

**MORPHOMETRIC CHARACTERISATION AND
IMPROVEMENT OF POTENTIAL GROWTH TRAITS IN
WAD SHEEP THROUGH CROSSBREEDING**

FATAI ISMAIL ADEWALE

B. Tech (Ogbomoso), M.Sc. Animal Production (Ilorin)

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CERTIFICATION

This is to certify that this thesis has been read and approved as meeting the requirements of the Department of Animal Production, University of Ilorin, Ilorin, Nigeria, for the Award of Doctor of Philosophy (Ph.D.) degree in Animal Production.

Dr. T. R. Fayeye
(Supervisor)

Date

Dr. F.E. Sola-Ojo
(Co-Supervisor)

Date

Annu
(Head of Department)

Date

(Internal/External Examiner)

Date

(External Examiner)

Date

DEDICATION

This work is dedicated to Yusuf Olaolu Ali (SAN) for his love, passion and kindness for animals.

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ABSTRACT

The need for larger sheep has compelled both the consumers and sellers in the middle and Southern parts of Nigeria to frequently opt for giant breeds of sheep from the Northern parts of the Country. Balami and Uda are the two largest Nigerian breeds of sheep and therefore have the potentials of improving, through crossbreeding, the body weight of small body-sized West African Dwarf (WAD) sheep. The objectives of this study were to determine: (i) the morphometric characteristics of traditionally managed WAD, Balami and Uda sheep; (ii) reproductive and growth performance of pure and crossbred sheep; (iii) heterosis, repeatability and heritability of economic traits; and (iv) best morphometric descriptors of body weight in pure and crossbred WAD, Balami and Uda sheep in Nigeria.

Three experiments were conducted. Experiment 1 compared the morphometric traits of 1017 traditionally managed sheep within North and Central Nigeria. Experiment 2 evaluated the growth and reproductive performance of pure and crossbred Uda, Balami and WAD Sheep using an unbalanced design, while Experiment 3 assessed the heritability and repeatability of growth traits and best morphometric descriptors of pure and crossbred sheep. Data collected were subjected to Analysis of Variance using a model of Factorial Design ($p < 0.05$).

The findings of the study were that:

- i. traditionally managed Balami sheep was superior to Uda and WAD in all morphometric traits. Males were superior to females in all morphometric traits.
- ii. WAD sheep had the highest conception (80%) and lambing rate for all the parities (80%);
- iii. lambs' birth weights increased with dams' age and parity;
- iv. crossbred lambs were superior over purebred WAD in all morphometric traits both at birth and at yearling stages;
- v. heterosis for body weight in Uda crossed with WAD was higher than in Balami crossed with WAD at birth (24.70% and 22.42% respectively) and at weaning (9.25% and -4.84% respectively);
- vi. WAD had higher repeatability for body weights (0.99) and total milk yield than other breeds; and
- vii. WAD sheep group had the most accurate classification (92.4%). The Dendrogram plot showed WAD sheep was closer to Uda than Balami while Uda crossed with WAD sheep was closer in body weight to the purebred Uda sheep.

The study concluded that genetic resources of Nigerian breeds of sheep could be described using morphometric traits. Crossbred sheep were superior to the purebred WAD sheep in morphometric traits, lamb birth and weekly body weights. The study recommended that to improve weaning weight, Uda sheep should be crossed with WAD sheep. However, to improve yearling weight, Balami sheep should be crossed with WAD sheep.

CHAPTER ONE

1.1 INTRODUCTION

Sheep farming is an essential means of livelihood and food security in most rural population, especially in developing countries (Amadou *et al.*, 2012). They play a major role in the economy and nutrition of farmers with meager resources in most developing countries (Muhammad *et al.*, 2006). They have been known to occupy a significant niche in the rural economy of Nigeria where they serve as source of income and also contribute tremendously to animal protein intake for the average Nigerian (Momoh *et al.*, 2013). The West African Dwarf (WAD) sheep are reared abundantly in sub-humid and humid parts of Nigeria and are the most abundant sheep breeds in the country (Davendra and MacLeroy, 1982), while Uda and Balami sheep are found mostly in arid and semi-arid regions. They are widely distributed in Nigeria and constitute a major component of the livestock production system which is marked by small flock sizes. They are found in the agro-ecological zones of Nigeria and make up about 41.3 million of the total livestock population (Premium Times, 2016). Sheep ability to tolerate extreme temperatures, weather inclement and diseases have been reported by Hoste *et al.*, (1988) and Salako (2004). Therefore, excellent and rapid growth performance of sheep (Momoh *et al.*, 2013) allows crossbreeding between superior and inferior genotypes to be adequate and complementary.

Indigenous livestock breed of African sheep are well adapted to the local environment, although their productivity is generally lower when compared to other parts of the world. The need to continually improve on livestock is evident as many countries today are rapidly losing their genetic resources which are a great challenge to food security due to the ever-increasing global warming (Hoffman, 2010). Stamp (1967) and Dennis (1972), reported

lambs' mortality rates to be between 15% and 20% in most sheep producing countries outside Africa. Adu and Ngere (1979) reported the limited meat production potential of WAD sheep which could impact negatively, on gross income due to its low growth rate, small body conformation and mature size. The authors' claim on the small-body size of WAD sheep is supported by the year in year out massive purchase and transportation of sheep from the Northern parts of country, especially rams during festive periods. Thus, there is dire need for WAD sheep producers to not only end the incessant movement of Northern sheep down the South-Western states of the country, but also exploit new sheep breeds in the face of the ever dynamic climates, feed resources and market choices. Improving indigenous animals such as the West African Dwarf is important as they serve as storehouse of unique genes which may be useful especially in the face of the inclement climate conditions (Salako and Ngere, 2002).

Crossbreeding is a practice that is employed by breeders and farmers as a rapid and cost-effective measure to improve efficiency of meat production by mating ewes and rams of two or more pure breeds (Charry *et al.*, 1992; Leymster, 2002). Balami and Uda sheep are largest long legged sheep in Nigeria (Bourn and Wint 1994; Roger, 1999) and therefore, no breeding program should elope them (Yunusa *et al.*, 2013a).

Falconer and Mackay, (1996) defined Heterosis as the difference between the hybrid and the mean of the two parents. It is used to determine the increase in performance beyond what is expected or calculated based on the parents of the offspring (Alkire, 2012). Heterosis and breed complementarity are essential tools to improve the productivity of commercial flock (Thomas, 2006). Breed complementarity allows a breeder to rely on the strength of different breeds as no single breed possesses all of the traits that affect profitability (Alkire, 2012). WAD sheep thrives in the trypano-endemic region of Southern humid Nigeria while Uda and balami sheep have characteristic large body sizes. Yunusa *et al.* (2013b) from their work on morphometric analysis of Nigeria indigenous sheep reported that Uda and Balami sheep were

expected to have shared the highest number of alleles while Uda and WAD were expected to share the least number of allele. Therefore, crossbreeding Uda and Balami with WAD gives prospect for improvement for meat in the latter. Uda and Balami sheep with their characteristic large body sizes have been reared successfully in the hot arid region of Nigeria (North) thriving under the high environmental temperature. However, little or no information is available on the performance of these animals or their offspring when reared in a different ecological zone. Repeatability estimates help animal breeders to timely determine early culling of dams that have poor performance. High repeatability estimate indicates considerable reliability can be placed on series of records while ewes with low productivity can be culled early in their lifetime (McNaughton and William, 1956).

Heritability provides information on how much confidence to place in the phenotypic performance of an animal when selecting parents of the next generation. It helps producers decide if it is more economical to improve traits via management or by selection. Hence, it helps in making many practical decisions in breeding methods (Sajjad, 2012).

Correlation is an important tool in selecting quantitative traits in animal production; two traits are correlated if a change in one is directly proportional to a change in the other (Fayeye, 2014). Thus, positive correlation connotes direct proportionality among traits while negative correlation means the traits are inversely correlated. The response of a particular trait to selection is the function of the cumulative result of direct selection for that trait and indirect selection for others with which it is of high genetic correlation (Ndjon and Nwakalor, 1998). Growth pattern and body development are essential in assessing body structure and conformation and an attempt to measure morphometric traits instead of the usual conventional weighing and grading is a prudent measure (Salako, 2006). Body measurement has been employed in selecting replacement animals and evaluating breed performance in a controlled environment (Shrestha *et al.*, 1984) as well as yearling weight in sheep production

(Aziz *et al.*, 1981). Characterisation is the profound knowledge, which contributes to the prediction of the genetic performance of an animal genetic resource (AnGR) in a defined environment and provides a basis for distinguishing different AnGR and for assessing available diversity (Yakubu *et al.*, 2012). Choice of breeds for improving the output from sheep should depend on the amount of information available on them (Momoh *et al.*, 2013). Animal characterisation therefore, gives a precise definition of the genetic properties of an AnGR and the environments to which it is known to survive and thrive well (Sponenberg *et al.*, 2000; Rege and Okeyo, 2010; Melesse and Negesse, 2011).

Principal component analysis (PCA) is a linear combination of optimally-weighted observed variables with sole purpose of defining the underlying structure among the variables in the analysis. Generally, factor analysis provides the means for analysing the structure of the correlations among a large set of measured traits by defining sets of traits that are highly interrelated, known as factors (Haur *et al.*, 2010). Cluster and Discriminant analysis of morphometric traits of sheep and other indigenous livestock has been done by some authors such as Yakubu *et al.* (2010a), (2010b); Salako and Ngere (2002); Yakubu and Ibrahim (2011) relying on the animals available around areas of study. However, movements by Fulani pastoralists and trading of livestock between South and Northern Nigeria have encouraged introgression. This genetic exchange between different ecological zones in Nigeria has made breed identification a difficult task in animal husbandry as any of the breeds can be mistaken for another. Therefore, there is a dire need to discriminate the animals with the best of trait(s) that best distinguish them especially, in the environment where they best thrive.

It is imperative to know the performance of sheep especially when they are introduced to different climate for crossbreeding. Although some works by Buvanendra and Adu (1990); Oyeyemi and Ogunsola (2011) have described the performance of Balami and Uda in the

North Eastern and South Western parts of the country. However, there is still inadequate information on the performance, behaviour and survivability of the duo when raised in the North Central part of Nigeria.

1.2 Justification

Previous efforts by breeders and farmers to improve the performance of the indigenous African breeds involve the introduction of exotic animals and crossbreeding practices which is gradually leading to the erosion and complete masking of important survival traits such as disease resistance associated with indigenous livestock. It has also led to the extinction of certain breeds (Gizaw *et al.*, 2011). Due to continual admixture of genes among Nigerian indigenous breeds of sheep as well as the threat of extinction faced by the indigenous genetic resources of Africa and the world at large (FAO, 2000; 2007). Hence, the need for a continued characterisation alongside the generation of genetic distances found among the Nigerian sheep amidst improving on animal production as many countries today are rapidly losing their genetic resources. Yunusa *et al.* (2013a and 2013b) in their reports on the morphometric characterisation of traditionally managed breeds of Nigerian sheep, considered fewer number of animals. West African Dwarf sheep is popularly known as small - body size sheep in Nigeria. This has compelled both the consumers and sellers in the middle and Southern parts of Nigeria to continually opt for superior breeds of sheep from other parts of the country, especially the Northern states, during festive period. It has been established from past works (Yunusa *et al.*, 2013a; and Oyeyemi and Ogunola, 2011) that Balami followed by Uda are the largest breeds of sheep in Nigeria. Therefore, crossbreeding WAD with the giant breeds will achieve the desired upgrading and improvement of WAD sheep. The long - legged sheep according to Buvanendra and Adu (1990) thrive well in the North, however, there is dearth of information on their performance, with regards to reproduction, growth and genetic traits and estimates when reared outside their indigenous abode. Thus, this present

study was set to investigate the performance of the newly introduced animals (Balami and Uda) and their offspring in their new environment (North Central). In a bid to offer adequate information on the performance of the crossbred WAD and their parents, the present work was thereby set to crossbreed WAD with Balami and Uda and vice versa, which will go a long way to boost sheep business in the North Central and South Western states of Nigeria.

1.3 Main Objective

The main objective of this study is to determine the morphometric, reproductive and growth performance as well as the descriptive traits that best differentiate purebred and crossbred WAD, Balami and Uda sheep in sub – humid zone of Nigeria

1.4 Specific Objectives of this Study were to:

- evaluate the morphometric characteristics of traditionally managed Uda, WAD and Balami sheep.
- determine the reproductive performance, growth performance and survivability of Pure and Crossbred Uda, Balami and WAD Sheep.
- determine inheritance and repeatability of economic traits and best descriptors that distinguish pure and crossbred Balami, UDA and WAD Sheep of Nigeria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.1 Ecological distribution of Nigeria breeds of sheep

Sheep are found in all the ecological zones of Nigeria. The Nigeria sheep is comprised of four major breeds namely: Balami, Uda, Yankassa and West African Dwarf (WAD) (Audu and Ngere, 1979). The Nigerian sheep are characteristically referred to as the long-legged (Balami, Uda and Yankassa) and the dwarf or short-legged (WAD). The long-legged sheep are indigenous to semi arid and arid zones of West Africa while the WAD sheep are found in all the humid West coast of Africa (Davendra and McLeroy, 1982).

Balami sheep are found in abundance in the North-Eastern (Audu and Ngere, 1979) and North-Western parts of the country such as Borno, Yobe, Sokoto and Kebbi. They are reared in a sparsely dense vegetation of arid zones of the country.

Uda sheep are also found majorly in North-Western and North-Eastern parts of Nigeria such as Sokoto, Kastina, Kebbi, Borno, Taraba, Bauchi and Yobe. The large number of Uda can be found between Niger state and the Northern reaches of the middle belt of Nigeria (Roger, 1999).

Yankasaare sheep are found majorly in the North Central zone of Nigeria (Niger and Kwara states). They are found in almost all the parts of the country (Roger, 1999). However, Yankasa population dwindles towards the seacoast and towards the core Northern border of Nigeria (Wosu, 2002).

WAD sheep are found in the Southern and Northern parts of Nigeria such as Oyo, Osun, Abia and Jos (Roger, 1999). They are widely distributed throughout the humid zones of Nigeria Africa (Davendra and McLeroy, 1982).

2.1.2 Distinctive features of Nigeria breeds of sheep

Balami sheep is the largest indigenous sheep in Nigeria (Roger, 1999). It has white and hairy coat. The ears are conspicuously large, long and pendulous. It also possesses a distinctive long tail (Roger, 1999). The average withers height of mature Balami sheep is 76cm (Yunusa *et al.*, 2013b). A mature Balami ewe weighs about 43 kg while the weight of the ram ranges between 40-80 kg (Buvanendra *et al.*, 1990). The ram has throat ruff and are horned or polled, while most of the ewes polled. One of the distinctive features of Balami sheep is its Roman large bulbous nose (Roger, 1999).

Uda sheep are the second largest breed of sheep and are distinguished by their coat colour pattern which ranges from completely brown or black forequarters and white at the rear (Roger, 1999). It is a long-legged breed with a straight and long face with an average height at wither of 77 cm (Yunusa *et al.*, 2013b). The mature males are usually horned while the ewes are polled. The average weights of its male and female range between 45-55 kg and 35-45 kg respectively (Adu and Ngere, 1979).

Yankasa sheep has white body colour with black patches around the eye socket and on the extremities such as the muzzle, ears and the feet (Roger, 1999). The Yankasa is a medium breed of Nigeria sheep with long thin tail. The ears are moderately long and droopy. The ram possesses large curved horns with an average wither height of 70-80 cm and weighs about 35-50 kg. its female weighs between 20-40 kg at maturity (Adu and Ngere, 1979). Emmanuel (2013) observed that the eumelanin patches on the ear, the hock, tail, eyes and the muzzle, which is the hallmark feature in Yankasa, is never brown but black. Yankassa ear according to Devendra *et al.* (1982) is moderately long. Also, the absence of wattle in Yankassa sheep have been reported by Emmanuel (2013) and similar features were also

reported by Rodero *et al.*, (1996) on Grazalema Merino and Lebrija Churro sheep of Andalusia

The WAD sheep is the smallest breeds of all the Nigerian sheep. It has a small and compact body. The colour ranges from all white, black or spotted black or brown on a white coat (Roger, 1999). Its variation in colour and patch distribution sometimes make it difficult to distinguish it clearly from the Yankasa sheep. The average height at wither of a mature WAD is 61.66 cm (Yunusa *et al.*, 2013b). The average weights of the adult male and female are 25-30 kg and 20-25 kg respectively (Adu and Ngere, 1979). The WAD sheep has been characterised with the presence of both black and white eumelanin patches (Emmanuel, 2013). Devendra *et al.* (1982) reported that the ear of the WAD is short and resemble other WAD across African continent. Adu and Ngere, (1979) reported types of WAD found across the country. However, Devendra and McLeroy (1982) argue that the WAD breed cannot be further categorised on the basis of appearance.

In general, from the description and analyses of distinctive features of the major breeds of Nigerian sheep, it can be inferred that the WAD sheep is closest to the Yankassa while the former is furthest from the Northern (long-legged) sheep. Thus, crossbreeding WAD sheep with the two giant breeds (Balami and Uda) will be hoped to improve the WAD sheep.

2.1.3. Economic importance of sheep in Nigeria

Sheep plays a major role in the food security and social well-being especially for the rural populace that is characterised with extreme poverty (Lebbie, 2004 and Duguma *et al* 2010). Adu and Ngere (1979) reported that 11% of the meat supplied from slaughter-houses in Nigeria comes from sheep, and they also laid emphasis on the prospect of sheep business provided the rural unregistered slaughters are taken into consideration.

Small ruminants such as sheep are the principal domesticated animals in terms of total numbers and production of food and fibre products (Winrock, 1983). This attribute may be

linked to their lower feed requirements compared to cattle, because of their body size (Okunlola, *et al*, 2010). In addition, the ease in sheep rearing allows for easy integration of small ruminants into different farming systems (Hirpa and Abebe, 2008).

The demand and consumption patterns for sheep are dependent on the large importation of northern animals from the northern states which indicates a huge potential market in the south for indigenous breeds of sheep (Samberg and Cassaday, 1985).

At the traditional management level, sheep is believed to yield a higher output and income than for instance, goats which are considerably more prolific, but sheep are advantageous animals due to their bigger size, heavier weight, lower mortalities and higher returns (Upton, 1985).

Nigerian breeds of sheep such as the WAD and Yankasa are very important not only because they are quick source of income but also because their qualitative traits appear to possess selective and distinct properties which could serve as a reliable indicator to confront the economic pressure on the variety for genetic improvement.

However, sheep has been described generally to be susceptible to disease (Samberg and Cassaday, 1985) and have high mortality rate especially during preweaning periods (Matthewman, 1980 and Upton, 1985). The WAD sheep have been reported to produce light-weight lambs and this has always affected their reproductive performance. Wilson (1980) reported birth weight, litter size and parity as the major causes of the sub-humid sheep (WAD) mortality. Therefore, crossbreeding such breed (WAD) with superior lamb-producing breeds will improve the reproductive and growth performance of the former.

2.2.0. Morphometric characterisation of indigenous sheep of Nigeria

Animal characterisation gives precise definition of the genetic properties of an Animal Genetic Resources (AnGR) and the environments to which it is known to survive and thrive

well (Sponenberg *et al.*, 2000; Rege and Okeyo, 2010). Characterisation of animal genetic resource (AnGR) includes all activities associated with the identification, quantitative and qualitative description of breed populations along the natural habitat and production systems to which they are found. The rate of industrial livestock operations is growing so fast that it doubles traditional mixed farming systems and six times as fast as traditional grazing systems (FAO, 2007). Koney (2004) observed that sheep among other ruminants have been given the least priority as regards management, nutrition breeding and health in spite of the fact that they have many merits over some other classes of livestock and are found in all towns and villages in some African countries such as Ghana. Morphometric characterisation therefore, is done to assess body structure and conformation through measurement of body traits of a breed of animal between or within a population in their natural locations or ecological zones. It entails all the description and documentation of the physical traits of a breed (Rege 1992). Morphometric characterisation can also be referred to as the important phenotypic characteristics used in breed identification and classification (Yakubu *et al.*, 2010). The first step of the characterisation of local genetic resources is to assess variation of morphological traits (Delgado *et al.*, 2001). Past works on morphometric characterisation such as Hamito, (2009); FAO (2012) and Salako and Ngere, (2012) of ruminant animals have yielded an anatomical reference points which are tailored when there is need for characterisation.). The following are some of the Anatomical reference points described by Hamito, (2009); FAO (2012) and Salako and Ngere, (2012): Ear Length (EL), Fore Leg Length (FLL), Rear Leg Length (RLL), Body Length (BL), Shoulder Width (SW), Neck Circumference (NC), Heart Girth (HG), Rump Height (RH), Head Length (HL), Head Width (HW), Rump Width (RW), Rump Length (RL), Tail Length (TL), Wither Height (WH), Horn Length (HnL). Yunusa *et al.* (2013a); (2013b) and Yakubu and Ibrahim (2012) have worked on the morphometric characterisation of the Nigerian sheep but either with few numbers of animals or outside the

animals' ecological zones. Sampling animals from different locations within the natural ecological zones will reduce measurement error due to transportation and adaptability rigor the animals are subjected to when moved down to the Southern markets.

2.2.1. Principal Component Analysis (PCA)

Principal component analysis (PCA) is a series of linear, interdependent combination of weighted observed variables for defining the underlying structure among the variables in the analysis. It is a factor analysis that provides the means for analysing the structure of the correlations among a large set of measured traits by defining sets of traits that are highly interrelated, known as factors (Haur *et al.*, 2010). It is a multivariate statistical tools used to arrive at a more reliable assessment of morphometric relationship among livestock breeds (Yakubu *et al.*, 2009). The number of components generated in PCA equals the number of traits input in the study and the first few components accounts for the highest proportion of the total variance. The PC analysis is usually verified for adequate determinant factor, sample adequacy using Kaiser-Meyer-Olkin test and sphericity using Bartlett's test. The PCA is designed to transform the variables in a multivariate data set $X_1, X_2, \dots, X_p$ into new variable $Y_1, Y_2, \dots, Y_p$, which are uncorrelated with each other and account for describing proportions of the total variance of the original variables (Everitt *et al.*, 2001; Mulyono *et al.*, 2009)

defined as –

$$Y_1 = a_{11}X_1 + a_{12}X_2 + \dots + a_{1p}X_p$$

$$Y_2 = a_{21}X_1 + a_{22}X_2 + \dots + a_{2p}X_p$$

$$Y_p = a_{p1}X_1 + a_{p2}X_2 + \dots + a_{pp}X_p$$

with coefficients being chosen so that, $y_1, y_2, \dots, y_p$ account for decreasing proportions of the total variance of the original variables $x_1, x_2, \dots, x_p$. For adequate interpretability of

the principal components, the varimax criterion of the orthogonal is employed in the rotation of the factor matrix. Also, since body measurements are intercorrelated both phenotypically and genetically (Lukefahr & Ozimba, 1991; El-Mahdy, 1998; Akanno and Ibe, 2005), the analyses of the desired traits should investigate interdependence among the predictors. Yakubu and Ayoade (2009) observed that the prudent use of Principal component analysis is achieved when morphological traits are interdependent and this will facilitate the loadings that explain the highest variation in the data set over the dependent variable. Therefore, generated components or loadings decrease the dimension of the explanatory variables and eliminate any possible dependence among explanatory variables (multicollinearity).

The use of analysis of variance and common correlation estimates have been widely used to characterise phenotypic and genetic relationships among traits in a breeding and selection project. However, PCA is a valuable and more refining method for analysing data on linear body measurements traits (Miserani *et al.*, 2002; Posta *et al.*, 2007). The application and outcome of PCA have had significant impact on the management of livestock as well as help in conservation and selection of multiple economic traits by animal breeders (Yunusa *et al.*, 2013a). PCA has been used as a tool to assess the body shapes and structures of animals which underscores evolutionary trend and also creates basic understanding of the of the continual morphological process in the body dimensions of the animals during growth phase (Salako, 2006). Past works on morphometric characterisation of small ruminants have generated different number of components loaded highly with traits (Khargharia *et al.*, 2015; Yunusa *et al.*, 2013a; 2013b and Yakubu *et al.*, 2009). Traits such as Ear Length, Tail Length, Body Length and Heart Girth have been used to describe some Nigeria breeds of sheep (Yunusa *et al.*, 2013a and 2013b).

2.2.2. Discriminant and Multivariate analysis of sheep

Discriminant analysis is used usually when the clusters are known *a priori*. It is an analysis done to classify a set of observations, into already known groups (Hardel and Simar 2007). Some researchers have employed the concept of discriminant analysis which also serves as a classificatory rule in allocating observations into their known groups. A number of researchers including Fisher (1936), Lachenbruch (1975), Krzanowski and Hand (1997), Desu and Geisser (1973) have applied discriminant analysis extensively in various fields where mostly linear discriminant function (LDF) was the main classification function obtained for classifying the known observations.

Discriminant analysis employed to determine which morphological trait has more discriminating power than the other in categorising the breeds (Yakubu and Isa, 2011). Discriminant analysis of morphometric traits of sheep and other indigenous livestock has been done by some authors such as Yakubu *et al.* (2010a), (2010b); Salako and Ngere (2002); Yakubu and Ibrahim (2011) with available animals around the study area. It is used to segregate one group from the other by elucidating a network of relative distance between groups. It has also helped the breeders to classify correctly, breeds of animals and determine the percentage of the misclassified ones due to gene admixture (Yakubu and Isa, 2011). Most work on morphometric differentiation of Nigerian indigenous small ruminant populations has been done using analysis of variance (Fajemilehin & Salako, 2008). However, such method of analysis is inadequate and not all-encompassing as multifactorial analysis of morphological traits are more appropriate to assess phenotypic variation within and between sheep populations; and to appropriately discriminate different sheep types because of the empirical consideration of all measured morphometric traits (Zaitoun *et al.*, 2005; Dossa *et al.*, 2007; Traore *et al.*, 2008; Yunusa *et al.*, 2013a and b). This becomes essential due to

uncontrolled mating and geographical overlap which are leading to the endangerment of breed purity.

2.3.0. Survivability of sheep production in Nigeria

Weather inclement through enormous heat, floods and seasonal drought is one of the challenges facing livestock production (Serjian *et al.*, 2016). This leads to the death of animals thereby causing production loss (Gaughan and Cawsell-Smith, 2015). Change in weather is the short term of climatic condition which animals are exposed to when introduced to a new ecological zone for crossbreeding purpose. Seasonal changes hence, feed shortages have been reported to be the cause of seasonal variation in meat prices which is often influenced by environmental conditions (Timon and Hanrahan, 1986). The authors observed that in the semi-arid regions, where a large proportion of the sheep is found there is a huge difference in the amount of feed available in the raining and dry seasons. Therefore, during the dry seasons and pursuant feed shortages, producers are forced to reduce the total number of animal units. This creates an excess supply that, in turn, causes a decrease in prices.

Drought has been reported to affect the productivity of ruminant animals as the less hardy and large ruminants are reduced or sold off during a pronounced drought while the more hardy animals such as the goat and WAD are retained (Queiroz *et al.*, 1985). Because it is certain that the newly introduced animals are bound to experience the shock due to the new environment, it is imperative for the breeder and the entrepreneur to examine reproductive and growth performance of the animals alongside their offspring. Also, diseases have been reported to be major cause of lamb mortality. Hence, low productivity in sheep enterprise (Yapi *et al.*, 1990). Opasina (1985) reported some diseases affecting the survivability and productivity of WAD sheep in the South-Western region of Nigeria. Among the disease reported are pneumonia, gastroenteritis, trypanosomiasis, babesiosis, helminthiasis and ectoparasitic infestations of ticks, lice, fleas and mange. In general, Northern sheep such as

Balami and Uda have been reported by (Buvanendra and Adu, 1990), Adu and Ngere (1979) for poor performance when reared outside their natural ecological zones.

2.3.1. Lamb survivability

Sheep are generally known to have poor survivability especially when raised outside their ecological zones and this has predisposed them to disease outbreak (Matthewman, 1980; Upton, 1985 and Samberg and Cassaday, 1985). Fogarty *et al.* (1985) reported the survival of lambs from birth to weaning to be a major factor affecting the number of lambs weaned per lambing and found it to be highly dependent on lamb weight weaned per lambing. A couple of studies have shown that between 5-59% of lambs die within 1 year of age in different agro-climatic conditions with neonatal lambs being at greater risk (Yapi *et al.*, 1990; Green and Morgan, 1993; Nash *et al.*, 1996; Mukasa-Mugerwa *et al.*, 2000; Sawalha *et al.*, 2007 and Bratte, 2015). Lamb mortality is a complex trait that is influenced by the ewe's maternal ability and the lamb's capability for survival, in addition to management practices and environmental variables at the time of birth and during the rearing period (Morris *et al.*, 2000; Southey *et al.*, 2001). Survival index of the lambs up to 90 days was reported to be 0.76 while the overall mortalities were 21% for West African Dwarf sheep in the South-Western part of Nigeria (Mack, 1983). The biological and economic efficiency of lamb production is much pertinent from increasing the number of lambs weaned per ewe rather than just improving growth rate (Dickerson, 1978). Unfortunately, efforts by breeders and farmers to improve the performance of the indigenous African breeds involve the introduction of exotic animals and cross breeding practices which eventually has led to the erosion and complete masking of important survival traits which is disease resistance associated with indigenous livestock as well as the extinction of certain breeds (Gizaw *et al.*, 2011). Vatankhah and Taleb (2009) observed that management strategies should be manipulated when possible to specially treat lambs that are born in unfavorable environment in order to reduce lamb mortality rates.

2.3.2. Ewe milk yield

Although, Milk production from small ruminants kept for meat has received little attention in Africa, its importance in the preweaning phase of life of the lamb cannot be underestimated (Reynolds, 1986). The only natural and main nourishment for lamb from birth to weaning is milk, which affects their growth and development (FAO, 1989). Therefore, optimal milk yield is an ultimate factor in producing lambs of prudent weight at weaning. Selection for increased growth rates to weaning is synergistic to selection for higher milk production from the ewes Reynolds (1986). Poor weight and growth of lambs have been attributed to poor dams' milk yield (Bosna, 1939) alongside the impact of environmental stress on the dams' performance. Bradford (1972) observed the importance of nutritional importance of milk when he concluded that about 50% of the response to selection for weaning weight is attributed to improved milk production. A similar conclusion was also made by Barlow (1978) on cattle. At optimal situations, milk production increases during the first few weeks of lactation and then gradually decreases (Kehrli and Shuster, 1994; Crepaldi *et al.*, 1999; Gootwine and Pollott, 2000). The authors identified Breed, Parity, Season of calving, nutrition, frequency of milking and Geographic region as factors affecting milk yield during lactation period. Reynolds (1986) observed that genetic selection for high milk yield has increased the importance of early lactation feeding, but with meat-purpose animals, the timing of supplementation during lactation is less critical. However, milk production is important, ensuring as it does a high pre-weaning growth rate. Unlike in dairy business where cows are generally expected to provide milk for humans as well as for the calf consumption even at the detriment of the calves, the offspring of the small ruminants such as the lambs are less likely to be affected, as human consumption of sheep milk is less acceptable.

2.4. Crossbreeding in Nigeria sheep production

Cross breeding is the process of breeding with the aim to produce offspring that share the traits of both parent lineages or to create an animal with hybrid vigour (FAO, 2013). Hybrid vigour is the result improved or increased function of any biological trait in a crossbred. Also, crossbreeding is a practice that involves a rapid and cost-effective measure to improve efficiency of meat production by mating ewes and rams of two or more pure breeds (Charry *et al.*, 1992; Leymster, 2002). Crossbreeding offers the advantage in taking advantage of the different and complementary strong points of two or more breeds and to utilise hybrid vigour (Thomas, 2001). It is a tool for improvement and upgrading animal genetic potentials through mating of two or more breeds. It is a practice employed for commercial production especially in countries where highly developed pure breeds are available and expectation for heterosis is high. Omeje and Nwosu (1984) observed that gradual replacement of local genes through crossbreeding and artificial selection has been the basis of initial development in many countries. Most of the genetic changes occur via change of breeds through crossbreeding aimed at improving indigenous breeds towards exotic from the developed world (Nimbkar *et al.*, 2008). Generally, livestock breeding is an act of identifying, selecting and mating parents of the next generation. Traditionally, a livestock farmer's target, with male and female animals is to multiply the pairs through mating the duos with superior male and female outside his flock. Therefore, the continuous desire for improved performance in the next generation has resulted to intense selection and identification of the parent which is dependent on a more detailed evaluation of the available breeds (Olori *et al.*, 2009).

Also, when breeding is targeted solely for genetic improvement, the act of identifying, selecting and mating parents of the next generations assumes a new plan and much more than the primary livestock producers are involved. This includes setting up of a new breeding

programme (Olori, *et al.*, 2005), where records are structured and managed to elucidate the genetic value of every selected candidate. Thus, crossbreeding is done to take advantage of heterosis, obtain average breed effects, to form an adequate design of flock, to target viable markets and to create breeding plan for a herd. The indigenous breeds of many species of livestock low genetic resources for production, but possess required qualities such as adaptability, tolerance to hot (or wet climatic) conditions, resistance to many diseases that are prevalent in the tropical regions and general optimal performance under inadequate feeding and management conditions (Cunningham, 1992). In addition, many species of farm stocks that are high producing from advanced countries introduced into tropical and subtropical conditions degenerate due to lack of adaptability and resistance to tropical disease (Ayorinde, 1990). Thus, crossbreeding of native breeds with another superior native breeds is expected to produce upgrading of their genetic potentials and bring about considerable improvement in production with optimal capacity to withstand the direct and indirect effects of inclement of weather. The genetic investigation of the crossbred allows probing which is not limited to the importance of individual and maternal heterosis and environment –interactions, but also for particular combinations of genes which only manifest the merits when they are crossed to other population (Sheridan, 1986).

Although, crossbreeding has been used mainly to seek improvement in milk production especially with dairy cattle in the developing countries (FAO, 2013), however, a couple of crossbreeding have also been done among breeds of sheep. Also, a number researcher in some countries has used prolific breeds of sheep to improve flock productivity (Aboul-Naga, 1996; Gootwine *et al.*, 1995; Lassoued and Rekik, 2001). Crossbreeding of WAD sheep with other breeds such as Balami, Uda, Yankassa and their crosses have been done by researchers such as Bratte (2015) and Oyeyemi and Oguusola (2011). When breeds are crossed, new allelic combination form are created in the crossbred sheep which therefore, have increased

heterozygosity relative to the parents that produce them (Oyeyemi and Ogunsola, 2011). However, there is little information in the crossbreeding of the Northern sheep with the West African Dwarf sheep in the sub-humid zone of Nigeria.

