COMPARATIVE GROWTH PERFORMANCE AND SEMEN CHARACTERISTICS OF INDIGENOUS NAKED NECK TSWANA AND BLACK AUSTRALORP x NAKED NECK TSWANA CHICKENS UNDER AN INTENSIVE MANAGEMENT SYSTEM IN BOTSWANA

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COMPARATIVE GROWTH PERFORMANCE AND SEMEN CHARACTERISTICS OF INDIGENOUS NAKED NECK TSWANA AND BLACK AUSTRALORP x NAKED NECK TSWANA CHICKENS UNDER AN INTENSIVE MANAGEMENT SYSTEM IN BOTSWANA

A dissertation submitted to the Department of Animal Sciences in partial fulfillment of the requirements for the Degree of Master of Science (MSc) in Animal Science (Animal Breeding and Reproduction)

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DECLARATION

I hereby declare that the dissertation hereby submitted by me for the Master of Science degree at Botswana University of Agriculture and Natural Resources, is my own independent work and has not previously been submitted by me at another University/Faculty for the award of any other degree or diploma**.**

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ABSTRACT

This study investigated growth performance and semen characteristics of naked neck Tswana and black Australorp X naked neck Tswana chickens. The birds were raised under intensive management system from day old to 20 weeks of age. In the first study, a total of 66 Australorp x Tswana crossbred chickens and 66 purebred indigenous Tswana chickens were housed in a deep litter house and evaluated for growth performance (body weight) every fortnight from 4-20 weeks of age. The chickens were provided with water and commercial feeds ad libitum. Males of both crossbred and purebred chickens were generally heavier than their age-matched female counterparts at different ages. Body weight was however significantly higher in Australorp x Tswana crossbred males (2920.93 ±57.73) and females (2224.27 ±59.19) than their indigenous purebred counterparts (2467.26 ±59.97) and (1839.31 ±57.04) at 20 weeks of age respectively. There were significant differences in body weight of purebred naked neck Tswana males (1088.56 ±32.47) and females (931.54±30.88) from 10 weeks of age. Growth was also more enhanced in crossbred Australorp x Tswana males than Females. Crossbreeding can therefore be used as a strategy to improve growth performance of indigenous Tswana chickens raised under an intensive management system.

In the second experiment, semen parameters of the birds were evaluated. Semen collection from sixty four (64) purebred naked neck Tswana and sixty four (64) crossbred (Black Australorp X naked neck Tswana) sires at 20 weeks of age was accomplished by the abdominal massage technique Semen parameters with respect to ejaculate volume, pH, sperm motility, sperm concentration and sperm viability were examined for each cock. Crossbred cocks had significantly higher ($p<0.05$) ejaculate volume (0.41 ± 0.005), sperm motility (81.79 ± 0.66) and ejaculate concentration (4.78 ± 0.03) than their purebred naked neck counterparts. However, the degree of semen pH (7.05 ± 0.03), semen color (1.00 ± 0.09) and the percentage of live (76.8 ± 29.4) and dead sperm (23.2 ± 29.1) showed no significant differences ($P>0.05$) between the 2 chicken breeds under study.

Key words: Growth performance, Semen characteristics, F1 crosses, indigenous naked neck chicken, intensive system

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CHAPTER 1: GENERAL INTRODUCTION

Indigenous Tswana chickens account for about 13% of the 23 million national poultry population and are the most common type of poultry raised in rural areas of Botswana (Kgwatalala *et al.*, 2012). They are a source of high-quality protein (meat and eggs), provide income and are part of the cultural life of the society (Kgwatalala *et al.*, 2012). Their products (meat and eggs) are preferred by the majority of people in rural areas because of their color, taste, leanness and suitability for special dishes (Kgwatalala et al., 2012). According to Kgwatalala et al., (2012) Tswana chickens are mainly owned by women and, as such, provide an avenue for empowerment of the disadvantaged members of these largely patriarchal societies.

Kgwatalala *et al.* (2012) reported the existence of several strains/breeds within the indigenous Tswana chicken population such as normal, naked neck, frizzled, rumpless and dwarf phenotypes. Indigenous Tswana chickens survive under stressful environmental conditions including high disease incidence, poor nutrition and high temperatures, all qualities that form the basis for low-input, sustainable agriculture for the rural and resource-poor communities (FAO, 1998a, b).

The major drawback with Tswana chickens is their low productivity in terms of meat and egg production. Exotic chickens on the other hand, produce higher number of eggs and more meat than indigenous chickens but are not adapted to stressful environmental conditions such as high temperatures, diseases and poor nutrition (Kgwatalala and Segokgo, 2013). Methods that can be used to improve productivity of Tswana chickens include within breed selection and crossbreeding. Contrasting and complementary of exotic and indigenous chickens could be exploited through crossbreeding to produce a hybrid.

1.1 Justification

Crossbreeding of Tswana and exotic chickens is practiced by some farmers in Botswana, but it is uncontrolled, and the production performance of the resultant crosses remains unknown. There is need to come up with well-designed crossbreeding programs involving Tswana and exotic chickens and to characterize the production performance of the resultant crosses. Kgwatalala *et al.* (2012) evaluated growth performance of naked neck, normal and dwarf strains of Tswana chicken under an intensive management system and found superior growth performance in the naked neck strain compared to the other two strains. Superior growth performance in the naked neck strain compared to the other strains was attributed to better heat dissipation in the naked neck strain as a result of the naked neck and less body feathering. Crossbreeding the Naked neck strain of Tswana chicken with exotic chicken is therefore likely to produce a hybrid that produces a reasonable amount of meat and eggs and at the same time survive harsh local conditions especially high environmental temperatures as result of global warming.

1.2 Objective

The overall objective of the study was to evaluate growth performance and semen characteristics of indigenous naked neck and black Australorp X indigenous naked neck crossbred chickens under an intensive management system in Botswana.

Experiment 1: Comparative growth performance of naked neck Tswana and black Australorp X naked neck Tswana chickens under intensive management system in Botswana.

The specific objective was to:

- To compare growth performance of crossbred Autralorp x Naked neck chickens with pure-bred Naked neck Tswana chickens from day old to 20 weeks of age under an intensive management system.

The hypothesis tested were:

- Ho: There are no differences in the body weights of pure-bred Naked Neck Tswana chickens and Black Australorp x Naked Neck crossbred chickens under an intensive management system.

- H_A: There are significant differences in the body weights of pure bred Naked Neck Tswana chickens and Black Australorp x Naked Neck crossbred chickens under an intensive management system.

Experiment 2: Semen characteristics of indigenous naked neck and black Australorp x Tswana naked neck crossbred chickens under an intensive management system in Botswana.

The specific objective was to compare the semen parameters i.e. sperm motility, sperm concentration, percentage of live sperm versus dead sperm, semen colour, semen pH and ejaculate volume of crossbred Black Australorp (BA) x Indigenous Naked neck Tswana and pure naked neck Tswana chickens raised under an intensive management system.

The hypothesis tested were:

Ho: There are no differences in the semen characteristics of the naked neck Tswana cockerels and Black Australorp x Naked neck crossbred cockerels.

H_A: There are significant differences in the semen characteristics of pure bred naked neck Tswana cockerels and crossbred Black Australorp x Naked neck Tswana cockerels.

CHAPTER 2: LITERATURE REVIEW

2.1 GROWTH PERFORMANCE

FACTORS INFLUENCING GROWTH PERFORMANCE IN CHICKENS

Growth performance of chicken is influenced by factors including; genetics, ambient temperature, stocking density, nutrition and litter quality.

Genetics

The chicken growth hormone (cGH), a polypeptide hormone synthesized in and secreted by pituitary gland, is highly polymorphic and is involved in a wide variety of physiological functions such as growth, body composition, egg production, ageing and reproduction as well as immune responsiveness (Pipalia, 2003). According to Pipalia (2003), chicken growth hormone gene has been used as a candidate gene for marker assisted selection for improved performance.

