EFFECTS OF STOCKING DENSITY, GENOTYPE AND SEX ON THE GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF ROSS AND COBB BROILER CHICKENS

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DECLARATION

I, Siaga Rudzani, (student no: 11617568), hereby declare that this mini- dissertation submitted in partial fulfilment of the requirements for the degree of M.Sc. in Agriculture (Animal Science) in the School of Agriculture University of Venda has not been submitted previously for any degree at this or other universities. It is original in design and execution, and all reference material contained therein has been duly acknowledged.

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DEDICATION

I dedicate this work to my husband, Madzhiga Fulufhelo, son Ampfarisaho, daughters Unarine and Rinae. To them I say "Education is the key to success and never give-up". I took the time I should have used to care for you and used it for study and you encouraged and supported me all the way. You have been my pillar of strength and may God bless you.

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ABSTRACT

A total of 1386 male and female broiler chicks comprising 684 Ross 308 and 702 Cobb Avian48 day-old chicks were assessed for growth performance and carcass characteristics to 42 days of age. The broilers were raised at stocking densities of 30, 35, and 40 kg BW/m² during a 42-day production period. The effects of genotype, sex and stocking density were investigated. Cobb consumed less feed, gained more weight and was heavier than Ross at slaughter age (42days). Males consumed more feed, gained more weight and had a lower feed conversion ratio than females. Broilers raised at the stocking density of 30 kg BW/m² gained more body weight and were heavier at 42 days than those raised at 35 and 40 kg BW/m². There was a progressive reduction in feed intake with increasing stocking density. Sex significantly affected back and thigh weights as well as carcass, wing, drumstick, neck and shank weights, with higher means in males than females. There was also a progressive reduction in the weights and relative weights of carcass parts as stocking density increased. There were genotype x stocking density interaction effects on body weight gain during grower period and feed consumption during the entire study period.

Key words: Broiler chickens ·Density ·Genotype ·Sex ·Performance.

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CHAPTER 1: INTRODUCTION

1.1. Background

The ultimate goal of broiler producers worldwide is to maximise the kilograms of chickens produced per unit area of space, while simultaneously preventing production losses due to overcrowding, in order to achieve a satisfactory economic return. Several studies have been conducted to study the effect of stocking density (20 to 40 kg BW/m^2) on broiler performance. However, most of these studies were not always conclusive. Some studies showed that reducing stocking density had a significant effect on the performance of broilers (Škrbic *et al*., 2009), while others indicated that reducing stocking density had no influence (Thomas *et al*., 2004) or had a negative impact on broiler performance (Feddes *et al*., 2002, Abudabos *et al*., 2013). According to Grashorn and Kutritz (1991), the negative effects of stocking density on growth rate may be the most important economic argument for reducing stocking density. The authors compared the effects of stocking densities of 38 kg BW/m² and 50 kg BW/m² and concluded that a final body weight of around 2 kg was reduced to 1.85 kg when the higher density (50 kg BW/m²) was applied. Beg *et al*. (2011) conducted a similar experiment and concluded that such a decrease in weight may have a substantial impact on the monetary return and could also be an indicator of reduced bird welfare. In addition, Dozier *et al*. (2006) stated that even with broilers grown to 1.8 kg body weight, body weight gain, feed intake and dressing percentage were depressed as stocking density was increased from 25 to 35 kg BW/m², but abdominal fat was not affected. Nembilwi (2002) reported that high stocking densities reduce growth rate and increase mortality rate. Adequate stocking density is therefore essential for optimum broiler performance.

Labogo *et al*. (2003) evaluated the performance of two broiler strains (Cobb-500 and Ross 308) under the small scale production system. Beginning from week eight, every two to three days "full fed" birds that attained live weight of 2.4 kg or more, were slaughtered to determine dressed carcass weight and dressing percentage. For slaughter and carcass weights Cobb-500 had significantly higher mean values than Ross. A significantly higher proportion of Cobb-500 (65.7%) reached market age than Ross chickens (37.65%) at 8 to 9 weeks of age. A relatively higher marginal revenue and lower marginal cost was obtained for Cobb-500 than for the Ross chickens. It was concluded that Cobb-500 had better overall performance than Ross under the small-scale production system.

Justin *et al.* (2008) conducted a study comparing the production performance of Cobb and Ross broiler chickens. There were no significant differences between production performance of Cobb and Ross broilers. However, in general, production performance parameters showed that Cobb had higher values than Ross. Olawumi and Fagbouaro (2011) compared the carcass characteristics of Marshall, Arbor Acre and Hubbard, and observed a significant breed effect on live weight at 8 weeks. The Marshall genotype had a higher mean value and was superior to Arbor Acre and Hubbard in live body weight. However, the three breeds recorded similar mean values in dressing percentage, abdominal fat weight and liver and gizzard weights. With regards to sex effect, males were at 8 weeks of age superior to females in live body weight, eviscerated weight, back muscle weight, thigh muscle weight and drumstick weight. However, the two sexes had similar mean values in dressing weight, dressing percentage, carcass weight, carcass percentage, breast weight, abdominal fat weight and edible giblets weights. There were significant strain x sex interaction effects on all the traits considered. Regardless of sex, Marshall was more productive, feed efficient and gave more carcass yield than Arbor Acres and Hubbard when slaughtered at the same age under uniform management practices and environmental conditions. Males also yielded more meat than females.

Lopez *et al.* (2011) evaluated the effects of strain and sex on carcass characteristics, meat quality, and sensory acceptability of two broiler strains, a commercial strain (strain A) and a strain which was genetically selected to maximise breast yield (strain B). The study revealed that male broilers had higher live body weight, carcass weight, and breast weight and lower dressing percentage and breast meat yield than females. Broilers from strain B had higher breast yield and dressing percentage than strain A. There were no differences between the strains in consumer acceptability of appearance, texture, flavor, and overall acceptability, but with respect to aroma, breast meat from strain B was slightly preferred over that of strain A. Overall, the data suggest that all treatments yielded high quality breast and thigh meat, and that strain did not present variability in terms of consumer acceptability. Abudabos *et al.* (2013) assessed the effect of stocking density on carcass yield in female Ross 308 from 0-30 days of age and concluded that heavier breasts were obtained from birds which had been subjected to low stocking density. Increasing the stocking density of chicks from 28 to 40 kg of BW/ m^2 resulted in poor performance and it jeopardized the bird's welfare. Jovanir *et al.* (2013) evaluated the effect of strain, sex and age on carcass parameters of broiler chickens. Six breeds, namely Cobb 500 Slow, Cobb Fast, Ross 308, Ross 508, Hybro Plus and Avian 48, were used. It was concluded that Cobb 500 Slow males showed the maximum potential for weight gain at 47 days of age. Carcass and breast fillet yield showed significant differences, independent of breed, sex and slaughter age.

1.2. Problem Statement

Commercial broiler farmers generally select broiler genotype and sex that reach market body weight early, in order to maximise profit. However, many small scale farmers or broiler producers do not select, as they lack information on the appropriate strain - sex – stocking density combinations which can maximise profit.

1.3. Justification of the Study

In the last 30 years, the time taken to produce a chicken weighing 2 kg has been halved from more than 10 weeks to less than 6 weeks. Traits such as growth rate and carcass characteristics can be affected by both genotype, sex and stocking density. There is little information on the joint effects of stocking density, genotype and sex on growth and carcass characteristics of Ross and Cobb chickens. This study, therefore, examined the effects of stocking density, genotype, and sex and interactions, if any, on the growth and carcass characteristics of Ross and Cobb chickens.

1.4. Objectives

The main objective of the study was to investigate the effects of stocking density, genotype and sex on the growth performance and carcass characteristics of broiler chickens.