2.4.1. Heterosis in sheep breeding

Heterosis is the genetic gain from the difference between the hybrid and the mean of the two parents (Falconer and Mackay, 1996). It determines the increase in performance beyond what is expected or calculated based on the parents of the offspring (Alkire, 2012). It is the degree of deviation between the cross and mid-parent means. Heterosis has been found to be pronounced and greater in genetically distant or heterozygous parents than in closely related parents (Fayeye, 2014). Oyeyemi and Ogunsola (2011) reported 38% and 92% heterosis respectively for birth and live weight in WAD crossed with Yankassa and Uda sheep. However, there is scarcity of information in the weaning and yearling weights heterosis in the indigenous breeds of Nigerian sheep. The determination of heterosis in the successive growth phases of the Nigerian sheep will supply ample information about the best performing breed via the hybrid generated alongside the particular phase of growth and development in the life of the animal.

2.4.2. Complementarity in sheep breeding

Complementarity is a breeding advantage derived when the weakness of one breed is offset by the strength of the other breed(s) and vice versa (Schwenian, 2014). Breed complementarity evaluates the strengths and weaknesses of potential breeds and selecting those that complement each other which eventually results in an animal possessing the best traits of both breeds (Alkire, 2012). Breed complementarity allows a breeder to rely on the strengths of different breeds as no single breed possesses all of the traits that affect profitability (Alkire, 2012). Complementarity is independent of location or season as the weakness of the WAD sheep are always masked with the superiority of the long-legged

sheep. Oyeyemi and Ogunsola (2011) and Bratte (2015) reported the hybrid vigour and complementarity in crossbreeding pure WAD with Yankassa and Uda sheep in Oyo and Osun state respectively.

2.5. Reproductive factors affecting lambs' birth weights

The reproductive performance of sheep is the gross biological interplay of all reproductive activities such as puberty, oestrus, ovulation, fertilization, implantation, gestation and successful lambing (Fadare, 2015). It reflects the fecundity, fertility and prolificacy of an adult animal (Khan *et al.*, 2000). Growth and reproductive performance of some Nigeria breeds of sheep such as Yankassa, Uda, Balami and WAD have been investigated Bratte (2015) and Oyeyemi and Ogunsola (2011) in the rainforest agro- climatic zones of Nigeria. Also, birth weights of the lambs were reported by Gama *et al.* (1991) to be the best indicator or predictor of lambs' survivability. Reproductive performance, viability and growth performance traits have also been used to investigate some small and large ruminants outside Nigeria. These traits were then used to formulate overall productivity indices in the animals (ILCA, 1982). Reproductive performance of 1.5 lambs per ewe per year has been recorded among the West African dwarf sheep in some areas of southwest Nigeria (Mack, 1983). The following are factors affecting lambs production:

2.5.1 Number of parity

Parity has been reported by a number of researchers to affect lambs' birth weights. Fasae *et al.*, (2012); Gbangboche *et al.*, (2009); Gbangboche *et al.*, (2006) and London and Weiner (1995) reported heavier lambs for dams of more parities. Some physiological changes during subsequent pregnancy have been observed to impact more weights in the lambs at birth. Khong *et al.* (2003) observed that the first pregnancy causes some physiological reprogram in the womb of the dam such that it increases vascularisation which enhances greater blood

volume expansion during the second pregnancy (Campbell and McGillivray, 1984) each of which will facilitate relatively greater fetal growth in subsequent pregnancies.

2.5.2. Age of the dam

Older ewes have been reported by a couple of researchers such as Ali *et al.* (2006); Mohamed *et al.* (2009) and Buvanendra and Adu, (1990) to produce heavier lambs than younger ewes. Older dams, provided nutrition and other factors of management factors are adequate, are expected to have lambed more (more parity) which is one of the key determinants of birth weight in lamb production. However, some authors like Gama *et al.* (1991) and Dalton *et al.*, (1980) have reported differing reports on the importance and effect of dams' age on the survivability of lambs. Generally, age of the animal has been reported to affect some genetic gain (heterosis). Gowe and Fairfull (1982) observed that heterosis for some traits is affected by age during early growth phase and over production cycles.

2.5.3. Gestation Length

Gestation length according to Bellows and Ansotegui (2005), is the physiological period of development of foetus in the dam. It is affected by a number of factors such as sire breed (Fogarty *et al.*, 2005), age of the dam, litter size and lamb's birth weight (Cardy and van Vleck, 1978 and Amoah *et al.*, 1996). Vatankhah *et al.* (2000) and Koyuncu *et al.* (2001) reported longer gestation lengths for older dams. Pregnant ewes with single lambs also had longer gestation length when compared with those carrying multiples (Osinowo *et al.*, 1994; Vatankhah *et al.*, 2000; Koyuncu *et al.*, 2001; Dwyer, 2003; Fogarty *et al.*, 2005). Lamb weight was also reported to have significant influence on gestation length (Knight *et al.*, 1988; Vatankhah *et al.*, 2000; Fogarty *et al.*, 2005) which may be more prolonged when the dam is carrying a male lamb (Koyuncu *et al.*, 2001; Vatankhah *et al.*, 2000; Fogarty *et al.*, 2005). Bradford *et al.* (1972) and Dwyer *et al.* (1996) concluded that genotype of the lamb is more reliable than the dam in determining gestation length. Osinowo *et al.*, (1994);

Vatankhah et al., (2000) therefore concluded that selection for a reduction in gestation length may indirectly increase prolificacy.

Iyiola-Tunji *et al.* (2010) concluded that gestation length showed low and non-significant relationship with birth weight; birth type and lamb genotype.

2.5.4 Birth type

Differing reports on the influence of birth type on lambs' birth weights have been made by a number of researchers. While some reported that lambs born as twins and triplets generally had lower weights at birth than those born as singles, others reported otherwise. Fasae *et al.* (2012) reported a non significant effect of birth type in lambs of Yankasa, West African Dwarf breeds. Gbangboche *et al.* (2006) reported heavier weight for single lambing than multiple birth type in djallonke sheep in Soudanian zone. Bratte (2015) reported superiority in birth weight of single ram lamb over ewe lamb single birth in some indigenous breeds of Nigerian sheep. Galal *et al.* (1981) observed that production of multiple births in sheep often resulted to lower lamb birth weights and poor survivability. Atkins (1980) and Petrvic *et al.* (2011) observed that breed effect and lambing type interactions could affect lambs' birth weight.

2.5.5 Sex of the lamb

The influence of lamb sex on the birth weights of lambs have been reported by a number of researchers. Male lambs at birth, were reported to have heavier weight than female lambs (Fasae *et al.*, (2012); FAO, (1989) and Buvanendra and Adu (1990). Haqq *et al.* (1994) observed that the relatively smaller weight of female lamb at birth can be attributed to the effect of the presence of a Y-chromosome with the products of *sry* gene activation i.e androgens and mullerian-inhibitor substance which has sex-specific effects on fetal growth thereby making the males appear to grow faster than respective females *in uterus*. Ebangi *et al.* (1996) also reported the continuous production of the growth-promoting hormone,

androgen, in the male animals will make them have superior growth over the females. However, age and breed of the female animals can suppress the effect of the male hormone in the latter. For instance, Adejoro and Salako (2012) reported higher value of shoulder width for Balami female than its male. This may also be due to the need for physical support as a wider shoulder offers more support during mating.

2.6 Heritability estimates of economic traits in sheep

Heritability is the proportion of the phenotypic variation in a population that is expressed by genetic factor (Fayeye, 2014). It can also be defined as total differences between animals due to additive gene effect that are transmitted to the offspring. Sajjad (2012) observed the importance of heritability in realising adequate animal evaluation methods, selection methods and mating systems as it measures the relative importance of hereditary and environmental impacts on the development of a specific quantitative or economic trait. Also, heritability estimate is important at determining the relative contribution for genetic and environmental impacts on a given trait or character. Thus, estimates of heritability inform animal breeder about breeding method and procedures and how efficient a particular selection will be. It is usually calculated with the formular:

Broad-sense heritability captures the proportion of phenotypic variation due to genetic values that may include effects due to combination of dominance and epistasis and it is mathematically expressed as: $h^2 = VG/VP$. Whereas, narrow-sense heritability whose formular is $h^2 = VA/VP$, is employed to capture only that proportion of genetic variation that is due to additive genetic values (VA). Narrow-sense is most important in animal selection programmes, because response to artificial or natural selection depends on additive genetic variance (Sajjad, 2012). Moreover, resemblance among relatives is mostly driven by additive genetic variance (Hill, 2008). Generally, low and below average heritability estimates of economic traits in sheep has been reported by a couple of researchers. McNaughton and

William (1956) and Blackwell and Henderson (1955) reported low to moderate heritability estimates for birth weights in Merino sheep). Haggert (2002) observed that heritability estimates for litter size in sheep are usually of low to medium size. However, Duguma *et al.*, (2002); Lee *et al.* (2009); Mroczkowski *et al.* (1981); Olivier *et al.*, (2001) and Piwczyński (2009) all reported negative and very low heritability estimates for same sheep: such as – 0.0720-0.203 for fertility; number of lambs born with previous parity (– 0.060-0.260); number of lambs reared by the dam (– 0.039-0), although, the pronounced differences and low values were attributed to the statistical method employed.

2.7 Repeatability estimates of economic important traits in sheep

Repeatability is a measure of the tendency for an animal to maintain the present performance in future (Fayeye, 2014). It could also mean the average proportion of differences in the present records that is likely to be repeated in subsequent records. This proportion of variance includes additive gene effect, dominance and epistatic portions as the gene or gene combinations remain the same throughout the life of animal. Repeatability gives the upper limit of heritability in the broader sense. It is estimated through the regression of the future performance on past performance. It could also be derived as an intra class correlation among records of traits on the same individual by analysis of variance (Ibe, 1995).

Sajjad (2012) noted that the reason that accuracy decreases when repeatability is high is that the higher repeatability means that the degree of similarity between observations is due to non-transmittable effects, environment, and non-additive genetic factors. Low repeatability estimates of some economic traits such as litter size, birth weights, milk yield and weaning weights, in sheep have been reported several authors. Haggert (2002) reported low repeatability estimates for litter size in White Alpine, Brown-Headed, the Black-Brown Mountain and the Valais Black-Nose sheep of Switzerland. Whereas some authors have reported heritability estimates for litter size in sheep as high as 0.20 (Johansson and Hansson,

1943; Sidwell, 1956). All research and reports in the study of Nigerian breeds of sheep have left dearth or no information on the repeatability estimates of some economic traits and a study to investigate the inheritance and correlations of records in the lives of the Nigerian sheep will go a long way to improve them.

2.8 Genetic correlations of economic important traits of sheep

Genetic correlation has to do with the analysis of covariance where the values of one trait are correlated with those of another trait. Phenotypic trait, which is the estimate of association between two visible characters in Nigerian breeds of sheep have been reported by Emmanuel (2013). Environmental correlation is the association of traits with the animal environment (Falconer, 1989). Oseni et al. (2006), observed that differing expression of qualitative traits may represent some adaptive features and mechanisms related to adaptability and survivability of animals in different ecological zones in the country. Maciejowski and Zieba (1982) observed that a couple of external traits or parts are positively correlated to body weight while some have been attributed to majorly influence growth (Ibe, 1995). For instance, Heart Girth has been reported by (Lukuyu *et al*, 2016) to be useful in the prediction of live weights in large ruminants. . Okpeku and Nodu (2013); Okpeku, (2010) and Oyeyemi and Ogunmola (2011) reported some correlation values between birth weights and other traits in some Nigeria sheep and goats respectively. However, their reports, especially on sheep did not capture or represent all the long-legged and short-legged types of Nigerian sheep.

2.9 Improving the West African Dwarf sheep

The increased demand in animal protein especially for meat has generated a big concern in the face of challenges facing the rearing and production of small ruminants such as sheep in the humid part of Africa. Over the next two decades, meat demand is projected to double in developing countries, and problems such as parasitic disease among others, has been found to be the major constraint in animal production in the sub-humid and non forested parts of the

humid zone of Africa (Gbangboche, 2006). Some biological characteristics such as poor growth rate, body structure, dwarfism even at maturity stage, have been used as limiting factors for the use of WAD sheep as meat source or meat production, and they are known to have very low income when used for that purpose (Adu and Ngere, 1979).

It has been documented and proven that the breeding of disease- resistant, trypanotolerant livestock such as West African Dwarf (WAD) sheep (Mauwena 1986; 1987; Osaer, 1994) has been more economically viable and more sustainable, than controlling trypanosomosis and other worm disease. A number of researcher like Bonfoh *et al* (1996); Abassa (1992) ; Troare (1993) have developed breeding framework to improve the growth performance of WAD sheep through selection in some African countries.

Oyeyemi and Ogunsola (2011), Gbangboche (2006) and (2005), Bratte (2015) Sowande and Sobola (2008) have worked on improvement of the WAD sheep and its morphometric traits. While the information on the trypanotolerant trait of the WAD sheep has been reported by a couple of authors, there is still a paucity of information on the growth and reproductive performance (improvement) of the WAD sheep and the survivability of the superior breeds of sheep in the sub-humid part of Nigeria. Therefore, crossing the WAD with some giant breeds from the Northern part of the country will not only supply information on the growth performance but also enlighten the breeders on the best breed to use for what purpose.

CHAPTER THREE

MORPHOMETRIC CHARACTERISATION OF TRADITIONALLY MANAGED UDA, BALAMI AND WAD SHEEP

3.1 Introduction

The domestic animal diversity has been used to provide information on the genetic variations among and within breeds of species used for food and agriculture (Cardellino and Boyazoglu, 2009). Domestic animal diversity is important for food security and essential to meet uncertain future demand of population increase, climate change and more virulent diseases pathogens. It is therefore, a measure that not only depends on the number of breeds but also on genetic diversity within and between the breeds (Crepaldi *et al.*, 2001).

The characterisation of domestic animal diversity is essential to meet future needs in the sub-Saharan Africa in general. The genetic approach is essential for the determination of genetic variability which is an important element in conservation of genetic resources and for breeding strategies (Anila and Paolo, 2012). The morphological characterisation of African animal genetic resources is presently gathering increased attention (Traore *et al.*, 2008; Yakubu and Akinyemi, 2010; Yakubu and Ibrahim, 2011). Comparison based on morphological properties - though not all encompassing - can give a reasonable representation of differences among the breeds. It also serves as the foundation upon which DNA analysis can be built (Yunusa *et al.*, 2013b). The characterisation of the small ruminant animals in developing countries will play an important role in maintaining and retaining genetic resources for future improvement in livestock production, (Peter *et al.*, 2012). This can be partly achieved through the analysis of morphological traits to obtain information variation within and across populations using classical multivariate analysis such as principle components and discrimination analysis which have been shown to be sustainable in accessing variation within and can discriminate different population types when all measured

morphological variables are considered simultaneously (Yakubu *et al.*, 2010b; Legaz *et al.*, 2011). Delgado *et al.*, (2001) noted that knowledge of morphometric characteristics marks the first steps in classification of Farm Animal Genetic Resources (FAnGR).

Schwenian (2014) noted that there are 1000 breeds of sheep worldwide, while only a handful of sheep breeds are usually of economic importance to a country's commercial industry and all breeds should be considered important as they contribute to the genetic diversity of the species and world industry. Adequate works on linear body measurements of Northern Nigeria breeds of sheep like Balami and Uda is rare. Yakubu *et al.*, 2005; Afolayan *et al.*, (2006); Sowande and Sobola, (2008); Chineke, (1996); Akpa *et al.*, (2010) elucidated the relationship between linear body measurements and live weight of West African Dwarf and Yankasa sheep in Nigeria. Yakubu (2010) outlined a couple of positive relationships between body linear measurements and body weight of Yankasa sheep and recommended that such association may be essential tool for selection as positive correlations of traits suggest that the traits are under the same gene action (i.e. pleiotropy).

3.2 Main Objective

The main aim of the survey is to characterise traditionally managed breeds of sheep such as the WAD, Balami and Uda in locations where they are abundantly and naturally found.

3.3 Specific Objectives

The specific objectives of the study is to characterise Uda, Balami and West African Dwarf Sheep using morphometric traits

3.4. Materials and Methods

A total of 1017 animals comprising 371 Balami, 291 UDA and 355 WAD sheep were sampled from the traditionally managed flocks and markets across the ecological zones in Nigeria. The ecological zones visited were part of North-West (Sokoto, Kebbi), North central

(Kwara,) and South-West (Oyo). Kwara State is located on latitude 8°30' and 8°50'N and longitude 4°20' and 4°35'E of the equator (Kwara State Geography, 2017); Sokoto on 13°3'39.31''N latitude and longitude 5°14'20.47''E (LatLong.net, 2017); Kebbi state on latitude 12°25'54.33"N and longitude 4°11'44.24"E (LatLong.net, 2017) while the longitude and latitude coordinates of Oyo state are 4° 00' 00" E and 8° 00' 00" N Both Sokoto and Kebbi are found in the Sudan Savannah belt while Oyo and Kwara states are located in the Southern Guinea savannah as shown in Figure 3.1.

From Table 3.1, the markets covered in Sokoto state were *Ilela and Achida* while that of Kebbi were *Ambrosa and Arugungu*. For Kwara state, surveys were carried out at *Ipata, Ajase and Zango* markets. The markets visited in Oyo were *Akinyele, Igbeti and Ojoo* while the homesteads of the local farmers at *Iware, Onidundu, Asanla and Amosun* at Akinyele Local Government were also contacted. 290 and 81 Balami; 110 and 181 Uda were sampled in Sokoto and Kebbi respectively, while 258 and 97 WAD was sampled in Oyo and Kwara state respectively.

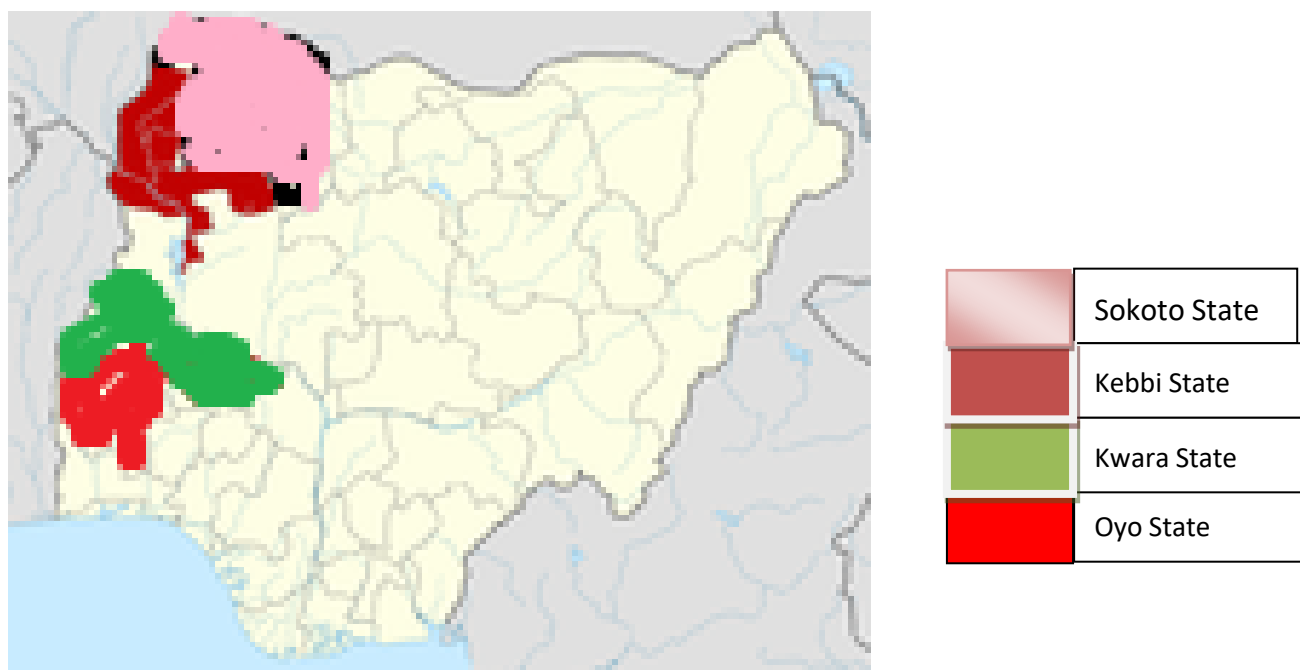


Figure 3.1: Map of Nigeria with study locations

Table 3.1: Summary of sampling procedure of WAD, Uda and Balami sheep

Sample Animals	Animals	Number	Ecological Zones			Markets
			Zones	State		
	Balami	371 (Male=236) (Female=135)	North-West	Sokoto (290 Balami, 110 Uda)	Sudan Savanna	Ilela, Achida
	UDA	291 (Male=159) (Female=132)		Kebbi (81 Balami,181 Uda)		Ambrosa, Arugungu
	WAD	355 (Male=180) (Female=175)	North Central	Kwara (97)	Guinea Savannah	Ipata, Ajase, Zango
			South-West	Oyo (258)		Akinyele, Igbeti, Ojoo

3.5 Data Collection

Data were collected from both male and female of each breed. The presence of two incisors was used to categorise the 23-month old sheep while four incisors marked that of 35-month sheep. There were no birth records. Therefore, dentition was used to determine the age (FAO 1994). Animals were grouped under age 1-23 months (23-month or less than 2 years) and 2 years (35-months or less than 3 years). A total number of 236 males and 135 females of Balami; 159 males and 132 females of Uda; 180 males and 175 females of WAD sheep were used for the study. The linear body measurement was taken with a measuring tape (cm). The methods for the measurement was in accordance with Anatomic reference point described by Hamito, (2009); FAO (2012) and Salako and Ngere, (2012). The traits measured were: Ear Length (EL), Fore Leg Length (FLL), Rear Leg Length (RLL), Body Length (BL), Shoulder Width (SW), Neck Circumference (NC), Hearth Girth (HG), Rump Height (RH), Head Length (HL), Head Width (HW), Rump Width (RW), Rump Length (RL), Tail Length (TL), Wither Height (WH), Horn Length (HnL), Horn Base Circumference (HnBC), Scrotal Width (ScW) and Scrotal Length (ScL). The anatomical reference points which were depicted in Figure II are as follows:

- i. WH: The distance covered from the flat ground on which animals stood, to the withers of the animal.
- ii. RH: This is the distance covered from the flat ground to the rump.
- iii. BL: This measured the length from the base of the tail to the base of the head.
- iv. HG: The circumference around the chest just behind the front legs and withers.
- v. NC: This is the circumference around the neck close to the withers.
- vi. SW: The distance from the backbone at the shoulders to the brisket between the front legs

- vii. RW: It is the distance between the outer edges of the major hip bones on the right and left sides.
- viii. ScL: The length of the scrotum from the point of attachment to the body to the tip
- ix. ScW: The circumference of the scrotum divided by 2.
- x. HnL: The length of the horn from the cranial bone to the tip
- xi. HnBC: The circumference around the base of horn
- xii. HL: The distance measured from the cranial bone to the mouth
- xiii. HW: The distance measured between the two temporal bones of the head
- xiv. EL: The length of the ear from the point of attachment to the cranial bone to the tip
- xv. TL: The length of tail from the caudal bone to the tip.
- xvi. FLL: The length measured from the patella bone to the hoof
- xvii. RLL: The length measured from the curved joint of the back leg to the hoof
- xviii. RL: the length of bone from the rump area to the caudal

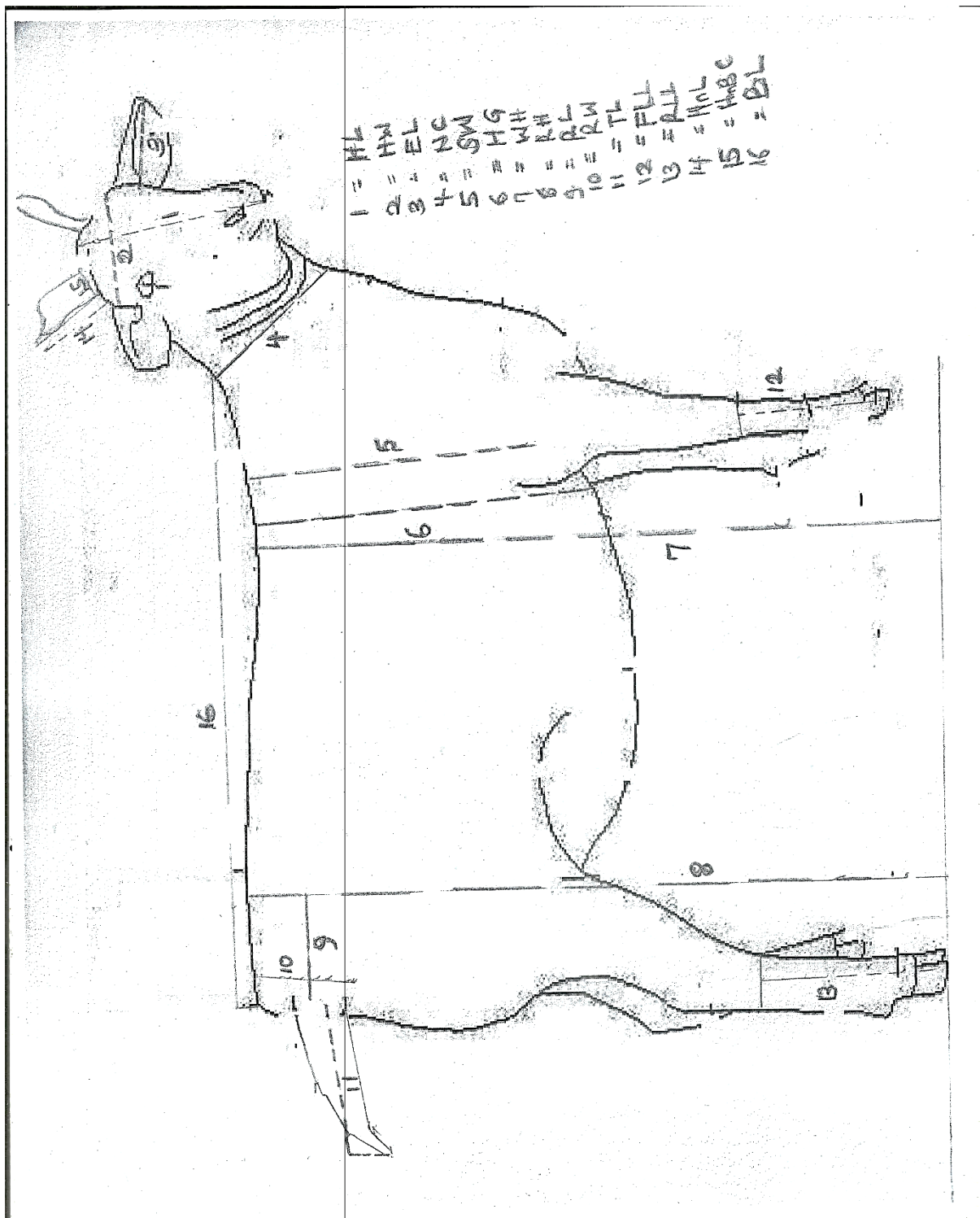


Figure 3.2: Annotated sheep diagram showing the morphometric traits measured.

Ear Length (EL), Force Leg Length (FLL), Rear Leg Length (RLL), Body Length (BL), Shoulder Width (SW), Neck Circumference (NC), Hearth Girth (HG), Rump Height (RH), Head Length (HeL), Head Width (HW), Horn Length (HL), Rump Width (RW), Rump Length

(RL), Tail Length (TL), Withers Height (WH), Horn Base Circumference (HnBC), Testicle Width (TeW), Testicle Length (TeL).

3.6 Data Analysis

Descriptive statistics for the variables was generated for each breed and this depicted the means and standard error for the means. Data were analysed using the General Linear Model procedure (PROC GLM) of SAS 9.4. to test the fixed effects of breed, sex, age and their interactions. Mean separation was done using Duncan's Multiple Range Test (Steel and Torrie, 1980) of the same statistical package at probability level of 5%. Tukey-Kramer Grouping was used to determine the interactions.

The linear model employed for characterizing Uda, Balami and WAD sheep was:

$$Y_{ijk} = \mu + \alpha_i + S_j + A_k + (BS)_{ij} + (BA)_{ik} + (SA)_{jk} + (BSA)_{ijk} + e_{ijk}$$

where,

Y_{ijk} = record of morphological traits of each animal

μ = overall mean

α_i = fixed effect of the i th breed (i = Balami, Uda and WAD)

S_j = fixed effect of j th sex (j = male, female)

A_k = fixed effect of k th age (k = 23 months, $\geq$ 35 months old)

$(BS)_{ij}$ = interaction effect of i th breed and j th sex\

$(BA)_{ik}$ = interaction effect of i th breed and k th age

$(SA)_{jk}$ = interaction effect of j th sex and k th age

$(BSA)_{ijk}$ = interaction effect of breed, sex and age

e_{ijk} = random error associated with each record (normally, Independently and identically distributed with zero mean and constant variance)

3.7 Results

Table 3.2 shows that Ear Length differed significantly ($p<0.005$) between Balami and WAD while there was no significant difference between the former and Uda. The length of ear was significantly different between male and female with mean values of 13.13 cm and 13.69 cm respectively for males and females. There was also significant difference in EL with respect to Age. The older sheep had bigger EL with average value of 15.63 cm compared to 12.62 cm for the younger ones. The Fore Leg Length (FLL) of Balami and Uda were similar but differed significantly ($p<0.005$) from that of WAD. There was no significant difference in FLL between the sexes although the male had a higher value. The FLL of the 24-35month (35-month) old sheep were significantly ($p<0.005$) different from the 1-23month (23-month) old sheep. There was no difference in the Rear Leg Length (RLL) of Balami and Uda but both differed significantly ($p<0.005$) from WAD. The male sheep had longer ($p<0.005$) RLL compared to the female. There was significant difference in the RLL between the 35-month old sheep and 23-month sheep. There was significant ($p<0.005$) difference in Body Length (BL) between Balami, Uda and WAD with mean values of 101.67, 97.68 and 90.90cm respectively. The male sheep had longer BL and significantly ($p<0.005$) different from that of the female. Also, the 35-month sheep BL was longer and significantly different from that of the 23-month sheep. There was significant difference ($p<0.005$) in Shoulder Width (SW) among the breeds of sheep. Balami sheep had the widest SW with 5cm and 8cm bigger than Uda and WAD respectively. The male SW was higher and differed significantly ($p<0.005$) from that of the female. The 35-month sheep had broader shoulder and was significantly different from that of 23-month sheep.

The Neck circumference (NC) of Balami had the highest value and was significantly ($p<0.005$) different from that of Uda but similar to that of WAD. The male sheep's NC was bigger and significantly ($p<0.005$) different from that of the female. The 35-month sheep's

NC was also significantly ($p<0.005$) different from that of 23-month sheep. The Heart Girth (HG) was significantly ($p<0.005$) different in Balami, Uda and WAD with value range of 71.13, 61.20 and 55.81cm respectively. The male HG had a bigger value and significantly ($p<0.005$) different from that of the female. There was also significant ($p<0.005$) difference between the HG of the 23-month and the 35-month sheep with the latter having a bigger value. There were significant ($p<0.005$) differences between the Rump Heights (RH) of Balami, Uda and WAD with value range of 76.30, 68.87 and 59.57 respectively. The male sheep had significantly ($p<0.005$) bigger RH compared to the female.

There was significant difference in the RH of the 35-month and 23-month sheep. There was similarity in the Rump Width (RW) of Uda and WAD however, both had lesser values and differed ($p<0.005$) significantly from Balami, while male sheep had significantly wider rump than the female sheep. The 35-month sheep differed ($p<0.005$) significantly in RW compared to the 23-month sheep. There were significant ($p<0.005$) differences in the Rump Lengths (RL) of Balami, Uda and WAD. Balami rump was about 1cm and 3cm longer than Uda and WAD respectively. There was no significant in the RL of male and female sheep. The RL of the 35-month sheep differed ($p<0.005$) significantly from that of the 23-month sheep. Balami sheep had significantly ($p<0.005$) longest Head Length (HL). The male and the older sheep showed superiority in HLs compared to the female and the younger sheep. There was similarity in the Head Widths (HW) of Uda and WAD but both differed significantly ($p<0.005$) from that of Balami with values of 14.66, 15.02 and 18.16cm respectively. The male sheep had higher HW value and was significantly different from that of the female sheep. The heads of the 35-month sheep were wider and differed ($p<0.005$) significantly from those of the 23-month sheep.

