RELATIONSHIP OF HAEMOGLOBIN AND POTASSIUM POLYMORPHISM WITH CONFORMATION, MILK PRODUCTION AND BLOOD BIOCHEMICAL PROFILES IN AGROPASTORAL GOAT

BY

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DEPARTMENT OF ANIMAL SCIENCE

FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY

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A DISSERTATION SUBMITTED TO THE POSTGRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE

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ZARIA, NIGERIA

2012

DECLARATION

I declare that the work in the Dissertation entitled **"Relationship of Haemoglobin and Potassium Polymorphism with Conformation, Milk Production and Blood Biochemical Profiles in Agropastoral Goat"** has been performed by me in the Department of Animal Science under the supervision of Professor G.N. Akpa, Professor B. I. Nwagu and Professor I. A. Adeyinka. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Dissertation was previously presented for another degree or diploma at any University.

Sam, Idorenyin Meme

_____	_____	_____
Name of Student	**Signature**	**Date**

CERTIFICATION

This Dissertation entitled Relationship of Haemoglobin and Potassium Polymorphism with Conformation, Milk Production and Blood Biochemical Profiles in Agropastoral Goat by Sam, Idorenyin Meme, meets the regulations governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to the memory of my Father, Late Elder M.E. Effanga , for his love and care during the formative stages of my life, and to my husband, Mr Meme Sam, whose determination to train me to higher degree has greatly transformed my life.

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ABSTRACT

The dairy characteristics of small-holder agropastoral goats were evaluated using records obtained from a total of 250 does at Jigawa and Katsina States over a period of one year. The data collected included milk yield, udder characteristics, body conformation traits, blood metabolites profile, haemoglobin and potassium gene and genotypic frequencies. The potential of using these polymorphic genes and coat colour variations as markers for milk yield was also determined. The effects of location, parity and breed on milk yield, udder and conformation traits were also evaluated. The data obtained in this work were analysed using General Linear Model of SAS. The results show that total milk offtake was 29.35kg, average daily yield 248.22g, initial yield 243.57g, peak day 33.04 days, peak yield 358.72g, lactation length 118.26days and last test day yield 100.68g. The milk yield characteristics, udder and body conformation traits were significantly ($P< 0.05$) influenced by age, parity, coat colour and breed. The correlations amongst milk yield characteristics were significantly positive ($P<0.01$-0.05; $r=0.005$-0.926). The average udder characteristics were; udder Height (UH) 12.39cm, udder circumference (UC) 31.86cm, distance between teat (DT) 8.76cm, teat length (TL) 3.52 and teat circumference (TC) 5.00cm. The correlations between udder and milk yield characteristics were positive and ranged from moderate to high (($P<0.01$-0.05; $r =0.07$-0.52). The means of the conformation traits were: body weight (BWT), 28.83kg; stature (ST), 65.43cm; Body depth (BD), 79.04cm; Height at withers (HW), 60.82cm; Heart girth (HG), 69.83cm; and Body length (BL), 60.68cm. The correlation between body conformation traits with milk yield characteristics were low to moderate ($P<0.01$-0.05; $r = 0.01$-0.39). Two haemoglobin variants HbA and HbB with three genotypes were identified, HbAA, HbAB and HbBB, Gene frequencies were 0.683 and 0.316 for HbA and HbB, respectively while their genotypic frequencies were 0.467, 0.431 and 0.099 for

HbAA, HbAB and HbBB, respectively. Two potassium types were identified HK and LK, their gene frequencies were 0.844 and 0.156; their genotypic frequencies were 0.91 and 0.01 for HK and LK, respectively. Milk production traits varied significantly ($P< 0.05$) with Hb-types. HbAA and HbAB were superior on ADY and PY to HbBB. Potassium types had no significant ($P>0.05$) influence on milk yield characteristics. Hb-types significantly ($P<0.05$) influenced packed cell volume (PCV) and Haemoglobin concentration (HB) in the blood while K-types significantly ($p<0.05$) influenced Na concentration. The mean values of blood biochemical profiles were 28.47% PCV, 9.49g/dl HB, 136.40mmol/l Na, 64.44g/L Total protein, 31.12 g/L Albumin, 33.12 g/L globulin and 4.44 g/L glucose. Animals with combination of haemoglobin AA, and high potassium (HK) with brown/white coat colour (AAHKBW) were superior in most of the milk production characteristics, while those with combination of HbAA, HK and white coat colours (AAHKW) were superior to other combinations in body conformation traits. It was concluded that the high preponderance of allele HbA and HK in the study area suggests that these alleles are favoured by natural selection in North West zone of Nigeria and should be explored as indirect selection criteria for milk yield characteristics in goats.

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ABBREVIATION

AABB	Combination of HbAA and Brown/Black Colour
AABW	Combination of HbAA and Brown/White Colour
AADB	Combination of HbAA and Dark Brown Colour
AAHK	Combination of HbAA and HK
AAHKBW	Combination of Hb-AA, HK-Type and Brown/White Coat Colours
AAHKDB	Combination of Hb-AA, HK-Type and Dark Brown Colours
AAHKW	Combination of Hb-AA, HK-Type and White Coat Colours
AALK	Combination of HbAA and LK
AAW	Combination of HbAA and white Colour
ABBB	Combination of HbAB and Brown/Black Colour
ABBW	Combination of HbAB and Brown/White Colour
ABDB	Combination of HbAA and Dark Brown Colour
ABHK	Combination of HbAB and HK
ABHKBW	Combination of Hb-AB, HK-Type and Brown/White Coat Colours
ABHKDB	Combination of Hb-AA, HK-Type and Dark Brown Coat Colours
ABHKW	Combination of Hb-AB, HK-Type and White Coat Colours
ABLB	Combination of HbAB and Light Brown Colour
ABLK	Combination of HbAB and LK
ABW	Combination of HbAB and White Colour
ADY	Average Daily Yield
AI	Artificial Insemination

BBBW	Combination of HbAA and Brown/White Colour
BBDB	Combination of HbBB and Dark Brown Colour
BBHK	Combination of HbBB and HK
BBHKBW	Combination of Hb-BB, HK-Type and Brown/White Coat Colours
BBHKDB	Combination of Hb-BB, HK-Type and White Coat Colours
BBLB	Combination of HbBB and Light Brown Colour
BBLK	Combination of HbBB and LK
BBW	Combination of HbBB and White Colour
BD	Body Depth
BL	Body Length
BB	Brown/Black
BW	Brown/White
BW	Bornu White
BWT	Body Weight
CC	Coat Colour
Cmbs	Combinations
CRS	Crosses
CV	Coefficient of Variation
DNA	Deoxyribonucleic acid
DT	Distance between Teats

FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Statistics
ft	Foot
g	Gramms
g/l	Grammes/Litre
GLM	General Linear Model
HbAA	Haemoglobin Genotype AA
HbAB	Haemoglobin Genotype AB
HbBB	Haemoglobin Genotype BB
Hb-CC	Combination of Haemoglobin Type and Coat Colour Variations
HB	Haemoglobin Concentration
Hb-K Type	Combination of Haemoglobin and Potassium Types
Hb-K-CC Type	Combination of Haemoglobin Type, Potassium Type and Coat Colour Variations
Hb-Type	Haemoglobin Type
HG	Heart Girth
HK	High Potassium
HKBB	Combination of HK and Brown/Black Colour

HKBW	Combination of HK and Brown/White Colour
HKDB	Combination of HK and Dark Brown Colour
HKLB	Combination of HK and Light Brown Colour
HKW	Combination of HK and White Colour
HW	Height at Withers
IFPRI	International Food Policy Research Institute
IY	Initial Yield
KB	Kano Brown
Kg	Kilogramme
K^H	High Potassium Allele
K^L	Low Potassium Allele
K-Type	Potassium Type
L	Litre
LDY	Last Day Yield
Light Brn	Light Brown
LK	Low Potassium
LKBW	Combination of LK and Brown/White Colour
LKDB	Combination of LK and Dark Brown Colour
LKW	Combination of LK and White Colour

LL	Lactation Length
LMY	Lactation Milk Yield
LOS	Level of Significant
MAS	Marker Assisted Selection
MAX	Maximum
MIN	Minimum
Ml	Mililitre
Mmol/L	Milimoles/Litre
MOET	Multiple Ovulation Embryo Transfer
MT	Metric Ton
NA	Not Available
Na	Sodium
Ns	Not Significant
Obs	Observation
PCV	Packed Cell Volume
PD	Peak Day
PPRV	Peste Des Petits Ruminant's Virus
PY	Peak Yield

RS	Sokoto Red
SAS	Statistical Analysis System
Se	Standard Error
ST	Stature
TC	Teat Circumference
TL	Teat Length
TP	Total Protein
TY	Total Yield
UC	Udder Circumference
UH	Udder Height
Vs	Versus
WAD	West African Dwarf

CHAPTER ONE

1.0 INTRODUCTION

Nigeria is endowed with large numbers of small ruminants which are yet to be fully investigated for milk production. Goats are the largest in number among ruminant livestock, totaling about 53.8 million (FAOSTAT, 2008). Goats are predominantly owned by the rural households and ownership is spread across all human age groups and sexes (Akpa, 1999). Goats form the most important group of milk producing animals after dairy cattle in both temperate and tropical agriculture. The dairy goat industry is rapidly gaining importance throughout the world (Bogoro *et al*., 1999).

More than any other mammalian farm animal, the goat is the main supplier of dairy and meat products for rural people, especially in developing countries. As a dairy producer, the goat can accomplish one of the three aspects of the demand for goat milk. The first one is home consumption. This demand is increasing because of the growing populations of people, and here the old saying of the "goat being the cow of the poor people" is quite fitting. The second aspect of the demand for goat milk is the special interest in goat milk products, especially cheese and yoghurt, in many developed countries. The third aspect of the demand for goat milk derives from the affliction of people with cow milk allergies and other gastro-intestinal ailments. These two latter aspects of the demand for goat milk are quite different from the "goat being the cow of the poor people"; here, goat milk is wanted or even needed by people of all income levels (Haenlein, 2004).

Poor health and productivity arising from malnutrition in developing countries like Nigeria are well known problems (IFPRI, 1994). It has been reported that protein malnutrition problem

persisting in developing countries could be largely mitigated using small ruminants for both meat and milk production (Freund, 2000). Therefore, taking advantage of the genetic diversity of the indigenous goats, it would be possible to improve the milk production potential of the indigenous goats through selection.

Genetic variations among the small ruminant varieties that are indigenous to Nigeria have been the focus of 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 (Salako *et al*., 2007; Akpa *et al*., 2011). Advances in the field of biotechnology have led to introduction of techniques such as routine electrophoresis employed for the detection of polymorphism at protein and enzyme loci as well as other serological and immunogenetic procedure for measurement of variation (Salako *et al*., 2007) . Information from this type of study could be useful as genetic markers for important economic characters and diseases and could aid significantly in selection of superior animals for breeding purposes. Research and reports on Nigeria indigenous goats based on molecular standpoint are limited.

Blood parameters have been widely used to determine genetic diversity in animal population. The concentration of metabolites in animal blood is an important indicator associated with production. (Casasus *et al.,* 2002). The development of different traits in animals depends on the good order of a complex of biochemical processes each of them functioning under a rigorous genetic control (Mariana *et al*., 2006).

Haemoglobin, an important erythrocyte protein inherited by co dominance in Mendelian fashion has been reported to be a useful marker through which many economic traits, with which it is associated, have been improved in farm animals (Akinyemi and salako 2010). Potassium is one of the intracellular elements which constitute the structure of an organism. Its main function is to

regulate intracellular density of cells (Ellory and Tucker, 1970). In ruminant, there are two potassium types, high Potassium (HK) and low potassium (LK). The low Potassium is dominant to the (HK) type. The HK and LK allele gene frequencies are different among goat breeds (Pembeci, 1978); and potassium types have been proved to be genetically controlled (Al-Samarrae and Younis, 2011).

Haemoglobin and potassium types can be determined easily at postnatal period of young animals and these components are not affected by environmental factors (Gurcan *et al*., 2010). Many studies have been conducted using different sheep and goat breeds to determine the level of various blood parameters and to evaluate the any relationship between blood biochemical polymorphism and production traits (Gonzales *et al*., 1984; Soysal and Ulku, 1998; Shahrbabak *et al*., 2009; Gurcan *et al.,* 2010; Akinyemi and Salako 2010). These associations have been utilized as a polymorphic marker among domestic animals.

Coat colour of animals is very important to a characteristic that allows easy differentiation among individuals and breeds by farmers. Coat colours allow one to differentiate among individuals within the same breed in terms of intensity, patterns and amount of each colours (Becerril *et al*., 1994). Coat colour has been shown to be related to productivity, because the ability of an animal to eliminate excessive body heat to its surrounding environment depends on morphological characteristics of hair coat colours (Maia *et al*., 2005; Mustafa *et al.*, 2011).

Body measurements are related to milk yield either genetically or phenotypically and could be a useful tool for predicting milk production (Waheed and Khan, 2011). Body measurements are important tools for phenotypic description, these measurements include body length, height at withers, body depth, rump height (Hassan and Ciroma, 1990). Relationship between live weight

and body measurement has been reported in some Nigerian breed (Hassan and Ciroma, 1990; Akinyemi and Salako, 2010; Abubakar, 2009; Ibrahim, 2010).

Although some goat breeding programmes are available in Nigeria, they are mostly centralized and limited to Research institutes without major effect on the larger goat base population. Given the ever growing human population, particularly in the urban areas of Nigeria, the concurrent demand for animal protein is ever increasing. In these over-populated urban areas, the shortage of adequate grazing and the relatively high maintenance costs of cattle, makes goat farming an alternative for milk production.

1.1 Problem Statement

Nigeria's population has grown over the years to about 170 million . The average protein intake has remained inadequate protein. The indigenous breed of goat can be improved through proper breeding and selection to increase dairy product supplies, to supplement cow milk and to provide supplementary income to the smallholder goat producers and milk processosr.

1.2 Justification

In Nigeria, there is little information on dairy characteristics of the indigenous goats based on on-farm research, most reports on milk production of indigenous goats emanated from Research Institutes and Universities.

There is limited information on the association between blood biochemical profiles and milk production traits in Nigerian indigenous goats. More so, there is paucity of information on relationship between coat colour and milk yield characteristics in these indigenous breeds. All these necessitated this research. If the ever widening shortfalls in dairy product supplies are to be

met through local production, there is need to take advantage of genetic diversity of indigenous goats in order to supplement milk from cow. Information from this research will be good alternative to the conventional methods of trait selection based on performance records once these genes are proven to be associated with milk yield and conformation traits; and it will also improve our knowledge of the genetic background of our indigenous goat herds.

1.3 Objectives

The objectives of this research were to:

1) Evaluate milk production characteristics, udder and body conformation traits and blood biochemical profiles of Nigerian indigenous goats.

2) Determine the factors affecting milk yield, udder and body conformation traits in Nigerian indigenous goats.

3) Establish the relationship between milk production characteristics, udder and body conformation traits; and blood biochemical profiles in Nigerian indigenous goats.

4) Determine haemoglobin and potassium polymorphism as well as their gene and Genotypic frequencies; and their effects on milk yield characteristics and blood biochemical profiles.

5) Determine the potential marking ability of the polymorphic genes as selection tool for conformation and milk production traits.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 World's Goat Populations

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 disseminated all over the world because their great adaptability to varying environmental conditions and the different nutritional regimes under which they were evolved and subsequently maintained (Devendra, 1985). Accurate statistics are required to determine the future outlook of goat population and their productivity. They are also needed before any improvement policies can be planned on a realistic basis and implemented with confidence (Aziz, 2010). Table 2.1 presents numbers of goat in different parts of the world their percentages out of the total number of goats.

