GENETIC PARAMETERS OF RHODE ISLAND RED AND WHITE CHICKENS AND THEIR RECIPROCAL CROSSES

BY

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CERTIFICATION

This thesis entitled "Genetic parameters of Rhode Island Red and White chickens and their reciprocal crosses" by name meets the regulations governing the degree of Master of A.B.U, Zaria and is approved for its contribution to scientific knowledge and literacy presentation.

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. I have not been presented in any previous application for higher degree. All quotations are indicated and the source of information are specifically acknowledge by means of references.



.....

GABCHE AGNES E.

DEDICATION

I dedicate this study to papa and mammy (Mr. and Mrs. Gabche C.A.) for their endless care and love. To my Brothers and sisters (Nii Charles, Nii James, Florence, Vincent, Maurice, Kieth, Harkson, Lilian, Akogho, Dabo, Sango and Mah) for their love and concern.

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ABSTRACT

The genetic parameters derived from 695 F_1 progenies of two strains of Rhode Island chickens and their reciprocal crosses were compared.

The least square analysis of variance was used in comparing the four genetic groups. While a one-way random model was used in estimating the genetic parameters. Variables used for analysis comprised body weight at time of hatch (B-0); four (B-4); eight (B-8); twelve(B-12); sixteen (B-16); twenty (B-20); forty(B-40); weeks of age and at sexual maturity (BSM), age at sexual maturity (ASM), first egg weight (FEWT), Average egg weight (AEWT), 280 days egg production (EN280D), Average shape index (ASI), shell thickness (AST); Haugh Unit (AHU) and yolk index (AYI) measured on each pullet.

The results indicated that strain crossing improved B-12, B-16, B-20; decreased ASM; increased EN280D and improved ASI, AHU and AYI. The RxW cross was better than its reciprocal cross and also show maximum heterosis in the desirable direction in the above traits.

The heretability estimates obtained ranged from -0.42 to 1.33, -0.07 to 1.10, 0.03 to 0.89, -0.18 to 1.56 for RxR, WxW, RxW and WxR genetic groups, respectively. Generally, heritability estimates were higher in the crossbred than purebred for most body weight traits, ASM, EN280D and some egg quality traits based on the sire's parent breed. The results are consistent with the notion that there were genetic differences between the purebred males that affects the production characteristics of their crossbred progeny differently than their purebred progeny. The results indicated that non-additive genetic variation exist for various component of egg laying production which can be exploited through selection based on cross-line performance.

Sex-linkage effect was found to be more important than maternal effect. This indicated that a specialised male female line is required for maximium production. The genetic correlation was positive between early body weight (B-8,B-20) and EN280D, ASM and AEWT. whereas EN280D and early body wieght were negatively correlated with ASM and AEWT.This indicated that selection of chickens can be done at early age based on body weight without any detrimental effect on ASM and EN280D.

It was concluded, based on the results that RxW cross is the best genetic group for commercial exploitation.It's production can be improved by selection based on both pure and crossbred progeny.

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CHAPTER ONE

INTRODUCTION

Strain crosses by virtue of their superiority for economic traits over their parents are the choice for commercial exploitation. The superiority is due to heterosis or hybrid vigour (Ghostley and Nordskog, 1951; Cole and Hutt, 1977). Hybridization makes use of both additive and non-additive gene effect (dominance and/or Epistasis). The utilization of hybrid vigour has been a major component of applied breeding programmes (Legates, 1988).

However strain crosses differ among themselves in their performance due to differences in nicking ability of the strains. The amount of heterosis in strain crosses usually depends upon the extent of heterozygosity attained by hybrids. Therefore strains should be evaluated periodically in cross performance for their better exploitation in commercial poultry breeding programmes (Dutt et al., 1990).

Selection within purelines is the most commonly employed breeding technique for the production of commercial layers (Cole and Hutt, 1977). The success of this breeding strategy is dictated by the extent to which the gains made in purelines are realised in the crosses. The effectiveness of selection based on pureline performance relative to the crossline performance depends mainly on the comparative size of heritabilities for economic traits of pure-bred and crossbred progeny (Chaudhary et al., 1996).

Crossbred heritability is related to the amount of genetic variation among purebreds for crossbred performance. Wei et al. (1991b) showed in a one loci model that heritability of crossbred is not a linear function of the heritability in parental lines if dominance exists and it should be estimated separately for different lines and their

crosses.

Most estimates on the flock under study are based on additive genetic variance only. Information on both additive and non-additive genetic variance would be of value in formulating the most effective breeding schemes.

Maternal and sex-linkage effect have been deduced from analyses of family structured populations. If the sire component of variance is larger than the dam component this is usually evidence of sex linkage (Hogsett and Nordskog, 1958) but the reverse - a larger dam than sire component is usually taken as evidence of maternal effect (King et al., 1963).

In selection for economically important traits breeders usually consider many traits at a time. The study of the genetic correlation between economically important traits is very essential in the formulation of program for selection and improvement of laying flock. Such information is also helpful in predicting direct and correlated response due to selection (Krishna and Chaudhary, 1987).

The present studies were undertaken to estimate the percent heterosis in crosses; the heritabilities for purebred (h^2_p) and crossbred (h^2_c); the reciprocal effect and the genetic correlation between some economically important trait in layers.

Results of these studies would help in choosing the most promising strain cross and also the optimum breeding technique for improving the cross.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 CROSSBREEDING IN POULTRY

Crossbreeding is defined as the mating of one purebred with another. In earlier days, it formed the first stage in search for new breeds but today, strain crosses by virtue of their superiority for economic traits over their parents are of choice for commercial exploitation (Dutt et al., 1990). The superiority is due to heterosis or hybrid vigour (Ghostley and Nordskog, 1951; Cole and Hutt, 1977).

The capitalisation on heterosis is only possible if one selects at the same time. This selection however does not take place on the basis of the performance of the lines itself but on the basis of that of the cross that is selection for combining ability (Tijen, 1977).

In the classical procedure of pure breeding within strains or breeds together with the selection of the superior individuals (mass selection) or group of individuals (family selection) one makes use of the additive effect of the genes. In contrast hybridisation means that one makes use of the non-additive effects (dominance and/or epitasis). These non-additive effects are not predictable from the performance of the parent generation, thus the cross progeny of the lines or strains has to be tested. The system is known as breeding for the combining ability of the parental lines (Tijen, 1977; Cole and Hutt, 1977).

In crossbreeding the chances of bringing complementary genes together and of releasing any cryptic gains that have been accumulated during earlier inbreeding are

much increased with the result that on balance, crossbred stock ought to and sometimes does, show better average growth rate, vigour and egg production than its purebred parent.

Lerner (1954) reported that crosses of purelines have greater uniformity for the expression of some traits effects which can be explained by the buffering qualities of the heterozygous genotypes in relation with a changing environment.

2.1.1 HETEROSIS

In crossbreeding, whatever the precise genetic make-up of the parents, we expect the average performance of the cross progeny to approximate closely the midway performance of the parents so long as inheritance is based exclusively on additive genes. Any deviation from expected performance in such matings is known as heterosis.

If the progeny exceed expectation we have positive heterosis commonly called "Nicking;" if they fall short of expectation, heterosis is negative. The manifestation of heterosis arises from epistasis, linkage or complementary gene action (Singh, 1990). Tijen (1977) reported that if a large number of the gene present show dominance or over dominance for a number of characteristics we can expect the cross to be better than the parents from which it is derived.

The amount of heterosis in strain crosses usually depends upon the extent of heterozygosity attained by hybrids, which inturn depends upon the diversity of the strains (Dutt et al., 1990).

Hale and Clayton (1965) reported a mean superiority of the F_1 cross over the mid-parent level for egg production and sexual maturity between light Sussex, Brown leghorn

and their reciprocal crosses. A 6% heterosis has been observed for egg production between Dessi, Rhode Island Red and their reciprocal crosses (Acharya and Kumar, 1971). Sheridan and Randall (1977) obtained a substantial heterosis for egg production/hen day and total egg mass between White Leghorn, Australorps and their crosses.

For body weight, a little evidence of positive heterosis has been reported between White Rock, New Hampshire and their reciprocal crosses (Niphon et al., 1971) and also between Rhode Island Red, Desi and their reciprocal crosses (Sharma et al., 1971). Whereas a negative heterosis was obtained for this trait between purebred White Leghorn and their half-sib from NewHampshire Sire (Taran et al., 1972).

A little positive heterosis was reported for the traits yolk index and yolk colour between Rhode Island Red, Desi and their reciprocal crosses but that of egg weight was small and negative (Kumar et al., 1971). However, a desirable heterotic effect was obtained for egg weight, age at sexual maturity and egg number between purebred White Leghorn and their half-sib from NewHampshire sire (Taran et al., 1972) and also between two strains of White Leghorn and their reciprocal crosses (Yadav et al., 1991).

Heterotic effect of different magnitude have been reported for egg production (0.18 to 12.27%); egg weight (-1.82 to 5.89%); age at sexual maturity (-5.30 to 2.1%); 280 days egg production (-2.57 to 2.64%); bodyweight at day old (-2.29 to -0.470%); bodyweight at 8 weeks (-4.96 to 9.25%); body weight at 16 weeks (-3.68 to 0.48%); and bodyweight at 40 weeks (-5.03 to 1.80%) between several strains of white leghorn and their reciprocal crosses (Verma et al., 1985; Dutt et al., 1990). From their

observations, Dutt et al. (1990) concluded that the magnitude and direction of heterosis not only varies from cross to cross but also from trait to trait.

2.1.2 RECIPROCAL EFFECT

The sources of reciprocal differences between animals have been attributed to sex-linked and maternal effects. These effects have been deduced from analyses of family structured populations. If the sire component of variance is larger than the dams' component, this is usually taken as evidence for sex-linkage (Hogsett and Nordskog 1958; Jerome et al., 1956) but the reverse - a larger dam's than sires' component is usually taken as evidence for maternal effects (King, 1961; King et al., 1963).

Literature on the source of reciprocal effect on egg production traits varies.

Taylor and Lerner (1939 and 1941) noted in several of their matings that the dam seemed to influence shell thickness and egg size more than the sire. A similar maternal effect in the percentage of firm albumen has also been obtained (Lorenz and Taylor, 1940; Shultz, 1953b). Whereas Osborne (1953) obtained lower estimates of heritability from the dams' component for egg size and further concluded that it could be due to sex-linkage. A similar result was obtained by Hale and Clayton (1965) and Taran et al. (1972). But Jaffé (1966) reported a similar sires' and dams' component of variance for egg weight.

Redman and Sheffner (1961) demonstrated sex-linkage from reciprocal effects in all egg quality traits studied except specific gravity. Earlier Shultz (1953b) also obtained evidence of sex-linkage in egg shape from crosses between inbred lines.

For body weight, Hazel and Lamoreux (1947) found maternal effect on body

weight at 22 weeks of age and showed that this amounted to 5 percent of the total variance. A similar effect was obtained by Sharma et al. (1971) on body weight up to the age of 8 weeks in Rhode Island Red, Desi and their reciprocal crosses. Whereas Hale and Clayton (1965) and Krause et al. (1965) reported higher estimates of sires' than dams' component of variance for body weight in light Sussex, Brown Leghorn and their reciprocal crosses and suggested sex-linked effect. Similar results were latter obtained by other investigators (Taran et al., 1972; Chaudhary et al., 1996).

Jain and Chaudhary (1984) observed significant ($P \leq 0.05$) reciprocal differences between White Leghorn, Rhode Island Red and Desi crosses for body weight at hatch and 2 months but not at 5 month of age. Their results suggested the existence of sex-linked effect. Sani et al. (1991) obtained a higher heritability from sires' component of variance than from dams' component for bodyweight at 18 weeks, 22 weeks, 33 weeks of age in Rhode Island Red chickens and concluded that it could be due to the existence of sex-linkage for this trait.

Pirchner and Krosigk (1973) reported higher heritability estimates from dams' components than from sires' component for egg production and sexual maturity, thus indicating the presence of maternal and/or dominant effect. Maternal effect on sexual maturity had been previously reported by Acharya and Kumar (1971). On the contrary, Lerner (1945) estimated that the sires' component was 15% greater than the dams' component of variance for sexual maturity. Silva et al. (1976) reported that the sires' component of variance was larger than the dams' for egg production rate and egg mass which suggested the effect of sex-linkage.

Baker (1960) explained that the differences between sires' and dams' components of variance depend to a certain extent on the intensity of previous selection. The presence of these reciprocal effects are important in determining which reciprocal cross performs better and in deciding upon the use of either the sire or dam of a line in a cross (Eisen et al., 1967).

2.2 COMPARISON OF THE HERITABILITY OF BODY WEIGHT AND EGG PRODUCTION TRAITS BETWEEN PURE AND CROSSBRED PROGENY

Heritability (h^2) is defined as the ratio of additive genetic variance to phenotypic variance (D.S Falconer, 1989) $h^2 = \frac{VA.}{VP}$

The effectiveness of selection based on pureline performance relative to the crossline performance depends mainly on the comparative size of heritabilities for economic traits of purebred and crossbred progeny (Chaudhary et al., 1996). Crossbred heritability is related to the amount of genetic variation among purebred for crossbred performance (Wei and Van der Werf, 1994). Based on a one-locus model (Wei et al., 1991b) purebred heritability (or sire component of variance in purebred) differs more from crossbred heritability (or sire component of variance in crossbred) with larger dominance effect and/or large gene frequency differences between the parental populations.

