BIOMETRIC ASSESSMENT OF BODY WEIGHT AND BODY CONDITION SCORE IN YANKASA SHEEP

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DEGREE OF MASTER OF SCIENCE IN ANIMAL SCIENCE

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DECLARATION

I hereby declare that this work is the product of my own research efforts undertaken under the supervision of Professor T. Ibrahim, and has not been presented anywhere for the award of degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up(Ma'aruf Bashir Sani SPS/13/MAS/00009) were carried out under my supervision.

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APPROVAL PAGE

This is to certify that the research work reported here titled "Biometric assessments of body weight and body condition score in Yankasa sheep" has been examined and approved for the award of the Degree of MASTER OF SCIENCE IN ANIMAL SCIENCE of Bayero University, Kano.

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DEDICATION

This dissertation is dedicated to my ever supporting Dad Alhaji Ma'aruf Sani, my mum Hajiya Aisha Usman and my late lovely sister Mariya Muhammad Ibn Abdallah.

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ABSTRACT

The study was conducted to assess body weight, body condition score (BCS) and linear body measurements in Yankasa sheep in some selected local government areas of Kano State, namely, Bebeji (BBJ), Dawakin Kudu (DKD), Wudil (WDL), Shanono (SNN) and Dambatta (DBT). The animals were aged by dentition, weighed using a scale while linear body measurements were taken using measuring tape. Body condition score was determined twice a day based on a scale of 0-5 by two assessors. Variation in the traits and their relationships were analyzed using analysis of variance, Pearson correlation and step-wise regression analyses. For BCS, the experiment was conducted using a cross factor design and model III analysis of variance was carried out to determine the between sheep, and inter and intra assessor variation in the trait. The study revealed significant ($p<0.05$) variations across location, age group, physiological status and sex for all variables except for body length between locations, and BCS, tail length, head length and hind leg length across the sexes, as well as BCS across all physiological status. Bebeji recorded the highest average sheep weight of 26.27±0.80 kg while the lowest (22.80±0.84 kg) was observed in DBT. The highest BCS was also recorded in BBJ (2.37±0.10) while the least (1.60±0.11) was observed in DKD. There were strong positive correlations between live body weight and most of the linear body measurements as well as between the former and BCS. Repeatability and reproducibility of BCS were very high (0.828-0.982 and 0.791-0.939 respectively). Regression method of weight determination was second to weighing scale in terms of accuracy. Linear body measurements could serve as predictors and used in selection criteria to

increase body weight. The use of regression procedure to estimate body weight is also recommended in the absence of scale.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

In sub-Sahara Africa particularly Nigeria, livestock play important role in agriculture contributing about 12.7% of the entire agricultural domestic product (CBN, 1999). The country is one of the four leading livestock producers in the regionFAOSTAT (2006).Estimates from the Federal Livestock Department (FLD) by Federal Ministry of Agriculture in 2010 showed that there are 16,577,962 cattle, 56,524,075 goats (Yemi, 2010) and 57.8 million sheep (FAO, 2012)

Sheep (*Ovisaries*) are quadruped ruminant mammals typically kept as livestock. Like all ruminants, sheep are members of the order Artiodactyla, the even toed ungulates. It is one of the earliest animals to be domesticated for agricultural purpose. Sheep is raised for fleece, meat (lamb, hogget or mutton) and milk. Sheep has continued to be important for wool and meat today and are also occasionally raised for pelts, as dairy animals or as model organisms for science. Sheep husbandry is practiced throughout the majority of the inhabited world and has been fundamental to many civilizations. Specific terms for the various life stages of sheep exist, generally related to lambing, shearing and age. Being a key animal in the history of farming, sheep has a deeply entrenched place in human culture (Olufunmilayo, Williams, Sara and Bardara, 2000).

The economic importance of sheep in developing nations cannot be over-emphasized. Sheep with their small body size, high productive capacity and rapid growth rates are ideally suited to production by smallholders. They thrive in a wide variety of environments in the tropics and sub-tropics. It requires less capital as they can be completely maintained on pastures, browse, and agricultural waste products. In sub-saharan Africa, sheep provide almost 30% of the meat consumed and around 16% of the milk produced, (FAO, 2012).

Sheep population in Nigeria is estimated to be 57.8 million according to Food and Agricultural organisation (FAO, 2012). Resource Inventory Management (RIM, 1992) stated that 70% of small ruminants in Nigeria are found in the northern part of the country.

1.1.1 Body Weight in Sheep

Body weight depends on various genetic and environmental factors; among the former are body size and other morphometric traits which are also associated with productivity (Shankar and Mandal, 2010). Morphometric measurements are simple and easy to conduct, and allow estimating the animal's body weight with reasonable accuracy. However, these approaches are prone to errors in the localization of reference points and may be biased by anatomical distortion due to animal movement. Nevertheless, body measurements have been used to evaluate breed performance and characterize various types of ruminants, (Sowande&Sobola, 2008).

Live body weight (LBW) plays an important role in determining several characteristics of farm animals, especially the economically important characteristics (Pesmen&Yardimci, 2008). Estimating the live weight using body measurements is practical, faster, easier and cheaper in the rural areas where resources are insufficient for the breeder (Nsoso, Aganga, Moganetsi andTshwenyane, 2003). However, this fundamental knowledge of body weight estimation is often unavailable to farmers due to unavailability of weighing scales. Hence, the farmers have to rely on questionable estimates of the body of their animals leading to inaccuracies in decision-making and husbandry (Moaeen-ud-Din Ahmad, Iqbal & Abdullah, 2006).

The biometric measurements are used to assess several characteristics of animals. These measurements provide important evidences for the growth of the breed and the properties that change with environmental effects and feeding factors. In addition, body measurements are important data sources in terms of reflecting the breed standards (Riva, Rizzi, Marelli&Cavalchini, 2002) and are also important in giving information about the morphological structure and development ability of the animals. Body measurements differ according to the factors such as breed, gender, yield type and age. The most common parameters used for body measurements in sheep are head length, head depth, frontal width, ear length, body length, withers height, rump height, body depth, heart girth and tail length. Body weight estimations are done using body measurements by different statistical analysis (Gurcan, 2000).

The relationship between live weight and economically important yields is well known in farm animals and live weight estimations using the body measurements is a matter of concern for sheep industry. In general the correlation between heart girth and live weight is found to be higher in sheep and goats. Therefore, live weight can be predicted via morphometric measurements (Atta&El khidir 2004).

1.1.2 <u>Body Condition Score</u>

Body condition score (BCS) is a widely subjective method used in livestock to estimate the amount of animal body reserves at different stages of production. This method is based on visual for large ruminant and tactile in small ruminant assessment. The second type of assessment estimated body fat and muscle reserves by palpation of specific parts of the body of small ruminants. This method involves assigning a score to animals in relation to the amount of tissue reserves (fat and muscles) present in particular anatomical regions with specific prominences. These prominences are bones, ribs, spinous processes of the vertebral column, transverse processes, sacrum and lumbar vertebrae (Gaias, 2012)

Body condition scoring in sheep is an estimate of the muscle and fat cover of animal by palpation of different regions of the body, is done by accurate palpation of the lumbar region around the backbone in the loin area immediately behind the last rib (13th- 14th) and above the kidneys. In contrast to cow and goats, the presence of wool in sheep makes it difficult to assign the score. The BCS technique consists of the immobilization of the sheep and palpation of the spinous processes of the lumbar vertebrae to estimate the amount of fat and muscle according to the thickness of subcutaneous adipose tissue. By accurate palpation of the two bone protrusions (spinous and transverse processes), it is possible to evaluate the levels of fat deposits and the depth of the *Longissimusdorsi*muscle. When sheep are very thin (BCS<2), the fingers easly penetrate in the abdominal cavity. When the animal has much fat (BCS>4), it is difficult to push in the transverse processes (Gaias, 2012)

1.1.3 <u>Reliability of Body Condition Scoring</u>

The usefulness and reliability of a BCS is dependent on 3 aspects: repeatability**,** reproducibility, and predictability. Repeatability is the ability of an assessor to assign the same score for the same animal during repeated examinations, provided the animal's body condition has not changed. Repeatability is an assessment of within-assessor variability or within-assessor precision. Reproducibility is the ability of two or more assessors to independently assign the same score for the same animal. Reproducibility is an assessment of between-assessor variability or between-assessor precision. Reproducibility also indicates the likelihood that all parties in a discussion understand the body condition of the animal when a BCS is stated as well as the associated consequences of that body condition in regard to the desired goal for that animal.

Predictability is the ability of the BCS to reflect actual body components of an animal (William, 2000).

1.2 STATEMENT OF THE PROBLEM

Most of domestic breeds of sheep are still genetically unimproved, and the pressure of modern genetic improvement has increased the need to better understand natural genetic variation in sheep breed as a basis for selection (Adebambo, Williams, Blott& Urquhart 2004).

Proper measurement of live body weight, which often is hard in the village settings due to lack of weighing scales, is a prerequisite for achieving so many lofty goals that are always associated with either medical or economic status of the animals. Knowing the live bodyweight of small ruminants is important for a number of reasons, such as for breeding, correct feeding and health and is not always readily available (Slippers, Letty and de Villiers, 2000). Apart from taking live weight of meat animals, researchers also use other parameters such as body length, width of pelvis, height at withers and chest girths in order to adequately evaluate live animals (Atta&El khidir,2004). Under standard conditions properly calibrated livestock scales are the most accurate and consistent method for determining body weight. Under farm conditions however, where scales and records may be absent, it may be difficult to know the weight of sheep and goats (Abegaz&Awgichew, 2009). Some of these standard weighing scales coupled with their shortcomings are too expensive for most of small farmers (Mahieu, Naves andArquet, 2011). This has forced many farmers to rely on estimates of body weights using certain number of body characteristics which can be measured readily (Alade, Raji, andAtiku. 2008).

Body condition scoring is an important useful procedure that producers use to make management decisions regarding the selection of breeding stock, health of their animals and the quality and quantity of feed needed to optimize performance which in most situations wrongly understood due to unreliability of scoring. In most circumstances, body weight does not reflect an animal's actual condition, i.e., an animal with a large frame may have a higher body weight when at a low level of body reserves than another animal with a small frame but abundant reserves. Large variation in gross live weight may also occur because of changes in gut fill, pregnancy and parturition. The nutritional plane to which an animal has been exposed over a reasonable length of time is reflected by the extent to which fat is stored or muscle mass has been diminished. This must be precisely assessed and expressed as a condition score which will be used as a tool for sheep selection (Abebe, 2009).

1.3 JUSTIFICATION

Sheep is an important livestock species in the socio-economic lives of people around the world including Nigeria and potential of sheep for possible carcass yield was based on weight and changes in weight alone (Yakubu& Ibrahim, 2011). Increased productivity is one of the primary goals in sheep production, and growth is also a major concern to livestock farmers. However, over 80% of the small ruminant population in Nigeria is maintained at the small holder level, where the production system is largely extensive with its array of constraints (Osinowo, Abubakar, Buvanendran andLakpini 1994; Iyeghe, Osinowo, Abubakar, Nwagu andDennar 1996).

Ibe, (1989) reported that, a quantitative measure for animal conformation is desirable, as it will enable reliable genetic parameters for traits to be estimated and permit its inclusion in breeding Programme. Also, the relationship between scale weight and easily measured linear body traits will be useful for predicting body weight in situations where weighing facilities are not available as is the case in many African farming conditions. But the accuracy of these methods relative to actual body weight is yet to be established.

Body measurements are important in prediction of carcass weight and determination of certain body conformation traits that can be taken into consideration in selecting animals for genetic improvement. Also Measurable indices related to body weight and body condition score are important for selection, proper dosage of drugs and to a lesser extent in the modern animal husbandry for culling, slaughtering and assessing feed conversion performances(Abebe, Getinet and Mekonnen,2002).

Body condition score in sheep is critical during pre-breeding, mid-gestation, early lactation, weaning, and before sale. Body condition at mating is important as animals in poor condition may have difficulty in conceiving and have fewer offspring. If females are too thin at the midpoint of gestation they are likely to have small, weak offspring with low survivability and produce less milk. Management should be altered to try and address the problem. If animals are poorly conditioned during early lactation, they will have low milk production and wean smaller animals. These dams will draw upon body reserves losing further condition. Females with low BCS at weaning will take longer to breed and have lower conception rates. This lengthens lambing interval represents loss of production and potential profit (Abebe, 2009).

It would be an important step to examine the agreement between live weight estimation methods and accuracy of each method relative to actual body weight,ensure predictability in body condition scoring as well as to propose control of performances for further selection programs based on the relationship between body morphometry, body weight and condition score in order to contribute for the improvement of sheep productivity through selecting the actual and desired breeding stock.

