GENETIC PROFILE OF MORPHOLOGICAL TRAITS AND THEIR ASSOCIATION WITH PRODUCTION CAPACITY OF THE RED SOKOTO GOAT IN KATSINA STATE OF NIGERIA

BY

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NIGERIA

AUGUST, 2012

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M.Sc/Agric/03852/08-09

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, AHMADU BELLO UNIVERSITY ZARIA, IN PARTIAL FULFILLMENT FOR THE AWARD OF MASTER OF SCIENCE (M.Sc) IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE

AHMADU BELLO UNIVERSITY ZARIA

NIGERIA

AUGUST, 2012

DECLARATION

I declare that the work in the thesis entitled "GENETIC PROFILES OF MORPHOLOGICAL TRAITS AND THEIR ASSOCIATION WITH PRODUCTION CAPACITY OF THE RED SOKOTO GOATS IN KATSINA STATE OF NIGERIA" has been performed by me in the Department of Animal Science under the supervision of Prof. G.N. Akpa and Prof B.I. Nwagu.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any University.

Esther Oforodo Ijomanta ---------- ----------

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CERTIFICATION

This thesis titled "Genetic Profile of Morphological Traits and their Association with Production Capacity of the Red Sokoto Goats in Kastina State of Nigeria"by Esther Oforodo Ijomanta, meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, Nigeria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to God Almighty, without whose help, this would not have been possible. It is also dedicated to my most cherished and lovely family for their understanding, constant support, encouragement and prayers throughout the period of this work.

ACKNOWLEDGEMENT

I adore the name of God who has enabled and seen me through the course of my study successfully in this University and by whose strength and Grace this project has become a reality.

My sincere gratitude and appreciation go to my able supervisors Prof. G.N. Akpa and Prof. B.I. Nwagu for their encouragement, advice, patience and invaluable assistance in all stages of this project; words cannot actually express my gratitude. I was highly inspired by their charismatic leadership and supervision. Special thanks go to Prof. G. N. Akpa for linking me to the source of information and following it up to the very end. May God reward you abundantly.

I'm grateful to the H.O.D, academic and non academic staff of Animal Science Department, Faculty of Agriculture, A.B.U. Zaria for their moral support and encouragement. I also wish to thank the Fulani men who allowed me to make use of their animals for this research.

Our lives are all wrapped up in people and people in ours. I will like to appreciate all those who have in one way or the other contributed in making me what I am today. My heartfelt love and appreciation goes to my cherished husband, Mr. Martin Attah, my life time friend and confidant. Your understanding, calmness, maturity and unreserved love and care shown towards me have made me a better wife and mother. Thanks so much for the unending love shown to me. To my cuties, Shanae and Yves, Mummy loves you both dearly.

To my dearest parents, Mr and late Mrs. J.I.Ijomanta; I sincerely appreciate your parental love, prayers, care and commitment to give me a brighter future, though Mummy passed

away during the struggle. I pray God gives you eternal rest. Adieu Mummy, till we meet to part no more.

I cannot forget my dear siblings; Nene Vik-Benibo, Joseph, Samuel, Jerry, Gabriel and Deborah who have been so wonderful and supportive to me and I thank God for bringing us this far in the journey of life as a family. To my wonderful in-laws, I express my gratitude for your unalloyed, moral support, encouragement and prayers.

To Barrister Vik-Benibo and Mr and Mrs A.U.Anya, I express my gratitude. They are like a second family to me. Your words of advice and encouragement has been of great help and to Nikole, Sean, Sonari, Simdy, Agoo, Ike, Amanda, Buchi, Odinaka and Micheal, I want to say that I love you all.

Thanks to my very good friends; Memunat Azeez, Fustina Igwebuike, Oreka Yusuf, Yvonne Ekwue and Chinedu Valentine it's been a nice and rewarding experience having you all as friends all these years and by His Grace, our dreams and aspirations will all come to fruition.

To my colleagues, the journey together has been a wonderful experience. Special thanks to Dr. (Mrs) Idorenyin, Emilia Okafor, Ismail, Aliyu Abdulkareem, Alphonsus Cyprian, Onoru Asuku and Hosea Yakubu for their moral support and assistance.

ABSTRACT

This research was conducted to determine the morphological traits, production capacity and existing association between them in Red Sokoto goats in Kastina state. A total of 888 Red Sokoto goats (RSG) were used for the study out of which 152 lactating does were used to assess the milk production capacity of Red Sokoto goats. The morphological and morphometric traits were identified and measured and their associations with production capacity were assessed. The distributon and frequencies of the morphological traits were investigated and scored for the presence or absence of wattle (Wa^{w} or Wa^{+}), beard (Br^{b} or Br^{+}), horn (Ho^{+} or Ho^{p}), supernumerary teat (St^{t} or St^{+}) and head profile; straight or sub-convex (Hp^{sv} or Hp^{st}) . Wattle had a significant relationship ($p<0.05$) with beard (-0.12) but was not significant with head profile. Frequencies of the dominant alleles for RSG were 0.04 (Wa^{w}), 0.11 (Br^{b}), 0.00 (Ho^{p}), 0.02 (Hp^{sv}), and 0.13 (St^{t}). The average body weight (BWT), body length (BLT), heart girth (HG), thoracic depth (TD), height at withers (HAW), average ear length (AEL) and average horn length (AHL) were 25.3kg, 53.5, 69.4, 36.0, 58.1, 9.5 and 8.3cm respectively and the CV of the morphometric traits ranged from 11.26-25.19 with body weight (25.19) being the most variable and HAW (11.26) being the least variable trait. Wattle had no significant ($P>0.05$) influence on all body conformation traits. Beard significantly ($P<0.05$) influenced BLT and HAW. Head profile significantly influenced all body conformation traits except heart girth (HG). Zone had a significant ($P<0.05$) influence on all the body conformation traits except AHL while sex had a significant ($p<0.05$) influence on morphometric traits except AEL, and AHL. The average litter size (LS), parity, first test day yield (FTDY), average daily morning milk yield (ADMY), peak day (PD), last test day yield (LTDY) and total yield were 1.8, 3.8,

216.1mls,253.1mls, 375mls, 34.8 days, 105.2mls and 25103.4mls respectively. LS, parity and PD were more variable (21.44-43.5), while FTDY, ADMY, PY, LTDY and TY were less variable (4.70-18.96). The relationship between body morphological traits and lactating characteristics were also assessed. Parity significantly affected all body conformation traits. LS significantly affected body conformation traits except HG and HAW while litter composition (LC) significantly affected BWT, BLT and HG but not TD and HAW. Wattle had a significant effect on FTDY, ADMY, PY and LTDY but had no significant influence on PD and TY. Supernumerary teat had no effect on the lactation traits except for ADMY and TY which were low when present. Parity on the other hand significantly ($P<0.05$) affected FTDY, ADMY, PY and TY but had no significant ($p>0.05$) effect on PD and LTDY. LS and LC had a significant effect on all measured lactation traits of goats except FTDY, PD and LTDY. Zone had a significant ($P<005$) influence on lactation traits except FTDY. All the body conformation traits and lactation traits of RSG were significantly and positively ($P<0.05$; $P<0.01$) correlated. Qualitative traits had a low gene frequency of occurrence. Presence or absence of wattles had no effect on body conformation traits but had an effect on milk lactation characteristics. Goats with beards had longer bodies and grew taller, while those with normal two teats produced more milk than those with extra teats. Zone, sex and litter size influenced body conformation and milk yield characteristics in RSG. High incidence of multiple births indicates that RSG are highly prolific. The significant effect of parity on lactation traits, body weight and morphometric traits in this study therefore, indicates that parity of dam is an important factor to consider in making appropriate selectsion and /or culling decision in RSG.

TABLE OF CONTENTS

Title page - - - - - - - - - i

Declaration - - - - - - - - - ii

Certification - - - - - - - - - iii

Dedication - - - - - - - - - iv

Acknowledgement - - - - - - - - v

Abstract - - - - - - - - - vii

Table of contents - - - - - - - - ix

List of tables - - - - - - - - - xv

List of figures - - - - - - - - - xvii

List of plates - - - - - - - - - xviii

Abbreviations - - - - - - - - - xix

CHAPTER ONE

1.0 Introduction - - - - - - - - 1

1.1 Justification - - - - - - - - 5

1.2 Hypothesis - - - - - - - - 5

1.3 Objectives of the Study - - - - - - 6

CHAPTER TWO

2.0 Literature Review - - - - - - - 7

2.1 The Goat (Capra Hircus) - - - - - - 7

2.2 History of Goats- - - - - - - - 8

2.3 The Potentials of Small Ruminant Production in Nigeria - - 9

2.4 Some Benefits of Small Ruminant Animal Production - - 10

2.4.1 Milk Production - - - - - - - 10

2.4.1.1 Nutritional Importance of Goat Milk - - - - - 11

2.4.2 Meat Production - - - - - - - 12

2.5 Present Status of the World Goat Populations and Their Productivity 15

2.5.1 Number of goats in the world - - - - - 16

2.6 Advantages of Goat Keeping - - - - - - 24

2.6.1 Disadvantages of Goats - - - - - - 26

2.7 Indigenous Breeds of Goats - - - - - - 26

2.7.1 Sahalian Goat - - - - - - - - 26

2.7.2 Maradi (Red Sokoto) Goat - - - - - - 27

2.7.3 West African Dwarf Goat (WAD) - - - - - 28

2.8 Morphological Traits of Goats - - - - - 28

2.9 Descriptive Traits of Goats - - - - - - 29

2.10 Body Conformation Traits and Factors Affecting Them - - 31

2.10.1 Body Weight - - - - - - - - 31

2.10.2 Factors Affecting Body Weight and Linear Body Measurements. - 33

2.11 Relationship between Morphological and Conformation Traits - 37

2.12 Relationship between Body Weight and Linear Body Measurements 37

2.13 Relationship Between Descriptive and Body Conformation Traits - 39

2.14 Genetic Parameters and Relationship Estimations - - - 39

2.15 Estimation and Improvement of Body Weight and Genetic Parameters in Goats - - - - - - - 41

2.16 Morphometric Trait Values - - - - - - 43

2.16.1 Heart Girth - - - - - - - - 43

2.16.2 Height at Withers - - - - - - - 43

2.16.3 Body Length - - - - - - - - 44

2.17 Coat Colour Variations in Goats - - - - - 45

2.18 Goat Hair Types - - - - - - - 47

2.19 Wattles in Goats - - - - - - - 47

2. 20 Milk Yield, Composition and Estimations - - - - 47

2.21 The Red Sokoto Goat and Milk Production Potential - - 50

2.22 Efficiency of Milk Production - - - - - 52

2.23 Mammary Morphology and Relationship with Yield - - 54

CHAPTER THREE

3.0 Materials and Methods - - - - - 57

3.1 Study Location - - - - - - - 57

3.2 Animals and Their Management - - - - - 58

3.3 Measurements/Observation of Physical Parameters - - - 58

3.3.1 Body Conformation Traits - - - - - - 59

3.3.2 Qualitative Traits - - - - - - - 61

3.3.3 Production Capacity - - - - - - - 61

3.4 Milk Collection - - - - - - - 62

3.5 Milk Measurement - - - - - - - 62

3.6 Data Computation and Statistical Analysis - - -

CHAPTER FOUR

4.0 Results- - - - - - - - - 67

4.1 Morphological Traits and Their Gene/Genotypic Frequencies - 67

4.1.1 The Frequency (%) of Qualitative Traits of Red Sokoto Goats According to Zone, Coat Colour and Sex. - - - - 67

4.1.2 Correlation amongst Body Morphological Traits in Goats - - 75

4.1.3 Correlations between Dams Morphological Traits in Goats - - 75

4.1.4 Gene Frequencies of the Observed Qualitative Traits in Red Sokoto Goats - - - - - - - - - 75

4.1.5 Matrix of Genetic Distance of Red Sokoto Goats by Zone and Coat Colour - - - - - - - - 76

4.2 Conformation Traits and Factors Affecting Them - - - 84

4.2.1 Summary Statistics of Morphometric Traits of Red Sokoto Goats - 84

4.3 Milk Production Traits and Factors Affecting Them - - - 90

4.4 Relationship Estimations for Body Conformation and Milk Production Characteristics- - - - - - - - 96

CHAPTER FIVE

5.0 Discussion - - - - - - - 101

5.1 Morphological Traits and Their Gene/Genotypic Frequencies - 101

5.1.1 The Frequency of Qualitative Traits of Red Sokoto Goats According to Zone, Coat Colour and Sex - - - - - - 101

5.1.2 Gene Frequencies of the Observed Qualitative Traits in Red Sokoto Goats - - - - - - - - - 104

5.2 Conformation Traits and Factors Affecting Them. - - - 105

5.2.1 Mean Values of Body Conformation Traits According to Wattle, Beard and Head Profile - - - - - - 106

5.2.2 Mean Values of Body Conformation Traits According to Zone and Sex - - - - - - - - - 107

5.2.3 Mean Values of Body Conformation Traits according to Parity, Litter Size and Litter Composition. - - - - - 108

5.3 Milk Production Traits and Factors Affecting Them.- - - 109

5.3.1 Effect of Wattle, Supernumerary Teat, Parity, Litter Size and Zone on Lactation Traits. - - - - - - 111

5.4 Relationship Estimations for Body Conformation and Milk Production Traits - - - - - - - - - 112

CHAPTER SIX

6.1 Summary - - - - - - - - 114

6.2 Conclusion - - - - - - - - 115

6.3 Recommendation - - - - - - - 116

6.4 Major findings- - - - - - - - 117

References- - - - - - - - - - 118

LIST OF TABLES

Table 2.1: The amount of goat meat produced in the top ten countries, number of animals slaughtered and the average amount of meat produced per animal - - - - - 14

Table 2.2: Numbers of goats and sheep in different parts of the world, ratio of goat to sheep and their percentages out of the world total number - - - - - - - - - 17

Table 2.3: Numbers of goats in the top ten countries, the ratio of goats to sheep and their percentages from the total number in the world - - - - - - - - 20

Table 2 .4: The amount of goat milk produced in the top ten countries, number of dairy goats and the average amount of milk produced by a dairy doe - - - - - - - - 21

Table 4.1: Frequency (%) of the Qualitative Traits of Red Sokoto Goats According to Zone, Coat Colour and Sex - - 69

Table 4.2: Correlation amongst Body Morphological Traits in Goats - 78

Table 4.3: Correlations between Dam Morphological Traits in Goats - 79

Table 4.4: Gene Frequencies of the Observed Qualitative Traits in Red Sokoto Goats - - - - - - - - 80

Table 4.5: Gene Frequencies of the Observed Qualitative Traits in Red Sokoto Goats According Zone and Coat Colour - 81

Table 4.6: Matrix of Genetic Distance of Red Sotoko Goats by Zone- 82

Table 4.7: Matrix of Genetic Distance of Red Sokoto Goats by Coat Colour 83

Table 4.8: Summary Statistics of Morphometric Traits of Red Sokoto Goats 86

Table 4.9: Mean Value of Body Conformation Traits According to Wattle, Beard and Head Profile - - - - 87

Table 4.10: Mean Value of Body Conformation Traits According to Zone and Sex - - - - - - - 88

Table 4.11: Mean Values of Body Conformation Traits According to Parity, Litter Size and Litter Composition - - - - 89

Table 4.12: Summary Statistics of Milk Production Characteristics of Red Sokoto Goats - - - - - - 92

Table 413: Mean Values of Lactation Traits of Goats According to Wattle, Beard, Supernumerary Teat and Head Profile - 93

Table 4.14: Mean Values of Lactation Traits of Goats According to Parity, Litter Size and Litter Composition - - - - 94

Table 4.15: Mean Values of Lactation Traits of Goats According to Zone 95

Table 4.16: Correlation amongst Body Conformation Traits of Goats - 97

Table 4.17: Correlation amongst Lactation Traits of Goats - - - 99

Table 4.18: Correlation between Lactation and Body Conformation Traits in Goats - - - - - - 100

LIST OF FIGURES

Figure 2.1: Increasing world total goat meat production since 1990 - - 15

Figure 2.2: Number of goats in the world during the period from 1990 to 2008- 18

Figure 2.3: Total amount of goat milk produced during the period from 1990 to 2008- - - -- - - - - - 23

Figure 3.1: Body measurements in goats- - - - - - 60

LIST OF PLATES

Plate 4.1: Brown (B) - - - - - - - - 70

Plate 4.2: Light Brown (LB) - - - - - - - - 70

Plate 4.3: Dark Red (DR) - - - - - - - - 71

Plate 4.4: Brown and White (BW) - - - - - - - 71

Plate 4.5: Brown with White Spots - - - - - - 72

Plate 4.6: White with Black Spot- - - 72

Plate 4.7: Tassel - - - - - - - - - 73

Plate 4.8: Supernumerary teats - - - - - - 74

ABBREVIATIONS

ADY: Average Daily Morning Milk Yield

AEL: Average Ear Length

AHL: Average Horn Length

BLT: Body Length

Br^{+}: Absence of beard

Br^{b}: Presence of beard

BWT: Body Weight

CV: Coefficient of n variation

FTDY: First Test Day Yield

HAW: Height at Withers

HG: Heart Girth

Ho^{+}: Horned

Ho^{p}: Polled

Hp^{st}: Straight head profile

Hp^{sv}: Sub-convex head profile

LC: Litter composition

LG: Litter genotype

LS: Litter Size

LTDY: Last Test Day Yield

PD: Peak Day

PY: Peak Yield

St^{+}: absence of Supernumerary teat

St^{t}: Presence of Supernumerary teat

TD: Thorax Depth

TL: Tail Length

TY: Total Yield

Wa^{+}: Non wattled

Wa^{w}: Wattled

WAD: West African Dwarf goats

CHAPTER ONE

1.0 Introduction

Small ruminants are important genetic resources in the tropics, where they play a predominant role in the sustenance of the livelihoods of impoverished families especially in the rural areas. In Nigeria, they represent about 63.70% of the total grazing domestic animals (Yakubu *et al.,* 2010). The goat is a household animal in Nigeria and its importance cannot be over emphasized. It serves a number of purposes including socio-cultural, economic and nutritional needs of the producer (Gefu, 1992). Goats play an important role in the social life of many African people, being used as gifts, dowry, in religious rituals and rites of passage (Peacock, 2005). They are in fact the "small man's cattle", they are kept primarily for meat and cash income especially by peasant farmers in the country (Akpa, 2000). Goats perform the task of supplying human population with meat, milk, skin, hair and other products.

The World Health Organization (WHO) recommended protein requirement of an adult is 0.5- 1.0g per kg body weight per day (65g per day) and approximately 20g of this should come from animal protein source (Flachowsky, 1999). On the average, about 25g of animal protein per person per day and this ranges between 9g in Africa and 65g in North America (Flachowsky, 1999). Thus indicating that protein of animal origin for Africa is far below the recommended 20g per capita per day.

Animal milk source is one good source that can be used to bridge the gap. Out of 537403 × 10^3 metric tonne of total milk production from popular dairy animals in the world (cow,

buffalo, sheep and goats), goat contribute 10144 × 10^3 metric tonne which is about 5% (FAO, 2007). In Africa, goats contribute 2078 × 10^3 metric tonnes which is about 9.2% of total milk production (22501 × 10^3 metric tonne) from dairy animals in Africa (FAO, 1997).

Goat milk is a valuable source of protein, fat, calcium, iron, phosphorous, magnesium, and vitamins, particularly vitamin A. Recent studies have shown that several of these vitamins from goat milk are more easily absorbed than cow milk (Peacock, 2008). The small fat globule of goat milk makes it more easily digestible than cow milk and therefore particularly suitable for children and the sick (Peacock, 1996). Above all, goat milk fat and protein are readily digested; and the constituent amino acids absorbed more efficiently than those of cow (Jandal, 1996). Besides producing animal products, they also provide manure to maintain soil fertility (Suradiastra, 1993).

The Red Sokoto goat (RSG) or Maradi is the most predominant goat breed and accounts for about 70% of Nigeria's total goat population which has been estimated at 17.5 million (Ademosun, 1994). It is commonly found among the agro pastoralist mainly within the northern sub-humid and semi-arid zones of the country (Akpa *et al.,* 2001a). The breed is predominantly reddish brown in colour and is found in the savannah zone of Nigeria (8^0N - 11^0N) where it constitutes more than 90% of the goat population in that area. The breed weighs about 1.5 – 2.0kg at birth and reaches about 12.0kg when weaned at 3 months under good management. Weight of adult does and bucks are 20 – 35kg and 25 – 40kg, respectively (Osuhor *et al.,* 2002). The skin of Red Sokoto goat is reputed to be of high quality; therefore, it is used in the leather industry locally and internationally (Akpa *et al.,* 1998a).

The West Africa Dwarf (WAD) goat is widely distributed across the rainforest belt of southern Nigeria. They are short legged and small bodied animals, weighing between 22 and 26kg. They also present variable coat colours, ranging from black, brown, grey, red and white and sometimes combinations of these in a variety of patterns (Mourad *et al.,* 2000).