2.2.1 HERITABILITY OF BODY WEIGHT

The genetic control of growth rate and ultimate body size is based on a number of additive genes which are at least 16 in pairs (Hutt, 1949; Jull, 1952; Godfrey, 1953). It was further suggested by Godfrey (1953) that there is a recessive gene (rg) for small

body size, located between the S and K loci on the sex chromosome. This gene may be widespread in heterozygous form in normal fowls. Due to the additive nature of the gene, when two breeds are mated together, the immediate offspring tend to be intermediate in size.

The heritability estimates for body weight at different ages and in different genetic groups varied between 0.085 and 0.745 suggesting the trait to be from low to highly heritable (Hale and Clayton, 1965; Taran et al., 1972; Pirchner and Krosigk, 1973; Kumararaj et al., 1991; Chaudhary et al., 1996).

Most estimates were higher in crosses than in pures for body weights at all ages with the exception of 40 weeks body weight. Taran et al. (1972) obtained a higher heritability estimate in crosses than in the pures for body weight at sexual maturity (0.54 vs. 0.40) using the dams' and sires' component of variance in purebred white leghorn and their crossbred half-sib from NewHampshire sire. A similar difference was reported by Chaudhary et al. (1996) for body weight at 8 weeks (43.9 vs. 32.9%) and 20 weeks (61.8 vs. 35.6%) using sires' component of variance for pure and cross-line white leghorn strains. It was further reported by Chaudhary et al. (1996) that the higher heritability of crosses over pures for 8 and 20 weeks body weight was caused by their higher additive genetic variation as well as lower environmental variation compared with the pures. In addition, they obtained an excess of sire component of heritability in crosses over pures for body weights and suggested that body weight are influenced by non-additive gene effect.

Some investigators observed only a slight difference between the pures and crosses. Hale and Clayton (1965) obtained estimates of 0.34 and 0.45 (pures) and 0.82 (crosses) for pullet weight using the dam's component of variance in light Sussex, White Leghorns and their reciprocal crosses. While Kumararaj et al. (1991) reported values

ranging from 0.13 to 0.21 (pures) and 0.27 - 0.30 (crosses), 0.27 (pures) and 0.26 - 0.30 (crosses) for body weight at 20 weeks, sexual maturity and 40 weeks of age, respectively for two strains of White Leghorns and their reciprocal crosses.

On the contrary higher estimates were obtained in pures than crosses. Pirchner and Krosigk (1973) from sires' and dams' components of variance reported values of 0.51 - 0.74 (pures) and 0.10 - 0.67 (crosses) for body weight at 18 weeks of age in two strains of White Leghorns and their crosses.

Considering just the pure breeds, Abubakar et al. (1987) reported estimates of 0.26 and 0.16 for body weight at 40 weeks of age for male and female line respectively. While Oni et al. (1991) reported estimates of 0.413 and 0.044, 0.387 and 0.279, 0.045 and 0.148 for body weight at 16 weeks, 20 weeks and sexual maturity respectively in two strains of chickens.

2.2.2 HERITABILITY OF AGE AT SEXUAL MATURITY

Age at sexual maturity can be defined as the number of days after hatching when the first egg was laid. Hays (1924) observed that sexual maturity is determined by at least two dominant genes, one autosomal and the other sex-linked.

The heritability for sexual maturity ranged from 0.19 to 0.87 depending on the genetic group (Hale and Clayton, 1965; Pirchner and Krosigk, 1973; Kumararaj et al., 1991; Chaudhary et al., 1996). This suggest the trait to be low to highly heritable.

Some estimates are slightly higher in crosses than pures due to proportionately higher genetic variation in crosses. Prichner and Krosigk (1973) obtained heritability estimates of 0.38 vs. 0.25 using the sires' component of variance and 0.52 vs. 0.48 using

the dams' component of variance for crosses and pures respectively for sexual maturity in two strains of white leghorn and their crosses. Similarly Chaudhary et al. (1996) reported heritability estimates of 0.42 vs. 0.34 for crossbred and purebred, respectively using sires' component of variance for sexual maturity in pure and cross-line white leghorn.

Similar estimates were obtained in some studies. Hale and Clayton (1965) reported estimates of 0.66 and 0.31 vs. 0.35 and 0.29 using the dam's component of variance and 0.19 and 0.40 vs. 0.35 and 0.25 using the sire's component of variance for pures and crosses respectively for days to first egg in light Sussex, White Leghorn and their reciprocal crosses. Similar result was reported by Krause et al. (1965).

Kumararaj et al. (1991) obtained values of 0.45 and 0.43 (pures) and 0.87 and 0.37 (crosses) for two strains of White Leghorn and their reciprocal crosses.

When considering the pure bred only, Abubakar et al. (1987) reported estimates of 0.33 and 0.23 for male and female line, respectively. While Oni et al. (1991) obtained values of 0.373 and 0.224 for age at sexual maturity in two strains of chickens.

2.2.3 HERITABILITY OF EGG PRODUCTION

Egg production also known as fecundity is defined as the number of eggs produced in an agreed period of time regardless of other characters such as egg size, hatchability etc (Singh, 1990). Its heritability is based upon several pairs of genes.

The heritability estimates of egg number ranged from 0.04 to 0.787 depending on the genetic group and also on the period considered. Higher estimates in crosses than in pures have been reported by some investigators.

Taran et al. (1972) obtained heritability estimates of 0.18 vs. 0.14 for crosses and pures, respectively for egg number using combined sires' and dam's components of variance in white leghorn and their NewHampshire paternal half-sibs. Also Pirchner and Krosigk (1973) reported heritability estimates of 0.14 (crosses) and 0.18 (pures) using the sires' component of variance for percentage egg production up to 10 months of age, in two strains of White Leghorn and their crosses.

Whereas other investigators have reported lower estimates in crosses than in pures. Hale and Clayton (1965) reported heritability estimates ranging from 0.18 to 0.23 (crosses) and 0.18 to 0.36 (pures) using sires' component of variance for 250 days egg production in light Sussex, Brown Leghorn and their reciprocal crosses. Wei et al. (1995) reported values of 0.69 (crosses) and 0.09 (pures) for 65 weeks egg production in laying chickens. Chaudhary et al. (1996) also obtained lower heritability estimates for crosses than pures (0.123 vs. 0.187) using sires' component of variance in pure and cross-line White Leghorns.

However, some investigators did not observe any differences between the cross and the pure. Kumararaj et al. (1991) reported estimates of 0.257 and 0.343 (pures), 0.787 and 0.059 (crosses) for egg number for two strains of White Leghorn and their reciprocal crosses. Similar reports were made previously by Krause et al. (1965).

On the basis of purebred alone, Abubakar et al. (1987) reported estimates of 0.15 and 0.34 for male and female line, respectively. While Oni et al. (1991) obtained values of 0.133 and 0.215 for two strains of chickens.

2.2.4 HERITABILITY OF EGG WEIGHT

Egg size measured by weight is an important factor when eggs are graded. Long experiences show that size normally increased from first egg up to the time when the pullet has reached mature body weight which is usually 10 to 12 months of age. The size tend to decrease somewhat during the period of intensive laying (Mann, 1955).

As regard the inheritance of egg size, Hay (1924) reported from his experiment on Rhode Island Red chickens that at least 3 genes may be involved as follows:-

A gives very small eggs

A+B give small eggs with B being dominant

B gives medium eggs

C gives medium eggs

B+C give large eggs

A+B+C give medium eggs

The heritability of egg weight ranged from 0.04 to 0.96 depending on the genetic group and also the age of the bird. Heritability of early egg weight is not high (Lerner and Cruden, 1954; King and Henderson, 1954) but later measurements after 3 - 4 months production give higher estimates of heritability (Hale and Clayton, 1965; Pirchner and Krosigk, 1973).

The heritability estimates from strain crosses were higher than those from pure strains. Taran et al. (1972) obtained heritability estimates of 0.57 vs. 0.48 using combined sire and dam component of variance for egg weight in white leghorn and their paternal half sib from NewHampshire sire. Also Pirchner and Krosigk (1973) reported

heritability estimates of 0.48 vs. 0.46 using sire component of variance for egg weight at 8 months of age in two strains of White Leghorn and their crosses. A similar result was reported by Chaudhary et al. (1996). They obtained heritability estimates of 0.46 (crosses) and 0.450 (pures) for egg weight average between 36 and 38 weeks of age in pure and cross-line White Leghorn.

However some other researchers obtained lower heritability estimates in crosses than in pures for this trait. Kumararaj et al. (1991) reported values of 0.301 and 0.197 (pures), 0.104 and 0.040 (crosses) for egg weight in two strains of White Leghorns and their reciprocal crosses. Wei and Van der Werf (1995) obtained heritability estimates of 0.27 vs. 0.63 for egg weight between 30 and 35 weeks of age and 0.23 vs. 091 for average egg weight between 40 and 45 weeks of age, using sires' component of variance in white leghorn strains and their crosses. Whereas no specific trend was observed between the crosses and pures by other investigators, Hale and Clayton (1965) obtained heritability estimates of 0.37 and 0.55 (pures), 0.71 and 0.55 (crosses) using sire's component of variance in Light Sussex, White Leghorn and their reciprocal crosses.

In considering only the pure bred chickens, Abubakar et al. (1987) obtained values of 0.26 and 0.22 in male and female line respectively. While Oni et al. (1991) reported values of 0.102 and 0.090 for first egg weight for two strains of chickens.

2:2:5 HERITABILITY OF OTHER EGG QUALITY TRAITS

Literature on heritability of quality traits is based mostly on the pure bred progeny alone (Abubakar et al., 1993). Comparative study between purebred and crossbred heritability is scanty (Kumararaj et al., 1991).

2:2:5:1 EGG SHAPE

Shultz (1953b) obtained heritability estimates ranging from 0.16 to 0.25 over genetic groups by variance component analysis.. However higher values (0.60) were obtained by Hicks (1958) using the method of intraclass correlation. Shultz (1953b) further reported that the inheritance of egg shape depends on the breed.

Kumararaj et al. (1991) from their genetic analysis of two strains of white leghorns and their reciprocal crosses obtained heritability estimate from 0.31 to 0.73 vs. 0.17 - 0.21 for shape index for crosses and pures respectively. Abubakar et al. (1993) report a heritability estimates of 0.14 and 0.04 for shape index for strains A and B, respectively.

2:2:5:2 YOLK INDEX

Egg yolk consist of concentric layers of two kinds of tissue (white and yellow yolk) contained within the vitelline membrane. It is rich in lipids, protein, minerals, pigment and vitamins but only a small amount of carbohydrates (Romanoff and Romanoff, 1949).

Scheinberg et al. (1953) considered that yolk weight was influenced by dominance and epistasis as their estimate of heritability was only in the range of 0.0 to 0.12. Kumararaj et al. (1991) reported heritability estimates ranging from -0.25 to 0.01 vs. 0.03 to 0.18 for crosses and pures, respectively. While Abubakar et al. (1993) reported values of 0.62 and 0.00 for strain A and B, respectively.

2:2:5:3 HAUGH UNIT

Egg albumen consist of high percentage of water, a fairly large amount of protein a very small quantity of carbohydrates and ash and a trace of lipid. Water soluble vitamin riboflavin has been found in it (Romanoff and Romanoff, 1949). Measurement of the height and width of the thick white is commonly used and may be combined to form an index.

Heritability of albumen characteristics appear high. Estimates are 0.12 - 0.68 for albumen weight (Scheinberg et al., 1953) and 0.22 (Farnsworth and Nordskog, 1955), 0.55 and 0.17 (Johnson and Merrit, 1955) for albumen height. The last two values were in respect of different breeds, namely White Leghorns and Barred Rocks.

Jaffé (1966) reported values ranging from 0.40 to 0.61 for Haugh Unit in two strains of chickens. Pirchner and Krosigk (1973) obtained estimates of 0.38 (crosses) and 0.38 (pures) for albumen height at 8 months of age in 2 strains of white leghorn and their reciprocal crosses. Kumararaj et al. (1991) reported from 0.25 to 0.36 vs. 0.21 to 0.37 for Haugh unit for crosses and pures, respectively. While Abubakar et al. (1993) reported values of 0.01 and 0.00 for strains A and B, respectively.

The physiological approach to albumen quality has proved of value. Wilcox (1955) noted that a high level of lysozyme appeared to be associated with a large amount of firm albumen. Corttent and Winter (1955) have suggest that this enzyme maintains albumen condition by interacting with ovomucin. Further studies (Wilcox and Cole, 1957) have shown that differences in lysozyme level are inherited.

2:2:5:4 SHELL THICKNESS

The shell is composed of inorganic salts of calcium and to a lesser extent, of phosphorus and magnesium, embedded in an organic matrix of protein. It is supper-imposed on the shell membrane which is largely protein with a small amounts of water and minerals (Romanoff and Romanoff, 1949).