Table 2.1: Numbers of goats in different parts of the world and their percentages out of the world total number

CONTINENT	Number (million)	Percentage of world total (%)
Asia	514.4	59.7
Africa	291.1	33.8
Northern America	3.0	0.4
Central America	9.0	1.0
Caribbean	3.9	0.5
South America	21.4	2.5
Europe	18.0	2.1
Oceania	0.9	0.1
World	861.9	

Source: FAOSTAT, 2008

2.2 Economic Importance of the Goat in the Tropics and Subtropics

Goats play an important role in almost all farming systems of the tropics and subtropics. Among all the domestic animals, the goat doubtless has the widest range of adaptation. In the lower latitudes, it is consequently at home both in the humid rain forest zone and in the Semi arid and arid regions (Devendra and Burns, 1998; Kababya *et al*., 1998; Devendra, 2000). These characteristics include: ability to acclimatize, feed uptake and digestive capacity, fertility, diverse possibilities of utilization, favourable cost-yield ratio and almost complete absence of prejudices against goat products in the indigenous population (Wilson *et al*., 1985).

Its great disease tolerance, e.g. even against trypanosomiasis, enables the goats to gain ground in almost all living spaces. Non-fastidiousness with respect to the available vegetation makes it possible for the goat to live in very different habitats. As regards to the taste of the forage plants, the goat is less choosy than cattle or even sheep; it consumes even strongly aromatic or salt-containing herbs, so that it can thrive in regions poor in fodder and can also penetrate deep into the desert (Wilson *et al*., 1985). The great adaptiveness of goats is also manifested in the high reproductive capacity i.e. the high fertility and the short generation interval. The multifarious possibilities of utilization constitute a further significant feature of the goat, which favours its incorporation in the diverse socioeconomic situations of the tropical and subtropical area (Silanikove, 2000). In the foreground stands exploitation of the meat potential, followed by milk production and extraction of skins, hair, wool and, dung (Peters and Horst, 1981; Boyazoglu *et al*., 2005).

The relatively small body size of the goat signifies a low expenditure on the animal unit on one hand, while on the other hand the rapid, high reproductive capacity brings a short-term return on investment. The ease of handling and the good nature of goats enable them to be attended even by women and children. This not only means a reduction on cost of management but also enables

goats to be kept by households with little or no land. The goat and its products are not subject to any taboo. The goat has thus assumed an unrestricted, vital function in supplying cheap animal protein, above all in poorer families. In addition, it is integrated in the customs and rites of many tribes in which it has an important place as a sacrificial animal or celebration roast (Peters and Horst, 1981; Devendra, 1999).

2.3 The Indigenous Goats of Nigeria

2.3.1 Breeds and distribution

Goats in Nigeria are extremely diverse in types. Three main breeds have been recognized and described (Adu *et al.,* 1979; Ngere, 1985; Osinowo and Abubakar, 1989). They include the Sahel goats, Red Sokoto goat and West African Dwarf. Some other strains probably due to crossing are available, they include, Borno White (Kyalla), Borno Red, Kano Brown and Maiduguri Brown, named according to their areas of origin.

Their distribution is not even. The West African Dwarf (WAD) goats are found in the southern guinea and forest zones, the Red Sokoto goats are widely distributed in the Sudan and northern guinea, and the Sahelian goats are found in semi-arid zones of the country. Each of these breed is well adapted to its natural environment or vegetation (Ngere, 1985).

2.3.2 Sahel/Desert Goat

This breed is common in the arid or Sahel region of Nigeria. The breed is medium to large in size, long legged and covered with coat of short fine hair. The breed is highly adapted to nomadic life and wide range of vegetation from desert to semi-desert condition. It is tolerant to hot, dry environment but unsuited to humid regions. Many produce grade skins. All are used for meat and skin production, and a few can be described as good milker (Adu *et al.,* 1979; Adu and Ngere 1985).

2.3.3 Red Sokoto Goat

This is one of the few well defined breeds of goat in Africa. It is the most numerous goat breed in Nigeria originally confined to the Niger Republic and Sokoto province but has spread throughout the Savannah and forest belt. The breed is characterized with short ears which are curved horizontally, both sexes are horned, with uniformly dark red coat. The legs are shorter than those of the Sahel breed. The skin of the Red Sokoto goat is among the most valuable of all goat skins. The breed is a good meat animal (Adebambo *et al*., 1994). In Niger it is commonly milk yielding about 0.5kg in dry season and up to 1.5kg in wet season. Birth weight varies from 1.0 – 2.5kg. It is a relatively small animal; at maturity 23 – 30 kg, (Ngere, 1985).

2.3.4 West African Dwarf Goat

This breed is confined to the tropical forest belt of Southern Nigeria and other West African countries such as the Cameroom. They are small sized and short legged, hardly higher than 50cm height at withers. These breed has a variety of coat colour but black and brown colours predominate. The breed is rated high for its hardiness and tolerance to trypanosomiasis. The

breed is highly prolific with a high percentage of twining and triplet, (Osinowo and Abubakar, 1989).

2.4 Present Status of world Goat Productivity

Goats are kept primarily to produce milk, meat, and fibre. Although limited information is available on the production of fibre from goats.

2.4.1 Milk Production

Dairy goat is considered the cow of the poor. Dairy goats produce about 15.2million metric tons (MT) of milk, accounting for 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's goat population producing about 15% of the world's goat milk, which is mostly used for Cheese production (Lejaouen and Toussaint, 1993; Aziz, 2010). Table 2.2 shows the amount of goat milk produced by the ten top countries in the world, along with the total number of dairy does and the average of milk produced per doe (FAOSTAT, 2008).

Table 2.2**:** Goat milk production in the top ten countries of the World

Country	Goat Milk Production (Million MT)	Number of Dairy Goats (Million)	Milk Produced per dairy doe(Kg)/lactation
India	4.0	30.2	132.5
Bangladesh	2.2	27.1	80.0
Sudan	1.5	NA	-
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

Source: FAOSTAT, 2008

2.4.2 Tropical dairy goat breeds

There are 160 popular goat breeds available worldwide which are based on the size of populations, productivity and unique characteristics. Among these, the level of milk production data collected from 46 countries are available for 89 breeds and five high yielding breeds in this list are considered as improver breeds for the developing countries. They are Alpine, American LaMancha, Saanen, Toggenburg and Nubian. The Saanen is more popular for its extensive use in cross breeding programmes worldwide resulting in evolution of new breeds, often with new names. Some of the available data show that the average milk yield of the breed Saanen generally exceeds 2000 kg while that for Alpine in UK and Nordic goats in Norway yield more than 1,900 kg in a single lactation. Individual best performance records show that the American Toggenburg yielded 3,023 kg, Alpine 2,916 kg, Saanen 2,695 kg, LaMancha 2,454 kg and Nubian 2,423 kg of milk.

2.5 Goat Production System

About four goat production systems have been identify in the tropics, they include; subsistence, extensive, intensive and semi-intensive (Devendra and Burns, 1998). The intensive system is not common, due to increasing pressure on land (Adenova, 1985; Otchere *et al*., 1985). Although intensive and semi-intensive systems exist on some government and corporate farms in Nigeria (Nuru, 1985), these rely mostly on grazing reserves, sown pasture and the use of industrial by-products. The extensive traditional systems are predominantly practised in Nigeria (Gefu and Adu, 1982; Ademosun, 1985). The management systems have resulted in low productivity due to

low level of nutrition and diseases (Ademosun, 1985) coupled with losses resulting from accidents, thefts or conflicts following crop destruction by animals (Egwu *et al.,* 1995).

2.5.1 The Subsistence System

In this system, a few goats are kept to meet domestic needs for meat and milk. In this system, the goats may be allowed to range or may be tethered. This system is practiced nationwide especially in Southern Nigeria (Sumberg, 1985). The ranging goats (Upton, 1988) are characterized by scavenging and roaming around home and farmsteads, in search of feed. Animals are left to roam especially during the day. No forage crops are grown and manure is not returned to the cultivated crops, so links with crop production are slight. The entire village stock is a single interbreeding flock, and usually there are no attempts to control mating. Animals receive virtually no veterinary care, and mortality rate is relatively high, though variable labour cost is negligible (Akpa, 1999).

In the tethering system (Ndamukong *et al.,* 1989), animals are housed at night and adult tethered during the day. Access to fresh grazing is provided by shifting the tethering site. This system is practised in Nigeria, mainly during the cropping season to avoid damage to crops (Francis, 1988; Mijindadi and Lufadeju, 1995).

2.5.2 The Extensive System

This is generally practiced in regions where the land is not immediately suitable for agricultural improvement and or is too difficult or costly to fence. In Nigeria, the system does not provide

housing and the animals therefore, spend the night in streets. It involves a minimum amount of labour and expenses. This system of production is not so common in the tropics (Devendra, 1982).

2.5.3 The semi-intensive system

This system is in between extensive management and zero grazing, but usually involves controlled grazing of fenced pastures with some supplementary concentrate feeding. Animals are usually housed at night and fenced in paddocks during the day (Ndamakong *et al*., 1989; Akpa, 1999). In Nigeria, natural grazing is still the backbone of this system and animals are restricted from indiscriminate movement (Akpa, 1999). According to Mack *et al*. (1995), restriction of the movement of small stock in South Eastern Nigeria both during and after the cropping season is dictated by the production environment.

2.5.4 The Intensive system

The system involves "zero grazing". There is maximum protection from uncontrollable environmental factors, and it gives complete control over the destructive aspects of the goats feeding habits. Dairy goats in the tropics and small herds of goats in urban-fringe areas are often managed in this way. Confinement feeding for fatterning of goats is a production system widely practiced in the north (Akpa *et al*., 1995).

2.6 Performance characteristics of tropical goats

The productivity of small ruminants in the tropics is low compare to their counterparts in the temperate region but there is ample opportunity for improvement (Akpa, 1999).

2.6.1 Fertility and Prolificacy

Goat have a high fertility rate and high prolificacy ranging from 120 -135% (Adebambo *et al*.1994). Twining rate is generally high in goats up to 55 -60% and estrus cycle are short, about 18 days. Estrus period ranges from 24 – 48hours up to 72 hours (Devendra and Burns, 1998). These are generally shorter in yearlings. Estrus occurs all year round in the tropics. Kidding interval is about 8 months while generation interval is about 2 years. Litter size in goats is between 1.79 to 1.18 in Africa (Lebbie and Manzini, 1989; Mourad,1993; Osinowo and Abubakar, 1989; Odubote, 1996). Kidding interval is between 234 to 281days. However, postpartum intervals to first oestrus of 37.5 days in West African Dwarf (WAD) goats had been reported (Kirkpatrick and Akindele, 1974), this reports confirm the potential for twice yearly kidding under good management, although, one kidding per year is common and three in 2 years is achievable (Akpa ,1999).

2.6.2 Body Weight in goats

Birth weight has been reported to be positively correlated with growth rate, kid viability and weaning weight (Devevdra and Burns, 1983; Mukassa-Mugerwa *et al*., 1991). Egwu *et al.*(1995)

reported birth weight of 1.2-2.0kg in Red Sokoto goats and Sahel goats while the WAD was 1.0-2.0. Karua (1989) reported birth weight of 1.8kg for Malawian goats. Three months body weight of Red Sokoto goat in Niger was reported by Oumara, (1989) to be 9.05kg. However in Nigeria the weights range from 14-16kg (FMEST, 1984). Makun *et al*., (2008) reported birth weight in Red Sokoto and Sahelian goats kids to be 1.0g and 2.2g, respectively; while they reported their weaning weight to be 18.9kg. In another study, the Red Sokoto goat kids were reported to weigh about 1.5-2.0kg at birth while adults weighed between 20-35kg (Osuhor *et al*. 2002). The kids of Sahelian goats weighed between 2.1-2.8kg at birth and mature adults weigh between 31-50kg (Akinwole *et al*., 1991). Gadir and Zubeir (2005) reported birth weight and adult weight to be 4.8kg and 37.97kg, respectively in Saanen x Nubian goats. Average kid weight at birth and at 120 days was reported to be 3.49 and 15.78kg, respectively in pure crosses of Alpine, Damascus and Muriana goats (Amor *et al*., 2007). Animals are usually weaned at the age when they have attained weights between 300-400% of their birth weight, and about 30% of their mature weight (Ngere, 1985). In the indigenous goats, post weaning growth slows down immediately after weaning at 5 to 6 months and picks up in about 11 months of age (Ngere, 1985).

2.6.3 Growth rates

Gipson (1996) and Luginbuhl (1998) illustrated that growth can be effectively divided into two phases: growth before weaning or pre-weaning average daily gain and growth after weaning or post-weaning average daily gain. Growth starts at conception, and it is during the last third (trimester) of gestation that maximum weight increase takes place in the fetus (Tejon *et al*., 1994).

Engel and Greaser (1999) reported that temperate goats could gain more than 200g per day from birth to 100 days of age. Average growth rate recorded in Boer goats were 291, 272, 245 and 250g from birth to 100, 150, 210, and 270 days of age in male goats, respectively (Van Nickerk and Casey, 1988). The corresponding rates reported by Lu and Potchoiba (1988) in females goats were 272, 240 and 186grams/day. Abebe (1996) also reported that pre-weaning growth rate in Somali kids averaged 76g/day while crossbreed (Somali x Anglo-Nubian) kids grew at a significantly higher rates (83g/day). Egbunike *et al.* (1995) reported faster growth pattern for single and twin kids of West African dwarf goats than other birth types with values of 58.57, 48.57, 37.14 and 32.86g/day for singles, twins, triplets and quadruplets, respectively. Red Sokoto goats fed conventional concentrates gained 53.9g/day while goats supplemented with crop residues recorded 32.4g/day between birth and 90 days (Malau-Aduli *et al.,* 2004). Growth rate tend to fall below those temperate breeds probably due to poor husbandry and lack of genetic selection (Osinowo and Abubakak, 1989).

2.6.4 Milk Yield

There are several reports on the milk production of indigenous African goats. Available reports indicate that lactation milk yield range between 24 and 120kg . The highest peak yield has been observed in the Red Sokoto goats of Nigeria (850g); and the peak week range from 2-6 weeks (Akpa, 1999). Egwu *et al.* (1995) reported total milk yield of 25-40kg and 32-35kg in Sahel and WAD goats, respectively. Total milk yield in Red Sokoto was reported to be 45-75kg (Osinowo and Abubakak, 1989). Akpa (1999) reported, total milk yield, daily yield, peak week yield, peak week, initial yield and day - 120 yield to be 48.1kg, 400g,5.1kg, 4.0weeks, 569.80g and 260.3g,

respectively in Red Sokoto goats. Average daily milk yield of between 300-1000g was reported for the same breed by Malau-Aduli *et al*.(2003). Zahraddeen *et al*.(2009) reported partial daily milk yield to be 188.27g, 207.74g and 168.63g in Red Sokoto, Sahel and WAD, respectively. Makun *et al*. (2008) reported average daily yield in Sahelian and Red Sokoto goats to be 135 and 134g respectively, and their total milk yield to be 23.3 and 24.5kg respectively, Tendonkeng-Pamo *et al*. (2006), working with West African Dwarf goats had similar results. The milk yield of Sahelian does had been reported to be in the range of 800-1000g per day (Cisse *et al*., 2002). Greyling *et al*. (2004), working with South African indigenous and Boer goats also reported average daily yield to range between 800 and1000g. Awgichew *et al*. (1991) reported 24kg for total milk in Adal goat in Ethiopia. In Balkan goats, the average milk yield was reported to be approximately 129kg, with lactation length was 218days (Zujovic *et al*., 2011). There are variations in the reports on lactation length in African goats, even within breeds. From the reports, lactation length was 266, 92, 126, and 80 days in Blended goat, Red Sokoto, WAD, and Sahel goats, respectively (Egwu *et al*., 1995; Das, 1989; Osinowo and Abubakar,1989). The improved breeds such as the Saanen produced 331-1,010kg in 205-278 days; Toggenburg (532kg in 263 days) and Anglo-Nubian (143kg in 124 days) (Osinowo and Abubakar, 1989; Akpa, 1999). Supplementary feeding might be necessary to ensure greater milk production of lactating does and better survival of their young. Egwu *et al*. (1995) presented peak yield in Red Sokoto, Sahel and WAD to be 450-550, 500-600 and 600-700, respectively. In another research by Keskin *et al*. (2004), average lactation milk yield in Damascus goat and the German Fawn x Hair goat crossbred were 347.6 and 316.8L, respectively. Prasad and Sengar (2002), Mia *et al*. (1994) and Eknaes *et al*. (2006), in their separate studies showed that genetic make-up and nutritive intake of different breeds of goats greatly influenced the milk yield and its composition.