1.4 OBJECTIVES

The broad objective of this study was to assess body weight, body condition score and linear body measurements in Yankasa sheep, while the specific objectives were;

1. To determine the effects of location, age group, sex and physiological status on body weight, body condition score and linear body measurements andthe relationships amongthem.
2. To estimate repeatability and reproducibility of body condition scoring.
3. To predict live body weight from linear body measurements.
4. To compare the commonly used methods of weight determination in sheep.

CHAPTER TWO

LITERATURE REVIEW

2.1 OVER VIEW OF SHEEP GENETICS

There is strong evidence that, more than 1000 years ago, the domestication of sheep took place in Asia, a known center of diversity for a number of domestic animal species (Luikart*et al.,* 2001; Nowak, 1999). It is likely that these species were dispersed from this area to other regions. The various breeds of sheep today are adapted to a range of arid and semi – arid environmental conditions.DeoxyriboNucleic Acid (DNA) analysis has shown that domestic sheep descended from two ancestor species, one of which is the mouflon. The mouflons comprise *Ovismusion*and *O.orientalis*. Although the second ancestor has not been identified, both the urial and argali have been ruled out. The urial (*O. vignei*) is found from northeastern Iran to northwestern India. It has a higher number of chromosomes (58) than domestic sheep (54) which makes it an unlikely ancestor of the latter, but it interbreeds with the mouflon. The argali sheep (*O.ammon*) of inner Asia (Tibet, Himalayas, Altay Mountains, Tien-Shan and Pamir) has 56 chromosomes and the Siberian snow sheep (*Ovisnivicola*) has 52 chromosomes. This Soay ram demonstrates the wide variance in sheep traits that belies the prototypical appearance of the animal. Historical records show that sheep provided primitive pastoral people with meat, wool, tallow, skin and milk. (Nowak, 1999).

2.2 ECONOMIC IMPORTANCE OF SHEEP

The economic importance of sheep in developing nations cannot be over-emphasized. Sheep with their small body size, high reproductive capacity and rapid growth rates are ideally suited to production by resource-poor smallholders. In sub-Saharan Africa, sheep provide almost30% of the meat consumed and around 16% of the milk produced. FAOSTAT (2006).

Nigeria possesses about 57.8 million sheep. They thrive in a wide variety of environments in the tropics and sub-tropics. It requires less capital as they can be completely maintained on pastures, browse, and agricultural waste products. A flock of sheep can provide families with food each day in the form of milk but only in limited parts of the world are sheep milked for dairy food. Countries in Southern and Eastern Europe and some developing countries such as Syria and Turkey consume fresh sheep milk in reasonable quantities. Sheep milk is an excellent raw material for the milk processing industry especially in cheese production. Genotype, animal's feed, health, weather conditions, the number of lambs, milking technique, the botanical composition of the pastures and other factors have a great influence on sheep milk. The Mediterranean countries are the biggest producers of sheep milk(FAO, 2012). They contribute with approximately 47% in the overall world production of sheep milk. Sheep milk yields 18 to 25 percent cheese, whereas goat and cow milk only yield 9 to 10 percent. While sheep usually produce less milk than goats and much less than cows, sheep milk sells for a significantly higher price per pound, almost four times the price of cow milk. Large consumption of sheep milk is thought to lead to longevity. Bulgarian shepherds are noted for their exceptionally long lives, presumably from a diet of the produce of their sheep. Because of its high calcium content, sheep milk is also very good for the prevention of osteoporosis and for those people already suffering from it. Sheep milk is the most nutritious milk on sale in the world today. The only other milk that can be compared with it would be that of the camel and the water buffalo. (FAO, 2012).

2.3 PROSPECTS OF SHEEP PRODUCTION

Sheep produce food and fibre at relatively low cost from food materials and on land that often cannot be used in any other way. Their high and increasing efficiency is due not only to their ability to use low quality feed stuffs and sparse natural forage but also their early puberty, short gestation period, rapid growth rate and good marketability. Sheep do not compete with people, pigs or poultry for food because they can survive on forage alone and require little grain or concentrates for good production. Small ruminants produce about twice as much meat per animal unit in the tropics as cattle (Terill, 1983)

Sheep compete well with other livestock in quality of meat produced. Meat from sheep is generally tender than grass-fed beef. The animals can be marketed at a much younger age. Lamb meat is more established in marketing systems than in goat meat, but both are quite delicious, especially under one year of age. Sheep can supply efficiently and has low cost of production

(Terill, 1983).

Sheep are widely distributed in Africa and in Nigeria; they are a major component of the livestock production system which is characterized by small flock sizes. They are found in different agro-ecological zones of Nigeria and constitute about 22 million of the total livestock population (RIM, 1992). Sheep occupy a special place in the rural economy of Nigeria, where they are not only emergency source of fund but also contribute significantly to raise animal protein intake profile for the average Nigerian.Yankasa,Uda and Balami breeds found in the semi-arid regions of Nigeria are the most abundant sheep breeds in the country. Choice of breeds for improving the output from sheep should depend on the amount of information available on them. Additionally, growth performance is a key production indicator as it has implications in the reproductive efficiency of sheep. Fast growth performance allows sheep to breed early and contribute more lambs in their lifetime. Fast growth rate entails reaching market weight early, which brings a quicker income to the farmer. The majority of the sheep population of the semi-arid region of Nigeria is managed mainly under the traditional free-range system. Under this system of production, little or no information is available on factors affecting their productivity. For genetic progress, selection must be based on genetic merits instead of phenotype (Rashidi, Mokhtari, Safi, Mohammad and Abadi,2008)

2.4 ANIMAL GENETIC RESOURCE EVALUATION

In developing countries, livestock genetic resources in general have not been adequately characterized, evaluated or fully utilized through selection and in some cases local populations are threatened with extinction before their genetic value is even properly described and studied (Madalena, 1993). Similar to other classes of livestock, the genetic diversity in sheep can be expanded by the development of synthetic breeds through crossbreeding to combine the most important traits of economical and adaptation significance (Maijalaand andTerill, 1991). The role played by geographic isolation in influencing between breed differences to special products, characteristics, and phenotypic appearances has also been emphasized (Maijala andTerill, 1991). They have stated that the most important between breed variations observed was the specific adaptability of breeds to the prevailing climatic and feeding conditions within ecosystems, and these ecosystems range from sparse to ample feed and forage, desert to high humidity, from sea level to high mountains, from the equator to the northern and southern hemispheres.

The choice of the right type of animal to be raised in an area where it is best adapted results in higher productivity (Madalena, 1993). Therefore, considering the importance of environmental components such as improved management practices and nutrition in enhancing higher productivity, indigenous breeds not only do survive but also do produce under harsh and uncertain environmental conditions.

Appropriate genotypes must be used in environments where they can best express their inherent genetic potential (Madalena, 1993). Attempts to improve further the inherent genetic capacity of any livestock population beyond the scope of the nutritional or improved health care practices under which it is maintained will be counterproductive (Timon, 1993). As indicated by Laes – Fettback and Peters (1995) and Vercoe and Frisch (1987), it is thus necessary to identify the merit of available genetic resources, the possible integration of the animals into various production systems and to make effective use of their potential in order to quantify existing breed differences according to growth rate, growth potential and the response of the animals to different feeding challenges. Where feed supply is a major limiting factor, it is of paramount importance to look into both biological and economic factors affecting livestock productivity (Al Jassim*et al.,* 1996)

The real value of indigenous breeds is often under estimated mostly due to their poor appearance and relatively low productivity. Peters (1989) reported that there is an apparent lack of information regarding the identification production problems, possible interventions and performance of animals within existing production systems in order to properly utilize the available genetic diversity to enhance production. This is particularly true in developing countries, where breeds or types of livestock have not yet been fully identified and characterized, despite the fact that indigenous breeds survive and produce under unfavorable environments and limited availability of feed; above all they are also integrated parts of theentire prevailing production systems.

Currently, understanding has increased that introducing high yielding breeds of livestock and specialized modes of production in new areas can lead to a loss in genetic diversity among indigenous animals. However, in developing countries, the less intensive production systems are based on the existing species and breed only. It is, therefore, absolutely necessary to evaluate existing livestock genetic resources from a stand point of matching available genotypes with the environment under which they are expected to be maintained. (Peters, 1989).

According to Lahlou – Kassi (1987) and Peters (1989), a comparative small ruminant performance evaluation will address the following issues:

- Adaptation traits: these are some of the most important phenotypic traits which in one way or another might influence the adaptability of the animal to the prevailing environmental conditions (tolerance to diseases, parasites, heat).

- Reproductive traits (female reproduction performance such as age at puberty and first lambing, conception rate, prolificacy, male reproduction performance).

- Production traits (birth and weaning weight, growth rate, carcass yield and quality, fiber yield and quality) and survival rate.

The usefulness of genetic diversity among livestock breeds in enabling producers to meet new goals in animal production, which arise from the changes in consumer demands and also changes in economics of livestock production, has been known for long (Dickerson, 1969).

2.5 VARIATION IN SHEEP POPULATION

The phenotypic variation in a population arises due to genotypic and environmental effects, and the magnitude of phenotypic variability differs under different environmental conditions. Morphometric characters are continuous characters describing aspects of body shape (Riva *et al.*2004 and Cervantes *et al.,* (2009). Morphometric variation between populations can provide a basis for understanding flock structure, and may be more applicable for studying short-term, environmentally induced variation and thus more applicable to livestock management. According to Gizaw, Komen, Windig andHanotte(2007), morphological description is an essential component of breed characterization that can be used to physically identify, describe, and recognize a breed, and also to classify livestock breeds into broad categories. Dossa*et al.*(2007) reported that morphological measurements such as heart girth, height at withers and body length can be used for rapid selection of large size individuals in the field to enable the establishment of elite flocks

Selection is the basic method used both by nature and by humans to change the attributes of animals by changing the overall productivity. Breeders change the mean value of a character in a population by choosing the individuals to be used as parents to produce progeny in succeeding generation. This change is only possible if there is variation among individuals for the character. Individual animals are mostly selected based on their own performance to improve trait with high heritability (Ibe, 1989)

Selection in most of our farms are done based on individual animal performance, the decision about which animal to be selected as parents to next generation is mainly based on performance of individual animals. Selecting animals based on its performance maximizes the response to selection that can be achieved (Ibe, 1989)

2.6 IMPROVEMENT IN SHEEP PRODUCTIVITY

The first stage to improve productivity of a sheep flock therefore should focus on improving the feeding and reproductive management practices and providing better health services. Having done that, one could also plan for a long term genetic improvement through selection within the local flock or through crossbreeding or both. In order to bring such anticipated change, a better knowledge and understanding of the performance of the breeds is necessary.

Man has for a long time been manipulating and altering the genetic composition of livestock through crossbreeding, selection and inbreeding (Madalena, 1993).

In order to maximize the utilization of available breed resources, it is highly beneficial if the performance of animals is tested within the prevailing production system (Peters, 1989; Lahlou – Kassi, 1987). Such investigation may not reflect the true genetic potential of the animals studied. Peters (1989) reported that, it will be essential to study the animals under a controlled environment in order to quantify their genetic performance ability. On the other hand, livestock performance under a prevailing more fluctuating production environment could indicate prospects for improved productivity, generate management variables, identify production constraints and areas for improvement. Since small ruminants have to compete with other livestock species for available feed resources, their production performance will have to be as efficient as possible (Peters, 1989).

Throughout the production cycle, sheep producers must know whether or not their sheep are in condition (too thin, too fat, or just right) for respective stages of production: breeding, late pregnancy, lactation.

2.7.0 BREEDS OF SHEEP

2.7.1 Breeds of Sheep in the World

There are nearly 278 million sheep in the world (FAO, 2004). Sheep together with the other classes of livestock make a substantial contribution to the wellbeing of multitudes of people around the world in the form of meat, milk, fibre and skin. Sheep production contributes to the agricultural economy of countries. This is more prominent in developing countries than in developed ones. Ponzoni (1992) reported that currently there seemed to be a greater awareness of the need to identify, characterize, preserve and improve indigenous breeds which are thought to have some valuable attributes that could be used at present or sometimes in the future

A breed is a collection of individual within a species which share a certain number of morphological and physiological characters which are passed onto their progeny as long as they breed among themselves, (Ibe,1989). There are many breeds of sheep, but these are generally sub classable as wool class, hair class, meat class and dairy class breeds. Dual-purpose breeds are bred for both wool and meat. Major wool breeds include Merino, Rambouillet, Romney, Shetland, and Lincoln. Drysdale and Herdwick are bred specifically for carpet wool. Breeds of meat sheep include Beltex, Suffolk, Portland, Hampshire, Columbia, Texel, and Montadale. Breeders of dual-purpose wool class sheep concentrate on fast growth, multiple births, ease of lambing and hardiness. An easy-care sheep is the Coop worth that haslong wool and good lamb meat production qualities. Other dual-use breeds are the Corriedaleand Shropshire. Sometimes, sheep are used for both purposes equally and cross-breeding ispracticed to maximize both outputs. For example, Merino ewes providing wool may be crossed with Suffolk rams to produce lambs which are robust and suitable for the meat market,(Anonymous, 2014).