Taylor and Lerner (1939) reported the trait to have a genetic basis. Farnswoth and Nordskog (1955) obtained heritability of 0.27. Kumararaj et al. (1991) reported estimates ranging from -0.15 to 0.18 vs. 0.04 to 0.06 for crosses and pures respectively. While Abubakar et al. (1993) obtained estimates of 0.05 and 0.01 for strain A and B respectively.

However physiological approach to shell thickness has proved of values. Benesch et al. (1944) have shown that the presence of the enzyme carbonic anhydrase is necessary to catalyse the production of carbonate from carbon dioxide. Also the length of time an egg is retained in the uterus is important. Polin and Sturke (1955) showed that when a hen which laid premature, shell-less eggs, was induced to retain them the normal time, a shell was formed.

2:3 GENETIC CORRELATION BETWEEN SOME GROWTH AND EGG PRODUCTION TRAITS

Correlation is the relationship between two matrix characters. It can either be positive or negative. Correlation can be caused by genetic and/or environment. The genetic causes of correlation is chiefly pleiotropy. However linkage is a cause of transient correlation, particularly in a population derived from crosses between divergent

strains. Pleiotropy is simply the property of a gene whereby it affects two or more characters.

2:3:1 GENETIC CORRELATION BETWEEN BODY WEIGHT AT DIFFERENT AGES

The genetic correlation between body weight at different ages varies in magnitude and direction depending on the ages considered.

Clayton and Robertson (1966) reported a highly positive genetic correlation (0.84) between body weight at 12 and 20 weeks of age. Oni et al. (1991) also reported a highly positive genetic correlation (0.88 and 0.98) between juvenile body weight (16 and 20 weeks of age) in two strains of birds studied. Similar estimate (0.99) was reported between 18 weeks and 22 weeks of age in a flock of Rhode Island Red chickens. But when considering body weight at sexual maturity and juvenile body weight. Oni et al. (1991) obtained a negative genetic correlation (-0.13) in one of the strains studied. Similarly, Sani et al. (1991) reported value of 0.09 between body weight at 18 weeks and body weight at 32 weeks of age.

2.3.2 GENETIC CORRELATION BETWEEN BODY WEIGHT AND AGE AT SEXUAL MATURITY

Literature on genetic correlation between body weight and age at sexual maturity varies in magnitude and direction.

Clayton and Robertson (1966) reported negative genetic correlation (-0.38 and -0.48) between early body weights and age at sexual maturity. Oni et al. (1991) also obtained negative genetic correlation (0-0.39 to -0.40) between juvenile body weights (16 and 20 weeks) and age at sexual maturity. Similar negative values of -0.11 and -0.57

were reported by Sani et al. (1991) between early body weight (18 and 22 weeks) and age at sexual maturity. It was further concluded that early maturer grows faster and thus tend to be heavier at 16 and 20 weeks of (Oni et al., 1991).

When considering late body weights, Abubakar et al. (1987) reported a positive genetic correlation (0.42) between body weight at 40 weeks of age and age at sexual maturity. However one of the line they studied had a negative correlation (-0.17). Similarly Sani et al. (1991) reported a positive genetic correlation (0.42) between body weight at 32 weeks and age at sexual maturity. It was concluded by some investigators that late maturer were heavier in weight due to genetic factors (Hussain and Singh, 1964; Krishna and Chaudhary, 1987).

2.3.3 GENETIC CORRELATION BETWEEN BODY WEIGHT AND EGG WEIGHT

Literature on the genetic correlation between body weight and egg weight are conflicting.

Most investigators reported positive genetic correlation between these traits. Hogsett and Nordskog (1958) reported positive genetic correlation (0.61 to 0.56) and Hogsett et al. (1964) quoted figures varying from 0.24 to 0.74 between body weight and egg weight. Vonkrosig and Pirchner (1974) gave a value of 0.27, similar to that reported by Jerome et al. (1956). Hale and Clayton (1965) reported a positive genetic correlation (0.30 to 0.61) between pullet weight and egg weight. Whereas Jaffé (1972) reported values ranging between 0.24 and 0.59 depending on genetic group. Similar

positive genetic correlation (0.51 to 0.62) were obtained between body weight at first egg and egg weight in White Leghorn, NewHampshire and their reciprocal crossers (Taran et al., 1972). It was concluded that it is the size and secretory capacity of the oviduct rather than body weight per se which influences the egg size (Baker, 1960). Krishna and Chaudhary (1987) reported a positive genetic correlation (0.42) between body weight at sexual maturity and egg weight. They further concluded that with increasing body weight at sexual maturity, 90-day egg weight also increased. Similar reports were made by Kotaiah and Renganathan (1980).

On the contrary negative genetic correlation was reported by some investigators. Abubakar et al. (1987) reported a negative genetic correlation of 0.00 and -0.56 between body weight at 40 weeks of age and egg weight in two lines of chickens. Similar negative values ranging from -0.90 to -0.06 between juvenile body weight (16 and 20 wks) and first egg weight were also reported (Oni et al., 1991).

2.3.4 GENETIC CORRELATION BETWEEN BODY WEIGHT AND EGG PRODUCTION

In the literature the reports on the relationship between body weight and egg production are conflicting.

Negative genetic correlation (-0.31 and -0.51) between body weight and egg production were reported by Jerome et al. (1956). Hogsett and Nordskog (1958) reported widely differing values for the light (-0.24) and heavy (0.74) strains studied. Whereas Hogsett et al, (1964) obtained figures ranging from -0.52 to -0.13 based on

variance component within the crosses. Similar negative genetic correlation (-0.28 and -0.08) were reported by Jaffé (1972) in one of the strains studied. But the other strains showed positive genetic correlations (0.16 and 0.12).

Positive genetic correlations of 0.11 to 0.29 between early body weight and egg production were reported by Clayton and Robertson (1966). Similar positive genetic correlation between body weight at 40 weeks of age and egg production in the male line and a negative correlation (-0.50) was observed in the female line was also reported by Abubakar et al. (1987). Similar positive values (0.34) between body weight at sexual maturity and 90-day egg production were reported by Krishna and Chaudhary (1987) in White Leghorn. They concluded that with increasing body weight at sexual maturity and 90-day egg production were reported by Krishna and Chaudhary (1987) in White Leghorn. They concluded that with increasing body weight at sexual maturity egg production in the subsequent 90 days period increased.

Oni et al. (1991) reported positive genetic correlation (0.39 and 0.54) between juvenile body weight (16 and 20 weeks) and egg production, though a negative value (-0.99) was obtained in one of the strains between body weight at 16 weeks and egg production. They concluded that preliminary culling could be made at housing using pullet body weight at week 20. Similar positive values (0.05 to 0.50) were obtained by Sani et al. (1991) but the correlation between body weight at 32 weeks and egg production was low and negative.

However, it appears that every flock has an optimum range of body weight at sexual maturity. If the body weight at sexual maturity of the flock falls below optimum

level its relationship with egg production would be positive and if the average body weight at sexual maturity falls beyoung the optimum level it s relationship will be negative (Krishna and Chaudhary, 1987).

2:3:5 GENETIC CORRELATION BETWEEN EGG WEIGHT AND EGG PRODUCTION

Literatures on the relationship between these traits vary. Majority of published reports showed a large negative genetic correlation.

Farnsworth (1956) obtained values varying from -0.99 to 0.55 in eight generation of leghorns. Similar results were obtained by Abplanalp (1957). Hogsett and Nordskog (1958) got a negative value of -0.42 from light breeds and positive value of 0.37 for the heavy breed. It was suggested that negative genetic correlation between egg weight and egg production is a physiological phenomenon and depends on the rate of ovulation and the efficiency of the oviduct (Baker, 1960).

Hale and Clayton (1965) obtained values ranging from -0.70 to -0.07 in Brown Leghorn, Light Sussex and their reciprocal crosses. Similar negative values (-0.38 and -0.25) were reported between first egg weight, egg weight at 36 weeks of age and egg production have been reported (Clayton and Robertson, 1966). Whereas Jaffé (1972) reported values ranging from -0.15 to 0.04 in 3 strains of chickens. A moderate and negative genetic correlation (-0.34 to -0.18) between egg weight and egg production was reported in White Leghorn, NewHampshire and their reciprocal crosses (Taran et al., 1972).

Oni et al. (1991) reported a negative genetic correlation (0.53 and -0.63) between

weight of first egg and egg number. Also Sani et al. (1991) reported values ranging from -0.31 to 0.14 in a flock of Rhode Island chicken. The results were similar to previous report by Mohapatra et al. (1985). Similarly Abubakar et al. (1987) reported values of -0.93 and -0.25 in the female and male lines, respectively.

2.3.6 GENETIC CORRELATION BETWEEN AGE AT SEXUAL MATURITY AND EGG WEIGHT

Lerner and Cruden (1951) reported a significant genetic correlation (0.55 to 0.81) between early egg weight and sexual maturity. However, this correlation decreased with increase in period of laying. Negative genetic correlation ranging from -0.47 to -0.74 between age at sexual maturity and egg weight was reported in Brown Leghorn, Light Sussex and their reciprocal crosses (Hale and Clayton, 1965). Whereas Clayton and Robertson (1966) reported values of 0.36 and 0.14 between first egg weight, egg weight at 36 weeks of age and age at sexual maturity.

Krishna and Chaudhary (1987) reported low positive genetic correlation (0.31) between 90 day egg weight and age at sexual maturity. They further suggested that late maturing pullets laid larger eggs by the 90th day after sexual maturity. Similar results were reported by other investigators (Reddy et al., 1972; Nayak and Mishra, 1985).

Oni et al. (1991) reported negative genetic correlation (-0.03) in strain 2 and positive correlation (0.49) in strain 1 between first egg weight and age at sexual maturity. Similar negative genetic correlation were previously reported (Mishra et al., 1978; Abubakar et al., 1987).

Sani et al. (1991) reported a positive low to medium genetic correlation between egg weight and age at sexual maturity in White Leghorn chickens.

2.3.7 GENETIC CORRELATION BETWEEN AGE AT SEXUAL MATURITY AND EGG PRODUCTION

Hale and Clayton (1965) reported a negative genetic correlation ranging from -0.47 to -0.74 between age at sexual maturity and egg production in Brown Leghorns, White Sussex and their reciprocal crosses. Also negative genetic correlation (-0.60) was reported between the traits by Clayton and Robertson (1966).

Abubakar et al. (1987) reported a negative genetic correlation (-0.43 and -0.84) between age at sexual maturity and egg production in female and male lines, respectively. Similarly Krishna and Chaudhary (1987) reported a negative genetic correlation between age at sexual maturity and subsequent 90-day egg production. They further suggested that early maturing pullets were better producers in the 90-day production period due to genetic factors. Their findings were similar to those of previous investigators (Hussain and Singh 1964; Mohapatra and Ahuja 1971; Prakashbabu et al., 1975; Johari et al., 1985; Nayak and Mishra, 1985).

Oni et al. (1991) obtained negative genetic correlation (-0.47 and -0.98) between age at sexual maturity and egg production in two strains of chickens. Similar negative values (-0.83) were reported by Sani et al. (1991). They concluded that as selection for high egg number progresses pullets will mature early.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STOCK

Parent stock consisting of two strains of Rhode Island Red and Wthite Chickens selected for egg number maintained at the National Animal Production Research Institute, Ahmadu Bello University, Shika - Zaria, Nigeria were used for this study.

These two strains (Red and White) were used as breeders,in which 24 males and 216 females from each of the strains were used. The White and Red strains are henceforth refereed to as W and R, respectively.

3.2 MATING ARRANGEMENT

The parents were arranged in the following mating groups:-

	Number of Breeders	
Breeding Groups	Males	Females
R x R	12	108
R x W	12	108
W x R	12	108
W x W	12	108

R = Red strain W = White strain

(The first parent represents the male breed while the second the female).

The breeders were managed under deep litter system in a mating ratio of 1 cock : 9 hens. The hens were trapnested and the eggs laid were collected twice daily and pedigreed. Those laid on the floor were discarded.

3.3 HATCHING AND PEDIGREE OF CHICKENS

At weekly interval, good hatching eggs were sorted out, trayed, fumigated and set in a Western incubator with separate setter and hatcher compartments. Number of eggs set per Sire/Dam was recorded. Eggs set were candled on the 18th day and the infertile eggs for each Sire/Dam were recorded. After which the eggs were transferred into hatching trays divided into comparuments. The eggs of each sire/dam were placed in separate compartments.

The chicks were hatched on the 21st day, pedigreed by sire and dam and identified by wing-tags. The number of eggs hatched per hen was recorded. The pure and crossbred chicks were hatched in the same incubator on same date in 3 hatches at weekly interval from July 1995 to August 1995.

3.4 HOUSING AND EQUIPMENT

A total of 2327 chicks from the 4 genetic groups were housed. Chicks of all the 4 genetic groups obtained in a hatch were mixed during rearing.

Brooding of the chicks was under standard conditions on deep litter with wood shaving as litter material. The brooding pens were shielded by plywood/cardboard sheets while heat was supplied by means of kerosine stove in addition to 100 watts electric bulbs. Chick feeders and small plastic drinkers were used throughout the brooding period which lasted for 8 weeks.