According to Kiwuwa (1992), the broad genetic variability of African small ruminant breeds enables them to survive under stressful environmental conditions, including disease, poor nutrition, and high ambient temperature. Genetic variations among the small ruminant varieties that are indigenous to Nigeria have been a point of interest to geneticists. This is because the amount of genetic variation detectable in an animal population is related to the magnitude of genetic improvement achievable within the species. Thus, genetic variation has become the objective tool, traditionally used for improving animal species (Salako *et al.,* 2007).

The diversity of gene pool, different climatic conditions within the country, free mating and natural selection have given rise to different local populations of goats and sheep. Therefore, one would expect much differential adaptive development to be reflected in the morphology (Hall, 1991). According to Oseni *et al,* (2006), varied expression of qualitative traits may represent some adaptive mechanisms related to adaptation and survival in different ecological zones in the country. This is substantiated by the report of Odubote (1994) on the influence of certain qualitative traits on the genetic potential or adaptability of Nigerian goats hence, the need for the conservation of these unique genes for present and future use. This becomes evident in view of the fact that high level producing crossbreds do not perform under the low-input management typical of the smallholder production system (Rege and Gibson, 2003).

The first step of the characterization of local genetic resources falls on the knowledge of the variation of morphological traits (Delgado *et al.,* 2001). Based on previous studies carried out on Mediterranean goats (Lauvergne *et al.,* 1996) the morphometric criteria generally used to c1assify West Africa goats (Dossa *et al.,* 2007) are: height at withers (HAW), thorax depth (TD) and ear length (EL). Bourzat *et al.* (1993) also proposed the use of two combined indices that have shown good performance in differentiating homogeneous sub-populations within the Cameroonian and the Chadian goat populations (Bourzat *et al.,* 1993; Zeuh *et al.,* 1997); the slenderness index and the auricle thorax index. However, such type of indices have limited power and multifactor analyses of morphological traits are more appropriate to assess variation within and between goat populations (Capote *et al.,* 1998; Dossa *et al.,* 2007; Herrera *et al.,* 1996; Jordan *et al.,* 1993; Lanari *et al.,* 2003; Zaitoun *et al.,* 2005) and appropriately discriminate different goat types because all measured morphological variables are considered jointly.

Research and development investments to improve the relatively low level of goat's productivity do not match their potential importance, resulting in many goat breeds that are not genetically explored, especially in the developing countries. Nevertheless, goats are going to be more important source of livelihood for many more people in coming years and, thus, they deserve greater attention at both the micro and macro levels. Now, it is the time to consider and pay attention to the value and capacity of goats for producing food.

1.1 **Justification**

Studies on diversity and variability between indigenous goats as well as sheep breed on the basis of quantitative (Morphostructural) and qualitative (Morphological) variables have been extensively carried out on-station and on-farm in Southern Nigeria (Ozoje and Kadir, 2001; Ozoje and Mgbere, 2002). However, similar works especially on the qualitative traits of goats and sheep found in Northern parts of the country are scarce. This is inspite of the fact that vast majority of indigenous small ruminant are concentrated in the northern axis. Therefore, the present study will help in providing information on the distribution and frequencies of some qualitative (Morphological) traits and there association with production capacity in Red Sokoto goats traditionally managed in Northern Nigeria (Katsina State).

1.2 **Hypothesis**

H_O = There is no association existing between the morphological traits and production capacity in Red Sokoto goats in katsina state.

H_A = There is association existing between the morphological traits and production capacity in Red Sokoto goats in katsina state.

1.3 **Objectives of the Study**

1. To describe the morphological traits of Red Sokoto goats in Katsina state.

2. To determine the production capacity of Red Sokoto goats in Katsina State.

3. To determine the association existing between the morphological traits and production capacity in the goats studied.

CHAPTER TWO

2.0 Literature Review

2.1 The Goat (*Capra hircus*)

The goat is a member of the Bovidae family and is closely related to the sheep: both are in the goat-antelope sub-family caprinae. There are over three hundred distinct breeds of goat. Goats are one of the oldest domesticated species. Goats have been used for their milk, meat, hair and skin over much of the world. In the twentieth century, they also gained popularity as pets (Wikipedia, 2010).

Goat is one of the most populated ruminants in Nigeria (Yashim *et al.,* 2008). *Capra hircus* is sexually dimorphic, males have beards, horns, a rank odour, and are generally larger than the females. The odour stems from sex glands; the horns are hallow, and grow either scimitar or corkscrew. The hair is generally straight; however some breeds have wool, under coat colour varies and can be black, white, red and brown. Colour patterns include solid colour, spotted, striped, blended shades and facial stripes. The nose can be either straight or convex. European breeds have erect ears while India breeds do not. The Lamancha breed has no external ear. The tail is short and curved upwards. (Haenlein, 1992).

Female goats are referred to as nannies or does, intact males as bucks or billies; their offspring as kids. Castrated male is called wethers. Goat meat from younger animals is called kid or cabrito, and from older animals is called chevon (Wikipedia, 2010).

Humans usually control the breeding behaviour of domesticated *C. hircus*. Under human control *C. hircus* follows a polygynous reproductive system. In nature, feral groups follow this same pattern. In captivity, certain males may be chosen by humans to sire the young of several females. The females are then inseminated either directly by those males or by artificial insemination. Left to their own devices, male goats compete for rank, and the highest ranking males have access to mate with the females. Sex glands are used to produce pheromones which attract the males. Males fight by butting heads until one competitor surrenders (Vaughan *et al.,* 2000).

2.2 History of Goats

The goat (*Capra hircus*) is thought to have been the first animal to be domesticated for economic purposes around 9000 – 1000 BC. It was brought by migrant's pastoralist from Asia to Africa (Devendra and Mcleroy, 1988). There is hardly a climate zone without goats.

Immediately after domestication, physical differentiation into breeds and types began. Early physical changes affected the ears, horns, colour and hair type. These changes arose from natural mutation and from selection by goat keepers within the environment in which goats were reared, usually in relative isolation. Early goat keepers must have selected from the production characteristics which were appropriate to their needs. New blood probably entered goat populations when people migrated for economic reasons or in times of conflict. There is a huge range of size, colour, and hair type among modern breeds of goats (Peacock, 1996).

2.3 The Potentials of Small Ruminant Production in Nigeria

Small ruminant animals include goats (*capra hircus*) and sheep (*Ovis aries*). These animals are highly priced as they provide household meat for consumers and skin for local leather industry. Goats have been reported by Ozung *et al,* (2011) to contribute 16.0% and sheep 5.0% of total domestically produced meat in Nigeria, which has been estimated at 813,000 tonnes per annum. Sheep and goat skins have been estimated at 7,500 tonnes and 20,400 tonnes per annum (Ozung *et al.,* 2011). Milk from sheep and goats has been accepted in most developed countries as an alternative to cow milk and their contribution stands at 46% of the world total production of 7.3 million tonnes for sheep and 40% of the total world production of 7.2 million tonnes for goats in both the tropics and subtropics. (Ozung *et al.,* 2011).

Sheep and goats play a significant role in the food chain and overall livelihoods of rural households, where they are largely the property of women and their children (Lebbie, 2004). According to Adu *et al.* (1996) small ruminants in southern Nigeria are integral component of the household, where they contribute to the cultural, food and socio-economic life of the people. While Upton (1984) stated that the potential returns from sheep and goat keeping under the traditional management system are high. In south-west Nigeria, goats are used for customary rites in addition to meat production and religious purpose (Odeyinka and Ajayi, 2004). It has been documented that sheep and goats are the principal domesticated small ruminants in terms of total numbers and production of food and fibre production (Winrock, 1983). This attribute may partly be due to their lower feed requirements compared to cattle, because of their body size (Okunlola *et al.,* 2010). This

however, allows for easy integration of small ruminants into different farming systems (Hirpa and Abebe, 2008).

Traditionally, sheep and goats have served as means of ready cash and a reserve against economic and agricultural production hardship (Hamito, 2008). In temprate zones, goats are kept often as supplementary animals by small holders, while commercially, cows or buffaloes are kept for milk, cheese and meat; and sheep for wool and meat production (NDD, 2004). Okunlola *et al.* (2010) reported a similar trend in Tropical Africa where a majority of small ruminant is owned by individuals or families in rural areas and the number per group is small.

2.4 Some Benefits of Small Ruminant Animal Production

According to Mahmoud (2010) goats are mainly kept to produce milk, meat or fiber (Mohair and Cashmere). In Nigeria, goats are kept mainly for meat production; their milk is rarely used for human consumption (Butswat *et al.,* 2002).However, there is a growing awareness of the importance of goats as a source of milk for man (Malau-Aduli *et al.,* 2004).

2.4.1 Milk Production

Milk is obtained from cows, sheep and goats, buffaloes and camels (Ochepo and Momoh, 2010). The same authors also stated that, the most predominant milk is that from the cow. However, milk from sheep and goats has been accepted in most parts of the world, especially in the developed countries as an alternative to cow milk. In Nigeria, the use of

cow milk is common and production is insufficient to meet consumption needs either as fresh milk or fermented milk (Nono) (Joseph and Olafade, 1999).

Dairy goat is considered the cow of the poor. The goat eats little, occupies a small area and produces enough milk for the average unitary family, whereas maintaining a cow at home cannot be afforded by the homeowner, hence, the growing popularity of goat as the poor person's cow (www.goatworld.com). Dairy goats produce about 15.2 million metric tons (MT) of milk, accounting for about 2% of the world total amount of milk produced by livestock species (FAOSTAT, 2008). The developing countries produce approximately 83% of the total amount. In Europe, goat breeding is strongly oriented towards milk production, with only 3% of the world goat population producing about 15% of the world's goat milk, which is mostly used for cheese production (Lejaousen and Toussaint, 1993).

According to Jennes (1980), goats produce more milk compared to cows and other ruminants, because of better feed utilization efficiency, higher lactation persistency, mammary tissue comprising of greater proportion of the body weight and a more pronounced milk ejection reflex. Goat and sheep milk production is not popular in Nigeria; many households keep goats and sheep for other economic gains and not for milk, as such cultural practices are not common.

2.4.2 Nutritional Importance of Goat Milk

Extant literatures have shown that goat milk is rich in basic food nutrients. It has been reported by Ozung *et al.* (2011) that goat milk contains more B-casein and less α – casein than the cow milk, with a higher production of short and medium chain length fatty acid than the cow milk. The fats in goat milk are easily digested, because of their smaller fat

globules (Jennes, 1980). Vitamin A levels in goat milk is almost twice that of cow milk. Goat milk has higher medicinal value, high vitamin B content and high digestibility, which makes it helpful in relieving stress and constipation (James *et al.,* 2005).

The protein content of goat milk is higher than that of human milk in terms of total calories. The protein differs in composition but the total amino acid profile is similar (Jennes, 1980). The essential amino acids of goat milk are slightly in excess of infant requirement (Ochepo and Momoh, 2010). Goat milk is adequate for infants in essential fatty acids, with linoleic acid providing about 1% of total calories. The milk is rich in minerals (Calcium and phosphorous) and vitamins (C and D) which the cow milk lacks (Jennes, 1980). Hence, goat milk can be used for infants as well as post weaning diets for children (Jennes, 1980). According to Thear and Fraser (1986), children and adults who are allergic to cow milk do not react to goat milk. It has also been reported that many adults suffering from migraine and asthma find the problem alleviated when they used goat milk instead of cow milk.

2.4.3 Meat Production

Sheep and goats are good producers of meat for human consumption. The animals are excellent meat producers in view of their short generation intervals and the absence of religious taboos associated with their meat (Ozung *et al.* 2011). Goat meat is called chevon, while that of sheep is called mutton.

According to Acharya (1988), live weight constitutes an important economic trait in meat animals. The maradi goat (Red Sokoto Goat) has been reported to record better performance in the dry season relative to the WAD goat, due to the physiological characteristics of maradi goats as savanna animals showing a remarkable feature of water

economy (Ikeobi and Faleti, 1996). Maradi goats have longer limbs and generally larger trunks than the WAD goats and so would be expected to carry more flesh (meat). Ebozoje (1992) described the Maradi as a large, fast growing, and early retrieving meat breed.

Goat meat is widely consumed in the developing countries. According to FAOSTAT (2008), total meat inventory is about 280 million MT. Goat meat represents only 2% of this total. The total amount of goat meat produced in 2008 was 4.9 million MT. The developing countries produced approximately 97% of this amount, reflecting the great importance of goat meat to feed millions of people in these countries. The top ten countries producing goat meat are presented in Table 2.1. China leads the world in producing goat meat, accounting for 38% of the world total goat meat produced. The top ten countries producing goat meat are all from Asia and Africa, indicating the importance of goat meat to the people living in these areas. Goat meat production has been increasing from 2.65 million MT in 1990 to 4.93 million MT in 2008 (Figure 2.1). The major part of this amount is not traded as other major meats. It is usually produced and consumed locally among the poor in the developing countries. A profitable goat meat business can be ensured by proper knowledge of goat husbandry, budgeting and marketing techniques.

There are several challenges associated with increasing meat production including consumer education, producer education, lack of slaughter and processing plants and lack of organized breeding programs and markets and marketing channels.

Table 2.1: The amount of goat meat produced in the top ten countries, number of animals slaughtered and the average amount of meat produced per animal

	Amount of goat meat	Animals Slaughtered	Amount of meat Produced per animal
China	1.8	133.3	13.7
India	0.5	47.8	10.0
Nigeria	0.3	21.3	12.7
Pakistan	0.3	15.4	17.0
Bangladesh	0.2	30.0	7.0
Sudan	0.2	14.5	13.0
Iran	0.1	7.6	14.0
Indonesia	0.1	6.6	10.0
Ethiopia	0.1	7.6	8.5
Niger	0.1	4.4	12.0

Adapted: FAOSTAT, 2008

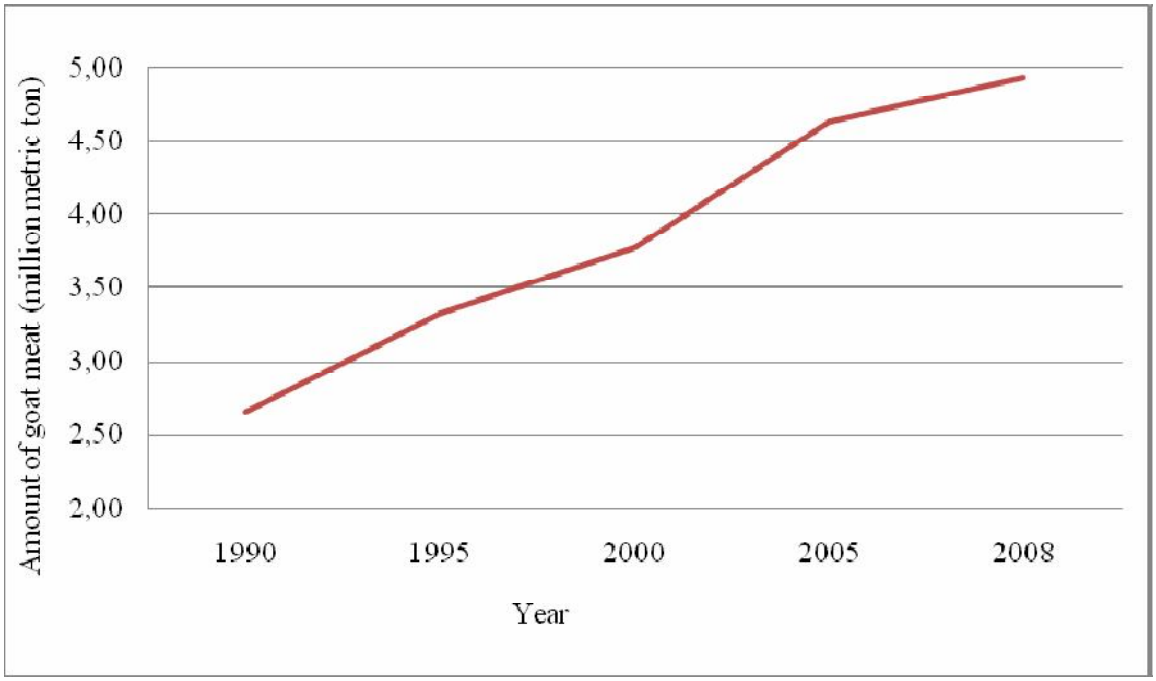


Figure 2.1: Increasing world total goat meat production since 1990(FAOSTAT, 2008)

2.5 Present status of the world goat populations and their productivity

Goats were among the first farm animals to be domesticated. As indicated by the archaeological evidence, they have been associated with man in a symbiotic relationship for up to 10,000 years (Ensminger and Parker, 1986). Goats are disseminated all over the world because of their great adaptability to varying environmental conditions and the different nutritional regimes under which they were evolved and subsequently maintained. They proved useful to man throughout the ages due to their productivity, small size, and non-competiveness with him for food (Mahmoud, 2010).

In the developing countries, goats make a very valuable contribution, especially to the poor in the rural areas. The importance of this valuable genetic resource is underestimated and its extent of contribution to the livelihood of the poor is inadequately understood. They are

often neglected in comparison with cattle and sheep (Mahmoud, 2010). Part of this attitude towards them can probably be due to recognition of their capability, rather any prejudice against them, as it is believed that goats are intelligent, independent, agile, and tolerant to many diseases and parasites and can look after themselves much better than other livestock species.

2.5.1 Number of goats in the world

Accurate statistics are required to determine the future outlook of the goat populations and their productivity. They are also needed before any improvement policies can be planned on a realistic basis and implemented with confidence. Table 2.2 presents numbers of goat and sheep populations in different parts of the world, along with the ratios of goat to sheep and their percentages out of the total number of goats and sheep in the world (FAOSTAT, 2008).

Table 2.2: Number of goats and sheep in different parts of the world, ratio of goat to sheep and their percentages out of the world total number

Content	Number (Million)		Ratio		Percentage	
	Goats	Sheep	Goats	Sheep	Goats	Sheep
Asia	514.4	452.3	1	0.9	59.7	42.0
Africa	29.1	287.6	1	1.0	33.8	26.7
N. America	3.0	6.9	1	2.3	0.4	0.6
C. America	9.0	8.1	1	0.9	1.0	0.8
Caribbean	3.9	3.1	1	0.8	0.5	0.3
S. America	21.4	73.1	1	3.4	2.5	6.8
Europe	18.0	133.9	1	7.4	2.1	12.4
Oceanic	0.9	113.1	1	119.2	0.1	10.5
World	861.9	1078.2	1	1.25		

Adapted: FAOSTAT, 2008

The world total number of goats and sheep were 861.9 and 1078.2 million respectively, that is about one goat to approximately 1.25 sheep in the world (FAOSTAT, 2008). There were tremendous variations among the different parts of the world regarding the number of goats, its ratio to sheep and their percentages. The largest number of goats was observed in Asia, followed by Africa, representing about 59.7% and 33.8%, summing up to 93.5% out of the total number of the world, respectively. The lowest number of goats was found in

Oceania, accounting for 0.1% out of the world total number. The ratio of goat to sheep ranged between one goat to 0.8 sheep in the Caribbean to one goat to 119.2 sheep in Oceania (FAOSTAT, 2008). The ratio of goat to sheep in Africa, Central America and Asia were approximately equal, indicating the considerable importance of goat populations in these parts of the world, especially to the poor and landless peasants.

The total number of goats in the world increased by 146% of the total number (590.1 million) encountered in 1990. Number of goats in the world has been increasing since 1990 by about 1% to 4% each year (Figure 2.2). During the same period, cattle number increased by 5%, while that of sheep decreased by 10%, reflecting the emergence of goats as a major livestock species.

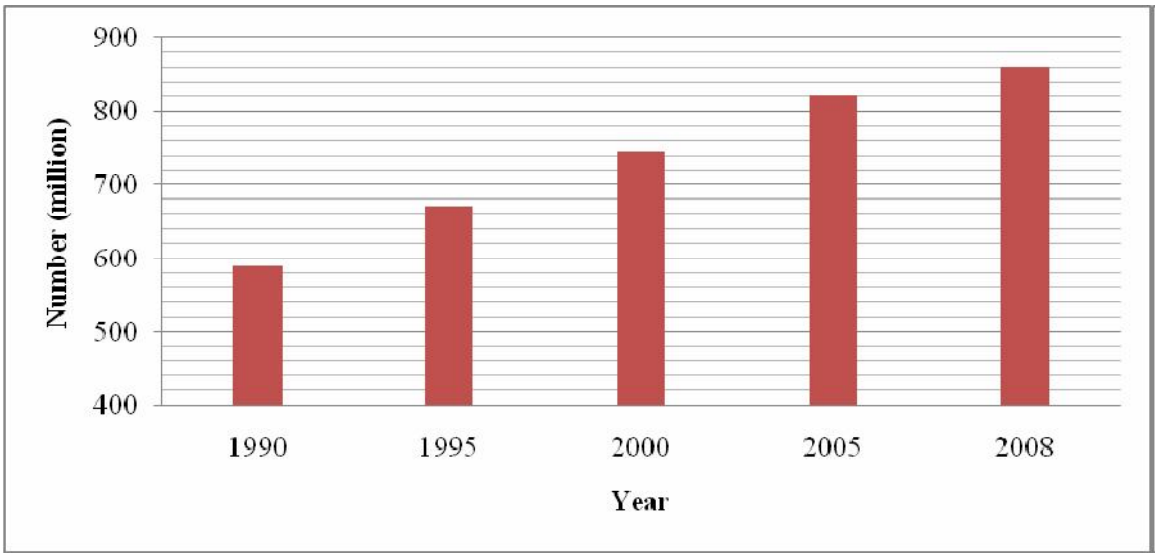


Figure 2.2: Number of goats in the world during the period from 1990 to 2008 (FAOSTAT, 2008)

The total number of goats in the top ten countries is presented in Table 2.3. Ten countries have approximately 65.7% of the world total number. Seven countries of this list are in

Asia, and the rests in Africa. The largest number of goats in the world was reported in China, followed by India, Pakistan and Bangladesh, all in Asia. Number of goats in these four countries constitutes about 45% of the world total. Great variation in terms of the ratio of goat to sheep exists among them, ranging between 1 goat to 0.02 sheep in Bangladesh to 1 goat to 2.13 sheep in Iran.