The specific objective are

1. To investigate whether stocking density, genotype and sex have effects on growth performance and carcass characteristics of broiler chickens.
2. To find out whether there are 2- and 3- factor interaction effects on growth and carcass characteristics of broiler chickens.

1.5. Hypotheses

1. There are no stocking density, genotype and sex effects on growth and carcass characteristics.
2. There are no interaction effects on growth and carcass characteristics.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Broiler chickens have been subjected to intensive genetic selection over the past several years, and this has resulted in increased growth rate. This has made them the fastest growing farm species (Meluzzi and Sirri, 2009). Ideally, broilers should have space required in order to express their full genetic potential and make the best use of feed. However, because of the need to reduce labour, housing, fuel and equipment costs, broiler chickens are reared in large-scale commercial intensive systems at high stocking densities in order to obtain maximum return per unit of floor area. It is assumed that as stocking density increases, the income from production also increases. However, high stocking densities make birds more fearful and susceptible to heat stress and these adversely affect their productivity (McLean *et al*., 2001; Eetevez, 2007).

Several authors have reported that broiler chickens of different genetic groups differ in growth rate, final body weight, feed intake and feed efficiency (Sosnowka-Czajka *et al*., 2005; Skomorucha *et al*., 2009). Reiter and Kutritz (2001) reported significant strain differences in body weight gain, whilst Skomorucha *et al*. (2007) did not find any strain effects on feed conversion. Yakubu *et al*. (2009) also reported significant strain and stocking density effects for some carcass characteristics. It has been further argued that the faster growth of selected strains of broilers is associated with increased appetite and an accelerated rate of voluntary feed intake which, in contrast to unselected strains, uses the digestive capacity of the gut almost to the full (McCarthy *et al*., 1983).

2.2. Stocking Density

Stocking density is not the sole crucial factor for broiler (Gallus gallus domesticus) welfare. Management and environmental factors are certainly also very important. Maximum stocking density may be defined as the number of birds or weight of birds per unit floor surface area. Depending on how well the birds meet growth rate goals, weight per floor surface area is optimized (from a production perspective) if it is reached just before slaughter. If, instead, the number of birds is used as a measurement, the individual body weight at which the birds are slaughtered will be of great importance both for bird welfare and optimal use of the buildings and other facilities (Beg *et al*. (2012). According to the industry, stocking density is currently expressed as mass per unit of space rather than numbers of birds being reared in a given area. The advantage of using bird weight per unit area is that the standards are consistent regardless of the target weight (Abudabos *et al.* 2013).

A review by Estevez (2007) pointed out that assigned bird stocking densities have been primarily driven by cost- benefit analysis. Poultry producers tend to increase the number of birds per unit of floor area in order to reduce housing, equipment, and labour costs per unit of floor space. However, realised profits may come with reduced bird performance, health, and welfare if densities are excessive. Reduced bird performance includes reduced final body weight, feed intake, and feed conversion, and often, a greater incidence of footpad dermatitis, scratches, bruising, poor feathering, and condemnations. The significance of stocking density in broiler production, (i.e. production performances, vitality and health condition of broilers) was established at the beginning of the development of industrial poultry production. Stocking density is considered as one of the most important environment factors affecting poultry because of its effect on the growth rate of broiler chickens.

Previously it was not clear whether or not the effect of stocking density on final body mass was in relation to size of feeding space, but results of Škrbić *et al.* (2009) showed that there was a negative effect of high stocking densities, even when feeding space per bird was adequate. According to Benyi *et al.* (2015a) broilers raised at the stocking density of 30kgBW/m² gained more body weight and were heavier at 49 days than those raised at 40 and 50 kg BW/m². To improve profitability, producers increase stocking density. However, because of concerns about animal welfare, maximum allowances for stocking density are now enforced in numerous countries. In Europe, the maximum allowed stocking density is 33 kg BW/m² (European Commission, 2007). However, higher stocking densities (up to 42 kg BW/m²) may be authorised if the producer addresses additional criteria, such as NH_3 and CO_2 concentrations within the shed, temperature, humidity, and mortality rate. High stocking densities are said to increase ammonia production, foot pad lesions, litter moisture, locomotion, heat stress, and preening. Numerous studies have also demonstrated that increasing placement density adversely affects growth performance, carcass yield, and skin scratches and tears (Dozier *et al.*, 2005, Dozier *et al.*, 2006).

2.3. Effects of Genotype

The success of poultry production has been strongly linked to improvements in growth performance and carcass yield and composition. Current commercial broiler chicken strains are the result of successful selection programmes for rapid growth and body conformation, especially favouring the breast muscles. Because the breast is the most valuable portion of the chicken carcass in the market, even small differences in breast yield among strains could have a significant economic impact. For this reason, the broiler industry is constantly interested in evaluating the performance of the commercially available strains; the weight and yield of breast meat is considered the most important variable (Scheuermann *et al.*, 2003). Several factors have been shown to affect carcass yield, carcass composition and the quality of meat. These factors include strain, nutrition, age, live weight and sex (Young *et al.*, 2001). Benyi *et al.* (2015a) evaluated the effect of genotype and stocking density on broiler performance during two subtropical seasons and found that the genotype had an effect on the percentage gizzard weight.

Olawumi *et al.* (2012) evaluated the effects of strain (Arbor Acres, Hubbard and Marshall) and age on production traits of commercial broiler chickens reared on full-feeding, under the same housing and feeding conditions. They concluded that genotype and age of the birds had highly significant effects on all the performance traits of broiler chickens. Arbor Acres and Hubbard appeared superior to Marshall in body weight, but the latter was better in shank length and breast girth than the former. With regards to feed conversion, Marshall was the poorest, Hubbard was intermediate and Arbor Acres was the best. Arbor Acres was adjudged the best and most profitable because the strain had the highest mean values in body weight and feed efficiency, coupled with the lowest feed conversion ratio at maturity.

Amao *et al.* (2011) evaluated some growth performance traits in Ross, Anak and Marshall strains of broiler chickens. There were significant strain differences in body weight, average daily gain, average feed intake and feed conversion ratio. The Ross strain was more favoured for body weight, average daily gain and lower feed intake and feed conversion ratio. Strains of birds showed highly significant and positive correlation with body weight, daily gain, feed intake and feed conversion ratio, while a very highly significant and positively correlation exists between feed conversion ratio and feed intake. The positive relationship for all the growth performance traits measured was a good indicator, and shows that the two strains (Anak and Marshall) can perform as expected with improvements in other aspect of management.

Hristakieva *et al*. (2014) carried out a study on effect of genotype on production traits in broiler chickens and concluded that one-day-old Cobb 500 broilers were heavier than Ross 308 broilers. At the end of the experiment, Cobb 500 broilers attained a higher live weight, and were heavier than Ross 308 birds by 6.29 %. The feed intake per kg weight gain over the entire experimental period of 49 days was 2.178 kg and 2.181 kg for Ross 308 and Cobb 500, respectively.

Shahin *et al*. (2005) studied the effects of breed (Hubbard and Anak), sex and diet and their interactions on carcass composition and tissue weight distribution of broiler chickens and concluded that carcass composition and ratios of muscle, bone, muscle, fat, meat and bone in the carcass did not differ significantly between breed groups. Male carcasses had more muscle, more bone, more fat-free carcass, and higher ratios of muscle, bone, muscle, but less fat, less meat and lower meat: bone ratio than female carcasses. Breed and sex did not influence the distribution of muscle and meat throughout the carcass parts. Breed differences in fat weight distribution were not significant. Anak had significantly higher proportions of bone in wing and neck than Hubbard.