At 8 weeks of age, chicks were transferred and managed in half walled pens on deep litter upto 20 weeks of age. The open sides have half walls 1.2m high and from the half wall to the roof with about 19mm wire mesh. Each pen measures about 4.3

x 3.4 meter and housed about 40 birds. There was a constant supply of light throughout. Using natural light in the day and electric bulb in the night. The feeders used were hoppers and the waterers were round pans.

At 20 weeks of age the chicks were separated and the females were placed in individual laying cages. Feed and water were available ad libitum in troughs along the side of the cages. The source of light as from now onwards was natural light.

3.5 MANAGEMENT

Throughout the experiment, feed and water were supplied ad libitum. Chicks were fed on chick mash from 0 - 10 weeks of age, grower's mash from 10 to 20 weeks of age and layer's mash from 20 weeks to maturity. All the rations were formulated and mixed at the poultry unit of NAPRI (see Appendix 1).

The birds were fed twice daily 8 - 9 a.m. in the morning and 2 - 4 p.m. in the afternoon.

Regular inoculation and necessary medications were given. However, there was an out break of Newcastle diseases at the age of four weeks, during which extra dosage of Lasota and antibiotics were administered.

The vaccination schedule against the appropriate diseases at different stages of the birds are shown in Appendix 2.

In addition to the vaccine, at six weeks, coccidiostat was given. At twelve weeks, the coccidiostat (booster) was given again. Debeaking was done at the age of twelve weeks.

3.6 DATA COLLECTION

Individual body weight at hatch, 4, 8, 12, 16, 20 and 40 weeks of age were taken using W and T Avery scale (5000g x 0.1g). Also weight in grams was recorded at the time of laying the first egg.

The age at first egg of each pullet was calculated as the days between the date of hatch and date of laying her first egg. The first egg weight to the closest 0.1g was also recorded. The weights of 3 to 4 eggs from each pullet were recorded at the age of 35 - 38 weeks. From which the average egg weight was calculated.

Egg production to 40 weeks of age was recorded for each pullet through daily collection. From which the number of eggs laid was calculated.

On the average, 4 eggs were collected at a weekly interval between 45 - 48 weeks of age for recording the egg quality traits. Only eggs laid between 6.30 a.m and 10.00 a.m were collected from the farm and transferred immediately to the experimental room. On arrival each egg was weighed to the nearest 0.1 grams.

The following measurements were obtained from each egg:

1. Weight of the egg to the closest 0.1 grams.
2. The height and width (diameter) of the egg using a vernier calliper in millimeters.
3. The egg was broken in a petri dish and the yolk height, yolk width and albumen height were measured in millimeters using a vernier calliper.
4. The shell was air dried for a night and the shell thickness was measured using a micrometer screw gauge in millimeters.

3.7 STATISTICAL ANALYSIS

3:7:1 CALCULATION OF EGG QUALITY TRAITS

- Shape index was calculated as:

$$\frac{W}{L} \times 100 \text{ (Shultz 1953b)}$$

where W = egg diameter (width)
L = egg height

- Yolk index was calculated as:

$$\frac{YH}{YW} \times 100 \text{ (Funk 1948)}$$

where YH = Yolk height
YW = Yolk width

- Haugh Unit was calculated as:

$$100 \log (AH + 7.57 - 1.3\ EW^{0.37}) \text{ (Haugh 1939)}$$

where AH = albumen height
EW = Egg weight

The observations from each bird were averaged for analysis.

3:7:2 GENETIC GROUPS COMPARISON

The data were classified by hatches and genetic groups for analysis of variance. The method of least square analysis was used as the subclass frequencies were unequal. The probability of obtaining significant differences was used to compare the means of different genetic groups and hatches.

Model: $\mathbf{X_{ijk}} = \boldsymbol{\mu} + \mathbf{G_i} + \mathbf{H_j} + \mathbf{(GH)_{ij}} + \mathbf{E_{ijk}}$

where

$\mathbf{X_{ijk}}$ = observation of the $\mathbf{K}^{th}$ hen from the $\mathbf{i}^{th}$ genetic group in the $\mathbf{j}^{th}$ hatch
$\boldsymbol{\mu}$ = overall means
$\mathbf{G_i}$ = effect of $\mathbf{i}^{th}$ breeding group
$\mathbf{H_j}$ = effect of $\mathbf{j}^{th}$ hatch
$\mathbf{(GH)_{ij}}$ = Effect of the interaction between the $\mathbf{i}^{th}$ breeding group and the $\mathbf{j}^{th}$ hatch
$\mathbf{E_{ijk}}$ = random error associated with each measurement NID $(0, \delta^2_e)$

S_i = Effect of the i^{th} sire
E_{ij} = Random error associated with the j^{th} individual NID $(0, \delta^2_\epsilon)$

The heritability estimates were calculated from the sire's variance component using the

formula:

$$h^2_s = \frac{4 \times \delta^2_s}{\delta^2_s + \delta^2_\epsilon} \quad \text{(Falconer ,1989)}$$

where h^2_s = heritability based on sire's variance component
δ^2_s = Sire's variance component
δ^2_ϵ = Error variance component

Standard error of heritability were calculated using sampling variance of intra-class

correlation (Falconer,1989).

3:7:6 GENETIC CORRELATION

The genetic correlations between some traits within each genetic group were computed

by one-way random model using Harvey's program (Harvey,1990).

3:8 DEFINITION OF TRAITS

B-0: Body weight in grams at hatch

B-4: Body weight in grams at 4 weeks of age

B-8: Body weight in grams at 8 weeks of age

B-12: Body weight in grams at 12 weeks of age

B-16: Body weight in grams at 16 weeks of age

B-20: Body weight in grams at 20 weeks of age

BSM: Body weight in grams at time of laying first egg

B-40: Body weight in grams at 40 weeks of age

ASM: Ages in days from hatch to day of laying first egg

FEWT: Weight of the first egg laid

AEWT: Average weight of 4 eggs laid between the age of 35 - 38 weeks

EN280D: The total number of eggs produced at the age of 280 days

ASI: Average shape index of 4 eggs collected between 45 - 48 weeks of age

AYI: Average Yolk index of 4 eggs collected between 45 - 48 weeks of age

AHU: Average Haugh Unit of 4 eggs collected between 45 - 48 weeks of age

AST: Average shell thickness in millimeters of 4 eggs collected between 45 - 48 weeks of age

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 COMPARISON OF MEAN PERFORMANCE OF THE DIFFERENT GENETIC GROUPS

4.1 BODY WEIGHT

Least squares means for body weights at different ages in each genetic group and hatch are presented in Tables 1 and 4, respectively. The pair-wise comparison of means of different genetic groups are shown by the superscripts (Table1). While the least squares analysis of variance for body weight at different ages are presented in Table 5.

No particular genetic group was consistently superior to the rest for body weight at all ages. However, the crossbred chicks were heavier than purebred chicks at all stages except for body weight at hatch and at sexual maturity.

BODY WEIGHT AT HATCH (B-0)

Significant differences ($P > 0.01$) were observed among genetic groups and the interaction between hatches and genetic groups. But the differences among hatches was not significant (Table 5).

The highest body weight at hatch was in WxW purebred chicks though not significantly higher than RxW crossbred chicks. This was followed by the RxR purebred and then WxR crossbred which were not significantly different even with the RxW crossbred. The differences in chicks body weight at hatch would primarily be due to the differences in egg size of these two breeds. The chick weight has been reported to be a function of the egg weight (Sharma et al., 1971). The results also indicated that the weight of crossbred chicks at hatch were closer to those of the dam's parent breed.

Similar observations were made by Nwagu and Nwosu (1994).

The chicks hatched in late July and August were not significantly different. This may be due to a uniform environment (that is the incubator) in which the chicks were hatched (Niphon et al., 1971).

BODY WEIGHT AT (B-4) AND 8 WEEKS (B-8)

Significant differences ($P < 0.01$) were observed among genetic groups and among hatches. Interaction between hatch and genetic groups were not significant (Table 5).

The highest body weight at 4 and 8 weeks of age was in RxW crossbred followed by WxR,RxR and WxW genetic group. The RxW cross was not significantly higher than its reciprocal cross. The two crosses were significantly heavier than the purebred. The purebred were not significantly different. Similar results were obtained by Mishra et al. (1969). These results are contrary to those of Sharma et al. (1971) where the performance of the crosses never exceeded those of the purebred. The brooding conditions of the birds were not efficient, in addition the chicks suffered from Newcastle diseases at the age of 4 weeks. The crosses may have adapted to the drastic environmental changes due to the buffering qualities of heterozyous genotypes in relation with changing environment. A similar observation was reported by Lerner (1954). This may have given the crosses a better advantages over the pure strains.

Chicks hatched in August were significantly heavier than those hatched in July. This may be due to the different climatic environment under which the chicks were brooded.Thus chicks hatched in August grew faster between four and eight weeks of age than those hatched in July.

BODY WEIGHT AT 12 WEEKS

Significant differences ($P < 0.05$) were observed among hatches. Interaction between hatch and genetic group and among genetic group was not significant. (Table 5).

The highest body weight was observed in RxW cross followed by RxR, WxR and WxW genetic groups. However, the differences were not significant. Crosses were observed to be closer to their sire's parent line. This indicated the presence of a sex-linked gene which influenced body weight at this age. Similar influence of sire's breed on body weight has been reported (Sharma et al., 1971).

The differences in hatches may be due to differences in climatic environment to which the chicks were exposed (Niphon et al., 1971).

BODY WEIGHT AT 16 WEEKS (B-16)

A slight significant difference was observed among the genetic groups. Interaction between hatch and genetic group and among hatches was not signifcant (Table 5).

The highest body weight was observed in RxW crossbred followed by WxR, RxR and WxW genetic groups. The only significant difference ($p < 0.05$)was observed between RxW crossbred and WxW purebred. The crosses were heavier than the pures. Oni et al. (1991) reported a significant difference between the purebreds for body weight at 16 weeks of age. However, the trend was similar to that observed in this study.

The body weights of the crosses were closer to those of their sire's parent line. This indicated some sort of sex-linked influence on body weight at this age.

BODY WEIGHT AT 20 WEEKS (B-20)

Significant difference ($P < 0.01$) was observed among genetic groups and among hatches. Interaction between genetic group and hatch was not significantly different (Table 5).

The highest body weight was observed in RxW genetic group followed by WxR, RxR and WxW genetic groups. RxW cross was significantly different from all other

genetic groups. WxR cross was not significantly different from RxR purebred but different from WxW purebred. Among the purebreds, RxR was heavier but not significantly different from WxW genetic group. A similar trend was obtained by Oni et al. (1991) though theirs was significant. Similarly, other investigators obtained a significant difference between the crosses at this stage (Dutt et al., 1990; Reddy et al., 1990). Kumararaj et al. (1991) reported that body weight at 20 weeks of age was improved by strain crossing. A finding similar to that of this study.

Differences in hatches may be due to differences in environmental conditions of brooding and rearing.

BODY WEIGHT AT SEXUAL MATURITY (BSM)

A significant difference ($P<0.01$) was observed among genetic groups. Interaction between genetic group and hatch and among hatch was not significantly different (Table 5).

The highest body weight was observed in WxW genetic group followed by WxR, RxW and RxR genetic groups. Significant difference was observed between the purebred and also between WxW and RxW genetic groups'. Kumararaj et al. (1991) also observed a significant difference in body weight at this stage among purelines and their reciprocal crosses. The WxW purebred was observed to have exceeded the crosses in body weight at this stage. Similar results were obtained by Mirhsa et al. (1978). The results also indicated that body weight at sexual maturity was a function of the breed or genetic group. It was also observed that late maturer were heavier in weight than the early maturer. This further suggest that egg-type chickens must reach a minimum body weight and age before they can commence egg production. This result was similar to the report by Siegal (1988).

The result further indicated that body weight of crosses at sexual maturity are similar to that of the male parent breed.

BODY WEIGHT AT 40 WEEKS (B-40)

A slight significant difference ($P<0.05$) was observed among genetic groups. Interaction between genetic groups and hatch and among hatch was not significantly different (Table 5).

The highest body weight was observed in the WxR genetic group followed by

WxW, RxR and RxW genetic group. Significant difference was observed between the reciprocal crosses. A significant differences between strain crosses have been reported (Dutt et al., 1990; Reddy et al., 1990).

The results indicated that body weight of the crosses at this age are similar to those of the male parent breed.

4:1:2 EGG PRODUCTION TRAITS

Least squares means for egg production traits in each genetic group and hatch are presented in table 2. and 4, respectively. The pair wise comparison of means of different genetic groups are shown by superscripts (Table 2).

No particular genetic group was consistently superior to the rest in egg production traits. However the crosses were superior to the pure strains for age at sexual maturity, 280 days egg production.

AGE AT SEXUAL MATURITY (DAYS) (ASM)

A significant difference ($P < 0.01$) was observed among hatch and among genetic group. Interaction between hatch and genetic group was not significantly difference (Table 5).

Sexual maturity was attained earlier in the crossbred than in the purebreds. The earliest maturing genetic group was RxW followed by WxR, RxR and WxW genetic groups. Significant differences were only observed between the crosses and the pure strains. Among the pure strains RxR matured 4 days earlier than WxW genetic group. It was also observed that pullets with Rhode Island Red chickens as their sire mature

earlier. This results indicated that sires and dams differ among themselves in their ability to transmit sexual maturity to their daughters. Thus males selected for breeding should be progeny of early maturing dams (Singh, 1990).