Table 2.3: Numbers of goats in the top ten countries, the ratio of goats to sheep and their percentages from the total number in the world

	Number		Ratio		Percentage Of world total	
	Goats	Sheep	Goats	Sheep	Goats	Sheep
China	149.4	136.4	1	0.91	17.3	12.7
India	125.7	65.0	1	0.51	14.6	6.0
Pakistan	56.7	27.1	1	0.48	6.6	2.5
Bangladesh	56.4	1.6	1	0.02	6.5	0.2
Nigeria	53.8	33.9	1	0.63	6.2	3.1
Sudan	43.1	51.1	1	1.19	5.0	4.7
Iran	25.3	53.8	1	2.13	2.9	5.0
Ethiopia	21.8	25.0	1	1.15	2.5	2.3
Mongolia	20.0	18.4	1	0.92	2.3	1.7
Indonesia	15.8	8.4	1	0.53	1.8	0.8
World	861.9	1078.2	1	1.25		

Adapted :(FAOSTAT, 2008)

Table 2.4: The amount of goat milk produced in the top ten countries, number of dairy goats and the average amount of milk produced by a dairy doe.

Country	Goat Milk Production (Million)	No of Dairy Goats (Million)	Milk Produced per dairy doe (kg)
India	40	30.2	132.5
Bangladash	2.2	27.1	80.0
Sudan	1.5	N.A	-
Pakistan	0.7	4.9	141.9
Spain	0.6	1.4	422.3
France	0.6	0.8	703.8
Greece	0.5	4.1	123.9
Iran	0.4	13.7	29.9
Somalia	0.4	6.6	59.7
China	0.3	1.4	194.8

Adapted: (FAOSTAT, 2008)

Considering the top ten countries in the world, (Table 2.4) the largest amount of goat milk was produced in India, followed by Bangladesh and Sudan (FAOSTAT, 2008). There were three European countries listed producing a considerable amount of goat milk: Spain, France and Greece. These three countries produce similar amounts of goat milk. In France, interest in dairy goats had led to the establishment of organized programs for selection, processing and commercialization of goat milk, which were produced mainly from Saanen and Alpine breeds. France led the list in terms of the annual milk production per dairy doe, while Iran reported the lowest milk production per dairy doe. China has the largest total number of goats in the world, but they were mainly kept for meat production. Milk production per dairy doe ranked third, behind France and Spain. China officially reported 1.4 million dairy goats which produced 0.3 million MT of milk (FAOSTAT, 2008). According to Luo (2009), China had about 5.8 million dairy goats in 2008. Both sources of statistics on goats may be questioned because they are not based on actual censuses, and the number of dairy goats is even more difficult to count due to the lack of breed definition.

Since 1990, interest in dairy goats had steadily increased, as manifested by the increase in milk production from about 10 million MT in 1990 to about 15.2 million MT in 2008 (Figure 2.3). The dairy goat industry has great potential for further growth. It has grown partly because of a trend towards self sufficiency by rural people, especially in developing countries, where goat milk can help to improve the nutrition of millions of people. In developing countries, much of the milk produced by goats is for family consumption, but goat milk can also be further processed into a variety of marketable products. Marketing of goat milk and its products is still in its infancy. So far, there have been no marketing efforts

attempted on a broad scale. As reported by Dubeuf and Boyazoglu (2009), less than 5% of the total milk produced by goats is marketed.

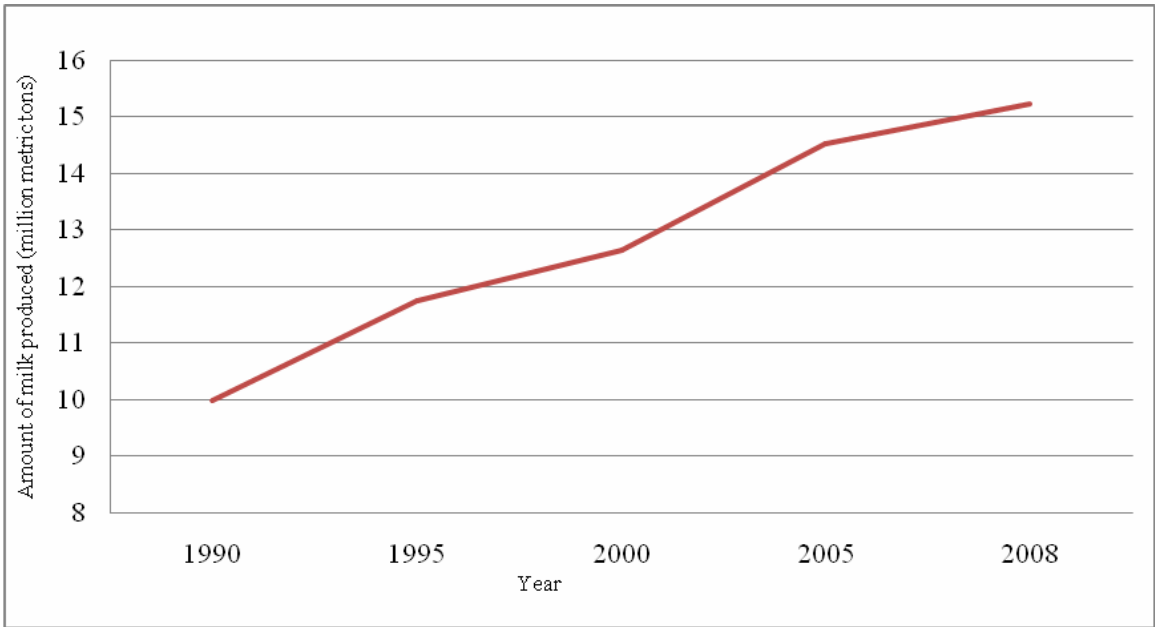


Figure 2.3: Total amount of goat milk produced during the period from 1990 to 2008 (FAOSTAT, 2008)

There are many challenges facing the dairy goat industry, including collecting complete and reliable data on all aspects of production through developing nationwide strategies, identifying superior and proven bucks that accelerate genetic improvement in the commercial herds and solving the seasonality problem to ensure consistent flow of goat milk. Seasonal breeding and the resulting annual fluctuations in goat milk supply had made development of new markets difficult and had dampened the importance of milk yield as a breeding goal (Haenlein, 1984). The development of a professional marketing system is part of the challenge to benefit from the fact that many people consuming dairy products prefer products from goats.

The potential of goats for sustainable supply of milk and meat for human consumption is unquestioned, and their contribution to improved nutrition of rural people is likely to increase. At the same time, goat cheese consumption is likely to increase also in developed countries. This is attributed to the image of goat cheese being a product of natural farm conditions compared with milk and milk products from high yielding dairy cattle in large industrial farms. Regarding goat meat, rising living standards in some parts of the world and the migration of people preferring goat meat to the developed countries, have increased the demand for goat meat in these areas (Alandia Robles *et al.,* 2006). Government programs to support goat farming should focus on research and education in the areas of breed improvement, farm management, control of infectious diseases, milk collection, processing and marketing.

2.6 Advantages of goat keeping

In many parts of the world where the geophysical properties of the terrain are not suitable for other livestock species, goats seem to be the best choice. The role of goats in supplying food to humans has been reported by Devendra (1985). Based on the accumulated information on goat characteristics, it can be stated that goats have a specific place in the animal agricultural economy of many countries. These characteristics can be summarized in the following points:

1. Goats can withstand heat stress and endure prolonged water deprivation. They have additionally great adaptability to adverse climatic and geophysical conditions, where cattle and sheep cannot survive.

2. They can efficiently utilize poor quality forage and cover long distances looking for food. Their peculiar feeding habits make it easier to choose diets to meet their requirements.
3. Goats are the most prolific domesticated ruminant. Faster reproduction contributes to the genetic progress that can be achieved and enables their owners to recover quickly from their investments.
4. Farmers and pastoralists are increasingly relying on goats as means of survival and a way of boosting their income (Peacock, 2005). The increasing frequency of droughts, with long-term environmental degradation is causing pastoralists to change from cattle or sheep to camels or goats.
5. Overgrazing makes rangelands increasingly suitable for browsing species such as goats.
6. The widespread decline in services supplied by governmental agencies encourages farmers to move from keeping cattle to goats.
7. Goats provide their owners with a broad range of products and socio-economic services and have played an important role in the social life of many people being used as gifts, dowry, in religious rituals and rites of passage (Peacock, 1996).

Goats, especially dairy ones, are an ideal species for poverty reduction and economic development for the poor in developing countries. Several reasons make goats particularly attractive for poverty reduction and improvement of family food security and livelihood of the poor in developing countries:

1. Goats are easily acquired by the poor as they require modest starting capital.
2. They can easily be tended by the weak, women or children.
3. They provide people with valuable nutrients.

4. Many people cannot drink cow milk as they are allergic to it.According to Restani, (2004) people with cow milk allergy could tolerate goat milk.

5. The growing demand for goat meat presents an opportunity for goat fattening.

Source: FAOSTAT 2008

2.6.1 Disadvantages of Goats Keeping

Susceptibility to predators, small value makes formal credit system uneconomical, small value also makes formal insurance system difficult to administer, susceptible to broncho-pneumonia and internal parasite. Source: African Farming Magazine (1996).

2.7 Indigenous Breeds of Goats

Several authors, (Devendra and Mcleroy, 1982; Ademosun, 1985 and Egwu *et al.,* 1995) reported on the ecology, morphology, and characteristics of 3 distinct breeds of goats in Nigeria, these include the Red Sokoto goat (Maradi), West African long legged (Sahel, Arab, Maure), and West African dwarf (Cameroon Dwarf, Nigeria Dwarf, Kirdi, and futa Djalon). Many other "transitional types" perhaps crosses known as Borno white, Borno red, Kano red and Maiduguri brown named according to their areas of origin are also encountered (Egwu *et al.,* 1995).

2.7.1 Sahelian Goat

The "West African long legged, "Sahel" Fulani", the desert or Sahalian goat is found along the northern border of Nigeria, particularly Borno State, where it is often known as "Balami, although this name has not been adopted as it would lead to confusion with the better known sheep breed Balami. Mason (1988) uses "Sahel, which seems appropriate, as

this race is distributed from Senegal to Sudan. This breed has thin appearance, narrow body and shallow chest. Both sexes are horned, about 70% with wattle, pendulous or semi-pendulous ears, the coat is white or dapple. Height at withers range between 65-85cm, while the chest girth is 70 – 85cm. The first kidding occurs usually at about 18 months, bearing mostly (70%) one or two kids, with lactation persisting to 5-6 months. it is kept primarily for meat (Devendra and Burns, 1983; Mason, 1996).

2.7.2 **Maradi (Red Sokoto) Goat**

According to Devendra and Burns, (1983) the Red Sokoto goat is one of the few well defined breeds in Africa. The Red Sokoto is also known as Kano brown or maradi goat. The Red Sokoto is the predominant goat and accounts for about 70% of Nigeria's total goat population which has been estimated at 34.4 million (Ademosun, 1993, Osuhor *et al.,* 1998). It is commonly found among the agro-pastoralists mainly within the sub-humid and semi-arid zones of the country (Akpa *et al.,* 2001a). Over 90% of Red Sokoto goats are managed by the pastoral Fulani (Taiwo *et al.,* 2005). The Red Sokoto goat was the source of 'Morocco leather' known in Europe from the medieval period onwards.

The skin of the Red Sokoto is reputed to be of high quality; therefore it is used in the leather industry locally and internationally for fine leather (Akpa *et al.,* 1998) and it is a large, fast growing and early maturing meat producing breed (Upton, 1987; Ngere, 1983) and can be used in improving the meat potentials of the West Africa Dwarf goats. The vast majority of this breed posses a dark brown coat, although very few may possess other coat colours as black, brown or white as a result of cross breeding. Their legs are notably shorter than the Sahel breed and they have short horizontal ears and shorter horns which goes

vertically backward. Their height at wither is about 65cm and they have an average weight of 25kg. Both sexes are horned and are adapted to arid zones where meat and skin production are their ultimate uses (Egwu *et al.,* 1995).

2.7.3 **West African Dwarf Goat (WAD)**

The West Africa Dwarf goat is found in West and Central Africa; they are indigenous to the forest and derived savannah and are well adapted to the humid zones (Egwu *et al.,* 1995). Their height at withers is about 40-50cm and 24.5kg in weight. New born kids average around 1.2kg at birth. Growth rate and milk yield are very low, but twin and triplet births are common and they breed at all times of the year. They are used almost exclusively for meat and skin production. The breed most useful peculiarities are its adaptation to the humid tropical environment and resistance to trypanosomiasis (Agyemang *et al.,* 1991).

The West Africa Dwarf goats are widely distributed across the rainforest belt of southern Nigeria. They are short-legged and small bodied animals. They also present variable coat colours, ranging from black, brown, gray, pied, red and white, and sometimes combinations of these in a variety of patterns (Odubote, 1994; Mourad *et al.,* 2000; Ozoje and Mgbere, 2002).

2.8 **Morphological Traits of Goats**

Oseni *et al.* (2006) reported that morphometric measurements are among the data needed in characterization and establishment of breed standards in West Africa Dwarf goat production. As with the presence of horns, beard is a character included by an autosomical sex-dependant gene, it is dominant in males and recessive in females. According to

Lauvergne *et al*. (1987) and Rodero *et al.* (1996), it is determined by the Br locus, the Br^b allele being bearded and the Br^A being wild. In the Andalusian white breed, there was a locus with two alleles that determined the colour: Wb for the white coat and Wk for the cream coat, the latter being dominant (Rodero *et al.,* 1996). Thiruvenkadan *et al.,* (2000) reported that the hooves and dewclaws of Salem goats are grey in colour. Devendra and Burns (1983) discovered that in Katiang breed of goats, the beards are invariably found in males but is less frequent in the females and in Criollo goats, beards are common in males but not in females. Osuhor *et al.* (1998) described Red Sokoto goats as having a well defined uniform dark brown colour.

2.9 **Descriptive Traits of Goats**

Wattles have been thought to aid thermoregulation (Odubote, 1994). In Andalusian sheep, it was identified that a single locus, Wa, exist with two alleles; Wa^w, Wattled and Wa^+, non wattled, the latter being wild and dominant, also various other authors have also cited high incidences of the wattled condition in West Africa Dwarf goats such as Odubote, (1994); Oseni *et al.* (2006); Yakubu *et al.*(2010).

In Andalusian goat, length of hair is due to one locus with two alleles: HL^2 for long hair and HL^+ for a wild type of short hair, the latter being dominant according to Rodero *et al.,* (1996). The body is covered with an outer coat of long straight hair reaching below the knees and hocks; it yields 100 – 150g of Pashmina annually in Pashmina goats (Gupta *et al.* 1994). Acharya *et al.* (1995) documented that long haired Sirohi goats performed better than short haired ones when subjected to similar environmental conditions while Peacock (1996) suggested that rough or dull hair coat could be a sign of illness.

Rodero *et al.* (1996) examined presence, absence and types of horn and reported that heredity regarding the presence or absence of horns is well known because of the importance of their genetic constitution in both sexes with regard to the animal's fertility. Rodero *et al.* (1996) also, examined that in Andalusian sheep, there were animals with and without horns. It is well known, that this character is sex-dependent. According to Devendra and Burns, (1983) the horns of Pashmina goat are long and sweep backwards, the Malabar breed of goat is horned in both sexes; Marwawi breed of goat has long corkscrew horns which is present in both sexes. In Creoule breed, short curved horns are present in the females and longer and twisted horns in males, in Fiji goats, both sexes are horned but polled goats also occur, in Mat'tou goats, both sexes are polled. Katjang breed of goats have horns which are scimitar shaped, curved upwards and backward and are well developed in both sexes.

Devendra and Burns (1983) reported that Sohihi breed of goats have ears generally short and upright while Creoule breed ears are erect and horizontal, similar observation was reported by ILRI, (2007) that Red Sokoto goat ears are short and usually carried horizontally but longer and semi-pendulous in Niger. Rodero *et al.,* (1996) reported that it is believed that the length of the ear is determined by a Mendelian autosomical gene, with intermediate heredity and its phenotype profile character with three variables; rigid, pendular and droopy in Andalusian goats. Rodero *et al.* (1996) also observed that phenotypically, ear size, orientation and direction all differed, even though only the first two variables were used to define the genetic profile in Andalusian sheep and the two classes of ear orientation were horizontal and droopy.

2.10 **Body Conformation Traits and Factors Affecting Them**

2.10.1 **Body Weight**

Weight has been the pivot on which animal production thrives. The knowledge on weight assessment is very necessary because as far as all animal production management is concerned, weight assessment remains the backbone on which it is hinged. The knowledge of body weight of goats is important for a number of reasons; it is related to breeding (selection), feeding and health care (Thiruvenkadan, 2005). Body measurements had been used to predict body weight by several authors in many breeds of goats; Sahel goats of Nigeria (Mohammed and Amin, 1997), Red Sokoto goats (Hassan and Ciroma,1992; Akpa *et al.,*1998a), West Africa Dwarf goat (Mayaka *et al.,* 1995) and Nguni goats (Slipper *et al.,* 2000).

Body measurement is important for the prediction of live weight, carcass weight and determination of certain body conformation traits that can be taken into consideration in selecting animals for genetic improvement (Akpa *et al.,* 2006). Otoikhian *et al.* (2008) showed that there is a positive correlation between increase in body parameters measured with weight gain. This means that animals at different age groups have differences in measurement of body parts like the distance between the eyes, eye length, ear width, body weight and tail length (Osinowo *et al.,* 1989; Otoikhian *et al.,* 2006). Body linear measurements in tropical breeds are some of the productive traits of goats where there are paucity of information (Yashim *et al.,* 2008). Animal live weight is an important feature but are seldom measured in rural areas due to lack of dependable accurate scale (Mayaka *et al.,*

1995). Scales are not readily available in most rural African farming communities (Mani *et al.,* 1991, Nesamvuni *et al.,* 2000).

However quantitative measures for animal conformation are desirable as it will enable reliable genetic parameters for these traits to be estimated and permit their inclusion in breeding programme (Ibe, 1989). Lawrence and Fowler (1998) recorded that live weight is probably the most widely used technique both in practice and in experimental work, in determining the growth rate in animals and in predicting their likely body composition and therefore the rate at which various tissues grow. Indeed the consensus view from a great deal of research work (Alphonsus, 2008) showed that live weight is the most important single predictor for many carcass traits and is the variable that is most important to hold constant in prediction equation which include other variables. This is especially true for body weight which is a good parameter for meat characteristics as larger sized animals produce more meat (Abegaz and Awgichew, 2009).

Ngere *et al.* (1984) and Osuhor *et al.* (2002) reported heavier weights for adult bucks compared with does while Ojedapo *et al.* (2007) reported heavier body weight for does in West African Dwarf goats. Hassan and Ciroma (1990) however reported body lengths ranging from 79 – 97cm for Red Sokoto goats aged 1 – 5 years.

Otoikhian *et al.* (2008) recorded that up to 74.4% of body weight can be assessed without having to weigh the goat. Studies have also shown that there are high and significant correlations between height at withers, heart girth and body weight at 1-2years of age suggesting that either of these variables or their combination could provide a good estimate for predicting live weight in Red Sokoto goat at an early age (Hassan and Ciroma, 1990).

2.10.2 **Factors Affecting Body Weight and Linear Body Measurements.**

1. **Age**

Fajemilehin and Salako (2008) reported that age strongly influenced body weight and body linear traits in West African Dwarf goats, as there were consistent increase in all the traits studied as the animals aged. This scenario was not surprising since the size and shape of the animal is expected to increase as the animal is growing with age. This was in consonance with the report of Orheruata and Olutogun (1994) in cattle. Ojedapo *et al* (2007) reported that age affected the least square means of body weight and some linear body measurements and the value obtained for all the measurements increased as the animals advanced in age. The slow growth that occurred in goats between 1½ - 2 years was not an indication that goat had attained maturity. It could be explained that in this period (1½ - 2 years) in goats, energy is centered towards weight gain than elongation of body parts. Thus, by measurement of some of the body parameters, the age of goats can be assessed and the timing for different management practices can be pegged accurately to bring goats to a good and desired weight at maturity (Imasuen and Otoikhian, 2004).