Hair class sheep are the original class of sheep in the world, developed for meat and leather. They are prolific and highly resistant to disease and parasites. Dorpers and Kahtahdins are composite breeds of wool and hair crosses with different degrees of wool/hair mixes within the hair class. True hair sheep such as St. Croix, Barbados Black belly, Mouflon, Santa Inez and Royal White shed their protective down fiber to an all hair coat in the Spring/Summer. Hair class sheep are becoming more popular for their no-shear aspects, (Anonymous, 2014).

Although, milk is no longer a major product of the sheep in many developed countries, such as North America and Australia, its importance has been maintained in other parts of theworld including some European countries. The world's known sheep dairy breeds include the following: the Fries Melkschaap, Lacaune, Chios and Awassi sheep, (Anonymous, 2014).

2.7.2 Breeds of sheep in Nigeria

In Nigeria, small ruminants contribute an estimated 35% to the total meat supply, they are more important in the north than in the south, and more important in rural than in urban areas. They are mainly kept for meat, milk, wool, skin and manure production (Payne, 1990).Sheep raising has become one of the most important means of livelihood and food security for the rural population.

Nigeria has basically four definitive breeds of sheep: the West African Dwarf (WAD), the Uda (UD), Balami (BAL) and the Yankasa (YANK) Olufunmilayo*et al.,*(2000). However, other breeds which are of less importance exist which include the Bororo and the Ara-Ara found in Niger and Anambra States (RIM, 1992).In a survey by RIM (1992), these two breeds were described.

Yankasa

Also Known By: Hausa, White Fulani, Y'ankasa

The Yankasa is a meat breed found in north and north central Nigeria. In size it is intermediate between Uda and the West African Dwarf sheep. The milk yield (kg) per lactation is between 30 and 56 kg and has a lactation length of 91 days. The peak milk yield per day is 960 grammes(Adu and Ngere, 1979). The coat colour of Yankasa is typically white with black patches around the eyes, ear, muzzle and sometimes the feet. The tail is long and thin, the ears moderately long and somewhat droopy. Rams have curved horns and a hairy white mane and ewes are polled (Aganga, Umunna, Oyedipe and Okoh, 1988).

Uda

Also Known as: Oudahbicolore (French), Bali-Bali, Bororo, Fellata, Foulbe, Houda,Louda, North Nigerian Fulani, Ouda, Pied

The Uda is one of the hair sheep breeds of the Sahel region. Haumesser and Gerbaldi (1980) studied traditionally-managed Uda flocks in Niger Republic; Wilson and Durkin (1983a, b) and Wilson and Light (1986) report on related sheep production systems in central Mali. It is a meat breed. It is a long-legged breed of sheep with distinctive coat colour of brown or black anterior and white posterior. They are large with straight and long face. The rams of the Uda are horned (Adu and Ngere, 1979) and the ewes are usually polled. Milk yield per lactation lies between 32 and 36 kg for an average lactation length of 91 days.

Balami

Balami is the largest bodied native sheep in Nigeria. As a pastoral animal, it is confined to the semi-arid north but it is favored as a stall fed breed by muslims throughout the Nigerian middle belt. It is white and hairy with pendulous ears, long-leg and a long thin tail (Adu and Ngere, 1979). Rams are horned but ewes are normally polled. Another feature that makes the Balami distinctly recognisable is its Roman, bulbous nose that distinguishes it from the Yankasa(Adu and Ngere, 1979). It has good potential as a meat producer and milk yield per lactation lies between 28 and 33 kg in 70 days.

West African dwarf

Also known as: Cameroons Dwarf, Djallonké, Forest-type, Fouta Djallon, Futa Jallon, Guinean, Kirdi, Kirdimi, Lakka, Nigerian Dwarf, Pagan, Savannah-type, Southern, West African Maned

The West African Dwarf is small bodied, compact breed which may be all white, black, brown or spotted black or brown on a white coat. Its variation in colour and patchy distribution make it difficult to distinguish it clearly from the Yankasa. Adult males weight approximately 37 kg. They have a well-developed throat ruff and are horned. Ewes have mature weights of 25 kg. The females are usually polled. Adu and Ngere (1979) reported that different types exist, mentioning the 'Pagan' variety on the Jos Plateau, and the 'Umuahia' variety near the Confluence, but there is no published account of such varieties. Devendra and McLeroy (1982) argue that the WAD breed cannot be sub categorized on the basis of appearance, and no performance data is available. They can be bred at the age of 7 to 8 months. They tend to have a short lambing interval. The prolificacy of adult ewes is low to moderate ranging from 1.15 to 1.50 lambs per lambing. At less than 100 g per day under good feed conditions, their growth rate is low and lamb mortality is high.

2.8 WEIGHT CHANGES IN YANKASA SHEEP

Growth in animals is defined as an increase in number of body cells and by growth and differentiation in body cells (Bathaei and Leroy, 1996; Orr, 1982). The growth rate and body size along with changes in body composition of animals are of great economic importance for efficient production of meat animals. According toBathaei and Leroy (1996), animal growth can be expressed as the positive change in body weight per unit of time or by plotting body weight against age. In another study (Gaten, 1986), it is suggested that growth in animals is mostly measured by an increase in body weight, leading to changes in body form and composition. As stated by Orr (1982), the increase in body mass of farm animals is primarily a reflection of the growth of carcass tissues consisting of lean, bone and fat

According to Velez, Raudales, Esnaola, and Murillo,(1993) animals though lose weight during the dry season where both quantity and quality of forage available are limited. Weight at a given stage of production is the best indicator, but because a wide variation in mature sizes between individuals and breeds exist, it is extremely difficult to use weight as simple parameters to determine proper condition.

2.9 LIVE BODY WEIGHT DETERMINATION

Animal live body weight is an important feature, but can seldom be measured in rural areas due to lack of reasonable accurate scales. Hence, farmers have to rely on questionable estimates of the body weights of their sheep, leading to inaccuracies in decision making. The primary method of weighing animals without scale is to regress body weight to body characteristics, which can be measured readily (Mayaka*et al.,* 1995). Body measurements have been used to predict body weight by several authors in many breeds of sheep (Aziz and Sharaby, 1993; Enevoldsen and Kristensen, 1997; Atta and El Khidir, 2004; Riva *et al.,* 2004; Afolayan *et al.,* 2006; Sowande and Sobola, 2007; Iqbal, 2010).They reported that different models might be needed to predictbody weight in different environmental conditions and breeds.

Under standard conditions properly calibrated livestock scales are the most accurate and consistent method for determining body weight. Under farm conditions however, where scales and records may be absent, it may be difficult to know the weight of sheep and goats (Abegaz and Awgichew, 2009). Some of these standard weighing scales coupled with their shortcomings are too expensive for most of small farmers (Mahieu, 2011). Apart from conventional use of scale, weight determination by estimating some linear parameter could be employed (Winrock International, 1992), there is a close relationship between the distance around animal's heart girth and its body weight.

2.9.10 Other methods of estimating weight of small ruminants

Weight band

A weight band is a specially marked tape used to measure the heart girth and convert that measurement to a fairly accurate estimate of the goat's live weight. De Villiers *et al.*(2010) described this procedure. Briefly, the weight band is wrapped directly behind the shoulder blade, down the fore-ribs, under the body behind the elbow and all the way around to the point behind the shoulder blade. The ends of the weight band are overlapped on top, on the goat's spine. Lastly, the resultant weight measurement is read off the weight band in kilograms.

Visual appraisal

This skill is developed through practice by estimating the weight of numerous animals without a board or weigh band. Visual determination of the weight of animals is often faced by errors like using the same estimate for more than one breed of a particular species (Otoikhian, *et al.,*2008a).Body structure can be deceptive when estimating weight (Slippers *et al.,*2000). For instance, Red Sokoto goats appear lighter than they actually are because of their light bones. Apart from bones and body structure problem in estimating weight, a white animal always looks bigger than it is (Otoikhian,*et al.,* 2008b).

Body Linear Measurements

There are a number of linear dimensions which can be used to quantify the size of an animal and to estimate weight. The most widely used body linear measurements include height at withers, heart girth, chest depth, body length, fore cannon bone, rump height, distance between eyes, ear length, ear width, paunch girth and tail length. Heart girth and cannon bone length are least affected by the posture of the animal. Abegaz and Awgichew (2009)

Prediction Models

Mathematical equations (Prediction models) can be developed based on large number of actual weight linear measurement data discussed above. The equations change the linear measurements into weight estimates, usually via a constructed table. Individual equations can be derived based on condition, sex and age of the animal. (Mahmud *et al.*2014b).

2.10.0 BODY CONDITION SCORE

2.10.1 Body condition and fat deposit

Body condition scoring describes the condition of a sheep by palpation, it is convenient, and is much more accurate than a simple eye appraisal in estimating the condition of muscling and fat development. Scoring is based on feeling the level of muscling and fat of deposition over and around the vertebrae in the loin region. In addition to the central spinal column, loin vertebrae have a vertical bone protrusion (spinouts process) and a short horizontal protrusion on each side (transverse process). Both of these protrusions are felt and used to assess an individual body condition score (Thompson and Bahhady1988).

The body condition score varied with the age of the animal, the weight and management and the geographical regions where flocks had been raised. The body condition score is a subjective method to assess the accumulation and mobilization of fat reserves in times of sufficient and scarce feed. Kabbali*et al.*(1992) showed that the rate of mobilization of fat reserves is a function of the severity and the duration of feed shortage, of the maturity of the animal and of its physiological state.

Body condition score and its use are important in terms of achieving the desired performance in certain physiological periods in sheep breeding where extensive conditions are dominant. It is indicated that there can be differences in values obtained in various physiological periods for the genotypes bred in our country and that basic studies should be carried out to determine these values (Biçer, 1991).

A body condition score of 3 versus 3.5 does not present a real difference, but a relative difference between a 2.5 and a 4 certainly is of concern. On average, a difference of one unit of condition score is equivalent to about 13 percent of the live weight of a ewe at a moderate (3 - 3.5) body condition score. Body condition scoring being a subjective way to evaluate the status of a sheep flock, never the less is a potential tool for producers to increase the production efficiency of their flock (Biçer, 1992).

Effects of age and weight

At birth, lamb sheep contain little fat, but as the weight of the carcass increases, the quantity of fat increases (Owen, 1976). In the same context, Berg and Walters (1983) added that fat deposition is believed to start out relatively slowly and increases geometrically as the animal enters a fattening phase. Bocquier*et al.*(1986) showed that when the lamb increases in weight, its body composition and carcass change; the proportion of bone tissues and muscles decreases whereas that of fat increases strongly. Goodwin (1971) showed that the fat tissues are the last to develop and are the more severely affected by the feed ration.

Owen (1976) added that the quite reduced fatty tail of animal at birth is determined genetically. In lambs and hogget, the proportion of essential parts of the body like head, legs, bones and internal body is large; the proportion of the muscles and fat is in contrast, low. The muscular fabrics increase more quickly than the essential parts and fat is the last to evolve and the most severely affected by the feed ration.

As for fat mobilization in periods of feed starvation, Burton *et al.*(1974) showed that this mobilization is a function on animal's maturity and its adiposity; the mobilization is more intense in adult rams than in young lambs and in fatty animals that in thin ones.

Effects of sex and physiological state of the animals

Bocquier*et al.*(1986) showed that at the same weight females are fattier than the males and produce carcasses which contain a stronger concentration of fat. In their survey on Serrana kids, R odrigues*et al.*(2006) tried to evaluate the effect of sex and carcass weight on the carcass composition of kids. They found that female kids showed a higher intramuscular fat proportion, a muscle/bone ratio and KKCF (kidney, knob and channel fat) than males. However, male kids had a higher bone proportion and muscle/fat ratio. All fat depots increased and the bone proportion decreased with an increase in carcass weight. The increase in carcass weight induced an increase in the muscle/bone ratio and a decrease in the muscle/fat ratio.

Banskalieva (1996) showed that the content of lipids in ram lambs contained greater quantities of unsaturated fatty acids than those of ewes. He noted that castration had no detectable effect on the fatty acid composition of the perrenal adipose tissue of lambs.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

The study was carried out in some selected local government areas of Kano State,namely,Shanono, DawakinKudu, Bebeji, Wudil and Dambatta. The State covers an area extending between latitude $9^o30'$ and $12^o30'$ North and longitude $8^o42'$ and $9^o30'$East in semi-arid region of Nigeria (Olofin, 2007). It is located at 481 meters above sea level (KNARDA, 2001). The vegetation type in the State is the northern guinea savannah and Sudan Savannah. Annual rainfall and temperature range between 787 to 960 mm and 21^oC to 39^oC respectively, (Ahmad, 1998).