2.6.5 Nutrients and composition of goat milk

The composition of goat milk is given in the Table 2.4 which shows that, the goat milk is similar in composition to cow and human milk with few exceptions.

Table 2.3: Nutrient composition of goat milk

Constituents	Composition
Total solid %	12.97
Energy Kilocalories	69
Kilojoules	288
Protein %	3.56
Lipid %	4.14
Carbohydrate %	4.45
Ash %	0.82
Calcium (mg)	134
Iron (mg)	0.05
Magnesium (mg)	14
Phosphorous (mg)	111
Potassium (mg)	204
Sodium (mg)	50
Zinc (mg)	0.30
Ascorbic acid (mg)	1.29
Thiamine (mcg)	40
Riboflavin (mg)	0.138
Niacin (mg)	0.277
Pantothenic acid	0.310
Vitamin B6 (mcg)	60
Folacin (mcg)	1
Vitamin B12 (mcg)	0.065
Vitamin A (mcg)	44
Vitamin D (mcg)	0.11
Vitamin E (mg)	0.03
Vitamin C (mg)	1

Source: Goatworld.com

2.6.5.1 Medicinal properties of goat milk

The importance of feeding of infants with goat milk has been recognized since ancient days. In developed countries like U.S and South Africa, the goat milk is specifically marketed for the infants (Morgans, 2010). The milk allergy problem common in infants fed with cow milk is rarely encountered when replaced with goat milk and it plays an important role in the formulation of infant formula (Haenlein,2004). The symptoms like gastrointestinal disturbances, vomiting, colic, diarrhea, constipation and respiratory problems can be eliminated when goat milk is fed to the infants (Haenlein,2004). The reason cited for the relief in respiratory problems when fed with goat milk can be attributed to the structure of casein micelle of the goat milk (Haenlein, 2007). The goat milk is naturally homogenized. It forms a soft curd and hence helps in easy digestion and absorption. Regular intake of goat milk significantly improves body weight gain, improves mineralization of skeleton, increases blood serum vitamin, mineral and haemoglobin levels (Morgans, 2010).

Other medicinal properties of goat milk are due to its higher concentration of medium chain fatty acids which play an important role in imparting unique health benefits in mal-absorption syndrome, steatorrhoea, chyluria, hyperlipoproteinaemia and during conditions of cystic fibrosis, gall stones and childhood epilepsy (Haenlein, 2007). The medium chain fatty acids minimize cholesterol deposition in the arteries, aid in dissolving cholesterol and gallstones and significantly contribute to normal growth of infants (Morgans, 2010).

2.6.5.2 Udder Characteristic and Milk production

Morphological udder traits are very important for dairy animals. These traits are of interest to the breeder because of their influence on applicability to mechanical milking, udder health and milk yield (Dag and Zulkadir, 2004). In goats, udder characteristics, milk production, milking time and rate are traits with adequate genetic variation to allow selection response (Akpa, 1999; Bhiyan *et al*., 2004). The knowledge of the relationships between individual characteristics of udder morphology is important for their inclusion into total selection indexes or construction of partial selection indexes for udder morphology and it will enables farmer to predict future correlated responses in milk-oriented selection programmes (Dag and Zulkadir, 2004).

There are few studies on the udder and teat dimensions in goats (Das and Sidhu, 1975; Masdol, 1980; Das and Singh, 1983; Kumar *et al.,* 1983; Narain *et al*., 1985; Montaldo and Martinez-Lozana, 1993; Akpa, 1999; Dag and Zulkadir, 2004; Gadir and Zubeir 2005; Prasad *et al*., 2010; Akporharho *et al*., 2011;). Factors that affect udder traits in goats include age, parity and season of kidding (Labussiere, 1988; Roger and Spancer, 1991; Akpa, 1999; Akporharho *et al*., 2011).

The most important factors contributing significantly to the variability of the depth, width and circumference which define udder size are lactation month, flock and yield (Labussiere, 1988; Sastry and Tripathi, 1988; Milerski *et al*., 2006). Other traits cistern height, teat position, length and width, showed high repeatability and were less dependent on yield and lactation month, which made them potential candidates for genetic improvement (Akpa, 1999). Moreover, cistern height, teat position and teat angle traits are the most important for udder adaptation to mechanical milking (Labussiere, 1988; Mahthar and Vrla-Anesti, 1994). Cistern height, vertical teat position and minimal teat angle favour letdown and drainage of the milk, which eliminate

lengthy stripping which wide teat angle are responsible for teat cup slipping and inhibition of the ejection reflex (Labussiere, 1988).

Stage of lactation has been reported to significantly influence mammary traits (Fernendez *et al.,* 1995; Bhiyan *et al*., 2004; Akpa, *et al*. 1999). Udder measurement increases with parity (Akpa et al. 2003). As lactation progresses, these traits diminished with milk yield. Teat size (length and width), decreases with stage of lactation; while udder width and cistern height increased with parities (Akpa *et al.* 2003).

Milk yield has been reported to greatly influence udder size (Chavan, 1990; Fernendez *et al*., 1995; Akpa, 1999; Prasad *et al*., 2010). The traits (depth, width and circumference) defining udder size, were highly dependent on total milk yield per lactation and test day milk yield (Labussiere, 1988).

Prasad *et al.* (2010) reported a positive correlation between all udder measurements (udder width, udder length and udder depth) and daily yield. Although the correlation was significant only with udder width, Czarnik (1994) had earlier reported similar results. Mavrogenis *et al.* (1988) observed that mammary characteristics (except udder size) can be selected for without modifying milk yield because genetic correlations with milk yield were low. Udder size was observed to be more of a limiting factor to yield in first lactation than in later ones (Akpa *et al*., 2003).The correlation between udder circumference, udder height, and distance between teat had been reported to be high and positive (Fernandez *et al*., 1995; Fernandez *et al*., 1997).

It has been observed that cows with pointed teat ends had the lowest milk flow rate (Seykora and McDaniel 1985); and bowl shapped udder in dairy cows yielded the maximum test yield (3.4kg), medium in goaty shaped udder (3.1kg) and less in round shaped udder (2.8kg) (Bhuiyan *et al*.,

2004). Contrary to this, other authors observed that milk yield did not differ significantly by classification of teat end shape (Seykora and McDaniel, 1985; Bharadwaj *et al*., 1987; Milerski *et al*., 2006). Appleman (1970) found that teat ends that were disk or inverted had wider streak canals than those with pointed or round ends. Teat with large diameter has slow milking than a small one. However, selection of a more pointed teat, could increase resistance to mastitis, but milk yield may not increase because of a tendency to milk incompletely animals with slower milk flow (Seykora and McDaniel 1985). Increased residual milk would tend to lower total yield; hence, faster milk flow in the flatter teat ends may compensate for increased infection rate (Seykora and McDaniel 1985; Dag and Zulkadir, 2004).

2.6.5.3 Factors influencing milk yield of goats

For genetic evaluation and selection of sires and dams for a certain trait, it is necessary to know the genetic and non-genetic sources of variation of the trait in order to make the necessary corrections of field data (Akpa *et al*., 2001). Usually, genetic and non-genetic factors affecting milk production are breed, lactation period, herd, litter size, age, parity, season or month and year, body condition score, body weight at kidding (Alderson and Pollack, 1980; lloeje *et al.,* 1980; Mavrogenis *et al.,* 1989; Kala and Prakash, 1990; Mavrogenis and Papachristoforou, 1990; Rabasco *et al.,*1993; Akpa *et al*., 2001; Zahraddeen 2009).

Does's body condition scores significantly influenced milk yield, this parameter increased with increase in doe's body condition score (Zahraddeen *et al.,* 2009). Morand- Fehr *et al.* (1982) stated that within genetic limits, nutrition during lactation is the primary factor that influences milk yield. There is positive and significant relationship between body weight and milk yield in

goats (Mishra *et al.,* 1980). These authors studying postpartum body weight in relation to milk yield, had the following weight classes for 68 Sirahi goats weighed within 12 hours of parturition: 24 - 26, 27 - 29, 30 - 32 and 33 - 35kg, and obtained corresponding average of 90 days milk yield of 40.23, 48.13, 52.30 and 53.80kg. Mukherjee *et al.* (1991), working on Bengal goats found that body weight at birth, 12 weeks of age and pre-weaning daily gain, significantly affected milk yield. They also observed that body weights of kids at 24, 36 and 52 weeks significantly influenced milk yield of first lactating does. Also goats that were heaviest at different stages of growth had the highest pre-weaning daily gain and milk yield. Correlation of lactation yield with body weights at birth and at 12, 24, 36 and 52 weeks of age showed that Black Bengal goats can be selected on their body weight at birth and 12 weeks of age for milk production.

Milk yield is significantly influenced by parity (Akpa, 1999; Zahraddeen *et al.,* 2009). Butswat *et al*. (2002) reported that milk yield of Sahel goat and Red Sokoto goats increased significantly up to the third parity and declined subsequent. Garcia *et al*. (1976) also found that the milk yield of Anglo Nubian, Alpine, Toggenburg and Saanen peaked in the third lactation. The effects of parity and age of doe on milk yield are well established (Mittal *et al.,*1977; lloeje *et al.,*1980; Kennedy *et al.,*1981; Kala and Prakash, 1990; Akpa,1999; Zahraddeen *et al.,* 2009), although they can be obscured by differences in management, season, nutrition, disease and other environmental factors (Devendra and Bums, 1983). This probably accounts for some seemingly inconsistent results and conflicting reports on age at maximum production. Several authors had found significant increases in total milk production with age, reaching a peak between 30 and 50 months of age and decreasing thereafter (Steine, 1975; Alderson and Pollack, 1980; lloeje *et al.,*

1980; Gall, 1981; Montaldo *et al.,* 1995; Akpa, 1999; Akpa *et al.,* 2002). Similar trend had been reported for lactation length (Garcia, 1982; Montaldo *et al.,* 1995). Browning *et al.* (1995), working with 220 Alpine does showed that lactation number affected milk yields with highest production recorded at second lactation (960kg) and lowest at seventh lactation (634kg). Does of parity 1 produced less milk than does of parity 2 and 3 (Rana *et al.,* 1982; Yadav *et al.,* 1983; Zeng and Escobar, 1995; Zujovic *et al*., 2011; Memisi *et al*., 2008); thus suggesting that lactation yield shows increasing trend as the order of lactation increases.

In two herds of Beetal goats originating from different parts of Punjab in India, Amble *et al.* (1964) analyzed 800 and 788 lactation records, and found that yield declined from the first to the second, then rose to the fifth, and declined in later lactations. Milk production in the fifth lactation was less than in the first. The data of Mittal *et al.,* (1977), on a much smaller number, indicated higher yield after four years of age than in younger does. Singh and Acharya (1980), using 3,827 lactation records from 1,439 Beetal does, found that milk yield was maximal in the third lactation, and then declined in the fourth and fifth.

Season of the year also affect milk yield significantly; Zahraddeen *et al.* (2009) reported that milk yield was higher during the dry season than the wet season. Iloeje *et al* (1981) and Akpa, (1999) had similar results. Kennedy *et al.* (1981) studied the joint effects of parity, age and season of kidding on milk and fat yield in dairy goats. They observed that differences between parities at the same age were large and significant, with does kidding at 20 - 22 months of age having maximum yield in first lactation. Milk yield in subsequent lactations tended to decrease as age at kidding increased, which points to the necessity for considering parity in developing age-correction factors.

Breed differences had been observed for milk yield and fat percentage in Gargano, Maltese and Saanen goats (Pilla *et al.,* 1982). Milk yield in the first 175 days of lactation in the breeds averaged 207.6, 280.0 and 358.3kg and fat percentage of 3.87, 4.06 and 2.86, for Gargano, Maltese and Saanen goats, respectively. Similarly, Zahraddeen *et al*. (2009) reported partial daily milk yield of 188.27kg, 207.74kg and 168.63kg for Red Sokoto, Sahel, and WAD goats, respectively. A comparison of milk and fat yield records of Alpine, La Mancha, Anglo-Nubian, Saanen and Toggenberg showed that Saanens had the highest average milk and fat yields for all lactations 977 and 34kg, respectively (Alderson and Pollak, 1980). Milk production of two developed synthetic dairy goats (Cukurova and Taurus) was evaluated under subtropical conditions (Guney *et al.,* 1992). It was observed that mi1k yield averaged 376kg and 352kg for Taurus and Cukurova, respectively. Taurus goats had longer lactation length than Cukurova goats. In India, Yadav *et al.* (1983) studied the milk production of four Indian breeds of goats (Jamnapari, Beetal, Barbari and Black Bengal). They reported breed differences in lactation yield, thereby suggesting differential genetic potential for milk production for these breeds.

2.6.6.1: Goat Diseases and Parasites

Disease is one of the major problems that decrease livestock productivity and in many instances results in serious economic losses to the tune of 20-30% of annual farm animal losses (Adu *et al*., 1986; NAERLS, 1990). Disease and health problems of small ruminant animals have been associated with deficiencies in nutrition and the management procedures employed (Las Cruces, 2000). Adu and Brinckman (1977) concluded that better management; through better feeding and health care are the most important ways of improving animal performance. The most

common diseases include diarrhea, Peste des petites ruminants (PPR), pneumonia Trypanosomiasis, Helminthiasis, Coccidiosis and ectoparasitism (Adeoye, 1985; Ndamukong, 1985; Smith *et al*., 1988; NAERLS, 1990; Adah *et al*., 1993; Ojo, 1994). The major reproductive problems of small ruminants however were reported to include abortions, still births, agalactia, mastitis, metritis, dystocia and perinatal mortality (Falade and Sellers, 1976).

Red Sokoto Goats were reported to be more susceptible to Kafancha strain of Trypanosoma congolense infection than the West African Dwarf goat breed in addition to verminous pneumonia caused by lung worms (Adah *et al*., 1993). Microorganisms commonly associated with small ruminant pneumonia were reported to be: Mycopplasma mycoides, Pasteurella multicida, Striptococcus spp, Staphylococcus aureus and Corynebacterium pyogens (Ndamukong, 1985: Njau *et al.,* 1988). Diarrhea has been shown to be a manifestation of several disease conditions in small ruminants (NAERLS 1990). Such diseases include helminthiasis, bacterial, viral and protozoan disease. Peste des petits ruminants (PPR) had been described as an acute contagious disease of small ruminants, which is caused by Peste des petits ruminant's virus (PPRV), a Paramyxovirus of the genus Morbilivirus, which is antigenically very similar to the rindeperpest virus (NAERLS, 1990).

2.6.6.2 Preventive measures against goat parasites

Internal parasite control is probably the most important health issue for goats (Engle *et al*., 2000). Roundworms, stomach worms (Osteriagia circumetinea) and coccidia are about the most significant internal parasites of goats. Goats were reported to be infested by grazing on pastures contaminated with droppings from other infested goats (Brown and Forrest, 2001).

External parasites such as lice, ticks, mites, horn flies, stable flies, horse flies, deer flies and mosquitoes may present serious problems to small ruminant production (Brown and Forrest, 2001) They are reported to cause irritation, help in transmitting of many diseases, causes anemia and poor health (Panhwar, 2005). Dipping was recommended as a means of controlling ticks in herd of Creole goats at every 2 weekly interval Alexandre *et al*., (2001). Mange mite (Sarcoptes, Demodatic, Chorioptes and Psorroptes spp) is also common, sometimes with incidence rate of 24 to over 80% for roaming animals (Adeoye, 1985). With regular washing, this may be reduced to fewer than 5%. Clipping of hair and washing with warm water and soap was recommended by Panhwar (2005) in addition to topical application of 0.5% malathion or 0.06% Lindane as spray, swab or dip thrice at the interval of 7 days.