2.4. Sex

In all avian species, females have a lighter skeleton than males. In broiler chickens, females are also less susceptible to bone deformities than males (Rose *et al*., 1996). Because male chickens are typically larger than their female counterparts, they have higher nutrient needs. When feeding a 'straight run' flock (i.e., both males and females), it is common to formulate feeds to meet the average nutritional requirements. This often leads to supplying more nutrients than the female chickens require, while not supplying enough to the males to achieve their potential growth (Jacob *et al*., 2011).

Engku *et al*. (2007) reported that males, whether raised in mixed or sex-segregated groups were generally superior to females. At all ages under study, males were superior to females in body weight and feed intake. There was a trend of increased superiority with increasing age for body weight and feed conversion ratio. Differences in mortality rate and percentage of carcass yield between sexes were small and not significant, while female birds showed indications of higher abdominal fat content than males, particularly at a young age of 22 days. The success of poultry meat production has been strongly related to improvements in growth and carcass yield, mainly by increasing breast proportion and reducing abdominal fat. Carcass composition can be modified by age, sex, handling and manipulation, and it is known that fat deposits increase with age (Ojedapo *et al.* 2008). Farran *et al.* (2000) reported that sex differences are also known to influence carcass fat and abdominal fat deposition. A number of experiments have shown that live body weight was influenced by gender, feed intake and utilisation, abdominal fat content and carcass composition. A number of studies demonstrated that female broilers have higher breast proportions, while in males the proportion of thighs was higher (Hristakieva *et al.* 2014).

Zuowei *et al.* (2011) conducted a study on the effect of stocking density on growth performance of broilers in sex-dependent fashion. Chickens were placed in low stocking density of 26kg/BW/m² and high stocking density of 42kgBW/m² groups. The high stocking density treatment significantly decreased the BW gain and feed conversion ratio (FCR). Male chickens had significantly higher feed intake (FI), BW gain, and FCR compared with females. Female broilers had interior BW gain and FCR when stocked at higher density from 36 to 42d of age. Female broilers need more space near marketing age than males at similar BW/m².

2.5. Interaction Effects

Shim *et al.* (2012) evaluated strain and sex effects on growth performance and carcass traits of contemporary commercial broiler crosses and concluded that there were significant strains x sex interaction effects on body weight gain from 0 to 21 and 0 to 48 days. Strain differences in growth rate and mortality rate increased with age. The cross with the fastest growth rate had the highest mortality rate. Because of differences in mortality and carcass yields, birds with the fastest growth (0-48d) did not produce the most salable meat.

Shahin *et al.* (2005) studied the effects of breed, sex and diet on carcass composition and tissue weight distribution of broiler chickens and concluded that breed x sex, breed x diet and sex x diet interactions did not significantly influence most carcass traits, indicating that the factors under consideration acted independently of each other. Benyi *et al.* (2015a) evaluated the effect of genotype and stocking density on broiler performance during two subtropical seasons and found that there were genotype x stocking density interaction effects on feed consumption during the grower and finisher stages, as well as on the relative weights of breast, gizzard and heart. Zuowei *et al.* (2011) conducted a study on the effect of stocking density on growth performance of broilers in sex-dependent fashion and concluded that there was a significant interaction of stocking density and age for FI, BW gain, and FCR. Stocking density, sex and age had a significant interaction effect on body weight gain and feed conversion ratio.

CHAPTER 3: MATERIALS AND METHODS

3.1. Study Area

The investigation was conducted in winter (July and August 2015) at the poultry facility of the School of Agriculture, University of Venda, Thohoyandou (22° 57' 58"S and 30° 29' 05"E) in South Africa. The climate of the area is subtropical with cold dry winters and hot rainy summers. The broiler house used in the study was similar to those used by small-scale farmers in the area.

3.2. Housing

The walls of the width were constructed with red bricks from the floor to the ceiling, while the walls of the length were constructed with red bricks for 1.0 m followed by 2.5 cm wire mesh to the ceiling. Heavy plastic sheeting on top of the wire mesh was used for ventilation. The house was divided into 36 pens each measuring 322 cm x 92.7cm (2.98m²). The floor was covered with wood shavings, and each pen was equipped with 2 tube feeders, 2 automatic drinkers, as well as two 175-Watt infrared bulbs for heating. The daily temperatures in the house during the study ranged from 8 to 21°C (with the mean of 18°C) (winter). In summer temperatures range from 26 to 42°C (with a mean of 35°C).

3.3. Experimental design

Three hundred and fifteen male and 369 female Ross 308 and 324 male and 378 female Cobb Avian48 day-old chicks were kept and fed a commercial broiler starter diet to 21 days, grower diet to 35 days, and finisher diet to 42 days of age (Table 3.1)

Table 3.1: Chemical composition (label values) of commercial broiler starter, grower and finisher feeds to be used in this study.

Composition(g/kg except ME)	Starter	grower	Finisher
Crude protein	200	180	160
ME(MJ/kg	2.76	13	13.20
ME: CP rations(MJg-1)	0.06	0.07	0.08
Fat	25.0	25.0	25.0
Fibre	50.0	60.0	70.0
Moisture	120	120	120
Calcium	12.0	12.0	12.0
Phosphorus	6.0	5.5	5.0
Lysine	12.0	0.0	9.0

*Supplied by Meadow Feeds, Randfontein, South Africa

The chicks were raised together in groups according to sex and strain for 6 days (acclimatization period). On day 7, the birds of each strain and sex were leg- banded and individually weighed. The chicks were then randomly allocated to 36 pens and randomly assigned to three predetermined stocking densities of 30, 35, and 40 kg BW/m². The number of birds per pen was calculated based on estimated 42- day body weights of 2.98 kg for males and 2,56 kg for females for Ross and 2.93 kg males and 2,49 kg females for Cobb. The equation used to calculate the number of birds per pen needed for the projected treatment densities is as follows: birds/pen = [final treatment density (kg/m²) x pen area (m²)]/projected final body weight (Dozier *et al*., 2005; Dozier *et al*., 2006). The calculated stocking densities of 30, 35 and 40kg BW/m² corresponded to 30, 35 and 40 males and 35, 41 and 47 females for Ross and 31, 36 and 41 males and 36, 42 and 48 females for Cobb chicks per pen. Each genotype – sex – stocking density combination was represented by three replicate pens. Feed and water were provided *ad libitum* and continuous lighting was provided by 40-watt fluorescent tubes. Feeder space /bird (for the predetermined densities of 30, 35, and 40 kg BW/m²) was 6.7, 5.0, 4.0cm and 5.4, 4.1, 3.3cm for Ross and Cobb respectively. The drinker space were 4.9, 3.6, 2.9 cm and 4.4, 3.0, 2.4cm for Ross and Cobb respectively.

3.4. Data Collection

After the initial weighing on day 7, the birds were weighed weekly until 42 days of age. Prior to each weighing, the birds were deprived of feed for 12 h. Feed consumed in each pen was recorded when the birds are weighed. After the last weighing on day 42, four birds were randomly sampled from each pen, slaughtered, defeathered and placed in polyethylene bags and chilled for 48 h, after which the carcasses were thawed and weighed. The following carcass parts were cut and weighed: breast, shank, neck, drumstick, thigh, wing, liver, gizzard (empty), heart and abdominal fat (fat surrounding the gizzard, rectum, cloaca and adjacent abdominal muscles).
Pen means were used for body weights, body weight gains, feed intake, feed efficiency and mortality rate, as well as carcass weight and the weights of the carcass parts. Pen means were used for all data (weights and relative weights), as well as feed intake and feed conversion ratio.