Major genes like the frizzle and naked neck gene are highly associated with heat tolerance. The naked neck gene is found to cause about 30-40% reduction in feather coverage and that has an advantage over their normally feathered counter parts in hot humid environment in terms of feed intake, growth rate and weight gain (El-Gandy, 2009). According to El-Gandy (2009) the naked neck broiler chicks tend to have a higher growth rate under hot conditions than their normal feathered counterparts because of their superior ability to dissipate heat and lower body temperature.

Ambient Temperature

High ambient temperatures (AT) reduce feed consumption (FC) and growth rates (GR) of broilers, thereby increasing the time needed to reach marketing weight and leading to low

efficiency and profitability of poultry meat production in hot climates (Geraert *et al.,* 1996). These negative effects of high ambient temperature have been found to be more pronounced in chickens with higher weight after hatching and more rapid growth rate than in those with lower weight after hatching and growth rate (Emmans and Kyriazakis, 2000).

Stocking Density

Density has an important and marked effect on growth of chicken (Cocnen *et al.,* 1996). According to Cocnen *et al.* (1996) density affects feed intake, feed efficiency, livability and that as a whole influence the growth of chicken. Therefore, birds housed with a high density are more likely to be affected by an increased environmental temperature than those of low density housing. Al-Shaheedl and Mukhlis (1991), observed that reducing stocking rate increased feed conversion efficiency in broiler.

High stocking density leads to an increase in ammonia production, foot pad lesions, litter moisture, locomotion and heat stress (Dozier *et al.,* 2005). Broiler chickens should be stocked up to 13 birds m^{-2} without negatively affecting growth performance, feed conversion ratio and the physiological responses of birds (Sekeroglu, 2011).

Nutrition

Higher growth rates are achieved if the daily nutritional requirement of the bird is met. The ability of the bird to achieve its daily nutritional requirement will, in part, depend upon the nutrient composition of the diet.

Feed form plays a greater role on nutrient digestibility and growth performance. Zang *et al.* (2009) reported that pellet diet results in a significant increase in body weight, average daily gain

and average daily feed intake in birds compared with mash diet during starter, grower and overall period. This is in agreement with Onbasilar *et al.* (2009) who found out that broilers fed crumble-pellet diets show improved weight gain, feed intake and feed conversion ratio compared to birds fed mash. Onbasilar *et al.* (2009) further outlined that the consumption of mash feed at different phases of the broiler's growth may be employed as a method of limiting feed intake. Birds offered mash spend more time consuming their feed compare to birds fed pellets and therefore, spend more energy in this process. Andrews (1991) suggested that the improvement in growth rate due to eating pellets is related to some extent to the increase in bulk density of pellets which in some situations increases nutrient intake.

Litter Quality

Broilers do not perform to their genetic potential in a poor environment. A careful selection, adequate management and proper storage and utilization of poultry litter are critically important to reduce environmental pollution and the spread of diseases (Musa *et al.*, 2012). According to Benabdeljelil *et al.* (1996) rice straws, sawdust, wood shavings and rice hulls solely or in combination can successfully be used as poultry litter without apparent effects on bird performance.

Alkis *et al.* (2009) reported that the use of alum (aluminum sulfate) in broiler litter management can improve profitability while reducing some of the environmental threats posed by litter. According to Alkis *et al.* (2009), treating litter with alum is very beneficial as alum reduces ammonia volatilization.

2.2 GROWTH PERFORMANCE OF THE NAKED NECK CHICKEN

Samaera (2003) reported that the live weight of Tswana naked neck chickens fed commercial diet was 1420 g at 19 weeks of age. Islam and Nishibori (2009) reported the body weight of Bangladesh naked neck to be 318 g and 1214 g at 8 and 16 weeks of age, respectively.

Tswana naked neck in the study of Thutwa *et al.* (2012) weighed about 600 g and 1600 g at 8 and 16 weeks of age respectively. According to Thutwa *et al.* (2012) the body weight of Tswana naked neck was also higher than that of Iran indigenous naked neck chickens at 19 weeks of age. Vali (2008) reported that the Iran naked neck males and females weighed 1416.1 g and 1058.3 g, respectively at 19 weeks of age while the Tswana naked neck males and females weighed 2286.69 g and 1493.80 g, respectively at that age even though they were both kept under improved management.

Kgwatalala and Segokgo (2013) reported significantly higher live weight 2543.68g and 1705.02g for naked neck males and females respectively while their normal counterparts weighed 2332.07g and 1567.50g for male and female respectively at 20 weeks of age.

Still in Botswana Kgwatalala *et al.* (2012) reported significantly higher body weights of naked neck compared to the normal and dwarf strains of indigenous Tswana chickens at various ages (Table 2.1). Norris *et al.* (2007) reported that the normal Venda breed had significantly lower growth rate than the naked neck at the same age. Islam and Nishibori (2009), Singh *et al.* (2001) and Vali (1992) also found the indigenous naked neck chickens to be superior to indigenous full-feathered chickens in body weight. A higher growth rate (Cahaner *et al.*, 1993) and meat yield (Barua and Howlider, 1991) has been observed in naked neck broilers than normally feathered counterparts when reared at a high or moderate ambient temperature. These findings are in line

with the study of Patra *et al.* (2002) who reported that the homozygous (Na/Na) and heterozygous (Na/na) naked neck broilers exhibited significantly higher body weight than the normal (na/na) broilers on day old (44.2±0.4 g) and fifth week (1088.3±16.0 g) of age. Relative to the na/na broilers, the Na/Na or Na/na broilers had higher body weight for the rest of the periods except at third week of age.

Table: 2.1 Body weights of male and female naked neck indigenous Tswana chickens at various ages raised under an intensive management system.

	Neked neck	
Age (weeks)	Male	Female
4	369.86±22.23	366.43±24.16
6	613.30±29.12	570.80±31.65
8	895.81±38.33	794.01±41.67
10	1197.8±45.95	1010.45±49.96
12	1515.55±54.66	1246.28±59.42
14	1832.35±63.72	1424.73±69.27
16	2218.02±74.40	1604.22±77.71
18	2516.27±89.42	1793.95±93.39
20	2705.78±91.42	1976.55±100.14

Adapted from Kgwatalala *et al.* (2012)

2.3 Growth performance of crossbred chickens

Kadigi *et al.* (1998) reported body weights of Black Australorp x Malawian local chicken crossbred males and indigenous chicken males at 8 weeks of 0.32±0.15 and 0.26±0.11kg, respectively) andt significantly higher body weights in crossbred males than their indigenous

counterparts at 20 weeks of age (2.14±0.01 and 1.783±0.03kg, respectively). Adedokun and Sonaiya (2002) also reported significantly higher body weights in Dahlem red x Nigerian native chicken crossbred males than in purebred native chicken males at 8 weeks (508±25.0 and 283±23.1g, respectively) and 20 weeks (1360±60.2 and 1191±40.5g, respectively) of age. Still in Nigeria, Momoh *et al.* (2010) reported significantly higher body weights in heavy local chicken ecotype x light local chicken ecotype crossbred males than in purebred light local chicken ecotype males from 12-20 weeks of age.

Khawaja *et al.* (2012) reported higher average day-old weight in Rhode Island Red (RIR) and Fayoumi X RIR crossbred chicken and the lowest day-old weights in Fayoumi. The results are consistent with the findings of Farooqn *et al.* (2001) who reported higher day-old chick weight in RIR (35.32 ± 0.86 g) and lower chick weight in Fayoumi chickens (30.74 ±0.72 g). Bekele *et al.* (2010) reported significantly higher body weights in males than females in the Naked neck x Fayoumi and Netch x Rhode Island Red F1 crosses with indigenous breeds as paternal lines and exotic breeds as maternal lines from 4-8 months of age. In Botswana, Kgwatalala and Segokgo (2013) reported significantly higher body weight (Table 2.2) in Black Australorp x Tswana crossbred males and females than indigenous purebred counterparts from 10-18 weeks of age.