Table 3.2: Fixed Effect of genotypes, sex and age on the morphometric traits centimeter (cm) of Balami, Uda and WAD sheep

Parameter	EL	FLL	RLL	BL	SW	NC	HG	RH	RW	RL	HL	HW	HnL	HnBC	TL	WH	ScL	ScW
Breed																		
Balami	14.79 ^a	27.69 ^a	30.99 ^a	101.67 ^a	48.90 ^a	34.95 ^a	71.13 ^a	76.30 ^a	20.21 ^a	19.26 ^a	22.86 ^a	18.16 ^a	6.32 ^c	6.36 ^c	39.19 ^b	73.47 ^a	10.07 ^a	6.32 ^a
Uda	14.82 ^a	27.20 ^a	30.10 ^a	97.68 ^a	40.54 ^a	30.16 ^b	61.20 ^b	68.87 ^b	18.95 ^b	18.20 ^b	20.24 ^b	14.66 ^b	11.74 ^a	9.64 ^a	32.09 ^b	65.19 ^b	8.05 ^b	5.58 ^b
WAD	10.95 ^b	25.45 ^b	28.05 ^b	90.90 ^c	35.82 ^c	35.14 ^a	55.81 ^c	59.57 ^c	18.87 ^b	16.35 ^c	17.49 ^c	15.02 ^b	10.78 ^b	9.44 ^a	18.20 ^c	56.12 ^c	7.32 ^c	3.87 ^c
RSM	<u>±3.45</u>	<u>± 9.42</u>	<u>± 9.81</u>	<u>±23.87</u>	<u>±13.36</u>	<u>±9.37</u>	<u>±16.45</u>	<u>±17.30</u>	<u>±5.52</u>	<u>±5.21</u>	<u>± 6.89</u>	<u>± 7.71</u>	<u>± 5.27</u>	<u>± 4.66</u>	<u>± 8.65</u>	<u>±21.95</u>	<u>± 4.28</u>	<u>± 2.90</u>
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0024	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0961	0.0001
Sex																		
Male	13.69 ^a	27.57 ^a	30.62 ^a	100.60 ^a	45.28 ^a	35.56 ^a	68.39 ^a	72.50 ^a	20.20 ^a	18.38 ^a	21.89 ^a	17.97 ^a	16.09 ^a	14.24 ^a	32.06 ^a	68.90 ^a	14.56 ^a	8.97 ^a
S.E.M	0.09	0.11	0.10	0.42	0.25	0.16	0.24	0.32	0.08	0.08	0.07	0.07	0.13	0.08	0.35	0.35	0.11	0.11
Female	13.13 ^b	25.64 ^b	28.43 ^b	91.40 ^b	37.97 ^b	30.96 ^b	56.10 ^b	62.48 ^b	18.24 ^b	17.33 ^b	18.33 ^b	13.38 ^b	0.08 ^b	0.14 ^b	26.70 ^b	9.63 ^b	0.06 ^b	0.04 ^b
S.E.M.	0.10	0.08	0.10	0.19	0.14	0.12	0.18	0.28	0.05	0.05	0.08	0.08	0.00	0.00	0.35	0.39	0.00	0.00
p-value	0.5015	0.328	0.192	0.0012	0.0002	0.0001	0.0001	0.0001	0.8160	0.9898	0.0001	0.0001	0.0001	0.0001	0.0009	0.0002	0.0001	0.0001
Age (Month)																		
24-35	15.63 ^a	31.98 ^a	34.72 ^a	118.84 ^a	52.17 ^a	40.33 ^a	72.83 ^a	80.32 ^a	23.10 ^a	21.35 ^a	20.74 ^a	17.39 ^a	12.85	10.76 ^a	38.56 ^a	76.52 ^a	11.75 ^a	8.63 ^a
S.E.M	0.10	0.10	0.11	0.49	0.29	0.16	0.29	0.37	0.07	0.07	0.06	0.04	0.30	0.26	0.38	0.38	0.25	0.18
1-23	12.62 ^b	24.77 ^b	27.79 ^b	88.30 ^b	38.43 ^b	31.08 ^b	59.62 ^b	63.73 ^b	17.96 ^b	16.63 ^b	19.56 ^b	15.55 ^b	8.12	7.46 ^b	26.48 ^b	60.65 ^b	7.30 ^b	3.96 ^b
S.E.M	0.06	0.04	0.07	0.14	0.11	0.08	0.13	0.24	0.03	0.06	0.07	0.07	0.26	0.16	0.31	0.36	0.13	0.06
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.5531	0.0251	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Breed/Sex	0.5005	0.0001	0.0001	0.0024	0.0001	0.0603	0.0001	0.0705	0.0307	0.0054	0.0531	0.0013	0.0001	0.0001	0.5975	0.3752	0.3063	0.0001
Breed/Age	0.0784	0.0001	0.0001	0.1291	0.0001	0.0001	0.0001	0.0001	0.0069	0.0037	0.0001	0.0001	0.0100	0.0021	0.0001	0.0002	0.0738	0.0001
Sex/Age	0.0806	0.1604	0.1201	0.7884	0.0451	0.0538	0.0047	0.8362	0.0001	0.0016	0.2784	0.1800	0.0001	0.0001	0.1897	0.6849	0.0001	0.0001
Breed/Sex/Age	0.0171	0.0316	0.0287	0.5458	0.2132	0.3843	0.0134	0.7208	0.0374	0.0001	0.0031	0.0024	0.0226	0.0125	0.2559	0.9817	0.1067	0.0001

^{abcd} Means along the same column with different superscripts are significantly ($p<0.005$) different

The Uda had a significantly ($p<0.005$) longest Horn (HnL) with 1cm and 5cm longer than WAD and Balami respectively. There was also a significant ($p<0.005$) difference in the HnLs of the male and female. The 35-month sheep had a significantly ($p<0.005$) longer horn than the 23-month sheep. There was no significant difference in the Horn Base Circumference (HnBC) of Uda and WAD but both differed significantly ($p<0.005$) from Balami with value of 8.93, 9.60 and 5.77cm respectively. The male sheep had a significantly bigger HnBC compared to the female sheep while the 35-month sheep had a significantly ($p<0.005$) higher value for HnBC compared to the 23-month sheep. There were significant ($p<0.005$) differences in the Tail Lengths (TL) of Balami, Uda and WAD. Balami had the longest tail followed by Uda and WAD and their tails with values of 39.19, 32.09 and 18.20cm respectively. There was also significant ($p<0.005$) difference between the TL of the male and that of the female. There was significant ($p<0.005$) difference in the TL of 35-month sheep and that of the 23-month sheep. There were significant ($p<0.005$) in the Wither Height (WH) of Balami, Uda and WAD with values: 73.47, 65.19 and 56.12cm respectively. The male sheep were significantly ($p<0.005$) taller than the female sheep. Also, the 35-month sheep had significantly ($p<0.005$) higher WH than the 23-month sheep. The Balami sheep had the longest Scrotal Length (ScL) and was significantly ($p<0.005$) different from Uda and WAD with values: 10.07, 8.05 and 7.32cm respectively. The males only had scrotum while the females had none. There were significant ($p<0.005$) differences in the Scrotal Width (ScWs) of Balami, Uda and WAD and the values of 6.32, 5.58 and 3.87cm for Balami, Uda and WAD respectively. The male sheep had average of 8.97cm for ScW. The 35-month sheep had significantly ($p<0.005$) wider scrotum compared with the 23-month sheep.

Table 3.3: Effects of interaction among Breed, Sex and Age on Ear Length (EL)

Breed	Sex	Age (Month)	EL (cm)
B	M	24-35	17.21 ^a
B	F	24-35	16.82 ^{ba}
U	M	24-35	16.70 ^{ba}
U	F	24-35	15.13 ^{ba}
U	F	1-23	14.83 ^{bc}
B	M	1-23	14.19 ^c
U	M	1-23	13.41 ^c
B	F	1-23	13.40 ^c
W	F	24-35	13.10 ^c
W	M	24-35	13.03 ^c
W	F	1-23	10.42 ^d
W	M	1-23	10.21 ^d
S.E.M.			±0.01

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different . B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

From Table 3.3, the interaction between Breed, Sex and Age showed significant difference ($P<0.05$). There was similarity in the EL of Balami and Uda male and female of 35 months old. Also, the EL of Balami and Uda male and female of 23 months was similar to that of WAD of 36 months while the 23 months WAD male and female had significantly least EL values.

Table 3.4 shows Balami female and Uda male both had high values and compared closely to Balami male. WAD male FLL was also similar to Uda female while WAD female significantly had the lowest FLL. There was similarity between the 35-month old Balami and 35-month old Uda and both breeds differed significantly from the rest of age categories. WAD of 35-month old was similar to Balami and Uda of 23-month old. 23-month old WAD had the least value for FLL and was significantly different from the rest. There was similarity in FLL 35-month old Balami male, Balami female Uda male and Uda female. The 35-month old Balami female, Uda male, Uda female were similar to 23-month Balami female and 34-month WAD. There was also similarity in the FLL of 23-month Balami female, 34-month WAD female, 23-month WAD male, 23-month Uda male and 34-month WAD female. The FLL values of 23-month Uda male, 34-month WAD female, 24-month Uda female and 23-month Balami male were similar. 23-month WAD female had the least value of FLL but was similar to 23-month Balami male.

Table 3.5 shows interactions between Breed, Sex and Age for RLL. Balami female had the longest RLL and was similar to Uda male, Balami male and WAD male. The RLL of the male of Uda, Balami and WAD was similar to that of Uda female but differed ($p<0.005$) significantly from WAD female which had the least value.

Table 3.4: Effect of interaction among Breed, Sex and Age (Month) on Fore Leg Length (FLL)

Breed	Sex	Means	Breed	Age	Means	Breed	Sex	Age	FLL (cm)
B	F	31.59 ^a	B	24-35	34.98 ^a	B	M	24-35	35.55 ^a
U	M	30.27 ^{ab}	U	24-35	33.20 ^a	B	F	24-35	34.42 ^{ab}
B	M	29.04 ^{ab}	W	24-35	26.20 ^b	U	M	24-35	34.38 ^{ab}
W	M	2765 ^{ab}	B	1-23	25.65 ^b	U	F	24-35	32.03 ^{abc}
U	F	2684 ^{ab}	U	1-23	25.23 ^b	B	F	1-23	28.76 ^{bcd}
W	F	23.78 ^c	W	1-23	23.90 ^c	W	M	24-35	28.44 ^{bcd}
						W	M	1-23	26.86 ^{cde}
						U	M	1-23	26.17 ^{cdef}
						W	F	24-35	23.96 ^{defg}
						U	F	1-23	23.60 ^{efg}
						B	M	1-23	22.54 ^{fg}
						W	F	1-23	21.64 ^g
S.E.M.									±0.09

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$) different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.5: Effect of interaction among Sex and Age on Rear Leg Length (RLL)

Breed	Age	Means	Breed	Sex	Means	Breed	Sex	Age	RLL (cm)
B	24-35	37.75 ^a	B	F	34.64 ^a	B	M	24-35	38.53 ^a
U	24-35	36.39 ^a	U	M	33.13 ^{ab}	U	M	24-35	37.45 ^{ab}
B	1-23	29.13 ^b	B	M	32.23 ^{ab}	B	F	24-35	36.96 ^{abc}
W	24-35	28.36 ^b	W	M	30.49 ^{ab}	U	F	24-35	35.33 ^{abcd}
W	1-23	27.96 ^b	U	F	29.95 ^b	B	F	1-23	32.33 ^{bcd}
U	1-23	26.68 ^b	W	F	25.83 ^c	W	M	24-35	31.06 ^{bcd}
						W	M	1-23	29.92 ^{cde}
						U	M	1-23	28.80 ^{def}
						W	F	1-23	26.01 ^{ef}
						B	M	1-23	25.93 ^{ef}
						W	F	24-35	25.65 ^{ef}
						U	F	1-23	25.56 ^{ef}
						U	F	1-23	24.56 ^f
S.E.M.									±0.09

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

There was no significant difference between 35-month Balami and 35-month Uda and both differed ($p<0.005$) significantly from 23-month Balami, 35-month WAD, 23-month WAD and 23-month Uda sheep. 35-month Balami male had the longest RLL and the value was in similar to 35-month Uda male, 35-month Balami female and 35-month Uda female. There was similarity in RLL of 35-month Uda male, 35-month Balami female, 35-month Uda female, 23-month Balami female and 35-month WAD male. There was also similarity in RLL of 35-month Balami female, 35-month Uda female, 23-month Balami female, 35-month WAD male, and 23-month WAD male. There was similarity in the RLL of all the just mentioned sheep with 23-month Uda male except 35-month Balami female. There were similarities also in RLL of 35-month WAD male, 23-month WAD male, 23-month Uda male, 23-month WAD female, 23-month Balami male, 35-month WAD female and 23-month Uda female. The 23-month Uda female had the least value and was significantly ($p<0.005$) different from 23-month and 35-month WAD males, 23-month Balami female and 35-month Balami and Uda male and female.

From Table 3.6, the effect of genotype and sex on BL showed no significant difference for Balami female, Balami male, Uda male, WAD male and Uda female but was significantly ($p<0.005$) different from WAD female which had the least value.

Table 3.7 shows the interaction between breed and sex had no significant difference in the SW of Balami female, Balami male and WAD male but these categories of animals had significantly ($p<0.005$) different from Uda male, Uda female and WAD female. There was no significant difference between 35-month Balami and 35-month Uda but both were significantly different from 35-month WAD and 23-month Balami. 23-month WAD was significantly ($p<0.005$) different from 23-month Uda and both were significantly different from 35 and 23 month WAD and Balami.

Table 3.6: Effect of interaction between Breed and Sex on Body Length (BL)

Breed	Sex	BL (cm)
B	F	108.80 ^a
B	M	108.28 ^a
U	M	104.93 ^a
W	M	104.74 ^a
U	F	100.86 ^a
W	F	90.57 ^b
S.E.M.		±0.56

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$) different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.7: Effect of interaction among Breed, Sex and Age on Shoulder Width

Breed	Sex	Means	Breed	Age	SW (cm)
B	F	51.60 ^a	B	24-35	56.96 ^a
B	M	50.98 ^a	U	24-35	53.57 ^a
W	M	47.39 ^a	W	24-35	46.41 ^b
U	M	41.69 ^b	B	1-23	46.01 ^b
U	F	38.82 ^b	W	1-23	38.66 ^c
W	F	37.68 ^b	U	1-23	26.94 ^d
S.E.M.					±0.18

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$) different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.8: Effect of interaction between Breed and Age on Neck Circumference (NC)

Breed	Age	NC (cm)
W	24-35	40.94 ^a
B	24-35	39.93 ^a
U	24-35	39.81 ^a
W	1-23	33.30 ^b
B	1-23	32.76 ^b
U	1-23	25.02 ^c
S.E.M		±0.09

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different . B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.9: Effects of interaction among Breed, Sex and Age on Heart Girth (HG)

Breed	Sex	Age	HG (cm)	Breed	Sex	HG (cm)	Sex	Age	HG (cm)
U	F	24-35	80.60 ^a	B	M	74.07 ^a	M	24-35	75.07 ^a
B	F	24-35	80.03 ^a	B	F	73.14 ^a	F	24-35	71.09 ^a
B	M	24-35	79.27 ^{ab}	W	M	70.86 ^a	M	1-23	63.31 ^b
U	M	24-35	74.46 ^{abc}	U	M	62.64 ^b	F	1-23	52.49 ^c
W	M	24-35	71.48 ^{abc}	U	F	60.25 ^b			
W	M	1-23	70.23 ^{abc}	W	F	51.96 ^b			
B	M	1-23	68.87 ^{bc}						
B	F	1-23	66.26 ^c						
W	F	24-35	52.63 ^d						
W	F	24-23	51.29 ^d						
U	M	1-23	50.82 ^d						
U	F	1-23	39.90 ^e						
S.E.M			±0.29						

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

From Table 3.8, there was no significant difference in NC of the 35-month WAD, Uda and Balami although WAD had the highest value followed by Balami and Uda respectively.

All the 35-month breeds of sheep had bigger values of NC and were significantly different from the 23-month breeds of sheep. The NC 23-month WAD was not different from the 23-month Balami but both were significantly different from the 23-month Uda.

Table 3.9 shows no significant difference in HG of Balami male, Balami female and WAD male. However, the values of HG for Uda male, Uda female and WAD female were significantly lower than the earlier mentioned sheep. There was no significant difference in HG of 35-month Balami and 35-month Uda but both had significantly ($p<0.005$) highest values compared to other Breed-Age categories. There was similarity between 23-month Balami and 35-month WAD. However, the latter was similar to 23-month WAD and differed ($p<0.005$) significantly from 23-month Uda. There was similarity between the HG of 35-month male and 35-month female but both differed ($p<0.005$) significantly from 23-month male and female. The 23-month male had bigger HG value and was significantly ($p<0.005$) different from the 23-month female. Also, there were similarities in the value HG of 35-month Uda female, 35-month Balami female, 35-month Balami male, 35-month Uda male, 35-month WAD male and 23-month WAD male. There were no significant differences in 23-month Balami male, 23-month WAD male, 35-month WAD male, 35-month Uda male, 35-month Balami male and 35-month Balami female. Also, there were similarities in the HG of 23-month Balami female, 23-month Balami male, 23-month WAD male, 35-month WAD male and 35-month Uda male. The HG of 35-month WAD female, 23-month WAD female, 23-month Uda male were similar but differed ($p<0.005$) significantly from 23-month Uda female.

Table 3.10: Effects of interaction between Breed and Age on Rump Height

Breed	Age	RH (cm)
B	24-35	85.12 ^a
U	24-35	84.70 ^a
B	1-23	72.32 ^b
W	24-35	67.14 ^b
U	1-23	60.14 ^c
W	1-23	57.20 ^c
S.E.M		±0.27

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$) different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

From Table 3.10, there was no significant difference in the RH of 35-month Balami and 35-month Uda. However, both differed significantly ($p<0.005$) from 23-month Balami, 35-month WAD, 23-month Uda and 23-month WAD. There was similarity in the RH of 23-month Balami and 35-month WAD but both differed significantly from 23-month Uda and 23-month WAD.

From Table 3.11, Balami female, Balami male and Uda male differed ($p<0.005$) significantly from Uda female. There were no significant differences in the RW of WAD male, WAD female and Uda female. There were no significant differences in the RW of 35-month Balami, 35-month Uda and 35-month WAD. However, this category of sheep had RW that differed ($p<0.005$) significantly from the 23-month of Balami, Uda and WAD. There was similarity in the RW of 23-month Balami and 23-month WAD; between 23-month WAD and 23-month Uda. Both the 35-month male and 35-month female differed ($p<0.005$) significantly from 23-month male and female. There was significant ($p<0.005$) difference in the RW of the 23-month male and 23-month female. There were no significant differences in the RW of 35-month Balami female, Uda male, Balami male, Uda female, WAD male and WAD female. There were also, no significant differences in the RW of 35-month WAD male, 23-month WAD male, 23-month Balami female and 23-month Uda male. There were similarities in the RW of 23-month Balami female, 23-month Uda male and 23-month WAD female. There was no significant difference in the RW between 23-month WAD and 23-month Uda. All the 35-month male and female of Balami, Uda and WAD differed ($p<0.005$) significantly from all the 23-month of the same breed of sheep.

Table 3.11: Effects of interaction among Breed, Sex and Age on Rump Width (RW)

Breed	Sex	Age	RW	Sex	Age	RW	Breed	Sex	RW	Breed	Age	RW
B	F	24-35	24.06 ^a	F	24-35	23.36 ^a	B	F	21.44 ^a	B	24-35	23.86 ^a
U	M	24-35	23.68 ^a	M	24-35	22.48 ^a	B	M	21.27 ^a	U	24-35	23.42 ^a
B	M	24-35	23.66 ^a	M	1-23	18.96 ^b	U	M	21.16 ^a	W	24-35	21.49 ^a
U	F	24-35	23.16 ^a	F	1-23	16.62 ^c	W	M	19.73 ^{ab}	B	1-23	18.85 ^b
W	F	24-35	22.88 ^a				W	F	19.65 ^{ab}	W	1-23	17.89 ^{bc}
W	M	24-35	20.11 ^b				U	F	18.88 ^b	U	1-23	16.62 ^c
W	M	1-23	19.35 ^a									
B	M	1-23	18.89 ^b									
B	F	1-23	18.82 ^{bc}									
U	M	1-23	18.63 ^{bc}									
W	F	1-23	16.43 ^{dc}									
U	F	1-23	14.61 ^d									
S.E.M			±0.03									

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.12: Effects of interaction among Breed, Sex and Age on Rump Length (RL)

Breed	Sex	RL (cm)	Breed	Age	RL	Sex	Age	RL	Breed	Sex	Age	RL
B	F	20.96 ^a	U	24-35	22.49 ^a	F	24-35	21.84 ^a	U	F	24-35	23.17 ^a
U	M	20.17 ^a	B	24-35	21.88 ^a	M	24-35	20.61 ^a	B	M	24-35	22.01 ^a
B	M	19.58 ^{ab}	W	24-35	19.30 ^b	M	1-23	17.33 ^b	U	M	24-35	21.81 ^a
U	F	18.47 ^{bc}	B	1-23	18.66 ^b	F	1-23	16.09 ^c	B	F	24-35	21.75 ^{ab}
W	F	17.45 ^c	U	1-23	16.15 ^c				W	F	24-35	20.59 ^{ab}
W	M	17.15 ^c	W	1-23	15.31 ^c				B	F	1-23	20.17 ^{ab}
									U	M	1-23	18.53 ^{bc}
									W	M	24-35	18.00 ^{bc}
									B	M	23	17.15 ^c
									W	M	23	16.31 ^{cd}
									W	F	23	14.32 ^{de}
									U	F	23	13.78 ^e
S.E.M												±0.03

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

From 3.12, there were no significant interactions in the RL of Balami female, Uda male and Balami male. There were similarities in the RLs of Uda male, Balami male and Uda female. The RLs of Uda female WAD female and WAD male were not significantly different. There were significant differences between the RLs of Balami female, Uda female, WAD female and WAD male; between Balami male and WAD female and female. The RLs of 35-month Uda and 35-month Balami were significantly ($p<0.005$) different from 35-month WAD, 23-month Balami, 23-month Uda and WAD. There were no significant differences in the RLs of 35-month WAD and 23-month Balami; 23-month Uda and 23-month WAD. There were significant ($p<0.005$) differences in the RLs of 35-month WAD, 23-month Balami and 23-month Uda and 23-month WAD. The RLs of the 35-month male and female sheep showed significant difference from those of 23-month male and female sheep. There were similarities in the RLs of 35-month Uda female, Balami male, Uda male, Balami female, WAD female and 23-month Balami female. This category of sheep was significantly different from 23-month Balami male, WAD male, WAD female, and Uda female. There were no significant difference in the RLs of 35-month Balami female, 35-month WAD female, 23-month Balami female, 23-month Uda male and 35-month WAD female. There were no significant differences in the RLs of 23-month Uda male, 35-month WAD male, 23-month Balami male and 23-month WAD male. There was similarity between 23-month WAD male and WAD female; 23-month WAD female and 23-month Uda female. All the 35-months male and female of each breed including 23-month Balami, except 35-month WAD male, was similar in RL and differed significantly from other categories of sheep.

Table 3.13: Effects of interaction among Breed, Sex and Age on Head Length (HL)

Breed	Sex	Age	HL (cm)	Breed	Sex	HL (cm)	Breed	Age	HL (cm)
B	M	24-35	25.99 ^a	W	M	23.57 ^a	B	1-23	24.38 ^a
W	M	24-35	25.97 ^{ab}	B	M	21.91 ^{ab}	W	24-35	22.58 ^a
B	F	24-35	22.77 ^{bc}	B	F	19.93 ^{bc}	W	1-23	19.62 ^a
W	F	24-35	21.17 ^{cd}	U	M	19.40 ^c	U	24-35	19.44 ^b
U	M	24-35	19.78 ^{cd}	W	F	18.63 ^{cd}	B	24-35	17.46 ^{bc}
W	M	1-23	19.18 ^{cd}	U	F	16.46 ^b	U	1-23	16.42 ^c
U	F	24-35	19.10 ^d						
U	M	1-23	19.02 ^d						
W	F	1-23	18.07 ^d						
B	M	1-23	17.83 ^d						
B	F	1-23	17.08 ^{de}						
U	F	1-23	13.83 ^e						
S.E.M			±0.05						

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

As shown in Table 3.13, there was no significant interaction in the Head Lengths of WAD male and Balami male but both differed ($p<0.005$) significantly from Uda male, WAD female and Uda female. There were similarities in the HLs between Balami male and Balami female; Balami female, Uda male and WAD female; WAD female and Uda female. There was no significance difference in the HLs of 23- month Balami and 35-month WAD however, both differed significantly from 23-month WAD, 35-month Uda, 35-month Balami and 23-month Uda. There were similarities in the HLs of 23-month WAD and 35-month Uda; 35-month Balami and 23-month Uda. Both 23-month Balami male and 35-month WAD male had similar HLs and were significantly different from the rest categories of sheep with respect to age and sex. There were no significant differences in the HLs of 23-month WAD male, 35-month Uda male, 35-month WAD female, 35-month Uda female, 23-month Uda male, 23-month WAD female, 35-month Balami female and 35-month Balami female. There was no significant difference between 35-month Balami female and 23-month Uda female.

Table 3.14 shows no significant interactions in the HWs of Balami male, Balami female, WAD male and Uda male. However, these sexes of breeds of sheep differed significantly from Uda female and WAD female. Also, there were similarities in the HLs of 35-month Balami, 35-month Uda and 23-month Balami but they all differed significantly from 35-month WAD and 23-month Uda. 35-month Balami differed ($p<0.005$) significantly from 23-month WAD, 35-month WAD and 23-month Uda. There were no significant differences in the HWs of 23-month and 35-month WAD; 35-month WAD and 23-month Uda. There were similarities in the HWs of 35-month Balami male, 35-month Uda male, 23-month WAD male, 23-month Balami female, 23-month Balami male and 35-month Balami female.

Table 3.14: Effects of interaction among Breed, Sex and Age on Head Width (HW)

Breed	Sex	Age	Means	Breed	Age	Means	Breed	Sex	Means
B	M	24-35	20.90 ^a	B	24-35	18.92 ^a	B	M	18.97 ^a
U	M	24-35	20.71 ^a	U	24-35	17.81 ^{ab}	B	F	17.59 ^a
W	M	1-23	19.77 ^{ab}	B	1-23	17.65 ^{ab}	W	M	17.41 ^a
B	F	1-23	18.25 ^{ab}	W	1-23	15.49 ^{bc}	U	M	17.16 ^a
B	M	1-23	17.05 ^{ab}	W	24-35	12.80 ^{dc}	U	F	13.12 ^b
B	F	24-35	16.94 ^{abc}	U	1-23	12.48 ^b	W	F	10.87 ^b
W	M	24-35	15.06 ^{bcd}						
U	F	24-35	14.90 ^{bcd}						
U	M	1-23	13.61 ^{cd}						
U	F	1-23	16.34 ^{cd}						
W	F	1-23	11.21 ^d						
W	F	24-35	10.53 ^d						
S.E.M			±0.06						

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Except for 35-month Balami male and Uda male, the HLs of breed-sex-age categories of the aforementioned were not significantly different from 23-month WAD male, Balami female, Balami male, 35-month Balami female, 35-month WAD male and 35-month Uda female. But all were significantly ($p < 0.005$) different from 23-month Uda male, Uda female, WAD female and 35-month WAD female. There were similarities in HLs of 35-month Balami female, WAD male, Uda female, 23-month Uda male and Uda female. There were no significant differences in the HLs of 35-month WAD male, Uda female, 23-month Uda male and Uda female, WAD female and 35-month WAD female.

Table 3.15 shows there was no significant interaction in the Horn Lengths of WAD male and Uda male but both differed ($p < 0.005$) significantly from Balami male. There were no significant differences in the HnLs of Balami, Uda and WAD females. The HnL of 35-month Uda male was similar to that of 35-month WAD male. There was no significant difference in the HnL of 35-month WAD and 23-month WAD male but both differed significantly ($p < 0.005$) from 23-month Uda, 35-month Balami and 23-month Balami. There were significant ($p < 0.005$) differences between 35-month male and 23-month male. However, the 35-month and 23-month females showed no disparity in their HnLs. There was no significant difference in the HnLs of 35-month Uda male and 35-month WAD male. There was significant ($p < 0.005$) difference in the HnL of 23-month WAD male and 23-month Uda male with the former having the longer horn. There was significant difference in the HnLs of 35-month and 23-month Balami males. There were no significant differences in all the 35-month and 23-month females of all the breeds.

Table 3.15: Effects of interaction among Breed, Sex and Age on Horn Length (HnL)

Breed	Sex	Age	HnL	Breed	Age	HnL	Sex	Age	HnL	Breed	Sex	HnL
U	M	24-35	25.03 ^a	U	24-35	12.51 ^a	M	24-35	21.07 ^a	W	M	22.13 ^a
W	M	24-35	23.52 ^{ab}	W	24-35	11.76 ^{ab}	M	1-23	15.10 ^b	U	M	21.35 ^a
W	M	1-23	20.75 ^b	W	1-23	10.37 ^b	F	24-35	0.21 ^c	B	M	10.78 ^b
U	M	1-23	17.68 ^c	U	1-23	8.84 ^c	F	1-23	0.06 ^c	B	F	0.00 ^c
B	M	24-35	14.68 ^d	B	24-35	7.65 ^c				W	F	0.00 ^c
B	M	1-23	6.88 ^e	B	1-23	3.53 ^c				U	F	0.00 ^c
B	F	24-35	0.00 ^f									
B	F	1-23	0.00 ^f									
W	F	24-35	1.00 ^f									
W	F	1-23	1.00 ^f									
U	F	24-35	1.00 ^f									
U	F	1-23	1.00 ^f									
S.E.M			±0.05									

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$) different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.16: Effects of interaction among Breed, Sex and Age on Horn Base Circumference (HnBC)

Breed	Sex	HnBC	Breed	Age	HnBC	Sex	Age	HnBC	Breed	Sex	Age	HnBC
WAD	M	18.75 ^a	U	24-35	10.12 ^a	M	24-35	17.49 ^a	U	M	24-35	20.24 ^a
U	M	17.48 ^a	W	24-35	9.56 ^a	M	24-35	13.57 ^b	W	M	24-35	19.12 ^a
B	M	10.36 ^b	W	1-23	9.27 ^a	F	24-35	0.00 ^c	W	M	1-23	18.38 ^a
B	F	0.00 ^c	U	1-23	7.37 ^b	F	1-23	0.00 ^c	U	M	1-23	14.73 ^b
W	F	0.00 ^c	B	24-35	6.93 ^b				B	M	24-35	13.10 ^b
U	F	0.00 ^c	B	1-23	3.92 ^c				B	M	1-23	7.61 ^c
									B	F	24-35	0.00 ^d
									B	F	1-23	0.00 ^d
									W	F	21-3	0.00 ^d
									U	F	24-35	0.00 ^d
									W	F	24-35	0.00 ^d
									U	F	24-35	0.00 ^d
S.E.M					±0.02							

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

From Table 3.16, WAD and Uda males had significantly ($p<0.005$) the widest HnBC, followed by Balami male with values range of 18.75, 17.48 and 10.36cm respectively. The HnBC of the 35-month Uda, 35-month WAD and 23-month WAD sheep showed no significant differences. However, they were significantly different from 23-month Uda, 23-month and 35-month Balami sheep. There was no significant difference in the HnBC of 23-month Uda and 35-month Balami but both differed significantly from 23-month Balami. There was significant ($p<0.005$) difference in the HnBC of males of the 35-month sheep and 23-month. There were no significant differences in the 35-month Uda, WAD and 23-month WAD male sheep. There was similarity in the HnBC of 23-month Uda and 35-month Balami males but both differed ($p<0.005$) significantly from 23-month Balami male. There were no significant differences in the HnBC of all the female breed of sheep.

Table 3.17 shows no significant interaction between breed and sex for tails of 35-month Balami and 35-month Uda sheep but both showed significant ($p<0.005$) difference from the rest of breed-age categories. There was significant ($p<0.005$) difference between the tail of 23-month Balami and 23-month Uda . The 35-month WAD sheep had significantly ($p<0.005$) longer tail compared to the 23-month WAD sheep.

Table 18 shows no significant interaction between breed and age on the WH of 35-month Uda and Balami but both differed ($p<0.005$) significantly from the rest categories of sheep. There were similarities in the WHs of 23-month Balami and 35-month WAD; 23-month Uda and WAD.

From Table 3.19, there was significant interaction between sex and age on the length of (ScL). The 35-month sheep had significantly ($p<0.005$) longer scrotum than the 23-males

The 35-month males' testicles were significantly higher than the 23-month males.

Table 3.17: Effects of interaction among Breed, Sex and Age on Tail Length (TL)

Breed	Sex	TL	Breed	Age	TL	Sex	Age	TL	Breed	Sex	Age	TL (cm)
B	M	42.20 ^a	B	24-35	46.98 ^a	M	24-35	38.44 ^a	B	M	24-35	48.13 ^a
B	F	40.77 ^a	U	24-35	43.15 ^a	F	24-35	35.64 ^a	B	F	24-35	45.83 ^{ab}
U	M	36.11 ^b	B	1-23	35.99 ^b	M	1-23	27.08 ^b	U	M	24-35	45.67 ^{ab}
U	F	33.02 ^b	U	1-23	25.98 ^c	F	1-23	25.17 ^b	U	F	24-35	40.62 ^{bc}
W	M	19.97 ^c	W	24-35	20.99 ^d				B	M	1-23	36.27 ^c
W	F	18.33 ^c	W	1-23	17.30 ^e				B	F	1-23	35.72 ^c
									U	M	1-23	26.55 ^d
									U	F	1-23	25.42 ^{de}
									W	M	24-35	21.52 ^{def}
									W	F	24-35	20.47 ^{ef}
									W	M	1-23	18.42 ^f
									W	F	1-23	16.19 ^f
S.E.M												± 0.07

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.18: Effects of interaction between Breed and Sex on Wither Height (WH)

Breed	Age	Means
U	35	81.21 ^a
B	35	80.86 ^a
B	23	69.83 ^b
W	35	63.27 ^{bc}
U	23	56.38 ^{cd}
W	23	53.91 ^d
S.E.M		±0.47

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$) different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.19: Effects of interaction between Breed and Sex on Scrotal Length (ScL)

Sex	Age	ScL (cm)
M	24-35	18.33 ^a
M	1-23	12.71 ^b
F	24-35	0.00 ^c
F	1-23	0.00 ^c
S.E.M		±0.03

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.20: Effects of interaction between Breed and Sex on Scrotal Width (ScW)

Breed	Sex	Means	Breed	Age	ScW	Breed	Sex	Age	ScW	Sex	Age	ScW
B	M	10.81 ^a	B	24-35	7.42 ^a	B	M	24-35	14.63 ^a	M	24-35	12.94 ^a
U	M	10.53 ^a	U	24-35	7.21 ^a	U	M	24-35	14.41 ^a	M	1-23	6.92 ^b
W	M	8.47 ^b	W	24-35	4.89 ^b	W	M	24-35	9.79 ^a			
			W	1-23	3.57 ^c	W	M	1-23	7.14 ^c			
			B	1-23	3.56 ^c	B	M	1-23	6.98 ^c			
			U	1-23	3.32 ^c	U	M	1-23	6.65 ^c			
			S.E.M						±0.02			

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; WAD = West African Dwarf. M = Male; F = Female.

Table 3.20 shows no significant interaction between breed and sex on the ScWs of Balami, Uda males but both differed ($p < 0.005$) significantly from WAD. There was no significant difference in the ScWs of 35-month Balami and Uda but both were significantly wider than that of 35-month WAD. There were no significant differences in the ScWs of all the 23-month Balami, WAD and Uda. The 35-month male had significantly wider ScW than the 23-month male. There was similarity in the ScWs of 35-month Balami and Uda but both differed significantly from 35-month WAD.