3.5. Data Analysis

The data were analysed by analysis of variance for a 3 x 2 x 2 factorial using the GLM procedure of Minitab 16 statistical software (Minitab, 2015). Three stocking densities, two genotypes and two sexes were tested. Tukey's procedure (Steel and Torrie, 1981) was used to compare treatment means.

The model used was:

$Y_{ijkl} = \mu + D_i + G_j + S_k + (DG)_{ij} + (DS)_{ik} + (GS)_{jk} + (DGS)_{ijk} + \varepsilon_{ijkl}$

Where

Y_{ijkl} = is the observation

μ = overall mean

D_i = effect of the i^{th} stocking density

G_j = effect of the j^{th} genotype

S_k = effect of the k^{th} sex

$(DG)_{ij}$ = interaction of the i^{th} stocking density, the j^{th} genotype

$(DS)_{ik}$ = interaction of the i^{th} stocking density and the k^{th} sex

$(GS)_{jk}$ = interaction of the $_j{}^{th}$ genotype and $_k{}^{th}$ sex

$(DGS)_{ijk}$ = interaction of the $_i{}^{th}$ stocking density, j^{th} genotype and $_k{}^{th}$ sex

ε_{ijkl} = random error

CHAPTER 4: RESULTS

4.1. Growth Performance

During the starter period, stocking density influenced body weight at 21 days of age, body weight gain and feed consumption (all at P<0.01) but had insignificant effects on feed conversion ratio and mortality rate. There were progressive reductions in 21-day body weight and body weight gain with increasing stocking density. For feed consumption, birds reared at 30 and 35 kg BW/m² did not differ significantly but consumed more feed than those arised at 40 kg BW/m² (Table 4.1). Genotype affected (P<0.05) body weight at 7 days of age and feed consumption with higher means in Ross than in Cobb. Sex affected (P<0.05) body weights at 7 and 21 days of age, body weight gain and feed consumption with higher means in males than females (all at P<0.05) but had no significant influences on feed conversion ratio and mortality rate (P>0.05).

There was a progressive reduction in body weight gain with increasing stocking density. With regard to feed intake, birds raised at the stocking density of 30 kg BW/m² consumed more feed than those raised at 35 and 40 kg BW/m but the 2 latter groups did not differ in feed intake (Table 4.2). Genotype had no significant effect on any of the traits during the grower period (P>0.05). Sex affected (P<0.01) body weight at 35 days, body weight gain and feed consumption. Males consumed more feed, gained more weight and were heavier at 35 days of age than females. There was a significant stocking density x sex interaction effect on body weight gain during 22-35 day as well as feed consumption at 7-42 day both at P<0.05) (Table 4.3).

During the finisher period, stocking density had significant effect on weight at 42 days of age (P<0.05) and feed consumption (P<0.01) but had no effect on body weight gain, feed conversion ratio and mortality rate. There was a progressive reduction in feed intake with increasing stocking density but for body weight at 42 days of age, birds reared at 30 kg BW/m² were heavier than those raised at 35 and 40 kg BW/m² but the two latter groups did not differ in body weight at 42 days. Genotype influenced (P<0.05) feed consumption with higher intake in Ross than Cobb. Sex had significant effects on body weight at 42 days of age and feed consumption (both at P<0.01) with higher means in males than females (Table 4.4). There was a genotype x sex interaction effect during 42-day body weight (P<0.01) as well as body weight gain at 7-42 day (P<0.05) (Table 4.5)

Table 4.1: Effects of stocking density, genotype and sex on broiler performance until 21st day of rearing (starter period).

	N	IBW (g)	BW_{21} (g)	BWG_{7-21} (g//b/d)	FC_{7-21} (g/b/day)	FCR_{7-21} (gf/gg/day)	MR_{7-21} (%)
Stocking density means							
30kgBW/m²	12	149^a	783^a	631^a	76^a	1.7^a	1.7^a
35kgBW/m²	12	152^a	745^b	593^b	74^a	1.76^a	1.2^a
40kgBW/m²	12	150^a	714^c	560^c	69^b	1.72^a	2.1^a
SEM		1.3	7.9	2	44.4	0.04	0.7
Genotype means							
Ross	18	148*	745	597	75*	1.72	1.4
Cobb	18	153*	751	592	71*	1.77	1.9
SEM		1.1	6.5	7	1	0.04	0.6
Sex means							
Male	18	152*	778*	622*	76.31*	1.72	1.8
Female	18	149*	717*	566*	69.69*	1.73	1.5
SEM		1.1	6.5	7	1.03	0.04	0.6
Significance							
Stocking Density (D)		ns	**	**	**	ns	ns
Genotype(G)		**	ns	ns	*	ns	ns
Sex (S)		*	**	**	**	ns	ns
D x G		ns	ns	ns	ns	ns	ns
D x S		ns	ns	ns	ns	ns	ns
G x S		ns	ns	ns	ns	ns	ns
D x G x S		ns	ns	ns	ns	ns	ns

IBW = initial body weight, BW_{21}= body weight at 21 days of age, BWG_{7-21}= body weight gain, FC= feed consumption, FCR= feed conversion ratio, MR = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain ns= not significant, N =number of observations, *p<0.05, **P<0.01.

Table 4.2: Effects of stocking density, genotype and sex on broiler performance from 22 to 35 days of rearing (grower period).

	N	BW_{35} (g)	BWG_{22-35} (g)	FC_{22-35} (g/b/day)	FCR_{22-35} (gf/gg/day)	MR_{22-35} (%)
Stocking density means						
30kgBW/m²	12	1764[a]	1019[a]	155[a]	2.16[a]	1.1[a]
35kgBW/m²	12	1642[a]	933[ab]	138[b]	2.11[a]	2.3[a]
40kgBW/m²	12	1613[a]	886[b]	135[b]	2.15[a]	0.4[a]
SEM		57.9	34.4	4.3	0.07	0.6
Genotype means						
Ross	18	1727	975	143	2.08	0.8
Cobb	18	1619	917	142	2.2	1.7
SEM		47.2	28.1	3.5	0.06	0.5
Sex means						
Male	18	1778*	1022*	150*	2.08	0.86
Female	18	1568*	869*	135*	2.2	1.61
SEM		47.2	28.1	3.5*	0.06	0.5
Significance						
Stocking Density(D)		ns	*	**	Ns	ns
Genotype(G)		ns	ns	ns	Ns	ns
Sex (S)		**	**	*	Ns	ns
D x G		ns	ns	ns	Ns	ns
D x S		ns	*	ns	Ns	ns
G x S		ns	ns	ns	Ns	ns
D x G x S		ns	ns	ns	Ns	ns

BW_{35} = body weight at 35 days of age, BWG_{22-35} = body weight gain, FC_{22-35}= feed consumption, FCR_{22-35} = feed conversion ratio, MR_{22-35} = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain, ns = not significant, N = number of observations, *p<0.05, **P<0.01.

Table 4.3: Stocking density x sex means for body weight gain during grower and feed consumption during the entire study periods.

Stocking density	sex	N	BWG_{22-35} (g/b/d)	FC_{7-42} (g/b/d)
30 kg BW/m²	Male	6	1118^{a}	134^{a}
35 kg BW/m²		6	1060^{ab}	130^{ab}
40 kg BW/m²		6	887^{bc}	122^{bc}
30 kg BW/m²	Female	6	919^{abc}	132^{ab}
35 kg BW/m²		6	808^{c}	111^{c}
40 kg BW/m²		6	884^{bc}	110^{c}
SEM			6.0	2.8
Significance				
D x S			*	*

BWG= body weight gain, FC = feed conversion, D = stocking density, S = sex, g/b/d = grams per bird per day, N=number of observations and **P<0.01,* P<0.05.

