
23	0.805	-0.344	0.100	0.138	0.795
24	0.736	-0.410	0.127	-0.022	-0.727
TOTAL VARIANCE EXPLAINED					
EIGEN VALUE	12.913	1.785	1.296	1.126	
%TOTAL VARIANCE	53.805	7.436	5.400	4.692	
CUMULATIVE %	53.805	61.242	66.641	71.333	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2, PC3= Principal component 3, PC4= Principal component 4.

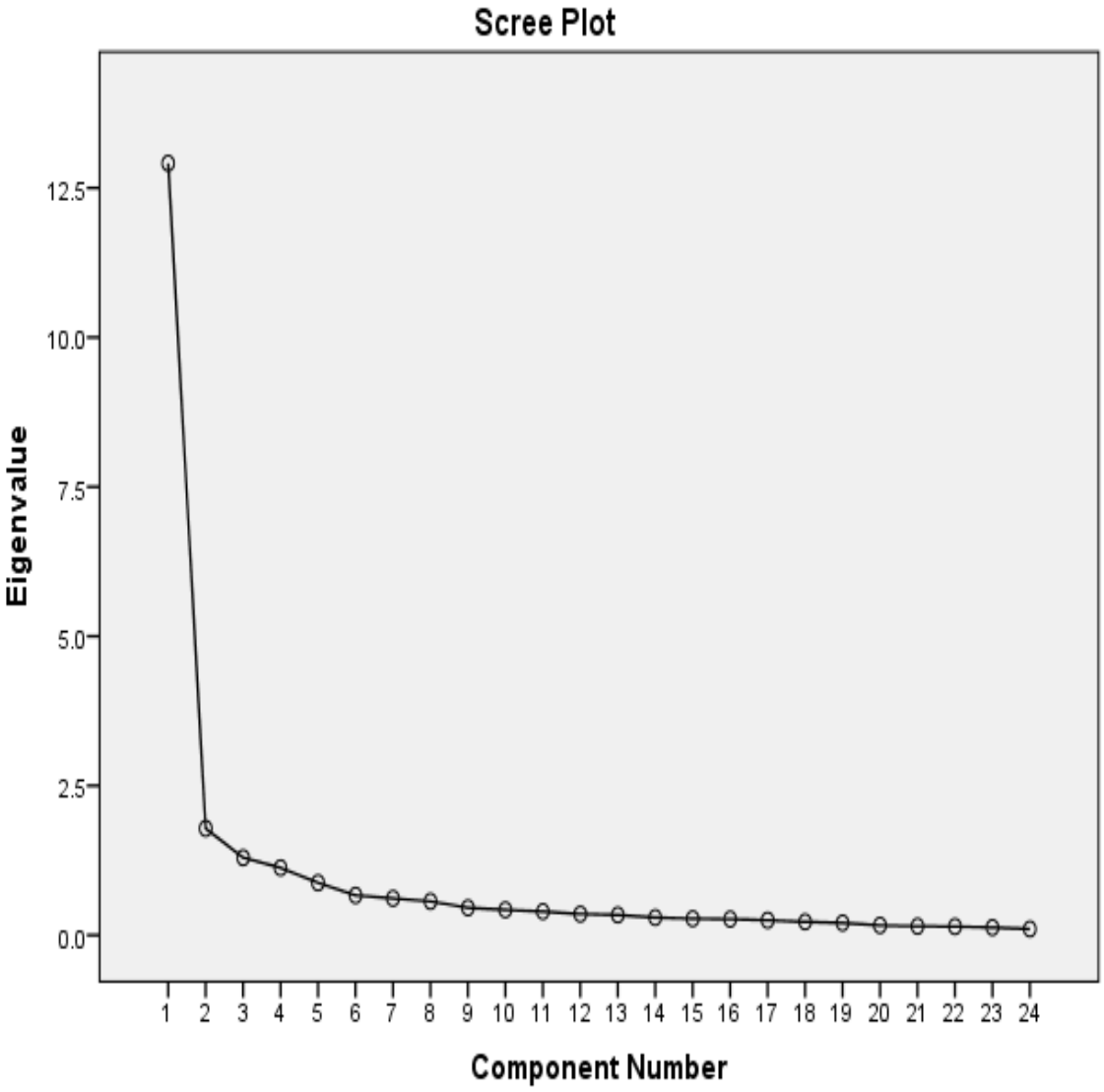


Figure 5.3: Eigen Values scree plot of egg number for 7 strains

5.5.6.4 Weekly body weight in pure bred YEC x YEC

The KMO measure of sample adequacy (0.908), Bartletts Test of sphericity ($p<0.000$) and the Chi square (5245.903) in pure bred YEC was significant. The eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight of YEC x YEC chicken is presented in Table 5.49. The eigen values showed that the amount of variance from the total variance explained by each components or factors. Three principal components were extracted from these strain with eigen values of 11.917 for PC1, 5.319 for PC2 and 1.219 for PC3. The three principal components accounted for 88.07% of the total variance on weeks 11 and 12, PC2 had a high positive loading on week 3 and 4 while PC3 was orthogonal to PC1 and PC2 and loading heavily on body weight at day-old.

Figure 5.4 shows the scree plot for the distribution pattern of the eigen values with respect to the first component. The first component which is characterized with the highest value 11.917 had the longest and most ascending curve followed by the other 2 significant components after which the curve flattens out in a declining form after the third component.

Table 5.49: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in Yoruba Ecotype Chicken.

Weeks	PC1	PC2	PC3	Communalities
Day-old	-0.055	0.442	0.774	0.798
wk1	-0.105	0.791	0.448	0.837
wk2	-0.133	0.920	0.181	0.897
wk3	-0.077	0.961	-0.051	0.932
wk4	0.065	0.951	-0.238	0.966
wk5	0.126	0.928	-0.278	0.954
wk6	0.467	0.800	-0.284	0.938
wk7	0.841	0.366	-0.156	0.866
wk8	0.939	0.190	-0.113	0.931
wk9	0.959	-0.095	-0.042	0.930
wk10	0.969	-0.073	-0.014	0.944
wk11	0.981	0.033	-0.018	0.964
wk12	0.986	0.011	0.001	0.972
wk13	0.978	0.037	0.039	0.959
wk14	0.049	0.131	0.319	0.122
wk15	0.957	-0.040	0.076	0.924
wk16	0.944	-0.109	0.042	0.904
wk17	0.941	-0.225	0.117	0.950
wk18	0.887	-0.189	0.166	0.851
Wk19	0.956	-0.125	0.076	0.935
wk20	0.952	0.057	0.112	0.922
TOTAL VARIANCE EXPLAINED				
EIGEN VALUE	11.917	5.319	1.260	
%TOTAL VARIANCE	56.746	25.327	6.001	
CUMULATIVE %	56.746	82.073	88.074	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2, PC3= Principal component 3.

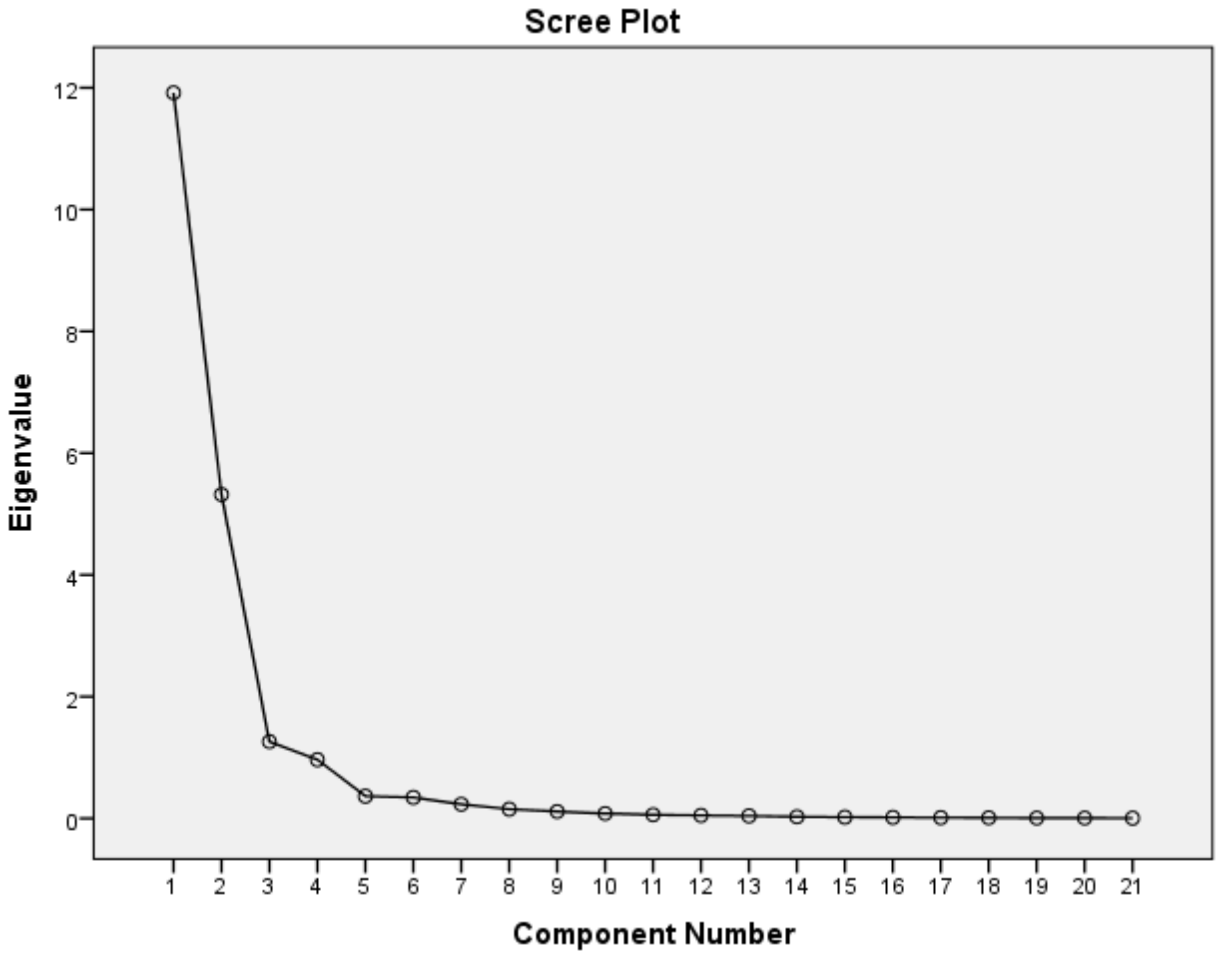


Figure 5.4: Scree plot for body weight in strain YEC x YEC

5.5.6.5 Weekly body weight in pure bred Goliath chickens.

The KMO measure of sample adequacy (0.885), Bartletts Test of sphericity ($p<0.000$) chi square (3799.804) in GG x GG strain was significant. The Eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight of GG x GG chicken is presented in Table 5.50. The Eigen values showed the amount of variance from the total variance explained by each components or factors. Two principal component were extracted from these strain with eigen values of 16.128 for PC1 and 2.634 for PC2 .The two principal components accounted for 89.344% of the total variance, PC1 had high positive loadings (correlation between the components and the variables) on weeks 15, 16, 17 and 18 while, PC2 was orthogonal to PC1 and loading heavily on body weight at week 4 and 5.

Figure 5.5 shows the scree plot for the distribution pattern of the Eigen values with respect to the first component. The first component which is characterized with the highest value 16.128 had the longest and most ascending curve followed by the next significant components (PC2) after which the curve flattens out in a declining form after the second component.

Table 5.50: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in GG x GG Strain of Chicken

PARAMETERS	PC1	PC2	Communalities
Day-old	0.784	0-.438	0.806
wk1	0.788	0-.291	0.705
wk2	0.552	0.696	0.789
wk3	0.401	0.881	0.938
wk4	0.477	0.850	0.950
wk5	0.764	0.489	0.823
wk6	0.882	0.119	0.792
wk7	0.922	0.062	0.853
wk8	0.947	0-.065	0.902
wk9	0.961	-0.108	0.935
wk10	0.952	-0.096	0.916
wk11	0.942	0.084	0.895
wk12	0.941	-0.041	0.888
wk13	0.946	-0.022	0.896
wk14	0.951	-0.038	0.906
wk15	0.974	-0.091	0.957
wk16	0.973	-0.113	0.960
wk17	0.974	-0.145	0.969
wk18	0.974	-0.130	0.966
Wk19	-0.972	-0.115	0.959
wk20	-0.974	-0.099	0.958
TOTAL VARIANCE EXPLAINED			
EIGEN VALUE	16.128	2.634	
%TOTAL VARIANCE	76.800	12.544	
CUMULATIVE %	76.800	89.344	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2.

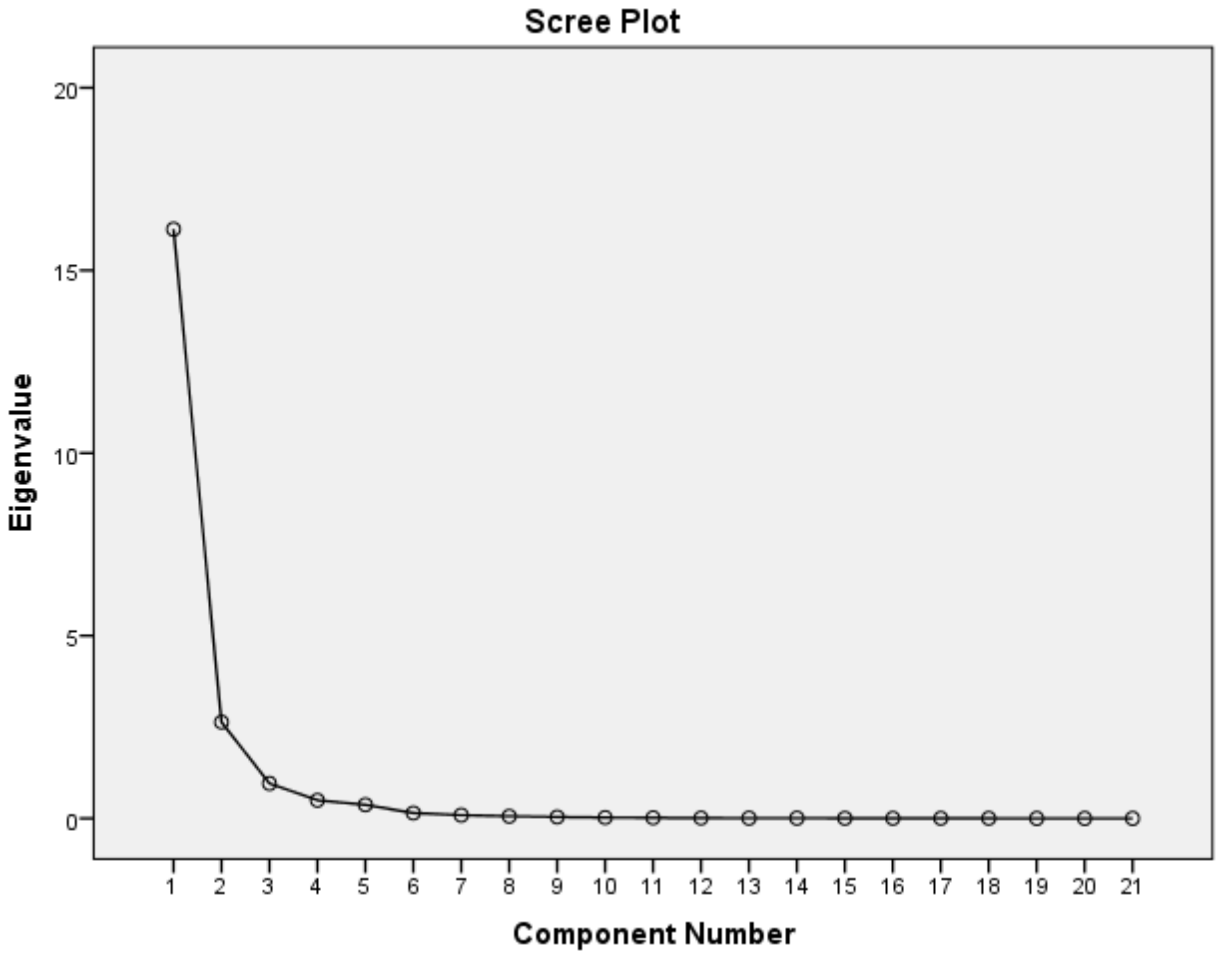


Figure 5.5: Scree plot for body weight in strain GG x GG

5.5.6.5 Weekly Body Weight in Sussex Chickens

The KMO measure of sample adequacy(0.941), Bartletts Test of sphericity ($p<0.000$) and the Chi square (5087.036) was significant in strain SS x SS. Table 5.51 presents the eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight in SS x SS chicken. One principal component was extracted from these strain with Eigen value of 9.379 for PC1. These principal component accounted for 92.282% of the total variance, PC1 had high positive loadings (correlation between the components and the variables) on weeks 13 and 14.

Figure 5.6, shows the Scree plot showing the distribution pattern of eigen values with respect to the components ,the first component was characterized with the highest value of 9.379 with the longest and most ascending curve after which it decline and flattens out.

Table 5.51: Explained Eigen Value, Percentage of Total Variance, Cumulative Percentage, Principal Component and Communalities of Weekly Body weight in SS x SS Strain of Chicken.

PARAMETERS	PC1	Communalities
Day-old	0.851	0.725
wk1	0.895	0.801
wk2	0.905	0.820
wk3	0.931	0.867
wk4	0.905	0.819
wk5	0.967	0.935
wk6	0.935	0.875
wk7	0.973	0.946
wk8	0.982	0.965
wk9	0.988	0.977
wk10	0.984	0.968
wk11	0.981	0.962
wk12	0.989	0.978
wk13	0.993	0.986
wk14	0.994	0.988
wk15	0.989	0.979
wk16	0.985	0.969
wk17	0.981	0.962
wk18	0.980	0.961
Wk19	0.978	0.956
wk20	0.970	0.940
TOTAL VARIANCE EXPLAINED		
EIGEN VALUE	9.379	
%TOTAL VARIANCE	92.282	
CUMULATIVE %	92.282	

Wk = Weeks, %= Percentage, PC1= Principal component 1.

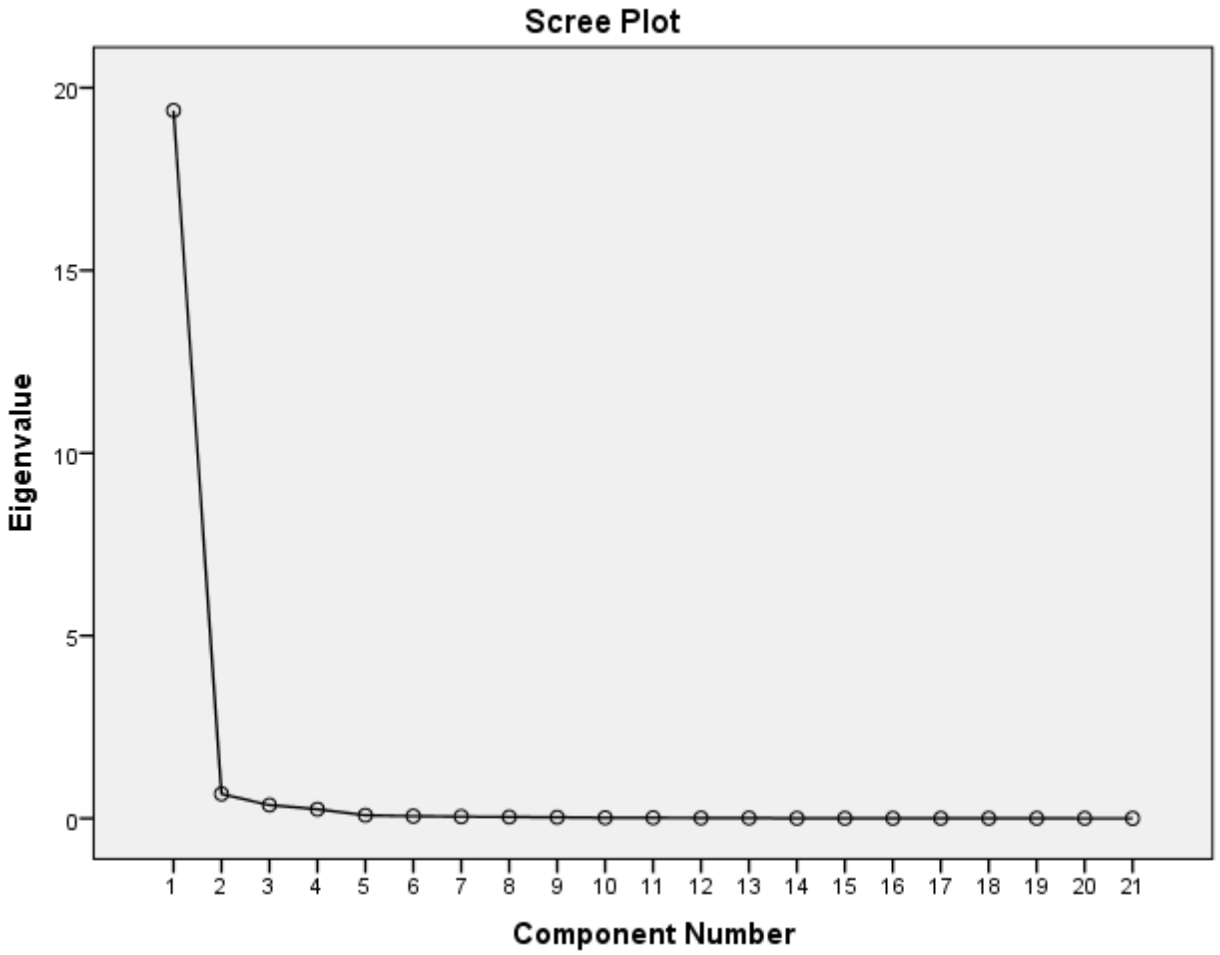


Figure 5.6: Scree plot for body weight in strain SS

5.5.6.7 Weekly Body Weight in Marshall Broiler Chickens

The KMO measure of sample adequacy (0.943), Bartletts Test of sphericity ($p<0.000$) and the Chi square (3642.892) was significant in MM x MM strain. Table 5.52 shows, the Eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight of MM x MM chicken. Two principal component were extracted from these strain with eigen values of 17.345 for PC1 and 1.230 for PC2 .The two principal components accounted for 88.453% of the total variance, PC1 had high positive loadings on weeks 13, 14, 15 and 16 while, PC2 was orthogonal to PC1 and loading heavily on body weight at week 1 and 2.