2.6.7 Mortality in goats

Mothering ability is a complex feature that is closely associated with the survival of kids and had been reported (Dalton, 1981) to greatly affect does ability to feed, shelter and perhaps protect the kid from predators. Chowdhury *et al.* (2002) stated that kid mortality is as a result of many interacting factors. In tropical conditions, mortality varies according to the viability of the new-born kids - birth weight and adaptability to post-natal period (Morand-Fehr *et al*., 1984), nutritional level of the does or to their milk yield (Alexandre, 1991; Osuagwuh, 1992; Hussain *et al.,*1995), litter size (Adebambo *et al.,*1994; Van Niekerk and Pimentel, 2004) and disease constraints (Alexandre *et al., 2001*). Tucho *et al.* (2000) reported that low doe milk yield could be responsible for high kid mortality. This report was in agreement with the findings of Hussain *et al.* (1995), who reported that survival rates of kids were positively correlated to the milk yield of dams. The mortality rates recorded for West African Dwarf goats (Adebambo *et al.,* 1994) revealed significant

relationships with the birth weight and type of birth. The authors obtained 12.26, 17.33 and 19.37% as percent mortality for singles, twins and higher multiple births, respectively. Hossain *et al.* (2004) obtained 41% as the mortality rate of kids of body weight of less than 0.8 kg; this was shown to decrease linearly to 6% with increase in weight.

2.7 Relationship between Conformation Traits and Milk Production in Small Ruminant

The success of selection in production of goat milk depends not only on direct improvement of milk trait performance (milk yield, content of milk fat or proteins), but also in improvement of other traits, such as body development or functional characteristics which also contribute to improvement of the production efficiency. Thus, it is necessary to include into the program of improvement of goat milk production those traits which have direct but also indirect impact on this production, such as the body conformation traits (Zujovic *et al.,* 2011; Waheed and Khan, 2011). The determination of absolute body dimensions is also very important, because they represent morphological and physiological basis for optimal expression of production and reproduction traits. (Riva *et al.,* 2002). Zujovic *et al*. (2011) reported significant correlation between height at withers, body weight, breast width, breast depth and rump width and total milk production in Balkan goats. Phenotypic relationship between milk yield and body weight in different goat breeds have been investigated by several researchers.

Iloeje and Van Vleck (1978) found that correlation between body weight and milk yield was 0.39 and 0.132 in Don and in German improvement goat, respectively. On the other hand, Gall (1980) found correlation of 0.36 between milk yield and body weight in German improvement goat. Dikmen *et al.* (2004) also reported significant correlation between body weight and

lactation milk yield in Saanen goats. Waheed and Khan (2011) reported that body weight, height at withers and depth traits and lactation milk yield (LMY) had positive phenotypic correlations (0.37, 0.82, and 0.16 to 0.44 respectively). They further reported correlations between height, depth and lactation length to be positive and ranged from 0.24 to 0.33 and 0.13 to 0.33 showing moderate relationship.

2.8 Coat Colour Variations in Goats

The Coat colour of animals is very important to farmers because it is a characteristic that allows easy differentiation among individuals and breeds. Coat colours allow one to differentiate among individuals within the same breed in terms of intensity, patterns and amounts of each colours (Becerril *et al*., 1994). Many breed associations have tried to characterize their breeds with specific colour pattern, and use it as a trademark, especially at every stage of breed formation.

Coat colours also may be related to productivity, because the ability of an animal to eliminate excessive body heat to its surrounding environment depends on morphological characteristics of hair coat which are colours (Maia *et al*., 2005). In subtropical climate, the degree of solar radiation is negatively associated with milk yield (Sharma *et al*., 1983) and reproduction (Gwazdauskas *et al*., 1975; Badinga *et al.,* 1985) among other things. In a study by Becerril *et al.,* (1994), the increase in milk yield was more in the whites than the blacks in Holstein cow. Schleger (1967) reported a positive correlation between coat colours and milk yield in Uawarra shorthorn dairy cattle. Maia *et al*. (2005) observed that white Holstein cows tended to present higher milk yield than the predominantly black ones, when managed in large stalls with fans and sprinklers in tropical environment. But King *et al*. (1988) reported that coat colour did not affect

milk yield under commercial conditions in Arizona that include environmental modification during summer.

Goat has been documented to have various colour patterns when processing their hide (Peacock, 1996; Akpa *et al.,* 1998) while the possible effect of coat colour pigmentations on morphometric traits have been discussed by several authors (Akpa *et al*., 1998; Ozoje and Kadri, 2001).

Colour in mammals depends on the presence of melanins in skin and hair (Searle, 1968). 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, and has varying amounts of cysteine in its polymers. The pheomelanic 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 very light. At the light extreme it is nearly white. At the dark extreme it can be confused with the browns of eumelanin. Generally, phaeomelanic colours have a reddish tinge (Sponenberg, 2004).

The position of eumelanin and pheomelanic areas determines the basic colour of goats, and the classification of goat colour depends on the specific pattern of pigmented areas. Another coat colour of the goat is due to the interaction of eumelanin (black/brown), phaeomelanin (red brown/tan/cream/white), and white spotting (white) (Sponenberg, 2004).

2.9 Nigeria's indigenous goats and milk production potential

The goat is generally known to produce relatively more milk per unit of live weight compared to the cow. The doe is known to produce three times, as much milk as the cow relative to body size (Wilson, 1988: Christopher and Richard, 1994; Makun *et al.,* 2008). The Nigeria's indigenous goats are well known for their meat characteristics. Numerous findings have been cited to this effect, (Hassan and Ciroma 1990; Akpa *et al.,* 1998; Akpa, 2000; Attah *et al.,* 2004; Iyiola-Tunji *et al.,* 2008). Their potential for milk production is indisputed although studies conducted had variable results (Ehoche and Buvanendra, 1983; Fajemisin, 1991; Akpa, 1999; 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 behavior of Red Sokoto goats under agropastoral and institutional system in the semi-arid climate of Nigeria revealed that milk production performance was better for agro-pastoral system than institutional system, except for lactation peak week and persistency Akpa *et al.* (2008). The differences in the two systems could be attributed to differences in nutrition and management of the goats. The agropastoral system had a better potential in terms of feed and water supply for milk production but lacked the management ability for sustainability Akpa *et al.* (2008).

Generally, the milk yield of the does drops after a few weeks and becomes negligible by the 15th week (Ngere, 1985; Akpa, 1999). Earlier studies carried out on the milk yield and composition of indigenous breeds of goats (Ehoche and Buvanendra, 1983; Fajemisin, 1991; Akpa *et al.,* 2005) found that milk yield and composition were significantly influenced by milking frequency. Increasing milking frequency also increased milk yield and composition. Milk yield was significantly and positively correlated with milk composition (r = 0.89-0.98) and the relationship was significantly enhanced by milking frequency.

It has been reported that once daily milking could reduce fixed cost and may be used strategically as a quota management tool and could become the production system of choice in programme intensification (Chistopher and Richard, 1994).

2.10 Blood biochemical polymorphism in livestock

Blood polymorphism studies have been conducted extensively to identify biodiversity among livestock animals. Biochemical particles of blood can be determined easily at the postnatal period of young animals and these components are merely or not affected by the environmental factors. Many researches were conducted to detect the different types of blood components such as haemoglobin, transferrin, albumin, glutathione and potassium. In general, the existence of blood potassium and glutathione polymorphisms in cattle (Evans and Philipson, 1957; Gonzales *et al*., 1984), sheep (Gurcan *et al.,* 2010) and goats (Soysal and Ulku, 1998) had been reported.

Several studies were also carried out to determined the association between biochemical polymorphism of blood and various traits (Alpan and Ertugrul, 1991). If an association exists, then the erythrocyte potassium and haemoglobin types in blood can be utilized as polymorphic markers among domestic animals (Kimura, 1968; Lush, 1971; Krishnamurthy and Rathnasthy, 1978; Gurcan *et al.,* 2010). Though some studies did not find any significant relationship with production traits (Soysal, 1983), a few studies displayed an important association between glutathione types and milk production traits in Finn sheep (Atroshi and Sondholm, 1982) and between the potassium and sodium types and some economical yield traits in livestock animals (Antunovic *et al*., 2004; Milewski and Szczepanski, 2006). However, Aygun and Mert (2007) reported that there was no relationship between the haemoglobin and transferrin types and milk

yield in Norduz goats (Aygun and Mert, 2007). Correlations have been calculated to show the relationship between various blood parameters in some studies. For example, while a high correlation was found between erythrocyte sodium and potassium values in Turkish Hair goat (Galip and Elmaci, 2001), non- significant correlation was detected between glutathione in erythrocyte and hematocrit values (Igbokwe *et al*., 1998). The relationship between blood parameters and production /reproduction traits may be controlled by the same genes, refered to as Pleitrophic effect" of genes (Gunes *et al*., 2008). These blood biochemical parameters presenting themselves in a polymorphic nature may be used as indirect selection criteria to improve production and reproduction traits of livestock (Kidd *et al*., 1974; Kimura, 1968; Lush, 1971 and Gurcan *et al*., 2010).

2.11 Potassium

Potassium is one of the intracellular elements which constitute the structure of an organism. Generally, the amount of potassium concentration is fairly high at intracellular membranes Kimura, 1968. The main function of potassium is to regulate the intracellular density of cells (Ellory and Tucker, 1970; Campbell, 1987). The level of potassium in plasma is relatively constant and varies in a very narrow range compared to the levels in erythrocytes (Aydin *et al*., 2008). Due to this condition the study on determining potassium concentration is usually carried in whole blood, it is concluded that the variation of potassium concentration in whole blood of goat reflects also the variation in potassium concentration of erythrocytes (Aydin *et al*., 2008).

Potassium and sodium concentrations of mammalian erythrocytes and their regulation constitute characteristics specific to these cells and also a consequence of their high specialization.

Polymorphism of erythrocyte potassium content was first described in sheep (Evans, 1954; Evans and Warren, 1957). The level of potassium concentration in goat blood is a genetically - controlled trait (Khattab *et al*., 1964). However, sodium concentration in erythrocytes small ruminant blood is not genetically controlled (Aydin *et al*., 2008).

Studies on blood biochemical polymorphism traits have shown that potassium concentration in red blood cells in ruminants are controlled by two alleles on a single gene, and they are K^H allele which is responsible for high potassium concentration in blood and K^L which is responsible for low potassium concentration in blood (Evans and King, 1955; Erkoc *et al.,* 1987; Reddy *et al.,* 1990; Nihat *et al.,* 2003; Nedjar *et al.,* 2008). The K^L is completely dominant while K^H allele is completely recessive which give rise to H^K phenotype (high potassium concentration) (Shahrababak *et al.* 2009). K^L K^H heterozygous dominants give rise to low potassium (LK) phenotypes (K^L blood type either homozygous or heterozygous) K^L K^L genotype is homozygous dominant which give rise to L^K phenotypes (Low potassium concentration) (Schreiber and Prosi, 1988; McManus *et al.,* 2009). LK cells are the consequence of low active cation-transport and high passive membrane permeability; whereas the HK cells display the reverse of this behaviour (Tosteson and Hoffman, 1960). The inheritance of potassium type in goat is similar to that in sheep (Aydin *et al*., 2008).

Potassium types are named LK (low potassium) for animal if the concentration of potassium in whole blood is below or equal to 13.00 mmol/L and HK (high potassium) if the whole blood potassium is over this value (Galip and Elmaci, 2001). Shahrbabak *et al.* (2009) explained that HK allele is predominant in dry climate and the LK allele found more in the normal and humid climate.

Most animal cells maintain high internal potassium and low sodium ion concentration due to the activity of the Sodium/Potassium (ATPase (Na/k – ATPase) pump in the membrane, which uses energy derived from the hydrolysis of ATP to accumulate potassium ions and expel sodium ions (Gurcan *et al.* 2010). The enzyme ATPase is intimately involved in the potassium or sodium-pump mechanism (Tucker, 1971). Erythrocyte potassium and sodium concentrations in domestic animals are associated with some production/reproduction traits such as milk production, body weight, mortality rate, fleece weight, fertility and adaption capacity (Rasmusen *et al.*, 1978; Mulei *et al*., 1988; Tucker *et al.*, 1973; Atroshi, 1979; Sengupta, 1974; Antunovic *et al*., 2004; Milewski and Szczepanski, 2006).

2.11. 1 Potassium types and production traits

The relationships between potassium types and productive and reproductive traits have been studied extensively in sheep. Al-samarrae and Younis (2011) reported that fertility, lambing and twining rate were all superior in HK type animals. The authors also reported that mean body weights of lambs at birth and weaning among the LK type were significantly higher, while phenotypic correlation between potassium concentration and body weights at birth and weaning weight for HK and LK pooled data were negative in direction and significantly different from zero. Fleece weight, fiber diameter alkali solubility, and wax content were all significantly higher for HK wool in the same study. Contrary to this report, in the study performed on black Bengal goats authors did not find correlation with milk yield traits and potassium types (Mandal *et al.,* 1988). Hrinca *et al.* (2008) pointed out that reproductive activity in sheep with LK phenotypes were more fertile and prolific than those with HK. Shahrababak *et al*.(2009) explained that high

potassium (HK) genotypes were favoured in areas where the climatic condition is dry with saline drinking water, while the low potassium (LK) allele are found in the normal humid climate. The authors further stated that, the relationship between potassium polymorphism and whole blood sodium concentration was negative. The animal with LK type have a high level of sodium because the concentration of Na and K is regulated by simple diffusion and Na – K-pump is semi active the need not regulate with active Na-K- pump, but the animal with HK type have a low level of sodium and regulate the concentration of Na and K with Active Na-K-pump.

2.12 Haemoglobins

One of the important blood proteins is haemoglobin. It has attracted attention because of its biochemical, biophysical and physiological properties, having relevance to selection phenomenon of animals (Raushenbach *et al.*1978; Hrinca, 2010). Haemoglobin is the iron-protein compound in red blood cell that gives blood its red colour and transport oxygen, carbon dioxide, and nitric acid. Haemoglobin is contained entirely in red blood cells, amounting to about 35% of their body weight. To combine properly with oxygen, red blood cells must contain adequate haemoglobin. Haemoglobin, in turn, is dependent on iron for its formation. A deficiency of haemoglobin caused by lack of iron in the body leads to anaemia (Akinyemi, 2010).

Haemoglobin is inherited by co-dominance in a Mendelian fashion. It has been reported by several researchers to be a very useful marker through which many economic traits to which it is associated have been improved in farm animals (Salako, 2002; Akinyemi and Salako, 2010). Variability at the locus is also analyzed to examine its degrees of association with some visible

traits, thereby widening the scope of its increasing accuracy of selection, targeted at genetic improvement of economic traits within the breed (Bindu and Raghavan, 2010).

2.12. 1 Electrophoresis

The term electrophoresis generally defines movement of charged particles through an electrolyte (buffer) when subjected to an electric current. In the case of protein the overall charge originates from the carboxyl (COOH) and amino (NH_2) groups, which can assume an electric charge according to the pH of the medium (Di Stasio, 1997). The technique has been used over the years as a tool for characterizing macromolecules and for assaying their purity.

Electrophoresis methods can be used to detect polymorphisms of major caprine blood proteins and protein variants determined by co-dominant alleles. According to Dally *et al.* (1980), Harris and Warren (1955) first demonstrated the existence of variable haemoglobin (Hb) types in small ruminant (sheep). Evans *et al.*(1956) designated the two Hb alleles as A and B; thus the three electrophoretic phenotypes are AA, AB, and BB. Akinyemi and Salako (2010) observed that Hb AA had higher oxygen affinity than Hb BB.