2. **Sex of Kids**

Studies have shown that sex does not have any influence on weight gain of goats (Otoikhian *et al.,* 2006; NSAP, 1991; Imasuen and Otoikhian, 2004). On the contrary, Akpa *et al.,* (1998a) reported that sex significantly influenced body weight, body length, height at withers and heart girth for different age groups in Red Sokoto goats with males recording higher values. Ozoje and Herbert (1997) also observed that sex did not significantly affect

body length, heart girth, leg length, and shoulder width either at birth or at any other age up to when the kids are weaned in West Africa Dwarf and Red Sokoto goats.

Fajemilehin and Salako (2008) reported in their study that more female animals than males were available for screening and so observed that sex had an influence on body weight and body linear measurements. Giving the impression that sex is an important source of variation for body weight and body linear measurements at the two age groups (young and adult) of animals available for measurement. They also observed that the females were heavier than males at these ages and linear measurements were superior because female goats grew faster than the bucks at early stage. This sex influenced differences in body weight and linear measurements was partly attributed to hormonal effect, that is, non release of androgen (which is known to have growth and weight stimulating effects) in male animals until the testes are well developed (Frandson and Elmer, 1981). Fajemilehin and Salako (2008) reported that male animals from only two age groups were available for screening and that this was because farmers will want to keep female goats in preference to males to minimize cost of feeding and to increase production efficiency. They also observed that most of the males were preferably castrated and fattened for sale as meat and as source of income to the owners. Further report (Fajemilehin and Salako, 2008; Ifut *et al.,* 1991) showed that sex significantly influenced body weight and body conformation in West Africa Dwarf goats. Akpa *et al.* (1998a) concluded that both sex and strains significantly influenced body weight and linear traits.

Whenzhong *et al.* (2005) reported that sex was a major non-genetic factor influencing body weight and growth rate. They observed that females were larger than males for all body sizes except withers height. Al – Shorepy *et al.* (2002) found that sex effect was significant

for all traits. Male kids were heavier and grow faster than female kids. A weight difference of 0.23kg (9.0%) at birth increased to 1.55kg (13.3%) at weaning. Sex difference increased with growth rate, indicating that male kids were more responsive to improvement in environment.

3. **Heart Girth**

Heart girth is also known as chest girth or chest circumference. it is measured as the circumference of the body at a point immediately behind the forelimbs, perpendicular to the body axis. Hearth girth measurement is considered because of its high heritability (Alade *et al.,* 2008) and association with body weight (Khan and Issani, 1994, Topal and Macit, 2004).

Isaac and Ibrahim, (2006) had in the result of their study that chest girth showed the highest correlation for both sexes. Their report was an indication that chest girth succeeded in estimating body weight more than any of the other linear body measurement. Giving the impression that heart girth would give the best estimate for predicting live weight of Red Sokoto goats at 1-2 years of age. Isaac and Ibrahim, (2006) concluded that although chest girth is the most highly correlated trait to body weight, combining it with other linear body measurement (height at withers and body length in a stepwise multiple regression) will produce the best predication equation for body weight. Thiruvenkadan (2005) suggested that the higher association of body weight with chest girth was possible due to relatively larger contribution in body weight by chest girth (consisting of bones, muscles and viscera).

4. **Breed**

Breed effect had been reported by Bilaspuri and Singh (1992), and could be attributed to body weight differences (Alade *et al.,* 2008). Moruppa and Ngere (1987) reported breed differences in regression coefficients of body weight on height at withers, heart girth, upper and lower fore limbs and hind limbs in Borno white and Red Sokoto goats, with the former maintaining higher values. Body weight and linear body measurements were found to be higher in Borno white when compared with Red Sokoto and West African Dwarf goats. Ozoje and Herbert (1997) revealed that Red Sokoto goat was superior to the West Africa Dwarf goat at maturity in terms of weight and body measurements.

5. **Season of Breeding**

Ozoje and Herbert (1997) found that season of breeding significantly affected body length, heart girth and leg length at birth. At 90 and 150 days, seasonal effect was significant for shoulder width and non significant on heart girth and body length. However, kids born in the dry season (October to April) had superior body length, shoulder width and leg length at birth. Fasae *et al.,* (2005) reported in the study of Yankasa ewes in the humid zone of Nigeria, that season had significant effect on live body weight, chest girth, trunk length and height at withers were significantly higher in the rainy season than in the dry season.

6. **Type of Birth**

The type of birth such as single, twins or triplets born is known to have some influence on birth weight, body weight, and linear body measurements. Ozoje and Herbert (1997) in their research discovered that type of birth had no significant effect on all measurements;

body length, heart girth, leg length and shoulder width. Amoa *et al.* (1996) reported a decrease in birth weight as the litter size increased.

Wenzhong *et al.* (2005) reported that all body size parameters except body length, chest girth, cannon circumference and height at withers were significantly affected by the type of birth and rearing. The kids born as twins had lower birth weight and slower growth rate when compared with those born as single. Alshorepy *et al.,* (2002) found that singles were heavier than twins from birth weight, 30 days weight and weaning weight and grew faster from 30 to 90 days of age.

2.11 **Relationship Between Morphological and Conformation Traits**

According to Oseni and Ajayi (2008), conformation traits that were highly correlated with body weight include body length, body depth, hearth girth, height at withers and height at rump. Akpa *et al.,* (1998a) also observed that brown and light brown Red Sokoto goats were predominantly heavier in body weight and had higher height at withers than other pigmented types. However, Semakula *et al.* (2010) reported that coat colour had no significant effect on height at withers of small East Africa goat breeds of Uganda. Ozoje and Kadir, (2001) also recorded no significant differences in body measurement taken on West Africa Dwarf sheep when coat type was considered.

2.12 **Relationship between Body weight and Body Measurements**

Thiruvenkadan (2005) reported that correlation co-efficient between body weight and body measurements were positive and strong. The correlation coefficient for different body weight ranged between 0.560 and 0.968. The chest girth accounted for maximum of 80.4

and 93.6% of body weight. Hamayun *et al.* (2006) observed high and significant correlation coefficient between height at withers and heart girth and body weight at 4 to 18 months of age in Beetal goats. Suggesting that either of these variables or their combination would provide a good estimate for predicting live body weight in Beetal goat at an early age. The correlation obtained for the above variables were (r = 0.638 and r = 0.552). Similar trend was also reported in Red Sokoto goats (Moruppa and Ngere, 1987).

Hassan and Ciroma (1992) found that body weight in Red Sokoto goat was correlated with body length, height at withers and heart girth within the age groups of 1 -2 years, 3 – 4 years and 5 years, respectively. Akpa *et al.* (1998a) reported that Red Sokoto goat body weight was significantly and positively correlated with body length (0.74, 063, 0.60 and 0.65), Height at withers (0.79, 0.60, 0.51, 0.47 and 0.46) and chest girth (0.72, 0.57, 0.76, 0.72 and 0.75), 1 – 6 months, 7 -12 months, 13 – 18 months, 19 – 24 months, and 25 – 36 months respectively. Concluding that based on the magnitude of the correlations, heart girth and body length could be used to estimate body weights in Maradi goat across all ages.

According to Singh *et al.* (1992), birth weight, body weight and body measurements can be used in selection indexes to improve body weight at 3 and 6 months of age. An index that incorporated body weight, body length, height at withers, and heart girth at 3 months gave the highest expected genetic gain at 3 and 6 months of age.

2.13 **Relationship Between Descriptive and Body Conformation Traits**

Ozoje and Kadir, (2001) reported that tassel significantly affected body measurement traits in West Africa Dwarf goats, goats with tassels had longer body length, height at wither, heart girth, shoulder width, tail length, heart depth, leg length and abdominal circumference.

Bratte *et al.* (1999) reported that the horn development generally increases with age and body size, and the coefficient of determination (R^2) relating average horn length (AHL) to ram age and body weight indicated that 84.13% of the variation in AHL could be attributed to its linear relationship with ram age, while 54.34% of the variation can be attributed to body weight. In Salem goats, the body measurements increased progressively as the age advanced (Thiruvenkadan *et al.,* 2000).

2.14 **Genetic Parameters and Relationship Estimations**

The genetic makeup of the individual includes additive and non additive genetic combinations. These combinations interact with the environmental conditions such as climate, nutrition and management and intrinsic factors such as sex, age, physiological status as well as other extrinsic factors (Maternal effect and random environmental factors) to determine the ultimate expression of animal performance (Wattiaux, 2002). The goal of livestock production is to produce quantity and quality products with maximum efficiency. Unbiased heritability and repeatability estimates as well as accurate correlations (genetic and phenotypic) among performance traits in the breeding objective and the selection criteria are required to design selection programme for livestock.

Estimation of genetic parameters is very important for any genetic improvement program. Heritability estimates for body weight traits in goats have been reported to be moderate to high (0.30 – 0.53) (Bosso *et al.,* 2007; Neopane, 2000). High repeatability estimates (0.70 – 0.89) have been reported for body weight and body measurements in goats (Tomar, 1979). Studies have also shown that body weight and body measurements are strongly and positively correlated in goats (Akpa *et al.,* 1998a; Atta and El-Khidir, 2004; Thiruvenkadan, 2005).

Heritability, repeatability and phenotypic correlations of growth traits of Red Sokoto goats were estimated (Iyiola – Tunji *et al.,* 2008). Heritability estimates were 0.99, 0.97, 0.76 and 0.70 for adjusted weaning weight, weaning weight, yearling weight and post weaning daily gain. The repeatability of birth weight, adjusted weaning weight and weaning weight was 0.39, 0.28, and 0.17, respectively. Findings from the study suggested that better appraisal of Red Sokoto goats for body weight will be possible by considering the relationship between post weaning daily gain and weaning weight. This relationship between post weaning daily gain and weaning weight could help breeders in early selection of replacement stock through performance testing.

Estimation of genetic parameters for some reproductive traits in Red Sokoto goats was conducted (Akpa *et al.,* 2004). From the study, heritability of gestation length, litter size, litter genotype and sex ratio was, 0.378, 0.589, 0.285 and 0.205, respectively. The genetic correlation of gestation length with litter size, litter genotype and sex ratio was – 1.031, 1.518 and 0.411, respectively. The genetic correlation of litter size with litter genotype and sex ratio was 0.867 and 0.269, respectively. The observed moderate to high heritability of those traits indicated the possibility of improvement through selection. Other studies on

relationship between reproductive traits in Red Sokoto goats (Akpa, 1996) revealed that the dam's body weight at kidding was negatively correlated with post partum interval to conception ($r = -0.62$, $P < 0.05$). Thus indicating that the heavier the body weight, the shorter the interval. The repeatability estimate for postpartum interval to conception was low (0.03).

According to Akpa *et al.* (1998b), the heritability of udder morphological traits in Red Sokoto goats was high for udder circumference (0.49) but low for teat length (0.16). The correlated relationship between the udder morphological traits was significant and positive ($P < 0.05$; $r = 0.24$). The positive relationships between morphological udder traits and the high heritability estimates of udder circumference, udder length and teat circumference indicated possible selection markers to improve the Red Sokoto goats milking ability.

2.15 **Estimation and Improvement of Body Weight and Genetic Parameters in Goats**

In the tropics, majority of indigenous small ruminant genetic resources are kept by small holders, making their involvement in improvement and conservation program essential (Kosgey *et al.,* 2006). So far, breeding improvements targeted at the small holder herds have failed to give desired results due to the movement of breeding does in the herds before the projects were concluded (Akpa *et al.,* 2001b). Genetic improvement programs in low input system could be greatly enhanced if they were designated to primarily target farmers (Ahuya *et al.,* 2005). Where flock sizes are small, farmers know their animals very well and in many cases can recall the pedigree of the animals (Oliver *et al.,* 2002). In demonstrating such programs, it is preferable to start with a few of the most important traits in a breeding objective rather than a combination of all the traits (Philipson *et al.,* 2006). If measurements

such as animal weights are linked to prices in organized marketing system, farmers will quickly realize how useful records are and adopt them (Kosgey and Okeyo, 2007). Adaptability of genotypes to the existing and future environment as well as the need and aspirations of the farmers is paramount for genetic improvement of small ruminants at smallholder level (Baker and Grey, 2004).

2.16 **Morphometric Trait Values**

2.16.1 **Heart Girth (HG)**

Heart girth measurement represents the circumference of the chest. Ojedapo *et al.* (2007) reported a significant (r = 0.934) and high correlation coefficient between body weight and heart girth. High correlation between body weight and heart girth has also been reported by Ibiwoye and Oyatogun, 1987) in Red Sokoto goats.

Akpa *et al.,* (1998a) reported mean values of chest girth of Red Sokoto goats at 1 – 6, 7 – 12, 13 – 18, 19 – 24, 25 – 30 and 31 – 36 months to be 44.6 ± 2.18, 57.7 ± 1.86, 60.1 ± 0.92, 70.9 ± 1.4 and 70.7 ± 1.60cm respectively. Thiruvenkadan (2005) found that the mean values of heart girth recorded in Kanni Adu kids at 0 – 3, 3 – 6, 6 – 9 and 9 – 12 months were 39.9 ± 0.45, 51.8 ± 0.51, 55.5 ± 0.67 and 58.2 ± 0.65cm respectively. He suggested that the higher association of body weight with chest girth was possible due to relatively larger contribution in body weight by chest girth (consisting of bones, viscera and muscles).

Mohammed *et al.* (2006) reported a mean heart girth in males at 4 – 12, 13 – 18, 19 – 24 and 25 – 36 months as 59.10 ± 0.86, 66.0 ± 3.19, 70.29 ± 1.19, 79.63 ± 0.96cm while that of females in the same age groups were repoted to be 57.60 ± 0.95, 61.29 ± 1.27, 64.00 ±

0.68 and 70.15 ± 1.80cm, respectively in beetal goats. Hassan and Ciroma (1992) recorded values of heart girth of Red sokoto goats at 1 – 2, 3 – 4 and 5 years of age to be 61.78 ± 0.73, 67.36 ± 0.51 and 75.77 ± 0.86cm respectively.

2.16.2 **Height at Withers (HAW)**

Height at withers is measured as the distance between the most dorsal point of the withers and the ground level. Thiruvenkadan (2005) reported a high correlation between height at withers and body weight in males of 6- 9 months and 9 – 12 months and in females of 0 – 3 months. The author further reported overall mean for height at withers (cm) of Kanni Adu kids at 0-3, 3-6, 6-9 and 9-12 months for males to be 46.7± 0.69, 58.1±1.23, 64.6±1.04 and 66.2 ± 2.81 respectively. Those of the females were 45.3 ± 0.63, 58.8 ± 0.64, 59.7 ± 6.31 and 65.5 ± 0.95 respectively.

Akpa *et al.,* (1998a) recorded overall mean values of height at withers of Red Sokoto goats at 1 – 6, 7 – 12, 13 – 18, 19 – 24, 25 – 30 and 31 – 36 months to be 38.1 ± 2.09cm, 47.5 ± 3.26, 53.3 ± 1.49, 53.5 ± 1.87, 64.1 ± 0.83, 64.1 ± 0.83cm for males respectively and 39.7 ± 3.29, 51.0 ± 0.89, 52.8 ± 1.37, 52.9 ± 1.25, 59.7 ± 1.41 and 59.8 ± 1.28cm for females respectively. They further reported that sex significantly influenced body weight, body length, height at wither and heart girth. Hassan and Ciroma (1992) reported overall mean values for height at withers of Red Sokoto goats for different age groups of 1 - 2 years, 3 – 4 years and 5 years to be 54.44 ± 0.72cm, 61.07 ± 0.49cm and 65.94 ± 0.97cm for females respectively.

Eugena, (2010) reported that the high positive correlation values between body weight, height at withers and heart girth indicates that as live body weight increase, the linear body

measurements will also increase. Adewumi *et al.* (2006) stated that body weight and linear measurements could be selected for at the same time. Attah *et al.* (2004) reported from their study that measurements such as chest girth, height at withers were at one stage or the other found to be highly correlated with body weight and gave a value of about 49cm for males and 47cm for females for height at withers.

2.16.3 **Body Length (BLT)**

Body length refers to the distance from the external occipital protuberance to the base of the tail. Mohammed *et al.,* (2006) recorded body length of males to be 59.60 ± 0.74, 64.38 ± 1.39, 69.42 ± 0.29, 78.15 ± 0.60cm while that of females were found to be 58.70 ± 0.84, 60.14 ± 0.50, 62.16 ± 0.60, 69.31 ± 1.85cm in goats aged between 4 – 12, 13 – 19, 19 – 24, and 25 – 36 months respectively. They further concluded that body weight was correlated with body length (0.49, 0.12, 0.70 and 0.78) in beetal goats. Ojedapo *et al.* (2007) and Akpa *et al.,* (2009) reported a high and positive correlation between body length and weight in West Africa Dwarf and Red Sokoto goats respectively. According to Akpa *et al.* (1998a) the mean body length of Red Sokoto goats for age group 1 - 6, 7 – 12, 13 – 18, 19 – 24, 25 – 30 and 31 – 36 months of age to be 36.7 ± 2.36, 44.5 ± 0.50, 51.0 ± 0.99, 55.7 ± 2.09 and 63.3 ± 2.20 respectively in males, while the females had 39.7 ± 3.29, 50.8 ± 0.83, 53.7 ± 1.43, 53.8 ± 1.48, 61.5 ± 1.00, and 62.1 ± 0.97 respectively. Thiruvenkadan (2005) recorded mean values of body length (cm) in Kanni Adu kid at 0-3, 3-6, 6-9 and 9-12 months to be 39.8 ± 0.44, 51.1 ± 0.29, 54.1 ± 0.28 and 57.2 ± 0.44cm respectively.

Ibe and Nwakalor (1987) reported that the high correlation between each linear body measurement and body weights is not surprising, since the latter is a measure of overall

body growth which itself is the sum total of increases in size of different structural body component. Orheruata *et al.* (1997) reported that the mean value for male and female Ndama cattle linear body measurements increased with age in a similar manner from birth to 30 months of age, but with the highest increase occurring during preweaning period, while the least increase was between 24 and 30 month post weaning Hassan and Ciroma (1992) reported mean body length of Red Sokoto goats at 1 – 2, 3 – 4 and 5 years as 79.15 ± 0.57, 85.43 ± 0.91 and 96.44 v 1.41cm respectively.

2.17 **Coat Colour Variations in Goats**

The Red Sokoto goats had been documented to have various colour patterns when processing their hide (Peacock 1996, Akpa *et al.,* 1998a). The possible effects of coat colour pigmentations on morphological traits was discussed by several authors (Akpa *et al.,* 1998a, Ozoje and Kadri, 2001). The study of coat colour was tied to the need for production of certain colour (usually white) in certain breeds of goats such as Angora or cashmere goats as well as many breeds which have breed specific colours or patterns (Sponenberg, 2004).

Colour in mammals depends on the presence or absence of Melanins in skin and hair (Searle, 1968). Melanins reside in cellular organelles called Melanosones, which are produced in melanocytes. The two main mechanisms by which pigmentation is reduced or absent are, absence or relative inactivity of melanocytes. Decrease or elimination of pigment by either of these basic mechanisms could be regional, or could involve the entire hair coat (Sponenberg, 2004).

Melanins occur as two types: eumelanin and phaeomelanin (Danchin – Burge, 2006). Eumelanin is generally black or chocolate brown, and is predominantly made of tyrosine. It is usually of one base colour. Phaeomelanin is generally reddish brown or yellowish tan. The phaeomelanic tans are extremely variable, and unlike eumelanin they frequently vary on an individual goat. Some goats have dark tan as well as pale cream phaeomelanic areas. This makes accurate identification of phaeomelanin tricky all times. Phaeomelanin could vary from very dark to very light. At the light extreme it could be nearly white. At the dark extreme it could be confused with the browns of eumelanin. Generally, phaeomelanic colours have a reddish tinge (Sponenberg, 2004).

The two types of melanin are important visually and genetically, and are usually considered as two discrete classes of pigment. Some overlap occurs between the two, but these overlaps are usually trivial to an understanding of the genetic control of colour in goats. Overlap could also occur visually, with very dark phaeomelanin being similar to lighter forms of eumelanin, but usually the two classes are distinct (Sponenberg *et al.1988*). According to Sponenberg (2004) the position of eumelanic and pheaomelanic areas determines the basic colour of goats and the classification of goat colour depends on the specific pattern of pigmented areas. Unfortunately, white spotting could obscure portions of goats, making it difficult (and at times impossible) to appreciate their pigmentation type and pattern.

The final colour of the goat could be due to the interaction of eumelanin (black/brown), phaeomelanin (Red brown/ tan/cream/white), and white spotting (white) (Sponenberg, 2004). It is thought that animals with a dark coat and therefore with greater absorption of thermal radiation, are more susceptible to heat stress than those with a light-coloured coat

(Turner *et al.,* 1984; Finch *et al.,* 1984). Acharya *et al.,* (1995) also reported that coat colour could affect thermoregulatory parameters.

2.18 **Goat Hair Types**

Hair types in goats had been categorized into rough and smooth (Peacock, 1996; Yakubu *et al.,* 2010) while others categorized it into long, medium, smooth, straight or curly (Tantia *et al.,* 2001). Hair type determines quality of fleece, thus a good quality hair is usually desired by most leather works and tanneries. In relation to production traits, Acharya *et al.,* (1995) discovered that long-haired sirohi goats performed better than their short haired counterparts.