Figure 5.7 shows the scree plot for the distribution pattern of the Eigen values with respect to the first component. The first component which is characterized with the highest value 17.345 had the longest and most ascending curve followed by the next significant components (PC2) after which the curve flattens out in a declining form after the second component.

Table 5.52: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in MM x MM Strain of Chicken.

PARAMETERS	PC1	PC2	Communalities
Day-old	0.577	0.037	0.334
wk1	0.247	0.932	0.930
wk2	0.752	0.529	0.845
wk3	0.952	0.078	0.912
wk4	0.959	-0.010	0.921
wk5	0.895	0.025	0.802
wk6	0.875	-0.054	0.768
wk7	0.950	-0.009	0.903
wk8	0.950	-0.068	0.907
wk9	0.959	-0.096	0.930
wk10	0.934	-0.064	0.877
wk11	0.981	0.001	0.962
wk12	0.968	0.009	0.938
wk13	0.988	-0.039	0.977
wk14	0.988	-0.032	0.978
wk15	0.989	-0.009	0.977
wk16	0.986	-0.052	0.975
wk17	0.982	0.005	0.964
wk18	0.983	-0.032	0.968
Wk19	0.940	-0.126	0.900
wk20	0.883	-0.174	0.809
TOTAL VARIANCE EXPLAINED			
EIGEN VALUE	17.345	1.230	
%TOTAL VARIANCE	82.596	5.856	
CUMULATIVE %	82.596	88.453	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2

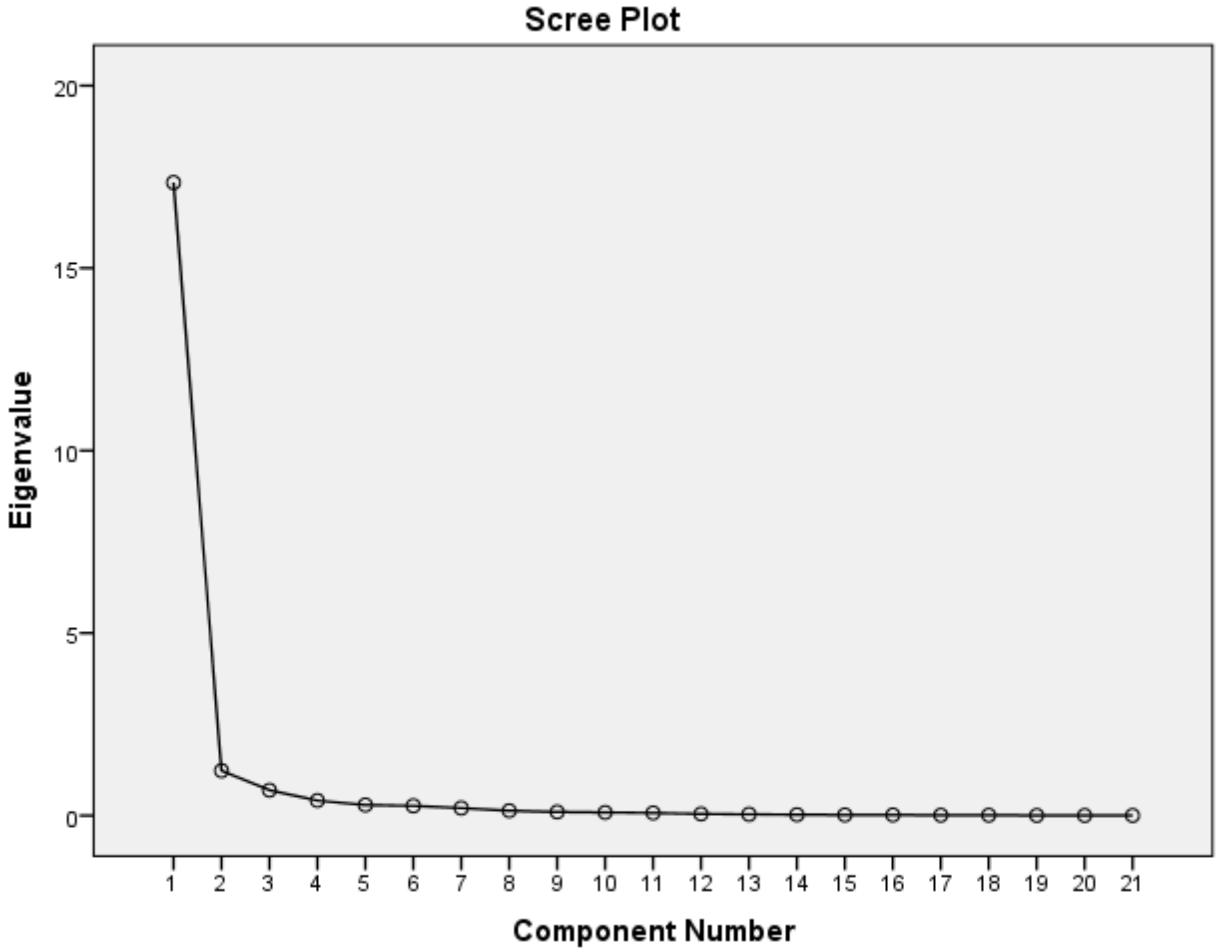


Figure 5.7: Scree plot for body weight in strain MM x MM

5.5.6.8 Weekly Body Weight in YEC x GG Cross Bred Chickens

The KMO measure of sample adequacy (0.890), Bartletts Test of sphericity ($p<0.000$), Chi square (2478.155) was significant in strain YEC x GG. The Eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight in YEC x GG chicken is presented in Table 5.53. The Eigen values showed the amount of variance from the total variance explained by each components or factors. One principal component was extracted from these strain with Eigen value of 19.367 for PC1. The principal component accounted for 92.225% of the total variance. PC1 had high positive loadings (correlation between the components and the variables) on weeks 11.

Figure 5.8, shows the Scree plot showing the distribution pattern of eigen values with respect to the components ,the first component was characterized with the highest value of 19.367 with the longest and most ascending curve after which it decline and flattens out.

Table 5.53: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage,

Principal Components and Communalities of Weekly Body weight in YEC x GG Strain of Chicken

PARAMETERS	PC1	Communalities
Day-old	0.872	0.760
wk1	0.898	0.806
wk2	0.857	0.735
wk3	0.968	0.938
wk4	0.964	0.930
wk5	0.959	0.919
wk6	0.972	0.945
wk7	0.973	0.948
wk8	0.971	0.942
wk9	0.974	0.949
wk10	0.976	0.953
wk11	0.991	0.981
wk12	0.986	0.972
wk13	0.986	0.973
wk14	0.984	0.968
wk15	0.976	0.953
wk16	0.976	0.953
wk17	0.972	0.944
wk18	0.966	0.933
Wk19	0.965	0.931
wk20	0.966	0.933
ESTIMATED TOTAL VARIANCE		
EIGEN VALUE	19.367	
%TOTAL VARIANCE	92.225	
CUMULATIVE %	92.225	

Wk = Weeks, %= Percentage, PC1= Principal component

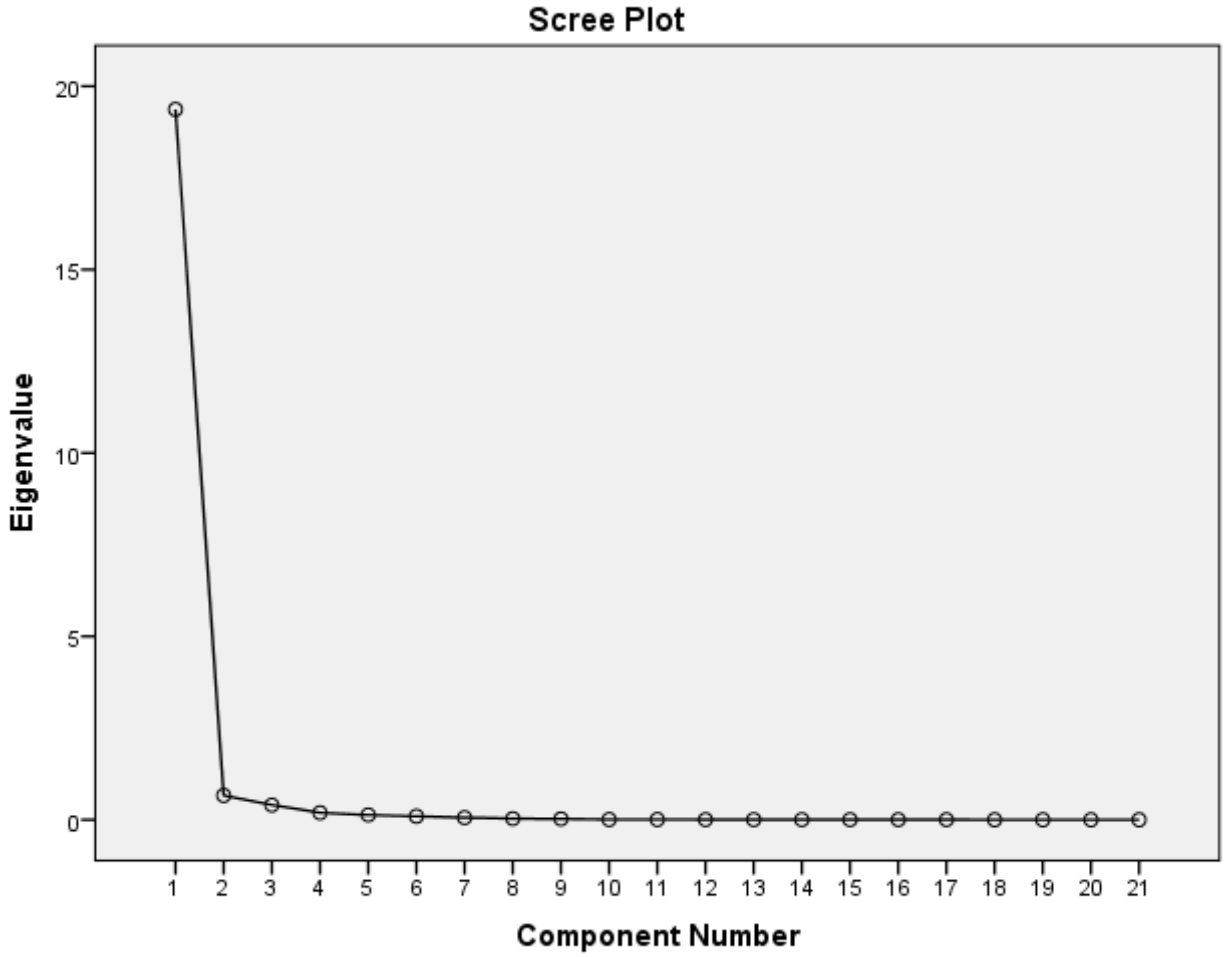


Figure 5.8: Scree plot for body weight in strain YEC x GG

5.5.6.9 Weekly Body Weight in YEC x SS Cross Bred Chickens

The KMO measure of sample adequacy (0.886), Bartletts Test of sphericity ($p<0.000$), Chi square (1868.57) was significant in YEC x SS strain. Table 5.54 shows, the Eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight of YEC x SS chicken. The communality values (0.276 - 0.983) showed that most of the variance has been shared among the variables imputed and which gave credence in classifying them with PCA. Two principal components were extracted from these strain with Eigen values of 17.776 for PC1 and 1.368 for PC2 .The two principal components accounted for 91.248% of the total variance, PC1 had high positive loadings on week 10 while, and PC2 was orthogonal to PC1 and loading heavily on body weight at week and 3.

Figure 5.9 shows the scree plot for the distribution pattern of the Eigen values with respect to the first component. The first component which is characterized with the highest value 17.776 had the longest and most ascending curve followed by the next significant components (PC2) after which the curve flattens out in a declining form after the second component.

Table 5.54: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in YEC x SS Strains of Chicken.

PARAMETERS	PC1	PC2	COMMUNALITIES
Day-old	0.516	0.101	0.276
wk1	0.862	0.129	0.760
wk2	0.818	0.439	0.861
wk3	0.772	0.604	0.960
wk4	0.770	0.577	0.927
wk5	0.897	0.363	0.937
wk6	0.956	0.164	0.940
wk7	0.977	0.028	0.956
wk8	0.972	-0.035	0.945
wk9	0.971	-0.064	0.948
wk10	0.985	-0.088	0.979
wk11	0.960	-0.195	0.959
wk12	0.964	-0.169	0.959
wk13	0.977	-0.152	0.978
wk14	0.979	-0.158	0.983
wk15	0.971	-0.187	0.977
wk16	0.974	-0.184	0.982
wk17	0.971	-0.189	0.979
wk18	0.975	-0.136	0.970
Wk19	0.966	-0.150	0.955
wk20	0.946	-0.190	0.931
ESTIMATED TOTAL VARIANCE			
EIGEN VALUE	17.776	1.386	
%TOTAL VARIANCE	84.648	6.600	
CUMULATIVE %	84.648	91.248	

Wk = Weeks, %= Percentage,PC1= Principal component 1,PC2 =Principal component 2.

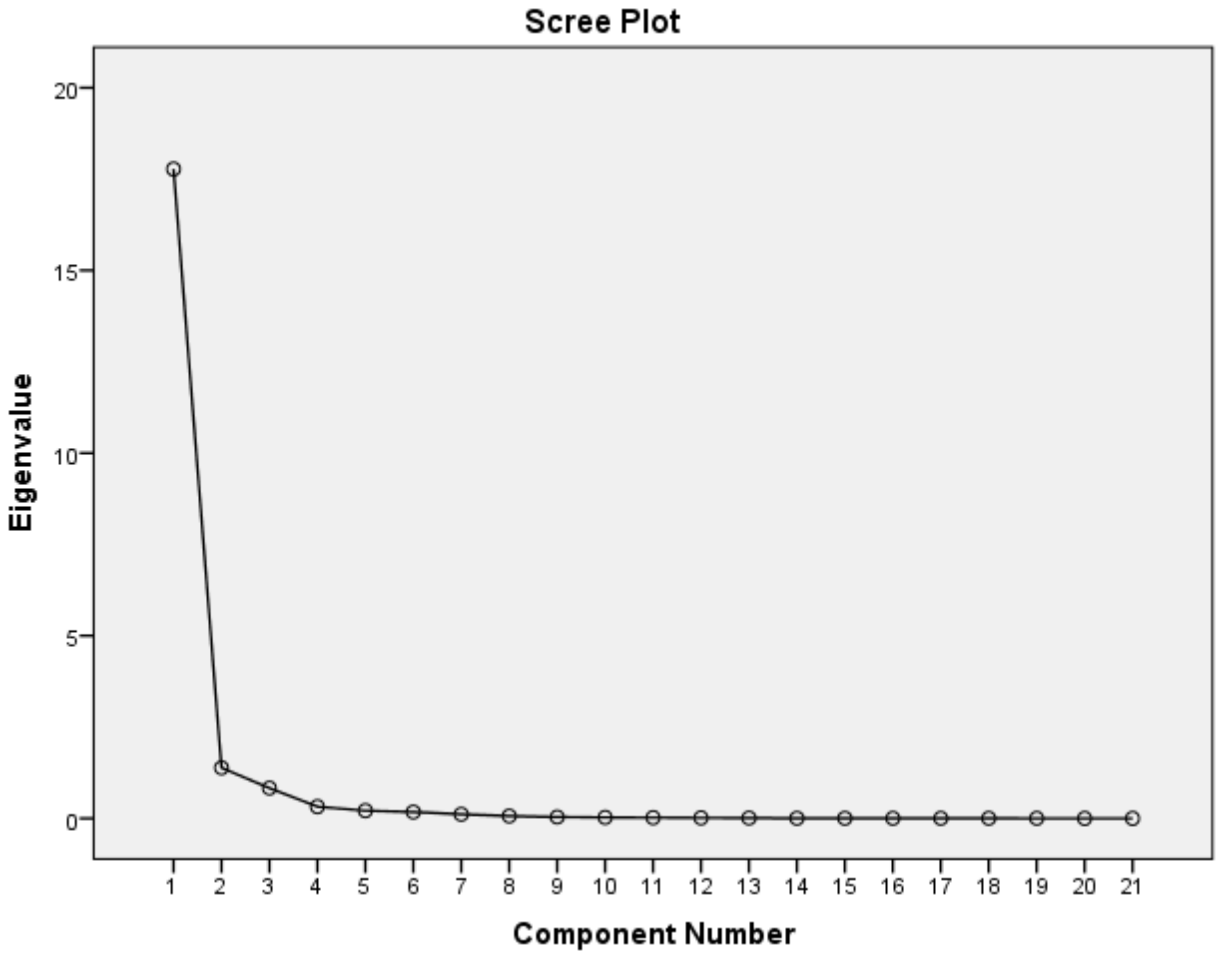


Figure 5.9: Scree plot for body weight in strain YEC x SS

5.56.10 Weekly Body Weight in YEC x MM Cross Bred Chickens

The KMO measure of sample adequacy(0.869), Bartletts Test of sphericity ($p<0.000$) and the Chi square (1627.448) was significant in strain YEC x MM. Table 5.55 shows the eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight in YEC x MM chicken. The communality values (0.122 – 0.972) suggest that most of the variance has been shared among the variables imputed, hence, there is need to classify them with PCA. One principal component were extracted from these strain with Eigen value of 18.764 for PC1. These principal component accounted for 89.351% of the total variance, PC1 had high positive loadings on weeks 15, 16, 17 and 18.

Figure 5.10, shows the Scree plot showing the distribution pattern of Eigen values with respect to the components, the first component was characterized with the highest value of 18.764 with the longest and most ascending curve after which it flattens out

Table 5.55: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in YEC x MM Strains of Chicken

PARAMETERS	PC1	COMMUNALITIES
Day-old	0.755	0.798
wk1	0.837	0.837
wk2	0.784	0.897
wk3	0.912	0.932
wk4	0.936	0.966
wk5	0.969	0.954
wk6	0.976	0.938
wk7	0.982	0.866
wk8	0.957	0.931
wk9	0.975	0.930
wk10	0.925	0.944
wk11	0.930	0.964
wk12	0.956	0.972
wk13	0.981	0.959
wk14	0.989	0.122
wk15	0.992	0.924
wk16	0.991	0.904
wk17	0.991	0.950
wk18	0.990	0.851
Wk19	0.986	0.935
wk20	0.987	0.922
ESTIMATED TOTAL VARIANCE		
EIGEN VALUE	18.764	
%TOTAL VARIANCE	89.351	
CUMULATIVE %	89.351	

Wk = Weeks, %= Percentage, PC1= Principal component 1.