Table 2.2: Body weights of males and females of F1 crosses and indigenous Tswana chickens raised under an intensive management system

	Males		Females	
Age (weeks)	F1 Cross	Tswana	F1 Cross	Tswana
4	235.14±17.05	259.24±12.59	225.63±11.16	251.60±12.59
6	461.82±24.14	438.50±17.83	411.15±15.80	416.91±17.83
8	727.61±31.89	647.50±23.56	634.03±20.88	610.04±23.56
10	1116.57±49.07[a]	878.91±36.24	911.42 ±32.12[b]	775.11±36.24
12	1438.16±53.69[a]	1131.33±39.65	1153.12±35.15[b]	1060.52±39.65
14	1719.17±60.62[a]	1403.06±44.77[a]	1343.21±39.69[b]	1208.57[b]±44.77
16	2124.65±73.60[a]	1660.77±54.38[a]	1567.53±48.21[b]	1363.14[b]±54.38
18	2378.00±73.95[a]	1897.77±54.62[a]	1774.93±48.41[b]	1545.14[b]±54.62

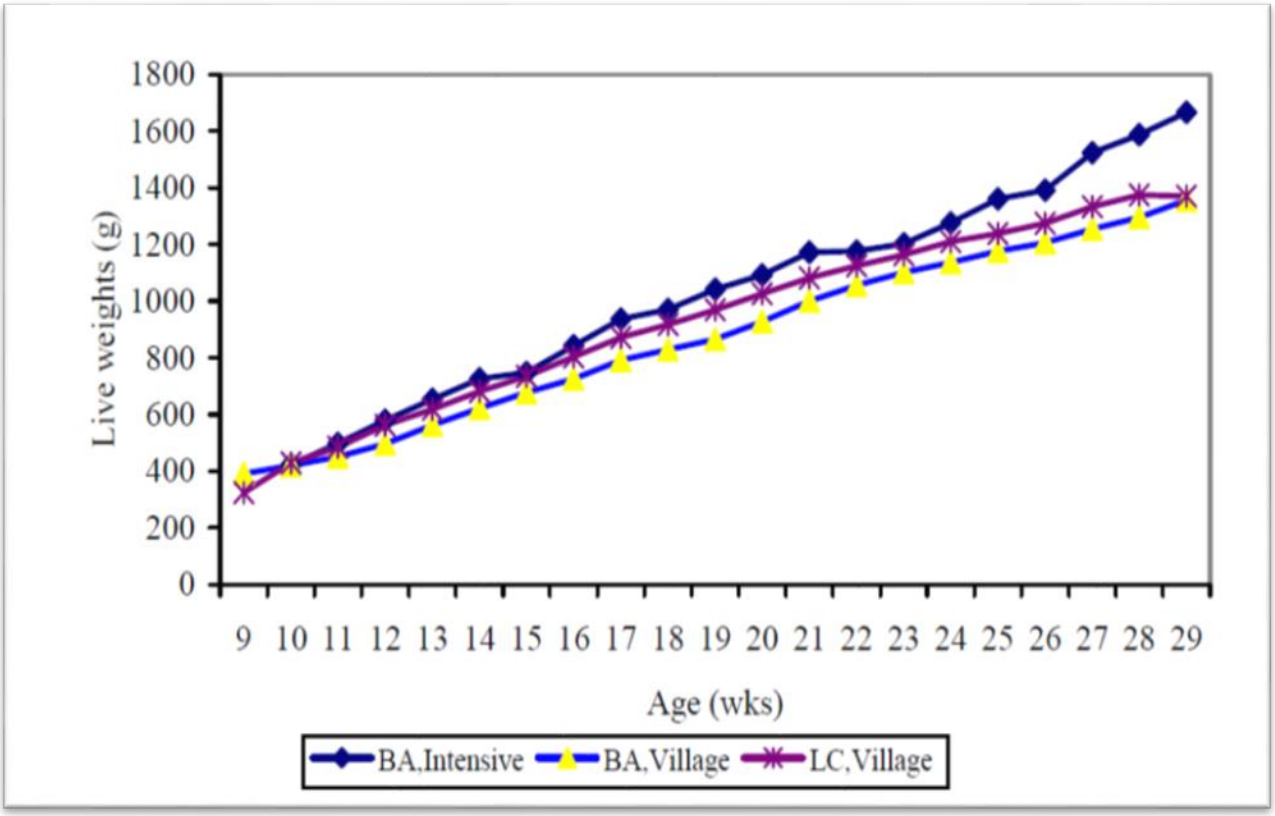
Means with different superscripts within sex at a particular age were significantly different from each other ($p<0.05$).

Adapted from Kgwatalala *et al.* (2013)

2.4 Growth performance of the Black Australorp

In Malawi, Gondwe and Wollny (2003) in their study compared growth performance of Black Australorp and Indigenous chicken of Malawi under different rearing system and found out that Indigenous chicken performed better under free range system while Black Austrolorp performed better under intensive system because of better management(Figure 2.1).

Figure 2.1 Live weight of Black Australorp and Local Chicken



Adapted from Gondwe and Wollny (2003)

2.5 SEMEN CHARACTERISTICS

GENERAL FACTORS AFFECTING SEMEN PRODUCTION

According to Anderson (2001) there are many factors that may influence the production of semen in chickens. Some of these factors are Ambient Temperature, Photoperiod or daylight length and Nutrition.

Ambient Temperature

Direct climatic factors acting on the birds include high ambient temperature and relative humidity, resulting in severe heat stress. Heat stress can be one of the main limitations in poultry production and reproduction, more especially in hot areas. Heat stress may be evaluated by measuring the rectal temperature which is the true reflection of the internal body temperature (Ayo & Sinkalu, 2007).

Photoperiod or daylight length

Most domestic birds are seasonal breeders and, in most birds, photoperiod stimulates spermatogenesis, especially semen production. According to Anderson (2001) the duration and intensity of photoperiod may have an effect on the conditioning of the chickens for reproduction. Short days do not stimulate gonadotrophin secretion, as they do not illuminate the photosensitive phase (Anderson, 2001).

Nutrition

Feed restriction causes stress in cockerels, while low water intake induces the males to lose body weight (Etches, 1996). Etches (1996) further highlighted that this disruption can lead to a permanent non-functional testis and a reduced reproductive performance in the mature cockerel.

The nutrient requirements of males have generally received less attention, and it is a common practice that cockerels are given the same diets that have been formulated for the hens (Etches, 1996). This affects the males in that they often suffer from chronic gout due to high amounts of calcium and protein intake that exceeds their metabolic requirements.

2.6 SEMEN CHARACTERISTICS OF INDIGENOUS CHICKEN

Several reports on semen characteristics of the domestic fowls have indicated that breed and strain significantly affect semen quality and quantity (Schneider, 1992; Bah *et al.,* 2001; Tuncer *et al.,* 2006; *Peters et al.,* 2008). Bah *et al.* (2001) reported semen volume of Sahel regional local breeding cocks to be averaged 0.28 mL.

Tuncer *et al.* (2006) reported semen volume of Denizli cocks to be 0.7 mls. It also falls within the range reported by Peters *et al.* (2008) 0.37-0.73 mL, 0.76 mL for Nigerian indigenous breeds. Still in Nigeria, the study of Ajayi *et al.* (2011) on the comparative effects of three Nigerian indigenous strains of local cocks on the semen quality and their morphological defects revealed that sperm motility and concentration were significantly lower in normal (66.67 and 3.33) than naked neck (70.00 and 4.86) and frizzled feather chickens (79.00 and 3.24), respectively. The abnormal sperm cells, non-motile sperm cells, sperm pH and semen volume were not significant among the three strains of indigenous chicken.

Ajayi *et al.* (2011) further reported that the morphological defects showed no breed or strain differences in the indigenous strains examined. Percentage defect was however more in the tail region than in other parts of the spermatozoa (2.36±0.06, 3.71±0.60 and 9.01±2.31%), respectively for head, mid-piece and tail. Higher percentages of tail defect were also reported by Tabatabaei *et al.* (2009) in exotic Ross-308 and indigenous chicken in Iran- 41.04±10.19 and

44.1±0.26%, respectively. Improper handling of ejaculates during processing for microscopy has been identified as a major cause for sperm abnormality [Ajayi *et al.* (2011)].