The environment is conducive for different livestock species (Muhammad *et al*., 2009). The population of cattle, sheep and goat as of 2011 in Kano State was 1,074,667, 2,712,370, and 3,043,895respectively (Kano State Ministry of Agriculture, 2014). The common crops grown in the state include legumes, cereals and vegetables.

3.2 SAMPLING PROCEDURE

Prior to commencement of the research, a reconnaissance survey of the study area was conducted. Multistage sampling was adopted in the study. The first stage involved the selection of five local governments areas (Shanono, DawakinKudu, Bebeji, Wudil and Dambatta) based on their suitability for sheep production, market and road access and willingness of people to participate.

The second stage involved purposive selection of two villages from each local government making a total of ten villages. Third stage was the identification and selection of six households from each village that kept at least ten sheep. The fourth stage was random selection of five animals from each selected household.

3.3 DATA COLLECTION

The data for this research was collected from November 2015 to March 2016. The animals used for the research were identified using permanent marker and aged by dentition method. Linear body measurements were taken using measuring tape while actual live weight was measured using small ruminant weighing scale graduated in kilogram. Body measurements were used to predict weight by tape, weight estimation formula and regression equation. All the selected animals were weighed using the four methods of weight determination. Body condition score was determined by palpation method. Age, body weight, body condition score and linear body measurements were assessed from three hundred sheep and from sixty households.

3.3.1 Ageing

Age of the animals was determined by dentition method (Abegaz and Awgichew, 2009) and the animals were categorized into three age groups as follows:

1. < 12 month (0 pair of permanent incisors)
2. 1-3 years (1-3 pair of permanent incisors)

3. Above 3 years (4 pair of permanent incisors)

3.3.2 Morphometric Trait Measurement

The linear body measurements considered during the conduct of this experiment were measured by one person using flexible measuring tape graduated in centimetre and they included the following:

1. Body length (BL): Refers to the distance from the base of the ear to the base of the tail (where it joins the body).
2. Chest depth (CD): Measures the distance from the backbone at the shoulder (standardize on one of the vertical processes of the thoracic vertebrae) to the brisket between the front legs.
3. Heart girth (HG): A circumferential measure around the chest just behind the front legs and withers
4. Head length (HL): Distance from external occipital protuberance to the tip of the nasal bone
5. Head circumference: A circumferential measure around the head just after the ear
6. Ear length (EL) Distance from base to tip of ear
7. Fore leg length (FLL) Distance from the surface of the ground level to front of sternum
8. Hind leg length (HLL): Distance from the bottom of the leg to the pin bone of hip
9. Height at withers (HAW): The distance from the surface of a platform on which the animal stands to the withers
10. Rump height (RH): The distance from the surface of a platform to the rump
11. Hip Width (HW): The distance between the outer edges of the major hip bones on the right and left side.
12. Tail length (TL): Distance from the dock to the tip of tail

3.3.3Weighing Methods

1. Weighing scale (graduated in kilogram): The assessor knew his weight first and then lifted the animal on the scale and stabilized and then recording its weight after subtracting his weight.
2. Regression equation: stepwise multiple regression equations were fitted using body measurements as prediction variables to estimate body weight.
3. Weight estimation formula: Heart girth^2 X body length ⁄300 (Khan, Iqbal, Riaz, Yaqoob, andYounas,2004)
4. Weighing tape (measures the circumference of heart girth and the corresponding weight)

3.3.4 Body Condition Score (BCS)

Condition scoring was done while the animals were standing upright and relaxed in a normal posture and was carried out by two assessors twice a day (morning and evening), using the system of Abebe (2009) used in sheep based on a scale of 0 to 5. Assessors remained blinded to the previous scores and did not discuss study results.The following describes the characteristics of the scores:

BCS 0: Extremely emaciated and on the point of death. It is not possible to detect any muscle or fatty tissue between the skin and the bone. Skin is sunken between visible ribs. There is no sterna fat in the sternum.

BCS 1 (emaciated): The spinous processes are prominent and sharp. The transverse process are also sharp, the fingers pass easily under the ends, and it is possible to feel between each process. The eye muscle areas are shallow with no fat cover. Ribs are clearly visible. Sternal fat is easily grasped and moved from side to side

BCS 2 (thin): The spinous processes feel prominent but smooth, and individual processes can be felt only as fine corrugations. The transverse processes are smooth and rounded, and it is possible to pass the fingers under the ends with a little pressure. The eye muscle areas are of moderate depth, but have little fat cover. Some ribs can be seen. There is a small amount of fat cover. Ribs are still felt. Sternal fat is wider and thicker but can still be grasped and moved slightly from side to side

BCS 3 (average): The spinous processes are detected only as small elevations; they are smooth and rounded and individual bones can be felt only with pressure. The transverse processes are smooth and well covered, and firm pressure is required to feel over the ends. The eye muscle areas are full, and have a moderate degree of fat cover. Ribs are barely seen; an even layer of fat covers them. Spaces between ribs are felt using pressure. Sternal fat is wide and thick. It can still be grasped but has very little movement

BCS 4 (fat): The spinous processes can just be detected with pressure as a hard line between the fat covered eye muscle areas. The ends of the transverse processes cannot be felt. The eye muscle areas are full, and have a thick covering of fat. Ribs are not seen. Sternal fat is difficult to grasp and cannot be moved from side to side.

BCS 5 (obese): The spinous processes cannot be detected even with firm pressure, and there is a depression between the layers of fat in the position where the spinous processes would normally be felt. The transverse processes cannot be detected. The eye muscle areas are very full with thick fat cover. There may be large deposits of fat over the rump and tail. Ribs are not visible and are covered with excessive fat. Sternal fat extends and covers the sternum. It cannot be grasped

3.4 EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

For BCS,the experiment was conducted using a cross factor design. Data on live body weight, linear body measurements and body condition score were first subjected to normality test using SAS (1999) version and because they were found to be normally distributed, were subjected to analysis of variance using the same statistical package.Where significant differences were detected, the means were separated using Duncan Multiple Range Test (DMRT). The model used for the analysis is given below:

$Y_{ijk} = \mu + L_i + A_j + S_k + P_l + E_{ijkl}$

Where: Y_{ijk}= the observation on the animal in thei^{th}location inj^{th} age group of k^{th} *sex* and of thel^{th} physiological status,

μ= overall mean

L_i= effect of the *i*th location (i= 1...5)

A_j= effect of the *j*th age group (j = 1... 3)

S_k= effect of *k*th sex (k= 1, 2)

P_l=effect of *l*th physiological status (l =1...4)

E_{ijkl}= residual error

Model III analysis of variance was carried out to determine the between sheep, and inter and intra-assessors variations in BCS. Repeatability, the proportion of the score variance attributable to scoring variation by the same assessor, and reproducibility, the score variance attributable to scoring variation by different assessors, was calculated using the method described by Jansen et al. (1985), using the following model:

$Y_{ijk} = \mu + A_i + a_j + s_k + (Aa)_{ij} + (As)_{ik} + (as)_{jk} + e_{ijk}$

Where:

Y_{ijk}= body condition score on the i^{th} animalby the j^{th} assessor for the k^{th} score

μ = overall mean

A_i = effect of the i^{th}animal (i = 1...n)

a_j= effect of the j^{th} assessor (j =1,2)

s^k= effect of the k^{th}score

$(Aa)_{ij}$= interaction of the i^{th}animal with the j^{th} assessor

$(As)_{ik}$=interaction of the i^{th}animal with the k^{th} score

$(as)_{jk}$= interaction of the j^{th} assessor with the k^{th} score

e_{ijk}= error term

Repeatability: $r1 = (V_{Total} - Vs - Ve) / V_{Total}$

Reproducibility: $r2 = V_A / V_{Total}$

Where:

V_A, v_a, v_s, v_{ha} and $v_e$are the variance components of A_i

a_j, s_k $(Aa)_{ij}$, $(As)_{ik}$,$(as)_{jk}$and*eijk,* respectively.

and the total variance $V_{Total} = v_A + v_a + v_s + v_{Aa} + v_{As} + v_{as} + v_e$

Pearson correlation analysis was used to determine the relationship between live body weight, body condition score and linear body measurements as contained in SAS (1999). Stepwise multiple regression models were fitted to obtain prediction equations of body weight from body measurement variables and body condition scoreas follows:

$$Y = a + b_0X_0 + b_1X_1 + b_2X_2 \text{............} b_nX_n + e_{ij}$$

Where: Y = Dependent Variable

$X_1 - X_n$= Independent Variable

a = The intercept of straight line

$b_0 - b_n$= The slope

e_{ij} = Error Term

The prediction equation with the highest coefficient of determination(R^2)value was used as the estimator of live body weight by regression method for comparison with other methods of weight estimation.

The relationships between body weight obtained using the different methods of weight measurement were determined using the Pearson correlation analysis. In addition,accuracy of the methods relative to actual weight was assessed using an index calculated as the ratio of estimated weight to the actual weight expressed in percentage, mathematically given as:

$= BW_{estimated}/BW_{actual} \times 100$

CHAPTER FOUR

RESULTS AND DISCUSSION

RESULTS

4.1.1: Effect of Location on Body Weight, Body Condition Score and Linear Body Measurements

Theeffect of location on body weight, body condition score and linear body measurements is presented in Table 1. There were significant (P<0.05) differences between the locations in terms of body weight with BBJ and SNN recording the highest values (26.27kg and 26.00kg, respectively) that were statistically similar, followedby DKD and WDL that were also statistically the same (25.10kg and 24.58kg respectively) followed BBJ and SNN, while DBT had thelowest value of 22.80 kg. There were also significant (P<0.05)differences in BCS, where the highest condition score (2.37) was observed in BBJ, followed by WDL (1.95), SNN and DBT thatwere statistically similar (1.73 and 1.60, respectively), whereas DKD was the least (1.60). On the other hand, there was no significant differences in BL across all the locations. However, the results for CD showed significant(P<0.05)variations between the locations, where WDL and SNN recorded the highest means (37.50 and 37.56 respectively), while BBJ, DKD and DBT recorded the lowest being statistically similar. There were significant(P<0.05)differences in HG between the locations with WDL having the highest (69.68) followed by SNN (69.07), DKD

(66.63) while BBJ and DBT recorded the lowest means (64.27 and 66.20 respectively) and were statistically similar. Height at withers was found to be highest in WDL and SNN (68.52 and 67.20 respectively) which differed (P<0.05) from DBT (65.13), while BBJ and DKD had the least values (61.46 and 63.03 respectively) and were similar statistically.In terms of RH the results showed significant (P<0.05)differences between the locations, where the highest was observed in WDL (67.45) followed by DKD and SNN (64.33 and 65.37 respectively) then BBJ and DBT (63.03 and 64.23 respectively). Similarly, significant(P<0.05)differences were observed in HW between the locations with BBJ recording the highest mean (15.33) followed by DKD, WDL and SNN (14.27, 13.92 and 13.50 respectively) while DBT recorded the least (12.87). Significant (P<0.05)differenceswere also observed in EL between the locations where WDL was found to have the longest ear (13.87) followed by DKD (13.83) SNN (12.97), BBJ (12.67) and DBT with the lowest (12.03). Similarly, significant (P<0.05)variations in TL were found between the locations where WDL (34.70) was found to be highest, followed by SNN and DKD (34.37 and 32.67 respectively), and BBJ and DBT that were statistically similar (31.27 and 31.60 respectively). HL was also found to be significantly different (P<0.05) across the locations, where WDL recorded the highest mean (22.58), followed by BBJ, DKD and SNNwith no significant differenceswhile DBT recorded the lowest (19.93). Result for HC showed no significant variations between WDL and SNN which were found to have the highest means, followed by DKD and DBT ,while BBJ had the least (38.73). For FLL, the result showed significant differences between the locations except for between DKD and WDL,with SNN recording the highest value (39.80) while DBT had the lowest (37.73). There were no significant differencesbetween all the locations in HLL except for SNN which recorded the highest mean.