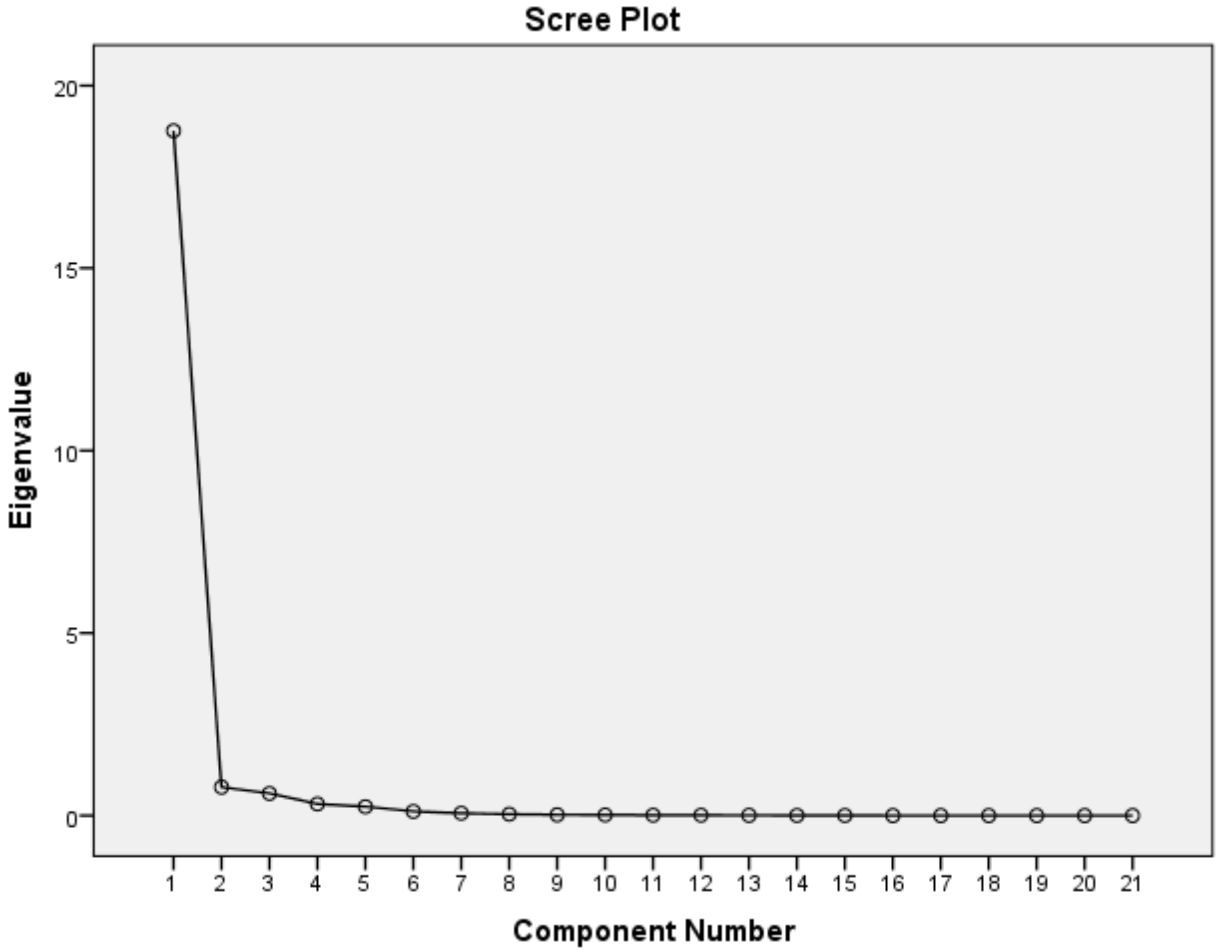


Figure 5.10: Scree plot for body weight in strain YEC x MM

5.5.6.11 Weekly Body Weight in GG x YEC Cross Bred Chickens

The KMO measure of sample adequacy (0.874), Bartletts Test of sphericity ($p<0.000$) and the Chi square (1928.152) in strain GG x YEC. Table 5.56 presents the Eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight of GG x YEC chicken. The communality values (0.664 - 0.990) showed that most of the variance has been shared among the variables imputed, which gave credence to classifying them with PCA. Three principal components were extracted from these strains with Eigen values of 16.270 for PC1, 2.145 for PC2 and 1.184 for PC3. The three principal components accounted for 93.329% of the total variance, PC1 had high positive loadings on weeks 12 and 13, and PC2 had a high positive loading on week 2 while PC3 was orthogonal to PC1 and PC2 and loading heavily on body weight at week 1.

Figure 5.11 shows the scree plot for the distribution pattern of the Eigen values with respect to the first component. The first component which is characterized with the highest value 16.270 which had the longest and most ascending curve followed by the other 2 significant components after which the curve flattens out in a declining form after the third component.

Table 5.56: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in GG x YEC Strains of Chicken

PARAMETERS	PC1	PC2	PC3	COMMUNALITIES
Day-old	0.754	0.000	0.308	0.664
wk1	0.258	0.499	0.779	0.923
wk2	0.539	0.633	0.138	0.711
wk3	0.758	0.536	-0.074	0.868
wk4	0.816	0.484	-0.028	0.900
wk5	0.841	0.465	-0.126	0.939
wk6	0.917	0.279	-0.185	0.952
wk7	0.944	0.216	-0.168	0.967
wk8	0.973	0.069	-0.088	0.959
wk9	0.955	0.029	-0.257	0.980
wk10	0.957	-0.042	-0.235	0.974
wk11	0.967	-0.061	-0.187	0.973
wk12	0.975	-0.119	-0.114	0.979
wk13	0.977	-0.151	-0.052	0.981
wk14	0.966	-0.210	-0.013	0.978
wk15	0.959	-0.243	0.039	0.981
wk16	0.943	-0.295	0.118	0.990
wk17	0.916	-0.332	0.171	0.979
wk18	0.911	-0.320	0.202	0.972
Wk19	0.904	-0.307	0.231	0.966
wk20	0.904	-0.296	0.243	0.964
ESTIMATED TOTAL VARIANCE				
EIGEN VALUE	16.270	2.145	1.184	
%TOTAL VARIANCE	77.478	10.215	5.636	
CUMULATIVE %	77.478	87.693	93.329	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2, PC3= Principal component 3.

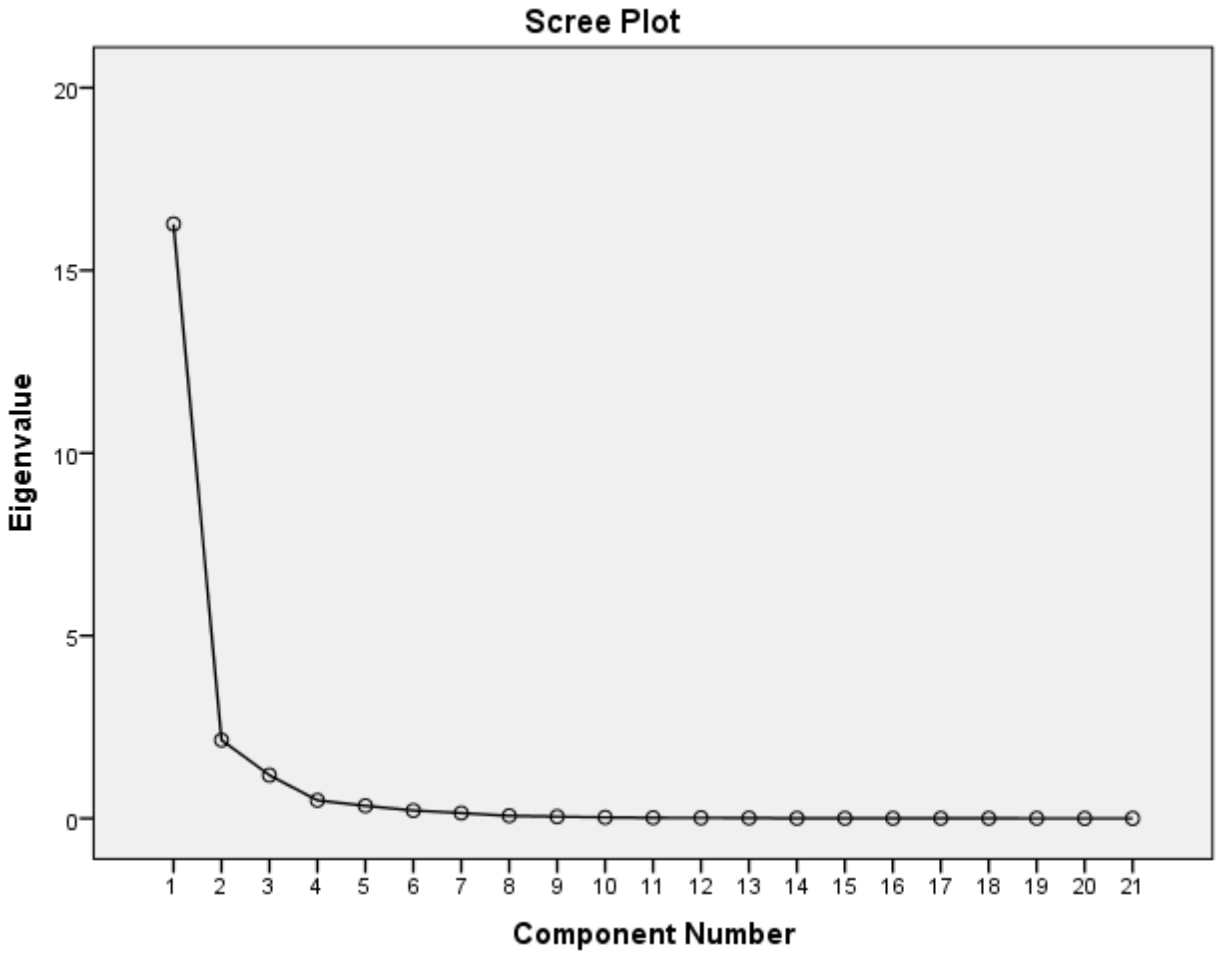


Figure 5.11: Scree plot for body weight in strain GG x YEC

5.5.6.12 Weekly Body Weight in SS x YEC Cross Bred Chickens

The KMO measure of sample adequacy, Bartletts Test of sphericity were not significant in strain SS x YEC hence, these gave credence that the variations are not reliable.The eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight of SS x YEC chicken is presented in Table 5.57. The communality values (0.974 - 0.990) showed that most of the variance has been shared among the variables imputed and which gave credence in classifying them with PCA. Two principal component were extracted from these strain with eigen values of 18.108 for PC1 and 1.770 for PC2 .The two principal components accounted for 94.657% of the total variance, PC1 had high positive loadings on week 10 and 11 while, PC2 was orthogonal to PC1 and loading heavily on body weight at week and 1.

Figure 5.12 shows the scree plot for the distribution pattern of the Eigen values with respect to the first component. The first component which is characterized with the highest value 18.108 had the longest and most ascending curve followed by the next significant components (PC2) after which the curve flattens out in a declining form after the second component.

Table 5.57: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in SS x YEC Strains of Chicken.

PARAMETERS	PC1	PC2	Communalities
Day-old	0.690	0.681	0.940
wk1	0.576	0.766	0.919
wk2	0.865	0.401	0.908
wk3	0.797	0.567	0.956
wk4	0.933	-0.053	0.874
wk5	0.964	0.034	0.930
wk6	0.956	0.006	0.914
wk7	0.956	-0.022	0.915
wk8	0.974	-0.113	0.960
wk9	0.970	-0.162	0.967
wk10	0.986	-0.116	0.986
wk11	0.988	-0.121	0.991
wk12	0.983	-0.099	0.975
wk13	0.978	-0.142	0.977
wk14	0.980	-0.137	0.980
wk15	0.982	-0.131	0.981
wk16	0.979	-0.154	0.982
wk17	0.970	-0.146	0.963
wk18	0.961	-0.137	0.942
Wk19	0.950	-0.141	0.923
wk20	0.937	-0.126	0.894
ESTIMATED TOTAL VARIABLE			
EIGEN VALUE	18.108	1.770	
%TOTAL VARIANCE	86.227	8.431	
CUMULATIVE %	86.227	94.657	

Wk = Weeks, %= Percentage, PC1= Principal component 1, PC2 =Principal component 2

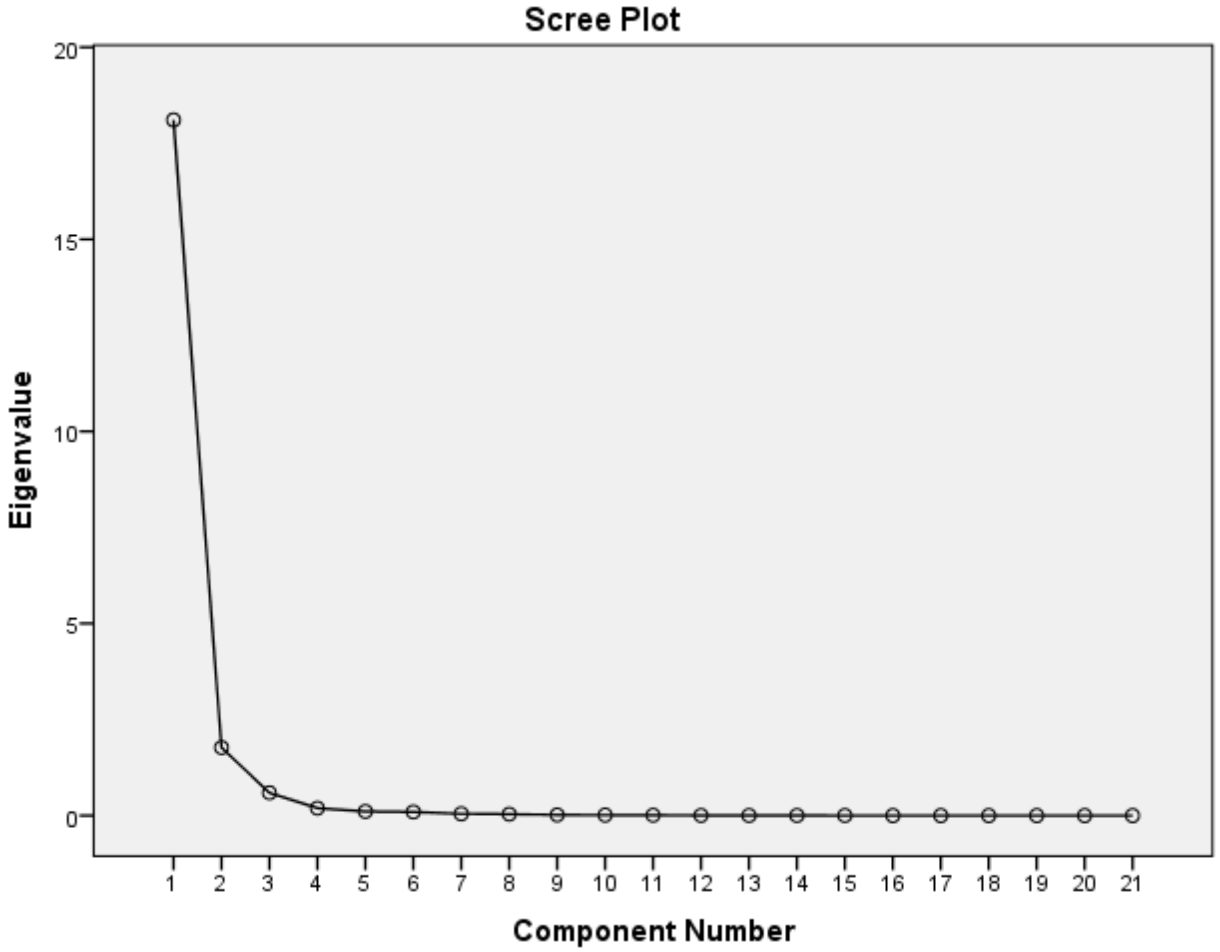


Figure 5.12: Scree plot for body weight in strain SS x YEC.

5.5.6.13 Weekly Body Weight in MM x YEC Cross Bred Chickens

The KMO measure of sample adequacy (0.868), Bartletts Test of sphericity ($p<0.000$) and the Chi square (2090.720) in strain MM x YEC gave credence to the use of PCA. Table 5.58 presents the Eigen values, percentage of total variance along with the rotated component matrix and communalities of weekly body weight in SS x SS chicken. The communality values (0.762 - 0.978) obtained showed that most of the variance has been shared among the variables imputed; hence, the classification with PCA is justified. One principal component was extracted from these strain with Eigen value of 19.906 for the PC1. This principal component accounted for 94.793% of the total variance, PC1 had high positive loadings on weeks 7, 8, 10 and 11.

Figure 5.13, shows the Scree plot showing the distribution pattern of Eigen values with respect to the components, the first component was characterized with the highest value of 19.906 with the longest and most ascending curve after which it declined and then flattens out.

Table 5.58: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of Weekly Body weight in MM x YEC Strains of Chicken.

PARAMETERS	PC1	COMMUNALITIES
Day-old	0.873	0.762
wk1	0.970	0.942
wk2	0.944	0.892
wk3	0.948	0.899
wk4	0.975	0.950
wk5	0.977	0.954
wk6	0.979	0.959
wk7	0.988	0.976
wk8	0.988	0.977
wk9	0.987	0.975
wk10	0.989	0.978
wk11	0.988	0.976
wk12	0.983	0.965
wk13	0.980	0.960
wk14	0.980	0.959
wk15	0.985	0.971
wk16	0.986	0.972
wk17	0.982	0.964
wk18	0.978	0.957
Wk19	0.981	0.963
wk20	0.977	0.954
ESTIMATED TOTAL VARIANCE		
EIGEN VALUE	19.906	
%TOTAL VARIANCE	94.793	
CUMULATIVE %	94.793	

Wk = Weeks, %= Percentage, PC1= Principal component 1.

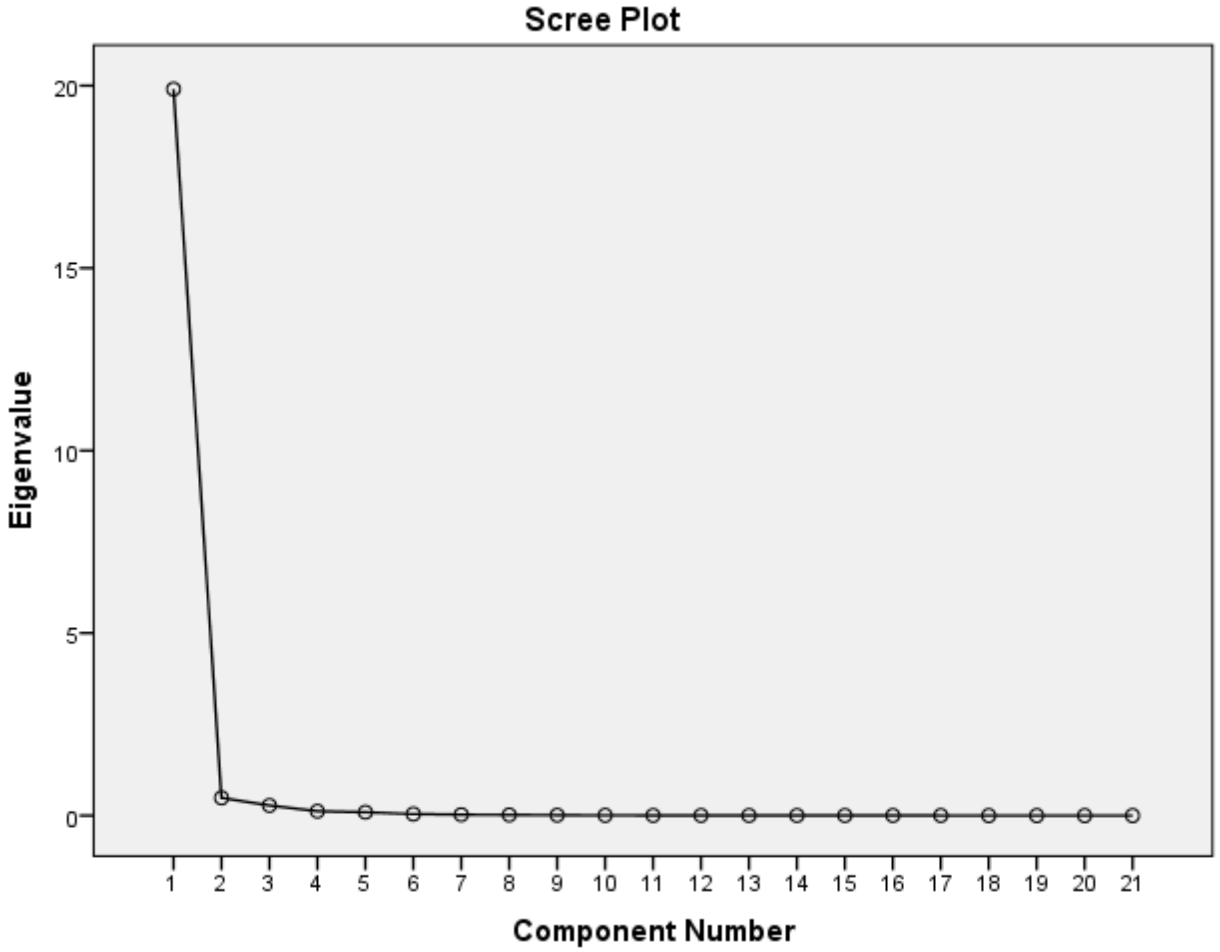


Figure 5.13: Scree plot for body weight in strain MM x YEC

5.5.6.14 Egg Parameters in Pure bred YEC x YEC Hens

Although the KMO measure of sample adequacy(0.566) was within the acceptable limit, However, the Bartletts Test of sphericity was not significant (P-value =0.110), The Chi square value in strain YEC x YEC was 37.413 .