Evans *et al*. (1956) identified the HbAA and HbBB as single bands with HbAA being the fastest single band towards the anode during electrophoresis while HbBB was the slowest. The HbAB, however, was identified as a double band having both the fast moving AA and slow moving BB. They also· discovered a fourth, rare haemoblobin type; HbAC which is mostly found in young (pre-adult) animals before maturity. This HbAC was refered to as the 'foetal haemoglobin'. Das *et al.,* (2004) and Salako *et al.* (2007) also reported similar haemoglobin types, but occurrences for each haemoglobin type vary from location to location. Johnson *et al.* (2002) recorded frequencies for HbAA and HbAB but had no records of the homozygous HbBB or the pre-adult

haemoglobin HbAC for Omani goats sampled. Guney *et al.* (2003), however had records in which all the Damascus goats were the homozygous HbBB while Das *et al.* (2004) recorded frequencies for both HbAB and HbBB, but HbAA was absent.

2.12.2 Hemoglobin types and hematological factors

In cattle blood, HbB were associated with higher erythrocyte values than HbA, while leukocyte values were highest with HbAB and lowest with HbAA (Anosa and Obi, 1980). Zhang *et al.,*(1984) reported that in Tibertan sheep of Hb type BB, there was a significantly higher packed cell volume than in HbAA sheep, while FAO,(2008) reported high PCV in HbAA animals.

Pieragostini *et al.,*(1994) confirmed the differences in hematocrit and hemoglobin concentration between HbA and HbB in Leccesse sheep, with HbA sheep exhibiting a higher PCV and Hb concentration followed by HbAB, HbBB, HbDAB and HbDBB, HbDAB and HbDBB exhibited highest leukocyte value, followed by HbBB and HbAB sheep.

2.12.3 Hemoglobin Types and Production Traits

Samarineanu *et al.* (1982) reported that in Romanian Brown cows in Moldavia, the hemoglobins type AB were superior to other types (AA, BB) in milk yield (2271-2900 vs. 1900-2471 litres) and milk fat yield (84.6 - 105.0 vs 67.5 - 103.7kg); cows of the BB type were inferior to the other two types (AB, AA) in milk yield and milk fat percentage. Petre *et al.* (1982) reported that Romanian Brown cows of Hb types A, AB and B showed an average first calving age of 45.14, 40.52 and 36.66 months, respectively, average milk yield of 2478, 2578 and 2277kg, and average

fat yield of 93.78, 97.62 and 85.56kg with differences in all the three characters being significant. Dally *et al.* (1980) further reported that there were no difference in the milk production of ewes with different Hb types. Seth *et al.* (1974) reported that ewes with Hb BB produced more milk than ewes with Hb AA or Hb AB between 6-9 weeks. Gootwine, (1988) reported that the AB genotype in lambs had higher milk production in the first lactation and in subsequent lactations. Similar advantage of HbAB in milk production was noted in the work of Reshef,(1965) and Eyal (1968) in Assaf dairy sheep.

Dally *et al.* (1980) reported that HbBB ewes lambs were youngest at first estrus, HbAB ewes were intermediate and HbAA ewes were oldest. They also reported that HbAB conferred higher fertility than did HbAA. These authors observed a minor advantage of the A allele over the B allele for ewe lamb prolificacy, which was confirmed by Hrinca *et al.* (2008).

Marian *et al.* (1983) reported that body weights and wool yield were highest for Hb type BB in Corriedale sheep. Kumaran *et al.,* (1984) mentioned that in cross bred cattle (Holstein-Friesian x Haryanas, Brown Swiss x Haryanas, Jersey x Haryanas and backcrosses to the exotic breed) there were no significant relationships of Hb type with body weight at birth, 12 or 14 weeks, age at first calving, first or second lactation milk yields, first or second dry periods, or the calving interval. However, in Jersey crossbred, first lactation length was significantly shorter in Hb type BB animals (226.22 days) than for all other types (310.62 - 338.00 days)]. Barowicz and Pacek (1984) observed that in Polish Long wool sheep, ewes of Hb type B had a higher lambing rate, litter size, lamb birth weight and fleece weight (87.5%, 1.36, 4.3kg and 3.91kg), respectively, than ewes of Hb types A and AB; the lowest values for the first three of these traits were for type A ewes (71.0%, 1.31 and 3.87kg). Lambs of type B ewes were superior to lambs of the other types (A, AB) for body weight, wool length and fleece weight.

Weimer *et al.*(1984) reported non-significant relationships of Hb and Tf types with the litter sizes at birth and weaning, the percentage of multiple births, the incidence of reproductive failure and wool production in Corriedale and Ramney-Marsh sheep in Brazil.

Yaman *et al.* (1986) observed that the average weaning weight in Karacabey Merino lambs of Hb type AA, AB and BB (41.55, 41.54 and 41.76kg, respectively) were non-significant when compared with the body weight (55.35, 53.54 and 53.96kg, respectively) at the end of the 3-month fattening period.

2.12.4 Hemoglobin Types and Adaptation Traits

Vicovan and Rascu (1989) observed that in local Romanian breeds of sheep (Palas Merino, Transylvanian Merino, Spanca, Tsigai, Turcana and Karakul), imported breeds (Australian Merino, Romney Marsh, Drysdale Corriedale, Polwarth and Finnish Landrace) and two synthetic lines (a meat-finewool line and a high-prolificacy line) the frequency of A allele was higher in the imported breeds than in the local breeds (28.8-100 vs 5.4 - 19.3%). Comparison of the gene frequencies in different age groups showed that there was a tendency for the frequency of the A allele to be lower in older than in younger animals (Vicovan and Rascu, 1989). Mortality to weaning also tended to be higher in AA lambs than in lambs of other phenotypes and the number of lambs weaned per ewe lambing was higher for AB and BB than for AA phenotypes in the Australian Merinos and Drysdales, and for AB in the high-prolificacy line than for other phenotypes (Vicovan and Rascu, 1989). Al-Timemi and AI-Murrani (1990) reported that Hb genotypes significantly affected body temperature and heat tolerance in Iraqi local Sharabi cows.

Evans and Warren (1958) reported that HbA had selective advantage in sheep at higher altitudes because it constituted the most common allele in highland breeds of English and Scottish sheep. Salako *et al*. (2007) reported that the Red Sokoto goats sampled in the South-West Nigeria had a higher frequency of HbB, suggesting they are fit for lower altitudes. Das *et al*.(2004) reported a higher frequency of HbB in Kolkata, West Bengal, India (altitude 42ft) in sheep.

2.13 Haematological and Biochemical Parameters in goats

The significance of determining haemotological and biochemical indices of domestic animals has been well documented (Oduye and Adadevoh 1976; Oduye and Otesile 1977; Obi and Anosa 1980; Bhergariu *et al*., 1984) and changes of these parameters have been studies in cattle (Gherguriu *et al.,* 1984), sheep (Kaushish and Arora 1977; Vihan and Rai 1987) and Red Sokoto goats (Tambuwal *et al.,* 2002). There is a great variation in the haematological and biochemical parameters as observed between breeds of goats (Azab and Abdel-Maksoud 1999; Tambuwal *et al.,* 2002; Daramola *et al.,* 2005). The normal haematological and biochemical values for normal healthy goats had been documented to be within the following range; 24-46%PCV, 8-12g/dl, 137-152mmol/l Na, 65.4-87.2g/l, 20-34.7g/l albumin, 35.4-54.6g/l globulin and 2.7-4.2g/l (Radostits *et al*., 2000).

Daramola *et al.,* 2005 reported the percentage of pack cell volume (PCV) in West African Dwarf goats to be 21-35%. This value was higher than that obtain by Tambuwal *et al.,* 2002 in Red Sokoto goat (25.7%), Azab and Abdel-Maksoud 1999 reported 27.25% PCV.

Serum total protein concentrations were 4.4 ±1.5/100 litre in Red Sokoto goat (Tambuwal *et al.,* 2002), 6.3± 0.7g/100L obtained in WAD sheep (Oduye and Adadevoh 1976), and 7.1g/100litre in WAD (Daramola *et al.,* 2005).

Haemoglobin concentration (HB) was reported to be 9.8g/dl in WAD goats (Tambuwal *et al*., 2002). The same author reported albumin concentration in WAD goats to be 3.4g/100ml and reported 2.5g/100ml in Red Sokoto goats, while Oduye and Adadevoh (1976) reported 2.5g/100ml. The concentration of sodium in the red blood cells was reported to be 135 mmol/litre in WAD, 138.0mmol/litre in Red Sokoto goats and 138.8 in WAD sheep (Daramola *et al.,* 2005).

The concentration of potassium was 48-60 mmol/litre, 5.3 mmol/litre for WAD goats and WAD sheep respectively as reported by Daramola *et al.,* 2005. Gurcan *et al.,* (2010) reported whole blood potassium concentration of 26.2mmol/litre and erythrocyte potassium of 11.1mmol/litre in Saanen x Malta cross breed goats. Gunes *et al.,* 2008 reported erythrocyte potassium concentration of 10.62-105.83 mmol/litre in Awassi sheep.

The concentration of glucose in the blood was reported to be 2.1mmol/litre in German improved fawn goats (Zubcic, 2001), MacDougall *et al.,* (1991) reported 3.4mmol/litre in Saanen goats and Jovanovic *et al.,*(1998) reported blood glucose concentration of 3.1mmol/litre.

2.14 Biotechnology options for Improving Livestock Production

Biotechnology is offering unprecedented opportunities for increasing agricultural productivity and for protecting the environment through reduced use of agro-chemicals. Biotechnology can be defined as any technique that uses living organisms or substances from such organisms to make

or modify a product, to improve plants or animals or to develop micro-organisms for specific purposes (McLaren *et al*., 2001). Biotechnology is not new, man has used it for thousands of years to manufacture products such as beer, wine and bread. Conventional plant and animal breeding which involves selection and mating of phenotypically preferred individuals is a good example of age-old application of biotechnology. What is new about biotechnology comes from more recent breakthroughs such as recombinant DNA technology and associated techniques, monoclonal antibody techniques, embryo manipulation technology etc. These have enhanced possibilities for manipulating biological systems for the benefit of mankind.

Techniques of modern biology such as molecular cloning of genes, gene transfer, genetic manipulation of animal embryo transfer, genetic manipulation of rumen microbes, chemical and biological treatments of low quality animal feeds for improved nutritive value, genetically-engineered immunodiagnostic and immunoprophylactic agents as well as vaccines are a reality today and are finding their ways into research and development programmes of developing countries (Olayemi *et al*. 2002).

Genetic improvement of livestock depends on access to genetic variation and effective methods for exploiting this variation. Genetic diversity constitutes a buffer against charges in the environment and is a key in selection and breeding for adaptability and production in a range of environments (McLaren *et al*., 2001).

In developed countries, breeding programmes are based upon performance recording and this has led to substantial improvements in animal production. Developing countries have distinct disadvantages for setting up successful breeding programmes; because infrastructure needed for performance testing is normally lacking because herd size are normally small and variability

between farms, farming systems and seasons of the year while reproductive efficiency is low, due mainly to poor nutrition, and communal grazing precludes implementation of systematic breeding and animal health programmes (Barillet *et al*., 2005).

2.14.1 Multiple Ovulation Embryo Transfer and Open Nucleus Breeding System

Multiple Ovulation Embryo Transfer (MOET) is a composite technology which includes superovulation, fertilisation, embryo recovery, short-term in-vitro culture of embryos, embryo freezing and embryo transfer. Benefits from MOET include increasing the number of offspring produced by valuable females, increasing the population base of rare or endangered breeds or species, ex-situ preservation of endangered populations, progeny testing of females and increasing rates of genetic improvement in breeding programmes (Van deWerf, 2007).

2.14.2 Indicator traits

Indicator traits are characteristics which are genetically correlated to traits of economic importance and are easier to measure than the latter. Such traits are usually not the target of genetic improvement but provide an indirect means of improving a targeted trait. Blair *et al.* (1990) reviewed some physiological and/or metabolic characteristics which might be considered as potential indicator traits. Traits such as testicular size in rams or bulls or FSH in ewe lambs (Bodin *et al.* 1986) have potential as indirect predictors of fertility. Indicator traits can improve genetic response by increasing accuracy of selection and reducing generation interval.

The value of an indicator trait will depend largely on the magnitude of co-heritability (square-root of the product of heritability of the indicator and of the target trait) and the genetic correlation between the two traits (Woolliams and Smith, 1988). Woolliams and Smith (1988) concluded that with high co-heritability, selection for the indicator trait alone can result in greater rates of response than is possible with progeny testing especially when breeding values are not accurately measured by progeny testing. Packed cell volume (PCV), an indication of the extent of anaemia, is widely used as an indicator trait for pathological conditions associated with anaemia.

2.14.3 Genetic Markers and Marker-assisted Selection

A genetic marker for a trait is a DNA segment which is associated with, and hence segregates in a predictable pattern as the trait. Genetic markers facilitate the "tagging" of individual genes or small chromosome segments containing genes which influence the trait of interest. Availability of large numbers of such markers has enhanced the likelihood of detection of major genes influencing quantitative traits. The method involves screening the genome for genes with a large effect on traits of economic importance through a procedure known as linkage analysis (Paterson *et al.,* 1988). The chances of major genes existing for most traits of interest, and of finding them are considered to be high. The process of selection for a particular trait using genetic markers is called Marker-Assisted Selection (MAS).

MAS can accelerate the rate of genetic progress by increasing accuracy of selection and by reducing the generation interval (Smith and Simpson 1986). However, the benefit of MAS is greatest for traits with low heritability and when the marker explains a larger of the genetic

variance than does the economic trait. Lande and Thompson (1990) suggested that about 50% additional genetic gain could be obtained if the marker explains 20% of the additive genetic variance and the economic trait could have a heritability of 0.2. MAS also facilitates increased rate of genetic gain by allowing measurement in young stock thereby reducing generation interval.

2.14.4 Transgenic Animals

A transgenic animal is an animal whose hereditary DNA has been augmented by addition of DNA from a source other than parental germplasm through recombinant DNA techniques. Transfer of genes or gene constructs allows for the manipulation of individual genes rather than entire genomes. There have been dramatic advances in gene transfer technology in the last two decades since the first successful transfer was carried out in mice in 1980 (Jaenish, 1988; Mitra *et al*. 2010).

Successful production of transgenic livestock has been reported for pigs, sheep, rabbits and cattle. The majority of gene transfer studies in livestock have, however, been carried out in the pig. Although transgenic cattle and sheep have been successfully produced, the procedure is still inefficient in these species (Erhardt and Niemann, 2007). Transgenesis offers considerable opportunity for advances in medicine and agriculture. In livestock, the ability to insert new genes for such economically important characteristics as fecundity, resistance to or tolerance of other environmental stresses would represent a major breakthrough in the breeding of commercially superior stock (Clements *et al.,* 1994). Another opportunity that transgenic technology could

provide is in the production of medically important proteins such as insulin and clotting factors from the milk of domestic livestock (Rege, 2010).

2.15 Characteristics of goat breeding programmes

Breeding programmes for sheep and goats generally operate within an industry that is based on low levels of resource inputs, i.e. low levels of feeding and low labour costs on a per animal basis (van de Werf, 2007). Goat production takes place largely in developing countries where selective breeding based on performance recording is often absent. A more substantial proportion of sheep production is found in developed countries such as Australia, France, New Zealand, South Africa and the United-Kingdom. These systems are so predominantly pastoralist-base and extensive in nature. An FAO working group report (Hoste, 2002; Oliver *et al*. 2005) made the following distinction between production systems and the opportunities within them for breeding programmes:

1) Subsistence-based production: among the world's poorest, with limited market development and limited inputs and scope for genetic improvement.

2) Market-based production: with better developed markets targeting urban populations, higher input levels and more specialized production systems, with scope for genetic improvement depending on cost of inputs and also on skills and information literacy of breeders and producers.

3) High-input production, with further specialization, emphasis on increased land and labour efficiency, and much more concern for food quality, food safety, animal welfare and the environment.