Table 1: Effect of Location on Body Weight, Body Condition Score and Linear Body Measurements

VARIABLES	Locations					
	BBJ	DKD	WDL	SNN	DBT	MS
BW	26.27±0.80[a]	25.10±0.83[ab]	24.58±0.70[ab]	26.00±0.79[a]	22.80±0.84[b]	117.24
BCS	2.37±0.10[a]	1.60±0.11[c]	1.95±0.10[b]	1.73±0.10[cb]	1.63±0.11[bc]	3.39
BL	66.60±0.76[a]	65.33±0.80[a]	65.97±0.67[a]	65.63±0.76[a]	65.40±0.80[a]	67.94
CD	34.80±0.35[b]	35.93±0.37[b]	37.50±0.31[a]	37.56±0.35[a]	35.83±0.37[b]	51.42
HG	64.27±0.80[c]	66.630.82[bc]	69.68±0.69[a]	69.07±0.78[ab]	66.20±0.82[c]	226.38
HAW	61.47±0.59[c]	63.03±0.62[c]	68.52±0.52[a]	67.20±0.59[a]	65.13±0.62[b]	288.95
RH	63.03±0.96[b]	64.33±1.00[ab]	67.45±0.84[a]	65.38±0.95[ab]	64.23±1.00[b]	89.87
HW	15.33±0.21[a]	14.27±0.22[b]	13.92±0.19[bc]	13.50±0.21[cd]	12.87±0.22[d]	36.49
EL	12.67±0.22[cd]	13.83±0.23[ab]	13.87±0.19[a]	12.97±0.21[bc]	12.030.23[d]	50.61
TL	31.27±0.59[c]	32.67±0.621[bc]	34.70±0.52[a]	34.37±0.59[ab]	31.60±0.62[c]	104.72
HL	21.30±0.21[b]	21.27±0.22[b]	22.58±0.29[a]	21.33±0.21[b]	19.93±0.22[c]	35.39
HC	38.73±0.45[b]	39.83±0.47[ab]	40.40±0.39[a]	40.57±0.45[a]	39.67±0,57[ab]	22.70
FLL	38.47±0.38[bc]	39.20±0.39[ab]	39.53±0.33[ab]	39.80±0.38[a]	37.73±0.39[c]	36.54
HLL	44.83±0.58[b]	46.07±0.60[b]	45.37±0.51[b]	48.00±0.57[a]	44.37±0.61[b]	137.78

Means in the same row with different superscripts are significantly different (P<0.05). MS= Mean squares, BBJ= Bebeji, DKD= Dawakin Kudu, WDL= Wudil, SNN= Shanono, DBT= Danbatta. BW= body weight, BCS= body condition score, BL=body length. CD= chest depth,HG= heart girth, HAW= height at wither, RH= rump height, HW= hip width, EL= ear length, TL= tail length, HL= head length, HC= head circumference, FLL= fore leg length HLL= hind leg length.

4.1.2:Effect of Sex on Body Weight, Body Condition Score and Linear Body Measurements,

Table 2 presents the effect of sex on body weight, body condition score and linear body measurements, the result showed significant($P<0.05$)differences between the sexesin most of the variables. Ewes were found to have higher body weight, body length, chest depth, heart girth, height at wither, rump height, hip width, ear length and fore leg length. On the other hand, rams had a significantly ($P<0.05$) higher value for head circumference (51.67) compared with females (38.98). However, there were no significant differences between males and females in BCS (1.90 vs 1.83), TL (33.14 vs 32.81), HL (21.08 vs 21.35) and HLL (45.67 vs 45.75).

Table 2: Effect of Sex on Body Weight, Body Condition Score and Linear Body Measurements

	Sex		
VARIABLES	MALE	FEMALE	MS
BW	21.59±0.55[b]	26.61±0.44[a]	22.30
BCS	1.90±0.07[a]	1.83±0.6[a]	0.36
BL	62.79±0.53[b]	67.26±0.42[a]	159.11
CD	25.28±0.24[b]	36.84±0.19[a]	7.14
HG	63.97±0.54[b]	68.73±0.43[a]	25.33
HAW	64.41±0.41[b]	65.39±0.33[a]	0.87
RH	63.43±0.66[b]	65.60±0.53[a]	20.58
HW	12.50±0.15[b]	14.71±0.12[a]	0.35
EL	12.57±0.15[b]	13.11±0.12[a]	0.35
TL	33.14±0.41[a]	32.81±0.23[a]	1.39
HL	21.08±0.14[a]	21.350.12[a]	2.82
HC	41.57±0.31[a]	38.98±0.25[b]	64.25
FLL	38.36±0.26[b]	39.23±0.21[a]	2.82
HLL	45.67±0.31[a]	45.75±0.32[a]	12.99

Means in the same row with different superscripts are significantly different ($P<0.05$). MS= Mean squares, BW= body weight, BCS= body condition score, BL=body length. CD= chest depth,HG= heart girth, HAW= height at wither, RH= rump height, HW= hip width, EL= ear length, TL= tail length, HL= head length, HC= head circumference, FLL= fore leg length HLL= hind leg length.

4.1.3;<u>Effect of Age on Body Weight, Body Condition Score and Linear Body Measurements</u>

The effectof age on body weight, linear body measurements and body condition score is depicted in Table 3. The result shows significant ($P<0.05$) differences between the animals within different age groups.Animals within the age group greater than three years had significantly ($P<0.05$) higherBW, BL, CD, HG, HAW, HW and HL (31.33, 71.53, 39.67, 74.43, 68.00, 16.10 and 22.60 respectively) , those between 1-3 years followed with 24.94, 65.66, 36.37, 67.24, 65.37, 14.04 and 21.54 for BW, BL, CD, HG, HAW, HW and HL respectively, while sheep under one year recorded the least BW, BL, CD, HG, HAW, HW and HL (17.75, 59.85, 32.51, 58.69, 60.66, 11.33 and 18.77 respectively). Similarly, the animals between the age of 1-3 years had significantly ($P<0.05$) higher BCS (1.95), followed by those above3 years (1.77) even though the two were statistically similar , while those under one year recorded the lowest (1.62). On the other hand, therewere no significant variations in, RH, TL, HC, and FLL for sheep between the age of 1-3 years and >3 years although they recorded the highest values (65.68 and 67.70, 33.19 and 33.56, 40.19 and 40.66 and 39.41 and 39.60 for 1-3yr and >3yr respectively), but differed significantly ($P<0.05$) from those under 1 year that recorded the lowest RH, TL, HC, and FLL value (58.86, 31.26, 37.66 and 36.56 respectively). Significant($P<0.05$)variations were also found in EL across the age groups where >3yrs had the highest value (13.17), followed by 1-3yrs (13.00) and <1yr (12.36). In the same vain, sheep >3yrs had significantly ($P<0.05$) the higher FLL (46.49) compared to those <1yr (43.96) and 1-3yrs (44.90).

Table 3: Effect of Age on Body Weight, Body Condition Score and Linear Body Measurements

VARIABLES	Age Group			
	<1Yr	1-3Yr	>3Yr	MS
BW	17.75±0.82[c]	24.94±0.44[b]	31.33±0.77[a]	775.36
BCS	1.62±0.10[b]	1.95±0.06[a]	1.77±0.10[ba]	1.52
BL	59.85±0.78[c]	65.66±0.42[b]	71.53±0.74[a]	482.60
CD	32.51±0.36[c]	36.37±0.20[b]	39.67±0.34[a]	237.95
HG	58.69±0.80[c]	67.24±0.43[b]	74.43±0.76[a]	165.95
HAW	60.66±0.61[c]	65.37±0.33[b]	68.00±0.57[a]	332.82
RH	58.86±0.99[b]	65.68±0.53[a]	67.70±0.93[a]	472.70
HW	11.33±0.22[c]	14.04±0.12[b]	16.10±0.21[a]	62.44
EL	12.36±0.23[b]	13.00±0.12[ab]	13.17±0.22[a]	14.97
TL	31.26±0.61[b]	33.19±0.33[a]	33.56±0.58[a]	67.79
HL	18.77±0.23[c]	21.54±0.12[b]	22.60±0.20[a]	88.49
HC	37.66±0.46[b]	40.19±0.25[a]	40.66±0.44[a]	197.41
FLL	36.56±0.39[b]	39.41±0.21[a]	39.60±0.37[a]	69.29
HLL	43.96±0.59[b]	44.90±0.32[b]	46.49±0.56[a]	93.02

Means in the same row with different superscripts are significantly different (P<0.05). MS= Mean squares, BW= body weight, BCS= body condition score, BL=body length. CD= chest depth,HG= heart girth, HAW= height at wither, RH= rump height, HW= hip width, EL= ear length, TL= tail length, HL= head length, HC= head circumference, FLL= fore leg length HLL= hind leg length.

4.1.4:Effect of Physiological Status on Body Weight, Body Condition Score and Linear Body Measurements

The physiological status as it affected body weight, linear body measurements and body condition score is presented in Table 4: the result showed no significant difference in BW between males and dry females as well as pregnant and lactating ewes, but pregnant and lactating recorded the highestvalues (30.35 and 30.11, respectively)than male and dry females (21.50 and 22.09 respectively). On the other hand, the result for BCS showed no significant variations between the males (2.00), dry females (1.71), pregnant (2.04) and lactating ewes (2.01). Findings on BL shows no significant differences in between males and dry females(62.62 and 64.09 respectively) as well as between pregnant and lactating(69.23and 70.97 respectively), but the latter were significantly longer than the former.For CD, it was observed thatpregnant and lactating hadsignificantly highermeans (38.73 and 38.46 respectively) than male and dry so also between pregnant and lactating than males and dry females (35.25 and 34.54 respectively). Significant ($P<0.05$) variations in HG due to physiological status of sheep were observed with pregnant ewesrecording the highest heart girth (73.23), followed by lactating ewes (70.17), dry ewes (64.64) while males recorded the lowest.In the same,a significant influence of physiological status on HAW was observed with pregnant and lactating ewes recording the highest values (66.97 and 67.76 respectively) that were statistically similar, but significantly ($P<0.05$) higher than dry ewes(64.37) and males (62.71). Pregnant and lactating ewes recorded significantly ($P<0.05$) higher means for RH (67.55 and 67.84 respectively) than males and dry ewes (63.43 and 62.90 respectively). Similarly, considerable ($P<0.05$) variations in HW caused by the animal's physiological statuswere detected with pregnant, lactating and dry eweshaving respective means of 15.70, 16.17 and 13.23, while males had 12.47. Significantly ($P<0.05$) longer earswere observed among lactating ewes (14.20) compared to males (12.72), dry ewes (12.83) and pregnant ewes (12.79) that were statistically similar. With respect to TL, it was observed that males, pregnant and lactating ewes had averages of33.19, 33.08,and

34.46,respectively) while dry ewes the lowest value of 31.61. It was also observed that significant variations existed in HLwith lactating ewes recording the highest value (22.66), followed by pregnant ewes (21.94),and males (21.09),while dry ewes recorded the lowestvalue. Males had the highest value for head circumference (41.43) that significantly(P<0.05) differed lactating ewes (40.48), pregnant ewes (40.05) and dry ewes (37.35) Lactating ewes had significantly (P<0.05) higher FLL (41.28), followed by pregnant ewes (39.73),males (38.31)while the lowest mean (37.83) was recorded among dry ewes. Significant (P<0.05)differences were observed HLL with lactating ewes recording the highest value (47.73) but there were no significant differences between males (45.66), dry ewes (44.64) and pregnant ewes (45.82).

Table 4: Effect of Physiological Status on Body Weight, Body Condition Score and Linear Body Measurements.

VARIABLES	Physiological status Male	Dry	Preg.	Lact.	MS
BW (kg)	21.50±0.62^b	22.09±0.70^b	30.35±0.69$_a$	30.11±0.89^a	161.75
BCS	2.00±0.08^a	1.71±0.09^a	2.04±0.13^a	2.01±0.11^a	0.46
BL	62.62±0.59^b	64.09±0.67^b	69.23±0.66^a	70.97±0.85^a	60.63
CD	35.25±0.27^b	34.54±0.31^b	38.73±0.31^a	38.46±0.39^a	49.81
HG	63.91±0.61^c	64.64±0.69^c	73.23±0.68^a	70.17±0.87^b	268.97
HAW	62.71±0.46^c	64.37±0.52^b	66.97±0.51^a	67.76±0.66^a	69.82
RH	63.43±0.75^b	62.90±0.84^b	67.55±0.83^a	67.84±1.07^a	85.18
HW	12.47±0.17^c	13.23±0.19^b	15.70±0.18^a	16.17±0.24^a	22.60
EL	12.72±0.17^b	12.83±0.19^b	12.79±0.19^b	14.2±0.25^a	69.29
TL	33.19±0.46^a	31.61±0.52^b	33.08±0.52^a	34.46±0.66^a	61.59
HL	21.09±0.16^c	20.26±0.19^d	21.94±0.18^b	22.66±0.24^a	8.08
HC	41.43±0.35^a	37.35±0.31^c	40.05±0.39^b	40.48±0.50^{ab}	49.66
FLL	38.31±0.29^c	37.83±0.33^c	39.73±0.33^b	41.28±0.42^a	43.49
HLL	45.66±0.45^b	44.64±0.51^b	45.82±0.50^b	47.73±0.65^a	107.43

Means in the same row with different superscripts are significantly different (P<0.05).
Preg.= pregnant, Lact.= lactating, MS= Mean squares, BW= body weight, BCS= body condition score, BL=body length. CD= chest depth,HG= heart girth, HAW= height at wither, RH= rump height, HW= hip width, EL= ear length, TL= tail length, HL= head length, HC= head circumference, FLL= fore leg length HLL= hind leg length.