Table 5.59 presents the Eigen values, percentage of total variance along with the rotated component matrix and communalities of egg parameters in YEC x YEC chicken. The communality values of 0.430 to 0.856 showed that most of the variance has been shared among the variables imputed, the egg parameters extracted three principal components that contributed 68.69% of the total variance explained by the 8 parameters tested. The principal component had Eigen values of PC1 (2.684), PC2 (1.674) and PC3 (1.138) with the first PC accounting for 33.548% of the total variance while, PC2 and PC3 accounted for 20.548% and 14.228% of the total variance. The first Principal component PC1 was characterised by high positive loading on egg width and egg number, PC2 had highly positive loading on shell-thickness and PC3 had highly positive loading on egg length.

Figure 5.14, shows the Scree plot of the distribution pattern of Eigen values with respect to the components. The first component was characterized with the highest value of 2.684 with the longest and most ascending curve after which it declined and then flattens out.

Table 5.59: Explained Eigen Value, Percentage of Total Variance, Cumulative Percentage, Principal Components and Communalities of Egg Parameters in YEC x YEC Strain of Chicken.

PARAMETERS	PC1	PC2	PC3	COMMUNALITIES
Egg number	0.855	-0.321	0.049	0.836
Egg weight	-0.084	-0.496	-0.420	0.430
Egg length	0.563	-0.338	0.633	0.832
Egg width	0.864	-0.007	0.112	0.759
Shell weight	0.508	0.351	-0.112	0.394
Shellthickness	-0.228	0.577	0.569	0.708
Albumen weight	-0.740	-0.347	0.433	0.856
Yolk weight	0.157	0.796	-0.146	0.680
ESTIMATED TOTAL VARIABLE				
EIGEN VALUE	2.684	1.674	1.138	
%TOTAL VARIANCE	33.548	20.548	14.223	
CUMULATIVE %	33.548	54.468	68.691	

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

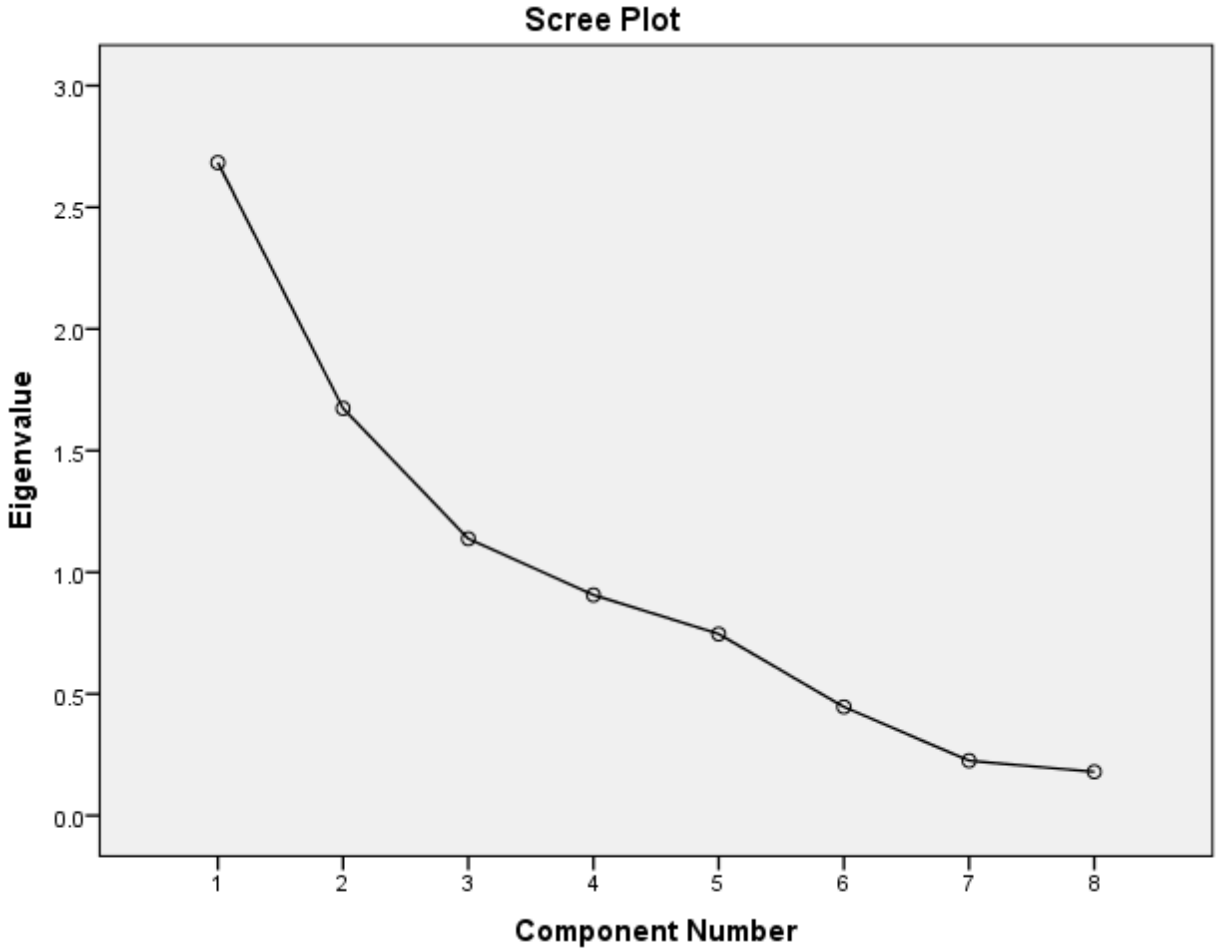


Figure 5.14: Scree plot for egg parameters in strain YEC x YEC

5.5.6.15 Egg Parameters in Pure bred GG x GG

The KMO measure of sample adequacy was low (0.118), Bartletts Test of sphericity was highly significant ($p<0.000$), The Chi square value was 65.084 in strain GG x GG. The Eigen values, percentage of total variance along with the rotated component matrix and communalities of egg parameters in GG x GG chicken is presented in Table 5.60. The communality values (0.118 to0.993) observed in this study suggest that most of the variance has been shared among the variables imputed, four principal components that contributed 90.335% of the total variance explained by the 8 parameters tested were extracted. The four principal components had Eigen values of PC1 (2.850, 1.962, 1.367 and 1.047 for PC1, PC2, PC3 and PC4, respectively. PC1 accounted for 35.625% of the total variance while, PC2, PC3 and PC4 accounted for 24.524%, 17.093% and 13.093 of the total variance, respectively. PC1 was characterized with high positive loading on yolk weight, PC2 had highly positive loading on egg number and albumen weight. PC3 had highly positive loading on egg length and PC4 had highly positive loading on egg length and albumen weight.

Figure 5.15, showed the Scree plot for the distribution pattern of Eigen values with respect to the components, The first component was characterized with the highest value of 2.850 with the longest and most ascending curve after which it declined and then flattens out.

Table 5.60: Explained Eigen Value, Percentage of Total Variance, Cumulative Percentage, Principal Components and Communalities of Egg Parameters in GG x GG Strain of Chicken.

PARAMETERS	PC1	PC2	PC3	PC4	COMMUNALITIES
Egg number	0.621	0.734	-0.224	0.134	0.993
Egg weight	0.679	-0.532	-0.335	0.178	0.888
Egg length	0.504	-0.307	0.555	0.545	0.953
Egg width	0.558	0.408	-0.679	0.097	0.948
Shell weight	-0.889	0.325	-0.199	0.030	0.936
Shellthickness	0.377	0.512	0.485	-0.522	0.912
Albumen weight	-0.112	0.715	0.345	0.539	0.934
Yolk weight	0.702	0.012	0.207	-0.355	0.663
ESTIMATED TOTAL VARIABLE					
EIGEN VALUE	2.850	1.962	1.367	1.047	
%TOTAL VARIANCE	35.625	24.524	17.093	13.093	
CUMULATIVE %	35.625	60.149	77.242	90.335	

%= Percentage,PC1= Principal component 1,PC2 =Principal component 2,PC3= Principal component 3,PC4 =Principal component 4

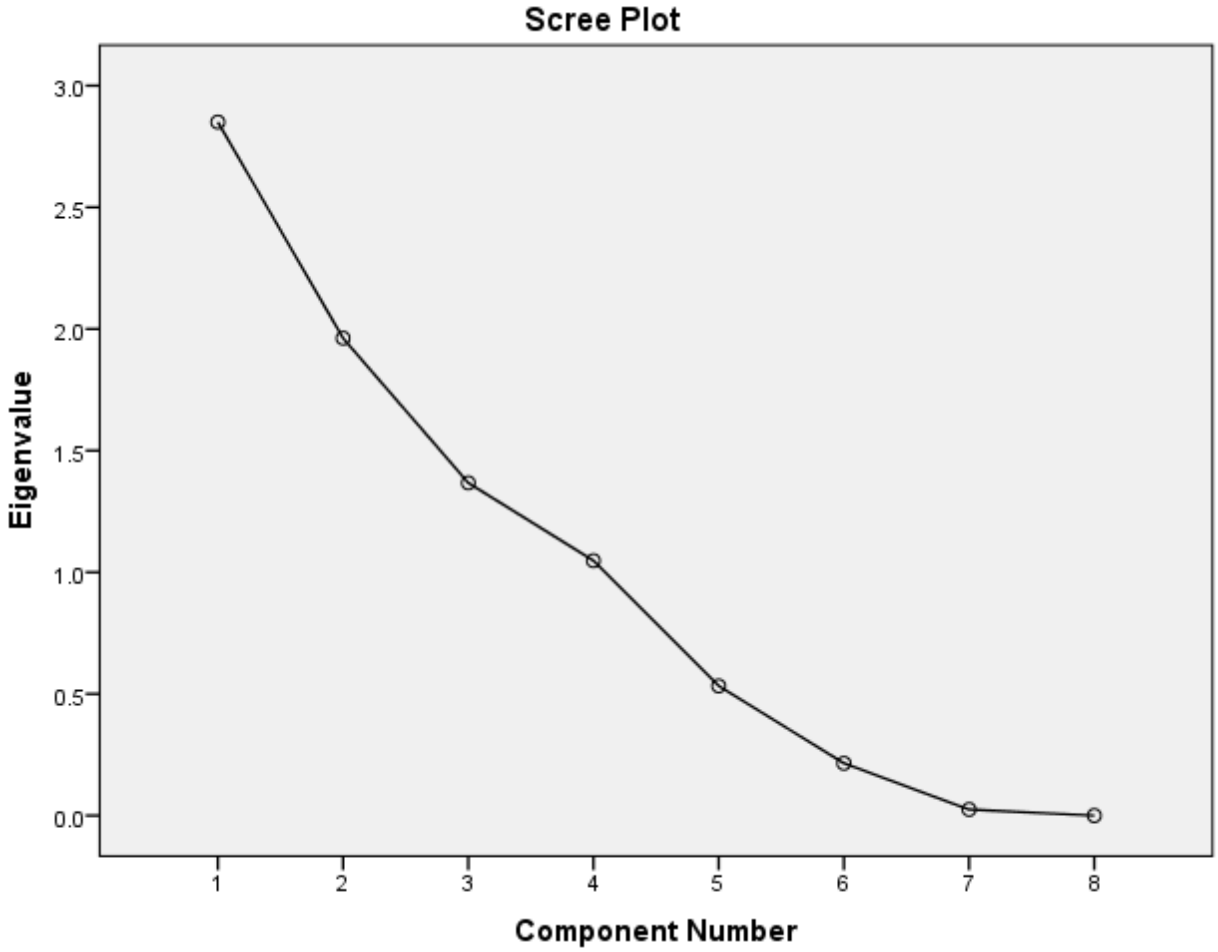


Figure 5.15: Scree plot for egg parameters in strain GG x GG

5.5.6.16 Egg Parameters in Pure Bred SS x SS

Kaiser-Meyer- Olkin measure of sample adequacy (0.104), Bartletts Test of sphericity ($p<0.002$), The Chi square 55.202 in strain SS x SS.

Table 5.61 presents the Eigen values, percentage of total variance along with the rotated component matrix and communalities of egg parameters in SS x SS chicken. The communality values (0.542- 0.973) showed that most of the variance has been shared among the variables imputed, the egg parameters extracted three principal components that contributed 75.116% of the total variance explained by the parameters tested. The principal component had Eigen values of (2.626, 1.858, and 1.526) for PC1, PC2 and PC3 respectively. PC1 accounting for 32.823% of the total variance while, PC2 and PC3 accounted for 23.221% and 19.071% of the total variance. PC1 was characterised with high positive loading on egg weight and shell thickness, PC2 highly positive loading on egg width and PC3 highly positive loading on shell weight.

Figure 5.16, shows the Scree plot showing the distribution pattern of eigen values with respect to the components ,the first component was characterized with the highest value of 2.626 with the longest and most ascending curve after which it decline and flattens out.

Table 5.61: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of egg parameters in SS x SS Strain of Chicken

PARAMETERS	PC1	PC2	PC3	COMMUNALITIES
Egg number	0.290	-0.043	-0.675	0.542
Egg weight	0.832	-0.103	0.276	0.780
Egg length	0.435	0.662	-0.185	0.661
Egg width	-0.249	0.856	0.020	0.795
Shell weight	0.180	0.508	0.695	0.774
Shellthickness	0.826	-0.089	-0.428	0.873
Albumen weight	0.546	0.523	-0.195	0.610
Yolk weight	0.765	-0.366	0.505	0.973
ESTIMATED TOTAL VARIABLE				
EIGEN VALUE	2.626	1.858	1.526	
%TOTAL VARIANCE	32.823	23.221	19.071	
CUMULATIVE %	32.823	56.044	75.116	

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

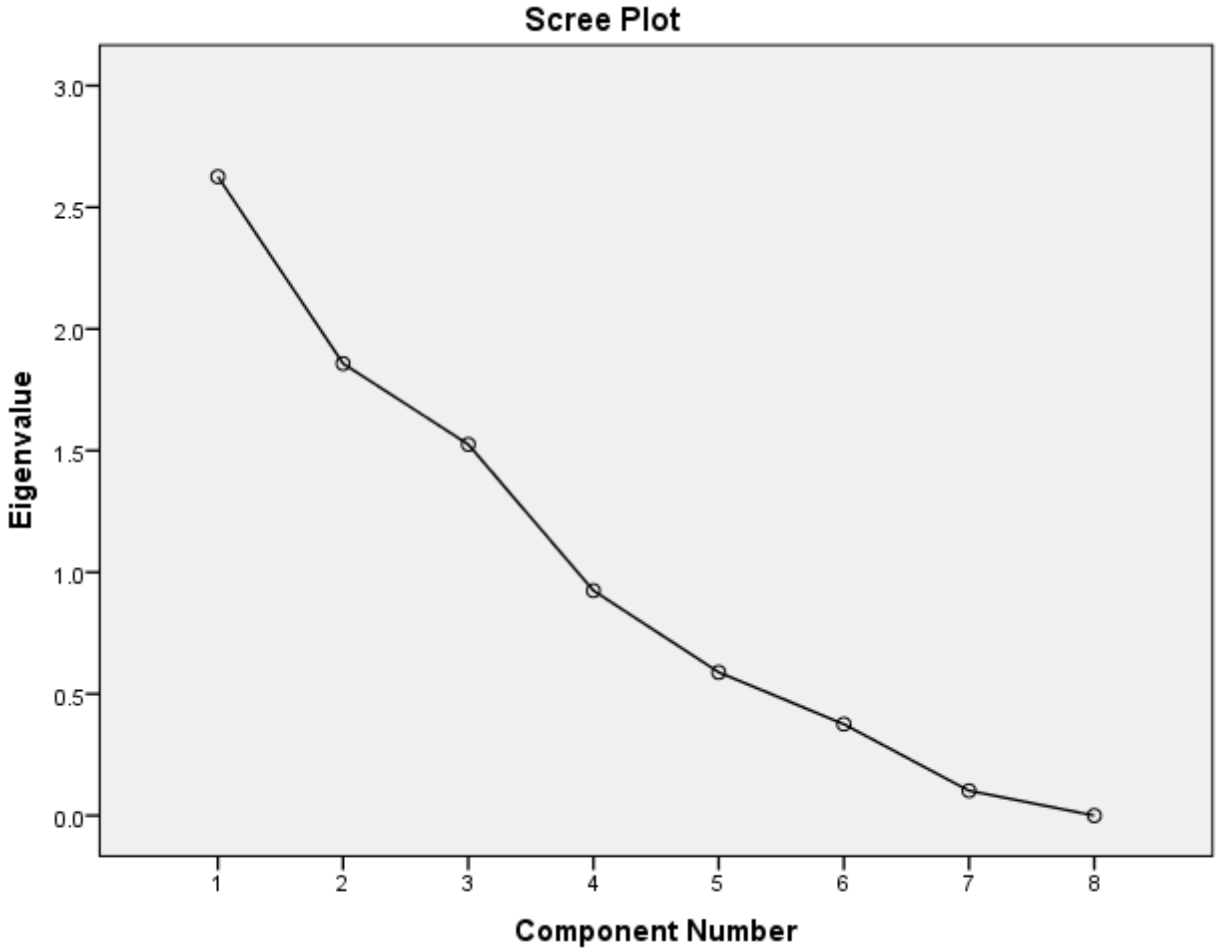


Figure 5.16: Scree plot for egg parameters in strain SS x SS

5.5.6.17 Egg parameters in cross bred strain YEC x GG

The Kaiser-Meyer- Olkin (KMO) measure of sample adequacy (0.348), Bartletts Test of sphericity was significant (P<0.000) and the Chi square (31.927) in strain YEC x GG**.**

The Eigen values, percentage of total variance along with the rotated component matrix and communalities of egg parameters in YEC x GG chicken is presented in Table 5.62. The communality values (0.502- 0.932) showed that most of the variance has been shared among the variables imputed, the egg parameters extracted three principal components that contributed 80.404% of the total variance. The principal component had Eigen values of PC1 (3.008), PC2 (2.205) and PC3 (1.221) with PC1 accounting for 37.599% of the total variance while, PC2 and PC3 accounted for 27.541% and 15.264% of the total variance. The first Principal component PC1 was characterized with high positive loading on egg weight, PC2 highly positive loading on shell thickness and PC3 highly positive loading on egg length.

Figure 5.17 shows the Scree plot showing the distribution pattern of Eigen values with respect to the components, the first component was characterized with the highest value of 3.008 with the longest and most ascending curve after which it decline and then flattens out

Table 5.62: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of egg parameters in YEC x GG Strain of Chicken.