3.8 DISCUSSION

The Ear Lengths mean values of Balami, Uda and WAD from this current study were slightly lower with about 2cm, compared to the values recorded by Yunusa *et al.* (2013a). This may be due to sampling effect as the animals used in this study were a mixture of lambs, mature rams and ewes. The positive influence of age on the increased EL is expected as such traits increase in tandem with age of animals. The older Balami and Uda sheep had the longest ears followed by the younger sheep of same breeds. WAD sheep had the shortest ears and the trends were in harmony with earlier reports that Balami and Uda sheep have large, long and pendulous ears (Roger, 1999).

The mean value lengths of Fore Leg of Balami, Uda and WAD from this study were lower compared to the values reported by Yunusa *et al.* (2013a) and Adejoro and Salako (2012). The reason for this may be the same for EL. The similarity between Balami and Uda with both having the longest Fore Leg were also observed in the present study and this is expected as both breeds are the largest, and tallest breeds of sheep in Nigeria, (Yunusa *et al.*, 2013a). The possession of longer Forelegs by some female breeds could be attributed to breed effect among the sheep sampled. The male Balami with longer front legs than the female could be attributed to the lack of oestrogen, which has a limiting effect on growth at the earlier ages. The older males of all the breeds had significantly higher longer forelegs compared to the females and this could be due to the continuous secretion of androgen hormone which triggers fast development (Ebangi *et al.*, 1996).

The Body Lengths (BLs) for Balami, Uda and WAD in this study were higher than the values reported for the same breeds by Yunusa *et al.* (2013a); Adejoro and Salako (2012); Abdulmajeed and Isa (2011); Sowande and Sobola (2008); Oyeyemi and Ogunola (2011) who reported 34.6 cm for 8-week old WAD lamb. Osaiyiwu *et al.* (2010) reported a higher value of 96.06 cm for Balami. The order of decreasing lengths is in tandem with some of the

previous works of the authors. The increased values from this study may be due to the use of sheep that were more than one year but less than two years for the survey. The superiority in (BLs) of Balami and Uda over WAD corroborates the reports of Yunusa *et al.* (2013a), Abdulmajeed and Isa (2011); Roger Blench (1999) on the sizes of Balami and Uda amongst the Nigerian indigenous sheep.

The values of Shoulder Width (SW) from this work for Balami and Uda were higher than the ones reported by Yunusa *et al.* (2013b) but in agreement for WAD female. Also, the present values were higher than the values reported by Adejoro and Salako (2012) for SW each for Balami male and female of one year old; Abdulmajeed and Isa (2011) for Balami and Uda. The differences in values might be linked to sampling of older animals, though less than two years. Osaiyuwu *et al.* (2010) recorded 27.85 cm for mature Balami. The higher value for SW of male compared to their respective female was in contrast with the findings of Adejoro and Salako (2012) who reported higher value for Balami female. The difference in values may be due to measurement of older males of each breed. Also, older Balami and Uda had the widest shoulders which agree with the reports of Osinowo *et al.* (1989) and Otoikhian (2008) that the two breeds are bigger than the WAD breed.

The values of Shoulder Width (SW) for Balami and Uda in this study are higher though in tandem compared with the reports of Yunusa *et al.* (2013b) where WAD had the least SW. Abdulmajeed and Isa (2011) reported lower values for 22-month old Balami and Uda while Osaiyuwu *et al.* (2010) recorded 41.26 cm for mature Balami. The disparity in values may be traced to the health status of the animals, access to adequate feeds, season, during measurement. The values presented in this study for NC are also in disagreement with the ones of Adejoro and Salako (2012) and the reason may be same as stated earlier for SW. Peter *et al.* (2012) reported higher mean values for male and female for the Djallonke and Sahel sheep in Ghana however, the values for older and younger sheep from this study are

similar with those of same authors. The bigger NCs found in the older animals in all the breeds from this present study might be due to the effect of advanced growth and maturity over the younger ones.

The values for Heart Girth (HG) in this study were lower than the values reported by Yunusa *et al.* (2013a) but higher than the report of Oyeyemi and Ogunsola (2011) who reported 38.8 and 44.2 cm for WAD and WAD cross respectively. The values from this study are in contrast with 67 and 75 cm reported by Adejoro and Salako (2012) for Balami male and female of less than two years in age. Osaiyuwu *et al.* (2010) reported a relatively high value of 95.68 cm for 18-24-month-old Balami. Sowande and Sobola (2008) reported HG values of 63 and 59cm for WAD male and female respectively. The higher HG found in the older Balami and Uda males and females confirm the superiority of both breeds over other breeds of sheep in Nigeria.

The significant difference between Balami and Uda for HG of this work was in contrast with work of Yunusa *et al.* (2013a) who reported 73.58cm and 75.1cm for the same breed respectively. The RH values of this study for WAD were higher than the report of Oyeyemi and Ogunsola (2011) who reported 44.4cm for WAD sheep of 8 weeks old. The overall superiority of Balami over Uda and WAD from this study supports the report of Osaiyuwu *et al.* (2010) in their description of Balami sheep. The present result also corroborates the report of Yakubu *et al.* (2010) where the use of rump height was one of the most discriminant variables distinguishing Djallonke and Red Sokoto goats.

The females of Balami had wider Rump compared to their males and this corroborates the findings of Adejoro and Salako (2012) on Balami of one year old; although, the values of the current study were higher and this may be due to more sampling of one year plus animals during this survey. The RWs reported for Uda and Balami were similar to the values reported by Yunusa *et al.* (2013a) and Abdulmajeed and Isa (2011). Osaiyuwu *et al.* (2010) recorded a

higher value of 23.14 cm for less than 2 years old Balami. The value from this study for female Uda was the same with the value reported by Yunusa *et al.* (2013a) but lower for WAD. The difference may be due to age differences of breeds of the animals. The similarities in the RWs of all the older (35-months) males and females hence, differing from the rest categories showed more mature WAD sheep were sampled compared to Balami and Uda and their general relative growth afford them the superior RWs over the younger (23-months) sheep.

Rump Lengths (RL) values of this present study were higher in males across the breeds compared to the females. Except for the Uda, the female rumps of the other two breeds were longer to the respective males and this is in harmony with the works of Adejoro and Salako (2012). Osaiywu *et al.* (2010) reported a higher value of 28.13 cm for 18-24 months old Balami. The order of decreasing RL from this study from Balami to Uda and to WAD is in tandem with the reports of Yunusa *et al.* (2013a) who reported higher values for RL. The bigger values for the females may be attributed to their rapid growth over the males when less than one year.

The value of Head Lengths (HL) from this study was low compared to the findings of Yunusa *et al.* (2013a). Sowande and Sobola (2008) reported HL values of 19.51 and 18.24 cm for WAD male and female. The HL values presented in this study are lower than the 29.7 and 26.9 cm reported by Abdulmajeed and Isa (2011) for Face Length of Balami and Uda respectively. The higher values for males compared to their respective females of each breed agrees with the findings of the aforementioned authors. The male of each breed had longer head and this is normal as the male growth rate surpass that of the female during yearling and after (Adejoro and Salako, 2012).

The values for Head width were lower compared to the measurements done by Yunusa *et al.* (2013a). HW values from this study for Balami and Uda agree with the findings of

Abdulmajeed and Isa (2011) who reported 16.7 and 13.6 cm for the two breeds of about 22 months old respectively. The values recorded for WAD are lower than the values: 12.19 and 12.16 cm by Sowande and Sobola (2008) for male and female respectively. The significant differences between Balami, Uda and WAD may be due to their order of sizes among the Nigerian breeds of sheep (Roger Blench, 1999); Yunusa *et al.* (2013b).

The values of Horn Length (HnL) from this study are low, except for WAD, compared to the findings of Yunusa *et al.* (2013a) who reported 25.67, 25.02 and 16.67 cm for Balami, Uda and WAD respectively. Olukole (2010) also reported higher values of 27.8 and 29.6 cm for Right and Left horn of 3.5 years Uda ram. Mature Uda and WAD rams had long horns, the former possessed longer and fatter horns while most mature Balami rams could be polled or having very short horns.

The Horn Base Circumference (HnBC) for Uda from this study is close to the 17.4 cm recorded by Olukole (2010). The older Uda had the widest horn base followed by the WAD males. This is expected as these two breeds, especially the Uda sheep, are preferentially selected for their long and fat horns.

Balami had the longest tails followed by the Uda and WAD sheep. The order of decrement is not in agreement with the records of Yunusa *et al.* (2013a). The length of tail from this study is also short compared to that recorded for an adult Balami by Osaiwuyu *et al.* (2010). The older Balami had longer tail than the value gotten by Yunusa *et al.* (2013a) while the tail length of Uda from this study was similar to the same authors' findings. One of the distinguishing features of Balami is the possession of long and thin tail. This is in agreement with the work of Yunusa *et al.* (2013a) that TL can be used to differentiate the Southern sheep from the Northern ones.

The Wither Heights for the breeds in this study were in slight variance with the values recorded by Yunusa *et al.* (2013a). The lengths of the long legged breeds (Uda and Balami)

from this study were higher than the values recorded by Salako and Adejoro (2012) for 3 years Uda male and female. The WH for less than 2 years Balami in this study was low compared to the value recorded by Oaiyuwu *et al.* (2010). Also, the 23-month Balami with greater height than older WAD and younger Uda confirmed the superiority in size of Balami over other breeds of sheep in Nigeria (Roger Blench, 1999).

Balami sheep had the longest scrota followed by Uda and WAD. The scrota were longer in the older animals compared to the young ones. The reason for this may be the increasing physiological demands of the older male animals. The secretion of testosterone in the testes for other sexual activities brings about, along increment in age, wider and longer scrota. The scrotal widths of Balami had the highest values followed by the two other breeds. Also, scrotal sizes were larger in the older sheep and the reason is similar for the TeL. The overall superiority of the 35-month sheep over the 23-month sheep may be as a result of the continual growing process of the latter as most of the former may have fully attain maturity.

CHAPTER FOUR

4.0 REPRODUCTIVE, GROWTH PERFORMANCE AND SURVIVABILITY OF UDA, BALAMI, WAD, CROSSBRED SHEEP IN SUB-HUMID REGION OF NIGERIA.

4.1 Introduction

The survival of lambs right from birth to weaning is an essential factor affecting the number of lambs weaned per breeding which is highly correlated with lamb weight weaned for a particular lambing (Fogarty, 1985). Diseases have been reported to be major cause of lamb mortality hence, low productivity in sheep enterprise (Yapi *et al.*, 1990). Morris *et al.*, (2009) stressed the importance of adequate knowledge and information on genetic parameters especially on lamb survival as this measure will greatly aid in generating genetic improvement choice.

One of the challenges facing livestock production is inclement of weather through enormous heat, floods and seasonal drought (Serjian *et. al.*, 2016). This leads to the death of animals thereby causing production loss (Gaughan and Cawsell-Smith, 2015). Change in weather is the short term of climatic condition which animals are exposed to when introduced to a new ecological zone for crossbreeding purpose. Because it is certain that the newly introduced animals are bound to experience the shock due to the new environment, it is imperative for the breeder and the entrepreneur to examine reproductive and growth performance of the animals alongside their offspring. This will therefore, assists in determining the progress of crossbreeding and its efficiency in the future, which was the main reason while the study was carried out. Improving sheep productivity through increasing the number of lambs weaned per ewe means increasing lamb growth rates, which has been a continuous target in Animal production (Thomson *et al.*, 2004). A number of countries have used prolific breeds of sheep to improve flock productivity (Aboul-Naga, 1996; Gootwine *et al.*, 1995; Lassoued and

Rekik, 2001). Fasae *et al.*, (2012) observed the importance of birth and weaning weights in determining the breeding potentialities of domestic animals at an early age which has long been recognized by livestock breeders. Birth and weaning weights of lambs are not only been influenced by genetic factors but also by physiological and environmental factors (Mandal *et al.*, 2006).

Indigenous livestock breed of Africa are well adapted to the local environment, although their productivity is generally low when compared to the other parts of the world. Efforts by breeders and farmers to improve the performance of the indigenous African breeds involve the introduction of exotic animals and cross breeding practices which is gradually leading to the erosion and complete masking of important survival traits which is disease resistance associated with indigenous livestock as well as the extinction of certain breeds (Gizaw *et al.*, 2011). Lamb survivability is one of the important factors affecting overall sheep flock productivity Morris (2000). Lamb mortality has been reported to be a major cause of lower productivity of sheep (Vatankhah and Taleb, 2009).

Reproductive performance is an essential trait in sheep production businesses, particularly for meat production (ILCA, 1982).

Crossbreeding is employed in taking advantage of the different and complementary strong points of two or more breeds and to utilize hybrid vigour (Thomas, 2001). Crossbreeding offers two distinct advantages over pure-breeding and these are heterosis and breed complementarity (Schwenian, 2011). Complementarity is achieved when the weakness of one breed is offset by the strength of the other breed(s) and vice versa (Schwenian, 2014). Breed complementarity means evaluating the strengths and weaknesses of potential breeds and selecting those that complement each other which eventually results in an animal possessing the best traits of both breeds (Alkire, 2012).

Heterosis is maximised when a crossbred ewe is mated to a crossbred ram (Schwenian, 2014). Fayeye (2014) observed that heterosis is greater in genetically distant or heterozygous parents than in closely related parents. Hybrid vigour and breed complementarity are essential tools to improving productivity of commercial sheep flocks and an organized cross breeding size (Thomas, 2006). In Nigeria, sheep is used mainly for meat production. Thus, rapid growth rate is of paramount importance for efficiency (Oyeyemi and Ogunsola, 2011).

According to Bellows and Ansotegui (2005), gestation length is the physiological period during which the fetus develops in the dam. It is the period that covers the terms from fertilization of egg by the spermatozoa to the delivery of the offspring. Gestation length is affected by several factors such as sire breed (Fogarty *et al.*, 2005), dam age, litter size and lamb weight at birth (Cardy and van Vleck, 1978 and Amoah *et al.*, 1996). Longer gestation lengths were recorded in 24-35 monthss by Vatankhah *et al.* (2000) and Koyuncu *et al.* (2001).

Ewes bearing single lambs also had longer gestation length when compared with those carrying multiples (Osinowo *et al.*, 1994; Vatankhah *et al.*, 2000; Koyuncu *et al.*, 2001; Dwyer, 2003; Fogarty *et al.*, 2005). Lamb weight was also reported to have influenced gestation length (Knight *et al.*, 1988; Osinowo *et al.*, 1994; Vatankhah *et al.*, 2000; Fogarty *et al.*, 2005) and may be longer when the dam is carrying a male lamb (Koyuncu *et al.*, 2001; Vatankhah *et al.*, 2000; Fogarty *et al.*, 2005).

Parity was implicated in lambs' birth weight as the birth weight increased with increase in parity. Weight at birth of lambs is a key to achieving optimal sheep production (Petrovic *et al.*, 2011) and also act as precursor to the later development of the sheep (Petrović, 2007). Gardner *et al.* (2007) observed that mastering the factors affecting differences in birth weight is essential and thus producing the synergy between birth weight to neonatal and adult

wellbeing. Dams' age, type of birth and sex of lamb are among factors that influence lambs' birth weight (Petrović *et al.*, 2009).

The main aim of taking linear measurement of live animals is to help describe the size and shape of such animals (Otuma, 2007). Also, measurement of morphometric traits have been used as tools for characterisation of breeds and for evaluation of breed performance which has been found helpful in analysing the effect of crossbreeding as a medium for selecting and replacement of animals (Adewumi *et al.*, 2006). Gizaw *et al.* (2007) reported that morphological description is an essential component of breed characteristics; they can be used to physically describe, identify and recognise a breed and also to classify livestock. Fasae *et al.* (2012) observed birth weight as an important parameter in meat producing animals as it has strong correlation with growth rate and adult size and also the viability of new born animals, while weaning weight has a high relative economic importance to the farmer.

4.1.1 Main Objective

The aim of this work was to examine the survival and performance of Uda, WAD and Balami sheep and the impacts of some fixed factors of reproduction on the variations in lambs' birth weight.

4.1.2 Specific objectives of this study are:

- to determine conception rate, number of lambs born and still birth per breed of ewes
- to determine the effect of Dam Age, Gestation Length, and Parity on lambs' birth weights of WAD, Balami and Uda sheep.
- to determine the effect of Lambing type on lambs' birth weights of Uda, WAD and Balami

- to estimate the effect of Sex on weight at birth of lamb belonging to Uda, WAD and Balami
- to estimate Sire and Dam breed effects on lambs' birth weights and morphometric traits in Balami, WAD, Uda and their crossbred
- to estimate heterosis in the crossbred lambs produced from Balami, Uda and WAD sheep.

4.2.0. Materials and Methods

4.2.1. Experimental site

This experiment was carried out at YOA Farms Limited, Afon, ASA Local Government Area, which is located on latitude 8°00'N and 9°10'N North of the Equator and longitude 2°45'W and 4°15'W East of Kwara state (Ministry of Lands and Survey, 2016). The annual rainfall in the study area ranges between 1,000mm to 1,500mm with average temperature of between 30°C to 35°C, (Kwara Agricultural Development Projects, 2006). The farm has paddocks of Guinea grass (*Panicum maximum*) and Elephant grass (*Pennisetum purpureum*).

4.2.2. Experimental Animals

A total of one hundred and nineteen sheep were procured and used for the study. Sheep were purchased from markets from two agro-ecological zones of Nigeria namely: Sudan Savannah (Sokoto and Kebbi states) and Guinea Savannah (Oyo and Kwara states). The animals comprised of three breeds (35, 30 and 45 for Balami, Uda and WAD sheep, respectively). The Balami and Uda sheep were purchased from *Ilela*, *Achida* and *Ambrossa* markets in Sokoto and Kebbi states. The WAD sheep were procured from *Akinyele*, *Ojoo*, *Igbeti* and *Ajase* markets in Oyo and Kwara states. Each of the three breeds included three rams. The rams procured were carefully selected based on the information from the livestock farmers or the sellers. After a thorough visual appraisals such as animal posture, drooling, body

conformation, eyes and nose condition; information on the libido of the rams were also supplied. The presence of two incisors was used to categorise the 1-year old sheep while four incisors marked that of the 2-year old sheep (FAO 1994). Dentition and keepers' information was a guide to avoiding old rams or ewes. All the female animals purchased nulliparous and belonged two age categories (less than 2 year and less than 3 years) and with the criterion that none had lambed before. On arrival, sheep were given water and glucose as antistress. Animals were identified with pen tags. Animals were treated against internal and external parasites.

4.2.2 Housing and Animal distribution

Each breeding group had a pen. Plates 4.1 and 4.2 show some of the the sheep in their pens.

4.2.3 Animals Feeds and Feeding

Formulated feed and water were served to ewes *ad libitum* in the morning and evening. They were also allowed to graze on cultivated paddock of Guinea and Elephant grass. Prior to mating, animals were dewormed and flushed. The ewes were fed with formulated ration based on their bodyweights (Table 4.1). Creep feeds were made available for the lambs when the mother could not produce adequate milk to suckle. Animal identification was done with ear tags. Lambs' nourishment was solely from dams' milk up to weaning period. When there was occurrence of dam's mortality, lambs were fostered to another dam of the same breed of the dead. This was done by robbing the mucous or faeces of the foster lamb to the nose of the new dam and vice versa and it began to suckle.

Table 4.1: Feed Composition

Feed Ingredients	Growers	Quantity	Maintenance	Quantity
	(Kg)		(Kg)	
Cassava peels	53.0		30.0	
Rice bran	33.0		16.0	
Corn bran	0.0		28.0	
Soybean meal	12.0		0.0	
PKC	0.0		25.0	
Urea	0.0		0.2	
Bone meal	0.0		0.3	
Salt	1		0.5	
Premix	1		0.0	
Total	100		100	

Source: (Aduku, 2004)

Calculated nutrients:

Growers: TDN = 97.32%, CP (%) = 11.65, Ca (%) = 0.26.

Maintenance: TDN= 77.45, CP (%) = 11.56, Ca (%) = 0.23

P (%) = 0.24

4.2.4 Breeding

Prior to breeding, ewes were weighed and flushed for three weeks. The ewes were synchronised using Prostaglandin ($\text{PGF}_2\alpha$). All the animals used were the ones with no trace of pregnancy. The ewes were introduced to the pen containing a ram for mating. WAD was the sire in the first pen and mated the WAD, Balami and Uda ewes. Balami was the sire in the second pen and was mated to Balami and WAD ewes while Uda male in the third pen was mated to Uda and WAD ewes (Table 4.2). The genotypes of the lambs in the first pen were WB, WU and WW. The genotypes in the second pen were BW and BB while UU and UW were the lambs in the third pen. All the ewes were allowed to remain with their lambs until weaning stage, after which another synchronising operation was set up. Thus, animals were bred at the same period of subsequent year. The WAD, Uda and Balami rams were marked with red, green and blue dyes, respectively. The dye stain on the female animal was used to identify the ram involved in the mating. The colours were then changed in each ram in the following week in order to ensure a particular ewe was mated more than once. The WAD rams were assisted in mating the taller Balami and Uda ewes through restriction of the ewes' movement and lifting of the rams or placing an object for mounting, to ease positioning at the pelvic region of the ewes.

Table 4.2: Breeding charts for mating the experimental animal

S/N	♂ x ♀	Genotype offspring	Number of offspring per parity		
			1st	2nd	3 rd
1	B x W	BW	14	9	5
2	U x W	UW	12	7	5
3	W x B	WB	12	7	6
4	W x U	WU	9	6	4
5	B x B	BB	10	9	6
6	U x U	UU	9	3	4
7	W x W	WW	10	7	5

B = Balami; U = Uda; W = West African Dwarf.

4.2.5 Lambing.

One hundred and fifty-nine lambs comprising of purebred WAD, Balami, Uda and their crossbred were the total of animals had at the end of three consecutive breeding years. Animals' identification was done with ear tags. The pattern of straight and reciprocal crossing, genotypes of offspring and number of lambs produced per parity is shown in Table 4.2.

4.3. Data Collection

Lambs were weighed at birth by placing them on the weighing scale. Gestation period was estimated from the onset of average number of mating to lambing day. Gestation lengths were grouped into two categories (149 – 153 and 154 – 158 days).

The weights of lambs were determined at birth, 4th, 8th, weaning and yearling by placing them on the weighing scale. Morphometric traits were measured at birth and at yearling. The traits measured are: EL, FLL, RLL, BL, SW, NC, HG, RH, HL, HW, HnL, RW, RL, TL, and WH. The method employed in the measurements was the same as described in the preliminary study. Pearson Correlation coefficient was used to determine correlations between weight at birth and all the measured traits when lambs were born and when weaned. Thus, 14 morphometric traits were measured on 158 lambs at birth and 69 lambs at weaning. The anatomical reference points (Hamito, 2009; FAO, 2012; Salako and Ngere, 2012) were as follows:

- i. WH: The distance covered from the flat ground on which animals stood, to the withers of the animal.
- ii. RH: This is the distance covered from the flat ground to the rump.
- iii. BL: This measured the length from the base of the tail to the base of the head.
- iv. HG: The circumference around the chest just behind the front legs and withers.
- v. NC: This is the circumference around the neck close to the withers.

- vi. SW: The distance from the backbone at the shoulders to the brisket between the front legs
- vii. RW: It is the distance between the outer edges of the major hip bones on the right and left sides.
- viii. HL: The distance measure from the cranial bone to the mouth
- ix. HW: The distance measured between the two temporal bones of the head
- x. EL: The length of the ear from the point of attachment to the cranial bone to the tip
- xi. TL: The length of tail from the caudal bone to the tip.
- xii. FLL: The length measured from the patella bone to the hoof
- xiii. RLL: The length measured from the curved joint of the back leg to the hoof

RL: the length of bone from the rump area to the caudal

4.4. Statistical Analysis

The General Linear Model (PROC GLM) procedure of Statistical Analysis Software System (SAS 9.4 2013) was used to generate the effect of Dam age, Gestation Length, Parity, Lambing Type, Sire breed and Dam breed on the average birth weight of lambs. Mean separation was done using Duncan's Multiple Range Test (Steel and Torrie, 1980) of the same statistical package at probability level of 5%. The linear model used was:

$$Y_{ijk} = \mu + J_i + R_w + S_j + A_k + T_p + Q_h + Z_d + (JR)_{iw} + (JS)_{ij} + (JA)_{ik} + (JT)_{ip} + (JQ)_{ih} + (JZ)_{id} + \dots + (JRSATQZ)_{i w j k p h d} + e_{i w j k p h d}$$

Where,

Y_{ijk} = average birth weight of lamb

μ = overall mean

J_i = fixed effect of the i th breed of the sire (i = Balami, Uda and WAD)

R_w = Fixed effect of the wth breed of the dam (w = Balami, Uda and WAD)

S_j = fixed effect of jth sex of lamb (j = male, female)

A_k = fixed effect of kth age of dam (k = 1 year or 2 year)

T_p = fixed effect of pth gestation length of dam (p = 149 – 153, 154 – 158)

Q_h = fixed effect of hth parity (p = 1st, 2nd, 3rd)

Z_d = fixed effect of lambing type (d = single, twin)

$(JR)_{iw}$ = interaction effect of ith breed and wth breed

$(JS)_{ij}$ = interaction effect of ith breed and jth sex

$(JA)_{ik}$ = interaction effect of ith breed and kth age

$(JT)_{ip}$ = interaction effect of ith breed and pth length

$(JQ)_{ih}$ = interaction effect of ith breed and hth parity

$(JZ)_{id}$ = interaction effect of ith breed and dth type

$(JRSATQZ)_{i w j k p h d}$ = interaction effect of all the fixed factors.

$e_{i w j k p h d}$ = random error associated with each record (normally,

Independently and identically distributed with zero mean and constant variance)

The General Linear Model (PROC GLM) procedure of Statistical Analysis Software System (SAS 9.4 2013) was used to generate the average birth and live weights at 4th, 8th, weaning and Yearling. Means separation was done using Duncan's Multiple Range Test (Steel and Torrie, 1980) of the same statistical package at probability level of 5%. The same method was used to estimate the effect of genotype on the morphometric traits at birth. The correlation procedure (PROC CORR) of Pearson's correlation coefficient of the same statistical package was used to investigate the correlations between birth weight and morphometric traits at birth and at weaning. The general heterosis was calculated by

subtracting the average weights of the purebred from the average weight of the crossbred while the specific heterosis was generated by subtracting the average weight of the purebred from the birth weight of the crossbred for straight and reciprocal cross. The percentage heterosis was generated by the proportion of the heterosis value to the average weight of the purebred multiplied by 100%. The formulae used for heterosis was due to the fact that the birth weights of the parents were unknown as the sheep were procured from the market. The formulae used can be represented as:

$$(A+B) / 2 - (C+D) / 2 = Y$$

$(A+B) / 2$ is the average weight of the crossbred

$(C+D) / 2$ is the average weight of the purebred

Y is the average general heterosis

Specific Heterosis E was calculated as:

$$A - (C+D) / 2 = E$$

General % Heterosis was derived by:

$$Y / C+D/2 * 100$$

Specific % Heterosis was derived by:

$$E / C+D/2 * 100.$$

The model used was:

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

Where: Y_{ij} = body weight measurement

μ = overall mean

a_i = effect of the i^{th} genotype.

e_{ij} = residual effect.

The values used for calculating heterosis were analysed using General Linear Model (GLM) procedure of the Statistical analysis system of SAS 9.4 (2013) for birth and live weights of the sheep.

The percentage number of lambs' born, weaned, yearling, conception and surviving dams was determined with the formulae:

% Number of lambs born = (number born/ Conception numbers) * 100

% Number of conception = (Number of conceptions / number of bred dams) * 100

% Number of lambs surviving to weaning for a breeding year = (Number of lambs during weaning/ number of lambs born) * 100

% Number of lambs surviving to yearling for a breeding year = (Number of lambs during yearling/ number of lambs born) * 100

% Number of dams survival per breeding year = (Number of survived dams at the end of breeding year/ number of bred dams at the beginning of breeding year) * 100.

The calculations and descriptive analysis using a 2 – D Clustered Column charts of Excel Microsoft Office, (2007).

4.5 Results

Table 4.3: The number of ewes bred, number of conception, number of lambs borne and number of still birth per parity.

Dam					
breed	Parity	No Bred	Conception	No lambed	Still birth
Balami	1st Parity	35	26	22	4
Balami	2nd Parity	23	13	12	1
Balami	3rd Parity	15	10	10	0
Uda	1st Parity	30	20	18	2
Uda	2nd Parity	19	11	9	2
Uda	3rd Parity	12	9	8	1
WAD	1st Parity	45	37	36	1
WAD	2nd Parity	30	23	23	0
WAD	3rd Parity	21	15	15	0

Table 4.3 shows the number of ewes bred, number of conception, number of lambs borne and number of still birth per parity. Balami had more of breeding ewes than Uda for all the parities while WAD had the most ewes. WAD ewes had superior conceptions and lambing number followed by Balami and Uda. Balami and Uda ewes had the equal and more numbers of still births compared to the WAD ewes.

Figure 4.1 shows that for all the parities, the WAD sheep had the highest percentage of conception. Balami had higher and lower number of conception at 1st and 3rd Parity respectively than Uda.

Figure 4.2 shows purebred Balami, Uda and WAD lambs had almost equal number of lambing and weaned lambs at Parity 1 except purebred Uda with higher percentage of weaned lambs. Purebred Uda had the highest percentage number of weaned lambs followed by purebred WAD and purebred Balami. At Parity 3, the bar shortened down from purebred WAD to purebred Balami for weaned lambs. The purebred Balami and Uda had no Yearling lamb at Parity 1; 2 and 3 respectively, while most number of Yearling lambs was found in purebred for all the breeding years except in Parity 2 when Uda had 66.67% and 57.14% for WAD. During the 3rd Parity, Balami cross (BW) had similar percentage of weaned lamb with purebred WAD and the next to them was the WAD cross (WU) and (WB). Except Parity 1, WB and WU had almost 65% to 70% weaned lambs and were better than the BW.

Table 4.4 shows the WAD sheep had the highest number of surviving ewes for all the breeding years followed by Balami and Uda ewes.

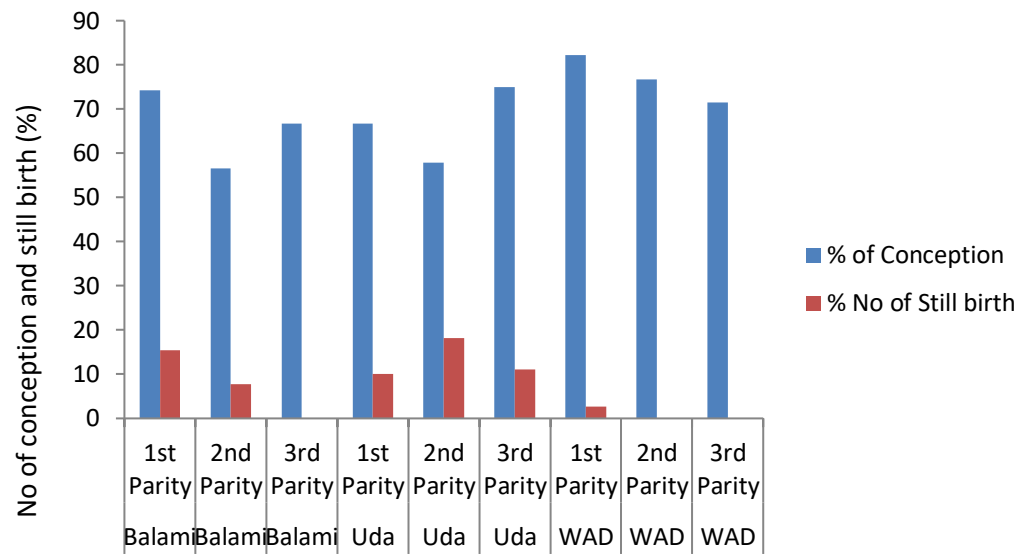


Figure 4.1: Conception and Still birth estimates of Balami, Uda and WAD sheep

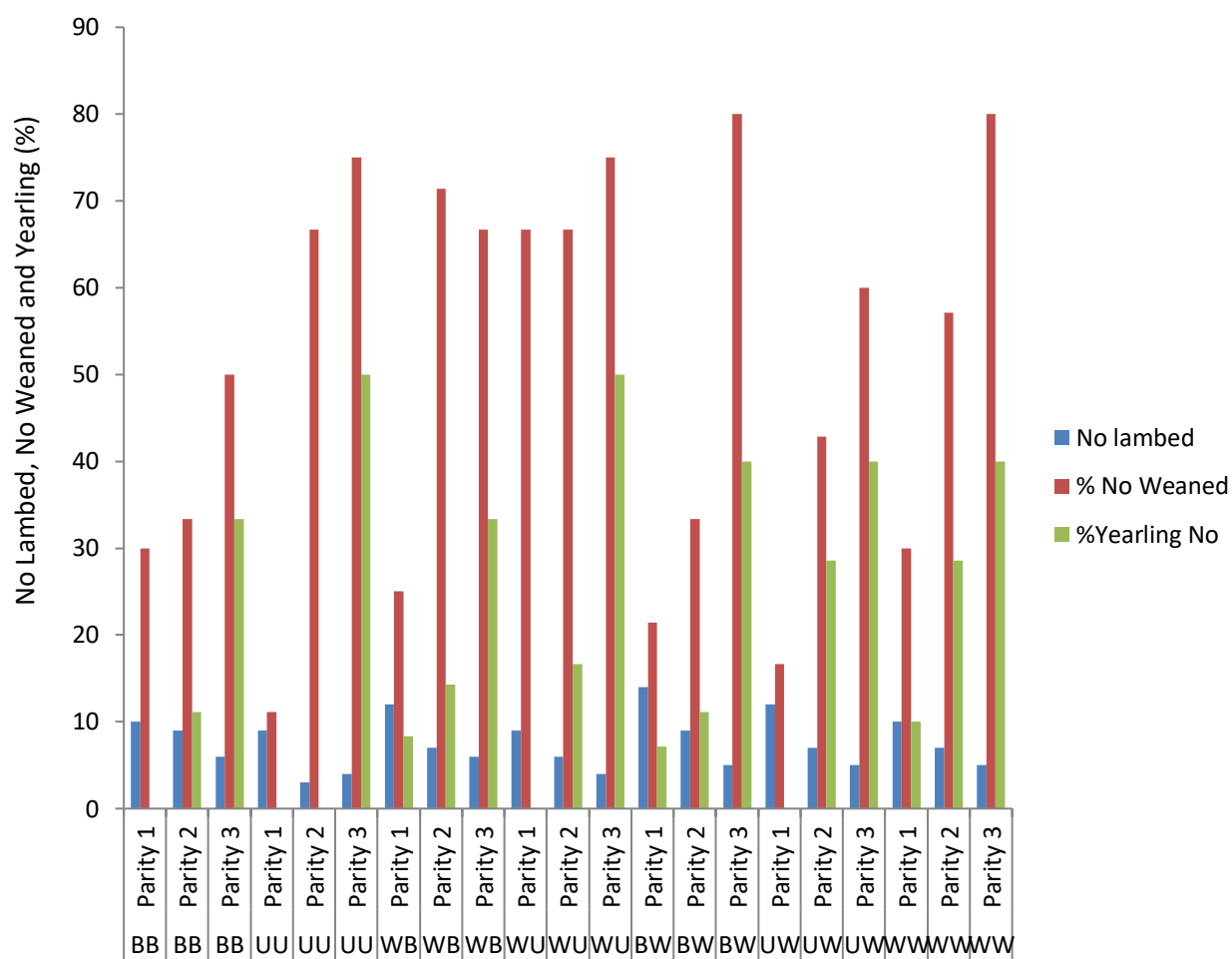


Figure 4.2: Percentage of lambs weaned and at yearling.