2.19 **Wattles in goats**

Wattles or tassels in goats refer to the loose bare of folded skin hanging from the neck of goats. It is also referred to as a hanging protuberance; a fleshy dewlap or caruncle (Wikipedia, 2010). Authors and researchers (Nolte, 2010) claimed that wattles had no obvious significance to the physiology of the goat. However Ozoje and Kadir, (2001) reported that wattle genes had significant influence on body measurements such as body length, heart girth and height at withers. Odubote (1994) had earlier concluded that the wattle occurrence had a role to play in thermoregulation.

2. 20 **Milk Yield, Composition and Estimation**

Nigeria is endowed with large numbers of small ruminants, which are yet to be fully investigated for milk production. Goats are the largest group of ruminant livestock in the country, totaling about 34.5 million, predominantly owned by rural households, with

ownership spread across all age groups and sexes (FDLPCS, 1991). The development of the Nigerian dairy goat will require a critical evaluation of all the locally available breeds and their potential for milk production. A number of studies have been carried out on the milk yield and composition of indigenous breeds of goat (Ehoche and Buvanendran, 1983; Fajeminsin, 1991). Generally, the milk yields of the does drop after a few weeks and becomes negligible by the 15th week (Ngere, 1985). These reports emanated from universities and research centres. Akpa *et al.* (2002), evaluated the milk yield characteristics of smallholder agro-pastoral Fulani Red Sokoto goats using a total of 92 does in 6 herds, collected over a 2 year period. The results indicated that the total yield was 79.8kg, daily yield 0.66kg, peak yield 1.21kg and day of peak production 28.7 day of lactation.

Zahraddeen *et al.* (2009), concluded that doe's body condition scores, parity, season and litter size significantly influenced milk yield. According to Akpa, (2009), the milk yield characteristics of Red Sokoto goats are highly variable and are significantly influenced by herd, season, parity and litter size of the doe. Highly positive and significant correlations exist between the total yield and the average daily yield, peak yield, initial yield and day 120 yield, a negative and significant correlation was observed to exist between the peak day and initial yield. The non-homogeneity of milk yield characteristics in Red Sokoto goats suggest the possibility of improving their daily production by selection of high yielding does. Selection for higher initial milk yield may also improve other milk yield characteristics (Akpa, 2009).

Accurate prediction of yield responses to increasing milk frequency is required for returns (Erdman and Varner, 1995). It has been reported that more frequent removal of milk

enables a longer maximal secretion rate (Barpele *et al*., 1995). In Red Sokoto goats, both total milk yield and efficiency of milk production were influenced positively by increasing milking frequency (Akpa *et al.,* 2001b). A study was carried out to determine the consequence of milking frequency on total yield, average daily yield, peak day, flow rate, dairy merit and persistency in Red Sokoto goat by Akpa *et al.* (2004). A total of thirty lactating does were divided into three groups on milking frequency basis of once, twice and thrice a day milking of 10 animals each. All the does were hand milked for a period of 120 days postpartum. Over the 120 days lactation period, total yield, average daily yield, peak yield, peak day, flow rate, dairy merit and persistency was 55.5kg, 0.47kg, 0.79kg, 33.8d, 3-7g/s, 10.6% and 96.1% respectively. Milking frequency significantly influenced total yield, average daily yield, peak yield, and milk flow rate but not peak day, dairy merit and persistency. Milk yield characteristics increased with milking frequency, but at a decreasing flow rate. In Red Sokoto goats milking frequency affected milk yield characteristics but not dairy merit and persistency. The high lactation persistency of these goats was an indication of their ability to maintain milk production throughout lactation.

As a dairy animal, the doe is known to produce three times as much milk as the cow (Wilson, 1988), relative to body size. There is ample evidence to show that milking thrice or four times daily increased milk yield and once daily milking reduced milk yield (Carruthers and Copeman, 1990). Milk yield and composition were significantly influenced by milking frequency. Milk yield was significantly and positively correlated with milk composition, and the relationship was significantly enhanced by milking frequency (Akpa *et al*., 2005). The higher the milking frequency; the higher the milk yield but with a decreasing flow rate.

2.21 **The Red Sokoto Goat and Milk Production Potential**

Nigeria is endowed with large numbers of small ruminants, which are yet to be fully investigated for milk production. The Red Sokoto goat is the predominant breed of goats in Nigeria. It is commonly found among the agro-pastoralists mainly within the northern sub-humid and semi-arid zones of the country (Akpa *et al.,* 2001a). Available information on the milking of indigenous African goats indicates that not much is known about their dairy characteristics (Akpa *et al*., 2001b*).* From the existing records, lactation milk yield ranged between 24.0 and 12.03kg, with peak yield observed in the Red Sokoto goats of Nigeria (Egwu *et al.,* 1995; Ruvuna *et al.,* 1995 and Akpa 1999a). Zahraddeen *et al.* (2009), observed peak milk yield in the third week of lactation. Variable peaks of lactation have been obtained in various studies. For instance, Butswat *et al.,* (2002) reported peak yield in the fourth week in Red Sokoto and Sahel goats in Bauchi. James and Osinowo (2004) reported that the West African Dwarf goats attained peak milk yield in the third week of lactation with Sahel goat and Red Sokoto goat in the second week. Ehoche and Buvanendran (1983) reported that the average Red Sokoto goat produced 545g of milk per day. Also, in monitoring Red Sokoto goats on the field, Akpa and Duru (1999) showed that one day or average of two days record in a week was adequate in estimating total milk yield and therefore could be used to monitor their milk yield characteristics.

A review of the performance of these goats shows favorable reproductive characteristics (Akpa, 1999a) such as high fecundity and short generation interval. The properties of a goat are not only determined by its genetic potential but also by the possibilities to manifest this

potential. The extent to which it is possible to do so is determined mostly by environmental factors (climate, feed, housing, health and general care) and animal factors (age, sex and production capacity). A good dairy goat gives about 3.4 liters of milk daily which is 900-1800kg milk in a 305 day lactation period (Haenlein, 1992). Akpa (1999b) reported that milk production of Red Sokoto goat in the agro-pastoral system for 120 days produced 79kg with an average daily yield of 0.664kg. Compared to cows, goats will be nutritionally more economical because of their small size, requires less food and of a type much cheaper than cow. This implies that the potential production of milk from goats could be future stimulated to increase the overall milk supply from dairy animals. Above all, goat milk fat and protein are readily digested; and the constituent amino acids absorbed more efficiently than those of cows (Jandal, 1996).

The goat is generally known to produce relatively more milk per unit of live weight compared to the cow. Also, as a dairy animal, the doe is known to produce three times as much milk as the cow (Wilson, 1988) relative to body size. It has been reported that once daily milking could reduce fixed costs and may be used strategically as a quota management tool and could become the production system of choice in a programme intestification (Christopher and Richard, 1994). Knowledge on their milk production efficiency and optimum milking frequency would be useful in achieving good management and selection programmes for an improved milk production (Akpa *et al.,* 2001b).

The development of the Nigerian dairy goat will require a critical evaluation of all the locally available breeds and their potential for milk production. Studies conducted on milk production of Red Sokoto goats had variable results (Ehoche and Buvanendran, 1983; Fajeminsin, 1991; Akpa *et al*., 2002; Akpa *et al*., 2008). Much of these variations could be

attributed to the management system under which the studies were conducted. A comparative study of milk production behaviour of Red Sokoto goats under agro-pastoral and institutional system in the semi-arid climate of Nigeria revealed that milk production performance was better for agro-pastoral system (23.5-69.7%) than institutional system, except for lactation peak week (8%) and persistency (22%) (Akpa *et al.,* 2008) . The differences in the two systems could be attributed to differences in nutrition and management of the goats. The agro-pastoral system had a better potential in terms of feed and water supply for milk production but lacked the management ability for sustainability.

Earlier studies carried out on the milk yield and composition of indigenous breeds of goats (Fajeminsin, 1991), and more recently Akpa *et al.* (2005) found that milk yield and composition were significantly influenced by milking frequency. Accurate prediction of yield responses to increasing milking frequency is required for sound decisions by dairy producers to optimize economic returns (Erdman and Varner, 1995). It has been reported that more frequent removal of milk enables a longer maximal secretion rate (Barpele *et al.,* 1995). In Red Sokoto goats, both total milk yield and efficiency of milk production were influenced positively by increasing milking frequency (Akpa *et al.,* 2001b).

Milk flow rate in goats is highly heritable (Ricordeau *et al.,* 1989). Selection for this trait has been suggested as a means of reducing the need for milking labour, since labour for milk harvest may account for as much as 80% of routine operational requirement of dairy farms (Akpa *et al.,* 2003). Milking frequency significantly influenced milk yield and milk flow rate. The higher the milking frequency, the higher the milk yield and milk flow rate.

2.22 **Efficiency of Milk Production**

There is limited information on the measure of efficiency of milk production in goats. Therefore, the biological advantages of goats as milk animals have been grossly underestimated (Akpa, 2009). The Red Sokoto goats are the most important breed of goats in Nigeria and contribute about 70% to the country's goat population (Osuhor *et al*., 1998). A knowledge of their milk production efficiency (dairy merit) and optimum milking frequency would be useful in achieving good management and selection programmes for an improved milk production (Akpa *et al*., 2001b).

Akpa *et al*.(2001b), investigated the influence of milking frequency on efficiency of milk production in Red Sokoto goats, the results showed that in 120 days lactation, the total milk yield and gross energetic efficiency of milk production (dairy merit) was 55.5kg and 8% respectively. Milking frequency significantly influenced efficiency of milk production. The characteristics estimating efficiency of milk production in Red Sokoto goats were highly variable. However, when compared with calculated 25.3% for Saanen goats (Gall, 1996), the Red Sokoto goat was 32% as efficient in milk production as Saanen goat.

Studies to determine milk yield and efficiency of estimation of total milk yield using average records in non-suckling Red Sokoto goats were carried out (Akpa and Duru, 1999) the results showed that 12 weeks milk yield characteristics of non-suckling Red Sokoto does was similar to already existing reports on the breed. Milking Red Sokoto once a day could supply a family of 8 members a daily requirement of 65g of milk. One day or average of two days weekly record was adequate in estimating total yield with minimum error, and therefore, could be used to monitor milk yield characteristics of these goats on the field.

2.23 **Mammary Morphology and Relationship with Yield**

The udder is the main body part of a dairy animal commonly understood to be related to its milk production capacity. In goats, udder characteristics, milk production, and milking time and rate are traits with adequate genetic variation to allow selection responses (Wang, 1989 and Mavrogenis *et al.,* 1989). The knowledge of the relationships between these traits can be utilized in the design of breeding programmes to improve milk quantity and quality, aid to identify certain morphological and physiological factors related to changes in these traits (Shook, 1989). There are rising interest on small ruminant morphological traits (Charon 1990, Mather and Vroyla-Anesti, 1994) with emphasis on the relationship of the traits with milk yield and milking management (Labussiere, 1988) and factors that affect them (Fernandez *et al.,* 1995).

In the Red Sokoto goats, studies were conducted to elucidate the udder morphological traits, factors affecting them and relationship with milk yield (Akpa *et al.,* 2003). The results showed that in lactating Red Sokoto goats, the average udder and teat size characteristics were; udder circumference 38.8cm; udder height 17.1cm; distance between teats 11.5cm; teat circumference 7.2cm; and teat length 5.2cm. Udder circumference and udder height were low in variability, while the teat size traits were moderately to highly variable. Thus, there is adequate variation in these traits to allow for selection response.

Akpa *et al.* (1998b) investigated the sources of variation in morphological udder traits of Red Sokoto goats and concluded that udder and teat size characteristics of Red Sokoto goats were similar to those found in dairy goats. These traits increased with increase in age

and parity of doe; thus indicating the possibility of the morphological aptitude of the goat udder to mechanical milking improving as parity and age of doe increased. Effect of coat type on these traits showed that does with smooth and shiny coat had higher udder circumference and udder length than those with rough and dull coat implying that coat type can be used for udder characterization of Red Sokoto goat. Wattles have no significant effect on the morphological udder characteristics in Red Sokoto goats. The udder size characteristics were positively correlated; implying that improvement in one would lead to improvement on the others.

According to Mavrogenis *et al.* (1989) increasing parity increased udder and teat size up to 3rd parity when it leveled at the fourth and fifth parities. Udder circumference, udder height, distance between teats and milk yield increased with increase in litter size. Udder size characteristics were positively correlated with milk yield. Low correlation of teat size with milk yield suggests that they can be selected for, without modifying milk yield because their genetic correlations with milk yield are nil or at best low.

Prediction of milk yield from external measures of the udder in Red Sokoto goat could be based on udder height, udder circumference, distance between teats and teat length. The positive correlation between udder and teat size traits would suggest that as udder height increases, udder circumference, teat length and teat circumference would increase correspondingly; thus making wider udder desirable since cistern height and teat position and angle may increase (Fernandez *et al.,* 1995). The season of kidding affected udder traits, and therefore; should be considered in designing breeding programmes to improve milk production in Red Sokoto goat. Does kidding in the wet season have larger udder circumference than does kidding in the dry season.

Akpa *et al.* (1998b), also concluded that coat colour can be used for udder characterization in Red Sokoto goat; and predication of milk yield from external udder traits can be based on udder height, udder circumference and teat length. However, the high heritability estimates of udder circumference, udder height and teat circumference may implicate them as possible selection markers to improving Red Sokoto goat milking ability.

CHAPTER THREE

3.0 **Materials and Methods**

3.1 **Study Location**

The survey was carried out in Katsina State. The State was zoned into three, namely Funtua, Katsina and Daura. Katsina State covers an area of 23,938 Sq, km, which is located between latitudes $11^0$08'N and $13^0$22'N and longitudes $6^0$52'E and $9^0$20'E. Katsina State forms part of the extensive plains known as the high plains of hausa land. The State is composed of undulating plains which generally rise gently from 360m in the northeast around Daura, to 600m around Funtua in the South West. Generally the State has two geological regions. The South and central parts of the State are underlain by crystalline rocks of the basement complex (from Funtua to DutsimMa), but in the northern parts cretaceous sediments overlap the crystalline rocks. In areas around Funtua and DutsimMa, there are numerous quartzatic and granitic hills which rise 60200m above the surrounding plains. These hills are probably the result of the intrusion of older granites into the basement complex which have undergone long period of denudation. Climatically, the State is classified into two Zones; tropical continental and semi arid continental. The South of the State (from Funtua to DutsimMa) belongs to the former with total annual rainfall figures ranging from 1000mm around Funtua to over 800m around DutsimMa. The North of the State has total rainfall figures ranging from 600-700mm annually. Generally, the climate varies considerably according to months and seasons. They are a cool dry (harmattan) season from December to February, a hot dry season from March to May, a warm wet season from June to September, a less marked season after rains during the months of

October to November, characterized by decreasing rainfall and a gradual lowering of temperature (www.cometonigeria.com).

3.2 Animals and their Management

A total of 888 Red Sokoto goats were used for this study. The animals were managed under the traditional small holder system. They were released for grazing in the morning at 8.00 and Kraaled at night. The goat houses were made using corn stalk for fencing and thatched roof for protection against heat and rainfall. There was no organized health care provision in terms of vaccination and deworming. However Veterinary officers were called to treat the animals when cases of ill-health occur. The kids were allowed to run with their dams.

3.3 Measurements/Observation of Physical Parameters

The measurement and observation of physical traits were carried out which lasted for a period of four months (November to February). Instruments used for the measurement include; measuring stick, weighing scale, flexible measuring tape (Tailor's tape) and measuring cylinder.

The following parameters were considered; body weight, age, sex, horn length, horn separation, tips separation, ear length, thorax depth, body length, height at withers and heart girth. The qualitative traits observed include, wattle, beard, coat colour, head profile and incidence of supernumerary teat. Information was sought on the litter size, parity and milk yield characteristics of each lactating doe.

3.3.1 **Body Conformation Traits (Morphometric Traits)**

The body measurements obtained includes:

1. **Body weight:** The body weight was taken for each goat using a weighing scale. Weight was taken in kilograms (kg). The goat was carried and weighed. The weight of the carrier of the goat alone (wt_1) was taken first before carrying each goat and the weight of the carrier with the goat taken (wt_2). The actual body weight of the goat was determined by subtracting the weight of the carrier and the goat from the weight of the carrier alone (wt_2-wt_1).
2. **Horn length (Hl):** The length of the horn was measured with the aid of a flexible tape from the base of the horn to the tip of the horn in centimeters.
3. **Horn separation (Hs):** This refers to the distance between the bases of the horns. Measurement was taken in centimeters using a flexible measuring tape.
4. **Tip separation (Ts):** The distance between the tips of the horn was taken with the use of a flexible measuring tape in cantimeters.
5. **Thorax depth (TD)**: The thorax depth was taken in centimeters using a flexible tape from the first rib towards the beginning of the tail i.e part of the body between the neck and the abdomen.
6. **Body Length (BLT):** Body length was taken from the point of the shoulder to the Ischium, i.e the distance from the base of the neck to the base of the tail.
7. **Height at withers (HAW):** This was measured in centimeters from the highest point on the dorsum of the animal to the ground surface at the level of the fore legs using a measuring stick.

8. **Heart girth (HG):** Measured as the circumference of the body at the point immediately behind the forelimbs, perpendicular to the body axis. This was also measured with a flexible measuring tape calibrated in centimeters (cm).
9. **Sex:** The sex of the goats was observed and noted and this was determined by the presence of the testes for males and the presence of udder for females.

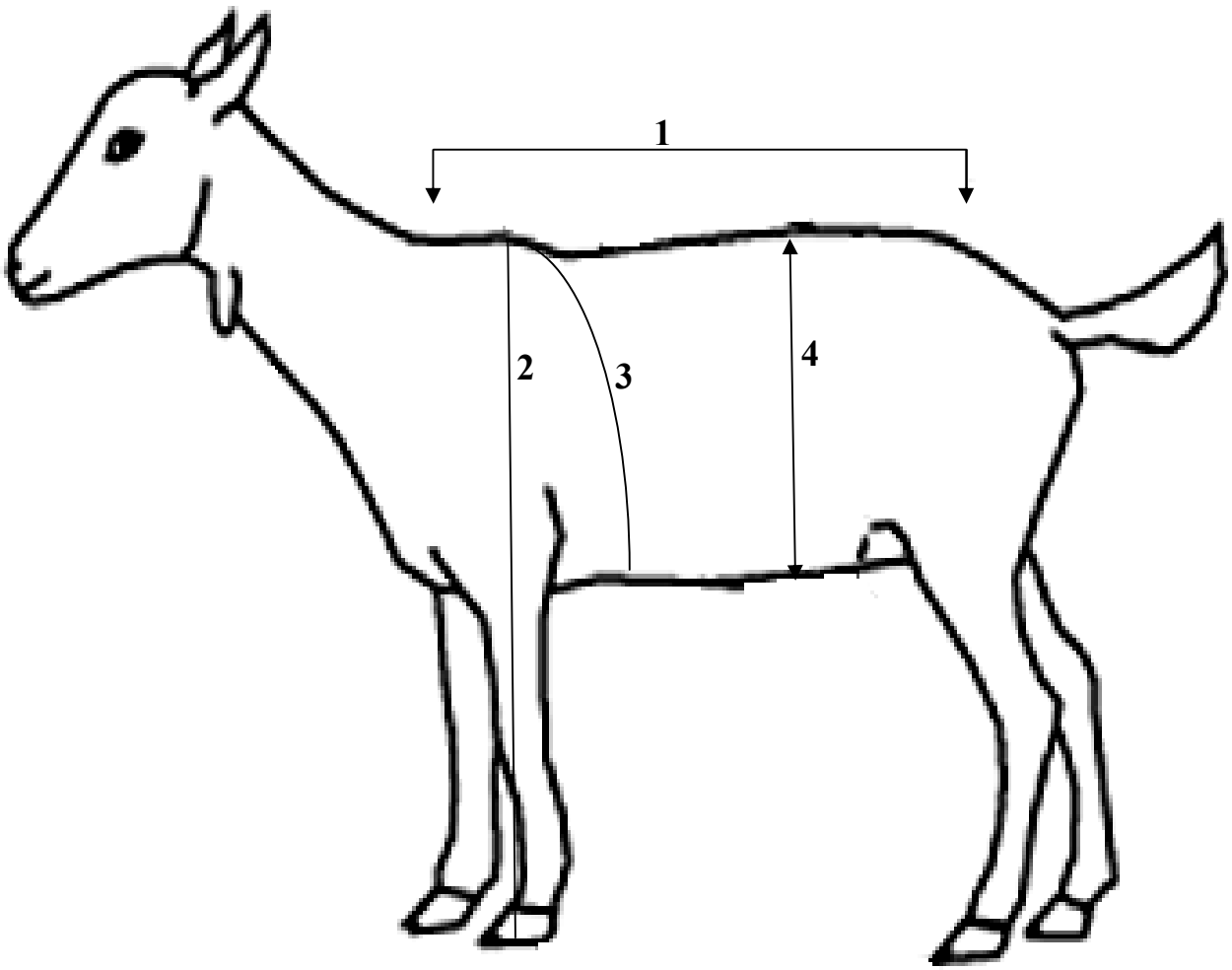


Figure 3.1; Body measurements in goats

1=body length; **2**=height at withers; **3**= heart girth; **4**=body depth

3.3.2 **Qualitative Traits (Morphological Traits)**

1. **Wattle:** On the basis of incidence of wattles (i.e loose fold of bare skin hanging from the throat in goats), animals were categorized into wattled (Wa^{W}) and non-wattled (Wa^{+}) goats.
2. **Beard:** The goats were scored on the presence (Br^{b}) or absence (Br^{+}) of beards.
3. **Head Profile:** The head shape of the goats were observed and noted as either straight, sub convex (slightly curved outwards) and sub-concave (slightly curved inwards).
4. **Ear Orientation:** Careful observation on the type of ear was made in terms of its orientation. This was noted as erect or droopy.
5. **Presence of Supernumerary Teat:** Observation was carried out on the presence (T^{t}) or absence (T^{+}) of extra teat and scored. The number of additional teat was also noted.
6. **Coat colour:** The coat colour was observed and noted as red, brown, light brown and mixed colours.