In South Africa, Makhafola *et al.* (2012) reported that semen volume of the Naked Neck were significantly higher (0.5±0.2) compared to Ovambo (0.3±0.2) but similar to Potchefstroom Koekoek cockerels (0.4±0.2). The semen pH of Ovambo cockerels was significantly higher (7.7±0.9) compared to Naked Neck (6.8±1.3) and Potchefstroom Koekoek cockerels (6.6±2.2). The sperm concentration of the Potchefstroom Koekoek (8.0 ± 5.0 × 10^9/ml) was significantly higher compared to Ovambo (3.8±6.2× 10^9/ml) and Naked Neck cockerels (6.3±6.2× 10^9/ml). Makhafola *et al.* (2012) revealed that the body weight of all three indigenous breeds were 2.0±0.3, 2.5±0.4 and 2.3±0.3 kg for Naked Neck, Ovambo and Potchefstroom, respectively. Furthermore, Makhafola *et al.* (2012) reported that body weight was negatively correlated with ejaculate volume, semen concentration and pH in naked neck and Ovambo but positive correlation was reported between body weight and volume in Potchfstroom Koekoek strains of Southern African indigenous cockerels. Body weight was reported by Gebriel *et al.* (2009) to have significant effect on concentration and motility but not on semen volume and pH in Norfa chickens. El Ghany *et al.* (2011) reported body weight influence on volume, concentration and motility but not pH in two local strains of chickens.

2.7 Semen characteristics of exotic chicken breeds (Black Nera, White Leghorn and Giriraja

A study by Peters *et al.* (2008) revealed that there were differences between strains with respect to semen volume, concentration, motility, active and sluggish spermatozoa. These observations were consistent with the report of Ezekwe and Machebe (2004). According to Peters *et al.* (2008)

the White Leghorn strain had the highest semen volume followed by Giriraja, Frizzled feathered, Normal feathered, Nera black, Alpha and then Naked neck with corresponding mean values of 0.73±0.01, 0.65±0.04, 0.60±0.02, 0.56±0.04, 0.47±0.02, 0.40±0.03 and 0.37±0.02 respectively. The Least square means for semen concentration as affected by strain of sire did not follow a similar pattern with that of semen volume.

The Naked necked indigenous strain had the highest semen concentration of (4.21±1.45 x10 ^{9}/ml) followed by the Normal feathered strain (4.05±0.65 x 10^{9} /ml), Nera black (3.89 ± 0.83 x 10^{9} /ml), White Leghorn Alpha (3.53 ± 0.53 x 10^{9} /ml), Frizzled feathered (3.45±0.46 x 10^{9} /ml) and Giriraja (3.11±0.42 x 10^{9} /ml) (Peters *et al.,* 2008). On sperm motility, the naked neck strain had the highest value for motile spermatozoa with a value of (87.35±10.12%) followed by White Leghorn (82.54±10.26%) and Alpha (82.50±10.00%), Frizzled feathered (73.22±10.01%), Normal feathered (72.56±10.92%), Nera black (70.00±9.88%) and finally Giriraja (62.55±10.26%). The value of semen motility for Frizzled feathered birds is consistent with the values reported for the Deshi fowl and its hybrids (Sarka *et al.*, 1996).

CHAPTER 3

COMPARATIVE GROWTH PERFORMANCE OF NAKED NECK TSWANA AND CROSSES BETWEEN BLACK AUSTRALORP x NAKED NECK TSWANA CHICKENS UNDER AN INTENSIVE MANAGEMENT SYSTEM IN BOTSWANA

Abstract

Indigenous Tswana chickens are better adapted to prevailing environmental conditions and diseases than their exotic counterparts. They however exhibit slower growth rate and less mature final weights than their exotic counterparts. On the other hand, exotic chickens produce higher number of eggs and more meat than indigenous chickens but are not adapted to stressful environmental conditions. Contrasting and complementary phenotypes of exotic and indigenous chickens can therefore be exploited through crossbreeding to produce a hybrid with improved growth potential than Tswana chickens and better adaptability to environmental stressors than exotic chickens. The current study was therefore aimed at evaluating growth performance of F1 crosses between Black Australorp and indigenous naked neck Tswana chickens relative to purebred indigenous naked neck Tswana chickens under an intensive management system in Botswana. A total of 66 Australorp x Tswana crossbred chickens and 66 purebred indigenous Tswana chickens were housed in a deep litter house and evaluated for growth performance (body weight) every fortnight from 4-20 weeks of age. The chickens were provided with water and commercial feeds ad libitum. Males of both crossbred and purebred chickens were generally heavier ($p>0.05$) than their age-matched female counterparts at different ages. Body weight was however significantly higher in Australorp x Tswana crossbred males (2920.93 ±57.73) and females (2224.27 ±59.19) than their indigenous purebred counterparts (2467.26 ±59.97) and (1839.31 ±57.04) at 20 weeks of age respectively. There were significant differences in body weight of purebred naked neck Tswana males (1088.56 ±32.47) and females (931.54±30.88) from 10 weeks of age. Growth was also more enhanced in crossbred Australorp x Tswana males than Females. Crossbreeding can therefore be used as a strategy to improve growth performance of indigenous Tswana chickens raised under an intensive management system.

Key words: *Growth performance, F1 crosses, indigenous naked neck chicken, intensive system*

3.1 Introduction

Almost every rural family in Botswana owns Tswana chickens, which provide a valuable source of family protein in the form of meat and eggs, and additional income (Kgwatalala *et. al.*, 2012). Indigenous Tswana chickens are mainly raised under traditional free running system under poor nutrition, poor housing and minimal healthcare (Kgwatalala *et. al.*, 2012). Little selection for enhanced production has ever been carried out in Tswana chickens and natural selection targeted adaptation to harsh environmental conditions and resistance to diseases at the expense of enhanced production. Moreki (1997) and Badubi *et al.* (2006) reported the existence of several strains/breeds within the indigenous Tswana chicken population such as normal, naked neck, frizzled, rumpless and dwarf phenotypes. Kgwatalala *et al.* (2012) evaluated growth performance of naked neck, normal and dwarf strains of Tswana chickens and found that of the three strains, the naked neck had the greatest growth potential probably because of their productive adaptability advantage emanating from their superior thermoregulatory functions (Horst, 1990). The naked neck gene reduces total body feathering by up to 20-40% (Singh *et al.*, 2001; Fathi *et al.*, 2008) and is involved in heat tolerance (Isidahomen *et al.*, 2012). Future crossbreeding programs involving Tswana chickens should therefore include the naked neck strain by virtue of its superior growth potential and heat tolerance in the face of global warming and climate change. Incorporating the naked neck gene in breeding programs is an important aspect of breeding for anticipated global warming and climate change (Developing climate-smart breeds to mitigate the anticipated effects of climate change).

Crossbreeding between Tswana chickens and some exotic chicken breeds is practiced by individual farmers throughout the country (Kgwatalala and Segokgo, 2013). Indigenous Tswana chickens exhibit low productivity in terms of meat and egg production while exotic chickens

produce higher number of eggs and more meat than indigenous chickens but are not adapted to stressful environmental conditions such as high temperatures, diseases and poor nutrition (Kgwatalala and Segokgo, 2013). Contrasting and complementary phenotypes of exotic and indigenous chickens can, therefore, be exploited through crossbreeding to produce a hybrid with improved growth potential than Tswana chickens and better adaptability to environmental stressors than exotic chickens.

The two most popular exotic chicken breeds in Botswana are the buff Orpington and black Australorp. Crossbreeding between Tswana and the Black Australorp is practiced by some farmers in Botswana but it is largely uncontrolled, and the production performance of the resultant cross remains unknown. The objective of this study was therefore to evaluate growth performance of Black Australorp x indigenous naked neck Tswana crossbred chickens relative to pure-bred indigenous naked neck Tswana when raised under an intensive management system in Botswana.

3.2 MATERIALS AND METHODS

3.2.1 *Study area*

The study was conducted at Botswana University of Agriculture and Natural Resources, Content Farm, Sebele, Gaborone, in the south eastern part of Botswana. This site is at an altitude of 994m above sea level and the coordinates are latitude 24° 33'S and longitude 25° 54' E. The study was carried out for 20 weeks from August to December 2014 and environmental temperature ranged between 25°C and 38°C and averaged 32°C during the study period.