Table 4.4: Effects of stocking density, genotype and sex on broiler performance from 36 to 42 days of rearing (finisher period).

	N	BW_{42} (g)	BWG_{35-42} (g)	FC_{35-42} (g/b/day)	FCR_{35-42} (gf/gg/day)	MR_{35-42} (%)
Stocking density means						
30kgBW/m²	12	2346[a]	519[a]	194[a]	2.69[a]	0.3[a]
35kgBW/m²	12	2186[b]	454[a]	181[ab]	2.91[a]	0.8[a]
40kgBW/m²	12	2141[b]	511[a]	175[b]	2.64[a]	0.6[a]
SEM		44.4	35.3	3.9	0.18	0.4
Genotype means						
Ross	18	2222	477	190*	2.89	0.7
Cobb	18	2227	512	176*	2.6	0.4
SEM		36.2	28.8	3.24	0.13	0.3
Sex means						
Male	18	2353*	516	192*	2.72	0.8
Female	18	2096*	473	174*	2.77	0.2
SEM		36.2	511.5	3.2	0.13	0.3
Significance						
Stocking density(D)		*	ns	**	Ns	ns
Genotype(G)		ns	ns	**	Ns	ns
Sex (S)		**	ns	**	Ns	ns
D x G		ns	ns	ns	Ns	ns
D x S		ns	ns	ns	Ns	ns
G x S		**	ns	ns	Ns	ns
D x G x S		ns	ns	ns	Ns	ns

BW_{42} = body weight at 42 days of age, BWG_{35-42} = body weight gain, FC_{35-42} = feed consumption, FCR_{35-42} = feed conversion ratio, MR_{35-42} = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain, ns = not significant, N = number of observations, $^*p<0.05$, $^{**}P<0.01$.

Table 4.5: Genotype x sex means for body weight gained during finisher and the entire study period

Genotype	Sex	N	BWG_{42} (g)	BWG_{7-42} (g/b/d)
Ross	Male	9	2411[a]	2260[a]
	Female	9	2033[c]	1888[c]
Cobb	Male	9	2292[ab]	2141[ab]
	Female	9	2160[bc]	2007[bc]
			51.3	51.5
Significance				
G x S			**	*

BWG_{7-42} = body weight gain, G = genotype, S = sex, g/b/d = grams per bird per day, N=number of observations and **P<0.01, *P<0.05.

For the entire study period (7-42 days of age), stocking density affected body weight gain (P<0.05) and feed consumption (P<0.01). For both traits, birds reared at 30 kg BW/m² had higher means than those reared at 35 and 40 kg BW/m² but the 2 latter groups did not differ. Genotype did not significantly affect any of the traits (P>0.05). Sex influenced (P<0.01) body weight gain and feed consumption with higher means in males than females (Table 4.6). There were significant stocking density x genotype interaction effects (P<0.01) (Table 4.7).

Table 4.6: Effects of stocking density, genotype and sex on broiler performance from 7- 42 days of rearing (study period).

	N	BWG_{7-42} (g)	FC_{7-42} (g/b/d)	FCR_{7-42} (gf/gg)	MR_{7-42} (%)
Stocking density means					
30kgBW/m²	12	2197^a	133^a	2.55^a	3.07^a
35kgBW/m²	12	2034^b	121^b	2.5^a	4.15^a
40kgBW/m²	12	1991^b	116^b	2.47^a	3.05^a
SEM		1.3	2	0.05	1.1
Genotype means					
Ross	18	2074	125	2.54	2.9
Cobb	18	2074	122	2.48	4
SEM		36.4	1.6	0.04	0.9
Sex means					
Male	18	2200*	129*	2.46	3.5
Female	18	1948*	118*	2.55	3.4
SEM		36.4	1.6	0.04	0.9
Significance					
stocking density(D)		**	**	ns	Ns
Genotype (G)		ns	ns	ns	Ns
Sex (s)		**	**	ns	Ns
D x G		**	ns	ns	Ns
D x S		ns	*	ns	Ns
G x S		*	ns	ns	Ns
D x G x S		ns	ns	ns	Ns

BWG_{7-42} = body weight gain at 42 days of age, FC_{7-42} = feed consumption, FCR_{7-42} = feed conversion ratio, MR_{7-42} = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain, ns = not significant, N =number of pen observed, *p<0.05, **P<0.01.

Table 4.7: Stocking density x genotype means for body weight gained during the entire study period.

Stocking density	Genotype	N	BWG_{7-42} (g)
30 kg BW/m²	Ross	6	2213^{a}
35 kg BW/m²		6	2157^{ab}
40 kg BW/m²		6	1852^{c}
30 kg BW/m²	Cobb	6	2182^{ab}
35 kg BW/m²		6	1911^{bc}
40 kg BW/m²		6	2129^{ab}
SEM			63.1
Significance			
D x G			**

BWG_{7-42} = body weight gain, D = stocking density, G = genotype, g/b/d = grams per bird per day, N=number of pens observed and **P<0.01, *P<0.05.

4.2. Carcass Characteristics

In terms of weight of carcass parts (Table 4.8), stocking density significantly affected thigh and drumstick weights (both at $P<0.05$) as well as carcass, breast and wing weights (all at $P<0.01$). There were progressive reductions in weights of the carcass parts with increasing stocking density. Genotype had a significant effect only on neck weight ($P<0.01$) with a higher mean in Cobb than Ross. Sex affected back and thigh weights (all at $P<0.05$) as well as carcass, wing, drumstick, neck and shank weights (all at ($P<0.01$), with higher means in males than females. With regard to percentage of carcass parts (Table 4.9), genotype and sex had no influence on any of the traits ($P>0.05$) but stocking density significantly affected percentage of breast.

There was a progressive reduction in the percentage of breast with increasing stocking density. There were no significant stocking density as well as 2- and 3 factor interaction effects on giblet weights (Table 4.10). With regards to percentages of giblets (Table 4.11), there were no significant effects of stocking density, genotype, and sex on any of the traits. There were significant stocking density x genotype interaction effect on drumstick weight, wing and fats percentage (all at $P<0.05$) (Table 4.12). There were significant genotype x sex interaction effects on drumstick and shank weight as well as wing percentage (both at $P<0.05$) (Table 4.13).

Table 4.8: Weights of carcass parts of males and females of two broiler strains raised at three stocking densities.

	N	CW (g)	BRW (g)	BACW (g)	THW (g)	WGW (g)	DSW (g)	NKW (g)	SHW (g)
Stocking density means									
30kgBW/m²	12	1948[a]	646[a]	388[a]	130[a]	103[a]	118[a]	51[a]	36[a]
35kgBW/m²	12	1785[ab]	582[ab]	351[ab]	122[ab]	95[ab]	109[ab]	49[a]	35[a]
40kgBW/m²	12	1692[b]	538[b]	333[b]	115[b]	91[a]	106[b]	48[a]	35[a]
SEM		49.08	22.7	12.9	4	2.3	2.9	1.2	1.3
Genotype means									
Ross	18	1801	587	355	122	95	111	47*	36
Cobb	18	1815	591	359	123	98	111	52*	35
SEM		40.1	18.5	10.6	3.3	1.9	2.3	1	1
Sex means									
Male	18	1897*	606	375*	129*	101*	118*	52*	38*
Female	18	1719*	572	339*	116*	91*	104*	48*	33*
SEM		40.1	18.5	10.6	3.3	1.9	2.3	1	1
Significance									
Stocking density (D)		**	**	*	**	*	ns	ns	ns
Genotype (G)		ns	ns	ns	ns	ns	ns	**	ns
Sex (S)		**	ns	*	*	**	*	ns	ns
D x G		ns	ns	ns	ns	ns	*	ns	ns
D x S		ns	ns	ns	ns	ns	ns	ns	ns
G x S		ns	ns	ns	ns	ns	*	ns	*
D x G x S		ns	ns	ns	ns	ns	ns	ns	ns

CW= carcass weight, BRW= breast weight, BAC= back weight, THW= thigh weight, WGW= wing weight, DSW= drumstick weight, NK= neck weight, SH, shank weight, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01

Table 4.9: Percentage of carcass parts of males and females of two broiler strains raised at three stocking densities.