3.3.3 **Production Capacity**

The production capacity traits determined include the following.

1. **Body Weight:** The body weight of each lactating goat was taken using a weighing scale and recorded in kilogram.
2. **Litter size:** This refers to the number of kids per kidding. Information was sought on the litter size per doe per herd.
3. **Parity:** Information was sought on the parity of the doe and recorded.

4. **Milk Yield:** Milk production of does that kidded within 7 days at the commencement of this study was monitored for a maximum period of 120 days post partum or until milk yield drops to 100ml/day.

3.4 Milk Collection

Milk was collected twice a week in the morning before the animals were released for grazing. New born kids were allowed to suckle their does freely for the first 6 days post partum to enable them receive colostrum and plenty of milk at this early stage in their life, as is the cultural practice in the farm herds. The night before the sampling days, the kids were separated from their does as this will prevent the kids from sucking before the milk is collected in the morning.

3.5 Milk Measurement

Milk yield was determined twice a week starting on day 7 post partum because herd owners would not allow their stocks to be milked earlier than one week post partum. Milking lasted for a period of 120 days or terminated when milk yield dropped to 100mls. The date of kidding, parity of the does and litter size were recorded.

Milk yield was based on once daily milking of the does in the morning. Kids were separated from their does on the evening proceeding the day of milking until after the test day milking. On the test day, the two halves of the udder of each lactating doe in all the herds were hand milked in the morning before 10am. The milk collected on the test day from each doe was measured using a measuring cylinder calibrated in mls.

Milk yield characteristics of each doe were assessed as follows:

- **Average dailymorning milk yield (ADMY):** The average of all test day yields within 120 days post partum.
- **First test day yield (FTDY):** The milk yield at day 7 post partum.
- **Peak yield (PY):** The highest recorded test day yield within the sampling period.
- **Peak Day (PD):** The day, out of the recorded test days, that had the highest yield.
- **Total Yield (TY):** Milk production over 120 days post partum calculated as $\Sigma i7xi$, where X_i is the estimated average daily yield in week i, i = 1-30.
- **Last test day Yield (LTDY):** Milk yield on day 120 post partum or the day with 100mls.

3.6 DATA COMPUTATION AND STATISTICAL ANALYSIS

The data collected were analyzed using the General Linear Model procedure of SAS (2001) and the significant means were separated by Duncan Multiple Range Test (Steel and Torrie, 1980).

Factors considered include; zone, sex, wattle, beard, head profile, parity, litter size and litter composition. The statistical analysis for body conformation traits was based on the general linear model below:

$$Y_{ijklm} = \mu + Z_{i+} S_j + W_k + B_l + H_m + e_{ijklm}$$

Where; Y_{ijklm} = Measured variable or value of any observation; μ = Overall mean; Z_i = Effect of i^{th} zone; S_j = Effect of j^{th} sex; W_k = Effect of k^{th} wattle; D_l =Effect of l^{th} beard; H_m = Effect of m^{th} head profile; e_{ijklm} = Residual effect/error term.

The relationship between milk production traits and wattle, beard, supernumerary teat, head profile, parity, litter size, litter composition, and zone was determined using the equation:

$$Y_{ijklmnop} = \mu + W_i + B_j + S_k + H_l + P_m + L_n + C_o + Z_p + e_{ijklmnop}$$

Where; $Y_{ijklmnop}$ = measured variable or value of any observation; μ= overall mean; W_i= effect of i^{th} wattle; B_j= effect of j^{th} beard; S_k= effect of k^{th} sex; H_l= effect of l^{th} head profile; P_m= effect of m^{th} parity; L_n= effect of n^{th} litter size ; C_o= effect of o^{th} litter composition ; Z_p= effect of p^{th} zone ; $E_{ijklmnop=}$ residual effect.

Summary statistics for morphometric and lactation traits were determined. Correlation amongst lactation and between body conformation and lactation traits was also carried out (SAS, 2001).

The distributions of the various traits were expressed in percentages. The frequency of the recessive alleles (Wa^+, Br^+ and H_0^+) were estimated using Hardy-Weinberg equilibrium (Falconer and Mackay, 1996) as shown below:

$$q = \sqrt{\frac{m}{M}}$$

Where; q = frequency of the recessive gene.

m= Observed number of animals exhibiting the particular recessive trait.

M = total number of animals sampled

From q above, the frequencies of the dominant alleles (Wa^w, Br^b and H_0^p) were calculated;

$P = 1 - q$

Where; P = Frequency of the particular dominant allele

The observed frequencies were tested against the expected Mendelian ratio of 3:1 corresponding to values of 0.75 for the dominant allele and 0.25 for the recessive allele using Pearson's Chi-square test. The null hypothesis (H_o) is that the population is in Mendelian proportions while the alternative hypothesis (H_a) is that the population is not in Mendelian proportions.

Pearson's chi-square test for goodness of fit states:

$$\text{Chi-square } (\chi^2) = \frac{(\text{Observed freq} - \text{Expected freq})^2}{\text{Expected freq}}$$

The level of significance of the test was examined at $P < 0.05$.

Genetic distance between the locations and coat colour of the goats were estimated at the wattle, beard, horn, head profile and supernumerary teat loci respectively using gene frequencies. The method of Bodmer and Cavalli-Sforza (1976) was adopted as follows:

$d^2 = (P_1 - P_2)^2$

Where; d^2 = genetic distance estimate between the two population

P_1= gene frequency of population 1

P_2 = gene frequency of population 2

CHAPTER FOUR

4.0 RESULTS

4.1 MORPHOLOGICAL TRAITS AND THEIR GENE AND GENOTYPIC FREQUENCIES

4.1.1 The frequency (%) of qualitative traits according to Zone, Coat colour and Sex.

Table 4.1 shows the frequency distribution of qualitative traits of Red Sokoto goats as affected by zone, coat colour and sex. Four colour patterns (Dark Red, Brown, Light Brown and Mixed colour) were observed in the goat population studied. Majority of the goats were brown in colour (46%), followed by light brown (25%), while the dark red (7%) goats were minimal in the studied population. The mixed coloured goats constituted 22% of the population.

The occurrence of wattle was of low frequency (8%) in Red Sokoto goat and this was observed in both sexes. The distribution of wattle in these goats according to colour pattern showed that its occurrence coincided with colour pattern distribution. The occurrence of wattle in these goats decreases as you move from the southern part (Malumfashi 45%) of Katsina State to the drier (Katsina 36%) and arid north (Daura 19%).

Possession of beard in these goats was evident in both sexes. Although this is a male characteristic, a preponderance of the females (65%) possessed it. Its occurrence was evenly spread in accordance with the distribution of goats in the locations and colour patterns studied. The occurrence of horns in the studied population was 100%. Two head profiles were observed (straight 97% and subconvex 3%). The occurrence of the two types of head profile cut across locations, colour pattern and sexes.

Out of the 811 female goats studied, 24% of them expressed supernumerary teat of varying degrees (1, 2 or 3). All the locations had reasonable occurrence of supernumerary teat with it being most frequent in Daura (44%) followed by Malumfashi (34%) and Kastina (22%) in that order. It was majorly exhibited in the dark red (46%) does; with prominence in the brown (23%) and with some significance in the mixed colour (19%) and light brown (12%) does.

TABLE 4.1: Frequency (%) of the qualitative traits of Red Sokoto goats according to zone, coat colour and sex

			FREQUENCY DISTRIBUTION									
			ZONE			COLOUR PATTERN				SEX		
TRAITS	**ALLELES**	**N**	**KAT**	**DAUR**	**MALF**	**B**	**LB**	**DR**	**MIXED**	**M**	**F**	**POLLED**
WATTLE	Wa^{w}	71	0.36	0.19	0.45	0.47	0.22	0.12	0.19	0.14	0.86	8
	Wa^{+}	817	0.33	0.35	0.32	0.46	0.26	0.09	0.21	0.09	0.91	92
BEARD	Br^{b}	170	0.32	0.31	0.37	0.43	0.26	0.06	0.25	0.35	0.65	19
	Br^{+}	718	0.33	0.34	0.32	0.47	0.25	0.08	0.21	0.03	0.97	81
HORN	Ho^{p}	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Ho^{+}	888	0.33	0.34	0.33	0.46	0.25	0.07	0.22	0.09	0.91	100
HP	Hp^{sv}	24	0.56	0.28	0.16	0.36	0.08	0.04	0.52	0.72	0.28	3
	Hp^{st}	864	0.32	0.34	0.34	0.46	0.26	0.07	0.21	0.07	0.93	97
ST	T^{t}	195	0.22	0.44	0.34	0.46	0.23	0.12	0.19			24
	T^{+}	616	0.37	0.29	0.34	0.46	0.26	0.06	0.22			76

Wa^{w} = wattled; Wa^{+} = non wattled; Br^{b}= presence of beard; Br^{+}= absence of beard; Ho^{p} = polled; Ho^{+} = horned; Hp^{st} = straight; Hp^{sv} = Sub-convex; St^{t} = presence of supernumerary teat; St^{+} = absence of supernumerary teat; B=Brown; LB=Light brown; DR= dark red; M=male; F=female; Kat=Katsina; Daur=Daura; Malf=Malumfashi



Plate 4.1: Brown (B)



Plate 4.2: Light Brown (LB)

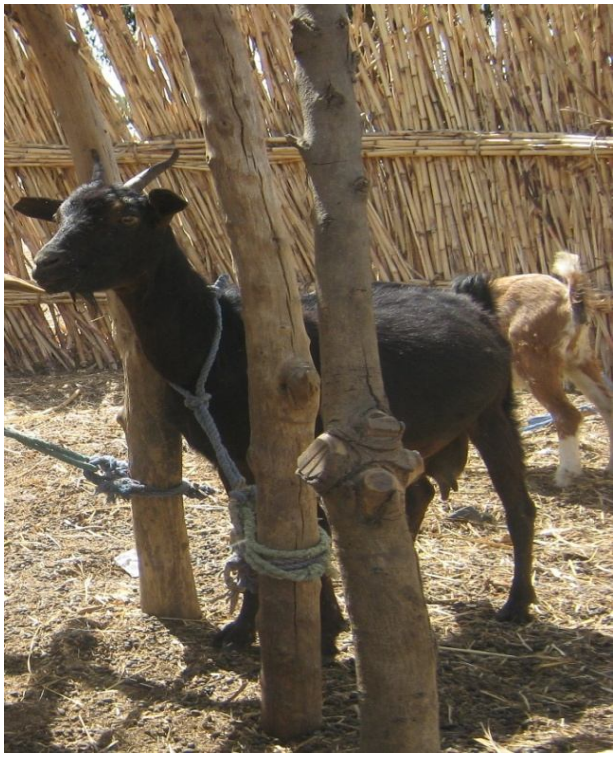


Plate 4.3: Dark Red (DR)



Plate 4.4: Brown and White (BW)



Plate 4.5: Brown with White Spots



Plate 4.6: White with Black Spots



Plate 4.7: Tassel



Plate 4.8: Supernumerary teats

4.1.2 Correlation between Body morphological traits in goats.

The correlated relationships between body morphological traits in Red Sokoto goats are presented in Table 4.2. Wattle was significantly ($P<0.05$) and negatively correlated with beard ($r = -0.12$). Thus, indicating especially in the females, that animals with wattle might be non-beard. Beard had no significant correlation with head profile ($P>0.05$; $r = 0.04$).

4.1.3 Correlations between dam morphological traits in goats

Table 4.3 shows the correlated relationship between dam morphological traits in goats. Litter size was positively and significantly correlated with parity litter composition and beard ($P<0.05$; $P<0.01$; $r = 0.16$-0.54). It appears that the higher the litter sizes the higher the parity of the doe; and the more the tendency for the doe to give birth to mixture of male and female.Does of with more litter size tend to have beard. The relationships of litter size with wattle, supernumerary teat and head profile were not significant ($P>0.05$; $r = -0.09$ to 0.09). Also parity was not significantly correlated with the measured dam morphological traits; except with beard ($P<0.05$; $r = 0.16$). This is an indication that beard in female goats goes with advancement in age and parity. Wattle, beard, supernumerary teat and head profile had no significant ($P>0.05$) relationships between them.

4.1.4 Gene frequencies of the observed qualitative traits in Red sokoto goats.

The gene frequencies of observed qualitative traits in Red Sokoto goats are shown in Table 4.4. Frequencies of the dominant alleles for Red Sokoto goats was 0.04 (Wa^w), 0.11 (Br^b), 0.00 (Ho^p), 0.02 (Hp^{st}) and 0.13 (St^t). These values were quite lower than the expected

Mendelian value of 0.75. However, higher frequencies were observed for the recessive alleles in Red Sokoto goats. The P-valves was highly significant ($p<0.01$).

Table 4.5 shows the gene frequencies of the observed qualitative traits in Red Sokoto goats according to location and coat colour. Frequencies of the dominant allele ranged between 0.02 to 0.06 (Wa^{w}) at the different zone and 0.04 to 0.07 (Wa^{+}) for coat colour. The gene frequencies observed generally for the dominant alleles at zone and for coat colour ranged between 0.00 to 0.12 while higher frequencies (0.89 to 1.00) were recorded for the recessive alleles at the various zone and different coat colours for wattle, beard, horn and head profile. The observed frequencies of supernumerary teat (St^{t}) on Red Sokoto goats was 0.08, 0.18 and 0.13 for katsina, Daura and Malumfashi respectively while that of the coat colour ranged between 0.79 to 0.88. The frequencies observed for the recessive allele for supernumerary teat was higher than those observed in the other traits.

4.1.5 Matrix of genetic distance of Red sokoto goats by zone and coat colour

The estimated genetic distance of Red Sokoto goats between Katsina and Daura were 0.0004, 0.0001, 0.0001 and 0.0001 at the wattle, beard, head profile and supernumerary teat loci, respectively (Table 4.6); and 0.0004. 0.0001, 0.0004 and 0.0025 for Kastina and Malumfashi, while the genetic distance estimated for the qualitative traits in Daura and Malumfashi was 0.0002 (wattle), 0.0004 (beard) and 0.0025 (supernumerary teat).

Table 4.7 shows the matrix of genetic distance of Red Sokoto goats by coat colour. The estimated genetic distance at the beard locus ranges between 0.0001 and 0.0016. At the wattle locus, the estimate observed was 0.0009 for BR and DR; LB and DR and DR and mixed colour patterns. The estimated genetic distance at the head profile locus for BR and

mixed, LB and mixed, DR and mixed was 0.004 while that observed at the supernumerary teat locus ranged between 0.0004 to 0.0081.

TABLE 4.2: Correlation amongst body morphological traits in goats

	WATTLE	BEARD	HEAD PROFILE
WATTLE		-0.12*	0.02 ^{ns}
BEARD			0.04 ^{ns}
HEAD PROFILE			

*= $p<0.05$ (significant); ns= (not significant)

TABLE 4.3: Correlations between dam morphological traits in goats

	LS	PARITY	LG	WATTLE	BEARD	SUP/TEAT	HP
LS		0.54**	0.27**	-0.09 ns	0.16 *	0.09 ns	0.07 ns
PARITY			0.13 ns	-0.04 ns	0.16*	0.06 ns	0.07 ns
LG				0.01 ns	0.08 ns	0.11 ns	0.09 ns
WATTLE					-0.19*	-0.21*	-0.11 ns
BEARD						-0.05 ns	0.02 ns
SUP/TEAT							0.06 ns

*= p< 0.05 (significant): **= p< 0.01 (highly significant); ns= not significant; LS (litter size); LG (litter genotype); Sup.Teat (supernumerary teat); HP (head profile).

TABLE 4.4: Gene frequencies of the observed qualitative traits in Red Sokoto Goats

TRAITS	ALLELES	EXPECTED	OBSERVED	GENE FREQ	P-VALUE	$\chi 2$ TEST
WATTLE	Wa^{W}	222	71	0.04	**	633.63
	Wa^{+}	666	817	0.96		
BEARD	Br^{b}	222	170	0.11	**	343.67
	Br^{+}	666	718	0.89		
HORN	Ho^{p}	222	0	0.00	**	0.00
	Ho^{+}	666	888	1.00		
HEAD PROFILE	Hp^{sv}	222	24	0.02	**	808.79
	Hp^{st}	666	864	0.98		
SUPERNUMERARY TEAT	St^{t}	202.8	195	0.13	**	221.00
	St^{+}	608.2	616	0.87		

Wa^{w} = wattled; Wa^{+} = non wattled; Br^{b}= presence of beard; Br^{+}= absence of beard; Ho^{p} = polled; Ho^{+} = horned; Hp^{st} = straight; Hp^{sv} = Sub-convex; St^{t} = presence of supernumerary teat; St^{+} = absence of supernumerary teat

TABLE 4.5: Gene frequencies of the observed qualitative traits in Red Sokoto goats according to zone and coat colour

			GENE FREQUENCY						
			ZONE			COAT COLOUR			
TRAIT	ALLELES	N	KAT	DAURA	MALF	BR	LB	DR	MIXED
WATTLE	Wa^{w}	71	0.04	0.02	0.06	0.04	0.04	0.07	0.04
	Wa^{+}	817	0.96	0.98	0.94	0.96	0.96	0.93	0.96
BEARD	Br^{b}	170	0.10	0.09	0.11	0.09	0.11	0.08	0.12
	Br^{+}	718	0.90	0.91	0.89	0.91	0.89	0.92	0.88
HORN	Ho^{p}	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ho^{+}	888	1.00	1.00	1.00	1.00	1.00	1.00	1.00
HEAD PROFILE	Hp^{st}	24	0.02	0.01	0.01	0.01	0.01	0.01	0.03
	Hp^{+}	864	0.98	0.99	0.99	0.99	0.99	0.99	0.97
SUP. TEAT	ST^{t}	195	0.08	0.18	0.13	0.13	0.12	0.21	0.12
	ST^{+}	616	0.92	0.82	0.87	0.87	0.88	0.79	0.88

*SUP. TEAT= supernumerary teat; BR (brown); LB (light brown); DR (dark red); Wa^{w} = wattled; Wa^{+} = non wattled; Br^{b}= presence of beard; Br^{+}= absence of beard; Ho^{p} = polled; Ho^{+} = horned; Hp^{st} = straight; Hp^{sv} = Sub-convex; St^{t} = presence of supernumerary teat; St^{+} = absence of supernumerary teat; Kat=Katsina; Malf=Malumfashi

TABLE 4.6: Matrix of genetic distance of Red Sotoko goats by zone

TRAITS	KAT vs DAURA	KAT vs MALF	DAURA vs MALF
WATTLE	0.0004	0.0004	0.0002
BEARD	0.0001	0.0001	0.0004
HORN	-	-	-
HEAD PROFILE	0.0001	0.0001	-
SUPERNUMERARY TEAT	0.001	0.0025	0.0025

Kat=Katsina; Malf=Malumfashi

TABLE 4.7: Matrix of genetic distance of Red Sokoto goats by coat colour

TRAIT	BR vs LB	BR vs DR	BR vs MIXED	LB vs DR	LB vs MIXED	DR vs MIXED
WATTLE	-	0.0009	-	0.0009	-	0.0009
BREAD	0.0004	0.0001	0.0009	0.0009	0.0001	0.0016
HORN	-	-	-	-	-	-
HEAD PROFILE	-	-	0.0004	-	0.0004	0.0004
SUP. TEAT	0.0004	0.0064	0.0004	0.0081	-	0.0081

BR (brown); LB (light brown); DR (dark red).

4.2 CONFORMATION TRAITS AND FACTORS AFFECTING THEM

4.2.1 Summary statistics of morphometric traits of Red Sokoto goats

The summary statistics of morphometric traits of Red Sokoto goats is presented in Table 4.8. The average body weight, body length, heart girth, thoracic depth, height at withers, average ear length and average horn length was 25.3, 53.5, 69.4, 36.0, 58.1, 9.5 and 8.3cm, respectively. The most variable trait was body weight (CV = 25.19%) followed by average ear length (22.7%) and heart girth (22.15%). However, height at withers (11.26%) and thoracic depth (13.28%) were less variable.