4.1.5: Relationship Between Body Weight, Body Condition Score and Linear Body Measurements

The Relationship between body condition score, body weight and linear body measurements is depicted in Table 5: The results showed highly significant (P<0.01) correlations between body condition score and body weight, (0.22), body length (0.18), chest depth (0.22), heart girth, (0.91), hip width, (0.24), head length, (0.23) and head circumference (0.23), as well as significant (P<0.05) with height at wither (0.15) and foreleg length (0.15).On the other hand,a negative correlation was found between the body condition score and hind leg length (-0.06).However, no significant correlations were observed between the body condition score and rump height (0.06), ear length (0.03) and tail length (0.09). There were highlysignificant (P<0.01) relationships between body weight and body length (0.68), chest depth (0.77), heart girth (0.73), height at wither (0.55), rump height (0.51), hip width (0.76), ear length (0.33), tail length (0.39), head length (0.57), head circumference (0.47), fore leg length (0.55) and hind leg length (0.51). Similarly, there was highly significant (P<0.01) relationships between body length and chest depth (0.70), heart girth (0.59), height at wither (0.52), rump height (0.50), hip width (0.72), ear length (0.30), tail length (0.34), head length (0.54), head circumference (0.38), fore leg length (0.46) and hind leg length (0.34). In the same vain, chest depth was strongly (P<0.01) correlated with heart girth (0.84), height at wither (0.78), rump height (0.61), hip width (0.69), ear length (0.35), tail length (0.51), head length (0.71), head circumference (0.61), fore leg length (0.58) and hind leg length (0.40). It was also observed that heart girth was significantly (P<0.01) associated with height at withers (0.69), rump height (0.59), hip width (0.62), ear length (0.26), tail length (0.39), head length (0.62), head circumference (0.50), foreleg length (0.53) and hind leg length (0.30). The results also indicatedthat height at withershad significant (P<0.01) correlations with rump height (0.63), hip width (0.43), ear length (0.37), tail length (0.54), head length (0.62), head circumference (0.61), fore leg length (0.67) and hind leg length (0.46). Highly significant (P<0.01) correlations were also observed between rump height and hip width (0.47), ear length (0.29), tail length (0.38), head length (0.55), head circumference (0.48), fore leg length (0.58) and hind leg length (0.40). Similarly, the relationships between hip width and ear length (0.32), tail length (0.34), head length (0.61), head circumference (0.38), fore leg length (0.47) and hind leg length (0.28) were highly significant (P<0.01) correlation. Ear length was significantly (P<0.01) associated with tail length (0.38), head length (0.33), head circumference (0.28), fore leg length (0.49) and hind leg length (0.49). The results also revealed highly significant (P<0.01) correlations between tail lengthand head length (0.45), head circumference (0.42), fore leg length (0.56) and hind leg length (0.40). Highly significant (P<0.01) correlations were also observed between head length and head circumference (0.62), fore leg length (0.61) and hind leg length (0.40). In a similar manner, highly significant (P<0.01) correlations were observed between head circumference and fore leg length (0.43) and hind leg length (0.37).The relationship between fore leg length and hind leg length (0.66) was also very strong (P<0.01).

Table 5:Correlations Matrix of Body Weight Body Condition Score and Linear Body Measurements

	BCS	BW	BL	CD	HG	HAW	RH	HW	EL	TL	HL	HC	FLL	HLL
BCS	1													
BW	0.22**	1												
BL	0.18**	0.68**	1											
CD	0.22**	0.77**	0.70**	1										
HG	0.19**	0.73**	0.59**	0.84**	1									
HAW	0.15*	0.55**	0.52**	0.78**	0.69**	1								
RH	0.06^{ns}	0.51**	0.50**	0.61**	0.59**	0.63**	1							
HW	0.24**	0.76**	0.72**	0.69**	0.62**	0.43**	0.47**	1						
EL	0.03^{ns}	0.33**	0.30**	0.35**	0.26**	0.37**	0.29**	0.32**	1					
TL	0.09^{ns}	0.39**	0.34**	0.51**	0.39**	0.54**	0.38**	0.34**	0.38**	1				
HL	0.23**	0.57**	0.54**	0.71**	0.62**	0.62**	0.55**	0.61**	0.33**	0.45**	1			
HC	0.23**	0.47**	0.38**	0.61**	0.50**	0.61**	0.48**	0.38**	0.28**	0.42**	0.62**	1		
FLL	0.15*	0.55**	0.46**	0.58**	0.53**	0.67**	0.58**	0.47**	0.49**	0.56**	0.61**	0.43**	1	
HLL	-0.06	0.51**	0.34**	0.40**	0.30**	0.46**	0.40**	0.28**	0.49**	0.40**	0.40**	0.37**	0.66**	1

**= P<0.01, *= P<0.05, ns= not significantBW= body weight, BCS= body condition score, BL=body length. CD= chest depth,HG= heart girth, HAW= height at wither, RH= rump height, HW= hip width, EL= ear length, TL= tail length, HL= head length, HC= head circumference, FLL= fore leg length HLL= hind leg length.

4.1.6: Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in <1 year Ram

Table 6 presents the analysis of variance, calculated variance components, repeatability (r_1) and reproducibility (r_2) of body condition scoring in <1 year rams. There were very highly significant ($P<0.001$) effects of y ram on BCS, as well as that of the interaction ($P<0.001$) between ram and assessor. However, assessor and score did not exhibit any significant influence on the trait. The estimated components of variance were 0.264, 0.002, 0.000, 0.024 and 0.026 respectively for ram, assessor, score, ram x score and error component. The repeatability and reproducibility estimates of BCS were 0.917 and 0.835 respectively.

4.1.7: Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in 1-3 years Ram

Analysis of variance, calculated variance components, repeatability (r_1) and reproducibility (r_2) of body condition scoring in 1-3 years ram is depicted in Table 7. There were significant ($P<0.001$) effects of ram as well as that of the interaction between ram x assessor and ram x score ($P<0.01$) on BCS. However, assessor and score did not exert any considerable influence on the character. The estimated components of variance were 0.254, 0.000, 0.000, 0.017, 0.017 and 0.033, respectively for ram, assessor, score, ram x score and error component. The values of repeatability and reproducibility of the character were 0.897 and 0.719, respectively.

Table 6:Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in<1year Ram

Source of Variation	DF	MS	Est. of Var. Comp.	r1	r2
Ram	38	1.129***	0.264	0.917	0.835
Assessor	1	0.231^{NS}	0.002		
Score	1	0.026^{NS}	0.000		
Ram x Assessor	38	0.073***	0.024		
Error	77	0.026	0.026		
Total	155	1.485	0.316		

DF= degree of freedom, MS= mean square, ***= P<0.001, NS not significant

Table 7:Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in 1-3years Ram

Source of Variation	DF	MS	Est. of Var. Comp.	r1	r2
Ram	59	1.119***	0.254	0.897	0.791
Assessor	1	0.067^{NS}	0.000		
Score	1	0.000^{NS}	0.000		
Ram x Assessor	59	0.067**	0.017		
Ram x score	59	0.068**	0.017		
Error	60	0.033	0.033		
Total	239	1.354	0.321		

DF= degree of freedom, MS= mean square, **=P<0.01, ***= P<0.001, NS not significant

4.1.8: Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in <1 year Ewes

Table 8 shows the analysis of variance, calculated variance components, repeatability (r_1) and reproducibility (r_2) of body condition scoring in <1 year ewe. Ewe and assessor had significant ($P<0.01$) effect on BCS,whereas the score is not significant. The estimated components of variance were 0.198, 0.009, 0.000, and 0.043 for ewes, assessor, score, and error component,respectively, while the repeatability and reproducibility estimates were 0.828 and 0.792, respectively

4.1.9: Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in 1-3 years Ewes

Analysis of variance, calculated variance components, repeatability (r_1) and reproducibility (r_2) of body condition scoring in 1-3 years ewes are depicted in Table 9. There were significant ($P<0.001$) effects of ewes, ewes x score, and score x assessor interactions, whereas assessor and score failed to exert any considerable influence on the trait. The estimated components of variance were 0.538, 0.001, 0.001, 0.016, 0.001 and 0.048 for ewes, assessor, score, ewes x score, score assessor and error component,respectively. The values of repeatability and reproducibility of the trait were 0.919 and 0.889, respectively.

Table 8:Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in<1 year Ewes

Source of Variation	DF	MS	Est. of Var. Comp.	r1	r2
Ewe	13	0.835***	0.198	0.828	0.792
Assessor	1	0.286**	0.009		
Score	1	0.000^{NS}	0.000		
Error	40	0.043	0.043		
Total	55	1.164	0.25		

DF= degree of freedom, MS= mean square, **=P<0.01, ***= P<0.001, NS not significant

Table 9:Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in1-3 years Ewes

Source of Variation	DF	MS	Est. of Var. Comp.	r1	r2
Ewe	126	2.234***	0.538	0.919	0.889
Assessor	1	0.096^{NS}	0.001		
Score	1	0.569^{NS}	0.001		
Ewes x Score	126	0.018***	0.016		
Score x Assessor	1	0.238*	0.001		
Error	252	0.048	0.048		
Total	507	3.203	0.605		

DF= degree of freedom, MS= mean square, *=P<0.05, ***= P<0.001, NS not significant

4.1.10: Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in>3 years Ewes

Table 10 depicts the analysis of variance, calculated variance components, repeatability (r_1) and reproducibility (r_2) of body condition scoring in >3 years ewes. There were highly significant (P<0.001) effects of ewe and ewes x score interaction as well as that of score (P<0.05).However, the effect of assessor was negligible. The estimated components of variance were 0.637, 0.000, 0.003, 0.030 and 0.008, respectively for ewes, assessor, score, ewes x score and error component, while the repeatability and reproducibility of the character were 0.984 and 0.939, respectively.

Table 10:Analysis of Variance, Calculated Variance Components, Repeatability (r_1) and Reproducibility (r_2) of Body Condition Scoring in >3 years Ewes

Source of Variation	DF	MS	Est. of Var. Comp.	r1	r2
Ewe	59	2.616***	0.637	0.984	0.939
Assessor	1	0.017^{NS}	0.000		
Score	1	0.417*	0.003		
Ewes x score	59	0.069***	0.030		
Error	119	0.008	0.008		
Total	239	3.127	0.678		

DF= degree of freedom, MS= mean square, *=P<0.05, ***= P<0.001, NS not significant

4.1.11: Prediction Equations for Estimation of Body Weight From Linear Body Measurements Using Stepwise Multiple Regression Analysis

Table 11 summarizes the prediction equations to estimate body weight fromlinear body measurements using stepwise multiple regression analysis.Equation 1 that had CD as the only predictor variable of live body weight gave the adjustedR^2(coefficient of determination) value of 0.59.However,when CD and the HG were considered together (equation 2), the R2 value increased drasticallyto 0.69, equation 1 and 2 were found to be good predictors even though not very reliable compared to equation 3, 4 and 5**.** Inequation 3, the R^2value increased to 0.70 which then increased to 0.71in equation 4.In the same vain, the adjusted R^2value changed to 0.72when CD, HG, HW, HL and HLL were considered together from equation 5, it shows that these equations appeared to be the most reliable predictors explaining that, the optimum number of predictors is three.

Table 11: Step Wise Multiple Regression Equations for Prediction of Body Weight From Linear Body Measurements

Steps	Regression equation	AR^2 .
1	Y= -31.42+1.55(CD)+0.07	0.59
2	Y= -28.81+0.94(CD)+1.40(HG)+0.13	0.69
3	Y= -34.30+0.85(CD)+1.40(HW)+0.19(HLL)+0.06	0.70
4	Y= -35.28+0.53(CD)+0.18(HG)+1.35(HW)+0.21(HLL)+0.05	0.71
5	Y= -33.92+0.61(CD)+0.19(HG)+1.42(HW)+-0.33(HL)+0.23(HLL)+0.15	0.72

CD= chest depth,HG= heart girth, HW= hip width, HL= head length, HLL= hind leg length AR^2= Adjusted R^2

4.1.12: Accuracy of Weight Estimation Methods in Sheep Relative to Actual Body Weight

Accuracy of weight estimation methods in sheep relative to actual body weight as shown by the indices is presented in Table 12. The mean body weight, standard deviations and indices of body weight, body weight estimated using tape (BW_{Tape}), body weight estimated using regression equation($BW_{Regression}$) and body weight estimated using formula($BW_{Formula}$) are also presented in the table. Based on age category, sheep under 1 year hadan actual mean body weight of 17.75 and SD of 2.99. BW_{Tape}hada mean BW of 20.11, SD of 3.9 and an index of 114.26,while$BW_{Regression}$recorded a mean BW of17.61, SD of 4.3 and 99.53 as an index,whereas$BW_{Formula}$was found to have a mean BW of 18.74, SD of 3.92 and the index of 106.4.Sheep aged between 1-3 years hadan actual mean body weight of 24.94 and SD of 6.63,BW_{Tape}hada mean BW of 29.43, SD of 6.25 and index of 121.12,$BW_{Regression}$recorded a mean BW of 25.17, SD of 5.04 and 103.37 as an index,while$BW_{Formula}$was found to have mean BW of 27.36, SD of 6.07 and the index of 112.21. The sheep >3 years recorded an actual mean body weight of 31.33 and SD of 7.56 andBW_{Tape}hada mean 36.87, SD of 5.68 and index of 121.73, while$BW_{Regression}$recordeda mean BW of30.76, SD of 4.91 and 100.75 as an index,whereas$BW_{Formula}$ was found to have mean BW of 35.91, SD of 6.42 and an index of 117.49.