Table 4.4: Number of bred ewes and the Number of surviving ewes per Parity

Dam breed	Parity	No of dam bred	Surviving dams No
Balami	1st Parity	35	23
Balami	2nd Parity	23	15
Balami	3rd Parity	15	9
Uda	1st Parity	30	19
Uda	2nd Parity	19	12
Uda	3rd Parity	12	6
WAD	1st Parity	45	30
WAD	2nd Parity	30	21
WAD	3rd Parity	21	9

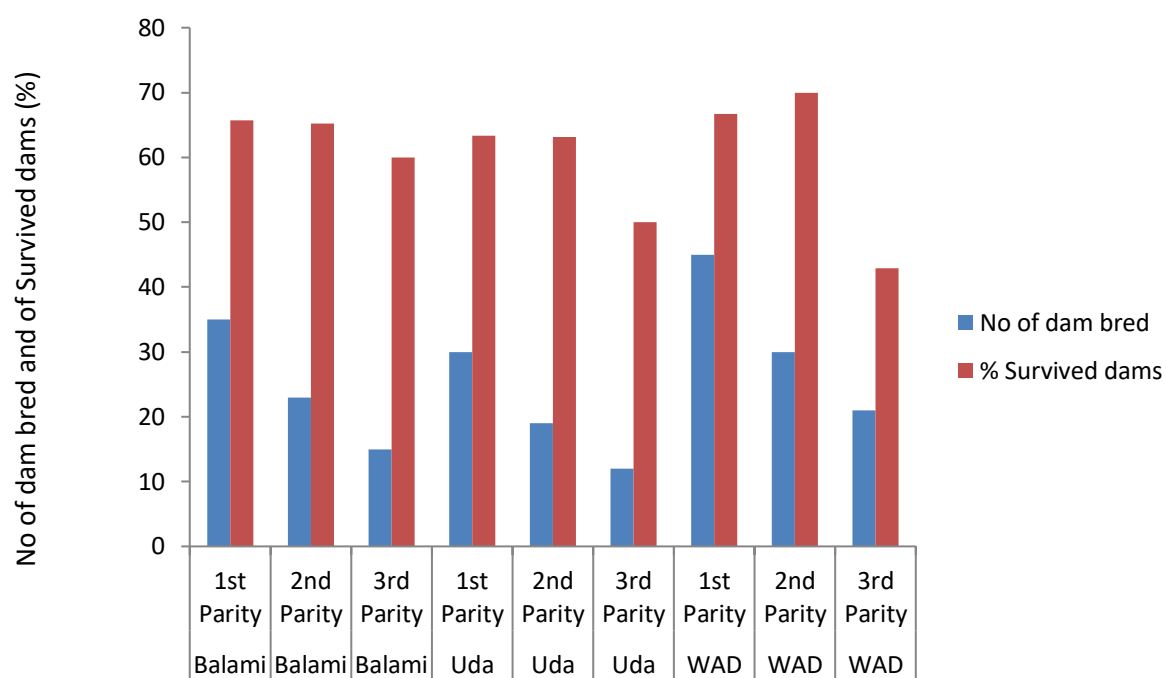


Figure 4.3: Percentage of surviving dams per parity.

From Figure 4.3, WAD sheep had the most number of breeding ewes for each parity followed by Balami and Uda. Balami and Uda ewes had almost equal number of surviving ewes at the end of Parity 1 and Parity 2 (65.71 and 65.21%) and were bit lower than that of the WAD (66.66% and 70%). At the Parity 3, Balami ewes survived the most followed by Uda ewes.

From Table 4.5, Purebred Balami had the highest birth weight. The weights at birth of purebred Uda, WAD crosses (WB and WU) were similar. There were no significant differences in the birth weights of WB, WU and BW except in UW. The pure WAD birth weight was significantly ($p<0.005$) the lowest compared to the rest of the genotypes. The weights at 4th week of purebred Balami and Uda were significantly different. WAD crosses except WU had similar weights but were significantly ($p<0.005$) different from purebred WAD. Purebred Balami at 8th week, showed superiority in weight and was significantly different from the rest of the genotypes. At weaning, BW and UW had similar weights with purebred Uda and all were significantly ($p<0.005$) from purebred Balami. At yearling, crossbred WAD showed superiority alongside purebred Balami over the rest of breeds of sheep. Plates 3 to 9 showed the sizes of the purebred and the crossbred lambs at birth and at 4 weeks old. The crossbred lambs had almost the same size compared to the purebred lambs while the former were as big as the purebred WAD at 4weeks old.

Plate 4.3 – 4.9 shows the purebred and crossbred lambs at day old. From the plates, purebred Balami lambs appeared to be the biggest followed by the crossbred lambs. The WAD lambs were the smallest of them all.

Table 4.5: Birth and live weights at 4th week, 8th week, weaning and yearling of pure and crossbred WAD, Balami and Uda sheep.

Genot ype	Birth	Weight (Kg)								No
		No	4 th	No	8 th	No	Weaning	No	Yearling	
BB	3.83 ^a ±0.17	25	7.18 ^a ±0.31	19	10.57 ^a ±0.29	14	13.27 ^a ±0.25	9	31.33 ^a ±1.20	3
UU	2.96 ^b ±0.05	16	6.43 ^b ±0.37	12	8.98 ^b ±0.40	10	10.63 ^b ±0.50	6	23.50 ^c ±0.50	2
WB	3.20 ^b ±0.13	24	5.51 ^c ±0.20	20	8.47 ^b ±0.48	12	9.07 ^c ±0.50	12	25.75 ^{bc} ±1.65	4
WU	2.91 ^b ±0.11	19	4.61 ^d ±0.22	18	5.60 ^c ±0.16	10	8.43 ^c ±0.45	13	22.67 ^c ±1.45	3
BW	2.97 ^b ±0.16	28	5.35 ^c ±0.17	22	8.52 ^b ±0.48	15	10.99 ^b ±0.23	10	28.53 ^{ab} ±0.64	4
UW	2.29 ^c ±0.08	24	5.74 ^b ±0.21	19	8.63 ^b ±0.33	12	10.58 ^b ±0.38	8	23.25 ^c ±2.21	4
WW	1.21 ^d ±0.03	22	2.33 ^e ±0.12	16	3.52 ^e ± 0.15	10	6.71 ^d ±0.16	11	16.98 ^d ±0.90	5

abcd Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; W = West African Dwarf.

Table 4.6 shows the effect of dam age on the lambs' birth weight was significant as the 24-35 months produced bigger lambs of 3.07kg than that of the 1-23 months of 2.61kg. There was similarity in the birth of weight of lambs produced from the two categories of gestation length. The 154 – 158 days category had lamb with weight 3.06kg while the 148 – 153 days was 2.75kg. The weights at birth of the lambs significantly increased with increase in parity numbers. The dams in their third parity produced significantly ($p<0.005$) bigger lambs at birth of 3.34 kg than 2.99 kg and 2.59 kg produced during their second and first parity, respectively. Lambing type had no significant difference in the birth weights of the lambs. The average birth weight from a single lambing was 2.95 kg and was greater in value than the 2.12 kg from twin lambing. The breeds of the sire played significant influence on the birth weight of the lambs. The average weight at birth of lambs sired by Balami was 3.57 kg and was significantly ($p<0.005$) different from 2.97 kg and 2.19 kg produced by Uda and WAD respectively. The effect of dam breed on lamb birth weight was significant ($p<0.005$) with Balami producing the heaviest lambs of average weight 3.47 kg while Uda and WAD's lambs averaged 2.87 kg and 2.42 kg, respectively. The male parent effect of Uda, WAD and Balami was evident as there was similarity in the weights of purebred Uda, UW, BW and WB. There were no significant differences in the weights of WB, BW, UU and UW but were significantly different from WU and the purebred WAD. Purebred WAD had significantly ($p<0.005$) the least weights across the periods.

Table 4.7 shows the effect of Lamb Genotype and Lamb sex on Birth weights. The purebred Balami had the highest value for weight at birth and was significantly ($p<0.005$) different from the rest of the genotypes. There were no significant differences in the Birth weights of purebred Uda, WB, UW and WU. BW had the second heaviest weight and was similar to UW lambs.

Table 4.6: Effect of Dam Age, Gestation Length, Birth Weight, Lambing Type, Parity, Lamb sire and Lamb Dam on Lambs' Birth Weights.

Factors	Birth Weights $\pm$ S.E.M	Number of Lambs	P – value
Dam Age			
24-35 months (< 3 years)	3.07 ^a $\pm$ 0.12	77	0.0001
1-23 months (<2 years)	2.61 ^b $\pm$ 0.10	81	
Gestation Length			
154 – 158	3.06 $\pm$ 0.16	50	0.8452
149 – 153	2.75 $\pm$ 0.91	108	
Parity			
3 rd	3.34 ^a $\pm$ 0.22	27	0.0001
2 nd	2.99 ^b $\pm$ 0.13	50	
1 st	2.59 ^c $\pm$ 0.10	81	
Lambing Type			
Single	2.95 $\pm$ 0.08	138	0.2104
Twin	2.12 $\pm$ 0.24	20	
Sire Breed			
Balami	3.57 ^a $\pm$ 0.09	53	0.0001
Uda	2.97 ^b $\pm$ 0.07	39	
WAD	2.19 ^c $\pm$ 0.13	66	
Dam Breed			
Balami	3.47 ^a $\pm$ 0.11	79	0.0001
Uda	2.87 ^b $\pm$ 0.06	35	
WAD	2.42 ^c $\pm$ 0.13	74	

^{abcd} Means along the same column with different superscripts are significantly ($p < 0.005$)

different. B = Balami; U = Uda; W = West African Dwarf.

Table 4.7: Effect of Lamb Genotype and Lamb Sex on Birth weight.

Lamb Genotype (number of lambs)	BW $\pm$ S.E.M
BB (25)	4.03 ^a $\pm$ 0.13
BW (28)	3.14 ^b $\pm$ 0.07
UW (22)	2.99 ^{bc} $\pm$ 0.14
WB(24)	2.86 ^c $\pm$ 0.06
WU(21)	2.84 ^c $\pm$ 0.12
UU(16)	2.81 ^c $\pm$ 0.11
WW(21)	0.88 ^d $\pm$ 0.07
Sex	BW $\pm$ S.E.M
Male (111)	3.04 ^a $\pm$ 0.09
Female (46)	2.37 ^b $\pm$ 0.13
P-value	p<0.0001

abcd Means along the same column with different superscripts are significantly ($p<0.005$) different . B = Balami; U = Uda; W = West African Dwarf.

Table 4.8: Effect of interaction between Lamb Genotype (LG) and Lamb Sex (LS) on Lambs' Birth weights.

Lamb Genotype	Lamb Sex	Birth weight $\pm$ SEM
BB	M	4.17 ^a $\pm$ 0.09
UW	M	3.17 ^b $\pm$ 0.12
BW	M	3.21 ^b $\pm$ 0.09
UU	M	3.09 ^{bc} $\pm$ 0.14
WU	F	3.06 ^{bc} $\pm$ 0.16
BB	F	3.00 ^{bc} $\pm$ 0.24
WB	M	2.96 ^{bc} $\pm$ 0.10
WU	M	2.73 ^{bc} $\pm$ 0.11
BW	F	2.73 ^{bc} $\pm$ 0.21
UW	F	2.71 ^{bc} $\pm$ 0.13
WB	F	2.60 ^{bc} $\pm$ 0.16
UU	F	2.46 ^c $\pm$ 0.16
WW	M	1.02 ^d $\pm$ 0.12
WW	F	0.64 ^d $\pm$ 0.15
P-value	p<0.0001	

^{abcd} Means along the same column with different superscripts are significantly ($p<0.005$) different B= Balami; U= Uda; W= WAD

The pure WAD had the least weight and was significantly ($p<0.005$) different from the rest of the lambs. The effect of sex of lambs on lambs' birth weights shows the male lambs at birth had significantly ($p<0.005$) superior weight than the female lambs.

Table 4.8 showed that the males of the pure and crossbred were superior in birth weights compared to their females. Balami male lambs had significantly ($p<0.005$) the heaviest weight. There were similarities in the birth weights of pure and crossbred Uda; crossbred Balami and crossbred WAD with respect to their sex. Purebred Uda had significantly ($p<0.005$) smaller weights compared to pure and crossbred Balami male and crossbred Uda male. Both pure WAD male and female had significantly ($p<0.005$) the least weights.

Table 4.9 shows that at third parity, there was no significant difference in the lambs' birth weights of Balami and Uda ewes while Uda ewes at their second parity had significantly ($p<0.005$) smaller lambs compared to Balami ewes at their third parity. There were similarities in the lambs' birth weights produced by second parity Uda, first parity Balami and first parity Uda ewes. The WAD ewes produced the least lambs' birth weights and except the WAD ewes at their third parity, the lambs produced were significantly ($p<0.005$) smaller to ones by Uda and WAD regardless of the parity. The lambs produced by Balami ewes mated to Balami sires had significantly ($p<0.005$) the heaviest lambs. There were similarities in the weights of lambs produced when WAD ewes were mated to Balami sires and vice versa; Uda and WAD; WAD and Uda and WAD and Balami.

Table 4.9: Effect of Interactions between Parity and Dam breed and between Sire breed and Dam breed on Birth weights of lambs on Birth Weights of lambs.

Parity	Dam breed	Birth Weight $\pm$ SEM
3 rd	Balami	4.12 ^a $\pm$ 0.19
3 rd	Uda	3.63 ^{ab} $\pm$ 0.23
2 nd	Balami	3.54 ^{ab} $\pm$ 0.14
2 nd	Uda	3.13 ^{bc} $\pm$ 0.16
1 st	Balami	3.11 ^{bc} $\pm$ 0.12
1 st	Uda	2.87 ^{bc} $\pm$ 0.14
3 rd	WAD	2.59 ^{dc} $\pm$ 0.15
2 nd	WAD	2.33 ^{de} $\pm$ 0.12
1 st	WAD	2.05 ^e $\pm$ 0.09
Sire breed	Dam breed	Birth weights $\pm$ SEM
Balami	Balami	4.07 ^a $\pm$ 0.06
Balami	WAD	3.22 ^b $\pm$ 0.06
Uda	WAD	3.13 ^{bc} $\pm$ 0.07
WAD	Uda	3.01 ^{bc} $\pm$ 0.07
WAD	Balami	2.99 ^{bc} $\pm$ 0.06
Uda	Uda	2.91 ^c $\pm$ 0.07
WAD	WAD	0.97 ^d $\pm$ 0.06

^{abcd} Means with different superscripts along same column are significantly different ($P < 0.05$)

B = Balami; U = Uda; W = West African Dwarf.

Table 4.10a: Effect of Dam Age, Gestation Length, Parity, Sire breed, Dam breed on lambs' birth weights.

DAMAGE	GESTATION LENGTH	PARITY	LAMBING TYPE	SIRE BREED	DAM BREED	BIRTH WEIGHT	S.E.M
24-35 months	154-158	3 rd	Single	Balami	Balami	5.00 ^a	0.239
24-35 months	154-158	2 rd	Single	Balami	Balami	4.900 ^{ab}	0.239
1-23 months	154-158	3 rd	Single	Balami	Balami	4.81 ^{abc}	0.138
1-23 months	149-153	3 rd	Single	Balami	Balami	4.65 ^{ab}	0.169
24-35 months	149-153	2 rd	Single	Balami	Balami	4.37 ^{abcde}	0.138
1-23 months	149-153	2 rd	Single	Balami	Balami	4.20 ^{abcde}	0.239
24-35 months	154-158	3 rd	Single	Balami	WAD	3.90 ^{cdef}	0.239
24-35 months	154-158	1 st	Single	Balami	Balami	3.87 ^{cdef}	0.138
1-23 months	149-153	3 rd	Single	Balami	WAD	3.70 ^{cdef}	0.239
1-23 months	154-158	2 nd	Single	Balami	Balami	3.70 ^{cdef}	0.239
24-35 months	154-158	2 nd	Twins	Balami	Balami	3.70 ^{cdef}	0.239
1-23 months	154-158	3 rd	Single	UDA	UDA	3.70 ^{cdef}	0.239
24-35 months	154-158	3 rd	Single	UDA	WAD	3.67 ^{cdef}	0.138
24-35 months	154-158	3 rd	Single	WAD	Balami	3.55 ^{def}	0.169
24-35 months	149-153	1 st	Single	Balami	Balami	3.53 ^{def}	0.119
1-23 months	149-153	1 st	Single	Balami	Balami	3.50 ^{def}	0.239
1-23 months	149-153	2 nd	Twins	Balami	Balami	3.50 ^{def}	0.239
1-23 months	154-158	2 nd	Single	Balami	Balami	3.50 ^{def}	0.239
1-23 months	154-158	3 rd	Single	UDA	UDA	3.50 ^{def}	0.239
1-23 months	149-153	3 rd	Single	Balami	WAD	3.50 ^{def}	0.239
1-23 months	149-153	3 rd	Single	WAD	Balami	3.40 ^{defg}	0.239
1-23 months	154-158	3 rd	Single	Balami	WAD	3.30 ^{defg}	0.169
1-23 months	154-158	3 rd	Single	WAD	UDA	3.30 ^{defg}	0.169
24-35 months	149-153	2 nd	Single	UDA	WAD	3.23 ^{defg}	0.119
24-35 months	149-153	2 nd	Single	Balami	WAD	3.23 ^{defg}	0.119
1-23 months	149-153	3 rd	Single	UDA	WAD	3.20 ^{defg}	0.169
1-23 months	154-158	1 st	Single	Uda	WAD	3.20 ^{defg}	0.169
1-23 months	154-158	1 st	Single	Balami	WAD	3.20 ^{defg}	0.169
1-23 months	149-153	3 rd	Single	UDA	WAD	3.20 ^{efg}	0.169
24-35 months	154-158	3 rd	Single	WAD	Uda	3.10 ^{efg}	0.239
24-35 months	149-153	2 nd	Single	WAD	Uda	3.10 ^{efg}	0.239
1-23 months	154-158	2 nd	Single	Uda	WAD	3.10 ^{efg}	0.239
24-35 months	149-153	2 nd	Single	WAD	Uda	3.07 ^{efg}	0.138
24-35 months	149-153	1 st	Single	Balami	WAD	3.04 ^{efg}	0.107
1-23 months	149-153	2 nd	Single	Balami	WAD	3.03 ^{efg}	0.138
24-35 months	154-158	2 nd	Single	Uda	Uda	3.00 ^{efg}	0.239
24-35 months	149-153	2 nd	Twins	WAD	Balami	3.00 ^{efg}	0.239
1-23 months	149-153	1 st	Twins	Balami	Balami	3.00 ^{efg}	0.239
24-35 months	149-153	2 nd	Single	Uda	Uda	3.00 ^{efg}	0.239

^{abcd} Means with different superscripts are significantly different (p<0.005)

Table 4.10b: Effect of Dam Age, Gestation Length, Parity, Sire breed, Dam breed on lambs' birth weights.

DAMAGE	GESTATION LENGTH	PARITY	LAMBING TYPE	SIRE BREED	DAM BREED	BIRTH WEIGHT	S.E.M
24-35 months	154-158	2 nd	Single	WAD	Uda	3.00 ^{efg}	0.239
1-23 months	149-153	2 nd	Single	WAD	Uda	2.95 ^{efg}	0.169
24-35 months	149-153	1 st	Twins	Uda	WAD	2.93 ^{efg}	0.138
1-23 months	149-153	1 st	Single	Balami	WAD	2.92 ^{efg}	0.107
1-23 months	149-153	1 st	Single	Uda	WAD	2.92 ^{efg}	0.107
24-35 months	154-158	2 nd	Single	WAD	Balami	2.90 ^{efgh}	0.239
24-35 months	154-158	2 nd	Single	Balami	WAD	2.90 ^{efgh}	0.239
24-35 months	154-158	1 st	Twins	WAD	Uda	2.90 ^{efgh}	0.239
1-23 months	149-153	2 nd	Twins	WAD	Uda	2.90 ^{efgh}	0.138
1-23 months	149-153	2 nd	Single	WAD	Balami	2.90 ^{efgh}	0.138
24-35 months	154-158	1 st	Twins	WAD	Balami	2.90 ^{efgh}	0.239
24-35 months	154-158	2 nd	Twins	Uda	Uda	2.90 ^{efgh}	0.239
24-35 months	149-153	1 st	Single	WAD	Uda	2.85 ^{fgh}	0.119
24-35 months	149-153	1 st	Single	WAD	Balami	2.78 ^{fgh}	0.119
24-35 months	149-153	1 st	Single	Uda	Uda	2.76 ^{fgh}	0.119
24-35 months	154-158	1 st	Single	Balami	WAD	2.70 ^{fgh}	0.119
1-23 months	149-153	1 st	Single	WAD	Uda	2.68 ^{fgh}	0.107
1-23 months	149-153	1 st	Single	Uda	WAD	2.65 ^{fgh}	0.098
1-23 months	149-153	1 st	Single	WAD	Balami	2.65 ^{fgh}	0.098
24-35 months	149-153	1 st	Twins	Uda	WAD	2.60 ^{fgh}	0.239
24-35 months	149-153	1 st	Twins	WAD	Balami	2.55 ^{fgh}	0.169
1-23 months	149-153	1 st	Single	Uda	Uda	2.53 ^{fgh}	0.138
1-23 months	149-153	1 st	Twins	Uda	Uda	2.50 ^{fgh}	0.117
1-23 months	154-158	2 nd	Twins	Uda	Uda	2.00 ^{ghijk}	0.239
24-35 months	149-153	3 rd	Single	WAD	WAD	1.50 ^{hijk}	0.239
24-35 months	154-158	3 rd	Single	WAD	WAD	1.40 ^{ijkl}	0.169
24-35 months	149-153	2 nd	Single	WAD	WAD	1.30 ^{ijkl}	0.239
1-23 months	149-153	3 rd	Twins	WAD	WAD	1.10 ^{ijkl}	0.239
1-23 months	154-158	2 nd	Twins	WAD	WAD	1.10 ^{kl}	0.239
1-23 months	149-153	3 rd	Single	WAD	WAD	1.00 ^{kl}	0.239
24-35 months	149-153	1 st	Twins	WAD	WAD	0.80 ^{kl}	0.138
24-35 months	154-158	2 nd	Twins	WAD	WAD	0.80 ^{kl}	0.138
1-23 months	149-153	2 nd	Single	WAD	WAD	0.80 ^{kl}	0.138
1-23 months	149-153	1 st	Single	WAD	WAD	0.66 ^l	0.090
1-23 months	149-153	1 st	Twins	WAD	WAD	0.65 ^l	0.090
1-23 months	154-158	1 st	Twins	WAD	WAD	0.60 ^l	0.169

abcd Means with different superscripts along the same column are significantly different

(P<0.05)

In Table 4.10a and b, with the exception of old Balami ewes in their third parity, there were no significant differences in the lambs' birth weights due to interaction effects of old and young ewes in their second and third parity, mated by Balami sire. Also, Balami sheep was superior as there were similarities in the birth weights of lambs produced by old Balami ewes in their first parity with old and young WAD ewes mated to Balami sires in their second and third parity for both single and twin lambing types with both gestation lengths coming to play. There was also similarity in twin lambing weights of lambs produced by young Balami and old WAD ewes in their respective second parity, mated to Balami sires, but were significantly ($p < 0.005$) heavier than the lambs produced when sires Uda and WAD were used as sires. The common trend observed in the lambs' birth weight is that there were no significant differences in the weights of lambs produced when Uda was mated to Uda or WAD ewes in their second and third parity and vice versa; young or old Balami ewes in their first parities regardless of gestation lengths. However, the numerical value is greater mostly when Balami was used as sires. The lambs produced from WAD ewes mated to WAD sire had the least weights and were significantly ($p < 0.005$) different from the other lambs' breeds. When twin lambing occurred, there was similarity in lambs' birth weight of the twins with young dams in their second or third parity. There were no significant differences in the interactions between dam age and gestation length, dam age and parity, dam age and lambing type, dam age and lamb sire, dam age and dam breed, gestation length and parity, gestation length and lambing type, gestation length and lamb sire, gestation length and dam breed, parity and lambing type, parity and lamb sire, lambing type and lamb sire and lambing type and dam breed.

Table 4.11a: Effects of Genotypes on Morphometric Traits of Lambs at Birth

Trt	BB	BW	WU	WB	UW	UU	WW
HL	12.36 ^a ±0.34	12.32 ^a ±0.27	12.11 ^{ab} ±0.45	11.75 ^{ab} ±0.21	11.25 ^{bc} ±0.29	10.56 ^{cd} ±0.27	10.27 ^d ±0.19
HW	10.12 ^a ±0.29	10.04 ^{ab} ±0.24	9.32 ^{bc} ±0.35	9.50 ^{abc} ±0.23	9.29 ^{bc} ±0.18	8.13 ^d ±0.24	8.82 ^{cd} ±0.18
NC	15.68 ^{ab} ±0.35	17.36 ^a ±0.54	16.84 ^{ab} ±0.77	14.92 ^b ±0.63	17.46 ^{bc} ±0.42	15.06 ^b ±0.84	16.45 ^{ab} ±0.96
TL	18.76 ^a ±0.76	17.57 ^{ab} ±0.83	17.42 ^{ab} ±0.85	15.67 ^{ab} ±0.77	16.96 ^{ab} ±0.59	15.69 ^b ±1.04	10.55 ^a ±0.46
HG	33.72 ^a ±0.93	32.96 ^{ab} ±0.69	32.74 ^{ab} ±1.08	31.42 ^{abc} ±1.06	33.58 ^a ±0.68	30.56 ^{bc} ±1.23	29.32 ^c ±0.62
RW	10.00 ^{ab} ±0.40	10.68 ^a ±0.21	8.00 ^{cd} ±0.43	8.02 ^{ca} ±0.52	8.88 ^{bc} ±0.43	7.44 ^d ±0.62	8.82 ^{bc} ±0.38
RL	8.28 ^{ab} ±0.29	9.00 ^a ±0.25	6.84 ^{cd} ±0.31	6.83 ^{cd} ±0.41	7.33 ^{bc} ±0.37	6.22 ^d ±0.41	7.55 ^{bc} ±0.34
WH	38.80 ^a ±0.81	36.46 ^{ab} ±1.07	35.95 ^b ±1.15	36.29 ^{ab} ±0.74	36.83 ^{ab} ±0.56	32.94 ^c ±0.4	25.82 ^a ±0.31
EL	11.08 ^a ±0.17	10.71 ^a ±0.34	9.79 ^b ±0.39	9.67 ^b ±0.21	10.25 ^{ab} ±0.17	9.69 ^b ±0.27	6.11 ^c ±0.25
FLL	15.55 ^a ±0.5	14.56 ^{ab} ±0.59	13.84 ^b ±0.61	14.04 ^{ab} ±0.53	14.63 ^{ab} ±0.42	12.38 ^c ±0.47	10.18 ^d ±0.21
RLL	17.00 ^a ±0.43	15.89 ^{ab} ±0.55	15.42 ^{bc} ±0.62	15.54 ^b ±0.49	16.00 ^{ab} ±0.38	14.13 ^c ±0.45	11.32 ^d ±0.25
BL	15.80 ^a ±1.41	48.68 ^a ±1.84	42.58 ^b ±2.35	39.77 ^{bc} ±0.51	48.63 ^a ±1.51	34.00 ^d ±1.28	36.09 ^{cd} ±1.06
SW	14.48 ^b ±0.39	14.64 ^{ab} ±0.39	14.79 ^{ab} ±0.30	14.23 ^b ±0.32	5.33 ^a ±0.41	13.91 ^{bc} ±0.29	12.73 ^c ±0.64
RH	40.60 ^a ±0.99	38.39 ^{ab} ±1.09	37.26 ^b ±0.13	38.17 ^{ab} ±0.84	38.42 ^{ab} ±0.54	34.30 ^c ±0.59	27.82 ^d ±0.22

^{abcd} Means along the same row with different superscripts are significantly ($p < 0.005$) different

. BB = Pure Balami, UU = Pure Uda, WW = Pure WAD, BW = Balami-WAD, UW = Uda-WAD, WB = WAD-Balami. WU = WAD-Uda.

From Table 4.11a, at birth, HLs of purebred Balami, Balami crosses and WAD crosses while Uda crosses were significantly ($p<0.005$) different from purebred WAD which was not different from the purebred Uda while purebred WAD were significantly ($p<0.005$) different, except purebred Uda, from the rest genotypes at yearling. Balami and their crosses showed high values for head width at birth while Balami crosses were significantly ($p<0.005$) different from their purebred and similar with rest at yearling. There were no significant differences in the neck circumferences at birth while all the purebred and crosses except Balami crosses, showed significant ($p<0.005$) difference from the purebred WAD at yearling. The purebred WAD showed significantly ($p<0.005$) the shortest tails both at birth and yearling. The heart girths of the purebred WAD significantly ($p<0.005$) differed from most of the genotypes at birth but were similar at yearling.

Table 4.11b shows that the purebred Balami and their crosses showed superiority in rump measurements, over the rest purebred and their crosses at birth while the crosses had similar values and were superior over the purebred WAD at yearling. There were similarities in the wither heights of the purebred and the crossbred both at birth and yearling. At birth and at yearling, purebred Balami showed the significantly ($p<0.005$) biggest ear lengths followed by the crosses which are also significantly ($p<0.005$) different from the purebred WAD. At birth, the crosses had similar leg lengths with the purebred Balami and Uda and are significantly ($p<0.005$) longer than the purebred WAD's while at yearling, the crossbred except the WU, had significantly ($p<0.005$) shorter legs than the purebred Balami and their crosses. There were similarities in the body lengths at birth while the purebred WAD had the significantly ($p<0.005$) shortest body at yearling. There were similarities in the shoulder widths of the pure and crossbred both at birth and at yearling. The rump heights of the crossbred were similar with those of the purebred while purebred Balami were significantly ($p<0.005$) the tallest followed by the crossbred.

Table 4.11b: Effects of Genotype on Morphometric Traits of Sheep at Yearling

Trt	BB	BW	WU	WB	UW	UU	WW
HL	24.33 ^a ±1.45	21.25 ^a ±0.75	22.00 ^a ±0.58	22.50 ^a ±0.48	21.25 ^{ab} ±0.85	22.50 ^a ±0.50	18.00 ^b ±1.09
HW	14.33 ^a ±0.33	12.25 ^b ±0.63	12.67 ^{ab} ±0.67	13.75 ^{ab} ±0.63	13.00 ^{ab} ±0.58	13.00 ^{ab} ±1.00	12.80 ^{ab} ±0.37
NC	51.00 ^a ±1.55	42.75 ^{ab} ±2.75	47.00 ^a ±4.51	50.75 ^a ±0.63	45.00 ^a ±3.76	51.50 ^a ±0.50	36.00 ^b ±1.92
TL	44.33 ^a ±0.67	35.00 ^{bc} ±1.83	34.00 ^c ±2.52	40.75 ^a ±0.85	33.25 ^c ±2.02	40.00 ^{ab} ±1.00	21.60 ^d ±1.42
HG	84.33 ^a ±3.82	78.50 ^a ±0.65	79.00 ^a ±1.53	82.75 ^a ±2.87	81.00 ^a ±2.27	80.00 ^a ±2.00	76.40 ^a ±2.82
RW	25.67 ^a ±1.86	22.50 ^{ab} ±1.26	23.33 ^{ab} ±1.76	25.00 ^{ab} ±1.29	23.00 ^{ab} ±1.29	25.00 ^{ab} ±1.00	21.00 ^b ±0.63
RL	22.33 ^a ±0.88	19.75 ^{bc} ±0.48	20.00 ^{abc} ±0.58	21.75 ^{ab} ±0.85	20.00 ^{abc} ±0.41	20.50 ^{ab} ±0.50	17.78 ^c ±0.79
WH	79.33 ^a ±1.20	68.00 ^{bc} ±1.22	66.67 ^c ±1.20	70.25 ^{bc} ±2.49	72.75 ^b ±1.11	67.00 ^c ±2.00	57.60 ^d ±0.81
EL	20.00 ^a ±0.38	15.25 ^{bc} ±1.18	15.00 ^{bc} ±0.58	18.00 ^{ab} ±0.58	14.25±1.11	16.50 ^{bc} ±1.50	8.00 ^d ±0.71
FLL	57.33±1.45	55.00 ^{ab} ±2.19	49.00 ^c ±2.65	53.75 ^{abc} ±1.49	51.00 ^{bc} ±0.71	51.50 ^{bc} ±1.50	43.40 ^d ±0.60
RLL	59.33 ^a ±1.45	56.75 ^{ab} ±2.29	50.67 ^c ±2.03	55.25 ^{abc} ±1.75	52.00 ^{bc} ±0.71	52.50 ^{bc} ±1.50	45.20 ^d ±0.58
BL	97.33 ^a ±1.20	92.75 ^a ±3.35	87.33 ^a ±0.88	89.50 ^a ±1.55	87.50 ^a ±0.65	88.00 ^a ±1.00	77.60 ^b ±4.23
SW	62.00 ^a ±2.08	55.00 ^{bc} ±1.68	56.00 ^b ±0.58	51.50 ^c ±0.50	52.00 ^{bc} ±0.71	55.50 ^{bc} ±0.50	52.60 ^{bc} ±1.29
RH	81.67 ^a ±1.45	69.50 ^c ±1.32	68.67 ^c ±0.88	72.00 ^{bc} ±2.42	74.50 ^b ±1.32	68.50 ^c ±1.50	59.20 ^d ±0.86

abcd Means along the same row with different superscripts are significantly ($p<0.005$) different

Table 4.12: Estimation of heterosis of body weights in the crossbred lambs

Heterosis		Heterosis Estimate			%Heterosis		
	Genotype	Birth	Weaning	Yearling	Birth	Weaning	Yearling
General	WB&BW	0.57	-0.49	3.99	22.42	-4.84	16.50
	WU&UW	0.52	0.81	2.72	24.70	9.25	13.44
Specific	WB	0.68	-0.95	3.60	26.98	-9.48	14.88
	BW	0.45	2.29	4.38	17.86	26.32	18.11
	WU	0.83	-0.27	2.43	39.57	-3.10	12.01
	UW	0.21	1.88	3.01	9.83	21.61	14.87

From the table above, crossbred WU had the greatest heterosis estimate at birth followed by crossbred

Table 4.12 shows at birth, the percentage general percentage heterosis of crossbred WB and BW was 22.42% and was lower than the 24.70% of crossbred WU and UW. WAD and Uda crosses were superior at weaning, than WAD and Balami crosses with negative heterosis. However, Balami and WAD crosses had higher heterosis estimates at yearling compared to other crossbred. WB. However, both showed negative estimates at weaning for specific heterosis. All the genotypes had positive specific heterosis at yearling with crossbred BW having the highest.