PARAMETERS	PC1	PC2	PC3	COMMUNALITIES
Egg number	0.733	0.352	0.479	0.890
Egg weight	0.900	-0.254	-0.196	0.914
Egg length	-0.025	-0.603	0.677	0.823
Egg width	0.195	0.723	-0.257	0.626
Shell weight	-0.621	0.340	-0.020	0.502
Shellthickness	-0.083	0.943	0.192	0.932
Albumen weight	0.743	-0.190	-0.522	0.860
Yolk weight	0.823	0.297	0.344	0.885
ESTIMATED TOTAL VARIABLE				
EIGEN VALUE	3.008	2.203	1.221	
%TOTAL VARIANCE	37.599	27.541	15.264	
CUMULATIVE %	37.599	65.140	80.404	

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

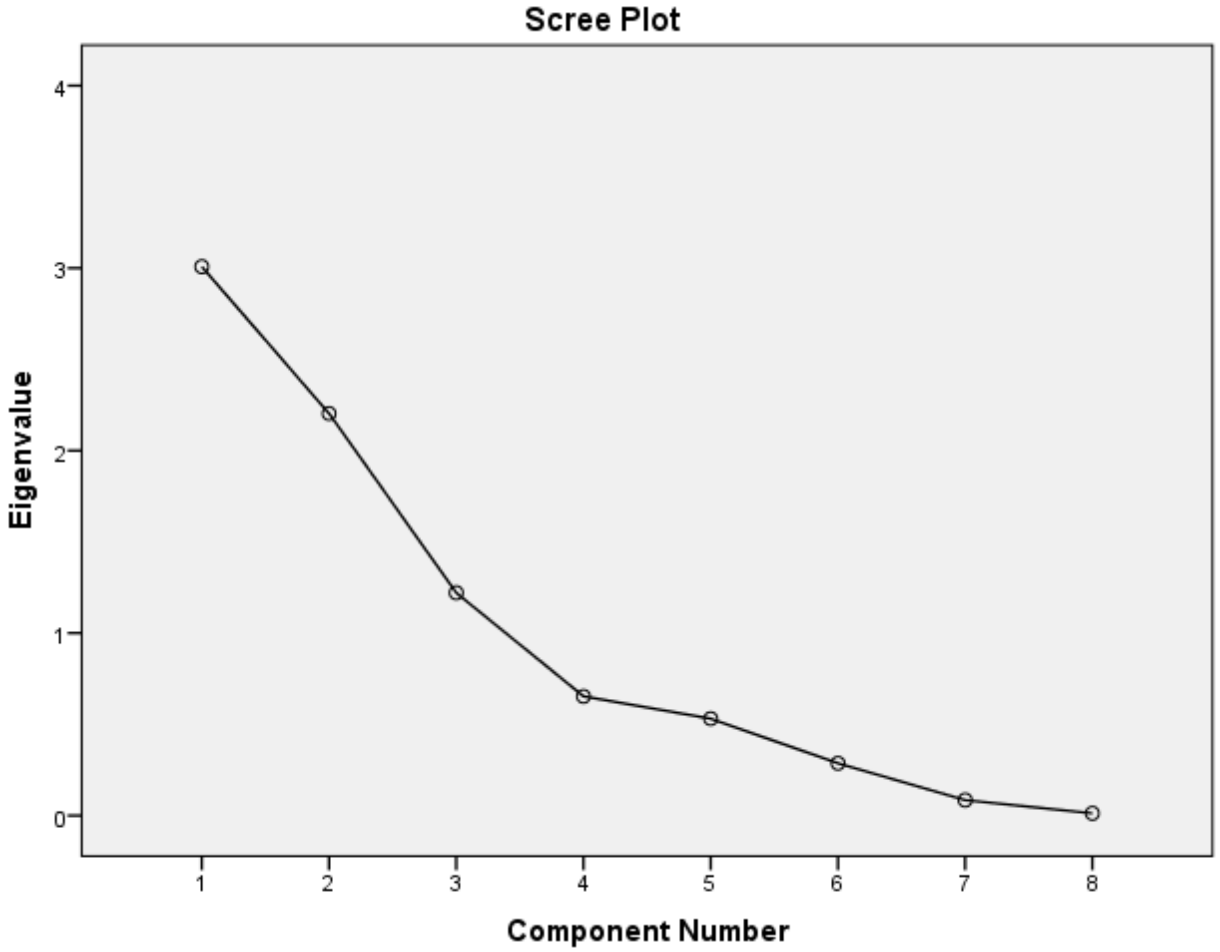


Figure 5.17: Egg Parameters in Pure bred YEC x GG

5.5.6.18 Egg parameters in cross bred strain YEC x SS

Although the Kaiser-Meyer- Olkin (KMO) measure of sample adequacy was within the acceptable limit (0.189), Bartletts Test of spericity was not significant (Pvalue = 0.279) and The Chi square value of 31.883 in strain YEC x SS .

Table 5.63 represents the Eigen values, percentage of total variance along with the rotated component matrix and communalities of egg parameters in YEC x SS chicken. The communality values (0.701- 0.901) obtained in this present study suggest that most of the variance has been shared among the variables imputed, the egg parameters extracted three principal components that contributed 77.845% of the total variance explained by the 8 parameters tested. The principal component had Eigen values of PC1 (3.173), PC2 (1.688) and PC3 (1.367) with PC1 accounting for 39.666% of the total variance while, PC2 and PC3 accounted for 21.095% and 17.084% of the total variance. The first Principal component was characterized by high positive loading on shell weight, PC2 highly positive loading on egg width and PC3 highly positive loading on shell thickness.

Figure 5.18 shows the Scree plot showing the distribution pattern of Eigen values with respect to the components, the first component was characterized with the highest value of 3.173 with the longest and most ascending curve after which it decline and flattens out.

Table 5.63: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of egg parameters in cross bred YEC x SS of Chicken.

PARAMETERS	PC1	PC2	PC3	COMMUNALITIES
Egg number	-0.860	-0.041	0.191	0.778
Egg weight	0.496	0.349	0.586	0.712
Egg length	0.697	-0.434	-0.340	0.790
Egg width	0.117	0.901	-0.173	0.855
Shell weight	0.856	0.360	0.198	0.901
Shellthickness	-0.525	-0.277	0.624	0.741
Albumen weight	-0.546	0.220	-.0636	0.750
Yolk weight	0.619	-0.557	-0.094	0.701
ESTIMATED TOTAL VARIABLE				
EIGEN VALUE	3.173	1.688	1.367	
%TOTAL VARIANCE	39.666	21.095	17.084	
CUMULATIVE %	39.666	60.762	77.845	

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

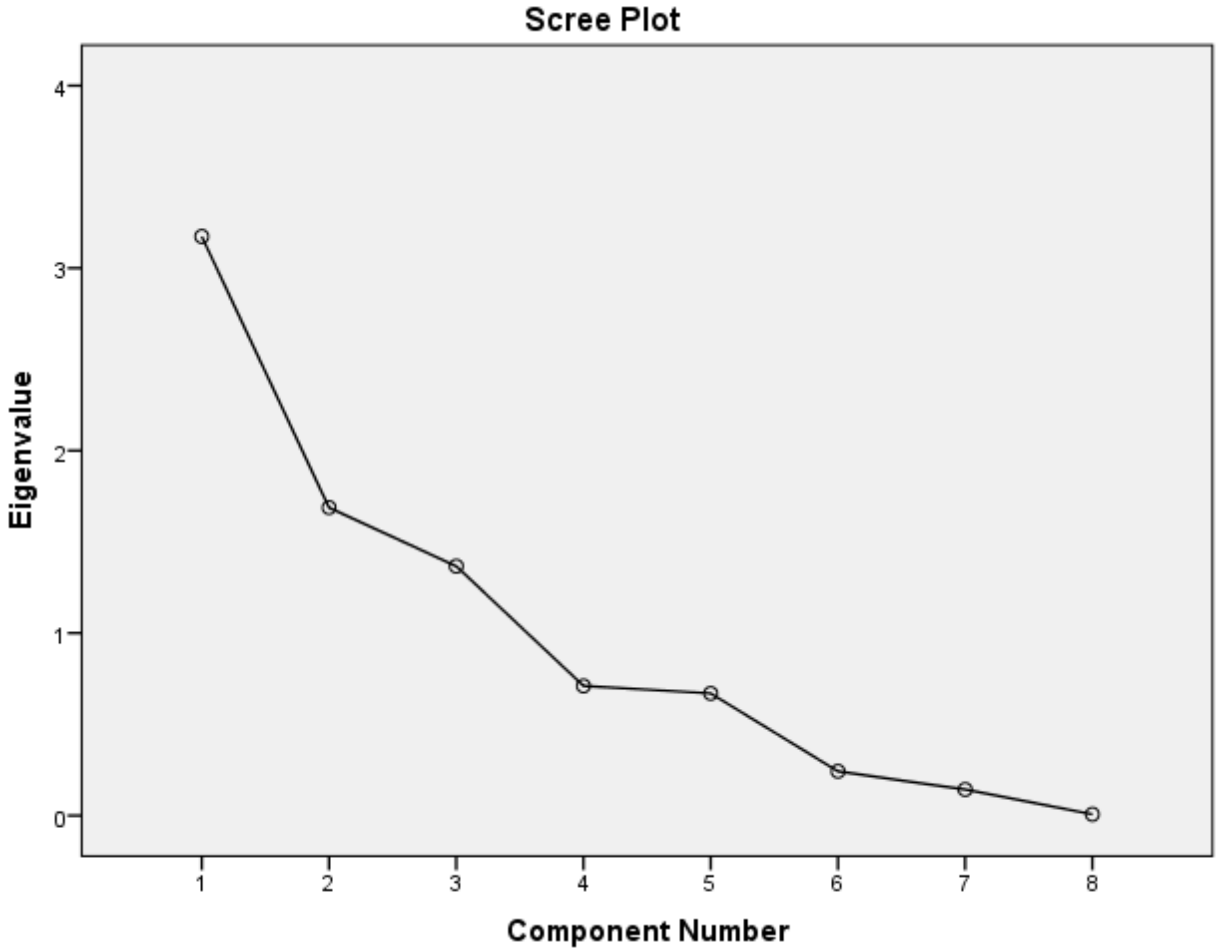


Figure 5.18: Scree plot for egg parameters in strain YEC x SS

5.5.6.19 Egg parameters in cross bred strain GG x YEC

The KMO measure of sample adequacy (0.268), Bartletts Test of sphericity was significant ($p<0.000$), the Chi square (18.689) in strain GG x YEC.

The Eigen values, percentage of total variance along with the rotated component matrix and communalities of egg parameters in GG x YEC chicken are shown in Table 5.64. The communality values (0.545 - 0.952) showed that most of the variance has been shared among the variables imputed, the egg parameters extracted four principal components that contributed 73.831% of the total variance explained by the 8 parameters tested. The principal component had Eigen values of (2.184, 1.344, 1.276 and 1.102) for PC1, PC2, PC3 and PC4 respectively. The PC1 accounting for 27.305% of the total variance while, PC2, PC3 and PC4 accounted for 16.799%, 15.947% and 13.779% of the total variance. The first Principal component was characterized with high negative loading on shell weight, PC2 highly negative loading on egg weight while, PC3 had highly positive loading on yolk weight and PC4 highly positive loading on shell thickness.

Figure 5.19, shows the Scree plot showing the distribution pattern of eigen values with respect to the components ,the first component was characterized with the highest value of 2.184 with the longest and most ascending curve after which it decline and flattens out.

Table 5.64: Explained Eigen Value, Percentage of total Variance, Cumulative Percentage, Principal Components and Communalities of egg parameters in GG x YEC Strain of Chicken.

PARAMETERS	PC1	PC2	PC3	PC4	COMMUNALITIES
Egg number	0.835	0.001	-0.147	0.098	0.728
Egg weight	0.033	-0.646	0.466	0.236	0.691
Egg length	-0.101	0.631	0.443	-0.139	0.625
Egg width	0.554	0.596	-0.047	-0.072	0.670
Shell weight	-0.894	0.125	-0.151	0.209	0.880
Shellthickness	-0.116	0.325	-0.204	0.889	0.952
Albumen weight	0.595	-0.145	0.117	0.395	0.545
Yolk weight	-0.057	0.173	0.872	0.148	0.816
ESTIMATED TOTAL VARIABLE					
EIGEN VALUE	2.184	1.344	1.276	1.102	
%TOTAL VARIANCE	27.305	16.799	15.947	13.779	
CUMULATIVE %	27.305	44.104	60.052	73.831	

%= Percentage, PC1= Principal component 1, PC2 =Principal component 2, PC3= Principal component 3, PC4= Principal component 4.

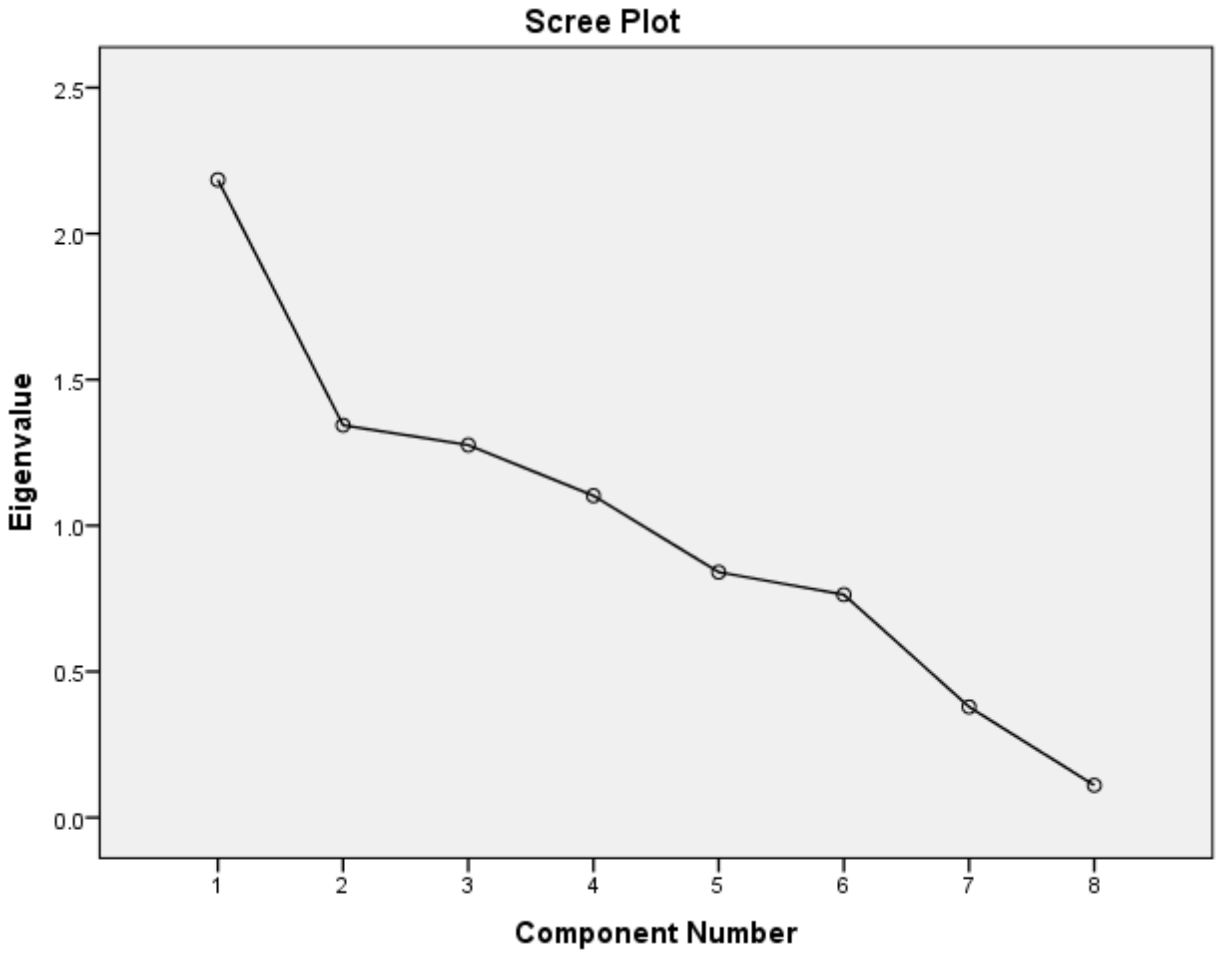


Figure 5.19: Scree plot for egg parameters in strain GG x YEC

Table 5.65: Explained Eigen Value, Percentage of Total Variance, Cumulative Percentage, Principal Components and Communalities of Egg Parameters in SS x YEC Strain of Chicken.

PARAMETERS	PC1	PC2	PC3	PC4	COMMUNALITIES
Egg number	0.282	0.834	0.186	-0.258	0.876
Egg weight	-0.797	0.364	0.266	-0.120	0.852
Egg length	0.774	-0.280	-0.366	0.198	0.851
Egg width	0.788	0.283	0.131	0.061	0.721
Shell weight	0.200	-0.407	0.767	0.113	0.806
Shellthickness	-0.426	-0.139	0.291	0.612	0.661
Albumen weight	-0.357	0.375	-0.488	0.548	0.807
Yolk weight	0.440	0.466	0.309	0.476	0.733
ESTIMATED TOTAL VARIABLE					
EIGEN VALUE	2.476	1.530	1.264	1.038	
%TOTAL VARIANCE	30.954	19.126	15.798	12.981	
CUMULATIVE %	30.954	50.080	65.878	78.859	

%= Percentage,PC1= Principal component 1,PC2 =Principal component 2,PC3= Principal component 3,PC4= Principal component 4.

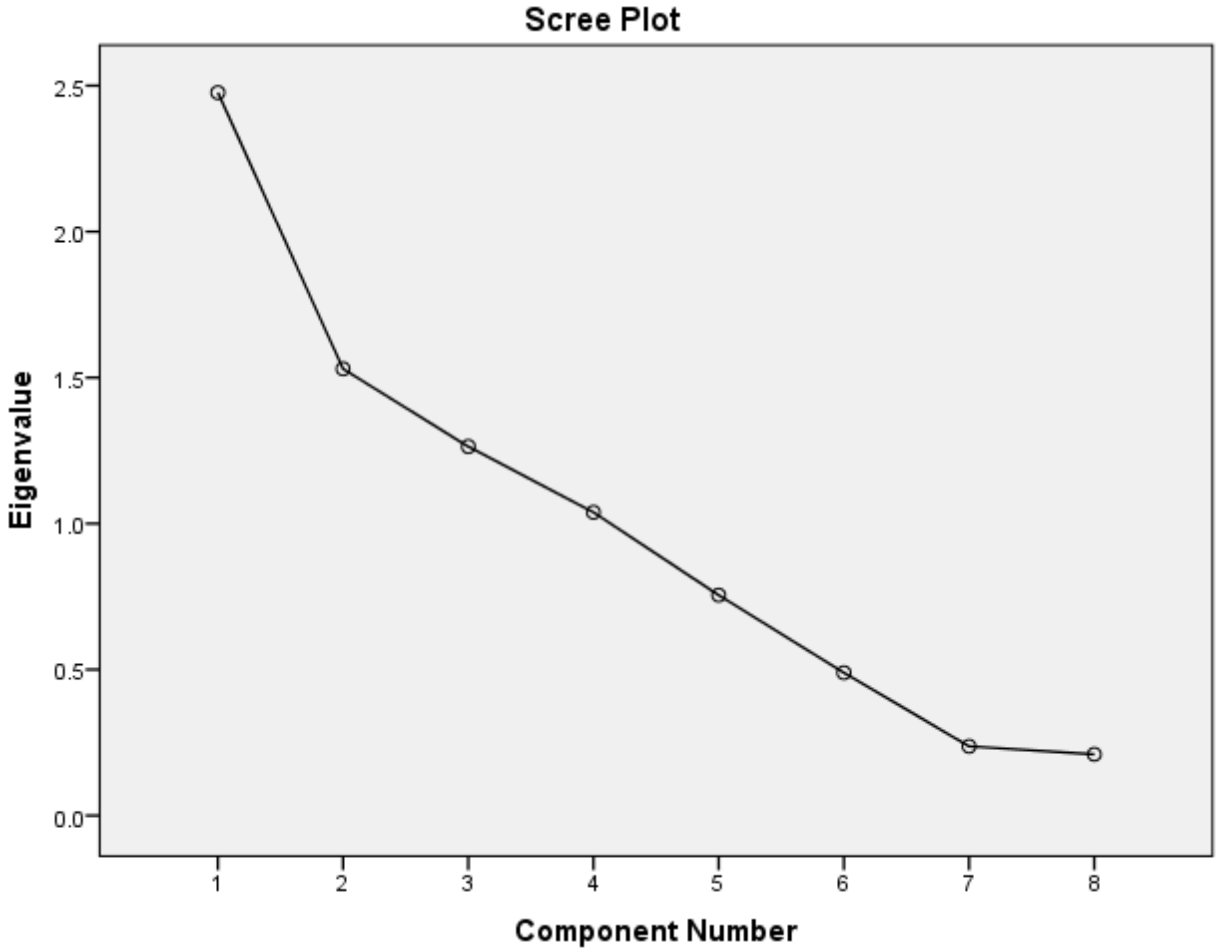


Figure 5.20: Scree plot for egg parameters in SS x YEC

5.5.7 Hierarchical Cluster Analysis

5.5.7.1 Cluster analysis for body weight in all the srains, pure bred and crossbred chickens

The strains were clustered according to their genetic similarity using body weight, egg number and egg weight. It was revealed by the dendogram that the strains were clearly separated from each other using body weight as a criterion. The dendogram for body weight in all the 10 strains is shown on Fig 5.21. The strains were closely related, with the mean genetic similarity among the 10 strains being 6% while MM x MM and SS x YEC were the most distinct .The strains were separated into two main clusters with the first cluster consisting of two sub-clusters that comprised SS x SS, YEC x GG, YEC x MM, GG x GG while the second sub-cluster consisted of GG x YEC, MM x YEC, YEC x SS, YEC x YEC. The second cluster is made up of MM x MM and SS xYEC as a distinct strain with mean genetic similarity of 25%.