On the basis of physiological status, males were observed to haveanactual mean body weight of 21.50 and SD of 5.69 andBW_{Tape}hada mean BW of 25.57, SD of 6.86 and index of 121.61, while $BW_{Regression}$recorded a mean BW of21.58, SD of 4.87 and 102.82 as an index,whereas$BW_{Formula}$was found to have a meanBW of 23.41, SD of 5.98 and an index of 111.53. Dry ewes had actual mean body weight of 22.09 and SD of 5.51 andBW_{Tape}hada mean BW of 26.20, SD of 6.34 and index of 119.77, while $BW_{Regression}$recorded a mean BW of22.38, SD of 5.39 and 102.20 as an index, whereas$BW_{Formula}$was found to have mean BW of 24.52, SD of 6.32 and a index of 111.68. The results also showed that, pregnant ewes recorded an actual mean body weight of 30.11 and SD of 6.20 andBW_{Tape}hada mean BW of 35.53, SD of 5.81 and index of 120.42, while $BW_{Regression}$recorded a mean BW of29.88, SD of 4.23 and 100.96 as an index, whereas $BW_{Formula}$was found to have mean BW of 33.65, SD of 6.23 and the index of 113.38. Similarly, lactating ewes was found to have an actual mean body weight of 30.35 and SD of 8.34 and BW_{Tape}hada mean BW of 34.01, SD of 6.01 and index of 116.33, while$BW_{Regression}$recorded a mean BW of29.97, SD of 5.74 and 102.42 as an index, whereas$BW_{Formula}$was found to have mean BW of 33.43, SD of 7.06 and the index of 113.25.BW_{Tape}recordedan R2 of 0.80, $BW_{Regression}$had an R2 of 0.85 while$BW_{Formula}$had the R2 of 0.83.

All the weighing methods used in this study appeared to be reliable and can be used in weighing of sheep, but their accuracy varied with their index value. The closer the index of each method to 100 the more reliable it is, $BW_{Regression}$had the index of 99.53 while $BW_{Formula}$recorded the index of 106.40 then BW_{Tape}method with 114.26, this shows that, regression method is the most accurate other than scale, next to regression method is the weight estimation formula and the tape method is the least accurate compared to others.

Table 12: Accuracy of Weight Estimation Methods in Sheep Relative to Actual Body Weight

	BW_{Actual}			BW_{Tape}				$BW_{Regression}$				$BW_{Formula}$			
Age	X	SD	CV	X	SD	CV	INDEX	X	SD	CV	INDEX	X	SD	CV	INDEX
1	17.75	2.99	16.85	20.11	3.90	19.40	114.26	17.61	4.30	24.42	99.53	18.74	3.92	20.9	106.4
2	24.94	6.63	26.58	29.43	6.25	21.24	121.12	25.17	5.04	20.03	103.37	27.36	6.07	16.3	112.21
3	31.33	7.56	24.16	36.87	5.68	15.41	121.73	30.74	4.91	15.97	100.75	35.91	6.42	17.9	117.49
PS															
1	21.50	5.69	26.47	25.57	6.86	26.83	121.61	21.58	4.87	22.57	102.82	23.41	5.98	25.5	111.53
2	22.09	5.51	24.94	26.20	6.34	24.19	119.77	22.38	5.39	24.08	102.2	24.52	6.32	25.4	111.68
3	30.11	6.2	20.59	35.53	5.81	16.35	120.42	29.88	4.23	14.61	100.96	33.65	6.23	18.5	113.38
4	30.35	8.34	27.48	34.01	6.01	17.67	116.33	29.97	5.74	19.15	102.42	33.43	7.06	21.1	113.25
R^2	1			0.80**				0.85**				0.83**			

X= mean, SD= standard deviation, CV= Coefficient of variation, PS= physiological status, **= P<0.01

4.1.13: Relationship Between Different Methods of Weight Determination in Sheep

The relationship between different methods of weight determination in sheep is as shown in Table 13: There highly significant correlations ($P<0.01$) between actual body weight of the animals and the body weight estimated using tape (0.80), body weight estimated using regression equation (0.85) and body weight estimated using small ruminant weight estimation formula (0.83). Similarly, another highly significant($P<0.01$) associationswere observed between weighing method using tape and regression equation method of weight determination (0.89) and weight estimation formula (0.96). The result also revealed a highly strong($P<0.01$) relationshipbetween regression method and weight estimation formula (0.90). This deduced that regression method is the best method in the absent of weighing scale, followed by weight estimation formula and the tape method appeared to be the least accurate compared with the remaining methods.

Table 13: Relationship Between Different Methods of Weight Determination in Sheep

	BW_{Actual}	BW_{Tape}	$BW_{Regressiom.}$	$BW_{Formula.}$
BW_{Actual}	1			
BW_{Tape}	0.80	1		
$BW_{Regression.}$	0.85	0.89	1	
$BW_{Formula.}$	0.83	0.96	0.90	1

BW= BodyWeight

DISCUSSION

Genetic improvement programs applied to livestock are conducted on the basis of two main approaches: selection and breeding systems.The potentials for genetic progress largely depends on the genetic variation in the traits and its relationship with other economic traits (Ceyhan, Kaygisiz&Sezenler, 2011)

4.2.1 Body Weight

A number of factors are responsible for variation in live body weight, as reported by Hussaini*et al.* (2013).Variation in body weight is a factor of genotype, feeding, management and environmental conditions. Several researches are in agreement with the findings of this study that location of animals affects its live body weight (Demiroren, Shretha&Boylan 1995, Sormunen&Suvela, 1999; Hansen & Shrestha, 2002; Fisher 2004; Rosa & Bryant, 2003).Majority of findings on the effect of location on body weight have shown that location has significant influence on important economic body features. The mentioned factors can be connected with vegetation growth (as a food source), temperature and day length, all of which depend on seasonal characteristic for different geographic locations. Year of production as well as season were similarly observed to exert significant influence on animals body weight as well (Dixit, Dhillon& Singh,2001).

In contrast to some findings(Jamssems&Vandepitte, 2004;Hussain*et al.,* 2013) which found that rams were significantly heavier than ewes,this study revealed that females (ewes) were heavier than males (rams).This could be attributed to the fact that data for the current study were generated after most of the matured rams were slaughtered during Ed-el-kabirfestival, as

Kano is a predominantly muslim state. On the other hand, Otoikhian,Akporhuarho and. Isidahomen (2008a) reported no significant difference in body weight between the males and females in Uda sheep, with respective means of23.15±1.51 and 22.00±2.22 kg that did not differ significantly. The authors explained that this might be as a result of additional weight gain of some of the females as a result of pregnancy as selection of the experimental animals did not include any form of pregnancy test.In another study on goats,Otoikhian, Akporhuarho, Oyefia and Isidahomen, (2008b) reported that sex did not have any considerable influence on weight gain of the animals.

The fact that this study revealed a positive relationship between live body weight and age category of animals agrees with the reports of several researches .For instance,Otoikhian*et al.*(2008a)observed that body weight of Uda sheep increased progressively as age advanced. The rate of growth however reduced with a slight decrease between 25-36 month of age when the increase in body size seemed to be slow, and statistically different from growth rate in the preceding age groups, gradually measuring up to full maturity. The findings of Prakash *et al.* (1990), Sinha and Singh (1997), Mandal*et al.* (2007) and Mandal, Pant, Nandy, Rout and Roy, (2003) in their research on Muzaffarnagari sheep as well as that ofHussain*et al.*(2013) on Thalli sheep, also corroborate this observation. Similar to this finding was also reported by Otoikhian*et al.* (2008b) in goat. Brown and Swan (2012) also reported that adult body weight was highly correlated phenotypically and genetically among ages, suggesting that one assessment of adult weight is sufficient for selection purposes.In another study carried out using Manchega sheep, it was shown that age of sheep had a significant impact on the live weights during breeding, lambing and weaning while correlations between body condition score and body weight inbreeding, lambing, weaning and dry periods for sheep was observed (Ada *et al.,* 2004)

The fact that lactating and pregnant ewes weighed significantly heavier than males and dry ewes probably due to foetal mass and udder weight as well as the fact that data for the current study were generated after most of the matured rams were slaughtered during Ed-el-kabir.Sezenler*et al.* (2011) observed that physiological state had a significant effect on body weight of sheep as eweswere found to have lower body weight than they had at pregnancy and after lambing and as well as after weaning period. A similar finding on Merino sheep was reported by Brown and Swan (2012). The relationships between BW and BCS of Türkgeldi sheep was also studied for different physiological periods by Arık, Yurtman, Özder andÖzdüven,(1997) which indicated that each BCS unit was equivalent to the changes of 10.961kg, 10.376 kg, and 7.310 kg at breeding, lambing and weaning weights respectively.

4.2.2 Body Condition Score

Body condition score and its use are important in terms of achieving the desired performance in certain physiological periods in sheep breeding where extensive conditions are dominant. It is indicated that there can be differences in values obtained in various physiological periods for the genotypes bred in the same country (Biçer, 1992)

The current study revealed variation in body condition score across the locations.Since this trait is factor of nutritional status of an animal, this variation is understandable because different geographical areas have different supplementation according to the availability of feed and individual farmers manage their animals differently from each other, even though the management systems is similar across the locations. Mona (2007) had stressed the fact thatcontribution of supplementation was an important factor affecting BCS, hence the supplementation serve as the major source of variation in the trait from one geographical region to another. Kabbali, Johnson, Johnson, Goodrich, and Allen,(1992) reported that, BCS varied with age of the animal, the weight, management and geographical region where the flocks have been raised. The fact that sex of an animal had no effect on its BCS because the animals of both sexes were managed together regardless of their sex, the animals had to compete with each other to satisfy their nutritional needs. This finding is in agreement with findings of Mona (2007) on Awassi sheep. However, Abi Saab, Sleiman, Wanna, El Kareh, and Farah(2000) and Baril*et al.*(1993), observed that rams tended to have higher condition scores, especially when fattened.

Age of Yankasa sheep significantly affected its BCS as revealed by the current study.Animals of age between 1-3 years had better BCS, while those younger had the poorest.This finding is in agreement with several reports.For example, Mona (2007) working on Awassi sheep observed that BCS, growth and body development of the sheep were influenced by age. (Burton, Anderson and Reid, 1974) showed that the rate of mobilization of the fat deposits was more intense in adult animals than in young sheep. Owen (1976), found that at birth, an animal contains little fat, however, the muscular components increased more quickly than the essential parts, whereas the deposits of fat were the last to evolve and the most severely affected by feeding conditions. Sezenler*et al.*(2011) on some indigenous sheep breeds in turkey, Mandal*et al.*(2012) in their research on Muzaffarnagari sheep andHussain*et al.*(2013)on Thalli sheep also reported similar findings.

The fact that physiological status of Yankasa sheep in the study area had no influence on its condition score, may not be unconnected to thenature of feeding, as the animals were fed randomly regardless of their physiological requirements. Body condition of pregnant and lactating ewes fall within the score of two (2) though it is within the normal but slightly low, Mona (2007) reported similar value of 2.56.However,Atti (1991) had shown that with certain phases of the reproductive cycle (pregnancy), the mobilization of fat deposits is inevitable in order to compensate the feed deficits caused by the physiological state of the female. Kabbali*et al.*(1992) reported that the rate of mobilization of fat reserves is function of the severity and the duration of feed shortage, the maturity of the animal and its physiological state. Similarly, Molina, Gallego, Tores, and Vergara, (2007) reported that ewes of the traditional system showed a notable reduction of body condition scores during pregnancy and lactation.Sezenler, Özder, Yıldırır, Ceyhan and Yüksel(2011) in their findings on some indigenous sheep breeds in turkey reported that BCS between breeds in different physiological periods were significantly different. The average minimum BCS was observed in Gokceada ewes for all physiological periods while the average minimum BCS was observed in 2 years old ewes in breeding and weaning periods and in 5 years old ewes in lambing period. Maximum BCS values were observed for 6 years old ewes in breeding period.