	N	C %	BR %	BAC %	TH %	WG %	DS %	NK %	SH %
Stocking density means									
30kgBW/m²	12	82.68[a]	27.41[a]	16.45[a]	5.55[a]	4.35[a]	5.02[a]	2.19[a]	1.51[a]
35kgBW/m²	12	80.62[a]	26.31[ab]	15.81[a]	5.48[a]	4.32[a]	4.94[a]	2.24[a]	1.59[a]
40kgBW/m²	12	78.44[a]	24.83[b]	15.41[a]	5.33[a]	4.24[a]	4.9[a]	2.25[a]	1.64[a]
SEM		1.393	0.573	12.98	0.121	0.085	0.088	0.066	0.047
Genotype means									
Ross	18	81.47	26.53	16.03	5.5	4.31	5.02	2.16	1.61
Cobb	18	79.7	25.84	15.74	5.4	4.31	4.88	2.29	1.55
SEM		1.138	0.467	0.287	0.099	0.069	0.072	0.054	0.038
Sex means									
Male	18	80.9	25.76	15.98	5.49	4.33	5.03	2.21	1.62
Female	18	80.27	26.61	15.8	5.42	4.28	4.87	2.24	1.54
SEM		1.138	0.467	0.287	0.099	0.069	0.072	0.054	0.038
Significance									
Stocking density(D)		ns	*	ns	ns	ns	ns	ns	ns
Genotype(G)		ns	ns	ns	ns	ns	ns	ns	ns
Sex(S)		ns	ns	ns	ns	ns	ns	ns	ns
D x G		ns	ns	ns	ns	*	ns	ns	ns
D x S		ns	ns	ns	ns	ns	ns	ns	ns
G x S		ns	ns	ns	ns	*	ns	ns	ns
D x G x S		ns	ns	ns	ns	ns	ns	ns	ns

C%= carcass percentage, BR%= breast percentage weight, BAC%= back percentage, TH%= thigh percentage, WG%= wing percentage, DS%= drumstick percentage, NK%= neck percentage, SH%= shank percentage, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and $^{*}P<0.05$ $^{**}P<0.01$.

Table 4.10: Weights of giblets of males and females of two broiler strains raised at three stocking densities.

	N	KDW (g)	HRTW (g)	GZW (g)	LIVW (g)	FTW (g)
Stocking density means						
30kgBW/m²	12	3.04[a]	13.26[a]	37.36[a]	73.65[a]	40.54[a]
35kgBW/m²	12	2.86[a]	11.46[a]	34.16[a]	66.65[a]	39.82[a]
40kgBW/m²	12	2.7[a]	11.03[a]	77.39[a]	535.87[a]	37.48[a]
SEM		0.11	0.874	24.781	221.09	1.966
Genotype means						
Ross	18	2.95	12.39	63.26	312.86	39.29
Cobb	18	2.79	11.45	36.02	137.92	39.26
SEM		0.09	0.713	20.234	180.52	1.605
Sex means						
Male	18	2.99	11.88	36.83	314.49	40.8
Female	18	2.75	11.96	62.45	136.29	37.76
SEM		0.09	0.713	20.234	180.52	1.605
Significance						
Stocking density(D)		ns	ns	ns	ns	Ns
Genotype(G)		ns	ns	ns	ns	Ns
Sex(S)		ns	ns	ns	ns	Ns
D x G		ns	ns	ns	ns	Ns
D x S		ns	ns	ns	ns	Ns
G x S		ns	ns	ns	ns	Ns
D x G x S		ns	ns	ns	ns	Ns

KDW=kidney weight, HRT=heart weight, GZW=gizzard weight, LIVW= liver weight, FTW= abdominal fats weight, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01

Table 4.11: Percentage of giblets of males and female of two broiler strains raised at three stocking densities.

	N	KID%	HRT %	GZ %	LIV %	FT%
Stocking density means						
30kgBW/m²	12	0.13^{a}	0.58^{a}	1.59^{a}	3.13^{a}	1.74^{a}
35kgBW/m²	12	0.13^{a}	0.52^{a}	1.55^{a}	3.02^{a}	1.81^{a}
40kgBW/m²	12	0.13^{a}	0.51^{a}	3.69^{a}	27.1^{a}	1.77^{a}
SEM		0.0	0.0	1.2	11.4	0.1
Genotype means						
Ross	18	0.13	0.57	2.97	15.77	1.8
Cobb	18	0.12	0.5	1.59	6.4	1.75
SEM		0.0	0.4	1.0	9.3	0.1
Sex means						
Male	18	0.13	0.51	1.58	15.66	1.76
Female	18	0.13	0.57	2.97	6.51	1.78
SEM		0.0	0.4	1.0	9.3	0.1
Significance						
Stocking density(D)		ns	ns	ns	Ns	Ns
Genotype(G)		ns	ns	ns	Ns	Ns
Sex(S)		ns	ns	ns	Ns	Ns
D x G		ns	ns	ns	Ns	*
D x S		ns	ns	ns	ns	Ns
G x S		ns	ns	ns	ns	Ns
D x G x S		ns	ns	ns	ns	Ns

KD%=kidney percentage, HRT%=heart percentage, GZ=gizzard percentage, LIV%= liver percentage, FT%= fats percentage, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01.

Table 4.12: Stocking density x genotype means for drumstick weight, wing and fats percentage

Stocking density	Genotype	N	DSW	WG%	FT%
30 kg BW/m²	Ross	6	117[ab]	4.44[a]	1.88[a]
35 kg BW/m²		6	116[ab]	4.13[a]	1.60[a]
40 kg BW/m²		6	100[b]	4.35[a]	1.92[a]
30 kg BW/m²	Cobb	6	119[a]	4.3[a]	1.6[a]
35 kg BW/m²		6	103[ab]	4.5[a]	2.0[a]
40 kg BW/m²		6	111[ab]	4.1[a]	1.6[a]
SEM			4.1	0.1	0.1
Significance					
D x G			*	*	*

DSW= drumstick weight, WG%= wing percentage, FT%= fats percentage, D= stocking density, G= genotype, N= number of observations and *P<0.05 **P<0.01.

Table 4.13: Genotype x sex means for drumstick, shank weight and wing percentage

Genotype	Sex	N	DSW	SHW	WG%
Ross	Male	9	122[a]	40[a]	4.2[a]
	Female	9	100c	31[b]	4.4[a]
Cobb	Male	9	114[ab]	36[ab]	4.4[a]
	Female	9	109[bc]	35[ab]	4.2[a]
SEM			3.3	3.2	0.1
Significance					
G x S			*	*	*

DSW= body weight gain, SHW= shank weight, WG%= wing percentage, G= genotype, S=sex, N= number of observations and *P<0.05 **P<0.01.