4.6. Discussion

The present study showed that percentage number of weaned lambs was greater than the percentage number of lambs attaining yearling and this was in agreement with the reports of Vatankhah and Taleb, (2009) on Lori-Bakhtiari lambs. The values from this study for weaned lambs are low compared to the results stated by Morris *et al.*, (2000) for Woodland and Rotamahana sheep. This may be due to the effect of harsh weather condition which impacted much especially, on the purebred. The purebred lambs, which are known to thrive well in the Northern part of the country (Buvanendra and Adu, 1990), could not withstand the unfavourable weather thereby, making them susceptible to disease outbreak. Samberg and Cassaday (1985) have reported the susceptibility of sheep; a major factor hindering the sheep business in Nigeria. Uda sheep has been reported by Adu and Ngere (1979) for poor performance when reared outside their natural ecological zones. Also, Upton (1985) generally described sheep with high mortality rate. However, the crossbred lambs performed optimally at weaning and yearling alongside the WAD which indicates some improvement in the crossbreeding investigation. Cardellino and Boyazoglu, (2009) observed that livestock biodiversity and improvement would be the source pool for genes that offer disease resistance, specific product qualities, resistance to draught and extremes in temperatures and production traits to be combined in newly formed breeds or crossbreds or hybrids. It is

noteworthy to mention the improvement via adaptability in the surviving pattern of the crossbred from the 1st Parity to the last year of breeding. The results from this study for conception rate, except for a couple of breeding years, are similar to the reports of Sharma *et al.* (2004) for controlled environment for Malpura ewes but higher than the reports from same authors when the aforementioned ewes were raised under combined stress. This may be due to the fact that the new environment the ewes from this study were introduced was similar to the one they came from. However, the present study has a fairly low results compared to the author's report on lambing the rate. The animals may have started feeling the extreme or inclement weather condition during lambing time. The reproductive performance and survivability of both the ewes and lambs from this study generally, were in accordance with the observation of Buvanendra and Adu (1990) on sheep introduced from sparse vegetation zones into densely populated zones.

The crossbred WB, BW and WU had similar birth weights except UW. The crossbred lambs at birth were superior at birth with regards to their body weights throughout and this was an indication towards achievement of advantage of crossbreeding. Lamb birth weight is crucial as it serves as a prerequisite for adequate growth. However, the yearling weight (31 kg) of purebred Balami in the present study was low compared to the 35 kg reported by Adu and Ngere (1979). The low weight may be as a result of unfavourable climate conditions that affected generally, the performance of the animals used for the study. Uda is one of the biggest Nigerian breeds of sheep (Yunusa *et al.*, 2013a) and the appropriateness of this study was evident as there were no significant differences in the birth weights of purebred UU and the crossbred. The reciprocal crossing, BW and UW also yielded superiority at birth over the purebred WW and slightly lower than the straight crosses. The result of this study was similar to the works of Oyeyemi and Ogunsola (2011) where Yankassa crossed with Yankassa-WAD; Yankassa crossed with Uda- WAD had superior birth weights than the pure WAD.

The small body size of the WAD was masked by the heavy bodies of Balami and Uda hence, complementarity came to play. The superior weight at birth of Balami in the present study is similar to that of Buvanendra *et al.* (1981) and Buvanendra and Adu (1990). Balami is the largest breed of sheep in Nigeria (Roger, 1999) and this was confirmed with the purebred weight at birth, 4th and 8th week. The claim of Yunusa *et al.* (2013a) that no breeding practice or method can elude Balami and Uda, being the two largest breeds in Nigeria was apparent in the growth of the crossbred lambs. The lamb weights at birth from the straight crossing were greater than that of the reciprocal crossing. This could be due to the effect of the large size of the Balami and Uda dams, thereby accommodating the big developing fetus as well as providing adequate nourishment through the body reserves.

The influence of dams' age on lambs' birth weights in the present study was in agreement with the reports of Ali *et al.* (2006) and Mohamed *et al.* (2009), on heavier lambs produced by older ewes. Thus, the present study affirms the significant influence of the age of the dams on lambs' birth weights. Also, older ewes produced significantly heavier lambs at birth compared to the 1-23 monthss and this is in tandem with the report of Buvanendra and Adu, (1990). The result from the present study disagrees with the work of Mohammed *et al.* (2009) where no significant differences were observed in the lamb birth weights of the D'mam breeds in the dam age of 2-3 years. Donald and McLean (1935), observed the superior heaviness of males and lambs from older ewes over females and lambs from (younger) two-year-old dams, in the English Leicester and Southdown breeds in New Zealand. The present results also tallies with the reports by Hight and Jury (1969) on significant heavier weight of lambs born to older ewes than lambs born to younger ewes.

The effect of gestation length on lambs' birth weights was not significant and this is in agreement with the results by Iyiola-Tunji *et al.* (2010) where similar lambs' birth weights were observed for different gestation lengths of 137, 151,152 and 153 days. However, some

authors such as Osinowo *et al.* (1994); Vatankhah *et al.* (2000); Fogarty *et al.* (2005) reported that gestation length influenced lamb weight. Although, the present results show the dams with longer gestation length had heavier lambs which affirms the investigations of Caro *et al.* (2013) but the difference was not significant.

The significant effect of dams' parity on lambs' birth weights in this study tallies with the work of Momoh *et al.* (2013). First pregnancy according to Khong *et al.* (2003), causes some physiological reprogram in the womb of the dam, for example, increases vascularisation which enhances greater blood volume expansion during the second pregnancy (Campbell and MacGillivray, 1984) each of which will facilitate relatively greater fetal growth in subsequent pregnancies. The increase in birth weight alongside in the present study was in agreement with parity with the observation of London and Weiner, (1995) who noted that during the first parity, there is an ongoing growing phase in ewes and the competition between fetal growth and maternal growth could justify the smallness of lambs at birth. Also, the variations in birth weight with respect to year of breeding, which is marked with Parity from the present study, can be attributed to incessant fluctuations in environmental factors such as temperature and disease outbreak which Assan and Mekuza, (2005) observed is hard to contain. Mukandan and Rajagopalan (1971); Nagpal and Chawla, (1984) observed that the main reason is the nutrition of the sheep which is a reflection of profound seasonal influence on herbage production and availability, hence, affecting the weight of lambs at birth.

The present study shows that lambs of single birth type appeared to possess similar weight with the ones from twin birth. The result of this study is contrary to the result of Momoh *et al.* (2013) and Iyiola-Tunji, (2010) where the authors concluded that litter size of single lambs were heavier than that of the twin lambs. The differences observed in the present study might be due to the effect in the disparity in weights of Balami and WAD sheep. The WAD ewe might have produced lambs of similar weights when mated with Balami and vice versa.

However, the trend of the present study on the effect of type of lambing on the birth weight of lambs was synonymous to the findings of Otuma (2007) on goats. Also, breed effect and lambing type interactions affected lambs' birth weight in the present study as the single birth WAD lamb was smaller compared to twins birth Balami sheep which tallies with the findings Atkins (1980) and Petrvic *et al.* (2011). Although, interactions of sire and dam breed, age and parity of the dams also played significant roles, the reason for superior single birth weights can be linked to increasing completion for nutrients by the developing fetuses, Galal *et al.* (1972). Also, differences in birth weight due to birth type can be as a result of limited space in the uterus during pregnancy as a single fetus is well accommodated and favoured than double or more fetuses (Babar *et al.*, 2004; Gamasaee *et al.*, 2010).

The significant effect of the breed of sire and dam on lambs' birth weight concurs with the claim of Yunusa *et al.* (2013a) that no breeding practice or method can elude Balami and Uda being the largest breeds in Nigeria were apparent in the present study, in the growth performance of the purebred and crossbred lambs). Balami is the largest breed of sheep in Nigeria (Roger, 1999) and this was confirmed in the superiority of lambs produced by the Balami dams. The lambs produced by both Balami and Uda dams were significantly bigger than the ones produced by the WAD and this could be due to the effect of the large size, thereby accommodating the big developing fetus as well as providing adequate nourishment through the body reserves. The reverse was observed in WAD which is known to be the smallest breed of sheep in Nigeria.

The result of this present study is in disagreement with the report of FAO, (1989); Buvanendra and Adu (1990) where heavier birth weights of males were recorded. Idris *et al.* (2010) reported heavier birth weight of female lamb. The relatively smaller weight of female lamb at birth can be traced to the effect of the presence of a Y-chromosome with the products of *sry* gene activation i.e androgens and mullerian-inhibitor substance which according to

Haqq *et al.* (1994) has sex-specific effects on fetal growth thereby making the males appear to grow faster than respective females in uterus. The purebred Balami demonstrated superiority in birth weight compared to the rest of the groups as breed effect was evident and this result agrees with the findings of Momoh *et al.* (2013); Combella *et al.* (1990). The significant higher birth weights of the crossbred compared to the purebred WAD was expected as the effect of crossbreeding and complementarity came to play and this was also observed by Oyeyemi and Ogunmola, (2011) on their works on the crossing of Yankassa with WAD.

It was observed from the present study that the crossbred WAD, Uda and Balami competed with the purebred of same sheep in all the measured morphometric traits and were superior in all traits when compared with pure WAD. The values for all the morphometric traits for Balami sheep at yearling in this study were greater than the reports of Adejoro and Salako (2012). The reason for this high values might be as a result of improvement in adaptation as the animals aged. Both Balami and Uda sheep are known to possess big ears (Roger, 1999) and the gene effect of the alleles for the big ears was dominant in the crossbred. The HL of the crossbred higher than the purebred WAD showed the effects of the breed difference and hybrid vigour which corroborates the report of Oyeyemi and Ogunmola (2011). The result also tallies with that of Leymaster (2002) on the longer face length of the crossbred compared to the purebred. The superiority of the crossbred over the purebred WAD on some of the morphometric traits such as HG which has been useful in the prediction of live weights in large ruminants (Lukuyu *et al.*, 2016) followed same trend with the results of Oyeyemi and Ogunmola (2011) on crossbred Yankassa-WAD sheep. The height at wither values from this study are low for WAD and Uda but similar to the reports of Okpeku *et al.* (2013). This may be attributed to the yearling phase, hence, younger animals used in the present study. Uda tail length and Balami body length values from this study are similar to the reports of Okpeku *et*

al. (2013). The overall superiority of the crossbred over the purebred with respect to morphometric traits was as a result of the achieved complementarity which revealed the advantageous combinations of couple of genes via crossbreeding. Also, the morphometric traits analysed in this study are useful at predicting the body weight of WAD sheep thereby, aiding their improvement (Sowande and Sobola, 2008).

The result of this present study revealed moderate values for specific heterosis (except for crossbred UW) and general percentage heterosis at birth, for Uda straight and reciprocal crosses despite the superiority of purebred Balami. This was due to the fact that average weight of the purebred was far greater in Balami than in Uda. This was expected as Balami had been described to be the biggest breed of Nigerian sheep (Roger, 1999). The superiority in birth and body weights of the crossbred lambs was apparent as the average body weights exceeded that of the purebred. This could be linked to the effect of the increase in heterozygosity in the crossbred which is a reflective of the reports of Charray *et al.* (1992); Leymaster (2002). The present result is low when compared to the General percentage heterosis of 38.75% reported by Oyeyemi and Ogunmola, (2011) on crossbred Yankassa WAD. The slight variation could be traced to the large size of the Uda and Balami sheep used in the present studies as against the Yankassa by the authors hence; bigger average weight of the purebred was expected. Also, the superiority with respect to live weight of crossbred Uda over that of Balami could be linked to more tolerance and adaptability of Uda. Lawrence (2015); Buvanendra and Adu (1990) both reported on the vulnerability and tendency to mortality respectively when Balami sheep were raised outside the Northern regions of the country. The genotypes with negative heterosis during weaning were improved at yearling as all the lambs showed positive heterosis and the crossbred BW and their reciprocals had the most superior General and Specific heterosis estimates at yearling which is an indication of increased tolerance and adaptability.



Plate 4.1: WAD Ewes and Lamb at yearling



Plate 4.2: Balami and WAD Ewes



Plate 4.3: Purebred Balami lamb at day old



Plate 4.4: Crossbred BalamiWAD lamb at day old

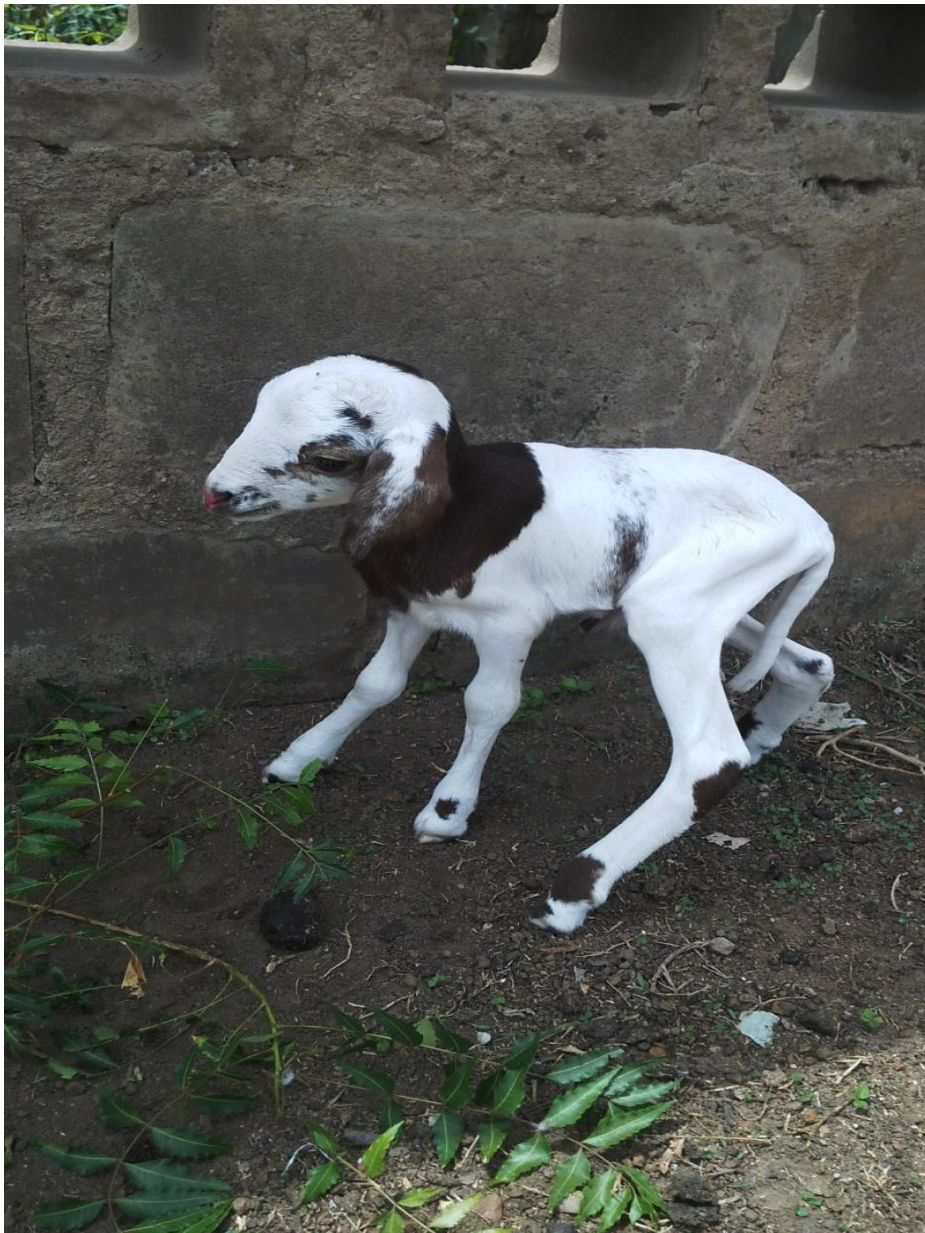


Plate 4.5: Crossbred WADUda lamb at day old



Plate 4.6: Crossbred WADBalami lamb at day old



Plate 4.7: Purered Uda lamb at day old



Plate 4.8: Purebred UdaWAD lamb at day old



Plate 4.9: Purebred WAD lamb at 4 weeks old.

CHAPTER FIVE

ESTIMATION OF GENETIC PARAMETERS IN BALAMI, UDA AND WAD SHEEP AND THEIR CROSSBRED PROGENIES

5.1 Introduction

Repeatability is the proportion of the variance of a single measurement that is due to genetic and specific environmental effects. These effects are then expected to be repeated in equal strength in subsequent measurements (Sajjad, 2012). Repeatability estimates help animal breeders to timely determine early culling of dams that have poor performance. High repeatability means that considerable reliability can be placed on single records while ewes with low productivity can be culled early in their lifetime (McNaughton and William, 1956). In animal production, growth and development have immeasurable impact on reared animals as they determine the value of the animals being produced (Gerrard and Grant, 2003). A substantial proportion of agricultural research focuses on how to make animal growth and development processes more efficient. Selection for increased weight hence, mature size, is a famous practice in animal husbandry although, little is known about the influence of such selection on the relative contributions of direct and maternal effects on birth weight and pre - weaning growth (Hinch *et. al.*, 1986). The continual increase in biological and economic efficiency of lamb production is much pertinent from increasing the number of lambs weaned per ewe rather than ordinarily improving growth rate (Dickerson, 1978).

Sheep have been studied to show large variation of body reserves, with higher weight during trimester stage of pregnancy, towards end of lactation and the dry period, and with lower weight in the early part of lactation (Cannas, 2004). Previous works have also shown a synergy between live body weight and milk yield within or between breeds of sheep Hansen *et al.* (1999); Van der Linden *et al.* (2009) and Mavrogenis and Papachristoforou (2000). Heritability is the most important factor in realising adequate animal evaluation methods, selection methods and mating systems as it measures the relative importance of hereditary and environmental impacts on the development of a specific quantitative or economic trait (Sajjad, 2012). In ordinary mating systems, the non-additive effects of dominance and epistasis do not influence permanent change in a population and this has consequently make heritability in the narrow sense more useful to the animal breeder than broad sense heritability. Lambs' main nourishment prior to weaning is milk and their growth and development at this stage is a function of adequate feeding and maternal ability (FAO, 1989). Milk is the only nourishment for lambs at tender age and an important source of nutrients throughout the nursing period (McNaughton and William 1956). Therefore, optimal milk yield is an ultimate factor in producing lambs of prudent weight at weaning. Munro, (1955); Folman *et al.* (1966) and Peart *et al.* (1972) observed that ewe milk yield can be affected by many factors such as breed, age, sex, birth weight and number of suckled lambs. There is scanty of information on the performance of Nigerian sheep regarding repeated records, and heritability estimates, hence performance of the dams and sires, especially when reared in other ecological zones. For instance, the long legged sheep such as Balami thrives well in the North despite the harsh condition but have poor performance as regards reproduction, growth and survivability when raised in the rain forest or Guinea savannah zone of Nigeria (Buvanendra and Adu, 1990). Adequate knowledge of small scale breeding frame and the

choice of management is essential for a long term opportunities for small ruminant productions in developing countries like Nigeria (Akpa *et al*, 2003).

Principal component analysis, according to Everitt *et al.* (2001), is a method for transforming the variables in a multivariate data set such as $X_1, X_2, \dots, X_j$, into new variables, $Y_1, Y_2, \dots, Y_j$ which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables. Principal Component (PC) analysis is an appropriate statistical tool for multivariate methodology which is used when traits or parameters are correlated. The main use of PC is to reduce data without compromising the relationship between traits in a dataset (Parés-Casanova 2012; Verma *et al.*, 2015). Thus, breaking the measured traits into components will result to smaller number of artificial variables i.e Principal Component that will account for most of the variance in measured traits.

Discriminant analysis of morphometric traits of sheep and other reared animals of same ecological zone has been done with a number of breeds in the discriminant analysis model by Salako and Ngere, (2002); Yakubu and Ibrahim, (2011) using the animals available around areas of study. Therefore, characterisation becomes imperative due to uncontrolled mating that is creating a big worry to preserving the purity of the indigenous breeds of sheep such as WAD, Balami and Uda and also to add to existing information on the superiority of certain breeds over others which usually serve as precursor for crossbreeding. Genetic distance is essential at determining the hybrid vigour or heterosis expected during crossbreeding. The farther two genotypes are the better the improvement that should be expected when they are crossed.

5.2 Main Objective

The objectives of the present study were to estimate the effects of genotypes and environment on the size at birth, week, weaning and yearling phases of lambs; dam weight loss during lactation and amount of milk suckled from Balami, Uda and WAD dams of

Nigeria indigenous sheep and also to determine the morphometric descriptors for both the traditionally managed and the progenies of sheep gotten from this present study.

5.3 Specific Objectives

- to determine the Repeatability estimates of lambs' body weights, weight loss during lactation and milk yield of Balami, Uda and WAD ewes used for the study
- to determine inheritance estimate for weights of the sires and dams throughout the breeding periods
- to estimate birth and live weight-morphometric correlations in Balami, Uda, WAD and crossbred sheep
- to determine the most significant morphometric descriptors for Uda, Balami, West African Dwarf Sheep and their crossbred using principal component analysis
- to differentiate between Uda, Balami, West African Dwarf Sheep and their crossbred using discriminant analysis

5.4 Materials and Methods

5.4.1 Experimental Animals

Records on 105 sheep comprising of 63 Balami ewes, 61 Uda sheep, 96 WAD ewes, 3 rams each and 158 lambs were used for this study.

5.4.2 Data collection

Records on dam and sires performance for the three breeding years were used to estimate repeatability and heritability for birth and live body weights of lambs at weaning and yearling in WAD, Balami and Uda sheep. 441 records comprising of 378 records for birth and weaning weights; 63 records for yearling for all the breeds of ewe were used for repeatability

estimate for weights. The same number of records was used for heritability taking into consideration the records of the pure and crossbred lambs. Milk yield was determined by weekly measurement of milk suckled by weighing the dam and lamb before and after suckling before taking the average weight. The night before the milk yield would be determined; the lambs were separated from the dams to ensure suckling did not occur over the night. The lambs and dams were then weighed before and after suckling. Faeces and urine were not weighed during this experiment as the animals seldom did so during the investigation. The same number of records was used for milk yield investigation up to weaning period. Weekly weights of the dams during lactation were determined by placing the dams on scale before feeding and this was done up to weaning stage.

Records of number of dams and lambs surviving through the 3 breeding years were determined. Number of pregnant ewes per breeding year, lambing numbers and still births were also determined.

5.4.3 Statistical Analysis

Repeatability and heritability were analysed using statistical packa Minitab 17 version (2013). The mathematical model for heritability and repeatability used to fix the effect of geotypes on body weight, milk yield and weight loss during lactation is:

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

Where,

Y_{ik} = performance of i^{th} individual of k^{th} genotypes

μ = the overall mean for each of the trait

g_i = fixed effect of i^{th} Genotype ($i=1,2,\dots,7$)

e_{ik} = residual error.

The variance components (i.e. δs^2 and δe^2 were obtained from ANOVA means square with the assumptions:

Mean Square Error (in the ANOVA table) = Mean Square sire (in the ANOVA table) = $\delta s^2 + \delta e^2$

Where k is the number of progeny within sire

Repeatability was estimated using the equation:

$$R^2_w = \frac{\delta w^2}{\delta w^2 + \delta e^2}$$

R is repeatability estimates

δw^2 is variance component between individuals

δe^2 is variance component between individuals

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

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

Where,

R is intraclass

K is the number of record taken per individual

N is number of individual.

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

$$h^2_s = \frac{4\delta s^2}{\delta s^2 + \delta e^2}$$

Where,

h^2_s is heritability estimates

δs^2 is Sire variance component

δe^2 is Error variance component

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

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

Where,

t is intraclass correlation

k is number of progeny within sire

s is number of sire

5.4.4. Principal Component Analysis of Balami, Uda, WAD and their crossbred

Out of the 17 morphometric traits measured during the preliminary study, 14 common traits to both male and female were selected for PCA. The model for the principal component analysis was defined as:

$$Y_1 = a_{11} x_1 + a_{12} x_2 + \dots + a_{1j} x_j$$

$$Y_2 = a_{21} x_1 + a_{22} x_2 + \dots + a_{2j} x_j$$

$$Y_j = a_{j1} x_1 + a_{j2} x_2 + \dots + a_{jj} x_j \text{ with the coefficients being chosen so that}$$

$Y_1, Y_2, \dots, Y_j$ account for decreasing proportions of the total variance of the original variables, $X_1, X_2, \dots, X_j$. Mean, standard deviation and coefficient of variation of each measurement were computed.

From the correlation matrix, data for the principal component factor analysis were generated.

To enhance the interpretability of the principal components, the varimax criterion of the orthogonal rotation method was employed in the rotation of the factor matrix. The criterion of minimum explained variance equal to or less than 70% to retain the main components was adopted in accordance with the method of Ferreira *et al.* (2013). The criteria used to discard of variables was based on recommendations from Jolliffe (1972), who suggested that the number of discarded variables be equal to the number of principal components whose variance (eigenvalue) is less than 0.7, and the suggestion of Khattree and Dayanand (2000),

that the variable that had the highest coefficient in absolute value of the principal component smallest eigenvalue (lowest variance) should be less important in explaining the total variance and therefore susceptible to discard.

5.4.5. Multifactorial discriminant analysis of morphometric traits of Balami, Uda, WAD and their crossbred

Stepwise discriminant analysis was performed to identify morphometric parameters that best serve as racial marker between the breeds of sheep investigated and also to determine which variable of the 14 traits that contributed the most in the Function. This was done with discriminant analysis option of variable classification using the Statistical Package for Social Science (Version 20). Factor analysis was done to generate genetic distances (Dendogram) among the 7 genotypes. Data were first subjected to Descriptive analyses to sort groups by means per all variables. The means generated per group were then used to generate the Dendogram plot using Euclidian Distance for Nearest Neighbour of Statistical Package for Social Science (Version 20).

In cross validation, each case was classified by the functions derived from all cases other than that case. The DISCRIM procedure (nearest-neighbour discriminant analysis) was used to find the percentage of correct assignment of each sheep to its genetic group.

5.4.6. Correlation analysis between Birth and live weights and morphometric traits of Balami, Uda, WAD and their crosses.

The General Linear Model (PROC GLM) procedure of Statistical Analysis Software System (SAS 9.4, 2013) was used to estimate the effect of genotype on the morphometric traits at birth and at weaning. The correlation procedure (PROC CORR) of Pearson's correlation

coefficient of the same statistical package was used to investigate the correlations between birth weight and morphometric traits at birth and at weaning

5.5 Results

Table 5.1 shows that at birth and at week 4 of lambing, WAD sheep had the highest repeatability estimates followed by Balami and Uda whereas, at week 8, weaning and yearling, Balami dams showed superiority followed by Uda and WAD. Uda dams had the least estimates for lambs' weights at birth and week 4. WAD sheep performed better than the Balami sheep at Wk0 and Wk4 while the latter showed better performance at weaning. Both WAD and Balami sheep showed similar performance at yearling.

Table 5.2 shows Repeatability estimates were generally high for weight loss during lactation except at week 8 where Uda had about average value.

Table 5.3 shows that for milk suckled during lactation, WAD and Uda dams had high values while Balami had the least and it was the week with optimal milk yield.

Table 5.1: Repeatability (R) estimates for WAD, Balami and Uda sheep for lambs' Body Weight.

Age	in		
Weeks (Wk)	R		
	WAD	Balami	Uda
Wk0	0.97±0.04	0.77±0.26	0.05±0.17
Wk4	0.98±0.03	0.94±0.08	0.22±0.31
Wk8	0.07± 0.45	0.92±0.47	0.76±0.39
Weaning	0.79±0.44	0.98±0.51	0.94±0.40
Yearling	0.99±0.42	0.99±0.51	0.99±0.42

Repeatability estimates are compared across the row.

Table 5.2: Repeatability (R) estimates for WAD, Balami and Uda dams' weight loss during lactation

Age in Weeks (WK)	Repeatbility estimates		
	WAD	Balami	Uda
WK0	0.99±0.01	0.96±0.06	0.99±0.02
WK4	0.99±0.04	0.98±0.02	0.98±0.04
WK8	0.99±0.01	0.99±0.02	0.47±0.39

Repeatability estimates are compared across the row.

Table 5.3: Repeatability (R) estimates for Average weekly milk yield in WAD, Uda and Balami sheep.

Age in Weeks

(WK)	R		
	WAD	Balami	Uda
Wk1	0.42±0.39	0.31±0.36	0.44±0.39
Wk4	0.75±0.28	0.50±0.16	0.75±0.28
Wk8	0.4±0.39	0.05±0.16	0.57±0.38

Repeatability estimates are compared across the row.

Table 5.4: Heritability (h^2) estimates for weights for purebred WAD, Balami, Uda and their crosses.

Age in weeks (Wk)	WW	BB	UU	BW	WB	UW	WU
Wk0	0.31±0.51	1.09±0.27	0.29±0.50	1.93±0.54	2.44±0.26	0.80±0.44	1.63±1.02
Variance	0.03, 0.02	0.07, 0.18	0.06, 0.04	0.01, 0.02	0.01, 0.01	0.00, 0.02	0.01, 0.02
Wk4	1.09±0.33	0.44±0.53	1.956±1.37	0.06±0.47	0.80±0.43	0.99±0.13	1.39±0.75
Variance	0.01, 0.04	0.01, 0.07	0.07, 0.01	0.00, 0.07	0.01, 0.02	0.02, 0.05	0.01, 0.02
Wk8	1.06±0.26	-0.08±0.0	0.545±0.52	-0.07±0.36	1.93±1.34	0.82±0.41	0.60±0.54
Variance	0.02, 0.06	-0.00, 0.12	0.05, 0.34	-0.00, 0.06	0.01, 0.14	0.01, 0.04	0.00, 0.02
Weaning	-0.49±0.77	-0.71±0.67	-0.841±1.16	1.33±0.68	1.46±0.83	0.93±0.26	0.31±0.57
Variance	-0.03, 0.28	-0.19, 1.24	-0.29, 1.64	0.10, 0.20	0.01, 0.02	0.01, 0.02	0.00, 0.05
Yearling	-0.47±0.74	-0.82±0.39	-0.979±1.31	0.82±0.41	0.49±0.26	-0.76±0.94	-0.74±0.93
Variance	-0.47, 4.46	-1.46, 7.37	-0.73, 0.97	0.22, 0.86	0.14, 0.97	-0.22, 1.39	-0.25, 1.59

Note: h^2 greater than 1 is assumed to be 1 while $-h^2$ no heritability and is assumed to be 0.

Heritability estimates are compared across the row. The numbers in the Variance are the values for the sire and dam components respectively.

Table 5.4 shows that purebred WAD and Uda lambs had relatively low heritability estimates while purebred Balami, BalamiWAD, UdaWAD and WADUda had high heritability estimates at birth. All genotypes at week 4 had positive heritability values with BW having the least. Only purebred Balami and BW at week 8 had negative heritability estimates while the rest of the genotypes showed very high and average values. All purebred Balami, Uda and WAD had negative heritability estimates both at weaning and yearling. Crossbred UW and WU were the only sheep that had negative heritability estimates. At weaning and yearling, BW had the best heritability estimates followed by WB. The small sample size used in this study for computing heritability estimates could be the reason for some outrageous and negative values. Also, the reason for the rare values can be traced to the negative variance components generated for calculating heritability.

Table 5.5 Shows the significance of sampling size. The Kaiser-Meyer-Olkin Measure of Sampling, Chi square and Bartlett's Test of Sphericity are all significant

In Table 5.6, positive low, average to high correlations values were found between traits. The highest correlation value was found in FLL/RLL while the least was between FLL and HL.

In Table 5.7, the first component has the greatest Eigen values followed by the second and third component. The first and second components account for 64% variance which is more than half of the total variance.

Principal Component Analyses (PCA) of morphological traits and Discriminant analysis of traditionally managed Balami, Uda and WAD sheep in Nigeria.

Table 5.5: KMO and Bartlett's Test of sampling of sheep

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.909
Bartlett's Test of Sphericity	Approx. Chi-Square	12832.274
	Df	91
	Sig.	(P<0.001)

Table 5.6: Correlation Matrix of traits of traditionally managed sheep.