4.2.3 Repeatability and reproducibility of BCS

A number of factors determine the animal's body condition status, most of which are related to nutrition but to some extent the physiological state plays an important role. The current research revealed a positive impact of animal on its condition score and this is expected as the judgment is conducted in the same day so the nutritional state of the animal may not significantly change regardless of their age group and sex. The significant interactions of animals with their assessors or score indicated that the differences varied according to the level of animal condition score with the greatest variation at high and low condition score. This gives an insight to the fact that the score was actually for the animals and the assessor worked with the same animals. Audige, Wilson, and Moris, (1998) reported similar findings on red deer hinds.

The repeatability and reproducibility of BCS in this research were found to be very close to one. The high value of repeatability showed the ability of the assessors to capture the actual condition score of an animal up to 98% and the reproducibility which ranged from 0.791-0.939 indicates the agreement of different assessors in capturing the actual score of a given animal up to 93%. A report similar to this was made by Audige*etal*. (1998).However Evans (1978) reported lower values in cattle.

4.2.4 Linear Body Measurements

Recently, body measurements and indices estimated from various combination of conventional and non-conventional body parameter not only provide superior guide to weight but are also used as indicators of type and function in domestic animals.

The environment by which an animal lives' significantly influences its linear body measurements, as the phenotype is the function of gene and environment. This study revealed a significant influence of location of an animal on its body measurements. Adejoro and Salako(2013) reported similar findings which indicated significant differences in withers height, body length, foreleg length, thorax depth, horck length, rump length, face length, face width, rear leg length, Cannon bone length measurements of Yankasa sheep across different location. Momoh*et al.*(2013) also reported that breed and non-genetic factors (environment inclusive) are the sources of variation in body weight, growth rates and body measurements of sheep. Hussaini*et al.*(2013) reported that variation in body weight and body measurements is a factor of genotype, feeding, management and environmental conditions. Milan *et al.*(2011) also reported that location had significant influence on important economic body features due to vegetation growth (as a food source), temperature and day length, all of which depend on seasonal characteristic for different geographic locations.

This study showed a significant difference between males and females in most of the linear body measurements with female having higher valuesthan males.This observation could still be attributed to the factthat data for the current study were generated after most of the matured rams were slaughtered during Ed-el-kabirfestival. On the other hand,Otoikhian*et al.*(2008a) workingon Uda sheep,observed that body measurements showed considerable variations between the sexes with those of malesbeing significantly higher than those of females.However in another study on goats,Otoikhian*et al.*(2008b) reported most body parameter did not display any significant variations between sexes. Afolayan*et al.*(2006) on their part observed that sex differences between the sexes existed for all body dimensional traits in Yankasa sheep,except for height and girth. Similarly,Olutugun*et al.* (2003) and Kanai *et al.*(2013) observed significant variations in body measurements between sexes among cattle breeds.Yakubu,Ogah, and Idahor (2009) asserted that sex related variations in body measurements might be attributed to differences in sex hormonal effects on growth.However, Oni *et al*. (2001) and Raji*et al.*(2014)in their researches on cattle,affirmedthat sex had no influence on body measurements.

The fact that age of sheep in this study significantly influenced its body measurements, with the values increasing as age advanced, was similarly documented by Otoikhian*et al.*(2008a) in Uda sheep; The authors reported that values of body parameters increased progressively as sheep increased in age, which however reduced in rate with between 25-36 months of age when increase in body size seemed to be slow, and statistically different from growth rate in the preceding age group gradually measuring up to full maturity.The same was also reportedin goats by Otoikhian*et al.*(2008b)Osinowo*et al.*(1989) andOtoikhian*et a.* (2006) .The authors reported that different age groups had different body measurements like BL, EL, TL, WH, HG, HL etc.

Brawn and Swan (2012) reported that the phenotypic variance and heritability of BCS varied significantly throughout the year. The phenotypic variance increased from the dry period through to a maximum at weaning. In contrast the heritability was highest in the period when the ewe was dry and was generally similar at all other times. The genetic variance was at its highest at weaning and at this time was 4 times the magnitude compared to measurements from the dry period. The genetic correlations between measurement times were moderate to high ranging from 0.38 to 0.90.These results are lower than those of Borg *et al.* (2009) who also estimated very high genetic correlations of 0.93 to 0.96 between BCS assessed at lactation, gestation and weaning. The phenotypic correlations between times of the year were also low ranging from 0.11 to 0.24

4.2.5: Relationship Between Body Condition Score, Body Weight and Linear Body Measurements

The fact that a significantly positive correlation was observed between body weight and body condition score in Yankasa sheep in this study is expected as the BCS is a function of fat and muscle deposition in various part of an animal body where palpation for condition scoring is done. Brown and Swan (2012) working on sheep under semi-intensive conditions of management,indicated that body weight and BCS were positively correlated with each othergeneticallywith values ranging from 0.34 to 0.65.Borg *et al.*(2009) and Mona (2007)working on animals maintained under intensive system of managementreported higher correlations that varied from 0.79 to 0.98.These observations suggest thatwith improved feeding, ewes of different ages are able to store more subcutaneous fat (Miller et al. ,1986, Banskalieva*et al.*1988 and Webb *et al.,*1994)., thus increasing thecorrelations between body weight and BCS .
The moderate correlation values obtained between body condition score and some of the linear body measurements tally with the findings of Mona ((2007),although the latter reported higher values.Similar results were obtained by Abi Saab *et al.,* (1999) and Sezenler*et al.*(2011) on some

indigenous sheep breeds in turkey as well as on some Britain crossbreeds (Geisler and Fenlon, 1979),Türkgeldi ewes (Arık*et al.,* 1997) andAwassi ewes (Treacher and Filo, 1995).

The high positive correlations observed between live body weight and most of the linear body measurements and between the linear body measurements in thisstudy were also documented by Otoikhian*et al.*(2008a) and Jamssems and Vandepitte(2004). Afolayan*et al.*(2006) noted that live weight was very highly (P< 0.001) correlated with body dimensional traits (0.76–0.94). The authors found that of the body dimensional characters, girth was the most related trait to weight, while variables such as height, length, girth, which are directly related to the size and weight of animal, displayed moderate to very high positive correlations with one another (0.79–0.87).They however discovered that the measure of bone (hip width) was negatively correlated (–0.40) with the measure of muscularity (defined as stifle/hip × 100),whereas low and sometimes non-significant correlations were obtained between muscularity and all the body dimensional traits (–0.34–0.10). The weight was generally unrelated (zero correlation) to the muscularity.Similarly, Afolayan*et al.*(2003) obtained a higher genetic correlation between weight and girth as compared to the correlation between weight and height across weaning and post-weaning ages of some bostaurus cattle breeds. Similarly, this observation agrees with that reported for some Nigerian cattle breeds (Umoh and Buvanendran, 1982). Younas*et al.,*(2013)Atta and El-Khidir (2004),Topal and Macit(2004) and Cam *et al.*(2010) also reported positive correlations of body weight and other body measurements. Pesmen and Yerminci (2008) reported that on Saanen goat, the phenotypic correlations between live weight and withers height, body length, body depth and heart girth were 0.36, 0.56, 0.38 and

0.64, respectively while the correlations between withers height and body length, body depth, hearth girth were 0.38, 0.48 and 0.40 (P<0.01).

4.2.6 <u>Step Wise Multiple Regression Method for Prediction of Live Body Weight from Linear Body Measurements.</u>

A stepwise multiple regression analysis was carried out when other body measurements were added, one at a time, to chest depth (Table 6). The essence was to determine how other body measurements would influence the precision of live weight predictions compared to using chest depth alone. It was observed that heart girth, hip width, hind leg length and head lenth appeared to be important additional variables to chest depth to obtain up to 73% prediction power of body weight.Mahmud *et al.*(2014a) reported that CD and HG recorded the highest positive correlations with the LBW. Similar results were obtained in previous studies on sheep (Atta and El-khidir2004; Pesmen and Yardimci, 2008; Cam *et al.,* 2010).Ozturk*et al.*(1994) found that live weight could be estimated accurately using heart girth parameter in sheep and goats. In addition the method was described to be handier comparing to other parameters since a tape measure is sufficient. Ozturk*et al.*(1994) showed that heart girth was the most appropriate parameter in predicting live weight using only one parameter in Konya Merino, but in case of using two parameters, body length and heart girth were found to be the most convenient. However in the event of using three parameters, the authors found that body length, heart girth and body depth was more appropriate.They further suggestedif it is necessary to increase the parameters in estimating live weight, chest width, shank circumference could be added. The investigators however, cautioned that using many body measurements to predict the live weight is not a simple and easy process. Therefore the fewer theparameters that are used, the better.

Mahmud *et al.*(2014) noticedincreases in the coefficient of determination as more variables were included in the prediction equations.Similarly conclusions were drawn by Edea*et al.,*(2009) on Bonga and Horro sheep,Getachew*et al.*(2009) on Menz and Afar sheep and Tadesse and Gebremariam (2010) on Highland Sheep in Tigray Region, North-Ethiopia.

4.2.7 Relationship Between Different Methods of Weight Determination in Sheep and Their Accuracy Relative to Actual Body Weight

Relative to the actual body weight of sheep as measured on the scale, the index on Table 7 also demonstrated the abilities of the different methods to estimate an animal's live weight. In this regard, the regression equation method with the lowest ratio to the actual body weight,wasalso the most accurate predictor of body weight across all the age groups and physiological statuses, followed by weight estimation formula, while the least accurate was the use of tape. This fact was similarly documentedby Stajnko*et al.*(2009) in cattle as well as Enevoldsen and Kristensen (1997).

It is assumed that weighing scale used to determine the weight of the experimental animal was the most accurate method of weight determination. The fact that weights estimated using the regression method had the highest correlation (0.85) with the actual weights compared to the correlation coefficients between the latter and those derived using the small ruminant weight estimation formula is (0.83) and small ruminant weighing tape (0.80),could probably be due to the fact that regression method entails the use of several body measurements than the other methods.Afolayan*et al.*(2006) in their research on Yankasa sheep, discovered that the addition of other measurements to chest girth in multiple regression analyseswould result in significant improvements in accuracy of prediction even though the extra gain was small. However, under field conditions, live weight estimation using chest girth alone would be preferable to combinations with other measurements because of difficulty of proper animal restraint during measurement. This thus reduces the practical usefulness of using other body measurements in conjunction with chest girth (Berge, 1977).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMENDATION

5.1 SUMMARY

The study was conducted to biometrically assess body weight and body condition score and linear body measurements in Yankasa sheep in some selected local government areas of Kano State (Bebejsi, Dawakin Kudu, Wudil, Shanono and Dambatta). The animals were aged by dentition, weighed using a scale while linear body measurements which included body length, chest depth, heart girth, height at withers, rump height, hip width, ear length, tail length, head length, head circumference, fore leg length and hind leg lengthwere taken using measuring tape. Body condition score was determinedtwice a day based on a scale of 0-5 by two assessors.The resultsshowed significant differencesacross the locations, age groups, physiological status and sex for all the variables except for body length between the locations, BCS, tail length, head length and hind leg length across the sexes, as well as BCS across all the physiological status groups. There were strong positive correlations between live body weight and most of the linear body measurements as well as between the former and BCS. Thus, the use of these traits as selection criteria for body weight would yield positive responses.Repeatability and reproducibility of BCS were very high (0.828-0.982 and 0.791-0.939 respectively).The high values of repeatability of BCS indicate strong correlations between condition scores of an animal measured by the same assessor on two occasions,while the similarly high values of reproducibility show the agreement betweenthe two assessors in capturing the score of a given animal.Regression procedure was found to be the most accurate method of weight determination other than the use of a weighing scale.

5.2 CONCLUSION

In conclusion, BCS andmost of the linear body measurements had positive and high correlationswith body weight, indicating that thesetraits can be used for estimation of body weight in the field where scales are not usually available as well as selection criteria for increased body weight. The body condition score index utilized is also a valuable tool for investigation of the adequacy of management practices and it is a simple, repeatable and reproducible system.Although the relationships between the BCS and most linear body measurements were considerably positive,the correlations were weak with some body parameters (HLLRH, EL and TL),suggesting that these are different traits genetically.Regression method of weight determination was found to be the most accurate other than scale followed by weight estimation formula and tape method was the least accurate.

5.3 RECOMMENDATIONS

1. Sheep farmers should consider condition scores in selection and should be used routinely to assess the nutritional status of their animals.
2. Emphasis should be given to linear body measurements during selection for increased body weight in sheep breeding, considering thepositive and high correlations existingbetween them.
3. Regressionmethodof weight determination should be used in the absence of a weighing scale.

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