3.2.2 Experimental animals

A total of one hundred and twenty (120) hens of the naked neck strain of indigenous Tswana chickens, four (4) cocks of the naked neck strain of Tswana chicken and four (4) Black Australorp cocks were used as the foundation stock for breeding purposes. Four indigenous Tswana naked neck males and sixty indigenous Tswana naked neck females (1:15 mating ratio) were housed separately in a deep litter house and fed commercial grower pellets to produce fertile eggs. The other sixty females were housed with four black Australorp males in a separate deep litter house to produce fertile eggs. A total of 100 eggs were collected from each of the deep litter houses. Eggs collected each day were individually identified and stored at 18°C. On the fifth day of egg collection, all the eggs were incubated in an automatic egg incubator at 37.5°C and 65% relative humidity.

The resulting F1 progeny chickens were used to evaluate growth performance of Black Australorp x naked neck Tswana crossbred chickens relative to their age-matched purebred indigenous naked neck Tswana chickens under an intensive management system.

3.2.3 Housing and management

A total of 22 Australorp x Tswana crossbred chickens and 22 purebred indigenous Tswana naked neck chickens were housed together in a deep litter house for a total of 3 deep litter houses resulting in 3 replications. The chicks were fed chick starter mash ad libitum from day old to 2 weeks of age (Table 3.1). At 3 weeks of age, the chicks were individually identified using leg bands and thereafter, fed grower pellets until they were 20 weeks old. The nutritional composition of feeds given to the chickens are shown in Table 3.1 below. Water was provided *ad*

libitum during the brooding and growth phases. During the growth phase, chickens were vaccinated orally (via water) against Newcastle disease and Gumboro disease at two and eight weeks of age, respectively. Chickens were raised under natural light (~12 h light and 12 h dark periods) throughout study period.

Table 3.1. Nutritional composition of feeds given to chickens.

COMPOSITION	**CHICK STARTER (g/kg)**	**Grower pellets (g/kg)**
Protein	200	180
Moister	120	120
Fibre	50	60
Calcium	8	7
Fat	25	25
Phosphorus	6	5.5
Lysine	12	10

3.2.4 Measurement of growth parameter

Growth performance of purebred naked neck Tswana chickens and crossbred Black Australorp x naked neck Tswana chickens was evaluated as changes in body weight of individual chickens from 4-20 weeks of age. Body weights of individual chickens were taken fortnightly from 4-20 weeks of age using an electronic balance.

3.2.5 Statistical analysis

The experiment was set up as a completely randomized design with 3 replications per breed and 22 sampling units per replicate. Growth data were analyzed by General Linear Models procedures of Statistical Analysis System (SAS, 2009) version 9.2.1 and the model included the fixed effects of breed (purebred naked neck Tswana and Black Australorp x naked neck Tswana crossbred chickens) and sex (male and female) and the interaction between breed and sex (Model 1). The results are presented as least square means ± standard error and means separation were by paired t-test with Scheffe's adjustment to account for the differences in the number of sampling units of a particular sex per replication. The differences between means were declared significantly different at $p<0.05$.

Statistical Model

$Y_{ijk} = \mu + T_i + S_j + (T_i * S_j) + e_{ijk}$

Where; Y_{ijk} = body weight of subject (response variable)

μ = Overall mean.

T_i = Effect of the i^{th} breed (Purebred naked neck Tswana and crossbred Black Australorp x naked neck Tswana chickens).

S_j = Effect of j^{th} sex (male and female).

$(T_i * S_j)$ = interaction between sex and the breed of chicken.

e_{ijk} = Random error associated with ijk record

3.3 RESULTS AND DISCUSSION

There were no significant sex differences in the weights of crossbred Black Australorp x Naked neck Tswana chickens at 4 weeks of age (Table 3.2). Crossbred males were, however, significantly heavier ($p<0.05$) than their age-matched female counterparts from 6-20 weeks of age. In purebred naked neck Tswana chickens, there were no significant sex differences in body weights from 4-8 weeks of age. Males of purebred naked neck Tswana chickens were, however, significantly heavier than their age-matched female counterparts from 10-20 weeks of age. The early attainment of sexual dimorphism in body weight in crossbred chickens than in pure-bred naked neck Tswana chickens is consistent with Kgwatalala and Segokgo (2013) who reported significant sex differences in body weight in crossbred chickens (50% Australorp x 50% Tswana) and pure-bred normal-feathered Tswana chickens from 10-18 and 14-18 weeks of age, respectively.

Significantly higher body weight in purebred naked neck Tswana males than females at 20 weeks of age is consistent with Kgwatalala et al (2012) who reported body weights of 2705.78±91.42g and 1976.55±100.14g in purebred naked neck Tswana males and females, respectively at 20 weeks of age.

Table: 3.2: Body weights of males and females of Black Australorp x Tswana F1 crosses and Indigenous naked neck Tswana chickens under an intensive management system in Botswana

Age in Weeks	F_1 Cross		Tswana	
	Body weight (g)		Body weight (g)	
	Males	Females	Males	Females
4	262.68 ±10.47	222.66 ±10.74	331.65±10.88	337.85±10.35
6	467.14^{a} ±12.78	408.59^{b} ±13.10	544.66±13.10	521.84±12.63
8	848.10^{a} ±25.20	736.45^{b} ±25.83	813.76±26.17	746.78±25.89
10	1139.48^{a} ±31.26	1043.98^{b} ±32.05	1088.56^{a} ±32.47	931.54^{b}±30.88
12	1697.81^{a} ±31.26	1272.34^{b} ±43.31	1401.66^{a}±34.75	1168.75^{b}±33.05
14	2043.93^{a} ±40.12	1528.66^{b} ±41.13	1711.59^{a}±41.67	1363.85^{b}±39.64
16	2435.64^{a} ±44.16	1769.80^{b} ±45.28	2021.74^{a}±45.87	1507.60^{b}±53.41
18	2666.93^{a} ±54.06	2014.34^{b} ±55.43	2280.66^{a}± 56.15	1690.06^{b}±53.41
20	2920.93^{a} ±57.73	2224.27^{b} ±59.19	2467.26^{a}±59.97	1839.31^{b}±57.04

Means with different superscripts within bred were significantly different from each other

Body weights of male and female purebred naked neck Tswana chickens at 20 weeks of age reported in this study were higher than those of male and female Iranian naked neck chickens (1416.1 g and 1058.3 g, respectively) at the same age reported by Vali (2008). Higher body weight in crossbred males than females at 20 weeks of age found in the current study is consistent with Adedokun and Sonaiya (2002) who reported body weights of 1360±60.2 g and 1275±79.6 g in Dahlem Red x Fulani crossbred males and females, respectively, and body

weights of 1336±60.2 g and 1143±46.0 g in Dahlem Red x Yoruba crossbred males and females, respectively, at 20 weeks of age.

Adedeji *et al.* (2006) reported body weights of 1110.53±22.09 g and 993.96±22.68 g in crossbred Nigerian naked neck indigenous chicken x white leghorn males and females, respectively, at 20 weeks of age. Body weights of purebred naked neck and crossbred Black Australorp x naked neck Tswana chickens of both sexes at various ages reported in the current study are higher than the weights of purebred normal-feathered strain of Tswana chicken and crossbred Blue Australorp x normal-feathered strain of Tswana chicken of both sexes at similar ages reported by Kgwatalala and Segokgo (2013). Adedeji et al (2006) also reported higher body weights in crossbred Nigerian naked neck indigenous chicken x white leghorn males and females at 20 weeks of age (1110.53±22.09 and 993.96±22.68g, respectively) compared to male and female crossbred counterparts between Nigerian normal-feathered indigenous chicken and white leghorn which weighed 994.71±24.01 and 891.13±24.66g at 20 weeks of age, respectively.