	EL	FLL	RLL	BL	SW	NC	HG	RH	RW	RL	HL	HW	TL	
EL	1.000													
FLL	.282	1.000												
RLL	.306	.983	1.000											
BL	.428	.633	.640	1.000										
SW	.445	.508	.542	.681	1.000									
NC	.186	.440	.455	.623	.752	1.000								
HG	.384	.460	.491	.630	.875	.764	1.000							
RH	.492	.436	.458	.625	.657	.495	.642	1.000						
RW	.328	.442	.464	.620	.708	.681	.680	.512	1.000					
RL	.414	.451	.475	.594	.709	.601	.687	.548	.726	1.000				
HL	.320	.276	.294	.385	.569	.535	.629	.440	.480	.448	1.000			
HW	.292	.327	.356	.473	.547	.544	.527	.406	.588	.569	.420	1.000		
TL	.632	.328	.338	.528	.569	.281	.526	.568	.439	.548	.312	.358	1.000	
WH	.477	.348	.363	.517	.568	.435	.542	.602	.426	.480	.367	.348	.518	1.000

a. Determinant = 3.05E-006

Ear Length (EL), Force Leg Length (FLL), Rear Leg Length (RLL), Body Length (BL), Shoulder Width (SW), Neck Circumference (NC), Hearth Girth (HG), Rump Height (RH), Head Length (HeL), Head Width (HW), Horn Length (HL), Rump Width (RW), Rump Length (RL), Tail Length (TL), Withers Height (WH).

Table 5.7: Principal components, Eigenvalues and percentage of variance explained by components

Component	Eigenvalues	% of Variance	Cumulative %
1	7.659	54.706	54.706
2	1.329	9.490	64.195
3	1.264	9.029	73.225
4	.694	4.955	78.180
5	.599	4.277	82.455
6	.497	3.548	82.457
7	.396	2.830	86.005
8	.361	2.582	88.836
9	.341	2.439	91.418
10	.309	2.204	93.856
11	.242	1.731	96.061
12	.179	1.276	97.068
13	.115	.823	99.891
14	.015	.109	100.00

Table 5.8: Principal Component Analysis of measured traits of sampled

Traits	Component			Communality
	1	2	3	
EL	.100	.848	.109	.741
FLL	.218	.165	.945	.967
RLL	.246	.182	.933	.965
BL	.491	.411	.554	.716
SW	.754	.411	.302	.829
NC	.851	.052	.278	.805
HG	.797	.354	.238	.816
RH	.446	.616	.272	.652
RW	.766	.229	.267	.711
RL	.674	.388	.261	.672
HL	.693	.216	.018	.527
HW	.685	.175	.145	.521
TL	.245	.820	.139	.752
WH	.358	.648	.171	.577

Extraction Method: Principal Component Analysis.

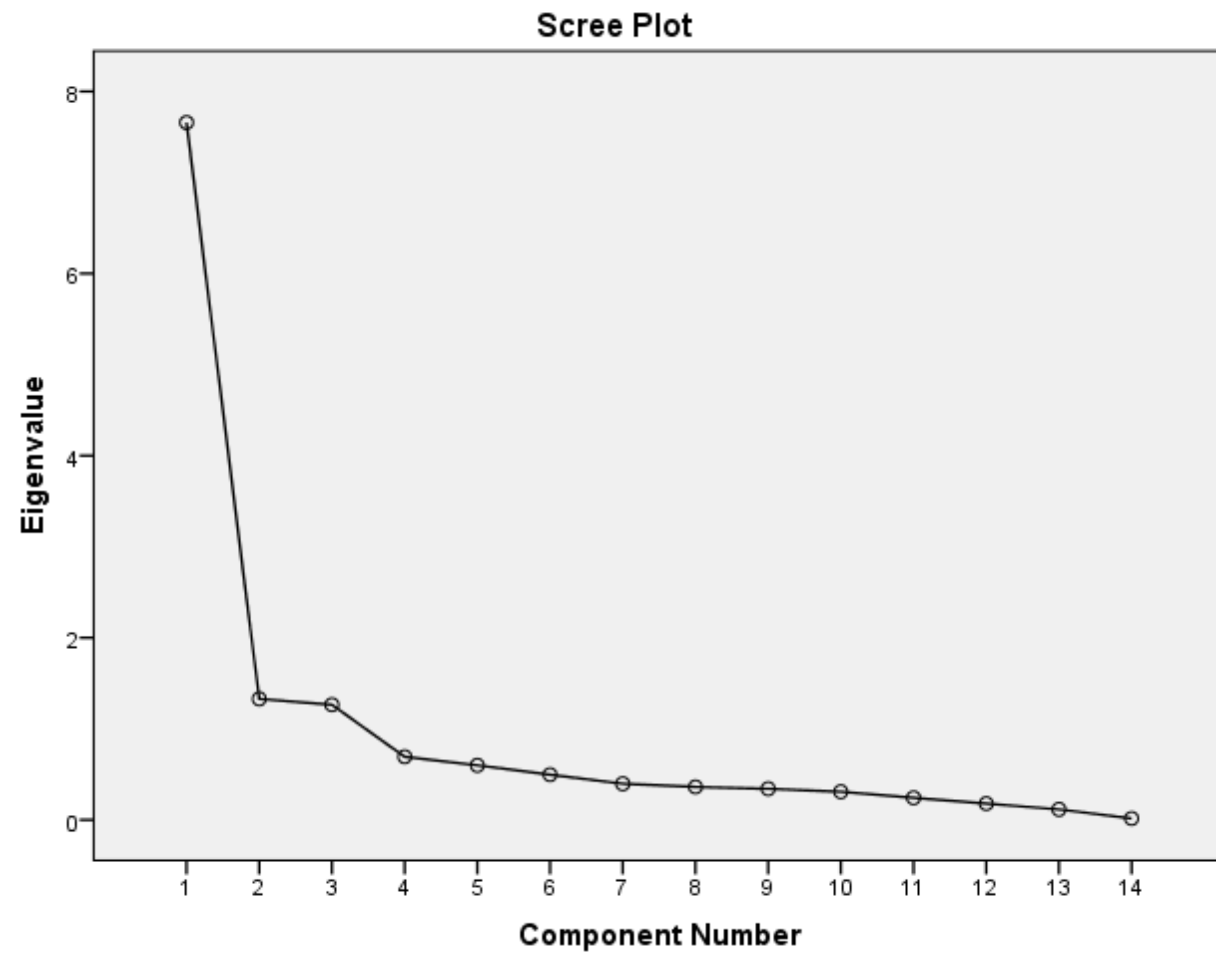


Figure 5.1: Pattern of distribution of Eigen values with respect to the number of components.

Table 5.8 shows that Component 1 was highly loaded with SW, NC HG and RW while only EL was found high in second component. The leg traits, FLL and RLL were highly loaded in the third component. The values for communality were high and average range was between 0.52 to 0.967

In Figure 5.1, the screeplot declines with highest slope to the second and almost have a flattened pattern after the third component.

Anti image matrices and Kaiser-meyer-Olkin measure of sample adequacy (0.909), Bartlett's test for Sphericity ($p < 0.001$), Chi square (12832.274) and the values of Communalities gave credence to the use of the PCA. Kaiser (1974) recommended an acceptable value of 0.5 for sample adequacy. The large communality values (0.521 – 0.967) observed in this present study suggest that a large number of variance has been shared among the input variables. 3 Principal Components (PC) were extracted from the traits used in the description of the Nigerian sheep. The extracted PCs accounted for more than half of the total variance (73.225%) after the Varimax rotation of the component matrix. There were variations in the trend of loadings of the morphometric measurements on each PC. The first component (PC1) contributed the largest portion of 54.706% to the total variance and it has high loading for SW, NC, HG and RW. The PC2 contributed a lower portion of the total variance (9.490%) and it has high loading for EL and TL. The last component (PC3) contributed the least portion, 9.029% to the total variance with a high loading of FLL and RLL. The values of the low loadings in PC1 ranged between 0.10 and 0.693 while PC2 and PC3 range values are 0.052 – 0.648 and 0.018 and 0.554 respectively. The Scree plot, Fig VI, shows the distribution pattern of the Eigenvalues with respect to the components. The first component which was characterised with the highest value of 7.56 had the longest and the most ascending curve followed by the other two significant components. The curve flattens out, in a declining pattern, after the third component.

Table 5.9 shows the Test of Equality result of group of means. The P-values showed that each variable can on their own predict sheep breeds. The variables with smaller Wilks' Lambda values have more predicting power compared with the ones with bigger values. TL has the most predicting ability of all the variables.

Table 5.9: Test of Equality Result of Group of Means

	Wilks'	F	P-Level
Traits	Lambda		
EL	.799	127.482	.000
FLL	.989	5.736	.003
RLL	.984	8.132	.000
BL	.892	61.104	.000
SW	.893	60.699	.000
NC	.959	21.527	.000
HG	.904	53.826	.000
RH	.881	68.503	.000
RW	.990	5.368	.005
RL	.956	23.396	.000
HL	.922	42.807	.000
HW	.964	18.663	.000
TL	.569	384.768	.000
WH	.910	50.035	.000

Table 5.10: Structure Matrix of Discriminant Functions

Traits	Function	
	1	2
TL	.708*	.532
EL	.427*	-.025
BL	.2`96*	.008
RL	.173*	.142
RLL	.101*	.089
FLL	.086*	.068
SW	.073	.681*
HG	.072	.640*
HL	.018	.589*
NC	-.084	.367*
HW	.080	.339*
RH	.286	.303*
WH	.241	.280*
RW	.053	.166*

**. Largest absolute correlation between each variable and any discriminant function*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.

Table 5.11: Wilks' Lambda Test of Functions

Test of Function(s)	Wilks' Lambda	Chi-square	Df	Sig.
1 through 2	.339	1090.673	28	.000
2	.805	218.426	13	.000

Table 5.10 shows loading of the discriminant functions. It is the correlations between the observed variables (the 14 continuous discriminating variables) and the dimensions created with the unobserved discriminant functions (dimensions). TL, EL, BL, RL, RLL and FLL are the six highly loaded traits in the first function have 85% discriminating ability of discriminating the breeds of sheep while the second function could only discriminate by 15%.

Table 43 shows the first test presented in this table which tests both canonical correlations ("1 through 2") and the second test presented tests the second canonical correlation alone.

The smaller the value of Wilks' Lambda the greater the function's discriminating ability hence, the first function has more influencing features at predicting the breeds of sheep.

In Table 5.11, the Chi-square statistic testing that the canonical correlation of the given function is equal to zero. The null hypothesis is that the function, and all functions that follow, have no discriminating ability. This hypothesis is rejected as it is violated by the present result. The Df shows the effect degrees of freedom for the given function. It is based on the number of groups present in the categorical variable and the number of continuous discriminant variables for the given function. It is based on the number of groups present in the categorical variable and the number of continuous discriminant variables. The number of variables is 14 and the df for the first function is 28 ($14 * 2$). The Sig is the p-value associated with the Chi-square statistic of a given test. The significant values show the null hypothesis that a given function's canonical correlation and all smaller canonical correlations are equal to zero is evaluated with regard to this p-value. The null hypothesis is rejected if the p-value is less than alpha thus, making the prediction by the function to be significant.

Table 5.12: The Nearest Neighbour Discriminant Analysis of Traditionally managed Breeds of Sheep.

Type of Count	Breed	Predicted Group Membership			Total
		1.00	2.00	3.00	
Original Count	Balami	255	76	40	371
	Uda	81	184	26	291
	WAD	10	17	328	355
Cross validated Count	Balami	68.7	20.5	10.8	100.0
	Uda	27.8	63.2	8.9	100.0
	WAD	2.8	4.8	92.4	100.0

1.00 = Balami; 2.00 = Uda and 3.00 = WAD.

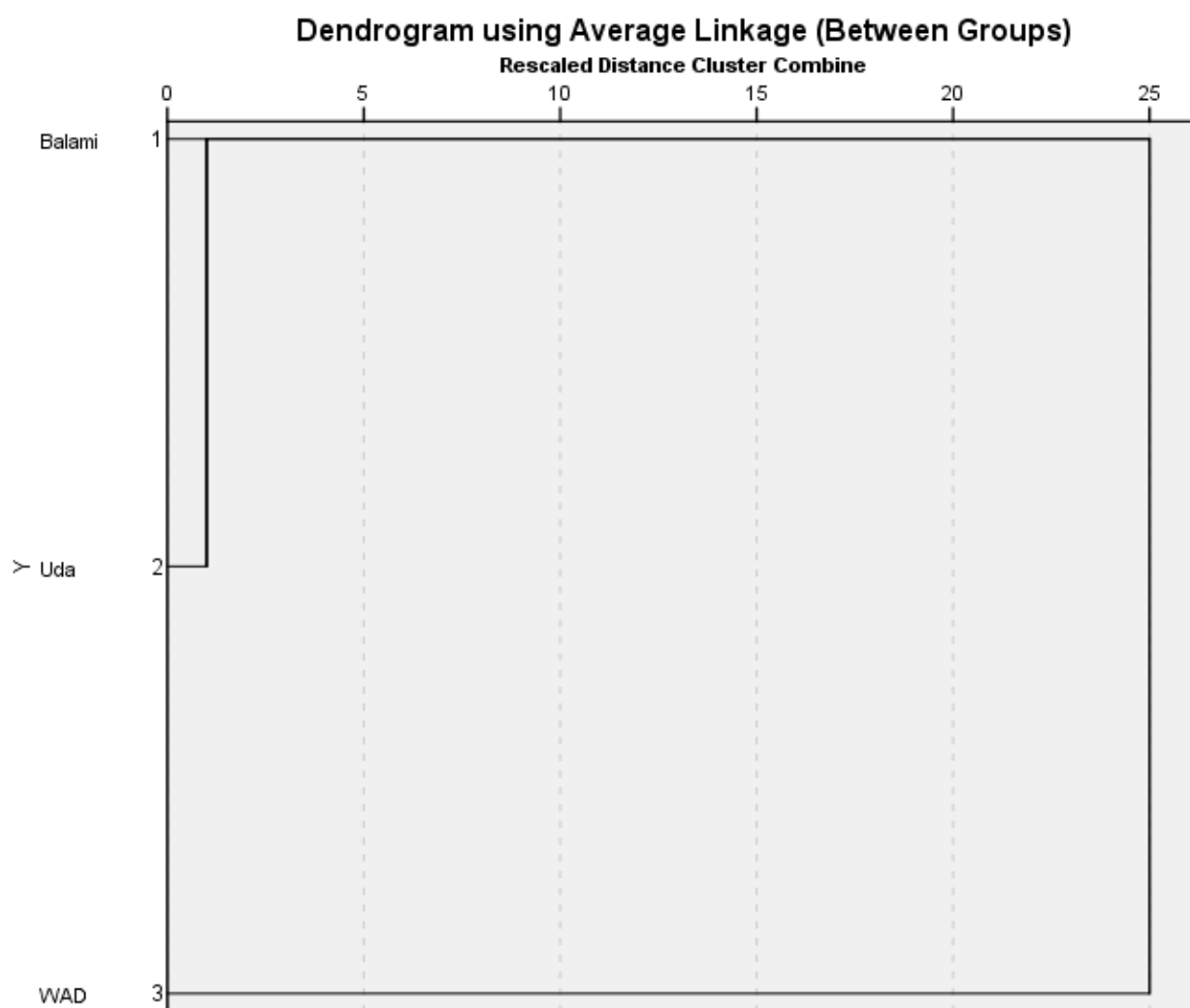


Figure 5.2: Dendrogram plot using average linkage between Nigerian breeds of sheep.

Table 5.12 shows the predicted frequencies of groups from the analysis. The arrangement of numbers in each column indicates how many were correctly and incorrectly classified. From the above result, of the 371 sheep that were predicted to be of Balami breed, 255 (68.7%) were correctly predicted, and 91 were incorrectly predicted (81 sheep were in the Uda group and 10 sheep in in the WAD group). 63.2% and 92.4% were correctly predicted for Uda and WAD respectively. therefore, the classification result excellently favoured the prediction of the WAD sheep. The cross validation shows the incorrect classification of Balami, Uda and WAD with their respective percentage values of 27.8% and 2.8% of Balami were misclassified as Uda and WAD respectively. 20.5% and 4.8% of Uda were misclassified as Balami and WAD respectively while 10.8% and 8.9% of WAD were misclassified as Balami and Uda respectively>

Figure 5.2 shows the genetic distances between the three breeds under investigation. The shortest distance is found between Balami and Uda and both are further apart from the WAD breed. The Euclidian distance measures the degree of genomic variances within and between animal populations. It is derived as difference in allele frequencies for all loci in animal genome. Euclidian distances shows the distances between the breeds of sheep studied. Longest genetic distance of 25units was obtained between WAD and Balami sheep. The distance between Balami and Uda was about 2 units.

Table 5.13 shows that he Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Shericity were all significant.

In Table 5.14, the Total Variance Explained shows component 1 has the highest Eigenvalues followed by the rest 3 components. All retained components account for 72% of the Total variance.

Table 5.13: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.				.618
Bartlett's Test of Sphericity	Approx. Chi-Square			1707.678
	Df			91
	Sig.			.000

Table 5.14: Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	4.213	30.091	30.091
2	2.964	21.174	51.265
3	1.726	12.326	63.592
4	1.193	8.520	72.112

Table 5.15: Component Matrix^a

Traits	Component				
	1	2	3	4	communality
HL	-.245	.767	.364	-.038	.782
HW	.882	-.274	-.076	-.038	.860
NC	.707	.097	-.461	.273	.796
TL	.017	.738	.176	.159	.601
HG	.439	.383	-.033	.501	.591
RW	.734	-.315	.470	.051	.755
RL	.711	-.286	.040	-.138	.607
WH	.754	.560	-.130	-.290	.863
EL	.462	.253	.501	-.274	.603
FLL	.334	.223	.222	.704	.707
RLL	.077	.577	-.304	-.304	.524
BL	-.782	.591	-.058	.069	.835
SW	-.035	-.079	.838	-.067	.714
RH	.729	..552	-.073	-.247	.859

a means 4 components extracted.

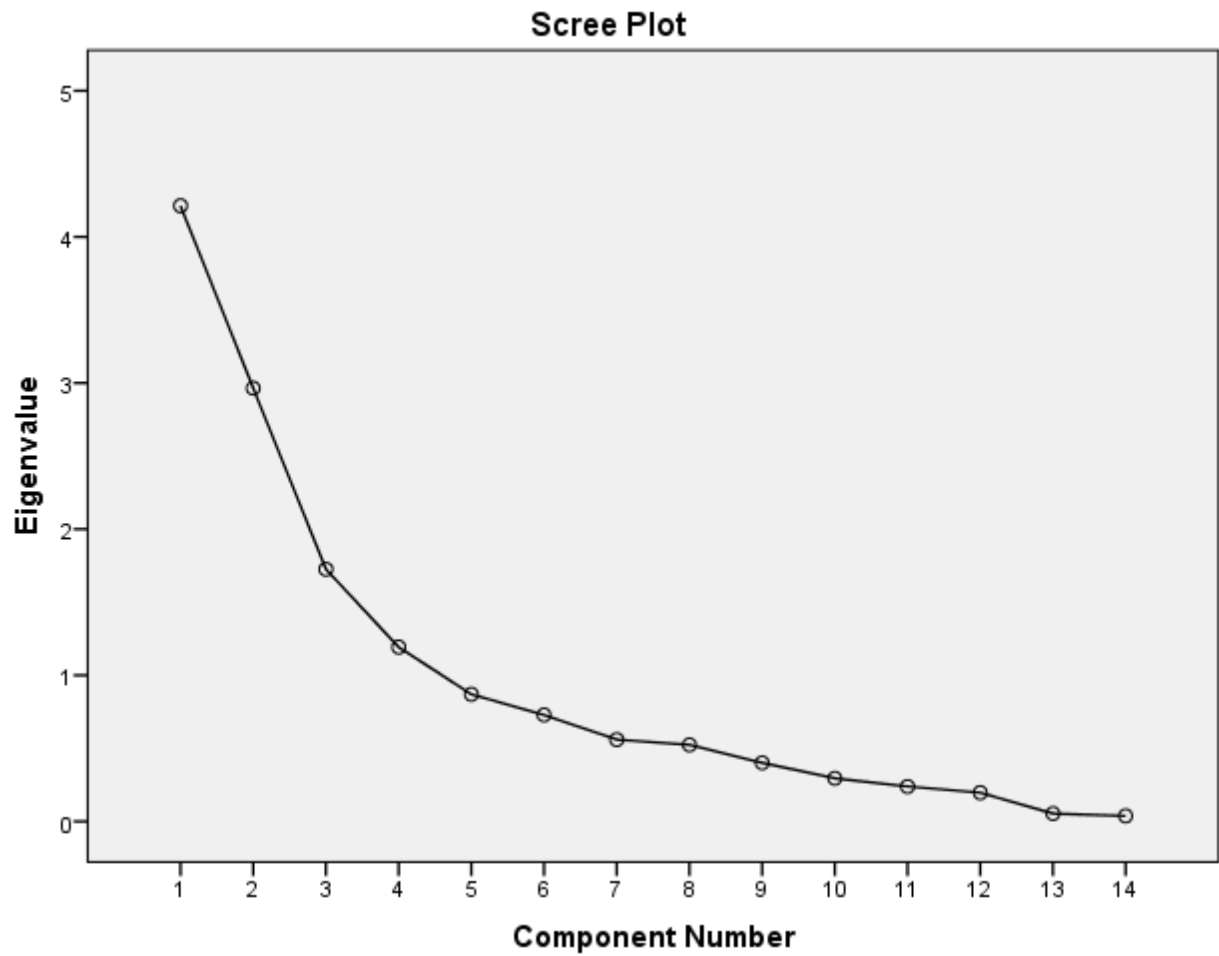


Figure 5.3: Screeplot with Eigenvalues distribution with respect to each component.

The plot depicts a pronounced decline orientation from component 1 to 4 after which a similar pattern was maintained in the rest of the components.

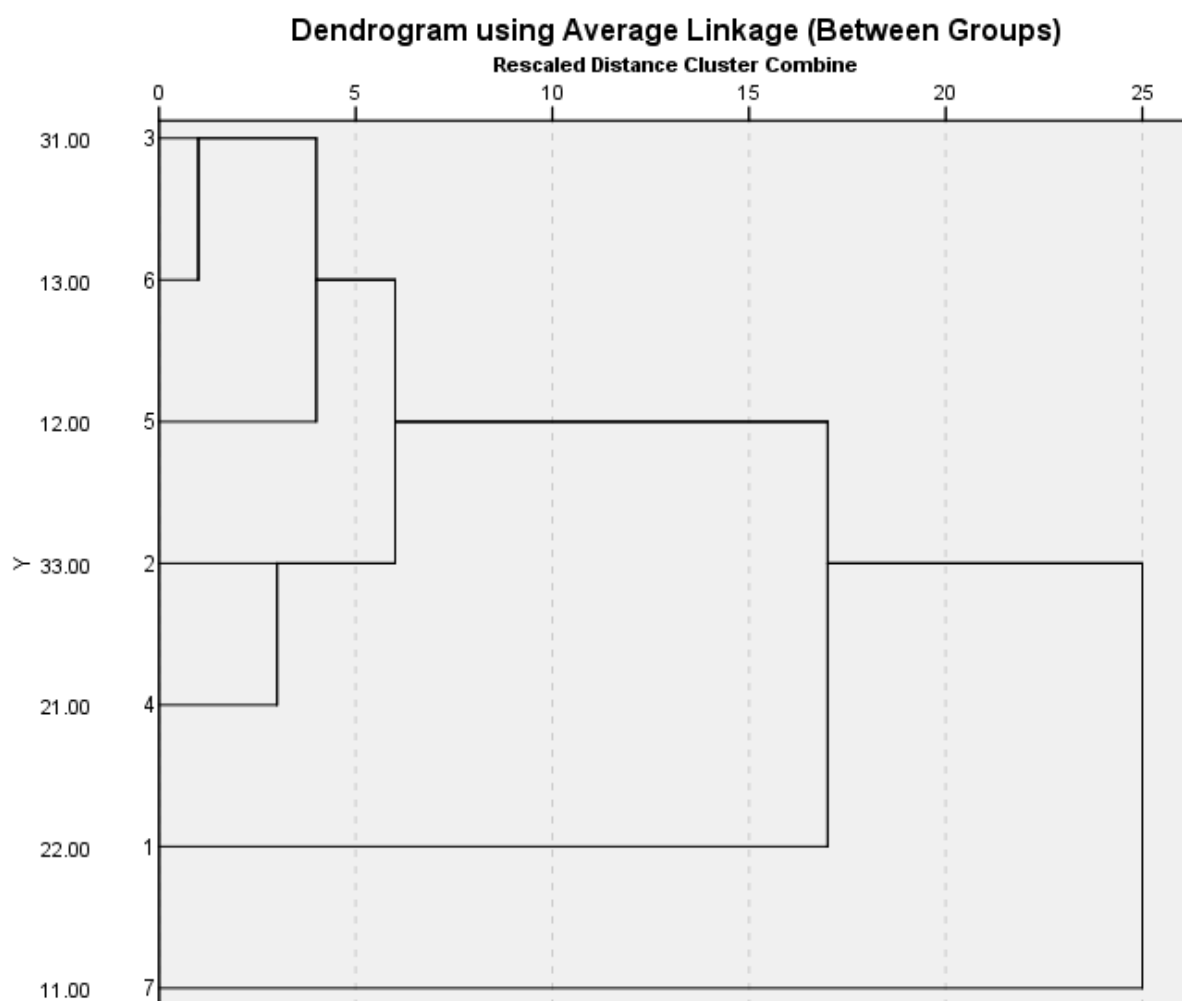


Figure 5.4: Dendrogram plot by Euclidean distance among the genotypes.

WAD, Balami and Uda are represented by 1, 2, 3, respectively while 12, 21, 33,31 are the crossbred sheep.

Table 5.15 shows that Component 1 was highly loaded with all the traits except HW, NC, RW, RL, WH, BL and RH. Component 2 has HL and TL with high loadings; while components 3 and 4 were highly loaded each with SW and FLL respectively. Component 1 has which contributed the most variance was highly loaded with the rump, body cephalic and heights measurement. Cephalic trait and tail were highly pronounced in the second component while component 3 and 4 were highly loaded with locomotive traits. The Communality values after Extraction were high and ranged between 0.524 - 0.863.

In Figure 5.3, WAD sheep was furthest to Balami followed by Uda sheep. UdaWAD and BalamiWAD sheep were the closest to the long-legged sheep (purebred Balami and Uda) while WADUda were close to the purebred WAD.

Tables 5.16: Correlations between birth weight (BW) and morphometric traits (MT) measurement of Purebred Balami at birth and at weaning.

		HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
	LW														
BW	1	0.75*	0.75*	0.89*	0.75*	0.96*	0.93*	0.84*	0.89*	0.75	0.89	0.98*	0.87*	0.89 [‡]	0.15
HL	0.41	1	0.60*	0.91*	0.82*	0.81*	0.78*	0.48	0.80*	0.60*	0.70*	0.70*	0.61*	0.80 [‡]	0.68*
HW	-0.18	0.17	1	0.55	0.92*	0.76*	0.72*	0.94*	0.87*	1*	0.95*	0.96*	0.82*	0.87 [‡]	0.08*
NC	0.14	0.63*	0.29	1	0.70*	0.90*	0.90*	0.56*	0.84*	0.55*	0.73*	0.73*	0.75*	0.84 [‡]	0.53*
TL	0.18	0.70*	0.39	0.86*	1	0.82*	0.75*	0.80*	0.88*	0.92*	0.90*	0.91*	0.76*	0.88 [‡]	0.36
HG	-0.03	0.41	0.52*	0.80*	0.87*	1	0.95*	0.80*	0.92*	0.76*	0.90*	0.89*	0.86*	0.92 [‡]	0.29
RW	-0.12	0.10	0.02	0.66*	0.60*	0.72*	1	0.76*	0.95*	0.72*	0.88*	0.88*	0.90*	0.95 [‡]	0.39
RL	-0.00	0.15	0.35	0.53*	0.62*	0.77*	0.76*	1	0.84*	0.94*	0.95*	0.95*	0.87*	0.84 [‡]	-0.12
WH	0.24	0.71*	0.56*	0.67*	0.86*	0.71*	0.16	0.34	1	0.87*	0.95*	0.95*	0.94*	1*	0.40
EL	-0.15	0.20	0.64*	0.71*	0.63*	0.81*	0.72*	0.83*	0.43	1	0.95*	0.96*	0.82*	0.87 [‡]	0.08
FLL	0.19	0.43	0.47*	0.57*	0.36	0.38	-0.02	0.09	0.57*	0.37	1	0.99	0.90*	0.95 [‡]	0.17
RLL	0.12	0.36	0.59*	0.53*	0.34	0.45	-0.08	0.09	0.56*	0.39	0.83*	1	0.91*	0.95 [‡]	0.17
BL	0.18	0.72*	0.52*	0.79*	0.71*	0.65*	0.39	0.47	0.64*	0.68*	0.60*	0.60*	1	0.94 [‡]	0.20
SW	0.02	0.16	0.55*	0.63*	0.48*	0.72*	0.54	0.70	0.39	0.81*	0.66*	0.62*	0.67*	1	0.40
RH	0.16	0.67*	0.53*	0.67*	0.75*	0.64*	0.08	0.12	0.93*	0.34	0.69*	0.68*	0.63*	0.37	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.16 shows the correlations between BW and all MTs were not significant. High correlation values were obtained in HL/NC, HL/TL, HL/WH, HL/BL and HL/RH. Medium significant ($p < 0.005$) correlation values were obtained in HW/HG, HW/WH, HW/EL, HW/RL, HW/BL, HW/SW and HW/RH. NC showed medium to high significant correlations with all the MTs with r values ranging from 0.53 – 0.86. TL and HG also correlated significantly with all the MTs except for FLL and RLL. RW and RL correlated significantly with RL, EL and SW. WH showed significant correlations with all height traits like FLL, RLL RH as well as with BL. EL showed significant correlations with BL and SW. FLL, RLL and BL were significantly correlated with the rest of the MTs. TL/HG had the highest correlated value of 0.88 while the lowest value of 0.49 was found in TL/SW. At weaning, there were strong correlations ($p < 0.005$) between BW and all the morphometric traits except with RH. HG and RW showed the highest correlations and the least was found in the RH.

Table 5.19 shows the estimate of Correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred BW at birth and at at weaning. There were no significant correlations between BW and MTs. RL/FLL showed the high significant negative value of -0.60 while the highest significant positive value of 0.99 was obtained in WH/RH. BW correlated highly and significantly with all the measured morphometric traits at weaning. Also, similar trend was observed among other morphometric traits.