Most of the world's goat production as well as many of the sheep systems would fall into the first category, whereas sheep production in developed countries falls into the second category, with some of these working towards the third category. Reproductive levels of breeding animals, especially males are relatively low compared with other species (van de Werf, 2007). In such a system, the multiplication factor, i.e., the number of commercial expressions resulting from investments in improved genotypes in the breeding nucleus, is relatively low. This makes it more difficult to introduce new technologies and justify large investments in improving individual animals. However, like other breeding programmes, there remains a significant return on overall investment in genetic improvement. Also in some more advanced sheep breeding programmes, the use of artificial insemination (AI) and across-flock evaluation has boosted the use of high profile rams and raised the value of individual breeding animals.

2.16 Breeding programmes and traits targeted goats

The goat farming systems focus on meat production (about 80%) with more emphasis in developed countries on dairy goat production and fibre production (Oliver *et al.* 2005). In dairy goat breeding, the most developed breeding programmes are found in France and are based on a strong goat cheese market. Based on AI and milk recording, France runs selection schemes for the Saanen and Alpine breeds, with 300,000 goats in 2,500 herds being recorded for milk traits. Dairy goat production is also recorded on smaller scales in Italy, Norway and Spain, with no more than a few thousand animals recorded in other countries (Montaldo and Mandredi, 2002). The main traits in dairy goat production are milk yield and protein and fat content of milk.

Being sex-limited and measured only after first production of progeny, these traits would benefit from MAS.

Goat meat production is widely spread throughout the developing world, but there are few breeding programmes of any significance. Genetic evaluation for Boer goats and other meat breeds is taking place in Australia and South Africa with weaning weight usually being the main trait measured. Ultrasound measurements of fat and muscle traits have had less attention, possibly because of their low heritability and multifarious nature. There are few studies concerning resistance to internal parasites in goats (Olayemi *et al.,* 2002) but these seem to indicate that faecal WEC's (worm egg counts) could be a similar selection trait as in sheep. However, the trait is hard to measure and there is no systematic recording and evaluation in breeding programmes.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The Study was carried out in Jigawa and Katsina States within the Sudan savannah zone of North-West Nigeria. Katsina lies between latitude 11°30 -13°01' North of the equator and longitude 07°41'- 10° East of Greenwich meridian. It is situated at an altitude of 464m (1525ft) above sea level. Generally, climate varies considerably according to seasons. The seasons 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, characterised by decreasing rainfall and a gradual lowering of temperature. Mean annual rainfall is about 780mm. Katsina State is hot for most parts of the year, even during the wet season. Mean annual temperatures range between 19° in the cold dry season to 38°, with the highest temperatures normally experienced in April and May, just before the rains (Ati *et al*., 2007). Jigawa State falls within latitude 11°-13°N and Longitude 8°-10°E. The mean annual rainfall varies from 500mm to 1000mm. Rainfall is higher in the Southern part of the State. The mean daily maximum and minimum temperatures are 35°C and 19°C, respectively. The maximum temperature has two peaks occurring in April and October. The lowest temperatures are recorded during the month of December and January. At this period the temperature can fall as low as 10°C or lower at night. The mean relative humidity can be as high as 80% in the month of August and as low as 15% in December. The State has an altitude of between 400 – 600m above sea level. There are two seasons in Jigawa State namely: rainy and dry seasons with the dry season lasting from November to May and the rainy season lasting between June and October, (Magashi, 2011;www.sateliteview.com;). Jigawa state has goat

population of about 2.3 million, www.fadama.net. The maps of the two states (Jigawa and Katsina) are shown in figure 1 and 2.



Fig 1: Map of Jigawa States

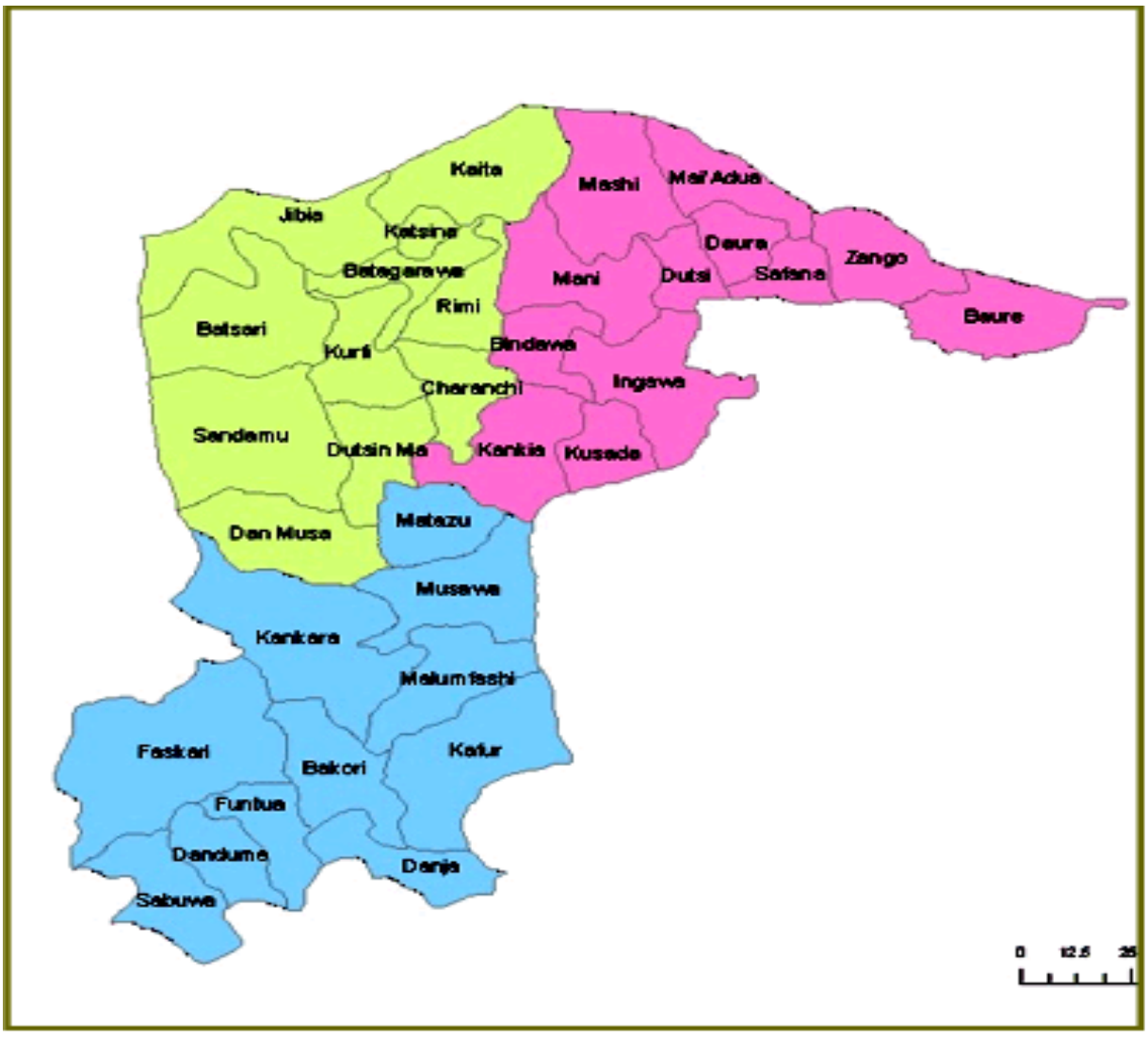


Fig 2: Map of Katsina State

3.2 The Animals and their Management

The goats were managed under the rural agropastoral system of management. The animals were taken out to graze every morning from 8.00am to 5.00pm by children and were penned at night. On return from grazing, the animals were penned in small open sided shades by tethering. New born kids were left to suckle their dams freely for the first 6 days postpartum to enable the kids take advantage of colostrums. Before setting out for grazing every morning, the goats were given water and supplement which included groundnut haulms, cowpea haulms and dry grasses. Each animal was tagged with a number for individual identication.

3.3 The Measurements

Smallholder agropastoral goat herds were studied between May 2010 and June 2011. A total of 250 does (whose parities were within 1-6) were hand milked twice a week and the milk obtained per each milking per doe was measured using graduated plastic beakers. Milking of does commenced from day 7 postpartum and lasted till the milk yield was less than 100ml. During milking, lactating does were kept calm by providing supplements in a feeder for them. The quantity of milk available per doe per test day was defined as partial morning milking (PMM). Kids were separated from their dams at 6.00p.m on the evening preceeding the day of milking. On the test day, the two halves of the udder of each lactating doe were hand-milked for all herds from 06.00 to 08.00a.m and the milk yield was recorded to the nearest gram. The average of the total volume of milk collected for the two test days was taken as the average daily yield of the doe for that week

The breed, coat colour and parity of does were recorded. The breeds were identified by peculiar characteristics as described by Ngere (1985). Coat colour was identified by visual appraisal; while parity was obtained through interaction with the farmers.

3.3.1: Udder Measurements

The Udder height, Udder circumference, distance between the two teats, teat length and teat circumference were taken as shown figure 1. The Udder and teat measurements were done using flexible tape (cm) as follows:

Udder Circumference: Measured at the widest point of the Udder round it.

Udder height: Measured from the rear attachment of the Udder to the front of it where it blends with the body.

Distance between Teats: -Measured between the base of the two teats.

Teat length: was measured as the distance from the upper part of the teat, where it hangs perpendicularly from the Udder to the tip of the teat.

Teat circumference: was measured at the widest point around the teat.

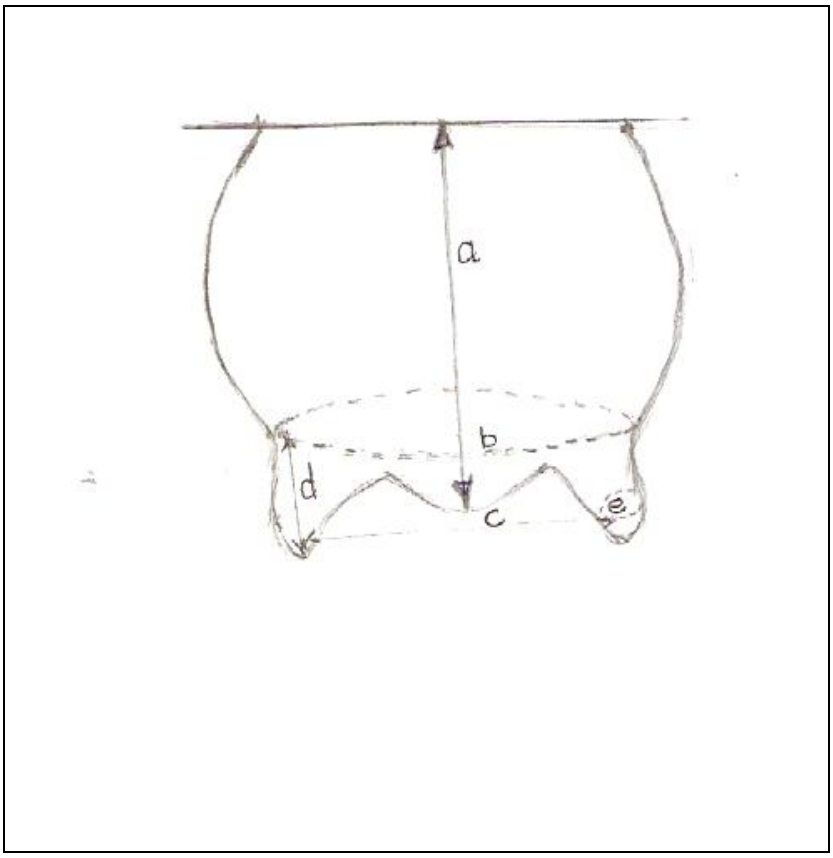


Figure 3: Udder and teat measurements

a= udder height, b= udder circumference, c= distance between teat, d = teat height, e = teat circumference.

3.3.2: Milk yield characteristics

Milk yield characteristics were measured as follows:

Average Daily Yield (ADY): - As average of all test day yields within the milking period.

Initial Yield (IY): - As milk yield at day 7 postpartum

Total Yield (TY): - As milk production during the lactation period up to the point where the production of the doe dropped below 100ml.

Peak Yield (PY): - As the highest test day yield during the lactation period

Peak day (PD): - As the day corresponding to the highest yield within the lactation period

Lactation Length (LL): - As the period from kidding to the point when the milk yield of the doe falls below 100ml

Last Test Day Yield (LDY): - Measured as the last test day yield before production drops below 100ml.

3.3.3: Measurement of Body Conformation traits:

The following body measurements were taken on each of the animals examined using flexible tape (cm).

- **Body Length (BL):** Body length was measured using a flexible tape, as the distance from the occipital protuberance to the base of the tail.
- **Height at Withers (HW):** The height was measured as the distance from the ground to the withers using a measuring tape.
- **Heart girth (HG):** The heart girth was measured by taking the measurement of the circumference of the chest with measuring tape.
- **Stature (ST):** The stature (rump height) was measured as the distance from the ground to the rump using a measuring tape.
- **Body Depth (BD):** This was measured by a measuring tape as the circumference of the region immediately after the hind leg towards the abdomen.
- **Body Weight (BWT):** This was measured using a bathroom scale in kg. Somebody mounted the scale for his weight to be known, then the weight of the person with goat was subtracted from the weight of the person alone to get the weight of the goat.

The sketch of how the body measurement was taken is shown in figure 2.

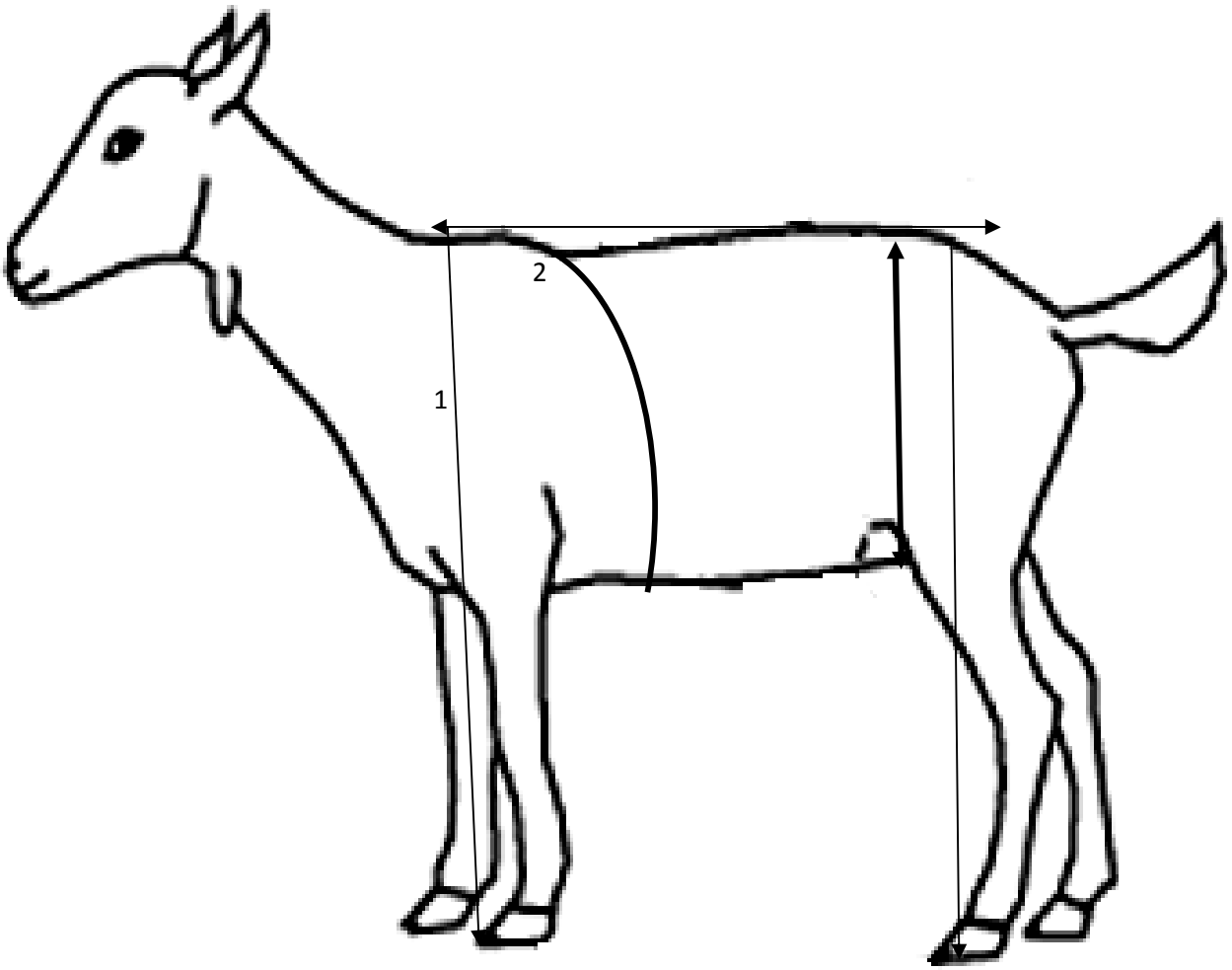


Figure 4: Body measurement

3.4 Blood Collection and Preparation for analysis

Five mililiter (5ml) of blood was collected from each of the sampled animals by jugular venipuncture, using needle and syringe into test tube containing Ethylene Diamine Tetra Acetic acid (EDTA) as anticoagulant and samples were properly labeled. The blood samples were then washed with normal saline and haemolysed with distilled water to release the haemoglobin. The supernatant was removed after centrifuging at 3000 rpm for 5 min and the sample haemoglobin stored until ready for electrophoresis. Cellulose acetate paper strip was used to separate the globin fractions. Electrophoresis was carried out in Shandon electrophoresis tank on cellulose acetate strips 34.5 x 150 with 0.26MTris buffer (pH 9.1) at the anode and cathode. The strips were run for 5 minutes at a constant voltage of 250v until a clear separation was observed. Interpretations were made based on the relative mobility of the haemoglobin bands towards the anode. The genotype that migrated faster was labeled HbAA, the slow moving fraction was identified as HbBB. The double band, consisting of both fast and slow band; was labeled HbAB as described by Khanolkar *et al*., 1963; Tella *et al*., 2000; and Das *et al*., 2004.