CHAPTER 5: DISCUSSION

5.1. Effects of Stocking Density on Growth Performance and Carcass Characteristics

The decrease in body weight, body weight gain as well as feed consumption observed in this study was reported by Estevez *et al.* (2007) and Skrbic e*t al*. (2009), while the insignificant effect of stocking density on feed conversion ratio was reported by Thomas *et al.* (2004), and Uzum and Toplu (2013). Skomorucha *et al.* (2009) reported increase in feed conversion ratio with increasing stocking density. The significant stocking x genotype interaction on body weight gain during the entire study period observed in this study is consistent with the results of Benyi e*t al.* (2011) who reported significant genotype x stocking density interaction effects on feed conversion ratio. The insignificance influence of stocking density on mortality rate during the different stages of growth observed in this study was reported by researchers such as Thomas *et al.* (2004), Skrbic *et al.* (2007) and Beg *et al.* (2011).

The significant effects of stocking density on carcass characteristics on carcass, breast, back, and wing weights observed in this study contradict with the results of Ravindran and Thomas, (2004), Thomas e*t al.*(2004) and Beg *et al.*(2011) who reported insignificant effects of stocking density on carcass characteristics. Uzum and Toplu (2013) reported insignificant influence of stocking density on back, wing, neck, gizzard, liver and abdominal fat weights.

5.2. Effects of Genotype on Growth Performance and Carcass Characteristics

The significant differences in initial body weight and feed consumption during the starter period observed in this study has been reported in earlier investigations. Similar results were reported by Taha *et al.* (2011). Feed consumption and heavier 35-day body weight of Ross 308 than Cobb during grower period has been previously reported in similar studies (Yakubu *et al.* 2010, Benyi *et al.* 2015a). The similar body weight gained by (597 *vs* 592) by Ross and Cobb respectively during the starter period despite the significantly higher feed consumption of Ross (75g *vs* 71g) suggests that Cobb utilised the feed more efficiently than Ross. Kosarachukwu *at al.* (2010) also reported significant differences in average feed intake across strains of broiler chicken. Ross consumed more feed than Cobb. The non-significant differences in 21-day body weight, body weight gain, feed conversion ratio and mortality rate during starter period was reported by Justin *et al.* (2008). On 35-day body weight gain, feed consumption, feed conversion ratio and mortality rate during grower and the entire periods as well as 42-day body weight, body weight gain, feed conversion ratio and mortality rate during finishing period was also reported by Justin *et al.* (2008). Justin *et al.* (2008) also conducted a study comparing the production performance of Cobb and Ross broilers and found no significant differences in performance traits. Reiter and Kutrits (2001) reported significant strain differences in body weight gain, whilst Skomorucha *et al.* (2007) did not find any strain effect on feed conversion ratio.

According to results genotype did not differ significantly in all traits except in neck weight, these results are consistent with the results reported by Shahin *et al.* (2005) who observed non-significant effects between genotypes in carcass composition. Olawumi and Fagbuaro (2011) reported insignificant strain effects on drumstick weight and abdominal fat weight whilst Youssa *et al.* (2002) observed insignificant strain effects on breast, wing, heart and liver weights.

The genotype x stocking density interaction effects on weight gain during the entire study period were caused by the differences between the genotypes. Similar results were reported by Shim *et al.* (2012) who evaluated strain and sex effects on growth performance and carcass characteristics and observed that there was significant strain x sex interaction effect on body weight gain from 0 to 48 days. However, Benyi *et al.* (2015a) reported genotype x stocking density interaction effects of feed consumption during the grower and finisher stages. The genotype x sex interaction effects on drumstick and shank weights and wing percentage as well as the genotype x stocking density on drumstick weight and wing percentage were previously reported by Olawumi and Fagbuaro (2011).

5.3. Effects of Sex on Growth Performance and Carcass Characteristics

The significant differences in sex on body weight, body weight gain, feed consumption and feed conversion ratio observed in the study have been previously reported by other authors (Sola-Ojo and Ayorinde, 2009, Lopez *et al.* 2011 and Olawumi and Fagbuaro 2011). Males were reported to be superior to females in performance traits including body weight, growth rate, feed intake and feed conversion ratio.

The heavier carcass parts (back, thigh, drumstick, wings, neck and shank) in males than females observed in this study is similar results to by Sola-Ojo and Ayorinde (2009). The non-significant differences in breast weight between males and females observed in this study contradicts the findings of Solo-Ojo and Ayorinde, (2009) which showed that breast weight in females was higher than in males. The higher weight of kidney observed in this study was also reported by Solo-Ojo and Ayorinde, (2009). Female broilers had higher gizzard and heart weights than males. This results contradict the report of Ojedapo *et al.* (2008) who reported that gizzard and heart weights were higher in males than females. In this study, the weight and percentage of abdominal fat were similar in males and females. Engku *et al.* (2007) and Benyi *et al.* (2015b) on the other hand reported that abdominal fat weight and percentage were higher in females than males as early as 22days of age. Almasi *et al.* (2012) suggested that this could be due to the fact that females start to store fat earlier than males; females start to store fat from 6 weeks compared to 8 weeks in males. The sex x stocking density interaction effects on initial body weight, body weight gain during grower as well as feed consumption during the entire study period were caused by the differences between the sexes.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The results of this study showed that birds raised at the lowest stocking density (30kg BW/m²) performed better in weight gain, carcass and giblets weights but consumed more feed than those reared at the higher stocking densities (35 and 40 kg BW/m²). Cobb 308 performed better at 21 and 42-days body weight than Ross Avian 48. Although Ross and Cobb did not differ in weight gained during the study period, Cobb performed better in terms of feed consumption and carcass weights than Ross. The results also revealed that in all stages of growth males were superior to females in weight gain, carcass weights and percentages as well as in kidney, liver, fat weights and liver percentage but consumed more feed.

6.2. Recommendations

In the tropics and subtropics that are characterised by extreme heat and humidity and scarce financial resources, profitable broiler production in these areas requires a genotype that grows fast, consume less feeds , utilises feed more efficiency and reach market weight early. Cobb Avian48 has more of these attributes than Ross 308. It is therefore recommended that for the efficient broiler production in the tropical regions, male Cobb Avian48 reared at the stocking density of 30kg BW/m² be considered.

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APPENDICES

Appendix 1: Mean squares of analysis of variance for initial body weight, 21-day body weight, body weight gain, feed consumption, feed conversion ratio and mortality rate during the starter period.

	df	IBW (g)	W_{21} (g)	BWG $_{7-21}$ (g)	FC_{7-21} (g/b/day)	FCR_{7-21} (gf/gg/day)	MR_{7-21} (%)
Stocking density (D)	2	32.1	14107.6**	14948**	193.28**	0.01	2.785
Genotype (G)	1	231.7**	288.6	221	82.55*	0.02365	2.723
sex (S)	1	124.1*	33393.9**	28243.5**	394.99**	0.00064	0.798
G x D	2	46.8	2170.3	1423.4	31.9	0.00407	11.107
S x D	2	129**	415.4	529.9	51.32	0.03869	6.057
G x S	1	61.8	2706.5	2088.9	0.51	0.1566	3.264
D x G x S	2	2.1	188.8	546.1	58.32	0.04183	9.833
Error	24	21.5	757.7	893.5	19.1	0.02269	5.92

IBW = initial body weight, BW_{21}= body weight at 21 days of age, BWG_{7-21}= body weight gain, FC= feed consumption, FCR= feed conversion ratio, MR = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain, ns= not significant, N =number of observations, *p<0.05, **P<0.01.