Figure 5.22 revealed the dendogram of body weight in purebred strains of chicken. From the dendogram, it was revealed that the strains were clearly separated from one another. Two main clusters were generated from the dendogram with the first cluster comprising of two sub-cluster that is made up of GG x GG and SS x SS in the first sub-cluster and YEC x YEC in the second sub-cluster diverging progressively from one another with mean genetic similarity of 6% among the three strains while from GG and SS is 1%. The second cluster consisting of MM x MM as a distinct strain with mean genetic similarity of 25% from other strains with respect to attainment of body weight.

Figure 5.23 represent the dendogram of body weight in crossbred strains. The genetic relatedness in the crossbred groups gave rise to dendogram with two main clusters.The first cluster consisting of GG x YEC, MM x YEC, YEC x SS in one sub-cluster and YEC x GG, YEC x MM in the second sub-cluster with mean genetic similarity of 1% and 4.5 between the two sub

clusters. The second cluster comprised only SS x YEC as a distinct strain while other strains diverged progressively, with mean genetic similarity of 25%.

5.5.7.2 Cluster analysis for egg number in all the srains, pure bred and crossbred chickens.

The dendogram for egg number in seven strains of chicken is shown in Figure 5.24. From the dendogram, all the strains were clearly separated from one another and two main clusters were generated. The first cluster was made up of three sub-set that comprised GG x GG, SS x YEC resulting in 1% mean genetic similarity. The second sub-set of YEC x GG, GG x YEC with 2% mean genetic similarity and thirdly YEC x YEC with mean genetic similarity of 4% from the other subsets. These sub-sets resulted into two sub-clusters having mean genetic similarity of 5%. The second cluster comprises of SS x SS and YEC x SS as most distinct, with mean genetic similarity of 4% from each other and 25 % with other strains in the other sub cluster.

Dendogram for egg number in the pure bred strains is shown in Figure 5.25. It was revealed from the dendogram that the strains were distinct from one another. Dendogram resulted into two clusters, the first comprises of both YEC x YEC and GG x GG with mean genetic similarity of 1%.The second cluster consist of SS x SS as a single distinct strain and mean genetic similarities of 25% with other strains in the first cluster.

Figure 5.26 showed dendogram for egg number in crossbred strains. The dendogram revealed two main clusters with the first consisting of two sub-clusters. The first was made up of sub-set YEC x GG and GG x YEC with mean genetic similarity of 1% while the second sub-cluster was made up of SS x YEC with mean genetic similarity of 3%. The second cluster consisted only YEC x SS as a distinct strain having 25% mean genetic similarities with the first cluster.

5.5.7.3 Cluster analysis for egg weight in all the strains, pure bred and crossbred chickens.

The dendogram for egg weight in all the strains of chicken is shown in Figure 5.27. It was revealed that the strains are clearly separated from one another by generating two distinct clusters that comprised YEC x YEC, SS x YEC and GG x YEC in the first cluster with a mean genetic similarity of 1%. The second cluster consisted two sub clusters with the first having GG x GG and SS x SS while the second sub-cluster made up of YEC x GG and YEC x SS having mean genetic similarity of 4% from the first sub-cluster and 21% from the first cluster.

Figure 5.28 shows the dendogram for egg weight in purebred strains. The dendogram revealed two clusters with the first consisting of GG x GG and SS x SS with mean genetic similarity of 1% while the second cluster comprises of only YEC x YEC as a distinct strain with mean genetic similarity of 25% from the first cluster.

Dendogram for egg weight in crossbred strain is represented in figure 5.29. The dendogram shows that two clusters with the first comprising GG x YEC and SS x YEC with mean genetic similarity of 1%, The second cluster consist of YEC x GG and YEC x SS with mean genetic similarity of 2% from each other and 23% from the first cluster.

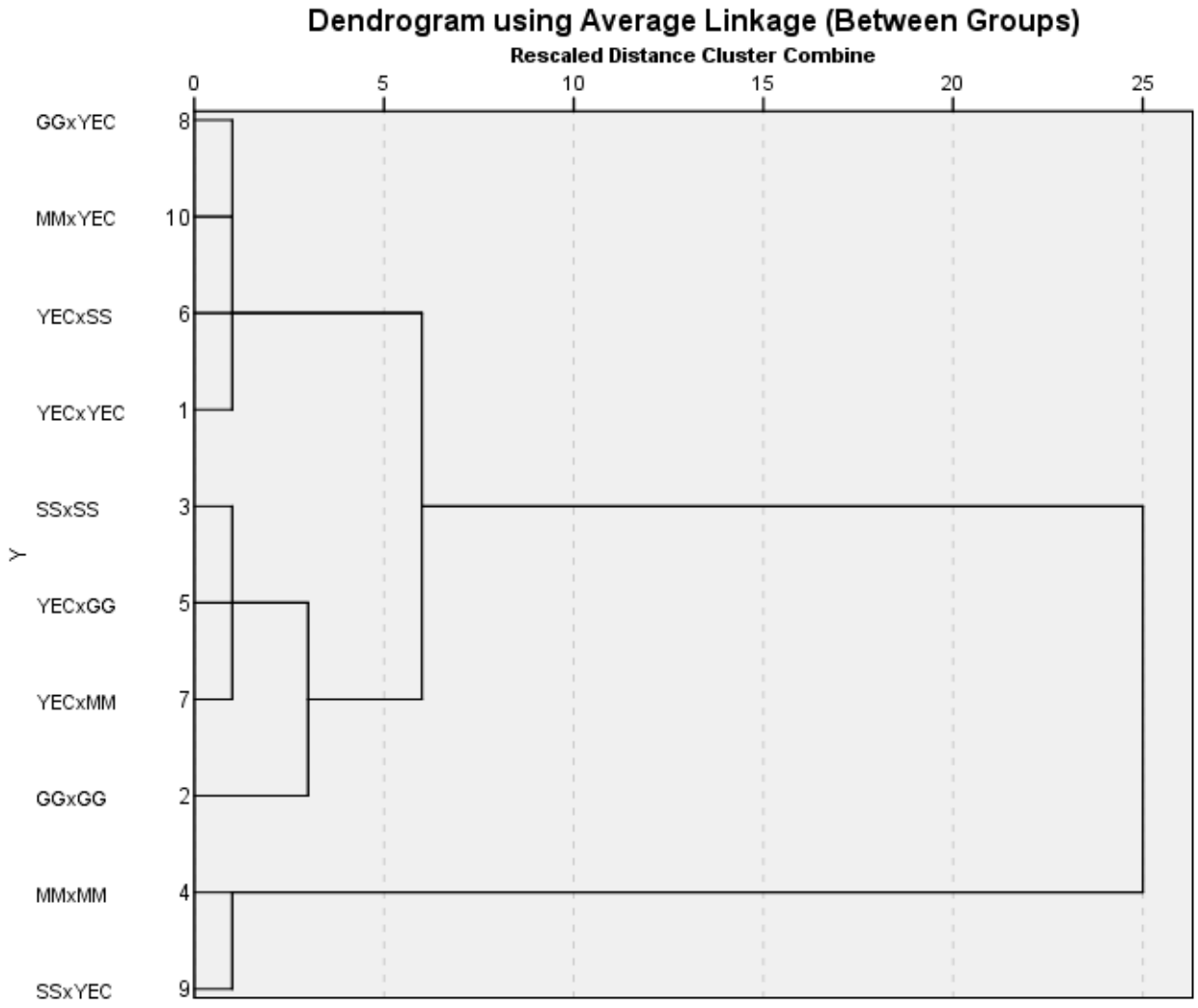


Figure 5.21: Dendogram for body weight obtained from average linkage (between groups) hierarchical agglomerative clustering among ten chicken strains

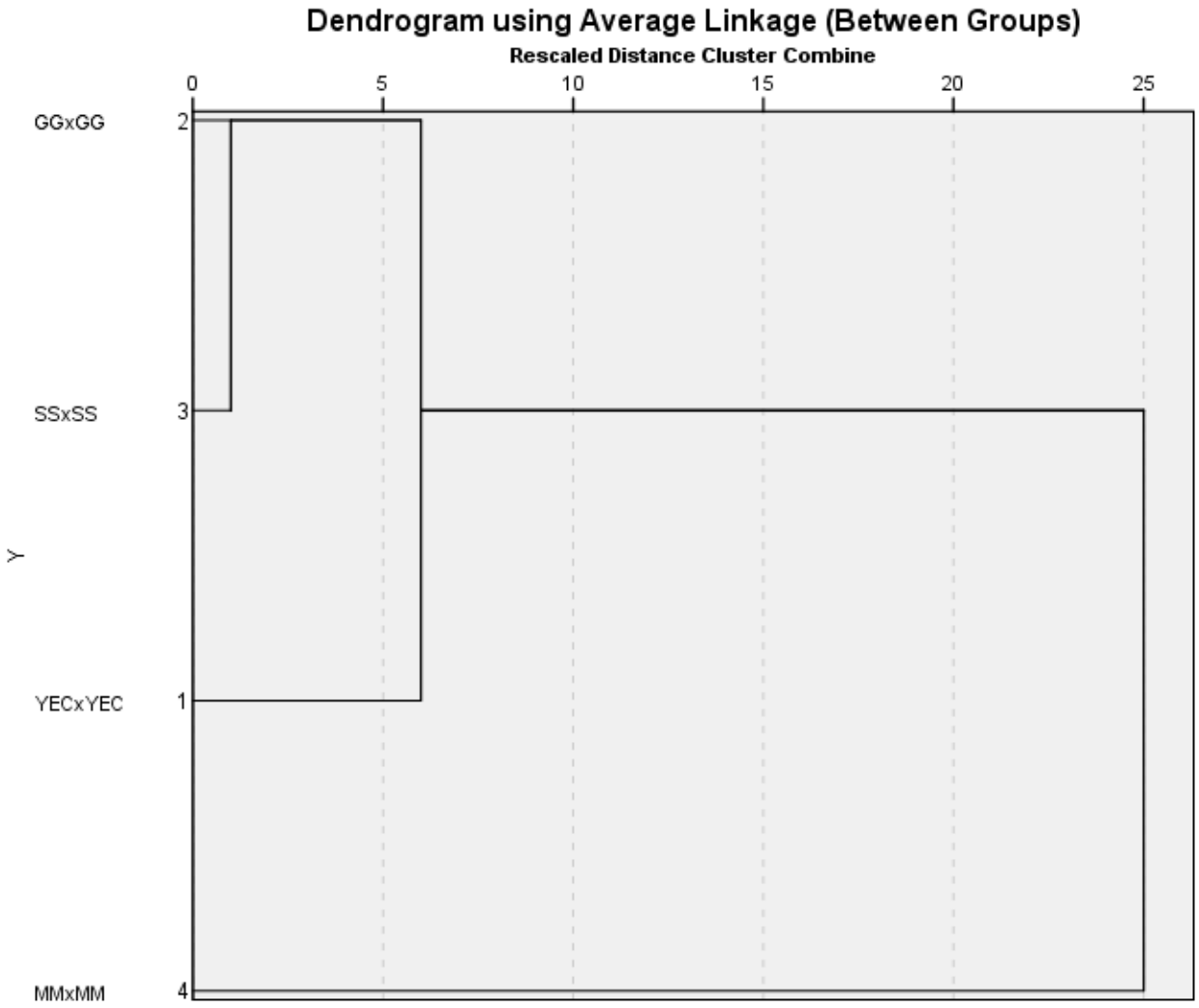


Figure 5.22: Dendogram for body weight obtained from average linkage (between groups) hierarchical agglomerative clustering among purebred chicken strains

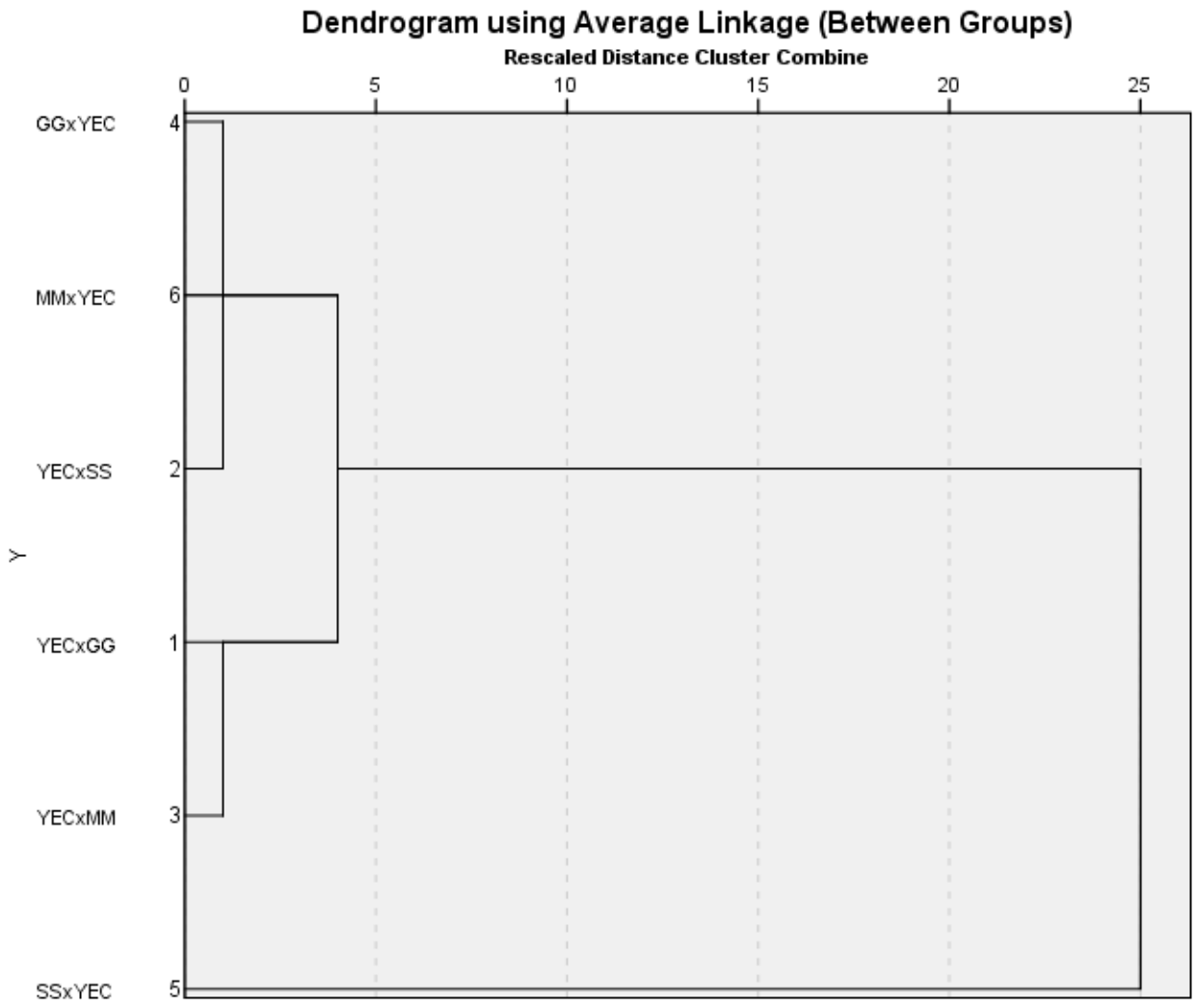


Figure 5.23: Dendogram for body weight obtained from average linkage (between groups) hierarchical agglomerative clustering among crossbred chicken strains

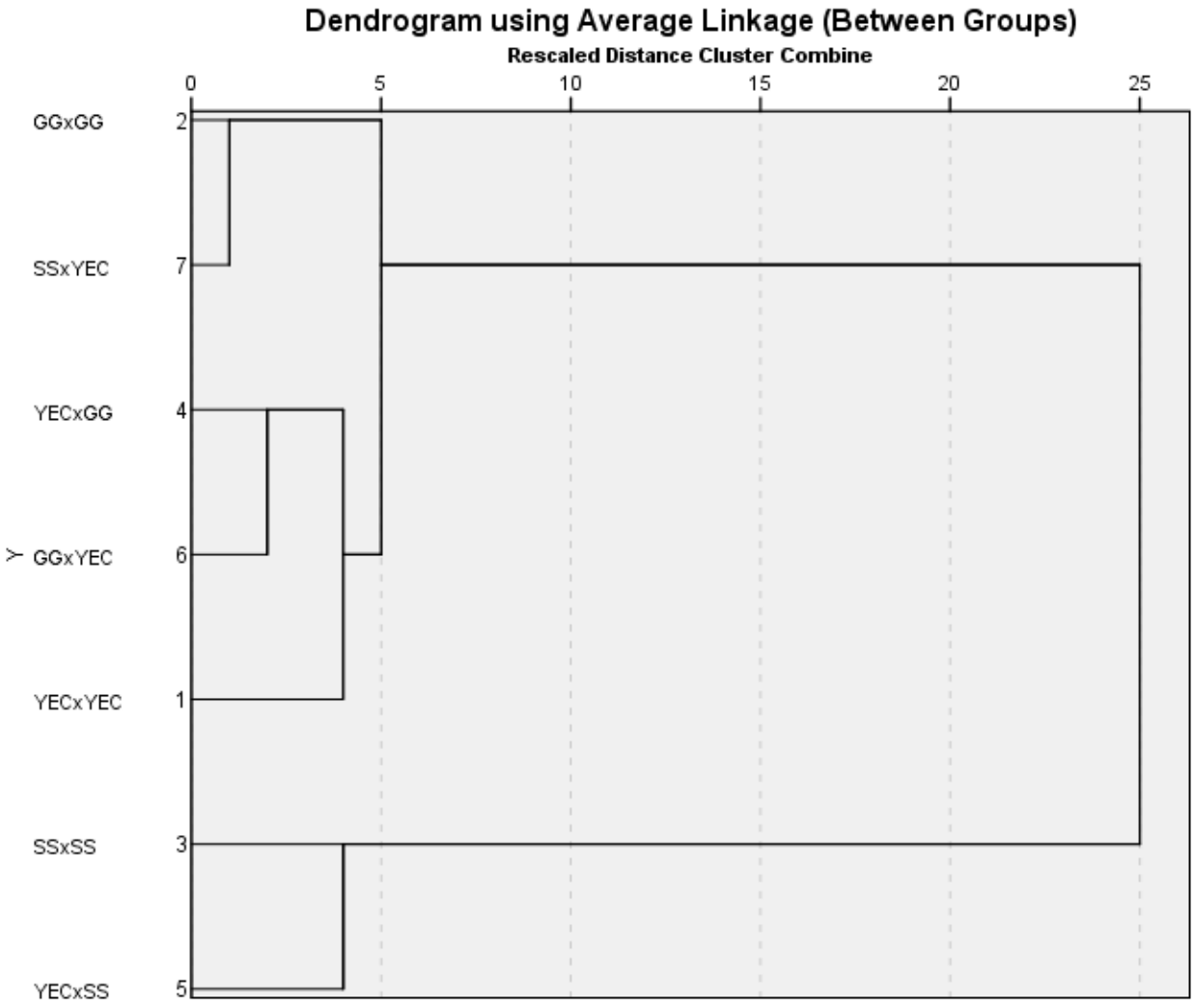


Figure 5.24: Dendogram for egg number obtained from average linkage (between groups) hierarchical agglomerative clustering among seven chicken strains