Table 5.17: Correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred BalamiWAD at birth and at weaning

BW		HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
	LW														
BW	1	0.62*	0.03	0.72*	0.56*	0.75*	0.91*	0.79*	0.7*	0.81*	0.88*	0.66*	0.70*	0.60*	0.79*
HL	0.29	1	0.61*	0.80*	0.75*	0.52*	0.63*	0.58*	0.75*	0.72*	0.72*	0.90*	0.73*	0.86*	0.81*
HW	-0.05	0.65*	1	0.66	0.37	0.43	0.17	0.00	0.44	0.35	0.35	0.74	0.60	0.70	0.44
NC	0.26	0.52*	0.44	1	0.68	0.69	0.85*	0.56	0.80*	0.92*	0.74	0.87*	0.92*	0.90*	0.73
TL	0.37	0.34	0.35	0.38	1	0.40	0.63	0.87*	0.84*	0.70	0.52	0.64	0.83*	0.88*	0.73
HG	0.23	0.18*	0.47	0.25	0.67*	1	0.61	0.55	0.83*	0.55	0.93*	0.80*	0.74	0.64	0.85*
RW	0.10	0.04	0.33	0.21	0.47	0.80	1	0.73	0.75	0.97*	0.73	0.63	0.79*	0.70	0.64
RL	-0.12	-0.12	0.27	0.29	0.50*	0.63*	0.52*	1	0.86*	0.67	0.67	0.52	0.74	0.70	0.78
WH	0.45	0.23	0.13	0.27	0.92*	0.61*	0.49*	0.27	1	0.74	0.86*	0.84*	0.93*	0.90*	0.94*
EL	0.24	-0.38	-0.55*	0.11	0.08	-0.42	-0.30	0.07	0.11	1	0.67	0.70	0.84*	0.79*	0.62
FLL	0.39	0.70*	0.28	0.32	0.20	-0.07	-0.04	-0.59*	0.29	-0.20	1	0.87*	0.74	0.70	0.93*
RLL	0.30	0.80*	0.31	0.15	0.18	-0.17	-0.17	0.01*	0.21	-0.22	0.91	1	0.83*	0.88*	0.89*
BL	0.16	0.23	0.41	0.34	0.84*	0.48*	0.20	0.31	0.75*	0.02	0.28	0.19	1	0.95*	0.81*
SW	-0.05	0.03	0.13	0.11	0.17	-0.11	#REF!	-0.22	0.19	0.03	0.18	0.11	0.57*	1.00	0.82*
RH	0.40	0.15	0.08	0.26	0.89*	0.60*	0.52*	0.27	0.99*	0.12	0.26	0.15	0.74*	0.19	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.18: Correlations between birth weight (BW) and morphometric traits (MT) measurement of purebred Uda at birth and at weaning

UU	LW	HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
BW	1	0.62	0.03	0.72	0.56	0.75	0.91*	0.79	0.80*	0.81*	0.89*	0.66	0.69	0.60	0.78
HL	-	1	0.61	0.80*	0.75	0.52	0.63	0.58	0.75	0.72	0.72	0.90*	0.73	0.86*	0.81*
	0.41														
HW	0.17		1	0.66	0.37	0.43	0.17	0	0.44	0.35	0.35	0.74	0.60	0.70	0.44
NC	0.15	-0.07	0.43	1	0.68	0.69	0.86*	0.56	0.81*	0.93*	0.74	0.87*	0.93*	0.91*	0.73
TL	0.41	-0.00	0.34	0.48	1	0.40	0.63	0.87*	0.84*	0.69	0.52	0.64	0.83*	0.88	0.73
HG	0.37	-0.24	0.30	0.64*	0.62*	1	0.61	0.55	0.83*	0.55	0.93*	0.80*	0.75	0.64	0.86*
RW	0.08	0.35	0.20	0.36	0.82*	0.33	1	0.73	0.75	0.97*	0.73*	0.63	0.79*	0.69	0.64
RL	0.32	0.07	0.12	-0.04	0.72*	0.16	0.63*	1	0.87*	0.67	0.67	0.52	0.74	0.69	0.78
WH	0.09	0.11	0.18	0.08	0.73*	0.57	0.68*	0.46	1	0.74	0.87*	0.84	0.93*	0.90*	0.95*
EL	-	0.54	-0.06	-0.13	0.23	0.04	0.39	0.38	0.43	1	0.67	0.69	0.85*	0.79*	0.62
	0.08														
FLL	0	0.28	0.15	-0.07	0.41	0	0.71*	0.22	0.65*	0.38	1	0.87*	0.74	0.69	0.94*
RLL	0	0.22	0.27	-0.09	0.32	-0.03	0.61*	0.13	0.57	0.27	0.95*	1	0.83*	0.88*	0.9*
BL	-	0.42	0.22	0.10	0.57	-0.10	0.61	0.60	0.40	0.47	0.37	0.33	1	0.96*	0.81*
	0.11														
SW	-	-0.04	0.07	0.19	-0.08	0.12	-0.40	-0.24	-0.09	0	-0.54	-0.53	0.21	1	0.82*
	0.25														
RH	0.20	0.42	-0.19	-0.43	0.32	-0.17	0.47	0.37	0.54	0.37	0.74*	0.74*	0.44	-0.40	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.18 shows correlations between birth weight (BW) and morphometric traits (MT) measurement of purebred Uda at birth and at at at weaning. BW did not correlate significantly with all the MTs. Correlations of HL, HW and HG with other MTs was insignificant. NC/HG, TL/RW, TL/RL, TL/WH had significant correlated values of range of 0.64 – 0.83. RW showed significant correlations with RL, WH, and FLL. RL and WH had no significant relationship with other MTs except for WH/FLL. EL, BL SW and RH showed significant correlations with other MTs. Highest correlation value, 0.96 was obtained in FLL/RLL. FLL/RH and RLL/RH were significantly correlated. At weaning, BW showed significant ($p<0.005$) relationship with only EL, FLL and RW

Table 5.19: Correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred Uda x WAD (UW) at birth and at weaning

Corr UW	LW	HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
BW	1	0.62	0.03	0.71	0.56	0.75	0.91*	0.78	0.79*	0.81*	0.88	0.66	0.69	0.60	0.78
					2						*				
HL	0.44	1	0.61	0.80*	0.75	0.52	0.63	0.57	0.75	0.72	0.72	0.90*	0.73	0.86*	0.81*
					*										
HW	0.21	0.24	1	0.65	0.36	0.42	0.17	0	0.43	0.35	0.35	0.73	0.59	0.70	0.44
NC	0.55*	0.37	-0.23	1	0.67	0.69	0.85*	0.55	0.80*	0.92*	0.74	0.87*	0.92*	0.90*	0.72
TL	0.05	0.53*	0.14	0.24	1	0.40	0.63	0.87*	0.84*	0.69	0.52	0.63	0.83*	0.88*	0.73
HG	-0.29	-0.19	-0.14	0.13	0.32	1	0.61	0.54	0.83*	0.54	0.80	0.93*	0.74	0.64	0.85*
											*				
RW	0.40	0.11	0.25	-0.08	-0.07	-0.45	1	0.72	0.75	0.97*	0.72	0.63	0.79*	0.69	0.64
RL	0.18	-0.30	0.12	-0.21	-0.15	-0.27	0.85*	1	0.86*	0.66	0.66	0.52	0.742	0.69	0.78
WH	-0.46	-0.20	-0.01	-0.55*	0.15	0.24	-0.29	-0.06	1	0.74	0.86	0.84*	0.93*	0.90*	0.94*
											*				
EL	-0.07	0.01	0.25	-0.25	0.07	-0.10	0.23	0.21	0.60*	1	0.66	0.69	0.84*	0.79*	0.62
FLL	-0.25	0.30	0.14	-0.01	0.60	0.70	-0.58*	-0.58*	0.38	0.02	1	0.87*	0.74	0.69	0.93*
					*	*									
RLL	-0.18	0.34	0.22	-0.04	0.55	0.58	-0.57*	0.02*	0.31	0.11	0.95	1	0.83*	0.88*	0.89*
					*	*					*				
BL	-0.38	-0.21	-0.05	-0.11	0.21	0.53	-0.20	-0.14	0.28	0.29	0.46	0.43	1	0.95*	0.81*
						*									
SW	0.03	0.23	-0.03	0.28	0.32	0.02	-0.27	-0.36	0.31	0.41	0.22	0.11	0.35	1	0.82*
RH	-0.41	-0.25	-0.05	-0.52*	0.06	0.18	-0.27	-0.06	0.97*	0.67*	0.28	0.25	0.28	0.35	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.19 shows the estimate of Correlation between birth weight (BW) and morphometric traits (MT) measurement of crossbred Uda x WAD (UW) at birth and at weaning. There were no significant correlations between BW and the MTs except with NC. There were significant correlations in HL/TL, NC/WH, TL/FLL, TL/RLL, HG/FLL, HG/RLL, HG/BL, RW/RL, RW, FLL, RL/FLL, RL/RLL, WH/EL, WH/RH, EL/RH and FLL/RLL. RL/FLL and RL/FLL showed negative significant correlation values of -0.58 and -0.57 respectively. BW showed significant correlations with all the morphometric traits at weaning. Positive and low to average correlation values were observed among other such as RH, BL, EL and RW.

Table 5.20: Correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred WAD x Balami (WB) at birth and at weaning

Corr WB	RealBW	HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
RealBW	1	0.62	0.03	0.72	0.56	0.75	0.94*	0.79	0.79*	0.81*	0.88*	0.66	0.70	0.60	0.79
HL	-0.00	1	0.61	0.80*	0.75	0.52	0.63	0.58	0.75	0.72	0.72	0.90*	0.73	0.86	0.81*
HW	-0.02	0.60*	1	0.66	0.37	0.43	0.17	0.00	0.44	0.35	0.35	0.74	0.60	0.70	0.44
NC	0.06	-0.22	-0.44	1	0.68	0.69	0.85*	0.56	0.80*	0.92*	0.74	0.87*	0.92*	0.90	0.73
TL	-0.39	0.18	0.18	0.05	1	0.40	0.63	0.87*	0.84*	0.70	0.52	0.64	0.83*	0.88	0.73
HG	-0.35	0.14	0.15	0.00	0.89*	1	0.61	0.55	0.83*	0.55	0.93*	0.80*	0.74	0.74	0.85*
RW	-0.13	-0.00	-0.15	0.40	0.67*	0.58*	1	0.73	0.75	0.97*	0.73	0.63	0.79*	0.70	0.64
RL	-0.34	0.06	-0.07	0.43	0.81*	0.70*	0.93*	1	1	0.67	0.67	0.52	0.74	0.70	0.78
WH	-0.43	0.15	0.36	-0.30	0.51	0.63*	-0.18	0.07	0.79*	0.74	0.86*	0.84*	0.93*	0.90	0.94*
EL	-0.39	0.17	0.36	-0.23	0.88*	0.80*	0.29	0.49	0.73*	1	1	0.70	0.84	0.79*	0.62
FLL	-0.17	0.13	0.39	-0.25	0.70*	0.62*	0.13	0.29	0.74*	0.85*	1	0.87*	0.74	0.70	0.93*
RLL	-0.26	0.17	0.29	-0.20	0.72*	0.69*	0.15	0.32	0.81*	0.80*	0.94*	1	0.83*	0.88	0.89*
BL	0.05	0.13	0.31	-0.37	0.53	0.64	0.10	0.10	0.64	0.62	0.79	0.83*	1	0.95	0.81*
SW	0.16	0.13	0.34	-0.49	0.43	0.42	0.00	-0.04	0.46	0.55*	0.73*	0.71*	0.93*	1	0.82*
RH	-0.38	0.18	0.31	-0.25	0.51	0.61*	-0.19	0.07	0.98*	0.73*	0.77*	0.84*	0.64*	0.47	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.20 shows the correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred WAD x Balami (WB) at birth and at at at weaning. Correlated values for BW and MTs were not significant. All MTs except BL and SW were negatively correlated with BW. HL was significantly correlated with HW. There were high positive correlations in TL/HG, TL/RL, TL/EL, TL/FLL, TL/RLL and TL/BL. HG showed a positive medium correlation values with RW, RL, WH, EL, FLL, RLL, BL and RH. Correlation between RW/RL had the highest value of 0.93. RW/RL was significantly correlated. There were significant correlation values between WH and other MTs except for SW. EL, FLL and RLL showed significant correlations with other MTs. BL also showed significant correlations with SW and RH. At weaning, BW showed positive but insignificant correlations with HW, TL, HG, EL, FLL, RLL and BL while low, average to high correlations were observed in other traits

Table 5.21: Correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred WAD x Uda (WU) at birth and at weaning

Corr WU	RealBW	HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
RealBW	1	0.62	0.03	0.72	0.56	0.75	0.91*	0.79	0.79*	0.81*	0.88*	0.66	0.70	0.60	0.79
HL	-0.16	1	0.61	0.80*	0.75	0.52	0.63	0.58	0.75	0.72	0.72	0.90*	0.73	0.86*	0.82
HW	-0.40	-0.32	1	0.66	0.37	0.43	0.17	0.00	0.44	0.35	0.35	0.74	0.60	0.70	0.44
NC	0.30	0.63*	-0.51	1	0.68	0.69	0.85*	0.56	0.80*	0.92*	0.74	0.87*	0.92*	0.90*	0.73
TL	0.28	0.55	-0.33	0.46	1	0.40	0.63	0.87*	0.84*	0.70	0.52	0.64	0.83*	0.88*	0.73
HG	0.44	0.67*	-0.39	0.68*	0.90*	1	0.61	0.55	0.83*	0.55	0.93*	0.80	0.74	0.64	0.85*
RW	-0.04	0.54	-0.25	0.67*	0.55	0.58*	1	0.73	0.75	0.97*	0.73	0.63	0.79*	0.70	0.64
RL	-0.16	0.12	0.04	0.33	-0.02	0.05	0.78*	1.00	0.86*	0.67	0.68	0.52	0.74	0.70	0.78
WH	0.59*	-0.06	-0.10	-0.05	0.69*	0.57	-0.07	-0.44	1	0.74	0.86	0.84*	0.93*	0.90*	0.94*
EL	0.56	0.46	-0.21	0.41	0.86*	0.90*	0.32	-0.15	0.78*	1	0.67	0.70	0.84*	0.79*	0.62
FLL	0.57	-0.22	-0.29	0.05	0.41	0.32	-0.31	-0.67*	0.77*	0.43	1	0.87*	0.74	0.70	0.93
RLL	0.13	0.53	-0.26	0.26	0.53	0.59*	0.23	-0.09	0.35	0.52	0.07	1	0.83*	0.88*	0.89*
BL	0.35	-0.38	-0.01	0.02	0.05	0.00	0.01	0.04	0.25	0.09	0.38	-0.73	1	0.95*	0.81*
SW	0.32	0.66*	-0.33	0.73	0.86*	0.93*	0.81*	0.36	0.39	0.80*	0.08	0.47	0.05	1	0.82*
RH	0.60*	0.00	0.15	0.02	0.72*	0.62*	-0.07	-0.49	0.99*	0.81*	0.80*	0.38	0.22	0.42	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.21 shows the correlations between birth weight (BW) and morphometric traits (MT) measurement of crossbred WAD x Uda (WU) at birth and at at at weaning. There was significant correlation of 0.61 between BW and RH. HL was significantly correlated with NC, HG and SW. HW had no significant correlations with other MTs. There were significant correlations between NC and RH, SW, BL, RW and HG. There were significant correlation values of 0.90, 0.69, 0.87, 0.86 and 0.72 with HG, WH, EL, SW and RH respectively. There were high correlation values of 0.91 and 0.93 in HG/EL and HG/SW respectively. RW had significant correlations with RL and SW. There was negative correlation of -0.67 and 0.77 between RL/FLL and RL/RLL respectively. WH showed significant correlation with EL, FLL and RH. There were significant correlations in EL/SW and EL/RH. FLL and RLL showed significant correlation values of 0.81 and -0.73 respectively for RH and BL. There were no significant correlations between BW and all the morphometric traits. However, positive and significant relationships were observed in some of the traits.

Table 5.22: Correlations between birth weight (BW) and morphometric traits (MT) measurement of Purebred WAD at birth and at weaning

Corr		HL	HW	NC	TL	HG	RW	RL	WH	EL	FLL	RLL	BL	SW	RH
WW	LW														
BW	1	0.62	0.03	0.72	0.56	0.75*	0.91*	0.79	0.79*	0.81*	0.88*	0.66	0.70	0.60	0.79
HL	-0.27	1	0.61	0.80*	0.75	0.52	0.63	0.58	0.75	0.72	0.72	0.90*	0.73	0.86*	0.81*
HW	-0.04	-0.01	1	0.66	0.37	0.43	0.17	0.00	0.44	0.35	0.35	0.74	0.60	0.70	0.44
NC	-0.08	-0.10	0.46	1	0.68	0.69	0.85*	0.56	0.80*	0.92*	0.74	0.87*	0.92*	0.90*	0.73
TL	-0.19	-0.01	-0.21	-0.18	1	0.40	0.63	0.87*	0.84*	0.70	0.52	0.64	0.83*	0.88*	0.73
HG	0.24	-0.56	-0.17	0.10	0.56	1	0.61	0.55	0.83*	0.55	0.93*	0.80*	0.74	0.64	0.85*
RW	0.19	-0.32	-0.27	-0.16	0.72*	0.68*	1	0.73	0.75	0.97*	0.73	0.63	0.79*	0.70	0.64
RL	0.17	-0.34	-0.30	-0.14	0.72*	0.70*	0.99*	1	0.86*	0.67	0.67	0.52	0.74	0.70	0.78
WH	0.29	-0.03	0.14	-0.30	0.44	0.23	0.68*	0.63*	1	0.74	0.86*	0.84*	0.93*	0.90*	0.94*
EL	-0.24	-0.25	0.46	0.34	0.13	-0.05	0.09	0.09	0.34	1	0.67	0.70	0.84*	0.79*	0.62
FLL	0.16	-0.02	0.27	-0.14	0.31	0.24	0.54*	0.50	0.91*	0.42	1	0.87*	0.74	0.70	0.93*
RLL	0.06	0.15	0.41	-0.07	-0.12	-0.13	-0.04	-0.05	0.54*	0.53*	0.70*	1	0.83*	0.88*	0.89*
BL	0.39	-0.26	-0.23	-0.44	0.47	0.32	0.36	0.32	0.25	-0.30	0.03	-0.43	1	0.95*	0.81*
SW	-0.27	-0.37	0.44	0.53*	0.15	0.07	0.11	0.12	0.19	0.95*	0.27	0.32	-0.28	1	0.82*
RH	0.38	-0.05	-0.03	-0.31	0.38	0.23	0.57*	0.53*	0.84*	0.30	0.79*	0.50	0.31	0.17	1

* means correlation with significant ($P \leq 0.05$) value. The vertical correlation grid is the correlation of traits at birth while the horizontal correlation is for weaning.

Table 5.22 shows correlations between birth weight (BW) and morphometric traits (MT) measurement of Purebred WAD at birth and at weaning. There were not significant correlations between the BW and MTs. There was negative correlation value of -0.56 in HL/HG. The correlations between TL and HG, RW, RL were significant. The correlation values between HG and RW, RL were significant. RW correlated significantly with RL, WH, FLL and RH. RL showed significant correlations with WH and RH. There were high significant correlation values between WH/FLL and WH/RH of 0.92 and 0.85 respectively. EL showed significant correlations with RLL and SW. There were also high correlation values between FLL/RLL and FLL/RH. At weaning, BW correlated significantly with NC, EL, BL and SW. However, very few significant correlations were found among other traits.

5.6 Discussion

The repeatability estimates obtained from this study were generally high. Buvanendra and Adu (1990) reported lower repeatability estimates at birth and 10th week respectively for Balami sheep. The variance in this present study may be due to the timely acclimatisation of the sheep prior to breeding and with advantage of carrying out the investigations in Kwara state which has similar weather to that of the North, where the sheep were known to thrive well. Repeatability estimates for weights in this work for birth and weaning are generally higher than the ones reported by McNaughton and William (1956); Sidwell and Grandstaff (1949) Canada range sheep and Navajo and Navajo crossbred ewes respectively. The difference can be attributed to the season of breeding which is more favourable in the present study. Balami, Uda and WAD ewes from the present study showed high performance repeatability which will facilitate selection in the future because culling is usually based on weaning weights McNaughton and William (1956).

Generally, all the dams had high repeatability estimate for weight loss during lactation and this may be as a result of breeding them, especially Balami and Uda, outside their natural abode and which had effect on their body conformation during lactation as most of them looked haggard and emaciated for a period of time during the study. Buvanendra and Adu (1990) had observed that the best performance of the Nigerian large sheep, especially Balami, is in the Northern part of the country. WAD dams also showed very high repeatable tendency for weight loss in association with disease epidemics and morbidity especially during raining season that lambing occurred. Despite the effect of change in environment, Balami and Uda dams still had fairly high to average repeatability values for milk yield and milk suckled which has been attributed to the management choice that ensured adequate flushing prior to breeding and unlimited access to feed and water during nursing period (Cannas, 2004). Bonsma (1939), observed the importance of dam milk yield when he concluded that weight

and growth of purebred and crossbred South African Merino lambs was less for lambs born to poor milking dams. All the repeatability estimates are favourable to the birth, weaning and yearling weights of the sheep which is depicted in the respective values in the growth performance. For instance, from the birth weights, the purebred Balami followed by Uda, demonstrated superiority in birth weight compared to the rest of the groups as breed effect was evident and this result agrees with the findings of Momoh *et al.* (2013); Combella *et al.* (1990). The birth and live weights of WAD lambs are similar to the findings of Fasae *et al.* (2012). The lambs by the WAD dams were significantly smaller than the ones by both Balami and Uda dams and this could be as a result of the effect of the large size, thereby accommodating the big developing fetus as well as providing adequate nourishment through the body reserves. The results from the present study on the estimate value for heritability at birth for purebred WAD and Uda are similar to the ones reported by McNaughton and William (1956); Blackwell and Henderson (1955). Up to week 4, all the genotypes except WB, showed positive heritability for weight, during the consecutive three breeding years when purebred Balami and BW had negative heritability. In addition, all the purebred genotypes had negative heritability estimates at weaning and yearling with the crossbred except BW, having excellent estimate values. The negative heritability estimates from the present study may be due to sampling error and few number of records. Although, Duguma *et al.* (2002); Lee *et al.* (2009); Mroczkowski *et al.* (1981); Olivier *et al.* (2001) and Piwczyński (2009) all reported negative and very low heritability estimates for Black Merino sheep: such as -0.0720 - 0.203 for fertility; number of lambs born with previous parity (-0.060 - 0.260); number of lambs reared by the dam (-0.039 - 0). The weaning estimate from the present study is higher than the report by Orhan (1997); McNaughton and William (1956) with WU having similar value with the latter author. Although, the purebred sheep had commendable estimate values for heritability at the early phase of growth but could not

match the excellent performance of the crossbred at weaning and yearling stages. Therefore, the choice and place for the breeding investigation maybe adequate for improving the WAD sheep. The poor estimate values gotten especially for the WAD during the later part of the growing phase was not desired and unexpected as they were reared in their adapted environment and this can be linked to the incessant infection and disease challenge faced during the investigation which the affected animals could not combat, despite timely intervention by the researchers. Also, because selection is not made based on birth weight but weaning weight, this reflect the prudence in the present work with regards to the later performance of the crossbred which is the hallmark for selection.

The result of the present study on the traditionally managed sheep was similar to other authors' works such as Yunusa *et al.* (2013b) for sheep. The prudence and appropriateness in the use of PCA as a multivariate statistical tool to describe these Nigerian breeds of sheep was apparent in the reduction of 14 traits to just 3 components which offered a vivid and all-encompassing description of their sizes and shapes. Verma *et al.* (2015) reported that PC could be used in breeding programs with sufficient reduction in the number of biometric traits to be recorded to explain body conformation. The correlations between components were zero and this will facilitate selection of sheep which will produce selection response in terms of the Principal Components (Pinto et al, 2006). The value (54.706%) contributed by the PC1 of this study, which bears two of the traits (HG and RW) as that found in the work of Khargharia *et al.* (2015) on Assam Hill goat of India, was greater than the 40.37% recorded by these authors but low compared to the 67.7% submitted by Salako (2006). This gap might be due to the formation of just 2 components by the authors as compared to the 3 from this study. The communality values for EL and TL (PC2) were high and had same variable of the same component recorded by Yakubu and Ayoade (2009) on Pseudoruminant mammals (rabbit). Parés-Casanova (2013) reported that the first two principal components could be

conveniently used in the estimation and comparison of ruminant animals. Hence, this could provide an opportunity to select the animals based on a small group of traits rather than on isolated traits. The Balami and Uda sheep have relatively big ears and long tails compared to the WAD sheep hence, the appropriateness of the use of the PC2 to describe these breed of sheep. Also, one of the distinctive features used to characterised Nigerian breeds of sheep is the length of legs. The Northern sheep in Nigeria are often referred to the Long-Legged while the South-West are called the Short-Legged. These facts make the weakest but relevant component (PC3) appropriate in describing the Nigerian breeds of sheep. The first function which comprises of TL, EL, BL, RL, RLL and FLL significantly predicts and distinguishes Balami, Uda and WAD. TL was found to be most discriminating of the six traits contained in the first function. The result from this study is in agreement with respect to TL, EL, RLL, with the work of Yunusa *et. al.*, (2013b) where TL, EL, and RLL were loaded in the first function for Balami, Uda, Yankassa and WAD sheep. The present result also agrees with Salako and Ngere (2002) where TL was found to be the most discriminating variable between Yankassa and WAD. The variables in the first function have been used as characteristic features to describe the Nigerian breeds of sheep. Balami and Uda sheep have been describe to possess long legs, long tails and long drooping ears while the WAD are known to have shorter the same features (Roger Blench, 1999). The present result was similar with the report of Agievezor *et al.* (2012) where tail length, rump height, chest girth, ear length and chest depth as the most discriminating variables to separate WAD, Yankasa, Uda and Balami sheep. The correct and incorrect classifications of the breeds showed the frequency of introgression in the Northern sheep towards the south. The correct classification for the WAD component was found to be the highest with less than 10% misclassified. The high number of Uda misclassified as Balami and vice versa in this study follows the same trend with the reports of Yakubu and Ibrahim (2011). This could be as result of alarming rate of

introgressions of genes between these two breeds. The continual practice of crossbreeding both breeds for some certain phenotypes like white coat colour and the pendulous ears found in Balami sheep might be the cause of introgression. Also, introgression in these breeds of sheep could be traced to massive migration of rams from North to South during festivals and the seasonal trans-human activities in the country where northern animals move southwards during dry season for grazing which could lead to interbreeding of sheep of different agro ecological zones. The incessant activities of Fulani pastoralists will continuously lead to indiscriminate flock movement and traditional livestock movement (Yakubu *et al.* 2010b). Traore *et al.* (2008) also noticed the indiscriminate movement between the Sahelian and Sudan-Sahelian (Mossi) sheep of Burkina-Faso. This result corroborates the findings of Agiviezor *et al.* (2012b) who reported generally, a poor genetic differentiation fixation index among the breeds of Nigerian sheep have been reported by Yakubu *et al.* (2010b), and indiscriminate mating and reduced grazing lands have been implicated as the causes. The farthest genetic distance was obtained between WAD and Balami sheep which was in contrary with the report of Yunusa *et al.*, (2013b). The distance between Balami and Uda was about small and this confirms the similarity and resemblance of both breeds with respect to their body sizes. From the outcome of this analysis, it is expected that Balami and Uda shared the highest number of alleles while Balami and WAD shared the least number of alleles. The result from this study revealed a dire need at improving WAD sheep with Balami. This observation is in variance with Yunusa *et al.*, (2013b) who concluded the Uda sheep should be used at improving the WAD and this may be due to more sampled animals in the present study. Also, Balami sheep, from the mean effects of the morphometric traits on the breeds table, is the largest and this supports the works of authors at asserting Balami to be the largest breed sheep in Nigeria, (Farid *et al.*, 2000). Based on the result of this morphometric analysis,

Uda and Balami sheep were expected to have shared the highest number of allele while Uda and WAD were expected to share the least number of allele.

The cause of negative correlations between traits can be deduced from Lush, (1984), when he observed that genes which have a beneficial effect on a trait and deleterious effect on another trait will have had their frequencies trimmed down to intermediate levels due to selection pressure which results in the genes contributing more to the additive genetic variance hence, negative correlations. The negative correlations between some traits which were more pronounced in the purebred, meant that selecting for such trait as Heart Girth (HG), will by itself cause deterioration of the other and since both and other btraits such as Birth Weight (BW) or Wither Height (WH) are equally important, thus selection for HG can be paused while BW is given more attention (Rae, 1952).

High phenotypic correlations between traits suggest appropriateness of PCA to classify traits. Previous research: Salako, (2006); Mulyono *et al.* (2009) reported significant correlations of most of these traits especially on Uda sheep. The overall high correlation values reported by these authors may be attributed to the stage of growth of animals used for that study. The use of animals during active growing phase means there is tendency for high correlation between body measurements. The animals used for this study comprised of day old, weaning and yearling categories of sheep and this might be the reason for some negative and relatively small correlation values.

The Principal Component analysis of the pure and crossbred Balami, Uda and WAD sheep resulted in traits reduction where only HW, NC, RW,RL, WH, BL, RH, HL, TL, SW and FLL loaded in the respective components, which can be used to describe the Balami, Uda, WAD and their crossbred. The variance accounted for due to loading of traits for component 1 from this present study, was low compared to the results of Yunusa *et al.*, (2013a); Peter *et al.*, (2012) and Yakubu and Ayoade, (2009) on Nigeria sheep, Djallonke and Sahel sheep and

rabbits respectively. The disparity in component variance might be as a result of the computation of the crossbred data and age differences of the animals used in the present study. The aforementioned authors maintained strictly, the use of purebred animals to measure the morphometric traits. Although, component 1 was expectedly, able to account for the largest portion of the total variance observed from this study, it could not be used solely to describe the purebred and crossbred WAD, Balami and WAD sheep. Also, because all loaded traits found in the same component have high correlation with the component after extraction, pleiotropy can be said to be implicated among the genes of the traits. Hence, this could facilitate selection of the animals based on a reduced group of traits which gives the prudence to principal component analysis. The pattern of loading trait, especially RL and WH in component 1, is similar to the report of Khargaria *et al.*, (2015) and Yunusa *et al.*, (2013a) on Assam Hill goat and Nigeria sheep respectively. Also, BL, WH, RH, and NC that were highly loaded in component 1 is in tandem with the reports of Peter *et al* (2012) for Djalonge and Sahel sheep. This underscores the importance of rump and heights measurements in describing the Nigeria sheep based on their morphometric traits. The high loading of HL in component 2 in this present study, is in variance with the report of Yunusa *et al.*, (2013a) on Uda and Balami sheep, while it tallies with the authors' work in the loading of TL in the same component. Although, TL was loaded in component 2, it marks a salient characteristic features distinguishing the WAD from the long legged sheep. The loading of SW in component 3 in this present work, is in variance to the reports of reports of Peter *et al* (2012) and Yunusa *et al.*, (2013a). The loading of FLL in this present study differs from the result reported by Yunusa *et al.*, (2013a). This is an indication that SW and FLL became less important as the broad appearance and leg traits of the sheep were fading out from the purebred and the crossbred of the long-legged sheep down to the purebred WAD. This is due to the improvement with respect to growth of the crossbred, which made them to compete

favourably with the long-legged purebred. However, one of the distinctive features used to characterised Nigerian breeds of sheep is the length of legs. The Northern sheep in Nigeria are often referred to the Long-Legged while the South-West are called the Short-Legged, which can make the weakest but relevant component (PC4) appropriate in describing the Nigerian breeds of sheep. The superiority of Balami sheep among the purebred sheep in this study was in disagreement to the reports of Yunusa *et al.*, (2013a) and this can be attributed to age categories of animals used for the present study. The closeness in distance between the Balami and Uda and the crossbred showed the shared alleles that took place in the process of crossbreeding. The furthest distance between WAD and the rest purebred left the crossbred at intermediated distance which suggests that the crossbred sheep shared more alleles with the giant sheep compared to the WAD sheep. Thus, the WAD sheep may have been improved as a result of increase in the number of alleles shared with the superior breeds.

Significant relationships between birth weight and morphometric traits were observed in all the crossbred except in WAD x Uda (WU). The relationship between measured morphometric traits and body weights of Sheep studied showed high and significant values at weaning. Even when the correlations between the BW and all the morphometric traits were insignificant, positive and significant relationship existed among other traits in the crossbred. This could be as a result of pleiotropic effect of the gene action influencing the traits. The crossbred Balami, (BW, WB) showed superiority in correlations with respective to birth weight and the measured traits and this was expected as the purebred Balami showed very high and positive correlations with BW and the traits measure. This points to the fact that both traits are highly correlated and suggests that an improvement for a particular body trait can initiate the improvement in body weight. Okpeku and Nodu (2013); Okpeku, (2010) observed similar trends in their work on sheep and goat respectively. However, there were more of low and non significant correlations between birth weights and other traits measured

and this could be due to the non active cell division stage of life of the lambs. At weaning, the cells are rigorously multiplying and growth pronounced hence, it reflected in the increase in the morphometric traits.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

The survey showed the superiority of Northern breeds (Balami and Uda) over the Southern West African Dwarf sheep. Male were also superior to female sheep in most of the morphometric traits considered. It is concluded that detailed breed description of Nigerian sheep genetic resources can be done using morphometric traits. However, such description would be influenced by age, sex and their interactions with the breeds under consideration.

The present study also revealed that besides disease outbreak encountered during this study, change of environment hence, inclements of weather, also affected dams and lambs' survivability, conception rate and still births. The result from the present study showed that birth and live weight and growth performance of the crossbred lambs competed favourably with purebred Uda and surpassed that of the purebred WAD. The male lambs had superior birth weights over the female lambs. Crossbred UW and WU showed superior percentage heterosis at birth except UW, suggesting improving the WAD sheep should be first considered by crossing with Uda sheep for weaning weight. The crossbred BW and UW were superior at weaning while their reciprocals showed negative heterosis. All Balami crosses were superior to the Uda crosses at yearling which means the Balami sheep can be used to achieve optimal yearling weights. The superiority in weight of the crossbred lambs over the purebred WAD showed that WAD can be improved with either of the two largest breeds of Nigerian sheep.

The results from this study show that lambs' birth weights were significantly influenced by Dam Age, Sire and Dam bred and Parity. The weights of lambs produced by the less than three - year ewes were significantly heavier than the ones by the less than two-year. Lambs produced by Balami sire and Balami dam were the most superior for birth weight followed by Uda and WAD. Birth weights of lambs increased with increase in parity. The interaction

between Parity and Dam breed, Sire breed and Dam breed significantly influenced lambs weights at birth. Also, all the genetic and non genetic factors significantly interacted to influence lambs birth weights. Thus, it can be established that numerous nongenetic genetic factors interact to influence the weight of the lambs at birth.

It was established from the present study that Balami, Uda and WAD ewes from the present study they showed high tendency of repeating the same performance in the future for birth, weaning and yearling weights. Although, culling is seldom done through birth weight estimates, dams producing heavy lambs at birth can be kept as birth weight acts as precursor of growth and live weight later in the future and this is in tandem with the report that birth weight has a synergistic effect on growth which is an essential yardstick when animals are raised for meat purpose. Dams showed high tendency of losing more weights during lactation in the future which could be due to disease outbreak during the study. Repeatibility estimates for milk yield were generally high which could be linked to adequate management of the sheep prior to pregnancy. The purebred lambs had superior heritability estimates during earlier growing phase but were later surpassed by the crossbred. Besides disease outbreak encountered during this study, inclements of weather also affected dams and lambs' survivability, conception rate and still births.

Most of the correlations among different biometric traits of the traditionnaly managed sheep were positive and significant and this suggested high predictability among the different traits, and also made them amenable for PC analysis. The eight parameters found in the three components: SW, NC, HG, RH, EL, TL, FLL and RLL were adequate to distinguish between the breeds. The present results may be explored to aid phenotypic selection which a means to enhancing body conformation. Tail length, Ear length, Body length, Rump Length, Rear and Fore leg length, because of their high discriminating ability, could be used to distinguishing between breeds of sheep that are indigenous to Nigeria. Also, large Euclidian distance

obtained for genetic gap between Balami and WAD sheep gives prospect for improvement if they are cross bred. Balami sheep with its large body size has been reared successfully in the hot arid region of Nigeria, thriving under the high ambient temperature. WAD sheep as well thrives in the trypano-endemic region of Southern humid Nigeria. With the wide genetic distance between the two populations, size of the body and trypano-tolerancy being mediocre in WAD and Balami respectively would be expected to improve in the hybrid.

The high correlations of birth weight with other parameters such as Heart Girth, in the crossbred suggested the adequate improvement of the WAD sheep. The data reduction analysis yielded cephalic, body and leg traits which can be used in describing the purebred and crossbred WAD, Balami and Uda sheep. The genetic distance between WAD, Balami, Uda and the crossbred showed the shared alleles that took place in the process of crossbreeding. The furthest distance between WAD and the rest purebred left the crossbred at intermediated distance and this may be as a result of the improvement of the WAD sheep. The correlation values for birth and live weights with morphometric traits measured for the crossbred bore similarity to that of the purebred Balami and in most cases, surpassed that of Uda and WAD. The high correlations of birth weight with other parameters such as Heart Girth, in the crossbred suggested the adequate improvement of the WAD sheep.

6.1 RECOMMENDATION

Further investigation of the results of the survey with molecular genetics study is imperative as the tendency for variations and deviations that occur in morphometric results when genetic studies were carried out. The use of the two giant

breeds of Nigerian sheep, Balami and Uda can be suggested at improving the WAD sheep for growth and hence, meet production. This study revealed that greatest improvement could be expected from the cross between Balami and WAD sheep.

Uda sheep should be given priority over the Balami sheep when weaning weight is the target while adequate yearling and survivability performance can be guaranteed with the use of Balami sheep.

As a result from the present study, effort should be directed at targeting lambing towards the dry season and to modify as much as possible, the environment to stabilise the introduced animals.

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