Appendix 2: Mean squares of analysis of variance for 35-day body weight, body weight gain, feed consumption, feed conversion ratio and mortality rate during the grower period.

source	df	W_{35} (g)	BWG_{22-35} (g)	FC_{22-35} (g/b/day)	FCR_{22-35} (g/b/day)	MR $_{22-35}$ (%)
Stocking density (D)	2	76655	54443*	1439.3**	0.00723	10.715
Genotype(G)	1	105441	30514	7.5	0.12778	6.359
Sex (S)	1	397074**	208151**	2073.6**	0.12665	4.951
D x G	2	122059	40324	170.9	0.1295	2.809
D x S	2	88203	52420*	165.6	0.11147	18.145*
G x S	1	13079	4332	225.6	0.03188	14.276
D x G x S	2	57616	15726	301.9	0.00817	6.526
Error	24	40115	14190	219	0.06034	4.546

BW_{35} = body weight at 35 days of age, BWG_{22-35} = body weight gain, FC_{22-35}= feed consumption, FCR_{22-35} = feed conversion ratio, MR_{22-35} = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain,ns = not significant, N = number of observations, *p<0.05, **P<0.01.

Appendix 3: Mean squares of analysis of variance for 42-day body weight, body weight gain, feed consumption, feed conversion ratio and mortality rate during the finisher period.

Source	df	W_{42} (g)	BWG_{35-42} (g)	FC_{35-42} (g/b/day)	FCR_{35-42} (gf/gg/day)	MR_{35-42} (%)
Stocking density(D)	2	139843**	15241	1141.8**	0.2486	0.655
Genotype (G)	1	245	11450	1913.2**	0.7576	0.558
Sex (S)	1	592221**	17268	3067.5**	0.0271	3.157
D x G	2	206644**	40891	420.1	0.7523	0.967
D x S	2	31252	4121	421	0.0133	2.453
G X S	1	133622*	35859	4.2	0.6229	0.558
D x G x S	2	26049	8423	455.2	1.0499	0.967
Error	24	23643	14973	189	0.2896	2.048

BW_{42} = body weight at 42 days of age, BWG_{35-42} = body weight gain, FC_{35-42} = feed consumption, FCR_{35-42} = feed conversion ratio, MR_{35-42} = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain, ns = not significant, N = number of observations, *p<0.05, **P<0.01.

Appendix 4: Mean squares of analysis of variance for 42-day body weight, body weight gain, feed consumption, feed conversion ratio and mortality rate during the study period.

Source	df	BWG_{7-42} (g)	FC_{7-42} (g/b/day)	FCR_{7-42} (gf/gg)	MR_{7-42} (%)
Stocking density (D)	2	124065	942.25**	0.01956	4.8
Genotype (G)	1	5890	92.65	0.04003	11.73
Sex (S)	1	549667	1054.42**	0.07412	0.2
D x G	2	208688	111.57	0.1361*	3.53
D x S	2	37317	186.23	0.06243	1
G x S	1	146612	116.09	0.04597	7.39
D x G x S	2	24027	32.55	0.05054	40.66
Error	24	24101	47.64	0.02778	14.14

BWG_{7-42} = body weight gain, FC_{7-42} = feed consumption, FCR_{7-42} = feed conversion ratio, MR_{7-42} = mortality rate, D= stocking density, G= genotype, S= sex, g/b/d= grams per bird per day, gf/gg = gram feed per gram gain, ns = not significant, N =number of obsrvations, *p<0.05, **P<0.01.

Appendix 5: Mean squares of analysis of variance for weights of carcass, back, breast, thigh, wing, drumstick, neck and shank weight of two broiler strains raised at three stocking density under three feeding regimes.

Source	df	CW(g)	BRW(g)	BW(g)	THW(g)	WIW(g)	DRW(g)	NEW(g)	SHW(g)
Stocking density(D)	2	202826**	35863*	9245*	699.1	401.22**	495.03*	34.9	0.49
Genotype (G)	1	1167	109	146	14.1	76.56	0.5	177.78**	0.39
Sex (S)	1	284711**	10252	11646*	1375.2*	875.17**	1677.59**	156.25**	204.25**
G x D	2	150759*	17942	5560	553.6	78.65	491.18	17.88	31.88
S x D	2	11336	1340	842	141.8	108.51	126.18*	4.69	3.6
G x S	1	15150	689	488	146	1.56	717.79*	2.78	120.09*
D x G x S	2	21930	5440	2180	234.5	69.27	100.03	16.84	7.14
Error	24	28901	6178	2022	193.2	64.58	99.27	17.01	18.8

CW= carcass weight, BRW= breast weight, BAC= back weight, THW= thigh weight, WGW= wing weight, DSW= drumstick weight, NK= neck weight, SH, shank weight, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01

Appendix 6: Mean squares of analysis of variance for percentage carcass, back, breast, thigh, wing, drumstick, neck and shank percentage of two broiler strains raised at three stocking density and three feeding regimes.

Source	df	C%	BR%	BA%	TH%	WG%	DS%	NK%	SH%
Density (D)	2	202826	20.21	3.301	0.1448	0.03809	0.04308	0.0111	0.5073
Genotype (G)	1	1647	4.25	0.781	0.904	0.0012	0.16391	0.13747	0.03568
Sex (S)	1	284711	6.527	0.285	0.502	0.01511	0.23515	0.0054	0.05219
G x D	2	150759	0.77	0.064	0.086	0.34926	0.0087	0.11927	0.01375
S x D	2	11336	1.59	0.61	0.324	0.01082	0.00041	0.01947	0.0082
G x S	1	15150	11.737	3.07	0.1366	0.41873	0.11257	0.8594	0.04199
D x G x S	2	21930	0.695	0.203	0.2709	0.04759	0.7735	0.08287	0.00457
Error	24	28901	3.933	1.483	0.1759	0.08589	0.9365	0.05158	0.02632

C%= carcass percentage, BR%= breast percentage weight, BAC%= back percentage, TH%= thigh percentage, WG%= wing percentage, DS%= drumstick percentage, NK%= neck percentage, SH%= shank percentage, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01.

Appendix 7: Mean squares of analysis of variance for weights of giblets of male and female of two genotype groups raised at three stocking density under three feeding regimes

source	df	KDW (g)	HRTW (g)	GZW (g)	LIVW (g)	FTW (g)
Density(D)	2	0.353	16.842	6962	867734	30.67
Genotype	1	0.224	0.02	6676	275461	0.01
Sex (S)	1	0.5476	0.061	5905	285788	83.36
G x D	2	0.3066	9.708	6484	253490	98.45
S x D	2	0.2002	1.184	6713	274578	97.03
G x S	1	0.6084	2.123	6939	905740	58.28
D x G x S	2	0.0073	12.594	6696	919514	60.21
Error	24	0.145	9.162	7369	586563	46.37

KDW=kidney weight, HRT=heart weight, GZW=gizzard weight, LIVW= liver weight, FTW= fats weight, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01

Appendix 8: Mean squares of analysis of variance for percentage of giblets of male and female of two genotype group raised at three stocking density under three feeding regimes

Source	Df	KD%	HRT%	GZ%	LIV%	FT%
Density(D)	2	0.00077	0.01384	18.06	2309	0.0166
Genotype	1	0.00085	0.03993	17.19	790	0.0227
Sex (S)	1	0.00016	0.03296	17.45	753	0.0028
D x G	2	0.00012	0.02633	17.38	748	0.5292
D x S	2	0.00102	0.00468	14.71	790	0.2535
G x S	1	0.00019	0.03187	18.37	2314	0.3652
D x G x S	2	6.2005	0.02503	17	2374	0.0672
Error	24	0.00045	0.02633	17	1569	0.113

KD%=kidney percentage, HRT%=heart percentage, GZ=gizzard percentage, LIV%= liver percentage, FT%= fats percentage, D= stocking density, G= genotype, S= sex, ns= not significant different N= number of observations and *P<0.05 **P<0.01