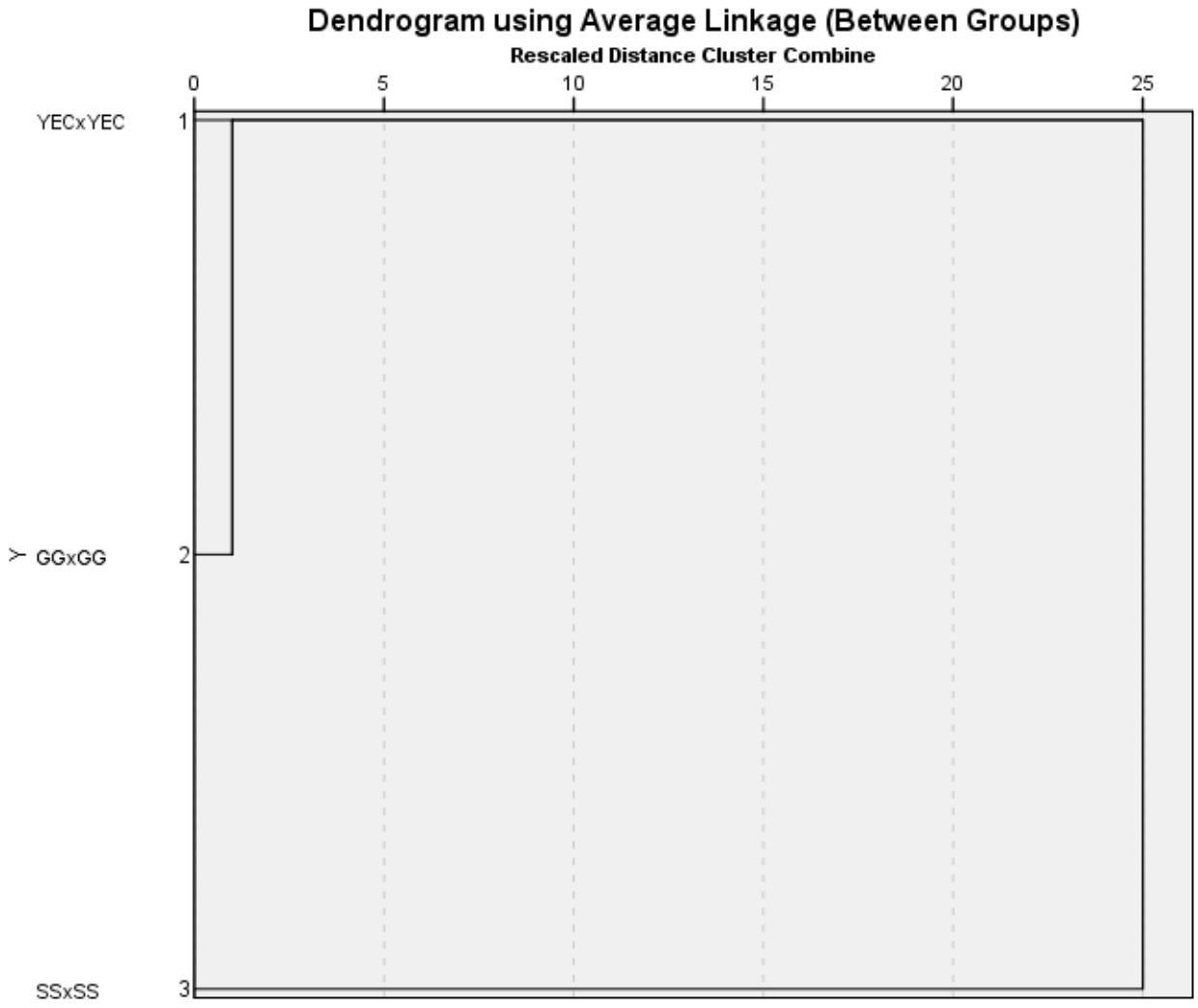


Figure 5.25: Dendogram for egg number obtained from average linkage (between groups) hierarchical agglomerative clustering among purebred chicken strains

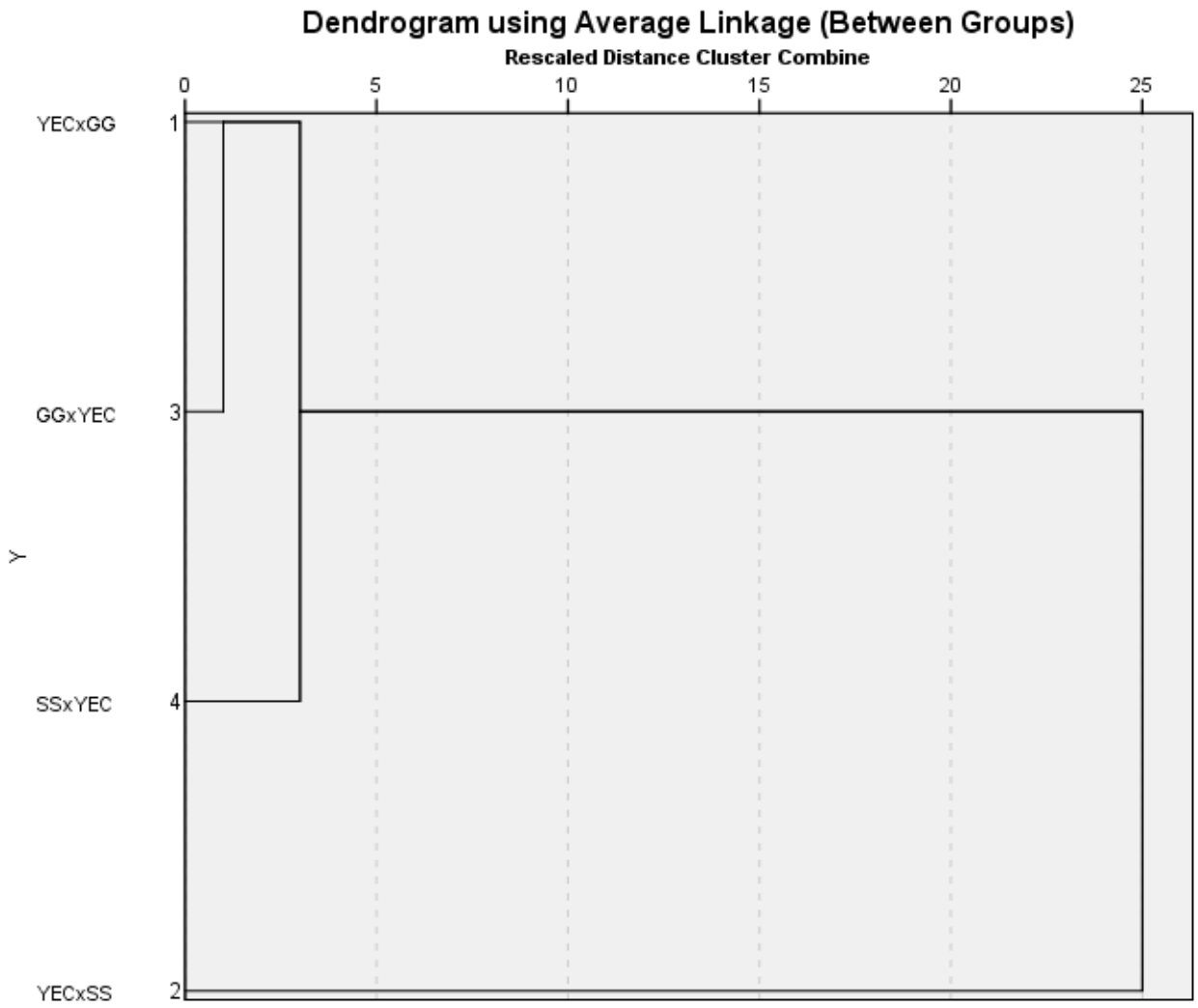


Figure 5.26: Dendogram for egg number obtained from average linkage (between groups) hierarchical agglomerative clustering among crossbred chicken strains

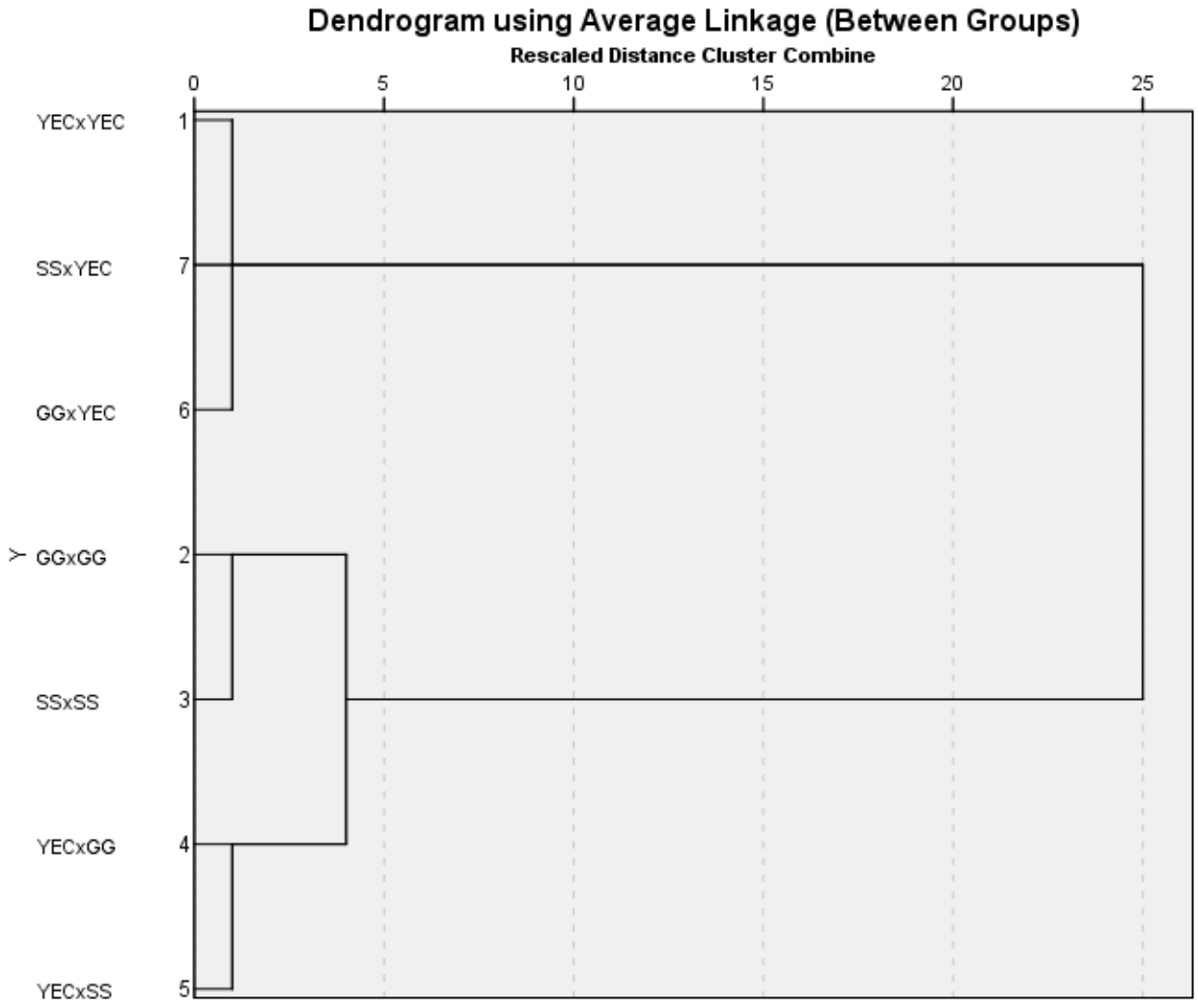


Figure 5.27: Dendogram for egg weight obtained from average linkage (between groups) hierarchical agglomerative clustering among seven chicken strains

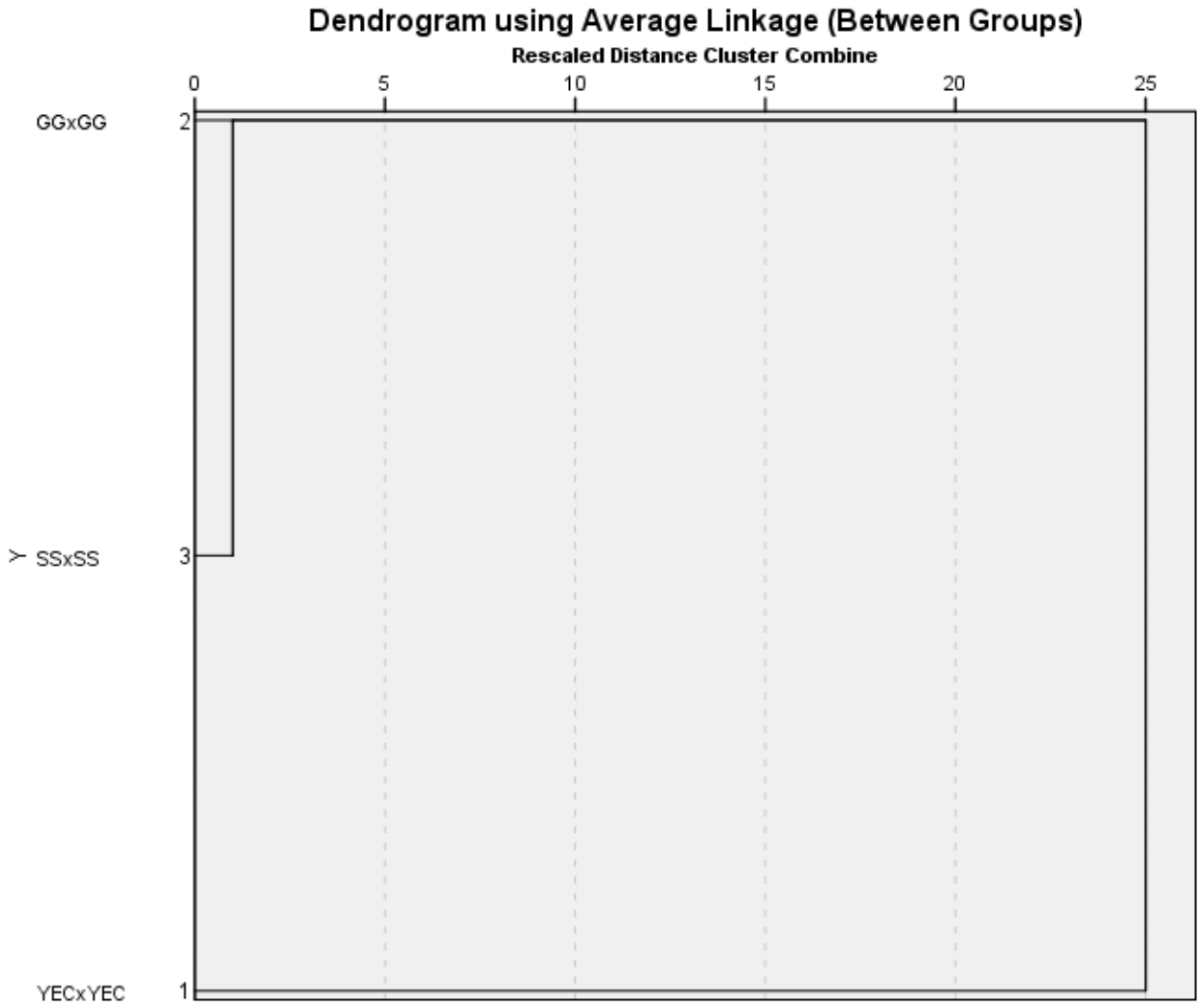


Figure 5.28: Dendogram for egg weight obtained from average linkage (between groups) hierarchical agglomerative clustering among purebred chicken strains

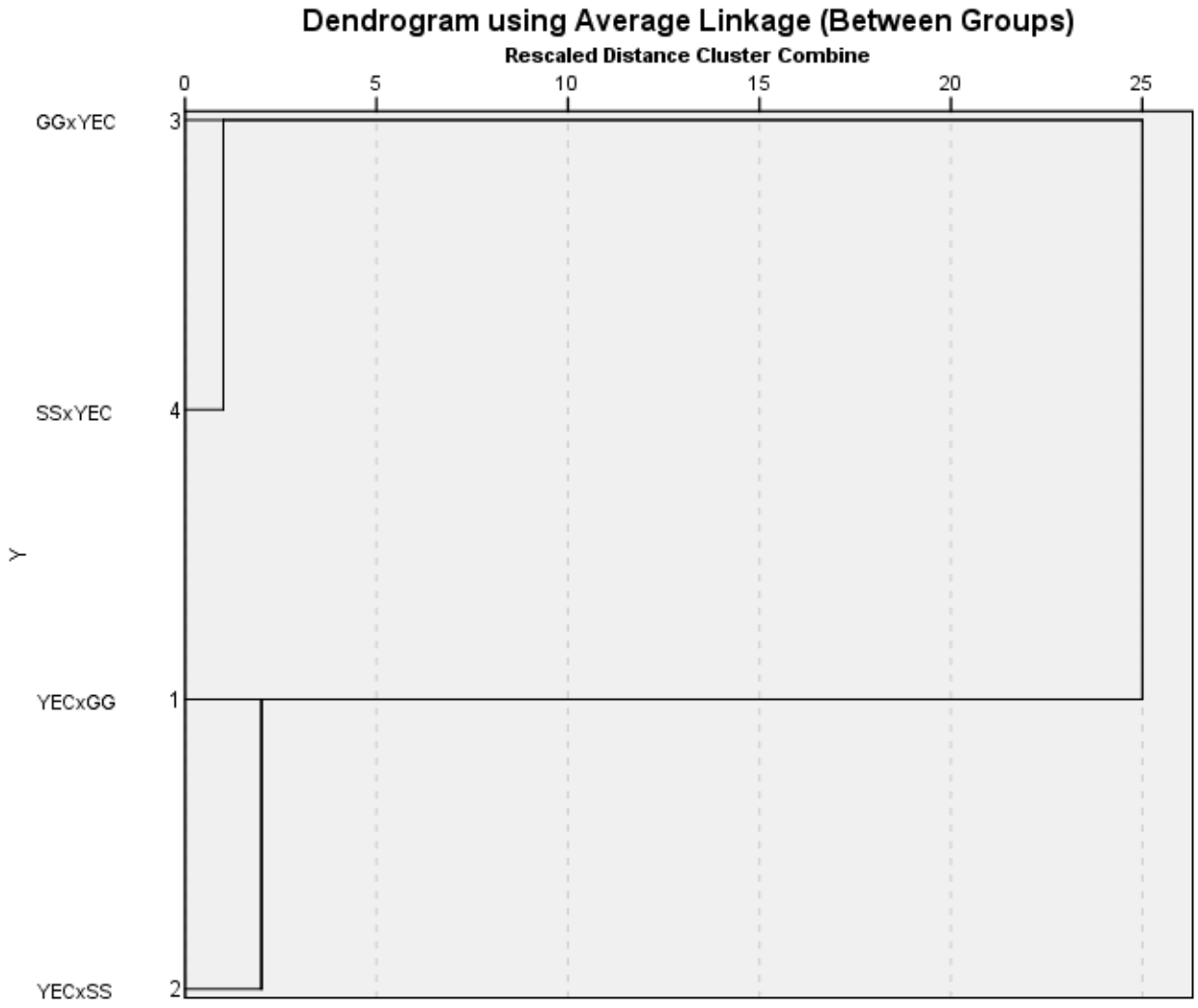


Figure 5.29: Dendogram for egg weight obtained from average linkage (between groups) hierarchical agglomerative clustering among crossbred chicken *strains*

5.6 Discussion

The low heritability estimates for body weight obtained in strains YEC,GG,SS and their cross breds in this study implies that the influence of additive genes were low and there is a large contribution fron the non-additive genes on the determination of body weights in the strains considered. It further suggests that heritability estimates for weekly body weight is largely a function of environmental factors. It is also possible to obtain low heritability where there is less genetic variability among different strains. Fayeye (2014) stated that crossbreeding may be appropriate other than direct selection for traits that are low in heritability. The heritability values obtained for body weight of chickens in the present study were lower than the value obtained by Rotimi *et al.* (2016) and Udeh (2017) for Nigeria Local Chicken from 4 to 20 weeks of age and those of Osei- Amponsah *et al*. (2013) who obtained an average heritability estimates of 0.54 for body weight in Ghanaian Local chicken from 0 to 40 weeks. Low heritability of body weight is not limited to this study. For instance, the increase in the value of heritability with the age of birds in purebred YEC, YECxGG and GGxYEC suggests that the genetic variability due to additive gene action is probably higher than the non-additive components at these ages. The results were in agreement with the report of Adeleke *et al*. (2011) who obtained moderate to high heritability heritability estimates for body weight in indigenous chicken as the age of bird's increases. The moderate heritability estimate obtained for GG in this study at week 4 is in accordance with the values reported for bodyweight (0.29 to 0.34) at week 8 to 12 by Le Bihan-Duval *et al*. (1997), Mignon- Grasteau *et al*. (1999) and Lariviere *et al*. (2009) in meat- type chickens. The high heritability estimates obtained for strain GG x YEC in this study suggests that additive gene component is important in this strain. This is similar with the findings of Dana *et al*. (2001) who reported high heritability estimates for body weight in Horro chicken of Ethiopia.