The results also indicated that pullets with heavier body weight at 16 and 20 weeks of age mature earlier than those with smaller body weight. This findings confirms the report by Abubakar et al. (1987) and Yadav et al. (1991). It was also observed that strain crossing reduced age at sexual maturity. Similar results were observed by Kumararaj et al. (1991) and Dutt et al. (1990).

The results indicated that pullets required a minimum age for sexual maturity which is a function of genetic group. The values obtained in this study for pure strains were higher than those by Oni et al. (1991), though lower than those reported by Acharya and Kumar (1971). The chicks suffered from Newcastle diseases which might have retarded their growth rate and thus increased age at sexual maturity.

Age at sexual maturity increased with a delay in date of hatching. A similar result was obtained by Acharya and Kumar (1971).

EGG WEIGHT

A significant difference ($P < 0.05$) was observed among genetic groups. The differences among hatches were not significant (Table 5).

A similar trend was observed for first egg weight (FEWT) and average egg weight between 35 - 38 weeks of age (AEWT). The WxW genetic group had the highest egg weight followed by WxR, RxW and RxR genetic groups. A significant difference was observed between the pure strains only. A similar result was obtained by Oni et al.

(1991). Also Dutt et al. (1990) reported similar initial egg weight in reciprocal crosses.

The results indicated that cross utilizing Rhode Island Red as the dam had higher egg weight than its reciprocal cross. However, crossbreeding did not improve egg weight traits. In addition birds with heavier body weight at sexual maturity also laid heavier eggs. This is suggestive of maternal influence on the trait. Similar results were reported by Kumar et al. (1971). Also they did not obtain a significant difference between the reciprocal crosses.

Egg weight followed the same trend as early body weight of the genetic groups. This was probably due to positive correlation between egg weight and early body weight (Jaap et al., 1962).

In general the mean values obtained in this study were below the standard reported for exotic birds in Nigeria (55.58g) (Singer,1976). This could be due to insufficient feed ingredients at times in the layer's mash.

280 DAYS EGG PRODUCTION (EN280D)

Significant difference ($P > 0.01$) was observed among genetic groups and among hatches (Table 5).

The highest egg number was observed in RxW crossbred followed by WxR, RxR and WxW genetic groups. The RxW was significantly different from WxR, RxR and WxW genetic groups. While WxR and RxR genetic groups were significantly different from WxW purebred. The results indicated that crossing increase 280 days egg production.

The observations were lower than those reported by Oni et al. (1991) for pure

strains. This may be due to differences in duration of collection. The results also indicated that birds that mature earlier produce more eggs than those that mature latter. Early maturer had more time to lay eggs. This confirms the finding of other investigators (Acharya and Kumar, 1971; Kumararaj et al., 1991). It was also observed that strain crossing improved body weight at 16 and 20 weeks of age, reduced age at sexual maturity and thus increased the number of eggs laid in 280 days of age.

4:1:3 EGG QUALITY TRAITS

Least squares means for egg quality traits in each genetic group are presented in Table 3. The pair wise comparison of means of different groups are shown by superscripts. The RxW cross was the best in most egg quality traits except in average shell thickness where WxR cross exceeded it.

AVERAGE YOLK INDEX (AYI)

Significant difference ($P<0.05$) was observed among the genetic groups only (Table 3).

The highest percent yolk index was observed in RxW genetic group followed by WxR, WxW and RxR genetic groups. A significant difference was observed between RxW cross and the purebreds and between WxR and RxR genetic group. The results showed that cross breeding improved the percent yolk index. Similar results were obtained by Kumar et al. (1971). The value obtained for Rhode Island Red were similar to those in literature (Johari and Singh, 1968; Kumar et al., 1971).

AVERAGE HAUGH UNIT (AHU)

Significant difference ($P < 0.05$) was observed among the genetic groups (Table 3).

On average crosses were slightly better than the purebreds. The highest Haugh unit was obtained for RxW crossbred followed by WxR, WxW and RxR genetic groups. A significant difference was observed between RxW and RxR genetic groups only. Significant difference was also observed by Kumar et al. (1971) among genetic groups. However, they obtained a higher value for Rhode Island Red strain than in the present study. The reasons for the low values may be that the eggs were not analysed immediately after collection. This was because the laboratory was far away from the farm. The results further indicated that crossbreeding improved average Haugh Unit.

AVERAGE SHELL THICKNESS (AST)

Significant difference ($P < 0.05$) was observed among genetic group (Table 3).

On average the crosses were better than the purebred pullets. The highest shell thickness was observed in WxR genetic group followed by RxW, RxR and WxW genetic group. A significant difference was observed between the WxR cross and WxW purebred. The values obtained in Rhode Island Red pullets in this study were higher than those in literature (Johari and Singh, 1968; Kumar et al., 1971). Patil et al. (1980) reported shell thickness of 0.34 mm and considered the value normal for table eggs. The high values obtained in this study could be due to the fact that thickness was measured with membrane intact (Asuquo and Afobruketa, 1991). However eggs with thicker shell survive better the rigours of handling. The results showed that crossing improved average

shell thickness.

AVERAGE SHAPE INDEX (ASI)

Significant difference was observed among the genetic group ($P < 0.05$) (Table 3).

The highest value was observed in the RxW genetic group followed by WxW, RxR and WxR genetic group. There was no significant difference between the first three groups. However they were significantly different from WxR genetic group. Kumar et al. (1971) also observed a significant difference among genetic groups. Crossing also improved average shape Index.

Table 1 The least square means (grams) for growth traits in the purebred and crosses.

Traits **	GENETIC GROUPS *				OBS
	1	2	3	4	
B-O	35.02^{b}±0.34	34.56^{a}±0.42	33.53^{ab}±0.46	32.4^{b}±0.45	695
B-4	193.09^{b}±2.89	201.41^{b}±2.37	221.42^{a}±3.22	214.07^{a}±3.11	695
B-8	486.84^{b}±7.68	476.47^{b}±6.29	517.36^{a}±8.21	516.27^{a}±8.53	695
B-12	791.76^{a}±39.63	731.86^{a}±42.26	825.26^{a}±47.01	761.17^{a}±8.53	491
B-16	951.25^{ab}±48.60	916.28^{b}±40.17	1058.52^{a}±46.81	996.34^{ab}±46.63	432
B-20	1135.97^{bc}±25.87	1077.89^{c}±20.82	1213.56^{a}±23.82	1165.41^{b}±23.62	390
BSM	1429.77^{c}±21.14	1520.0^{a}±24.38	1442.68^{bc}±19.67	1500.44^{ab}±23.62	269
B-40	1712.01^{ab}±25.31	1731.31^{ab}±28.33	1681.54^{b}±23.55	1760.69^{a}±27.5	24

- Means horizontally with the same letter are not significantly different ($P < 0.05$) in genetic group wise

* 1 = RxR, 2 = WxW, 3 = RxW, 4 = WxR

** B-0,B-4,B-8,B-12,B-16,B-20,BSM,B-40 = body weight at hatch, 4weeks, 8weeks, 12 weeks, 16 weeks, 20 weeks, sexual maturity, 40 weeks, respectively.

Table 2 The least square means for egg production traits in the purebred and crosses

Traits **	GENETIC GROUPS* 1	2	3	4	OBS
ASM	210.07^{a}±3.09	214.12^{a}±2.67	199.74^{b}±2.97	201.97^{b}±2.44	277
FEWT	45.11^{b}±0.59	47.48^{a}±0.68	45.76^{ab}±0.66	46.66^{ab}±0.55	267
AEWT	48.12^{b}±0.71	50.44^{a}±0.80	46.50^{ab}±0.78	48.48^{ab}±0.67	256
EN-280D	50.49^{b}±2.16	44.43^{c}±1.95	59.81^{a}±2.10	53.65^{b}±1.80	247

- *Means horizontally with the same letter are not significantly different ($P<0.05$) in genetic group wise*

* 1=RxR 2=WxW 3=RxW 4=WxR.

** ASM = Age at sexual maturity
FEWT = First egg weight
AEWT = Average egg weight
EN-280D = 280 days egg production

Table 3: The least square means for egg quality traits in the purebred and crosses

	GENETIC GROUPS*				
Traits **	1	2	3	4	OBS
ASI	75.47^{a}±0.36	75.64^{a}±0.32	75.81^{a}±0.32	74.42^{b}±0.32	236
AYI	47.81^{c}±0.31	48.63^{bc}±0.27	49.12^{a}±0.28	48.88^{ab}±0.27	235
AHU	44.39^{b}±0.46	44.96^{ab}±0.39	45.62^{a}±0.40	44.97^{ab}±0.39	236
AST	0.47^{ab}±0.006	0.46^{b}±0.006	0.48^{ab}±0.005	0.49^{a}±0.005	236

Means horizontally with the same letter are not significantly different ($P<0.05$) in genetic group wise

* 1=RxR 2=WxW 3=RxW 4=WxR.

** ASI = Average shape index
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness

Table 4: Least square means(g) of growth and egg production traits for different hatches independent of genetic group

Traits **	DATE HATCH* 1	2	3	C.V %
B-0	33.52^{a}±0.29	33.06^{a}±0.34	33.56^{a}±0.45	15.02
B-4	195.59^{c}±2.00	210.91^{a}±234	219.79^{b}±3.10	17.09
B-12	705.81^{b}±32.31	843.53^{a}±36.37	783.19^{ab}±46.72	59.99
B-16	981.09^{a}±34.67	1038.20^{a}±36.37	927.50^{ab}±46.62	45.54
B-20	1168.61^{a}±17.85	1215.01^{a}±18.65	1086.50^{ab}±23.9	18.73
BSM	1489.79^{a}±17.07	1489.71^{a}±18.52	1440.54^{a}±21.98	11.69
B-40	1738.56^{a}±2.11	1727.37^{b}±21.99	1698.24^{a}±21.98	11.50
ASM	201.26^{a}±0.48	210.53^{b}±2.34	211.65^{b}±2.78	10.50
FEWT	46.39^{a}±2.11	46.83^{a}±0.52	45.55^{a}±0.61	10.40
AEWT	48.71^{a}±0.57	49.44^{a}±0.63	48.51^{a}±0.73	11.66
EN-280D	48.01^{b}±1.57	53.29^{a}±1.69	54.99^{a}±1.95	29.16

Means with the same letters horizontally are not significantly different ($P<0.05$) in hatch group wise.

* 1 = 31/07/95 2 = 7/08/95 3 =14/08/95

** B-0,B-4,B-8,B-12,B-16,B-20,BSM,B-40 = body weight at hatch, 4weeks, 8weeks, 12weeks, 16weeks, 20weeks, sexual maturity,40weeks,respectively.

ASM = Age at sexual maturity
FEWT = First egg weight
AEWT = Average egg weight
EN-280D = 280 days egg production
ASI = Average shape index
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness

Table 5: Least square analysis of variance for growth and egg production traits.

Source of variation	DF	M.S B-0	M.S B-4	M.S B-8	DF	M.S B-12	DF	B-16	D.F	M.S B-20
Among groups	3	11329**	16378**	78824.39**	3	162319.31	3	387367.91	3	113037.07**
Among hatch	2	13.94	31029.52**	257462.43**	2	874662.30*	2	329862.35	2	56137.38**
Group x hatch	6	118.33**	1825.29	3819.28	6	187276.76	6	83522.33	6	31285.34
Error	683	25.19	1221.51	8574.22	479	215533.11	420	201436.38	375	47375.63
Total		694			490		431		389	

D.F	M.S B.SM	D.F	M.S B-D	D.F	M.S A.SM	D.F	M.S FEWT	D.F	M.S AEWT	D.F	EN280D
3	113037.07**	3	66531.78	3	2871.99**	3	62.37*	3	58.69*	3	2313.03**
2	56137.38	2	30510.93	2	5488.67**	2	29.60	2	18.65	2	1064.01**
6	31285.34	6	31285.34	6	386.37	6	28.04	6	21.29	6	319.77
255	29700.94	237	39288.45	265	475.54	225	23.16	244	32.35	235	229.41
266		248		276		266		255		246	

* = P>0.05, ** P>0.01

** B-0,B-4,B-8,B-12,B-16,B-20,BSM,B-40 = body weight at hatch, 4weeks, 8weeks, 12weeks, 16weeks, 20weeks,sexual maturity,40weeks,respectively.

ASM = Age at sexual maturity
FEWT = First egg weight
AEWT = Average egg weight
EN-280D = 280 days egg production
ASI = Average shape index
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness

4:2 PERCENT HETEROSIS IN STRAIN CROSSES

The percent heterosis in growth and egg production traits are presented in Table 6.

The reciprocal crosses exhibited differences in magnitude and direction of heterosis. This may be due to differences in the nicking ability of the strains (Dutt et al., 1990). This suggest that specialised male and female lines are required for optimum production.