Both purebred naked neck Tswana chickens and crossbred Black Australorp x naked neck Tswana chickens exhibited significant sex differences in body weight at early ages of 10 and 6 weeks of age, respectively, compared to 16 and 10 weeks of age in purebred normal-feathered Tswana and crossbred Blue Australorp x normal-feathered Tswana reported by Kgwatalala and Segokgo (2013). Early enhanced growth performance and early attainment of sexual dimorphism in crossbred Black Australorp x naked neck Tswana reported in this study compared to Blue Australorp x normal- feathered Tswana chicken reported by Kgwatalala and Segokgo (2013) could be attributed to the favorable effect of the naked neck gene on growth performance of chickens raised under high ambient temperatures (Patra et al., 2002; Fathi et al., 2008; Reddy *et al.*, 2008).

The favourable effect of the naked neck gene on growth performance compared to the normal-feathered gene might be due to its association with pronounced heat tolerance which does not adversely affect feed intake at higher ambient temperatures resulting in enhanced growth in crosses involving naked neck Tswana chicken compared to crosses involving normal- feathered Tswana chickens. Significantly higher body weights in both crossbred and purebred males than females during the post-brooding phase might be attributed to the differences in their hormonal profiles, aggressiveness and dominance of males over females when feeding especially when males and females are housed together (Kgwatalala *et al.*, 2015).

Purebred naked neck males and females were significantly heavier than their crossbred counterparts at 4 and 6 weeks of age (Table 3.3). At 8 and 10 weeks of age, purebred naked neck males and their crossbred counterparts had similar body weights. Crossbred males were however significantly heavier than their age-matched purebred counterparts from 12 to 20 weeks of age (Table 3.2). Significantly higher body weights in purebred naked neck males than crossbred Black Australorp x naked neck males at 4 and 6 weeks of age is contrary to Kgwatalala and Segokgo (2013) and Kgwatalala et al. (2015) who found similar body weights between purebred normal-feathered Tswana chicken males and their crossbred counterparts involving normal-feathered Tswana chicken and exotic chicken breeds at similar ages.

Table: 3. 3: Body weights of males and females of F1 crosses and indigenous naked neck Tswana chickens raised under an intensive management system in Botswana

Age in Weeks	Males		Females	
	Body weight (g)		Body weight (g)	
	…….		……	
	F_1 Cross	Tswana	F_1 Cross	Tswana
4	262.68^{b} ±10.47	331.65^{a} ±10.88	222.66^{b} ±10.74	337.85^{a}±10.35
6	467.14^{b} ±12.78	544.66^{a} ±13.10	408.59^{b} ±13.10	521.84^{a}±12.63
8	848.10 ±25.20	813.76±26.17	736.45 ±25.83	746.78±25.89
10	1139.48^{b} ±31.26	1088.56^{a} ±32.47	1043.98^{a} ±32.05	931.54^{b}±30.88
12	1697.81^{a} ±31.26	1401.66^{b}±34.75	1272.34 ±43.31	1168.75±33.05
14	2043.93^{a} ±40.12	1711.59^{b}±41.67	1528.66^{a} ±41.13	1363.85^{b}±39.64
16	2435.64^{a} ±44.16	2021.74^{b}±45.87	1769.80^{a} ±45.28	1507.60^{b}±53.41
18	2666.93^{a} ±54.06	2280.66^{b}± 56.15	2014.34^{a} ±55.43	1690.06^{b}±53.41
20	2920.93^{a} ±57.73	2467.26^{b}±59.97	2224.27^{a} ±59.19	1839.31^{b}±57.04

Body weights of purebred naked neck males at 4 and 6 weeks are higher than body weights of purebred normal-feathered Tswana chicken males at similar ages reported by Kgwatalala and Segokgo (2013) and Kgwatalala et al (2015) clearly indicating enhanced early growth in purebred naked neck males than their normal feathered counterparts. Significantly higher body weight in crossbred Black Austaralorp x naked neck Tswana chicken males than purebred naked

neck Tswana males from 12 to 20 weeks of age is consistent with Kgwatalala and Segokgo (2013) who reported significantly higher body weights in crossbred Blue Australorp x normal-feathered Tswana chicken males than purebred normal-feathered Tswana chicken males from 10 to 18 weeks of age. Kgwatalala *et al.* (2015) also reported significantly higher body weights in crossbred (50% Orpington: 25% Australorp: 25% normal Tswana) males than purebred normal-feathered Tswana males from 10-20 weeks of age. Momoh *et al.* (2010) reported significantly higher body weight in Heavy ecotype x light ecotype crossbred males than pure bred light ecotype males (973±15.28 and 874±6.42 g, respectively) at 20 weeks of age. Kadigi *et al.* (1998) also reported significantly higher body weights in Black Australorp x Malawian local chicken crossbred males than indigenous Malawian chicken males at 20 weeks of age (2.14±0.01 and 1.783±0.03kg, respectively).

Purebred naked neck females were significantly heavier than crossbred Black Australorp x naked neck Tswana chicken females at 4 and 6 weeks of age (Table 3.3). There were no significant differences in body weights between purebred naked neck Tswana females and their crossbred counterparts from 8 to 12 weeks of age. Crossbred females were however significantly heavier ($p<0.05$) than their age-matched purebred naked neck counterparts from 14 to 20 weeks of age. Significantly higher body weights in purebred naked neck Tswana females relative to their cross bred counterparts at 4 and 8 weeks of age are contrary to Kgwatalala and Segokgo (2013) who reported similar body weights between purebred normal-feathered Tswana females and Blue Australorp x normal-feathered Tswana females from 4 to 12 weeks of age. This clearly indicates more enhanced growth rate in purebred naked neck Tswana females than their crossbred counterparts at earlier ages.

Crossbred females exhibit slower growth rates at earlier ages (6 weeks of age and less) than their purebred naked neck Tswana counterparts but eventually exhibits faster growth rates with advancing age. Significantly higher body weight in crossbred than purebred females from 14 to 16 weeks of age is consistent with Kgwatalala and Segokgo (2013) who reported significantly higher body weights in crossbred Blue Autralorp x normal-feathered Tswana females than purebred normal-feathered Tswana females from 18 to 20 weeks of age. Kgwatalala *et al.* (2015) also reported significantly high body weights in crossbred females (50% Orpington: 25% Australorp: 25%Tswana) than normal-feathered Tswana females (1930.08±78.75g and 1692.10±68.20 g, respectively) at 20 weeks of age.

Adedeji *et al* (2006) reported higher body weight in crossbred naked neck x white leghorn females than purebred white leghorn females (993.96±22.68 and 907.18±35.22g, respectively) at 20 weeks of age. Adedokun and Sonaiya (2002) also reported significantly higher body weights in the Dahlem Red x Fulani ecotype crossbred females than purebred Nigerian indigenous chicken females at 20 weeks of age (1275±79.6 and 970±32.3g, respectively).

Significantly higher body weights in both crossbred males and females than their indigenous counterparts at the end of the study (20 weeks of age) are probably mainly due to breed complementarity (favorable breeding value for growth) according to Kgwatalala *et al.* (2015) and to some extent favorable gene combination value or heterosis. Crossbred males were significantly heavier than their indigenous counterparts from 12 weeks of age while for females it took crossbred females 14 weeks to be significantly heavier than their indigenous counterparts. Crossbred males thus had early enhanced growth compared to their female counterparts probably because of effective male growth hormones compared with female hormones (Kgwatalala and Segokgo 2013).

3.4 CONCLUSION

Crossbred chickens (males and females) exhibited faster growth rate than purebred naked neck Tswana chickens under intensive management system. Crossbreeding can therefore be used to improve growth performance of indigenous Tswana chicken under an intensive management system.

3.5 RECOMMENDATION

The study however should be repeated to evaluate other traits of economic importance such as egg production and meat quality of crossbred chickens under intensive management system in Botswana.