Similar trend was reported by Norris and Ngambi (2006) for body weight in local Venda chickens.

The lower heritability estimates obtained in the present study for egg number in YEC was greater than the 0.16 reported by Yousefi Zonuz *et al*. (2013) in Esfahan native chickens. The moderate to high heritability estimates obtain for egg number in other strains were similar to the findings of Kamali *et al*. (2007) who reported moderate heritability estimate (0.49) for egg number for the first 12 weeks of egg production in Iranian indigenous fowls. Dana *et al*. (2010) also obtained moderate to high heritability estimates (0.25 to 0.56), for egg number over a period of 4 to 16 weeks in Horro chicken of Ethiopia.

Low to moderate heritability estimates obtained for egg weight in this study at the early laying phase suggests that early lay egg weight is controlled largely by environmental factors in the investigated strains. The present results support the reports of Kamali *et al*. (2007) and Lwelamira *et al*. (2009) who recorded low heritability values for egg weight in Iranian native fowl and two Tanzanian chicken ecotypes, respectively. Niknafs *et al*., (2012) reported low to moderate heritability estimates (0.17 to 0.43) for egg weight in Mazandaren native chicken while, Yousefi Zonuz *et al*. (2013) also reported low heritability estimate of (0.36) for egg weight of Esfahan native chickens. However, the high heritability estimates obtained for egg weight from weeks 8 up to 24 weeks in YEC, GG, SS, YEC x GG, and YEC x SS, GG x YEC and SS x YEC fall generally within the range reported by Koerhuis *et al*. (1997). The relatively higher heritability estimates for egg weight at mid-lay suggest higher additive gene effects for egg weight of birds at mid-lay. The inconsistent increase observed for heritability estimates as the hen progress in lay suggest that the direct additive genetic variance increased with age for egg production cycle (Ledure *et al*., 2000). The result of the present study indicates that the

heritability estimates of egg production traits varies highly in different strains hence, change in heritability estimates over a period of time may result from the expression of different genes during egg production cycle.

Repeatability estimate for body weight in this study was generally low among all the strains, , which suggests a low additive gene effect on body weight and the need for multiple data to make reasonable selection decision on chick's body weight. The present result was in consonant with the findings of Badmus *et al*. (2013) who reported low to moderate repeatability for body weight in two lines and control groups of chickens. However, findings in this study differ from the reports of Ojedapo (2013) and Kabir *et al*. (2010) who reported high repeatability estimates for body weight in Marshall Broiler chickens. Sanda *et al*. (2014) also reported high repeatability estimates (0.70 to 0.88) for body weight in three strains of broiler at week 4 and week 10.

The low repeatability estimates obtained for body weight in this study further indicate that individual selection may not be appropriate in selecting birds for future production performance it is therefore important to rely on other records like pedigree or collateral records (relatives) in selecting individual for breeding purpose. Also this is an indication that environmental influence on body weight may be high in strains of chicken used in this study.

Low repeatability estimates for egg number obtained for strains YEC and YEC x SS in this study was in agreement with findings of Udeh (2010) who reported low repeatability estimates for egg number in commercial layer strain of chicken. However, the moderate to high repeatability estimates obtain for strains GG, SS, GG x YEC SS x YEC and YEC x GG were in accordance with the findings of Toye *et al*. (2012) who reported high repeatability estimates for egg number in light Harco birds. The result of the present study indicates that SS and GG will likely repeat their present performance on egg number in the future. Generally, strain SS had the

highest repeatability estimate among all the genotypic groups used, which is an indication that it will perform well if kept for future production. SS have been known to be good producers of egg 240- 260 egg /year (Wikipedia, 2014) in the temperate regions.

The low to moderate repeatability estimates obtained for egg weight in respect of strains YEC, YEC x GG, YEC x SS, GG x YEC and SS x YEC supports the findings of Toye *et al*. (2012) who reported low repeatability estimates for egg weight in the light Harco birds and Udeh, (2010) who obtained low repeatability estimates for egg weight in two strains of layer type chicken. Conversely, the high repeatability estimates obtained within some weeks in strains GG and SS were in accordance with the reports of Ayorinde and Sado (1988) who reported repeatability estimates of 0.58 to 0.60 for egg weight in Hubbard layers for a period of 56 days. Ibe (1984) had earlier reported an estimate of 0.76 for egg weight in white leghorn chickens while Korolev (1976) reported an estimate of 0.46 to 0.71 for egg weight in different lines of white leghorn. The result obtained in this study indicates selection decision can be taken on the different strains with high level of accuracy using one or two records. The difference in repeatability estimates for egg number and egg weight among the genotypic groups may be due to variation in the number and types of genes that are involved in egg production among them at different weeks. The observed variability in weekly estimates of repeatability may also be due to the variability in the degree of environmental factors that influences egg production. However, the negative but high repeatability estimates for egg production for some weeks among the strains is an indication that the present result will be exactly opposite in the future. Therefore, selection on the basic of such repeatability values is unreasonable as seemingly good individuals may turn out to be poor performers in the future.

The low genetic correlation between HBW and egg biometric traits for all the strains in the present study indicates that egg production traits considered were not influenced by the same set of genes. The positive association between HBW and EM gave an indication that as the body weight of hen increased the egg mass also increased. Positive and high associations obtained for EN and EW indicated that as the bird progressed in lay with increase egg number, egg weight also increased. Furthermore, egg number, egg mass, shell weight, shell thickness increased with egg weight which is in contrast with the findings of Olori and Sonaiya (1992) and Asuquo (1994) who reported based on their work on Lohmann brown broiler parent lines and Nigeria indigenous chicken, that shell weight and shell thickness will not change for the laying period but shell weight will reduce slightly towards the end of lay.

The low and negative phenotypic correlations between HBW and shell thickness in this study suggests that selection for high body weight may have a negative impact on the shell thickness of birds. Agaviezor *et al*. (2011) reported a negative correlation between body weight and shell thickness. An earlier report by Singh (1990) showed that birds with smaller body size layed smaller eggs, he therefore concluded that irrespective of egg size, the shell remains the same resulting in larger eggs having thinner shells. Ikeobi *et al.* (2004) also reported a high average shell thickness value in normal plumage strain chicken. Shell thickness is an important bio-economic traits which is needed by breeder to reduce egg shell breakages.

The high value recorded for egg weight and shell weight in this study differ from the findings of Yakubu *et al*. (2008) who reported low correlated values for egg weight and shell weight. Variation existed between egg internal quality traits as seen from the result, Albumen weight and egg weight were all positively and highly correlated among all the strains, which is an indication that albumen constitute the bulk of egg weight and most variation in egg weight

among the breed can be accounted for by the weight of the albumen. The results obtained in this study are in accordance with the reports of Asuquo *et al.* (1994) and that of Agaviezor *et al.* (2011), who stated that increased values in egg weight will lead to an increase in internal quality traits. Internal egg quality traits were relatively higher in cross bred and pure bred Sussex laying hens as compared to their pure bred local counterparts (YEC). Thus, the result suggests that selection for increased egg size would directly lead to an increase in albumen weight.

The values obtained for genetic and phenotypic correlation coefficients explained the strength of relationship or association to common causal effects for different traits. Falconer (1996) and Fairfull and Gowe (1990) reported that genetic correlation between egg production and egg weight and between egg production and body weight are generally negative. Also, Cheng et *al.*, (1996) obtained positive but low genetic and phenotypic correlations between egg number and body weight at 40 weeks. They however reported moderate to high phenotypic correlations between egg weight and body weight.

The disparity in the prediction models for late body weight can be attributed to variations among strains in weekly body weight. Furthermore, most of the predictions were accurately obtained at week 4 or with addition of weeks 1, 2 and 3. Hence, late body weight can be accurately predicted from early body weight. The R^2 obtained in this study was higher than the values obtained by Fayeye et al. (2016) while predicting body weight in Rhode Island. Also, Fayeye et al. (2016) concluded that body weight of chicken can be fairly accurately predicted at 0 to 3 weeks of age. It can be concluded from this present study that there is genotypic differences in the weekly prediction, with each strain having a specific week that best predict their late body weight. The present results for egg number and egg weight suggest that they can be predicted from early records. The best accuracy of predicting egg number and egg weight differs within the

strains.Egg number were best predicted by single inclusion or combining weeks (1, 3 and 4) while egg weight had weeks (1, and 4). This implies that these weeks involved in the models are important predictors of latter body weight, egg weight and egg number.

The significant contribution of cubic equation in explaining the total variation in 8 weeks body weight of YEC x YEC, SS x SS, GG x YEC and variation in 20 weeks body weight for GG x GG, SS x SS, YEC x SS, YEC x MM and SS x YEC is consistent with the previous reports of (Fayeye and Ayorinde, 2007, Yakubu *et al*., 2009, Semakula *et al*., 2011). The higher reliability of cubic estimation in explaining the variations in body weight at week 8 and 20 is in accordance with previous work of Semakula *et al*. (2011) who reported that cubic curve function predicted carcass weight of broiler chicken more accurately, The non-significant predictive models of body weight for Marshall (at weeks 8 and 20) and in Goliath (at week 8) suggests that all the models were not important for the prediction of body weight in the two strains. The present results suggests that different predictive function may be employed for predicting body weights in the different strains. For instance, 8 weeks body weights in YEC x MM, SS x YEC were better fitted by both cubic and quadratic equations while, the body weight of YEC x GG was better fitted by quadratic function, Body weight in MM x YEC was better fitted by sigmoid function, while in the prediction of 8 weeks body weight in YEC x SS was better fitted by Compound, Growth, Exponential and Logistics regression models. In predicting for body weight at week 20 in GG x YEC was better fitted by quadratic model, YEC x GG and MM x YEC were better fitted by both cubic and quadratic equations and YEC x YEC was better fitted by compound, growth, exponential and logistic equations. The result of this study reveals that genotypic factor can be responsible for differences in the curvilinear equation that can best predict 8 and 20 weeks body weight from early body weight. This present result implies that the independent variable (wk4) is

only partially responsible for the changes in body weight at weeks 8 and 20 of age in all the genotypic groups.

The positive relationship between weekly body weights gave an insight that latter body weight can be predicted from early body weights. Cumulatively, in the 20 weeks body weight for the 10 genotypic groups, PC1 had the largest share of the total variance and correlated highly with weeks 8, 11 and 9. The largest share of the total variance obtained in PC1 is expected. According to Salako (2006), the PC1 can be described as the generalized form of broilers. Pinto *et al*. (2006) used PCA to analyse performance and carcass trait measured in population of *Gallus gallus* and concluded that the first Principal Component generalized weight because the largest eigen value were associated with body weight at 35 and 42 days of age. Mendes (2009) opined that the first principal component provides an adequate summary of the data in most cases. The percentage of total variance is used as an index to determine how well the total factor solutions account for what the variables together represent (The 20 weekly body weights). The high loading at PC1 implies that there is a high positive correlation between the components and the variables. Considering the 20 weeks body weight measurement of 10 strains of chicken, PC1 had the largest share of the total variance and PC2 was orthogonal to PC1 .This implies that the two principal components could be used to define the weekly body weight of the chicken strains used in this study.However, they can further be used as selection criteria for improving weekly body weight in chickens.

Strains SS x SS, YEC x GG, YEC x MM and MM x YEC had just one Principal component, hich suggests that one PC is sufficiently to described the animals with respect to the amount of variance that exist in their weekly body weight. It further showed that the PCs were reliable in predicting body weight at week 20. Although, strains GG x GG, MM x MM, YEC x SS had two

PCs (PC1 and PC2). The additional contributions from PC2 to the cumulative percentage variance were comparatively lower. This implies that the highest variance is associated with the characterized weekly body weight describing these PCs. Also, in individual strains, PC 1 had the highest share of the total variance for egg characteristics. Egg quality traits in YEC x YEC were best described by 3PCs with high positive loading for egg width, egg number, and egg length and shell thickness. Strain SS x SS was best described by external quality traits (egg weight, egg width, shell thickness and shell weight). Similarly, YEC x GG and YEC x SS were both described by external qualities egg weight, egg width, egg length, shell thickness and shell weight while, strains GG x GG, GG x YEC and SS x YEC had both internal and external egg quality traits (yolk and albumen weight, egg weight, egg length, egg width, shell thickness, shell weight and egg number) as their descriptors. The result obtained on principal component analysis in this study were in agreement with the findings of Sarica *et al*., (2012) who reported that breaking strength, shell thickness, albumen height ,albumen index and haugh unit were most effective parameters of egg quality in an experiment involving five hen strains. In another study, Ukwu *et al*., (2017) reported three principal components comprising of both internal and external qualities traits in describing the eggs of Isa brown layer chickens.

The clusters obtained from the dendogram are an indication of genetic dissimilarities among the genotypes. It also showed that some of the strains were genetically closer than others. The similarity that existed between Marshall and crossbred SS x YEC could be attributed to their pattern of growth either at the early stage or grower phase and these similarity could be from their genetic stand point which means they may be closely related by state or decent. Similar report was obtained by Adeleke *et al.* (2011) for frizzle and normal feathered chicken using blood protein analysis. However, Okamoto *et al.* (1999) reported small genetic difference among

local chickens in Laos by investigating their blood protein polymorphism. In the purebred strains, the dendogram constructed indicate that Goliath, Sussex and YEC strain are closely related in the way they attainment their body weight while Marshall was not closely related thereby standing as a distinct strain; these differences in their relatedness can be attributed to the way these chicken strains attain maturity. Marshall is known to grow faster than other strains of chicken because they are meat type strain while it takes longer period for Goliath, Sussex and YEC because they are regarded as dual purpose strains of chicken. The dendogram obtained for crossbred strains indicate similarities in all the crossbred except for SS x YEC that was distinct from other strains. Generally, the dendogram for egg number revealed that the chickens involved in this study are closely related with respect to the genes for egg production. The first cluster showed that Goliath, YEC,SS x YEC, GG x YEC, YEC x GG are similar in their laying pattern while the second cluster SS x SS and YEC x SS gave an indication that the cross between Sussex hen and YEC cock resulted in crossbred chicks that were close in performance to the purebred Sussex. The trend in genetic relatedness for egg numbers can be attributed to the genetic background of the various strains used in this study. Sussex has been known to be a good layer of egg and this attribute separated it from other strains that were involved in this study. The dendogram for purebred strains suggests narrow genetic differences between Goliath and YEC for egg number while Sussex was far separated from the two, being the most distinct and the best among the purebred for egg number. In the crossbred strains YEC sire and dam crossed with Goliath dam and sire were similar in egg number while SS x YEC had small difference from them while YEC x SS was far separated from them and most distinct strain. The dendogram showed genetic similarity for egg weight between Sussex and Goliath dams, while other strains were far apart from the two purebred hens. The purebred Sussex, Goliath and their crossbred

with YEC cock were similar in egg weight this suggests that crossbreeding using YEC as the sire line will produce crossbreds hens with egg weight that is comparable with that of exotic GG or SS, which potentially lays bigger eggs than YEC. Dendogram for the purebred strains showed that the weight of eggs from Goliath and Sussex are similar and are genetically close while that of YEC were far distinct from them having the smallest weight among the strains examined. The dendogram constructed for the crossbred strains indicates that SS x YEC and GG x YEC and the reciprocal cross were similar in egg weights.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Summary and Conclusions

The present study was conducted at Hepzibah farms in Oyan, Osun state using a total of 529 chicks obtained from 971 eggs collected from YEC, GG, SS, MM and their crossbred strains of chickens to examine fertility, hatchability, early and late growth performance and survivability, egg production and quality characteristics, estimate genetic parameters, predictive models for growth and egg production traits in YEC and its crossbred in Nigerian humid tropics.

From the present study the following findings were made:

The crossbred MM x YEC had the highest %fertility (97.50%) followed by YEC x MM (83.33%) while hatchability was high in MM x YEC and GG x YEC with both having (89.74%). MM and MM x YEC had significantly ($p<0.05$) higher feed intake, weight gain and Feed conversion ratio than other strains. Cross-bred chicks that were produced by YEC cocks crossed with either Marshall or Goliath hens were heavier in weekly body weights than pure YEC and other cross-bred YEC. All the 10 strains displayed male biased sexual dimorphism. Reciprocal and interaction effects on body weight of chicks were pronounced among crossbred groups. Reciprocal effect favoured chicks that were hatched from purebred cocks and Yoruba ecotype hens.

YEC had 91.25% survivability while YEC x GG had the least 75% at the early stage however, YEC x GG had 100% survivability while YEC x MM had 87.5% at late growth phase The pure bred exotic chickens GG, SS, MM survived better during the late growth phase this can be as a result of

late adaptability to the tropical environment and the superior survivability of cross bred YEC x GG at the late growth phase shows that there is breed complimentary for this traits.

Cross breeding improved hen body weight of exotic chicken and crossbred with YEC cork while age at first egg was moderate for these strains but increased for their reciprocal cross bred hens

Pure bred Sussex and cross bred YEC x SS hens laid the highest number of eggs during this trial period. Pure bred Goliath consumed the highest feed to produce fairly high number of eggs and had the highest egg weight while pure bred YEC had the lowest.

Albumen weight, albumen height, albumen width were higher in purebred Goliath, Sussex and YEC x SS chicken than their other counterparts. Cross breeding favours the crosses between YEC cock and the exotic chicken hens for body weight, egg production traits, external and internal egg quality traits than their reciprocal cross breed. The use of egg strain (YEC and SS cock) as sire and meat strain (MM, GG hens) as dam gives us the highest body weight (weeks 8, 12, 14 and 20), egg number and AFE.

The moderate and high heritability estimates obtained in this study suggest that the genetic improvement for body weight will be effective in improving this trait in GG. The result indicates that different strains do exhibit high variation in genetic estimates for egg production traits. Hence, change in heritability estimates over a period of time may result from the expression of different genes during egg production cycle.

Repeatability estimate for body weight in this study was generally low among all the strains. Strain SS had the highest repeatability estimate for egg number and egg weight among all the genotypic groups.

Generally, genetic correlation between HBW and egg biometric traits was low in all the strains of chicken. High and positive correlation exists between egg number and egg weight in Sussex hens. Albumen weight and egg weight were positively and highly correlated in all the strains.

Pure bred Sussex had the highest albumen weight while YEC had the lowest albumen weight. Early body weights can be used as a tool in predicting the later body weight of all the strains. Also, cubic and quadratic models gave the highest R^2 values which indicate best accuracy in prediction of late body weight from early records of body weight.

Low variation exist in predicting weekly body weight of SS x SS, YEC x GG, YEC x MM and MM x YEC while High variation exist in predicting weekly body weight of GG x GG, MM x MM and YEC x SS.

The eggs of strains YEC x YEC, SS x SS, YEC x GG, YEC x SS can be effectively described by external quality traits. While, the eggs of strains GG x GG, GG x YEC and SS x YEC can be described accurately with both internal and external qualities. In the pattern of attaining body weight, purebred YEC, SS and GG were closely related than MM while crossbred SS x YEC were far apart in the dendogram, similarity exist in egg number of YEC and GG, egg weight in GG and SS were closer than YEC while YEC x GG and YEC x SS were closely related in the dendogram.

From the result of this study, it can be concluded that cross breeding with exotic strains improves body weight and egg production of YEC.

6.2 Recommendations

It is recommeneded from the study that the use of YEC Cocks and Marshall or Goliath hens will improve poultry meat production in Nigeria.

The superiority of purebred SS x SS and YEC x SS hen suggests that the use of Sussex or YEC as a terminal sire strain in crossbreeding program will be beneficial for improving egg number.

It is further recommeneded that improved livability of exotic chicken in humid tropics can be achieved through crossbreeding of exotc hens with YEC cocks.

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