4:2:1 BODY WEIGHT

The RxW cross showed maximum heterosis in desirable direction for body weight at 4, 12, 16, 20 weeks, of age. The results indicated that Rhode Island Red line may be used as male for commercial layer production. In addition the RxW cross showed negative heterosis for body weights at sexual maturity and 40 weeks of age. This is desirable for good layers. The magnitude and direction of heterosis for body weight at different ages are similar to those in literature (Ghostley and Nordskog, 1951; Verma et al., 1985; Dutt et al., 1990).

The results further showed that a large number of genes present for body weight showed dominance or overdominance effect. This suggest that due to the long term pureline selection on the flock, additive genes may have approached fixation and non-additive gene effects are now important for the trait (Pirchner and Krosigk, 1973). The results also indicated large differences in heterosis of body weight at hatch between the reciprocal crosses. These differences demonstrated maternal effect on day-old body weight. Similar results were observed by Nwagu and Nwosu (1994).

4:2:2 AGE AT SEXUAL MATURITY

The results showed heterosis in desirable direction for age at sexual maturity for the reciprocal crosses. The results are within the range (-5.3 - 2.1%) reported by other investigators (Verma et al., 1985; Dutt et al., 1990). Comparing the reciprocal crosses, RxW cross was better than WxR crossbred. This suggests that Rhode Island Red line should be used as male line for commercial exploitation. Since birds that mature early have greater potentials of producing more eggs though small in size.

4:2:3 EGG WEIGHT

The results showed heterosis of different magnitude and direction depending on the cross and the age of the bird. Negative heterosis was observed in the reciprocal crosses except for first egg weight in WxR cross. Negative heterosis for egg weight have been reported in literature (Verma et al., 1985; Dutt et al., 1990). The results suggested that Rhode Island White line should be used as male line for commercial layer production.

4:2:4 EGG PRODUCTION

The results showed that the reciprocal crosses exhibit heterosis in desirable direction for the trait. This indicated that a large number of gene present for this trait show dominance or overdominant effects (Tijen, 1977). Desirable heterosis for this trait have been obtained by Verma et al. (1985). Also Acharya and Kumar (1971) obtained a 6% heterosis for egg production. This result is contrary to those reported by Dutt et al. (1990) who obtained a negative heterosis for all the crosses observed except for one of them. Comparing the reciprocal crosses. RxW was better than WxR cross. This suggested that Rhode Island Red line should be used as male for commercial layer production.

4:2:5 OTHER EGG QUALITY TRAITS

The results indicated that RxW had maximum heterosis in the desirable direction for all egg quality trait except for shell thickness. This suggested that Rhode Island Red line should be used for as male line for commercial layer production. This results are in agreement with those reported for yolk index (Kumar et al., 1971).

Table 6 Percent heterosis in crossbred for growth and egg production traits

	GENETIC GROUPS**	
TRAITS*	3	4
B-0	-0.781	-3.936
B-4	10.842	7.160
B-8	8.312	8.539
B-12	8.329	-0.084
B-16	13.361	6.701
B-20	9.633	5.354
BSM	-2.158	1.793
B-40	-2.330	2.267
ASM	-5.826	-4.774
FEWT	-1.155	0.786
AEWT	-1.581	-1.627
EN280D	20.030	13.052
ASI	0.330	-1.510
AYI	2.090	0.960
AHU	2.099	0.222
AST	0.65	1.73

** 3 = RxW 4 = WxR

* B-0,B-4,B-8,B-12,B-16,B-20,BSM,B-40 = body weight at hatch, 4weeks, 8weeks, 12weeks, 16weeks, 20weeks, sexual maturity,40weeks,respectively.

ASM = Age at sexual maturity
FEWT = First egg weight
AEWT = Average egg weight
EN-280D = 280 days egg production
ASI = Average shape index
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness

4:3 COMPARISON OF THE HERITABILITY OF BODY WEIGHT AND EGG PRODUCTION TRAITS BETWEEN PURE AND CROSSBRED PROGENY

Heritability was determined from sire's component of variance in both purebred and crosses (Table 7 and 8). The estimates are presented in Table 9 and 10.

4.3.1 *HERITABILITY OF BODY WEIGHT*

The results indicated that heritability estimates for body weight at different ages in different genetic groups varies between -0.02 to 1.34 (Table 9). This suggests the trait to be low to highly heritable. Similar results were obtained by Kumararaj et al. (1991). On the contrary Chaudhary et al. (1996) observed moderate to highly heritable estimates. The negative values obtained in this study and the relatively large standard error may be due to the small population size used (Chaudhary et al., 1996). The results suggested that body weight is controlled by non-additive genetic effects.

Among the purebred, heritability of body weight ranged from 0.09 to 1.33 in RxR genetic group and from -0.02 to 0.77 in WxW genetic group. Some of the values were very low when compared to the estimates reported in literature which ranged from moderate to high (Oni et al., 1991). This could be due to the low management conditions under which the traits were measured. However, the results still indicated that body weight exhibited some genetic variance in the flock for faster improvement. Comparison of the two purebreds, RxR had a higher heritability estimate than WxW except for body weight at 4 and 40 weeks of age. The higher

heritability of RxR over WxW at these ages was due to higher additive genetic variation (Table 7). Differences in heritability estimates among purebred was also reported by Oni et al. (1991) and Chaudhary et al. (1996).

Among the crossbred, heritability estimates ranged from 0.18 to 0.89 and -0.18 to 1.14 for the RxW and WxR crosses, respectively. The magnitude of heritability in crosses was slightly different from that obtained in purebred. Pirchner (1977) and Kumararaj et al. (1991) also reported only slight differences in the heritability between crossbred and purebred pullets. Comparing the two crosses, a general tendency of higher estimates in RxW than WxR was also evident except for body weight at hatch and 8 weeks of age. This was due to the higher genetic variation and lower environmental variation of RxW over WxR at these ages (Table 7). The differences in heritability estimates between the two crosses may be due to strain variation (Kumararaj et al., 1991). This further suggest that a specialized male and female line may be important to take care of the body weight trait. Thus the better option is to use Rhode Island Red strain as the male in the crosses.

Further comparison of the cross- and purebred based on the sire's parent breed, estimates were generally higher in RxW cross than in RxR purebred except for body weight at hatch and at sexual maturity. Similar higher estimates in WxR than WxW were observed for Body weight at hatch, 12 and 20 weeks of age. This was due to higher genetic variation and lower environmental variation for these traits in the crosses. The excess of sire's component of heritability in crosses over the pures at some age showed that body weights are influenced by additive and non-additive

genetic effect. Higher estimates in crosses than in pures were reported in literature. (Asuquo and Nwosu, 1987; Chaudhary et al., 1996).

The results further indicated that the heritability of body weight in a particular cross depends on the male parent strain for body weight at 12 and 16 weeks of age. This is suggestive of the role of sex-linked effect in determination of body weight at some age and that of maternal effect at certain ages. Sex-linked effects in determination of body weight was also reported by Krause et al. (1965). While maternal effect on body weight was reported by Sani et al. (1991).

4.3.2 HERITABILITY OF AGE AT SEXUAL MATURITY

The heritabilities for age at sexual maturity ranged from 0.36 to 0.78 over genetic group (Table 10). Generally estimates were higher in strain crosses than in purebred due to proportionately higher genetic variation and lower environmental variation in crosses. Chaudhary et al. (1996) and Pirchner and Krosigk (1973) also reported higher estimates in crosses than in pures. On the contrary Krause et al. (1965) and Hale and Clayton (1965) observed similar estimates in pures and crosses.

Among the purebred, the results indicated that heritability estimate was higher in RxR than in WxW (Table 10). This is due to the higher genetic variance in RxR than in WxW (Table 8). A similar result was obtained by Oni et al. (1991) though their values were lower than those estimated in this study. This may be due to differences in sample size and method of statistical analysis.

Among the crossbred RxW had a higher estimate than WxR. This was due to higher genetic variation and lower environmental variation in RxW as compared to

WxR. This is suggestive of the role of sex-linkage effect in determination of Age at sexual maturity in chickens. This result further confirmed that only male from early maturing dams should be selected for breeding purposes (Singh, 1990).

4.3.3 HERITABILITY OF 280 DAYS EGG PRODUCTION

The heritability estimates of egg production to 280 days of age ranged from 0.08 - 1.56 over genetic groups (Table 10).

This suggest the trait to be low to highly heritable. The estimates were similar to those of Sani et al. (1991) but higher than those of Kumararaj et al. (1991).

Among the purebreds WxW had a higher estimate than RxR. This was due to the higher genetic variance and lower environmental variance in WxW over RxR genetic group. The trend was similar to those estimated by Oni et al. (1991), although higher values were obtained in this study. The differences may be due to sample size and method of analysis.

Among the crosses WxR had a higher estimate than RxW. This is due to higher genetic and lower environmental variance in WxR than RxW cross. The magnitude of heritability in crosses were closer to those of their male parent line. This is suggestive of sex-linked gene in determination of 280 days egg production. It further suggest insignificant bias due to maternal effect.

Comparison of the purebred and crossbred based on the sire's parent breed, estimates were higher in WxR cross than WxW purebred. A reversal was observed between RxW and RxR genetic group. This indicated the presence of a sex-linked

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gene in W sire for egg production which is absence in R sire. Results in literature are conflicting. Higher values in crosses than pures were reported by some investigators (Hale and Clayton, 1965; Chaudhary et al., 1996) where as Krause et al (1965) reported higher estimates in pures than in crosses.

4.3.4 HERETABILITY OF EGG WEIGHT

The results of heritability estimates of egg weight ranged between -0.08 and 0.59 indicating the trait to be low to highly heritable (Table 10). These values lie within the range reported in the literature (Pirchner and Krosigk, 1973; Wei and Van der Werf, 1995).

The general observations also indicated that heritability estimates of egg weight at first egg were lower than those at 35 - 38 weeks of age. Similar results were obtained by King and Henderson (1954).

Among the purebreds WxW had a consistently higher heritability of egg weight than RxR due to higher genetic and lower environmental variation between them. Oni et al. (1991) and Kumararaj et al. (1995) also observed differences in heritability of egg weight among purebred pullets.

Among the crosses RxW had a consistently higher heritability estimates than WxR. This may be due to higher genetic variance in the latter. Comparing the purebred and crossbred, based on the sire's parent breed, estimates were higher in RxW cross than RxR purebred. On the contrary it was lower in WxR cross than WxW purebred. This indicated the presence of a sex-linked gene in R sire for egg

weight which is absent in W sire. Results in literature are conflicting. Chaudhary et al. (1996) reported higher estimates in crosses while other investigators reported lower estimates in crosses (Kumararaj et al., 1991; Wei et al., 1995).

4.3.5 HERITABILITY OF EGG QUALITY TRAITS

The heritability estimates of egg quality traits ranged between -0.29 and 0.45, 0.19 and 0.67, -0.42 and 0.64, -0.06 and 1.10 for average shape index, average yolk index, average Haugh unit and average shell thickness, respectively (Table 10). Some of the values were lower than those in the literature (Pirchner and Krosigk 1973; Kumararaj et al. 1991). Very low estimates observed in some of the egg quality traits, may suggest the traits to be influenced by dominant, over-dominant or epistasis effect of gene. Similar influence of dominant and epistasis effect of gene on yolk index was suggested by Scheinberg et al. (1953).

Among the purebred the heritability of egg quality was consistently higher in WxW than in RxR. This was due to higher genetic variation in WxW genetic group. A similar trend was obtained by Abubakar et al. (1993). Kumararaj et al. (1991) also reported differences in inheritance of egg quality traits among inbred lines.

Among the crosses, RxW had a consistently higher estimate than WxR. This was due to higher genetic and lower environmental variation in RxW cross.

Comparing the crossbred and purebred, heritability estimates were higher in crosses than in pures for all egg quality traits measured except for shell thickness. These results are similar to those reported by Kumararaj et al. (1991) for shape index, Haugh Unit but contrary to their report for yolk index and shell thickness. On the

contrary, Möeller (1952) reported shell thickness to be higher in crosses than in the pureline. However Pirchner and Krosigk (1971) did not observe any differences in heritability estimates between crosses and pures for albumen quality. Estimates of heritability of egg quality traits have been reported to depend on the breed, the flock and the intensity of selection practiced on the parents in the past (Baker, 1960).

Table 7: Variance components of growth traits in purebred and crossbred

Traits*	Variances	GENETIC GROUPS** 1	2	3	4
B-0	Sire	7.693	1.369	0.411	3.062
	Error	54.244	25.058	8.725	7.669
B-4	Sire	56.707	198.324	247.059	50.637
	Error	1161.995	1090.602	1358.567	1524.222
B-8	Sire	667.085	443.348	310.116	490.631
	Error	8064.052	8894.224	10523.611	9906.319
B-12	Sire	4272.927	-2586.166	3828.272	4129.267
	Error	25718.680	453471.583	22259.68	253524.835
B-16	Sire	678.344	662.20	6228.411	-33898.354
	Error	18934.496	36201.953	28863.482	808023.809
B-20	Sire	3399.322	2865.946	14254.734	5600.008
	Error	32190.303	51648.260	49694.773	47278.036
BSM	Sire	10594.794	7425.339	4521.415	2921.758
	Error	21328.380	31013.355	27568.621	19846.931
B40	Sire	1011.393	7093.912	7203.385	2471.854
	Error	43951.745	40074.302	42821.706	16492.018

** 1 = RxR, 2 = WxW, 3 = RxW, 4 = WxR

* B-0,B-4,B-8,B-12,B-16,B-20,BSM,B-40 = body weight at hatch, 4weeks, 8weeks, 12weeks, 16weeks, 20weeks, sexual maturity,40weeks,respectively.