CHAPTER 4

SEMEN CHARACTERISTICS OF INDIGENOUS NAKED NECK AND BLACK AUSTRALORP x TSWANA NAKED NECK CROSSBRED CHICKENS UNDER AN INTENSIVE MANAGEMENT SYSTEM IN BOTSWANA

Abstract: *Evaluation of semen quality is very important before selection of breeding cocks used for artificial insemination. The aim of this study was to characterize the semen parameters of Black Australorp x naked neck Tswana chickens and purebred indigenous naked neck Tswana chickens raised under intensive management system in Botswana. Semen collection from sixty four (64) purebred naked neck Tswana and sixty four (64) crossbred (Black Australorp X naked neck Tswana) sires (sixteen each of the two breeds) were randomly assigned to four deep litter pens in a Completely Randomized Design to evaluate their semen characteristics at 20 weeks of age and was accomplished by the abdominal massage technique. Semen parameters with respect to ejaculate volume, pH, sperm motility, sperm concentration and sperm viability were examined for each cock. Crossbred cocks had significantly higher ($p<0.05$) ejaculate volume (0.41 ± 0.005), sperm motility (81.79 ± 0.66) and ejaculate concentration (4.78 ± 0.03) than their purebred naked neck counterparts. However, the degree of semen pH (7.05 ± 0.03), semen color (1.00 ± 0.09) and the percentage of live (76.8 ± 29.4) and dead sperm (23.2 ± 29.1) showed no significant differences ($P>0.05$) between the 2 chicken breeds under study. Crossbreeding indigenous chicken with exotic breeds can therefore be used as a strategy to improve the semen characteristics of indigenous Tswana chickens under an intensive management system.*

Key words*: Semen characteristics crossbred Tswana chickens, purebred Tswana chickens, intensive system*

4.1 INTRODUCTION

The reproductive potential of poultry birds (cocks) is determined to large extent by the quality of the semen they produce (Islam *et al.,* 2002**).** The assessment of semen quality characteristics of poultry birds gives an excellent indicator of their reproductive potential and has been reported to be a major determinant of fertility and subsequent hatchability of eggs (Peters *et al.,* 2004).

According to Bratte & Ibe, (1989), sperm concentration of $50x10^6$ is adequate for good fertility in chickens and turkeys. The genetic effects of breeds, varieties and individuals within breeds on fertility and hatchability have been identified (Islam *et al.,* 2002). Several tests to evaluate semen quality have been described by Umesiobi (2004), but they have rarely been applied in on-farm settings. The industry previously relied on the evaluation of semen using colour and volume parameters, which gave estimates of sperm quantity (Okereke et al., 2008).

Semen volume and color are also evaluated to determine the teasing of male and presence of any lesion or infection in genital tract (Tarif *et al.,* 2013). The quality of semen may vary with breed and strain, age, body weight of cocks, collection technique and diluents used (Mosenene, 2009). There are reports that breed and seasonal differences may also affect semen production of cocks (Tuncer, 2008).

There are very limited studies on evaluation of semen quality of chicken breeds in Botswana. The objective of this study was therefore to evaluate semen parameters of Indigenous naked neck Tswana chicken and that of Black Austaralorp x Naked neck Tswana crossbred chicken raised under intensive management system in Botswana.

4.2 MATERIALS AND METHODS

4.2.1 Semen collection and Evaluation

Semen collection from sixty-four (64) purebred naked neck Tswana and sixty-four (64) crossbred (Black Australorp X naked neck Tswana) sires at 20 weeks of age was accomplished by the abdominal massage technique according to Hafez (1978). The birds were trained for collection of semen for two weeks. Each bird responded to massage by partial aversion of the cloaca, and semen was collected from the ventral lip of the vent in a tube maintained at ±38-40ºC.

The collected semen for each cock was subjected to microscopic examinations and physical evaluations according to Zemjanis (1970). Observations were made and the variation between strains with respect to semen characteristic were examined using the following parameters to characterize each cockerel's semen quality; semen volume, semen colour, semen motility, semen concentration, semen viability (% live vs % dead) and semen pH.

Semen volume: The ejaculate volume of the sample was macroscopically evaluated, immediately after collection, and recorded directly from the semen collection tube. Semen volume from each of the sire strain was measured with the use of a collection tube graduated in ml.

Semen motility: Sperm mass motility, scored on a scale of 0 and 5, was evaluated subjectively under a light microscope (X 40 magnification), giving a general indication of the type and intensity of sperm movement and the impact of movement on the number and size of the sperm agglutinates (Blesbois *et. al.,* 2008). Motility of semen sample was expressed as the percentage of cells that are motile under their own power.

A drop of semen was placed on a warm microscope slide with the aid of a micropipette, which was then covered with a glass cover slip to spread the semen in order to have a uniform thickness and to prevent drying. It was then placed under a microscope for examination at x40 magnification.

Semen concentration: The sperm concentration of an ejaculate was determined by using a Neubauer hemocytometer and the sperm count performed as described by Hafez and Hafez (2000). Briefly, a volume of 10µl semen was diluted with 990µl Sabax water in a flask and stored in a refrigerator, before counting, to immobilize the sperm. To determine the percentage live sperm, an eosin/nigrosin stain was used for the microscopic morphologic observations. Here a 10µl drop of fresh semen was mixed with 200µl of eosin-nigrosin stain, and a smear made from the mixture was placed on a slide and examined under X1000 magnification.

Approximately 100 sperm were counted to determine the percentage dead-live sperm (Lukaszewicz *et.al.,* 2008).

Sperm concentration was calculated using the formula: No. of sperm/ml = No. of sperm in $0.1mm^3$ x 10 x dilution rate x 1000 (ml = cubic centimeter or ml) (Bearden *et. al.,* 2004).

Semen pH: The pH of a fresh semen sample of each cockerel was determined with the aid of a digital pH meter**.**

4.2.2 Statistical analysis

Data collected on semen characteristics were analyzed by General Linear Models procedures of Statistical Analysis System (SAS, 2009) version 9.2.1 and the model included the fixed effects of

breed (Purebred naked neck Tswana and Crossbred Australorp x naked neck Tswana). The results are presented as least square means ± standard error and means separation were by paired t-test with Scheffe's adjustment to account for the differences in the number of sampling units per replication. The differences between means were declared significantly different at $p<0.05$.

Statistical Model

$Y_{ij} = \mu + T_i + e_{ij}$

Where; Y_{ij} = semen parameters from individual cocks (response variable)

μ = Overall mean.

T_i = Effect of the i^{th} breed (Purebred naked neck Tswana chicken and crossbred Black Australorp x naked neck Tswana chicken).

e_{ij} = Random error associated with ijk record

4.3 RESULTS AND DISCUSSION

The overall reported average ejaculate volume of a cockerel has been estimated at 0.7 ml for different poultry breeds (Tuncer *et al.,* 2008). All the breed ejaculate volumes recorded in the current study were less than this 0.7 ± 0.12 ml (Table 4.1) and some factors contributing to these lower semen volumes may include breed, age, body weight, excessive stimulation, season and environmental factors including management and the human factor. The ejaculate volumes obtained in this study are similar to those obtained by other researchers and are within the acceptable range for poultry artificial insemination (Hafez, 1978). Other researchers obtained mean ejaculate volume of 0.28 ± 0.14 ml, which is lower than the results obtained in this study (Bah *et al.,* 2001; Galal, 2007; Tuncer *et al.,* 2008).

The mean ejaculate volumes (0.41ml and 0.37 ml for crossbred cockerels and naked neck, respectively) obtained in this study were within the range of 0.34 -0.59 ml reported by Bilcik *et al.* (2005) on broiler cocks and 0.40-0.73 ml obtained by Peters *et al.* (2008) on seven different indigenous chickens of Nigeria. There was no significant ($P > 0.05$) difference in semen pH between the strains (Table 4.1). The semen pH for all the strains was slightly alkaline and ranged from 7.05 ± 0.03 for purebred naked neck Tswana to 7.06 ± 0.03 for crossbred Black Australorp X naked neck Tswana sire strains, respectively. These results are all within the range generally reported for poultry semen (Etches 1998). The pH of cockerel semen recorded by other researchers was 7.02 ± 0.01, 7.4 ± 0.2 and 7.68 ± 0.01 (Bah et. *al.,* 2001; Peters *et. al.,* 2008; Tuncer *et. al.,* 2008). A factor that could play a role in semen pH is the technique of semen collection and stimulation of the accessory sex glands. The accessory sex gland fluid is generally alkaline (Bah *et. al.,* 2001).