The influence of wattle, beard and head profile on body conformation traits is presented in Table 4.9. Wattle had no significant ($P>0.05$) influence on body conformation traits of these goats while beard significantly ($P<0.05$) influenced body length and height at withers but had no significant ($P>0.05$) effect on the other conformation traits. Head profile on the other hand, significantly ($P<0.05$) influenced all the body conformation traits except heart girth. Body length and height at withers were longer and higher for goats that had beard than those without beard by 2.8 and 1.1cm, respectively. Goats that had sub-convex head were superior in body conformation traits compared to the ones that had straight head. The superiority of sub-convex to straight head profile in terms of body weight, body length, thoracic depth, height at withers, ear length, tail length and horn length was 6.4kg, 6.8cm, 3.5cm, 4.4cm, 5.0cm, 3.1cm, and 2.3cm , respectively.

The mean values of body conformation traits according to zone and sex is shown in Table 4.10. Zone had significant ($P<0.05$) influence on all the body conformation traits except on horn length; while Sex of goat had significant ($P<0.05$) influence on the morphometric

traits except on average ear length, tail length and average horn length. The pattern of superiority of the zones in the measured traits was inconsistent. Male goats were superior to female goats in thoracic depth (1.8cm), while the females were superior in body weight (2.1kg), body length (2.4cm), heart girth (2.0cm), and height at withers (2.6cm).

Table 4.11 shows the effect of parity, litter size and litter composition on body conformation traits. Parity significantly ($P < 0.05$) influenced all the body conformation traits measured in the goats. Litter size had a significant influence on body weight (BWT), body length (BLT) and thoracic depth (TD) but had no significant effect on heart girth (HG) and height at withers (HAW). Litter composition had no significant ($P > 0.05$) effect on body conformation traits measured except on BLT ($P < 0.05$). The doe body conformation traits improved with increase in parity up to parity 6. However, increase in conformation traits stabilized for body weight at parity 4; body length at parity 4; heart girth at parity 2, thoracic depth at parity 2 and height at withers at parity 3. Body weight, body length and thoracic depth increased with increase in litter size of the doe. For litter composition of the doe, body length was better for does that gave birth to all males or mixture of males and females.

Table 4.8: Summary Statistics of Morphometric Traits of Red Sokoto goats

Characteristic	N	MEAN(+SE)	CV(%)	MIN	MAX
Body weight (kg)	888	25.3 ±0.40	25.19	16	49.0
Body length (cm)	888	53.5 ±1.04	21.72	32	89.0
Heart girth (cm)	888	69.4 ±0.74	22.15	46.8	72.2
Thoracic depth (cm)	888	36.0 ± 0.35	13.28	26.0	48.0
Height at withers (cm)	888	58.1 ±0.42	11.26	34.6	73.5
Average Ear length(cm)	888	9.5±0.51	22.7	5.0	21.0
Average Horn Length(cm)	888	8.3±0.39	21.2	1.6	22.0

TABLE 4.9: Mean value of body conformation traits according to wattle, beard and head profile.

FACTOR	N	BWT(kg)	BLT(cm)	HG(cm)	TD(cm)	HAW(cm)	AEL(cm)	TL(cm)	AHL(cm)
WATTLE	888	ns	ns	Ns	ns	ns	ns	ns	ns
Wattled	71	25.9	53.9	67.8	36.8	58.3	9.6	8.1	8.2
Non-wattled	817	24.5	53.4	69.5	35.9	58.1	9.7	8.4	8.3
BEARD	888	ns	*	Ns	ns	*	ns	ns	ns
Bearded	170	25.7	54.9[a]	69.7	36.1	58.3[a]	9.7	8.6	8.4
Non bearded	718	24.6	52.1[b]	68.1	36.0	57.2[b]	9.8	7.9	8.0
HEAD PROFILE	888	*	*	Ns	*	*	*	*	*
Straight	864	22.5[b]	53.3[b]	69.3	35.9[b]	57.9[b]	9.5[b]	8.4[b]	8.2[b]
Sub-convex	24	27.9[a]	60.1[a]	70.8	39.4[a]	62.3[a]	14.5[a]	11.5[a]	10.5[a]

*= $p<0.05$ (significant): **= $p<0.01$ (highly significant); ns= not significant); BWT (body weight); BLT (body length); HG (heart girth); TD (thoracic depth); HAW (Height at withers); AEL (average ear length); TL (Tail length); AHL(average horn length)

TABLE 4.10: Mean value of body conformation traits according to zone and sex

FACTOR	N	BWT(kg)	BLT(cm)	HG(cm)	TD(cm)	HAW(cm)	AEL(cm)	TL(cm)	AHL(cm)
ZONE	888	*	*	*	*	*	*	*	ns
Katsina	300	24.1 [b]	54.4 [b]	72.0 [a]	35.5 [b]	58.2 [a]	8.6 [b]	8.1 [b]	8.5
Daura	300	22.8 [c]	47.6 [c]	68.1 [b]	33.9 [c]	57.3 [b]	8.3 [b]	8.2 [b]	8.2
Malumfashi	288	27.1 [a]	58.4 [a]	67.9 [b]	38.7 [a]	58.8 [a]	12.2 [a]	8.7 [a]	8.2
SEX	888	*	*	*	*	*	ns	ns	ns
Male	77	23.7 [b]	53.1 [b]	67.7 [b]	36.2 [a]	55.7 [b]	9.6	8.6	8.2
Female	811	26.8 [a]	55.5 [a]	69.7 [a]	34.4 [b]	58.3 [a]	9.7	8.4	8.4

*= $p<0.05$ (significant): **= $p<0.01$ (highly significant); ns= not significant); BWT (body weight); BLT (body length); HG (heart girth); TD (thoracic depth); HAW (Height at withers); AEL (average ear length); TL (Tail length); AHL(average horn length)

TABLE 4.11: Mean values of body conformation traits according to parity, litter size and litter composition

FACTOR	N	BWT(kg)	BLT(cm)	HG(cm)	TD(cm)	HAW(cm)
PARITY	152	*	*	*	*	*
1	11	20.9 [c]	43.3 [c]	64.3 [b]	32.2 [b]	52.8 [c]
2	31	24.0 [b]	50.3 [bc]	66.3 [ab]	35.4 [a]	57.6 [b]
3	27	24.9 [b]	55.9 [b]	67.0 [ab]	36.0 [a]	58.7 [ab]
4	36	26.1 [ab]	58.4 [a]	70.9 [a]	36.9 [a]	59.9 [ab]
5	8	26.7 [ab]	58.6 [a]	70.8 [a]	37.3 [a]	61.1 [a]
6	39	27.0 [a]	61.4 [a]	70.3 [a]	37.5 [a]	61.8 [a]
LITTER SIZE	152	*	*	ns	*	ns
1	52	27.1 [a]	59.9 [a]	68.1	37.1 [a]	57.1
2	77	25.0 [b]	50.5 [b]	68.5	35.2 [b]	59.1
3	23	23.8 [b]	49.9 [b]	70.2	34.7 [b]	59.0
LITTER COMPOSITION	152	Ns	*	ns	ns	ns
Males	51	26.1	58.4 [a]	68.9	36.4	59.2
Females	58	25.6	53.7 [b]	68.9	35.6	57.4
Mixed	43	24.9	57.2 [ab]	68.0	36.9	58.7

*= $p<0.05$(significant); BWT (body weight); BLT (body length); HG (heart girth); TD (thoracic depth); HAW (Height at withers)

4.3 MILK PRODUCTION TRAITS AND FACTORS AFFECTING THEM

The summary statistics of milk production characteristics of Red Sokoto goats is presented in Table 4.12. The average litter size, parity, first Test day yield(FTDY), average daily morning milk yield(ADMY), peak yield(PY), peak day(PD), last test day yield(LTDY), and total yield for once a day morning milking were 1.72, 3.8, 216.1 mls, 253.1 mls, 375.1mls, 34.8, 105.2 mls, and 25103.4 mls respectively. The milk production characteristics were highly variable (CV=17.74 - 43.5%) except the last test day yield (CV=4.70%) which was less variable.

Table 4.13 shows the mean values of lactation traits of goats according to wattle, beard, supernumerary teat, and head profile. Beard and head profile of the lactating does have no significant effect on their milk production characteristics. However, wattle significantly ($P < 0.05$) influenced the milk production characteristics of the does except its effect on peak day which was non-significant ($P>0.05$). Presence of supernumerary teat had no significant effect on the milk production traits of the does except average daily yield and total yield ($P<0.05$). Wattled goats performed better than non-wattled ones. Lactating does with normal teats had better average daily yield and total yield than the ones with supernumerary teats.

The influence of parity, litter size and litter composition on the lactation traits of goats is presented in Table 4.14. Parity, litter size and litter composition significantly ($P < 0.05$) affected ADMY, PY and TY but they had no significant effect on peak day and LTDY. Parity significantly ($P < 0.05$) influenced FTDY, but litter size and litter composition did not. Increase in parity improved milk production performance of the does up to parity 4

after which performance became inconsistent. The higher the litter size of lactating doe the better their milk production performance. Does that gave birth to mixture of males and females had superior ADMY, PD and TY compared to those with males or females only which were similar in performance.

Table 4.15 shows the mean values of lactation traits of goats as influenced by zone. Zone significantly ($P < 0.05$) influenced the lactation traits measured except for FTDY. Generally lactating does from zone 3(Malumfashi) were superior in lactation performance, followed by the ones in Kastina and finally the Daura zone in that order.

TABLE 4.12: Summary statistics of milk production characteristics of Red Sokoto goats

Characteristics	N	MEAN (+SE)	MODE	CV (%)	MIN	MAX
Litter size	152	1.72 ± 0.06	2.0	37.5	1	3
Parity	152	3.8 ±0.13	6.0	43.5	1	6
First test day yield (mls)	152	216.1 ±2.69	216.0	25.32	100	300
Average daily milk yield (mls)	152	253.1 ±2.59	232.1	22.62	182	339
Peak yield (mls)	152	375.1 ±5.39	350.0	17.74	220	550
Peak day (day)	152	34.8 ±0.60	31.0	21.44	21	63
Last test day yield (mls)	152	105.2 ±0.40	100.0	4.70	100	120
Total Yield(mls)	152	25103.47±	19029.5	18.96	15656.7	38101.6

TABLE 4.13: Mean values of lactation traits of goats according to wattle, beard, supernumerary teat and head profile

FACTOR	**N**	**FTDY**(mls)	**ADMY**(mls)	**PY**(mls)	**PD(day)**	**LTDY**(mls)	**TY**(mls)
WATTLE	152	*	*	*	ns	*	*
Wattled	13	236.8[a]	277.8 [a]	420.0 [a]	37.8	108.2 [a]	27342 [a]
Non-wattled	139	214.3 [b]	250.8 [b]	370.8 [b]	34.6	104.9 [b]	24894 [b]
BEARD	152	ns	Ns	ns	ns	Ns	ns
Beard	50	214.2	252.1	274.59	34.1	104.8	25087.3
Non-beard	102	220.0	255.2	275.96	36.4	106.0	25136.4
SUP. TEAT	152	ns	*	ns	ns	Ns	*
Normal	109	212.9	263.5[a]	272.5	34.2	104.9	26200[a]
One super	21	227.2	251.9 [ab]	273.8	35.7	105.3	25193 [ab]
Two super	22	221.0	248.1 [b]	288.6	37.2	106.6	23490 [b]
HEAD PROFILE	152	ns	Ns	ns	ns	Ns	ns
Straight	142	215.9	253.7	377.5	34.9	105.3	25235
Sub-convex	10	218.1	244.0	340.0	34.3	104.2	23240

*= $p<0.05^{a,b,c}$ means within columns with different superscripts differ significantly; ns(not significant);

FTDY (first test day yield); ADMY (average daily morning milk yield); PY (peak yield); PD (peak day); LTDY (last test day yield); TY (total yield);

TABLE 4.14: Mean values of lactation traits of goats according to parity, litter size and litter composition

Factor	**N**	**FTDY**(mls)	**ADMY**(mls)	**PY**(mls)	**PD**(day)	**LTDY**(mls)	**TY**(mls)
PARITY	152	*	*	*	ns	Ns	*
1	11	194.8^{b}	216.8^{c}	313.0^{c}	32.2	105.3	21476^{c}
2	31	213.9 ^{ab}	244.5^{b}	365.0^{ab}	36.1	105.1	23659 ^{bc}
3	27	219.9 ^{a}	245.9^{b}	396.6^{a}	33.2	105.3	25763^{b}
4	36	221.6^{a}	265.5^{a}	399.3^{a}	33.2	105.4	27524^{a}
5	8	205.5 ^{ab}	265.3^{a}	359.7^{ab}	35.3	104.9	24269^{bc}
6	39	217.7^{ab}	244.9^{b}	336.6^{b}	33.4	105.2	23739^{bc}
LITTER SIZE	152	ns	*	*	ns	Ns	*
1	52	208.5	239.2^{b}	255.1^{b}	34.4	105.1	23517.1^{b}
2	77	215.7	259.8^{a}	284.6^{a}	34.8	105.7	25730.2^{a}
3	23	221.4	265.1^{a}	288.3^{a}	36.1	103.9	26591.6^{a}
LITTER COMPOSITION	152	ns	*	*	ns	Ns	*
Males only	51	218.9	250.9^{b}	369.3^{b}	33.9	105.5	24868.4^{b}
Females only	58	212.2	249.4^{b}	363.2^{b}	35.1	104.9	24098.0^{b}
Mixture	43	218.8	264.8^{a}	397.7^{a}	35.7	105.4	26738.3^{a}

*= $p< 0.05$ ^{a,b,c} : mean within columns with different superscripts differ significantly; ns(not significant); FTDY (first test day yield); ADMY (average daily morning milk yield); PY (peak yield); PD (peak day); LTDY (last test day yield); TY (total yield);

TABLE 4.15: Mean values of lactation traits of goats according to zone.

FACTORS	**N**	**FTDY**(mls)	**ADMY**(mls)	**PY(day)**	**PD**(mls)	**LTDY**(mls)	**TY**(mls)
ZONE	152	Ns	*	*	*	*	*
Katsina	68	213.7	256.5^{ab}	373.9^{ab}	35.5^{a}	106.3^{a}	25182.6^{ab}
Daura	44	218.5	249.9^{b}	364.3^{b}	35.7^{a}	104.3^{ab}	23988.8^{b}
Malumfashi	40	218.8	278.9^{a}	393.7^{a}	32.0^{b}	103.9^{b}	26532.5^{a}

*= P<0.05 ^{a,b} means within columns with different superscripts differ significantly; ns(not significant);

FTDY (first test day yield); ADMY (average daily morning milk yield); PY (peak yield); PD (peak day); LTDY (last test day yield); TY (total yield); LL (lactation length).

4.4 RELATIONSHIP ESTIMATIONS FOR BODY CONFORMATION AND MILK PRODUCTION CHARACTERISTICS

Table 4.16 shows the correlation amongst body conformation traits of goats. All the body conformation traits of Red Sokoto goat were positively and significantly ($P<0.05$; $P < 0.01$) correlated (r=0.09-0.67). The magnitude of the relationship between body weight with heart girth(r=0.67) and thoracic depth (r=0.60) were strong. Other relationships of body weight with Body length, height at withers, ear length and average horn length were moderate (r=0.24-0.41).

The relationships of body length, with heart girth, ear length and average horn length were low (r=0.09-016); while it was moderate with thoracic depth and height at withers (r=0.26-0.42). Heart girth had low correlations with thoracic depth, height at withers and ear length (r=0.11-0.13) but moderate with average horn length (r=0.37). The correlated relationships of thoracic depth with height at withers, ear length and average horn length were moderate (r=0.24-0.53). Height at withers, ear length and average horn length were moderately correlated (r=0.21-0.36).

TABLE 4.16: Correlation amongst body conformation traits of goats

	BLT(cm)	HG(cm)	TD(cm)	HAW(cm)	AEL(cm)	AHL(cm)
BWT(kg)	0.41**	0.67**	0.60**	0.46**	0.24*	0.34**
BLT(cm)		0.15*	0.42**	0.26**	0.09^{ns}	0.16*
HG(cm)			0.11*	0.13**	0.11*	0.37**
TD(cm)				0.53**	0.24*	0.29**
HAW(cm)					0.21*	0.35**
AEL(cm)						0.36**

*= p< 0.05, (significant), ** = p< 0.01 (highly significant); ns=not significant; BWT (body weight); BLT (body length); HG (heart girth); TD (thoracic depth); HAW (Height at withers); AEL (Ear length); AHL (average horn length).

Table 4.17 shows the correlations amongst lactation traits of goats. First test day yield (FTDY) had a positive and significant ($P < 0.05$; $P < 0.01$) correlation with ADMY, PY and TY ($r = 0.19 - 0.36$). Average daily milk yield was positively and significantly correlated with peak yield, peak day, last test day yield and total yield ($P<0.01$; $r=0.24-0.84$). The magnitude of the positive correlation of total yield with peak yield was high ($P<0.01$; $r = 0.76$) while it was moderate with PD and LTDY ($P<0.05$, $r = 0.21 – 0.26$).

The correlation between lactation and body conformation traits in goats is shown in Table 4.18. Body conformation traits of goats had no significant correlation with lactation traits except for ear length which had a negative and significant ($P<0.05$) correlation with lactation peak day ($r = -0.20$).

TABLE 4.17: Correlation amongst lactation traits of goats

	ADMY(mls)	PY(mls)	PD(day)	LTDY(mls)	TY(mls)
FTDY(mls)	0.36**	0.24**	-0.05 ^{ns}	0.03 ^{ns}	0.19 *
ADMY(mls)		0.84**	0.24**	0.33**	0.85**
PY(mls)			0.20*	0.18*	0.76**
PD(day)				0.14 ^{ns}	0.21**
LTDY(mls)					0.26**

*= p< 0.05, (significant), ** = p< 0.01 (highly significant); ns=not significant

FTDY (first test day yield); ADMY (average daily morning milk yield); PY (peak yield); PD (peak day); LTDY (last test day yield); TY (total yield);

TABLE 4.18: Correlation between lactation and body conformation traits in goats

	FTDY(mls)	ADMY(mls)	PY(mls)	PD(day)	LTDY(mls)	TY(mls)
BWT(kg)	0.01 ns	0.07 ns	0.12 ns	-0.12 ns	0.01 ns	0.07 ns
BLT(cm)	0.07 ns	0.09 ns	0.06 ns	0.09 ns	-0.02 ns	0.04 ns
HG(cm)	-0.07 ns	0.12 ns	0.09 ns	0.04 ns	0.05 ns	0.12 ns
TD(cm)	0.04 ns	0.15 ns	0.14 ns	0.05 ns	0.02 ns	0.09 ns
HAW(cm)	0.04 ns	0.02 ns	0.02 ns	-0.04 ns	0.07 ns	-0.12 ns
AEL(cm)	0.07 ns	-0.11 ns	-0.14 ns	-0.20*	-0.02 ns	-0.16 ns
AHL(cm)	0.06 ns	-0.03 ns	-0.14 ns	-0.06 ns	-0.04 ns	-0.06 ns

*= P<0.05, (significant); ns=not significant; FTDY (first test day yield); ADMY (average daily morning milk yield); PY (peak yield); PD (peak day); LTDY (last test day yield); TY (total yield); BWT (body weight); BLT (body length); HG (heart girth); TD (thoracic depth); HAW (Height at withers); EL (Ear length); AHL (average horn length).

CHAPTER FIVE

5.0 DISCUSSION

5.1 MORPHOLOGICAL TRAITS AND THEIR GENE/GENOTYPIC FREQUENCIES

5.1.1 The frequency of qualitative traits of Red Sokoto goats according to location, coat colour and sex.

The brown coloured goats were found to be predominant compared with the light brown goats, while black coated goats were fewer in number. This is in accordance with the report of Yakubu *et al.,* (2010) which revealed that in the Red Sokoto goats; the distribution of goats with red colouration (Phaemelanic Standard pigmentation) was greater than those with either black or chocolate brown colouration (eumelanic standard pigmentation).

The basic coat colours of brown, light brown, dark red and white with its other pattern mixtures were observed by other authors; (Peacock, 1996; Akpa *et al.,* 1998a and Asuku, 2010). Several authors however agreed that goats could have a very vast array of coat colour which could range from black, red, white and brown, and each of these could be spotted, striped, blended shades or facial stripes alone, (Haenlein, 1992; Vanghan *et al.,* 2000; Mileski and Myers, 2004).

Frequency of occurrence of coat colour variations could differ from place to place, however, this depends largely on cross breeding, though in all cases cited by various authors (Peacock 1996; Akpa *et al.,* 1998a; Yakubu *et al.,* 2010 and Asuku, 2010) the brown coat types was the most frequently occurring.

Wattle or tassel was absent in majority of the animals sampled. Only very few goat about 8% had this fold. This is in conformity with the findings of other authors (Yakubu *et al.,* 2010, Asuku, 2010) who recorded low frequencies in the occurrence of wattle in Red Sokoto goats. However, in West African Dwarf (WAD) goats, the wattle condition was reported having a higher frequency (17.16%) while 82.84% was non- wattle (Yakubu *et al.,* 2010). Similarly, Odubote (1994) and Oseni *et al.* (2006) reported frequencies of 69.10 and 64.30% respectively for the wattle gene in WAD goats of the rainforest zone of southern Nigeria.