Table 8: Variance components of egg production traits in purebred and crossbred

Traits*	Variances	GENETIC GROUPS** 1	2	3	4
ASM	Sire	95.936	50.239	69.697	148.461
	Error	510.450	508.866	430.606	324.430
FEWT	Sire	1.1470	3.436	4.422	0.829
	Error	28.168	19.919	27.918	13.403
AEWT	Sire	0.977	2.195	7.109	-1.184
	Error	16.817	12.836	21.854	59.695
EN280D	Sire	44.660	44.849	5.31	85.368
	Error	229.031	195.988	245.165	133.516
ASI	Sire	-0.301	0.375	1.123	0.169
	Error	4.432	5.346	8.817	4.902
AYI	Sire	0.261	0.159	0.675	0.492
	Error	5.666	4.907	3.344	3.666
AHU	Sire	-0.413	-0.0803	2.117	-0.409
	Error	4.381	4.730	11.126	16.709
AST	Sire	0.00026	0.00032	0.00001	-0.000038
	Error	0.00081	0.00084	0.0017	0.002506

** 1 = RxR, 2 = WxW, 3 = RxW, 4 = WxR

* ASM = Age at sexual maturity
FEWT = First egg weight
AEWT = Average egg weight
EN-280D = 280 days egg production
ASI = Average shape index
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness

Table 9: Heritability estimates (h^2_s) and their standard errors (s.e.) for growth traits in the purebred and crosses.

Traits*	GENETIC GROUPS**							
	1		2		3		4	
	h^2_s	s.e	h^2_s	s.e	h^2_s	s.e	h^2_s	s.e
B-0	0.50	±0.232	0.21	±0.168	0.18	±0.194	1.14	±0.052
B-4	0.19	±0.199	0.62	±0.228	0.62	±0.354	0.13	±0.169
B-8	0.19	±0.199	0.31	±0.319	0.11	±0.232	0.19	±0.199
B-12	0.57	±0.423	-0.02	±N.E.	0.59	±0.397	0.06	±0.132
B-16	0.14	±0.180	0.07	±0.160	0.71	±0.463	-0.18	±N.E
B-20	0.38	±0.309	0.21	±0.306	0.89	±0.536	0.42	±0.382
BSM	1.33	±0.923	0.77	±0.589	0.56	±0.533	0.51	±0.434
B-40	0.09	±0.242	0.60	±0.543	0.58	±0.552	0.52	±0.522

** 1 = RxR, 2 = WxW, 3 = RxW, 4 = WxR

* B-0, B-4, B-8, B-12, B-16, B-20, BSM, B-40 = body weight at hatch, 4weeks, 8 weeks, 12 weeks, 16weeks, 20 weeks, sexual maturity, 40 weeks, respectively.

h^2_s = Sire's component of heritability

s.e. = Standard Error of heritability

N.E. = Not estimated due to negative value.

Table 10: Heritability estimates (h^2_s) and their standard errors (s.e.) for egg production and quality traits in purebred and crosses.

Traits*	GENETIC GROUPS** 1 h^2_s	s.e.	2 h^2_s	s.e.	3 h^2_s	s.e.	4 h^2_s	s.e.
ASM	0.63	±0.635	0.36	±0.400	0.78	±0.615	0.65	±0.483
FEWT	0.28	±0.355	0.59	±0.614	0.38	±0.439	0.23	±0.289
EN280D	0.65	±0.652	0.74	±0.608	0.08	±0.205	1.56	±0.827
ASI	-0.29	±N.E.	0.26	±0.363	0.45	±0.482	0.43	±0.467
AYI	0.19	±0.356	0.23	±0.342	0.67	±0.593	0.47	±0.489
AHU	-0.42	±N.E.	-0.07	±N.E.	0.64	±0.593	-0.10	±N.E.
AST	0.57	±0.804	1.10	±0.747	0.030	±0.124	-0.06	±N.E.

** 1 = RxR, 2 = Wxw, 3 = RxW, 4 = WxR

* ASM = Age at sexual maturity
FEWT = First egg weight
AEWT = Average egg weight
EN280D = 280 days egg production
ASI = Average shape index
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness

h^2_s = Sire's component of heritability, s.e. = Standard Error of heritability
N.E. = Not estimated due to negative value.

4:4 RECIPROCAL EFFECTS

The sire's and dam's components of variance are presented in Table 11 and 12. Sire's and dam's component of variance were used to determine reciprocal effects.

4.4.1 BODY WEIGHT

The sire and dam's component of variance are presented in Table11. The results indicated that body weight at all ages was influence by sex-linkage except for body weight at hatch. However, this also depends on the sire's breed group considered.

For body weight at hatch, the sire's component of variance for WxW sire was lower than that of the dam's component. This is suggestive of maternal effect on body weight of the chick at hatch. This could be possible since the weight of chick at hatch depends on the egg weight which inturn depends on the pullet weight. This suggested that only eggs with good size should be selected for hatching. A similar result was reported by Sharma et al. (1971). On the contrary Jain and Chaudhary (1984) observed a sex-linked effect.

For body weight at 4 weeks of age, the sire's component was higher than that from the dam for both genetic groups. This suggest a sex-linked effect. These results are in agreement with those in the literature (Hale and Clayton 1965; Krause 1965), but contrary to those reported by Sharma et al. (1971).

The results showed a higher sire's than dam's component of variance for both

purebred only considering body weight at 8 weeks of age. This is suggestive of sex-linked effect in the two breeds of chickens. This is in agreement with those reported by Jain and Chaudhary (1984) and Chaudhary et al. (1996), but are contrary to the reports of Sharma et al. (1971).

For body weight at 12 weeks of age, the results indicated a higher sire's than dam's component of variance for the 4 genetic groups. This may be due to a sex-linked effect. This is in agreement with those obtained by Taran et al. (1972).

No specific trend was observed for body weight at 16 and 20 weeks of age. However, for body weight at sexual maturity, and at 40 weeks of age a higher sire's than dam's component of variance was observed for the 4 genetic groups. This suggests the presence of sex-linked effect. This is in agreement with those obtained by Sani et al. (1991).

4.4.2 EGG PRODUCTION TRAITS

The sire's and dam's components of variance for egg production traits are presented in Table 12.

4.4.2.1 AGE AT SEXUAL MATURITY

The results indicated a higher sire's than dam's component of variance for both RxR and WxW sire. This suggests the trait to be influenced by sex-linked gene. This is in agreement with the results obtained by Lerner (1945). But this is contrary to the reports of other investigators (Pirchner and Krosigk, 1973). Baker (1960) explained that sire's and dam's component of variance depend on intensity of selection on the flock.

4.4.2.2 EGG PRODUCTION 280 DAYS

The results indicated a higher sire's than dam's component of variance for both RxR and WxW sires. This is suggestive of sex-linked effect on the trait. Similar results were obtained by Silva et al. (1976). But this is contrary to those reported by Pirchner and Krosigk (1973).

4.4.2.3 EGG WEIGHT

The results depend on the age of the birds when the eggs were laid. For first egg's weight the sire's component was higher than dam's for R sire. This suggest the presence of sex-linked gene present in R sire but absence in W sire. However a reserve was observed for egg weight at 35 - 38 weeks of age which suggests the presence of maternal effect for both R and W sires. Literature on egg weight varies. Some investigators suggested the existence of sex-linkage effect (Osborne, 1953; Taran et al., 1973). On the contrary other suggested the existence of maternal effect (Taylor and Lerner, 1939 and 41). However, Jaffé (1971) did not notice any effect in his own studies.

4.4.3 EGG QUALITY TRAITS

Sire's and dam's components of variance are presented in Table 12. For average shape index the dam's component of variance was higher than the sire's for the 4 genetic groups. This suggest the presence of maternal/dominant effect of gene. The results are contrary to those observed by Redman and Shelfner (1951) and Shultz (1953b).

For average yolk index the sire's was higher than the dam's component of variance for the four genetic groups. This is suggestive of sex-linkage gene. A similar result was obtained by Redman and Sheffner (1951).

For average Haugh unit the sire's component of variance was higher than that of the dam's for W sire suggesting the presence of sex-linked effect. When considering the R sire a maternal effect was observed. This further suggest that there is a sex-linked gene presence in the W sire and not in the R sire that control Haugh Unit. Maternal effect was observed by Lerner and Taylor (1940). Whereas a sex-linked effect was reported by Redman and Sheffner (1951).

For average shell thickness the sire's component of variance was higher than the dam's for the 4 genetic groups. This is suggestive of sex-linked effect of gene. Similar results were reported by Redman and Sheffner (1951). But this is contrary to those reported by Lerner and Taylor (1939 and 1943).

Table 11: Sire's and dam's variance component of growth rate traits in purebred and crosses.

Traits*	Variance	GENETIC GROUPS** 1	2	3	4
B-0	Sire	7.98416	0.81461981	-0.49726	2.23318
	Dam	-1.823489	3.773907	5.54642	2.576331
	Error	55.77478	21.84297	4.09710	5.425078
B-4	Sire	183.391	188.03038	243.30885	-62.270542
	Dam	127.4341	70.020279	22.89038	90.824593
	Error	1008.05082	1030.95484	1339.47592	1603.2921
B-8	Sire	458.536807	709.426274	-490.89117	3053.45765
	Dam	-95.143715	-288.02789	1103.43958	9044.11783
	Error	8974.09993	8309.40983	24987.55076	10497.2961
B-12	Sire	3854.63513	175.50487	-4361.24136	3053.45765
	Dam	2688.63909	-19582.8729	3267.49297	9044.11783
	Error	3449.9638	470269.4632	24987.55076	245571.1979
B-16	Sire	390.2874	686.00269	6004.0776	-36431.8942
	Dam	1934.92643	-58.08475	1383.11246	21138.3678
	Error	34540.5980	18985.8254	27707.3653	798445.0135
B-20	Sire	415.22091	3631.03669	15070.5116	4485.94302
	Dam	15033.2465	1742.27035	5072.6224	9744.87855
	Error	39083.0936	33698.8356	53941.4744	38661.69208
BSM	Sire	10966.5598	7259.58931	5287.8577	3707.77319
	Dam	-1870.8430	-1742.27035	-3847.29290	-6859.17725
	Error	22826.6251	33698.8356	30635.03465	25911.11287
B-40	Sire	3595.64500	7002.47013	8088.8837	2893.59507
	Dam	-12695.55014	708.61602	-4799.72955	-3107.00757
	Error	54058.6673	3945.25901	46717.00081	19172.52494

** 1 = RxR, 2 = WxW, 3 = RxW, 4 = WxR

* B-0,B-4,B-8,B-12,B-16,B-20,BSM,B-40 = body weight at hatch, 4weeks, 8weeks, 12weeks, 16weeks, 20weeks, sexual maturity, 40 maturity,40weeks,respectively.

Table 12 Sire's and dam's variance component of egg production traits in purebred and crosses

Traits*	Variance	GENETIC GROUPS** 1	2	3	4
ASM	Sire	134.25727	84.156869	70.688524	157.087886
	Dam	-192.84639	-27.92528	-5.0317678	-76.252626
	Error	664.88929	532.86578	434.63066	390.972654
FEWT	Sire	4.842479	-1.0241280	5.16677	0.890258
	Dam	-7.082821	0.699187	-3.738573	-0.538639
	Error	25.590730	27.56351	30.898199	13.879647
AEWT	Sire	1.798965	0.459965	5.012888	-3.15582
	Dam	1.994135	3.982047	6.500829	15.398982
	Error	11.238967	13.35357	17.469707	46.290279
EN280D	Sire	63.0697216	50.44840	12.737807	85.44279
	Dam	-90.427081	-42.81235	-40.25617460	-0.5387203
	Error	301.019976	233.19483	277.83825	133.9791073
ASI	Sire	-0.30666	0.318184	-0.808160	0.102529
	Dam	0.02819	0.34465	11.27664	0.615849
	Error	4.40987	5.05808	9.55796	4.351516
AYI	Sire	0.03758	0.28185	0.99296	0.38800
	Dam	-1.53978	-0.74446	-1.89617	0.99100
	Error	6.90499	5.52932	4.916131	2.78057
AHU	Sire	-0.56452	-0.04174	1.80270	-0.221097
	Dam	0.78208	-0.23492	1.83749	-1.790879
	Error	3.75190	4.92642	9.609284	18.30883
AST	Sire	0.00024	0.00023	0.00002	0.00007
	Dam	0.00014	-0.00516	-0.00018	-0.00104
	Error	0.00070	0.00411	0.00155	0.00343

** 1 = RxR, 2 = WxW, 3 = RxW, 4 = WxR,

* ASM = Age at sexual maturity
EN-280D = 280 days egg production
AYI = Average yolk index
AHU = Average Haught Unit
AST = Average shell thickness
* AEWT = Average egg weight
ASI = Average shape index
FEWT = First egg weight

4.5 GENETIC CORRELATION BETWEEN SOME GROWTH AND EGG PRODUCTION TRAIT IN PURE AND CROSSBRED PROGENY

Genetic correlation between various traits in purebred and crossbred chickens are presented in Table 13 and 14, respectively. Generally the relationship was similar in purebred and crossbred.