The colour of the cockerel ejaculates did not differ significantly between the 2 sire breeds under investigation and were creamy-white (Table 4.1) indicating that the massage technique used may be acceptable for cockerel semen collection, in order to obtain good quality semen. Creamy-white ejaculates found in this study were consistent with Peters *et al.* (2008) who also reported creamy-white ejaculates (1.00 ± 0.03) in Nigerian indigenous naked neck cockerels. Machebe and Ezekwe (2005) revealed that variations in semen colour may arise in part due to the presence of contaminates or as a result of low sperm concentrations.

Table 4.1: The mean seminal characteristics of semen collected from the naked neck Tswana cockerel and Black Australorp X naked neck Tswana crossbred cockerels raised under an intensive management system in Botswana.

	Breed	
Parameters	F1 Cross	Naked neck Tswana
Ejaculate volume (ml)	$0.41^{a} \pm 0.005$	$0.37^{b} \pm 0.005$
Semen pH	7.05 ± 0.03	7.06 ± 0.03
Semen colour	1.00 ± 0.09	1.00 ± 0.08

Means within each row with different superscripts were significantly different from each other ($P<0.05$).

Sperm motility of crossbred cockerels was significantly higher ($p<0.05$) than that of purebred indigenous naked neck counterparts (Table 4.2). High sperm motility is regarded as a good indicator of high semen quality, with acceptable fertilizing ability and good fertility (Malejane *et. al.,* 2014). In agreement with the results of this study, Bah *et al.* (2001) recorded sperm motility in fresh semen samples of New Hampshire males of 73.9±0.2% and 83.2±0.6% in White leghorn. Peters *et al.* (2008) also reported sperm motility of 82.50±10.00% for improved indigenous crossbred (Alpha) cocks. Contrary to our results, Mosenene *et al.* (2009) reported lower sperm motility of 59.6 ±14.5%, 61.6 ±14.1%, 58.8 ±12.5% and 63.8 ±13.6% in Rhode Island Red, Potchefstroom Koekoek, New Hampshire and White Leghorn, respectively. The disparities sperm motility between the two studies could be attributed to the season of semen collection. The current study was carried out in the summer whereas that of Mosenene *et al.*

(2009) was carried out in winter. Season affects semen production and the rainy season has been shown to favour the rate of spermatogenesis. The rainy season has also been associated with a high ejaculate volume, sperm concentration and high fertility in poultry (Machebe and Ezekwe, 2005).

Table: 4. 2: The Mean (±SD) seminal characteristics of cockerel semen collected from two chicken breeds raised under an intensive management system.

	Breed	
Parameters	F1 Cross	Naked neck Tswana
Sperm motility (%)	$81.79^{a} \pm 0.66$	$75.02^{b} \pm 0.63$
Concentration ($x10^{9}$ sperm/ ml)	$4.78^{a} \pm 0.03$	$3.17^{b} \pm 0.03$
Live sperm (%)	76.8 ± 29.4	75.2 ± 33.3
Dead sperm (%)	23.2 ± 29.1	24.8 ± 29.5

Means within each row with different superscripts were significantly different from each other ($P<0.05$).

According to Obidi *et al.* (2008) cockerels are seasonal breeders and generally produce more semen at the onset of the breeding season (long daylength) and lower volumes towards the end. Light intensity also affects semen characteristics during the warm and cold season, resulting in lower ejaculate volumes relative to the rainy season, which may be attributed to reduced spermatogenesis and a higher sperm mortality rate. High relative humidity also causes a temporary decrease in sperm production and hence lower ejaculate volumes and sperm concentration that could affect sperm motility and fertility (Obidi *et. al.,* 2008).

The sperm cell concentration or sperm density is usually an indication of the number of sperm cells per unit volume (ml) of seminal plasma (Malejane *et al.*, 2014). The ejaculate concentration of crossbred Black Australorp X naked neck Tswana cockerels was significantly higher ($p<0.05$) than that of their purebred indigenous naked neck Tswana counterparts. The concentration of spermatozoa in crossbred cocks and indigenous cocks was higher than 1.2 billion/ml semen (Nwagu et al., 1996), 2.0 billion sperm/ml semen by Keskin et al. (1995) and Sarka et al. (1996) but lower than 7.0 billion sperm/ml semen (Hafez, 1978). The differences in sperm concentration can only be attributed to the fact that strains are from different genetic backgrounds. Higher sperm concentration in crossbred cocks than their indigenous counterparts could be attributed to the favourable effect of increased heterozygosity or heterosis effect on fitness (survival and reproduction) traits. This is consistent with Peters et al. (2008) who observed strain differences in semen concentration in Nigerian indigenous cocks.

This study revealed that the simple inexpensive method of eosin-nigrosin staining could be used to evaluate cockerel semen quality/viability and as a consequence, estimate the fertilizing capacity of the sperm. There was no significant difference in sperm viability (dead and live sperm) between the two cock strains under investigation. The percentage of live sperm recorded in this study was high, ranging between 75.2 ± 33.3% and 76.8 ± 29.4% purebred naked neck Tswana and crossbred cockerels, respectively. Tselutin *et al.* (1999) reported the number of live sperm without any abnormalities in cockerel semen to vary from 91 to 94%, which is higher than the results obtained in this study. However, Siudzinska and Lukaszewicz (2008) recorded 58 to 70% live, morphologically normal sperm and Lukaszewicz et al. (2008) reported 70 to 80% live normal sperm, which are consistent with the results obtained in this study. Mosenene et al. (2009) also reported the number of live sperm to be 75.9 ± 33.3% and 80.7 ± 27.9% in South

African indigenous cockerels. The percentage dead sperm recorded during semen collection in the two sire strains ranged between 23 and 24%, which is more consistent with the 18 to 24% recorded by Mosenene et al. (2009) and 27% recorded by Siudzinska & Lukaszewicz (2008).

4.4 CONCLUSION

Crossbred cocks exhibited significantly higher semen parameters than their purebred naked neck counterparts under intensive management system.

4.5 RECOMMENDATION

The study should however be repeated to evaluate the semen parameters of chicken under extensive management system commonly practiced in rural areas of Botswana.

CHAPTER 5: GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 General Discussion

The ultimate purpose of this study was to investigate growth performance and semen characteristics of naked neck Tswana and black Australorp x naked neck Tswana chickens when raised under intensive management system. Growth performance was determined in Chapter 3 while semen characterization was determined in Chapter 4.

The results in chapter 3 showed that body weights were significantly higher in Australorp x Tswana crossbred males (2920.93 ±57.73) and females (2224.27 ±59.19) than their indigenous purebred counterparts (2467.26 ±59.97) and (1839.31 ±57.04) at 20 weeks of age respectively. There were significant differences in body weight of purebred naked neck Tswana males (1088.56 ±32.47) and females (931.54±30.88) from 10 weeks of age. Growth was also more enhanced in crossbred Australorp x Tswana males than Females.

In the second study (Chapter 4) semen parameters with respect to ejaculate volume, pH, sperm motility, sperm concentration and sperm viability were examined for each cock. Crossbred cocks had significantly higher ($p<0.05$) ejaculate volume (0.41 ± 0.005), sperm motility (81.79 ± 0.66) and ejaculate concentration (4.78 ± 0.03) than their purebred naked neck counterparts. However, the degree of semen pH (7.05 ± 0.03), semen color (1.00 ± 0.09) and the percentage of live (76.8 ± 29.4) and dead sperm (23.2 ± 29.1) showed no significant differences ($P>0.05$) between the 2 chicken breeds under study.

5.2 General Conclusion

Crossbred chickens (males and females) exhibited faster growth rate than purebred naked neck Tswana chickens under intensive management system. Both purebred naked neck Tswana and Black Australorp x naked neck Tswana crossbred chickens produced semen of acceptable quality. Crossbred cocks however produced better quality semen than their purebred counterparts. Crossbreeding can therefore be used as a strategy to improve semen characteristics of indigenous Tswana chicken under an intensive management system and that might boost reproductive performance under anticipated hotter environment due to global warming.

5.3 General Recommendations

The study however should be repeated to evaluate other traits of economic importance such as feed intake, egg production and meat quality of crossbred chickens under intensive management system in Botswana.

Further studies on reproductive performance of both crossbred males and females should be carried out.

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