In this study, relatively low percentage of wattle condition was recorded for male (14%) compared to the female population (86%). Comparatively, there was apparent variation in wattle incidence between the sexes, with the females having an edge over the male goats. The present results obtained on Red Sokoto goats are in conformity with the findings of Yakubu *et al.* (2010).

Possession of beard was evident in both sexes of Red Sokoto goats and this is in-line with the report of Yakubu *et al.* (2010). However, there was sexual dimorphism in its distribution as majority of the males sampled exhibited the trait than females. Yakubu *et al.* (2010) stated that, the sexual difference observed is not unexpected since the occurrence of beard is due to a locus which is dominant in males and recessive in females. It is a secondary sexual characteristic under male hormonal action, thus, females displaying the trait are likely to have threshold levels of androgenic hormone. However, Rodero *et al.* (1996) stated that beard is sex independent.

This study revealed that the presence of horn in Red Sokoto goats was not sex dependent as all the goats studied had horns (100%). This result is in contrast with the report by Rodero *et al.* (1996) who reported that horn presence is sex dependent in Andulasian sheep. The contrast could be as a result of the different species considered. According to Yakubu *et al.* (2010) both sexes of WAD and Red Sokoto goats were horned (100% in each case). However, in sheep, the horn condition only manifested in males, as females were all pooled.

The phenotypic frequency (polled) obtained in Red Sokoto goats is not in agreement with the 75% reported for horn proportions in Twasna goats in Botswana (Katongole *et al.,* 1996) but agree with the 100% stated by Yakubu *et al.*(2010) in Red Sokoto goats in Nigeria. Inter-sexuality, which is a recessive trait associated with the dominant allele for polledness, could be responsible for the non- observation of polled goats in the surveyed agro ecological zones. Odubote (1994), stated that the frequency of polled trait as observed in WAD and Red Sokoto goats should not be taken as zero, but that it tends towards zero.

It was observed that does with the normal two teat conditions were the most prevalent among others and this corroborates the findings of Odubote (1994), Ozoje (2002), Amao *et al.* (2003) and Bemji and Popoola (2011). Bemji and Popoola (2011), reported the highest frequency (92.70%) for the normal two teat condition in West Africa Dwarf goats. Several studies have pointed to the fact that udder and teat characteristics are important determinants of milk yield and ease of milking in dairy animals (Rogers and Spencers, 1991; Peris *et al.,* 1996; De la Fuente *et al.,* 1999). The variations that occur in the expression of supernumerary teat in mature females are the normal two teat condition, occurrence of one extra teat, two extra teats and the occurrence of three extra teats. In a

survey of 500 WAD goats, Ozoje (2002) reported a similar trend that the relative distribution of teats varied; 57% had two teats, 29% had three teats and 15% had four teats. Odubote (1994) observed that the occurrence of supernumerary teats could be attributed to the presence of a recessive mutant allele which presents this characteristic feature in the homozygous state.

5.1.2 Gene frequencies of the observed qualitative traits in Red Sokoto goats.

The result on the low gene frequency occurrence of the qualitative traits agrees with the findings of Yakubu *et al.* (2010) on the low occurrence of beardedness, polledness and wattle gene. The result also agrees with that of Odubote (1994) and Adedeji *et al.* (2006) on the low occurrence of beardedness and polledness, but contradicts their submission on the high incidence of wattle gene. Moreso, the present finding on wattle occurrence is inconsistent with the earlier work of Ozoje and Kadri (2001) where the gene for wattle was estimated to have frequency of 0.39. This could be as a result of different number of goats used in both studies.

Genetic distance makes it possible to evaluate the degree of genetic similarity between two populations by measuring the probability of one or more characters appearing in one of the populations but not in the other (Sournia, 1991). The minuscule values obtained at the wattle and beard locus of Red Sokoto goats were similar to that obtained by Yakubu *et al,* (2010) and are indications of phylogenetic relationship between the three locations and coat colour studied.

5.2 Conformation traits and factors affecting them.

The coefficient of variability (CV) gives an indication of the variation present for a trait and allows comparisons in terms of variations between traits that are measured on different units of scale. The high CV observed in the body conformation traits maybe due to the great individual variability present in the morphological traits of the animals sampled. This is especially true for body weight which is a good parameter for meat characteristics, as larger sized animals produce more meat (Abegaz and Awgichew, 2009). The high variability of body weight and heart girth indicates the possibility for improving these traits through careful selection. Hassan and Ciroma (1990), Akpa *et al.* (1998a) and Asuku, (2010) also reported body weight to be highly variable.

The average body weight of 25.3kg agrees with the range of 16-30kg reported by Hassan and Ciroma (1990) for both males and females from ages 1-5 years for Red Sokoto goats. However, Osuhor *et al.* (2002) gave a range of 20-40 kg for both males and females in Red Sokoto goats. Hassan and Ciroma (1990) also reported height at withers (HAW) of 56-67cm and Ngere *et al.* (1984) reported mean HAW for Red Sokoto goats as 58.2cm. The average result of 58.1 cm gotten in this study falls within this range. Asuku (2010) gave a value of 57.7 cm for height at withers while Attah *et al.* (2004) gave a value of about 49 cm for males and 47 cm for female. The mean heart girth of 69.4 cm falls within the range of 61 – 76 cm reported by Hassan and Ciroma (1990). However, Asuku (2010) reported a mean hearth girth of 65.0 cm while Akpa *et al.* (1998a) reported a range of 44.6 – 70.7 cm which corresponds with the value obtained in this study. Hassan and Ciroma (1990) reported body length ranging from 79 -97 cm for Red Sokoto goats. However, the average body length recorded in this study was 53.3 cm which falls within the range of 36.7 – 63.3

cm reported by Akpa *et al.* (1998a). The shorter body length obtained in this study which compared to the results obtained by Hassan and Ciroma (1990) could be due to the fact that larger numbers of animals were used in this study and majority of them were females compared to more males and fewer number of animals used by Hassan and Ciroma (1990).

5.2.1 Mean values of body conformation traits according to wattle, beard, and head profile

The incidence of wattles (tassels) was low and had no significant effect on any of the body conformation traits measured, this agree with the report of Asuku (2010) who observed low incidence of tassels in Red Sokoto goats. However, Ozoje and Kadri (2001) reported that wattle genes significantly influenced body length, heart girth, height at withers, shoulder width, tail length, abdominal circumference, leg length and heart depth in WAD sheep. They concluded that, presence of wattles meant longer body lengths, greater heart girth, height at withers, shoulder width and all other body parameter. Odubote (1994) and Oseni *et al.,* (2006) had also earlier reported high frequencies of the tasseled or wattled condition in WAD goats in the southern parts of Nigeria. Yakubu *et al.* (2010) also recorded a substantial frequency of occurrence for tassels in WAD goats. None of the aforementioned authors however, carried out any research to find existing relationships if any of the tasseled or wattled condition on body morphometric traits. This diversity or phenotypic differentiation amongst Red Sokoto goats, WAD goats and all other breeds might not be unrelated with territorial distribution and the historical and cultural context. Flock movements and tradition livestock exchange might have affected wattle occurrence, a major gene already implicated in thermoregulation (Odubote, 1994).

Beard had a significant effect on body length and height at withers. Goats with beard had longer body length and grew taller than goats without beard while goats with biconvex head were superior to those with straight head in all the body conformation traits measured. However, little or no literature is available which likens beard and head profile with body conformation characteristics.

5.2.2 Mean values of body conformation traits according to zone and sex.

Zone had a significant effect on all the body conformation characteristics measured. This could be attributed mainly to variations in nutrition and management practices carried out on each herd in the different zones sampled.

The effect of sex on body morphometric trait was significant. Female goats were superior to males. The result obtained in this study is similar to that reported by Asuku (2010). Fajemilehin and Salako (2008) revealed that sex is an important source of variation for body weight and body linear measurements of goats. They linked this effect to the presence or absence of androgenic hormones in both sexes. According to Ojedapo, *et al.* (2007) sex had a significant effect on body weight and some linear body measurements. Akpa *et al.* (1998a) also reported a significant effect of sex on body measurements of Red Sokoto goats; bucks weighed heavier and had wider heart girth than does while the does had longer body length and higher height at withers. In an ideal situation, a fully matured buck of similar age to a doe weighs more. Osuhor *et al.* (2002) reported heavier weights for adult bucks than does. The females weighing heavier than males in this study could be as a result of small population of males sampled, the owners of each herd do sell majority of their bucks at yearling leaving behind only one or two bucks to service the females. As a result,

more does (female) than bucks (males) were available for the study. This could also be because farmers will want to keep female goats in preference to males to cut feeding cost and to increase production efficiency.

Negative selection could be another possibility where bigger males are sold or consumed. Fajemilehin and Salako (2008) reported that in the forest deciduous zone of south western Nigeria, goat farmers kept more females than male goats because majority of the males are preferably castrated or fattened for sale as meat and source of income to the owners in time of financial crisis before celebrating their first or second birthday. Ojedapo *et al.* (2007) had greater number of female WAD goats sampled and attributed it to the fact that majority of the males were usually sold as yearling. However, Hassan and Ciroma (1990); Mohammad *et al.* (2006); Akpa *et al.* (2009) all had equal or greater numbers of male goats in their studies. In all cases, however, the animals sampled were either from research institutes, business farms or small holder herds.

5.2.3 Mean values of body conformation traits according to parity, litter size and litter composition.

In this study, dam parity exerted significant influence on body weight up to the 6^{th} parity. This is in line with the report of other authors like Osinowo *et al.* (1999) and Awemu *et al.* (1999), who also reported increase in body weight with parity up to the 6^{th} parity. However, Alphonsus *et al.* (2010) reported an increase in body weight up to the 5^{th} parity which declined subsequently. The difference in parity might be due to variation in breeds and management. Awemu *et al* (1999) reported significant effect of parity on birth weight and body weight of lambs and kids. However, full reproductive capacity is not attained in any species at the first reproductive circle (Lavasseur and Thibault, 1980), thus as parity

increases, does are expected to give birth to heavier kids. Therefore, available information on the parity level at which full reproductive efficiency is attained will help a lot in culling programme for dams of advanced parity.

The significant effect of parity on linear body measurements was similar to the findings of Alphonsus *et al.* (2010) but contrary to the findings of Alade *et al.* (2008) who reported non significant effect of parity on heart girth at various ages of WAD kids. Also, Akpa *et al.* (2006) observed non significant effect of parity on HAW, dorsal length and hearth girth of Yankasa sheep.

5.3 Milk production traits and factors affecting them.

The mean litter size of 1.72 obtained in this study is similar to 1.74 reported by Iyiola – Tunji *et al.* (2008) and Akpa *et al.* (2004) in the same breed but higher than 1.6 reported by Akpa *et al.* (2005) and the range of 1.5 to 1.7 reported by Adu *et al.* (1979) in Red Sokoto goats. The differences in the average litter size in these studies may be attributed to environmental differences, nutrition as well as managerial factors involved in the different studies.

Goat keeping and production are profitable activities and it is known that increasing prolificacy is one of the factors that determine the profitability. The litter size in this study ranged from 1 to 3. This is consistent with the report of Akpa *et al.* (2010) and Amoa and Gelaye, (1990) but lower than the 1-4 reported by Amoah *et al.* (1996).

The average daily morning milk yield (ADMY) of 254.1g in this study was comparable to the twice daily milking of 466.9g reported by Akpa *et al.,* (2003) and range of 450-550g reported by Nuru (1985) but different from twice daily milking of 664g reported by Akpa

(1999a) for agropastoral Red Sokoto goat in Zaria. The observed differences could be as a result of once daily partial morning milking carried out in this study while the other authors milked twice a day in their studies. Another factor could be due to differences in management of the goats, (some of the studies were carried out under institutional management which is basically semi-intensive in nature) while this report was based on the performance of Red Sokoto goats under agro-pastoral Fulani system of management which involved herding the animals for pasture during the day, kraalling them at night with some level of feed supplementation. Morand-fehr *et al.* (1982) stated that within genetic limits, nutrition during lactation is the primary factor that influences milk yield.

Available reports on the milking of indigenous African goats indicate that not much is known about their dairy characteristics. From such reports, lactation milk yield ranges between 24 and 120.3 kg and the peak week from 2 to 6 weeks; with the highest peak yield of 850g observed in Red Sokoto goats of Nigeria (Egwu *et al.,* 1995, Ruvuna *et al.,* 1995, Akpa, 1999).

Peak milk production of Red Sokoto goats was observed in the fourth week of lactation and this corresponds with the report of Akpa *et al.* (2003). Variable peaks of lactation have been obtained in various studies. Zahraddeen *et al.* (2000) reported peak milk yield in the third week, Butswat *et al.* (2002) reported peak milk yield in the fourth week in Red Sokoto goats. James and Osinowo (2004) reported that West African does attained peak milk yield in the third week of lactation and Red Sokoto goats in the second week. Variations in peak week could be attributed to environmental and nutritional factors.

5.3.1 Effect of wattle, supernumerary teat, parity, litter size and zone on lactation traits.

Wattled does produced more milk than non wattled does. Supernumerary teat had a significant effect on average daily yield and total yield of Red Sokoto goats in this study. Does with extra one or two teats produced less milk compared to does that had two normal teats. This result is in contrast with report of Osuagwuh (1985) who observed that supernumerary teats do not affect milk yield of the animal nor prevent kids from suckling. However, they present a problem when abnormally large and do not deliver milk to the kids leading to emaciation and death.

Milk yield was significantly influenced by parity. The parameter increased progressively up to the 4th parity and declined subsequently. This disagree with the observations of Zahraddeen *et al.,* (2009) and Butswat *et al.,* (2002) that milk yield of Red Sokoto goats increased significantly up to the third parity and declined subsequently. This difference could be attributed to nutrition. The observed lowest yield in the first parity and the apparent highest yield in the fourth parity disagree with previous reports by Julio (1991); Zeng and Escobar, (1995); Akpa *et al.* (2002) who observed highest yield in the second and third parity but corresponds with the lowest yield observed in the first parity. The significant effect of parity on milk yield characteristics observed in Red Sokoto goats have been reported in other breeds of goats (Kaka and Prakash, 1990; Salah *et al.,* 1991).

The significant effect of litter size on milk yield characteristics observed in Red Sokoto goats agree with the report of Akpa *et al* (2002) who concluded that does with two or more kids produce more milk than does with single kid. The trend towards increased production

of milk with increased litter size agree with previous observations that goats with multiple kids produce more milk than goats with single kids (Rabasco *et al.,* 1993; Browning *et al.,* 1995; Zygoyiannis, 1994). The differences in milk yield due to litter size could probably be attributed to the extra pressure or stimulation on the mammary gland as a result of the additional suckling of the second and third kid. Rai and Chorey (1965) stated that the increased milk yield arising from multiple births depends on the number of kids suckled and not on the number born.

The effect of zone on milk yield characteristics of Red Sokoto goats was significant. Akpa *et al.* (2002) concluded that, the effect of herd on the milk yield characteristics of Red Sokoto goats was significant and variable. The zone and herd effect maybe attributed mainly to variations in nutrition and management and only to some extent to the strain of does. Waheed *et al.* (1977) studied the feeding and management effects on herd differences in milk yield and observed that difference among herds accounted for 27% to 37% of the total variation in milk yield.

5.4 RELATION ESTIMATIONS FOR BODY CONFORMATION AND MILK PRODUCTION TRAITS.

A high and significant correlation was observed between the body conformation traits of goats. This result concurs with Eugena, (2010) who reported that the high positive correlation values indicates that as live body weight increases, the linear body measurements will also increase. Adewumi *et al.* (2006) stated that the implication of this is that the traits (body weight and linear measurements) could be selected for at the same time. The result from this study is also in agreement with the report of Raymond *et al.* (1987), which relates that, high correlation indicates that the total size of the animal is a

function of both the length and body circumference. Attah *et al.* (2004) reported from their study that measurements such as chest girth, height at withers were at one stage or the other found to be highly correlated with body weight. Also, Mohammed *et al.* (2006) and Ojedapo *et al.(*2007) reported a high and positive correlation between body length and body weight in adult Beetel goats and West African dwarf goats respectively. Akpa *et al.* (2009) also reported similar associations for body length and body weight in Red Sokoto goats.

Majority of milk yield characteristics in Red Sokoto goats were positively correlated and this agree with the report of Akpa *et al.* (2002). Therefore, selection to improve any one of these traits might lead to an improvement in the others. The interrelationships between first test day yield, average daily yield, total yield, peak yield and last test day yield, which were positive, indicate that all these variables measure the milking capacity of the goats. Positive relationship between milk yield characteristics have also been reported by Mittal (1979).

CHAPTER SIX

6.1 SUMMARY

A total of 888 Red Sokoto goats were used to characterize the goats in this study; out of which 152 lactating does were used to determine milk production characteristics of Red Sokoto goats. The brown coloured goats were predominant in this study. Wattle occurred in very low frequencies. There was sexual dimorphism in the distribution of beards as most of the males sampled exhibited the trait than females. Presence of horn was not sex dependent as all the goats studied had horns. The frequency of occurrence of supernumerary teat in Red Sokoto goat is low; does with the two normal teats were the most prevalent.

The gene frequency of the qualitative traits was low and the genetic distance of these traits showed minuscule values at their various loci. Physical characteristics which could serve as indicators for production performance were assessed in relation to body conformation traits, presence or absence of wattle had no effect on body conformation traits. Beard had a significant effect on body length and height at withers. Zone and sex significantly influenced the morphometric traits measured.

Mean litter size of 1.72 was obtained in this study, high incidence of multiple birth in Red Sokoto goats indicate it to be a prolific breed when provided with adequate nutrition. Available reports on the milking of indigenous African goats indicate that not much is known about their dairy characteristics.

The following parameters (wattle, supernumerary teats, parity, litter size and zone) which could serve as indicators for production performance were assessed in relation to milk

production traits; the presence of wattle had a significant effect on lactation traits. It was also observed that presence of supernumerary teats had a significant effect on some of the milk characteristics likewise parity, litter size and zone.

A high and significant correlation existed between the body conformation traits, similarly, majority of milk yield characteristics in Red Sokoto goats were positively correlated. Therefore, selection to improve any one of these traits might lead to an improvement in the other traits.

6.2 CONCLUSION

This study has shown that the dominant alleles in Red Sokoto goats were found to segregate at lower frequencies for wattle (0.04), beard (0.11), horn (0.00), headprofile (0.02) and supernumerary teats (0.13). Estimates of genetic distance showed the closeness of Red Sokoto goats within the three zones and the observed coat colours at the wattle, beard, head profile and supernumerary teat loci. The occurrence of wattle in both sexes was low and 24% of female goats had supernumerary teat. Does of higher parity in the herd tend to be beard while wattled does tend to be non- bearded and have no supernumerary teat. Goats with beard had longer body and grew taller; also beard in female goats goes with advanced age and parity. Litter size increased with parity; the more the litter size the more mixed the birth type, and does with higher litter size tend to be beard.

Presence of wattle had no influence on body conformation traits of Red Sokoto goats but increased total milk yield of lactating does. Goats with normal two teats produced more milk than those with extra teats. Zone, sex, parity and litter size influenced body conformation traits of goats. Increase in parity improved milk production up to the 4^{th}

parity and body conformation traits. Increase in litter size increased milk production of Red Sokoto goats. From this study, zone influenced milk yield characteristics of goats. The variation existing in milk yield of Red Sokoto goats is an indication that their dairy potentials are largely unimproved, which could be done through selection and better management practices.

The significant effect of parity on body weight and linear body measurements in this study therefore, indicates that parity of dam is an important factor to consider in making appropriate selection and/or culling decision on Red Sokoto goats. It is also an important factor in any breeding programme aimed at improving performance of the goat.

6.3 RECOMMENDATION

- ✓ Further research should be carried out on the various indigenous breeds of goats to determine the genetic distance existing between them.
- ✓ Effort should be intensified to preserve in particular, the wattle gene which has been implicated with higher milk production in RSG.
- ✓ Selection should also be geared towards specific coat colours.
- ✓ Effort should be made to select against supernumerary teats in Red Sokoto goats since its presence is associated with poor performance especially with milk production
- ✓ The relationship between qualitative traits and body measurement need to be verified with a larger population of goats, as this could possibly help in selection of productive goats.

- ✓ Large sample size should be used when comparing frequencies of genes. Larger sample size is also helpful when investigating traits or physical characteristics that are not so common such as supernumerary teats and wattle. Large sample sizes will remove bias and a tendency for results to skew towards one direction.

6.3 MAJOR FINDINGS

- ✓ Qualitative traits had a low gene frequency of occurrence.
- ✓ Goats with beard had longer body length and grew taller.
- ✓ Goats that had normal two teats produced more milk than those with extra teat.
- ✓ Wattle significantly increased milk yield of Red Sokoto goats
- ✓ Zone influenced milk yield characteristics of Red Sokoto goats.
- ✓ Milk yield of does increased up to the 4^{th} parity.

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