4.5.1 GENETIC CORRELATION BETWEEN BODY WEIGHT AT DIFFERENT AGES

The results indicated that the genetic correlation between body weight at different ages was positive for both the purebred and crossbred. But the correlation between early body weight and late body weight was lower. This suggests that birds that are heavier at 8 and 20 weeks of age do not continue to be heavier throughout their production year due to genetic causes. Similar results were obtained by Sani et al. (1991) and Oni et al. (1991). It may further be suggested that the pleiotropy genes involve in genetic correlation between body weight at different ages affect both purebred and crossbred equally. However, the genetic correlation was slightly higher in the crossbred than in the purebred chickens. This implies that selection of pullet based on body weight can be done at an early stage without increasing the matured body weight. This is desirable for good layers.

4.5.2 GENETIC CORRELATION BETWEEN BODY WEIGHT AND AGE AT SEXUAL MATURITY

The genetic correlation between body weight and age at sexual maturity varies in magnitude and direction depending on the age of the bird.

Body weight at 8 weeks and 20 weeks of age was negatively correlated with the age at sexual maturity in the purebred and crossbred chickens. Similar results

have been reported (Clayton, and Robertson 1966; Thiyaga et al., 1983; Sani et al., 1991; Oni et al., 1991). This indicated that early maturer in these genetic groups grow faster and thus tend to be heavier at 8 weeks and 20 weeks of age due to genetic causes(such as pleiotropy). The results suggested that selection of pullets can be done at early age based on the body weight without any detrimental effect on age at sexual maturity.

However, body weight at sexual maturity and at 40 weeks of age was positively correlated with the age at sexual maturity in the purebred and WxR crossbred chickens. Similar results were observed by Krishna and Chaudhary (1987) and Oni et al. (1991). The results indicated that late maturer tend to be heavier in weight due to genetic causes. In addition, as age at sexual maturity decreases body weight at 40 weeks of age also decreases which is desirable for efficient layers. On the contrary, a negative genetic correlation was observed between body weight at sexual maturity, body weight at 40 weeks and age at sexual maturity in RxW crossbred chickens. This may be due to transient correlation in the cross caused by linkage. However, Abubakar et al. (1987) also observed a negative value in one of the lines studied.

4.5.3 GENETIC CORRELATION BETWEEN BODY WEIGHT AND EGG WEIGHT

Genetic correlation between body weight at sexual maturity, body weight at 40 weeks of age and egg weight was low to highly positive in the four genetic groups. The results vary in magnitude depending on the genetic group and the age of the bird. These results are similar to those in literature (Jaffé, 1972; Taran et al., 1972;

Thiyaga et al., 1983; Krishna and Chaudhary, 1987; Sani et al., 1991; Oni et al., 1991). This indicated that heavy birds lay bigger eggs than lighter ones due to genetic causes. It may also be due to physiological causes, since heavy birds have bigger size and higher secretary capacity of the oviduct (Baker, 1960). However, early body weight traits (8 and 20 wks) were negatively correlated with egg weight. This indicated that pullet that are heavier at early age matured early and lay more eggs which are smaller in size due to genetic causes. Similar results were obtained by Oni et al. (1991).

4.5.4 GENETIC CORRELATION BETWEEN BODY WEIGHT AND 280 DAYS EGG PRODUCTION

The genetic correlation between body weight and 280 days egg production varies in magnitude and direction depending on the age of the birds and the genetic group.

The genetic correlation between body weight at 8 weeks, 20 weeks of age and 280 days egg production was positive for the four genetic groups. Similar results were reported by Clayton and Robertson (1966). These results indicated that early maturer have heavier body weight at 8 and 20 weeks of age and thus lay more eggs than late maturer due to genetic causes. The result further suggested that selection of pullet can be done at early age without any detrimental effect on 280 days egg production.

A negative genetic correlation was observed between body weight at sexual maturity, body weight at 40 weeks of age and 280 days egg production in the purebred and WxR crossbred chickens. This indicated that early maturer tend to have low body weight at sexual maturity and 40 weeks of age thus lay more eggs, which is

required of good layers. Similar results were obtained in literature (Hogsett et al., 1964; Jaffé, 1972; Oni et al., 1991). The results further indicated that the body weight at sexual maturity of the above genetic group falls beyong the optimum level (Krishna and Chaudhary, 1987).

On the contrary the RxW crossbred chicken had a positive genetic correlation between body weight at sexual maturity, body weight at 40 weeks of age and 280 days egg production. This could possibly be due to a transient correlation caused by linkage in the cross. However similar results have been reported in literature (Krishna and Chaudhary, 1987; Abubakar et al., 1987). The results indicated that body weight at sexual maturity of RxW cross falls below the optimum level.

4.5.5 GENETIC CORRELATION BETWEEN EGG WEIGHT AND AGE AT SEXUAL MATURITY

The results vary in magnitude depending on the genetic group and the age of the bird.

The results showed a positive genetic correlation between egg weight and age at sexual maturity in the purebred and crossbred chickens. This indicated that as the age at sexual maturity increases egg weight also increases due to genetic causes. The correlation also increased with an increased in period of laying. Similar results were observed by other investigators (Lerner and Cruden, 1951; Clayton and Robertson, 1966; Abubakar et al. 1987; Krishnan and Chaudhary, 1987; Sani et al., 1991). In addition late maturers are heavier in weight and thus will lay larger eggs due to large size of their oviduct (Baker, 1960).

4.5.6 GENETIC CORRELATION BETWEEN AGE AT SEXUAL MATURITY AND 280 DAYS EGG PRODUCTION

The results indicated a negative genetic correlation between age at sexual maturity and 280 days egg production in the four genetic groups.

This indicated that early maturing pullets were better producers due to genetic causes. These findings confirm reports in literature (Hussain and Sing 1964; Hale and Clayton 1965; Clayton and Robertson 1966; Nayak and Mishra 1985; Johari et al., 1985; Abubakar et al. 1987; Krishna and Chaudhary, 1987; Oni et al., 1991; Sani et al., 1991). In addition, birds that matured early had a longer period of lay before the age of 280 days compared to late maturer. This probably gave the early maturer an advantage. This indicated that as selection for egg number progresses birds will mature early.

4.5.7 GENETIC CORRELATION BETWEEN EGG WEIGHT AND 280 DAYS EGG PRODUCTION

The results showed a negative genetic correlation between egg weight and 280 days egg production in the purebred chickens. This indicated that early maturing birds lay more eggs which are smaller in size. This may be associated with physiological process and depends on the rate of ovulation and the efficiency of the oviduct (Hale and Clayton, 1965; Clayton and Robertson, 1966; Taran et al., 1972; Mohapatra et al., 1985; Abubakar et al., 1987; Oni et al., 1991; Sani et al., 1991; Baker, 1960). On the contrary Farnsworth (1956) obtained values ranging from -0.99 to 0.55 while Jaffe (1972) reported value of zero.

However, positive genetic correlation was observed between average egg weight and 280 days egg production in the crossbred chickens. This may be due to a transient correlation caused by linkage in the crosses. The results indicated that

crossbred laid more eggs which were larger in size as compared to the purebred. Thus pureline selection based one gg number does not have any detrimental effect on egg weight in the crosses.

Table 13: Genetic correlation between some growth and Egg production traits in purebred chickens (RxR (Top right hand side) and WxW (bottom left handside)

Traits*	B-8	B-20	BSM	B-40	ASM	FEWT	AEWT	EN280D
B-8	*	0.518	0.245	0.063	-0.763	-0.225	-0.379	0.783
B-20	0.894	*	0.034	0.079	-0.941	-0.476	-0.622	0.025
BSM	N.E	0.192	*	1.103	0.133	0.477	1.217	-0.051
B-40	0.345	0.083	1.141	*	0.323	0.883	0.933	-0.938
ASM	-1.136	-1.047	0.582	0.360	*	0.790	0.933	-0.938
FEWT	N.E	N.E	N.E	N.E	N.E	*	1.339	-0.883
AEWT	-0.956	-0.886	0.493	1.953	1.717	N.E	*	-1.244
EN280D	0.934	0.383	-1.505	-0.440	-1.243	N.E	-1.957	*

* B-8,B-20, BSM,B-40 =Body weight at 8weeks, 20weeks, sexual maturity,40 weeks, respectively.

ASM = Age at sexual maturity

FEWT = First egg weight

AEWT = Average egg weight

EN-280D = 280 days egg production

Table 14: Genetic correlation between some growth and Egg production traits in crossbred chickens (RxW = Top right hand side and WxR = bottom left hand side)

Traits*	B-8	B-20	BSM	B-40	ASM	FEWT	AEWT	EN280D
B-8	*	1.065	1.282	1.052	-1.366	-0.407	-0.958	1.452
B-20	1.325	*	0.878	0.115	-0.399	-0.481	-0.724	0.650
BSM	0.814	0.273	*	1.664	-0.497	1.148	1.297	0.650
B-40	0.572	0.189	1.014	*	-0.634	1.322	1.380	0.989
ASM	-0.583	-0.688	0.165	0.446	*	0.024	0.301	-1.286
FEWT	-0.573	-0.709	1.319	1.309	0.464	*	0.921	-0.947
AEWT	0.842	-0.799	1.151	0.994	1.244	0.483	*	0.093
EN280D	0.334	0.012	-0.347	-0.43	-1.042	-0.435	1.124	*

* B-8,B-20, BSM,B-40 = Body weight at 8weeks, 20weeks, sexual maturity,40 weeks, respectively.

ASM = Age at sexual maturity

FEWT = First egg weight

AEWT = Average egg weight

EN-280D = 280 days egg production

CONCLUSION

Reciprocal crossing was used to test the performance of the F_1 progenies of two breed of Rhode Island Red and White chickens. From the results presented and discussed, the following conclusions were made.

1. Genotypes responded differently to growth and egg production performances.
2. Crossbreeding improved early body weight traits (12, 16 and 20 weeks of age), decreased age at sexual maturity (ASM), improved some internal egg quality (ASI, AHU, AYI) and increased egg number within 280 days of age (EN 280D). .
3. The crosses exhibited reciprocal differences in mean performance. This implies that specialised male and female lines are required for commercial egg production. The RxW cross was a better option.
4. No considerable improvement was made in egg weight as crossbred pullets laid eggs of average weight of the purebred or even lower.
5. Reciprocal crosses exhibited differences in heterosis. The RxW cross showed maximum heterosis in desirable direction for some body weight traits (12, 16 and 20 weeks of age), age at sexual maturity, 280 days egg production and all internal egg qualities except shell thickness.
6. Most heritability estimates were higher in crosses than pures based on the sire's parent breed. The RxW cross exhibited higher heritabilities in these traits than its reciprocal cross. This suggested the existence of non-additive genetic variation in these traits. This may be exploited through a selection method based on

crossline performance.

7. Sex-linked was important for traits such as body weight (B-4, B-8, BSM and B-40); age at sexual maturity (ASM); 280 days egg production (EN280d); average shell thickness; average yolk index. Whereas maternal effect was important for body weight at hatch (B-0) and average shape index (ASI). Thus specialized male and female lines are required for optimum production.

8. Selection of the pullets can be done based on early body weight (12 - 20 weeks) without any detrimental effect on age at sexual maturity and 280 days egg production.

9. Also bearing in mind the moderate heritabilities of early body weight, it should be easy to increased early body weight by selection without at the same time increasing matured body weight in the strains.

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APPENDICES

Appendix 1: Composition of Feed

INGREDIENTS	CHICK MASH	GROWER MASH	BREEDERS MASH
Maize	54.2	43.0	49.0
Rice bran	10.0	20.0	12.0
Groundnut cake	23.5	12.2	20.2
Soyabean meal	7.5	-	10.0
Cotton seed cake	-	20.0	-
Lime stone	1.5	1.5	5.5
Bone meal	2.75	2.75	2.75
Salt	0.3	0.3	0.3
Vitamin Premix	0.25	0.25	0.25
Total %	100	100	100
Calculated Analysis			
Total (phosphorus) P%	0.43	0.73	1.00
Lysine %	0.65	0.64	0.64
Methionine %	0.27	0.30	0.30
Calcium %	1.00	1.00	1.00
Crude protein %	19.25	15.72	18.32
Energy kcal	2800	2400	2400

Appendix 2: Inoculation schedule for the birds

Age of birds (weeks)	Diseases Inoculated Against	Vaccine	Route
1 (Day old)	Marek's diseases	Marek's vaccine	I/m
1 (Day old)	Newcastle	NDV (Hitchner)	I/0
2	Infectious Bursal Disease (Gumboro)	IBDV (Apathogenic)	I/m
2	Newcastle	NDV - Lasotol	Oral in water
5	Gumboro (IBD)	NDV - Ḱomorov	I/m
6	Newscatle	NDV - Komorov	I/m
16	Newscatle	NDV - Komorov (Booster for laying birds)	I/m
18	Gumboro (IBD)	IBDV (Avirulent) (Booster for laying birds)	I/m