Hematocrit value (%) was determined by the microhematocrite method as described by Burtis and Ashwood (1994); the blood samples were centrifuged at 10,000 rpm for 5mins within two hours after the blood samples were collected. The haemoglobin concentration was determined by cyanmethemoglobin method. The potassium and sodium concentrations in the blood were determined by colorimetric method using spectrophotometer. The erythrocyte potassium (Ke) below or equals to 13.00mmol/L was labeled Low Potassium (LK). Conversely, the erythrocyte potassium above 13mmol/L was tacked High Potassium (HK): (Galip and Elmaci, 2001). Total protein was obtained using Biuret method as explained by Tietz 1995. Glucose level was determined after enzymatic oxidation in the presence of glucose oxidase as described by Barham

and Trinder (1972). Measurement of albumin was based on its quantitative binding to the indicator 3, 3, 5, 5 – tetrabromo- m cresol sulphonephthalein (bromocresol green, BCG) (Grant *et al*., 1987). Globulin concentration was calculated from total protein and albumin, by subtracting albumin from total protein.

3.5 Statistical Analysis

The data generated from the study were analysed using General Linear Model (GLM) procedure of SAS (SAS, 2000). The model incorporated Hb-type, K-type, Parity, age, breed and coat colour as fixed factors while milk yield characteristics, udder and conformation traits and blood biochemical profiles were the dependent variables. Duncan Multiple Range Test (DMRT) procedure of SAS was used to separate the significant means. The linear model was as follows:

$Y_{ijln} = \mu + H_i + K_j + P_l + B_n + E_{ijln}$

Where

Y_{ijln} = Measurement on traits

μ = Population mean

H_i = Effect of i^{th}haemoglobin types (i = AA, AB, BB,)

K_j = Effect of j^{th} potassium types (j = Lk, Hk)

P_l = Effect of l^{th}Parity (l = 1, 2, 3, 4, 5, 6)

B_n = Effect of n^{th} Breed (n = RS, BW, CRS, KB)

E_{ijln} = Random error effect

The t-test analysis was used to test the differences between the two locations. All correlation coefficients and test of significance were done using SAS (2000).

Haemoglobin genotype and gene frequencies were estimated as follows:

$$\text{Genotypic frequency of AA} = \frac{\text{No of individuals with AA x 100}}{\text{No of individuals Sampled}}$$

$$\text{Genotypic frequency of AB} = \frac{\text{No of individuals with AB x 100}}{\text{No of individuals Sampled}}$$

$$\text{Genotypic frequency of BB} = \frac{\text{No of individuals with BB x 100}}{\text{No of individuals Sampled}}$$

$$\text{Allelic frequency of A} = \frac{\text{AAx2 + AB}}{\text{Total no. of alleles}}$$

$$\text{Allelic frequency of B} = \frac{\text{BBx2 + AB}}{\text{Total no. of alleles}}$$

Expected genotypic frequency was calculated using the formula $p^2 + 2pq + q^2 = 1$

While the genotypic frequencies for potassium types were estimated using the square root method as defined by Cotterman (1954). Based on this method, the homozygote genotypic frequency was found by taking the square root of homozygote recessive gene frequency, and HK alleles were dominant over LK alleles.

Chi- square test was used to estimate the conformation mode of the goat population to the Hardy-Weinberg genetic equilibrium.

The empirical formula used was $\chi 2 = \Sigma \frac{(\text{observed} - \text{expected})2}{\text{Expected}}$

The combined effect of haemoglobin genotype, potassium type and coat colour (Hb - K - coat colour) on milk yield and body conformation characteristics was further analysed using GLM procedure of SAS (2000), the model used was

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

Where μ = overall mean

α_j = Effect of i^{th}K- Hb –CC combinations (i=AAHKW, AAHKDB, AAHKBW, ABHKW, ABHKDB, ABHKBW, BBHKDB, BBHKBW)

e_{ijk} = random error



Fig 5: crosses/ brown and white coat colour



Fig 6: Red Sokoto/dark brown coat colour



Fig. 7: Red Sokoto/brown and black coat colour



Fig.8: Sahel/white coat colour



Fig 9: Kano Brown/light brown colour

CHAPTER FOUR

4.0 RESULTS

4.1 Milk yield characteristics

The mean values and coefficient of variation (CV) for milk yield characteristics of goats in Jigawa State are presented in Table 4.1, the results indicate that average daily yield (ADY) was 247.07g; total yield (TY) 32.34kg; initial yield (IY) 254.07g; peak day (PD) 31.273ays; peak yield (PY) 342.27; lactation length (LL) 130.07 days and last day yield (LDY) 107g. Measures of milk yield capacity in goats exhibited low to moderate variability, varying from 4.43 to 16.42, (Table 4.1). The lowest variability was recorded for lactation length while the highest was peak day. In Katsina State, the mean values for milk yield characteristics were 255.10g, 25.62kg, 213.75g, 35.99days, 373.11g, 100.54days and 105.56g for ADY, TY, IY, PD, PY, LL and LDY, respectively (Table 4.2). The variability in these traits were low to moderate (5.17 – 22.19), the most variable trait was PD while the least was recorded for LDY.

Table 4.1: Mean values of lactation performance of goats in Jigawa State

Characteristics	No	Means(±s.e)	CV(%)	MIN	MAX
ADY(g)	150	247.07±2.06	7.98	177.50	307.73
TY(kg)	150	32.34±0.34	10.66	21.91	45.24
IY(g)	150	254.07±3.33	12.10	160.00	390.00
PD(days)	150	31.27±0.36	16.42	21.00	67.00
PY(g)	150	342.27±3.52	10.79	240.00	490.00
LL(days)	150	130.07±0.45	4.43	122.00	154.00
LDY(g)	150	107.00±0.05	5.81	100.00	130.00

ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, MIN = Minimum, MAX = Maximum

Table 4.2: Mean values of lactation performance goats in Katsina State

Characteristics	No	Means	CV	MIN	MAX
ADY(g)	100	255.10±3.27	12.80	182.00	339.00
TY(kg)	100	25.62±0.49	19.30	15.66	36.86
IY(g)	100	213.75±3.41	15.95	100.00	300.00
PY(days)	100	35.99±0.79	22.19	21.00	63.00
PY(g)	100	373.11±6.62	17.77	220.00	550.00
LL(days)	100	100.54±1.00	9.57	77.00	122.00
LDY(g)	100	105.56±0.54	5.17	100.00	120.00

ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, MIN = Minimum, MAX = Maximum

The overall mean values for milk yield characteristics in the 2 states are shown in Table 4.3. The results indicate that ADY, TY, IY, PD, PY, LL and LDY were 248.22g, 29.56kg, 243.57, 33.04 days, 358.73g, 118.26 days and 106.69g, respectively. The overall milk yield traits were of low to moderate variability (5.97 – 21.14). The highest variability was recorded for PD while the lowest was recorded for LDY. Table 4.4 shows the mean values of milk yield characteristics of goat according to location. The results indicate that there were significant ($P<0.05$) differences in all the parameters measured in the two locations except for ADY and LDY. Jigawa state was superior in TY, IY and LL, while Katsina state was superior in ADY, PD and PY.

Table 4.3: Mean values of lactation performance of goats in Jigawa and Katsina States

Characteristics	No	Means(±s.e)	CV %	Min	Maxi
ADY(g)	250	248.22 ± 1.85	11.51	177.50	339.00
TY(kg)	250	29.56 ± 0.39	21.05	15.66	45.24
IY(g)	250	243.57 ± 3.12	20.35	100.00	390.00
PD(days)	250	33.04 ± 0.44	21.14	21.000	67.00
PY(g)	250	358.73 ± 3.73	16.17	220.00	550.00
LL(days)	250	118.26 ± 1.04	13.84	77.00	150.00
LDY(g)	250	106.69± 0.42	5.97	100.00	130.00

ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, MIN = Minimum, MAX = Maximum

4.4 Lactation performance of goats across location (Jigawa and Katsina States)

Milk yield characteristics	Jigawa	Katsina	LOS
ADY(g)	247.07±2.12	255.10±3.27	NS
TY(kg)	34.98 ± 2.07^{a}	25.01 ± 0.49^{b}	**
IY(g)	263.46 ± 3.92^{a}	220.51 ± 3.40^{b}	**
PD(days)	31.08 ± 0.08^{b}	35.99 ± 0.79^{a}	**
PY(g)	349.12 ± 4.20^{b}	386.28 ± 6.62^{a}	**
LL(days)	130.07 ± 0.45^{a}	100.50 ± 1.00^{b}	**
LDY(g)	107.44 ± 0.55^{a}	105.56 ± 0.54^{b}	**

**= $p<0.05$; a,b = means within the same row with different superscripts differ significantly, ns = not significant, LOS = level of significant; ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield,

Milk yield characteristics were significantly ($P<0.05$) influenced by Age (Table 4.5). Howeever, the results indicate non-significant ($P>0.05$) effect of parity on peak day and last test day yield (Tables 4.5). Also breed of doe had significant ($P<0.05$) effect on all the milk yield parameters measured except on PD and LDY (Table 4.6).

Table 4.5: Effect of parity on lactation performance of goats in Jigawa and Katsina States (means ±s.e)

parity	No	ADY	TY (kg)	IY	PD	PY	LL	LDY
		*	*	*		*	*	
1	48	208.15±4.67^{c}	26.70±0.77^{c}	202.18±7.57^{b}	30.49±0.82	285.64±7.98^{b}	126.85±1.01^{c}	103.18±1.06
2	56	253.83±4.04^{b}	33.06±0.66^{b}	265.08±6.55^{a}	32.67±0.72	352.10±6.91^{a}	130.73±0.87^{ab}	109.14±0.92
3	57	268.76±4.26^{a}	36.37±0.69^{a}	272.02±6.89^{a}	31.81±0.75	367.34±7.27^{a}	134.32±0.92^{a}	108.00±0.97
4	48	258.36±7.79^{b}	33.45±1.28^{b}	257.71±12.63^{a}	29.50±1.38	355.36±13.32^{a}	129.50±1.69^{b}	105.71±1.78
5	26	255.00±8.79^{b}	33.35±1.44^{b}	272.09±14.25^{a}	30.36±1.56	351.64±15.03^{a}	131.18±1.90^{ab}	108.00±2.01
6	15	248.93±4.73^{b}	32.86±0.78^{b}	263.53±7.66^{a}	30.42±0.84	353.79±8.09^{a}	131.32±1.02^{ab}	106.95±1.08

a, b, c = column means under the same factor with different letters differ significantly; .ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield

Table 4.6: Mean values (±s.e) of milk yield characteristics of goats in Jigawa and Katsina States according to breed

Breed	No	ADY	TY (kg)	IY	PD	PY	LL	LDY
		*	*			*		
Crosses	69	248.76 ±2.90[a]	33.18 ±0.48[a]	257.93 ±4.72	31.26 ±0.51	343.36 ±4.96[a]	133.01 ±0.63[a]	107.12 ±0.66
Sahel	11	236.03 ±11.91[b]	30.86 ±1.95[b]	235.00 ±19.29	30.17 ±2.11	309.17 ±20.35[b]	130.50 ±2.57[b]	103.00 ±2.72
Red sokoto	158	246.79 ±3.09[a]	32.03 ±0.51[a]	251.21 ±5.00	31.28 ±0.55	345.49 ±5.28[a]	131.94 ±0.67[a]	107.42 ±0.70
KB	12	231.25 ±13.05[b]	29.94 ±2.14[b]	250.00 ±21.13	32.80 ±2.31	343.00 ±22.29[a]	127.40 ±2.82b	102.00 ±2.97

*P < 0.05 a, b = column means under the same factor with different letters differ significantly; ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, KB = Kano Brown

The effect of parity on milk yield characteristics indicated that does in their 3rd parity were significantly ($P<0.05$) superior to does in parities 1, but similar to does in parity 2, 4, 5, and 6 in terms of IY and PY, but parity 3 was superior to other parites in ADY and TY(Table 4.5).

The effect of breed on lactaction performance is shown in Table 4.6. The results indicate that breed of doe influenced ADY, TY, PY and LL, the Red Sokoto and the Crosses had significantly ($P<0.05$) higher values than the Sahel and Kano Brown.

The estimates of phenotypic correlations between milk yield characteristics in this study are shown in Table 4.7. Highly positive and significant ($P<0.01$; $r = 0.216$-0.926) correlations were observed among the lactation characteristics. However, negative correlation was observed between IY and PY, while very low relationships were observed between PD and all other milk yield characteristics. Average daily yield had positive and high correlation with all other parameters measured except peak day. Total yield also had positive and high correlation with other parameters except peak day.

Initial milk yield had a high and positive correlation with peak yield, but low and negative correlation with peak day and had no significant ($P>0.05$) correlation with lactation length and last day yield. Peak yield had positive ($P<0.05$) correlation with last day yield, but had non-significant ($P<0.05$) correlation with lactation length. Lactation length had significant ($P<0.05$) correlation with last day yield.

Table 4.7: Phenotypic correlation between the milk yield characteristics of goats in Jigawa and Katsina States

Characteristics	ADY	TY	IY	PD	PY	LL
TY	0.926**					
IY	0.713**	0.625**				
PD	0.442**	0.053	-0.162			
PY	0.820**	0.727**	0.702**	0.005		
LL	0.425**	0.609**	0.108	0.085	0.196	
LDY	0.389*	0.375*	0.286*	0.065	0.311*	0.261*

**P < 0.01, *P < 0.05; ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield,

4.2 Udder characteristics

The means and coefficient of variation (CV) of udder characteristics of goats in Jigawa and Katsina States are shown in Table 4.8. The results indicate that udder characteristics averaged, 12.39cm, 31.87cm, 8.76cm, 3.52cm and 5.00cm for udder height, udder circumstance, distance between teat, teat length and teat circumference, respectively. The traits showed low to moderate variability. The Lowest variability was recorded for udder height (10.67%), while the highest was teat length (22.58%).

Table 4.8: Udder characteristics (cm) of Lactating goats in Jigawa and Katsina states (mean±s.e)
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CHARACTERISTICS	NO	MEANS (±s.e)	CV(%)	MIN	MAX
UH	250	12.39±0.12	10.67	9.00	17.00
UC	250	31.87±0.41	10.72	20.00	45.00
DT	250	8.76±0.15	20.36	4.00	13.00
TL	250	3.52±0.09	22.58	2.00	8.00
TC	250	5.00±0.08	15.73	3.00	8.00

UH= udder height, UC= udder circumference, DT= distance between teat, TL= teat length, TC= teat circumference

Parity and breed significantly (P<0.05) affected udder characteristics (Tables 4.9 and 4.10). Differences were observed in the parity of does, the result showed that udder height and teat length were longer and udder and teat circumference were larger in parities 3, 4, 5 and 6, than parities 1 and 2 (Table 4.9).

Table 4.9: Mean values (±s.e) for Udder conformation traits (cm) of goats in Jigawa and Katsina States according parity

parity	No	UH	UC	DT	TL	TC
		*	*	*	*	*
1	48	10.87±0.26^{c}	25.21±0.92^{d}	8.09±0.33^{c}	2.08±0.21^{c}	3.79±0.18^{d}
2	56	11.98±0.23^{b}	29.40±0.79^{c}	8.16±0.28^{c}	2.79±0.18^{bc}	4.63±0.15^{c}
3	57	12.66±0.24^{b}	33.87±0.84^{b}	8.68±0.29^{bc}	3.90±0.19^{ab}	5.28±0.16^{b}
4	48	13.03±0.27^{a}	34.87±0.93^{b}	9.58±0.33^{b}	4.45±0.21^{b}	5.74±0.18^{a}
5	26	13.71±0.44^{a}	39.86±1.54^{a}	8.96±0.55^{bc}	5.21±0.35^{a}	5.96±0.29^{a}
6	15	14.64±0.50^{a}	40.55±1.74^{a}	11.27±0.63^{a}	5.23±0.39^{a}	6.14±0.33^{a}

*P < 0.05; a, b, c, d = column means under the same factor with different superscripts differ significantly. UH = Udder Height, UC = Udder Circumference, DT = Distance between Teat, TL =Teat Length, TC = Teat Circumference

Table 4.10: Udder conformation traits (cm) of goats in Jigawa and Katsina States according to breeds (mean ±s.e)

Factor		No	UH	UC	DT	TL	TC
			*	*		*	*
Breed	Crosses	69	12.97±0.16[a]	32.07±0.57[a]	8.69±0.20	3.57±0.11[a]	5.01±0.11[a]
	Sahel	11	11.33±0.68[b]	28.00±2.35[b]	8.17±0.84	3.92±0.57[a]	5.50±0.45[a]
	Red sokoto	158	12.65±0.18[a]	32.09±0.61[a]	8.97±0.22	3.50±0.14[a]	5.03±0.12[a]
	Kano brown	12	11.40±0.75[b]	28.40±2.57[b]	7.40±0.92	2.80±0.59[b]	3.80±0.49[b]

*P < 0.05; a, b = column means under the same factor with different superscripts differ significantly. UH = Udder Height, UC = Udder Circumference, DT = Distance between Teat, TL =Teat Length, TC = Teat Circumference .

The phenotypic correlations amongst udder characteristics in this study are shown in Table 4.11.

The correlations amongst udder characteristics were moderate to high and significantly ($p<0.05$; $r = 0.211$-0.647) positive.

Table 4.11: Coefficient of phenotypic correlation amongst the udder characteristics of Lactating goats in Jigawa and Katsina States

Characteristics	UH	UC	DT	TL
UC	0.647**			
DT	0.211	0.375**		
TL	0.503**	0.602**	0.243	
TC	0.437**	0.542**	0.216	0.653**

**P < 0.01; UH = Udder Height, UC = Udder Circumference, DT = Distance between Teat, TL =Teat Length, TC = Teat Circumference

The correlations between udder conformation traits and milk yield characteristics are shown in Table 4.12. The ranges of positive to negative estimates were observed. Udder height had positive and moderate significant ($p<0.05$) relationship with average daily milk yield, total yield, initial yield, peak yield and lactation length, but had non-significant ($p>0.05$) correlation with peak day and last test day yield. Udder circumference had a high and positive correlation with average daily yield, total yield, initial yield, and peak yield. However, UC was negative and non-significantly ($p>0.05$) correlated with peak day milk yield. Distance between teats had a moderate, but significant ($p<0.05$) correlation with average daily, initial and peak milk yields, and positive but non - significant ($p>0.05$) correlation with total yield and last test day milk yield. It had negative and non- significant correlation with peak day and lactation length. Teat length and circumference were positively and significantly ($P<0.05$) correlated with average daily, total, initial, and peak milk yield (Table 4.12).

Table 4.12: Coefficient of phenotypic correlation between lactation characteristics and udder characteristics of goats in Jigawa Katsina States

Characteristics	ADY	TY	IY	PD	PY	LL	LDY
UH	0.338*	0.339*	0.273*	0.007	0.374*	0.333*	0.072
UC	0.532**	0.470**	0.489**	-0.101	0.559**	0.214	0.111
DT	0.254*	0.179	0.299*	-0.007	0.249*	-0.069	0.094
TL	0.331*	0.328*	0.215	-0.063	0.317*	0.219	0.208
TC	0.310*	0.316*	0.296*	-0.020	0.279*	0.269*	0.056

**P < 0.01, *P < 0.05, ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, UH = Udder Height, UC = Udder Circumference, DT = Distance between Teat, TL =Teat Length, TC = Teat Circumference

4.3 Body Conformation Traits

The means and CV values for conformation traits of goats in the two states are shown in Table 4.13. The results indicate that body weight (BWT), stature (ST), body depth (BD), height at wither (HW), Heart girth (HG) and body length (BL) were 28.84cm, 65.43cm, 79.04cm, 60.82cm, 69.83cm and 60.68cm, respectively. The traits had low variability (6.97-17.17%). The lowest variability was recorded for stature; while the highest was body weight. The mean values of conformation traits of goats according to location is shown in Table 4.14, the results indicate that there were no significant (P□0.05) difference in all the parameter measure except in body weight, in which Jiawa state was superior to Katsina.

Table 4.13: Conformation traits (cm) of goats in Jigawa and Katsina States (mean±s.e)

CHARACTERISTICS	NO	MEANS (±s.e)	CV(%)	MIN	MAX
BWT	250	28.84±0.41	17.17	17.00	58.00
ST	250	65.43±0.39	6.97	49.00	78.00
BD	250	79.04±0.66	10.30	54.00	108.00
HW	250	60.82±0.39	7.73	44.00	76.00
HG	250	69.83±0.51	8.51	51.00	98.00
BL	250	60.68±0.42	8.57	46.00	91.00

BWT = Body Weight, ST = Stature, BD = Body Depth, HW = Height at Wither, GH = Heart Girth, BL = Body Length, MIN = minimum, MAX = maximum

Table 4.14: Body conformation traits of goats according to location (means±se)

Location	No	BWT	ST	BD	HG	BL	HW
Jigawa	150	29.67±0.47[a]	68.25±1.56	80.44±0.21	70.78±0.60	60.68±0.45	60.82±0.46
Katsina	100	24.86±0.52[b]	65.51±1.46	78.51±1.19	69.83±0.64	56.82±86	59.41±0.51
LOS		*	NS	NS	NS	NS	NS

* = $p<0.05$; a,b = means within the same column with different superscripts differ significantly, n= no of observation; ns = not significant, LOS = level of significant

Parity of doe significantly (P<0.05) influenced all body conformation traits while breed of does similarly influenced BWT and HG (Table 4.15).

Table 4.15: Body conformation characteristics in goats of Jigawa State and Katsina states according to parity and breed (means±se)

Factor		No	BWT	ST	BD	HW	HG	BL
			*	*	*	*	*	*
parity	1	48	25.89±0.92^{c}	62.00±0.88^{c}	73.69±1.50^{c}	57.18±0.89^{c}	65.85±1.16^{d}	55.92±0.96^{c}
	2	56	28.62±0.79^{bc}	65.58±0.76^{b}	78.53±1.30^{bc}	61.10±0.77^{b}	69.04±1.00^{cd}	60.35±0.84^{b}
	3	57	28.45±0.84^{bc}	65.40±0.80^{b}	78.35±1.37^{bc}	60.72±0.81^{b}	69.75±1.05^{bc}	61.57±0.88^{ab}
	4	48	30.76±0.93^{b}	67.53±0.89^{ab}	83.03±1.52^{b}	63.00±0.90^{ab}	72.08±1.17^{ab}	62.63±0.98^{ab}
	5	26	29.86±1.54^{b}	66.21±1.46^{ab}	80.50±2.50^{b}	61.14±1.49^{b}	71.14±1.93^{bc}	63.36±1.61^{ab}
	6	15	34.00±1.73^{a}	68.73±1.65^{a}	87.82±2.82^{a}	64.82±1.69^{a}	76.09±2.18^{a}	65.18±1.82^{a}
			*				*	
Breed	Crs	69	28.71±0.57^{a}	65.92±0.55	78.69±0.93	61.55±0.55	69.61±0.72^{ab}	60.21±0.60
	Sahel	11	24.00±2.35^{b}	63.67±2.24	74.83±2.24	59.50±2.27	65.83±2.95^{b}	66.67±2.46
	RS	158	29.27±0.61^{a}	65.03±0.58	79.81±0.99	60.06±0.59	70.24±0.77^{ab}	61.45±0.64
	KB	12	29.40±2.57^{a}	64.60±2.45	77.60±4.19	60.80±2.49	71.60±3.23^{a}	61.40±2.69

*P < 0.05; a, b, c, d = column means under the same factor with different superscripts differ significantly. BWT = Body Weight, ST = Stature, BD = Body Depth, HW = Height at Wither, HG = Heart Girth, BL = Body Length, Crs = crosses, LB=light brown, RS=Red Sokoto, KB= Kano Brown

The phenotypic correlation observed amongst body conformation traits are shown in Table 4.16. Highly positive and significant (P<0.01) correlations (r =0.563-0.911) were found among various body conformation traits. Their correlation with milk yield characteristics is shown in Table 4.17. Ranges of low positive to negative estimates were observed. Body weight was positively and significantly (P < 0.05) correlated with average daily yield, initial yield and peak yield, but negatively correlated with peak day. Low correlations were observed between all body conformation traits measured with LL and LDY. The relationship between HG and LDY was highly positive and significant (r =P < 0.05; r = 0.676).

Table 4.16: Coefficient of phenotypic correlation amongst the Body conformation traits of goats in Jigawa and Katsina States

Characteristics	BWT	ST	BD	HW	HG
ST	0.615**				
BD	0.745**	0.747**			
HW	0.623**	0.851**	0.734**		
HG	0.911**	0.710**	0.819**	0.697**	
BL	0.563**	0.669**	0.646**	0.682**	0.621**

**P < 0.01; BWT = Body Weight, ST = Stature, BD = Body Depth, HW = Height at Wither, HG = Heart Girth, BL = Body Length

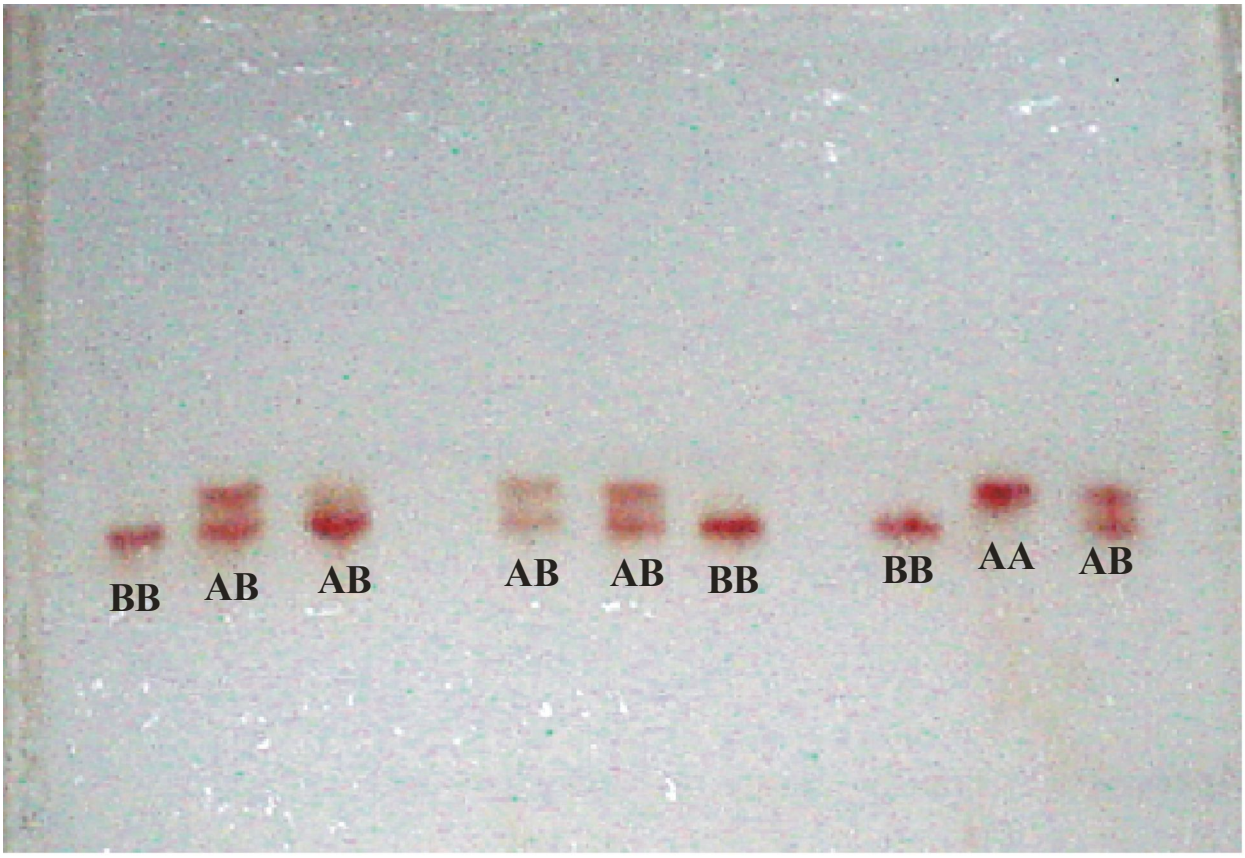
Table 4.17: Coefficient of phenotypic correlation between milk yield and conformation characteristics of goats in Jigawa States

Characteristics	ADY	TY	IY	PD	PY	LL	LDY
BWT	0.245*	0.203	0.384**	-0.105	0.328*	0.009	0.110
ST	0.288*	0.247*	0.389**	-0.105	0.330*	0.068	0.099
BD	0.220	0.163	0.337*	-0.181	0.254*	0.009	0.098
HW	0.293*	0.245*	0.407**	-0.105	0.363**	0.049	0.107
HG	0.254*	0.201	0.403**	-0.113	0.344*	0.001	0.076
BL	0.335*	0.314*	0.399**	-0.082	0.379**	0.137	0.118

**P < 0.01, *P < 0.05, ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, BWT = Body Weight, ST = Stature, BD = Body Depth, HW = Height at Wither, GH = Heart Girth, BL = Body Length

4.4 Electrophoretic haemoglobin pattern

Electrophoresis results showed haemoglobin bands distinct movement toward anodic end of the electrophoretogram and two electrophoretically distinct haemoglobin variants were identified. The fast moving haemoglobin was designated Hb A, while the slow moving HbB. Individual animals possessed either one or both of the haemoglobins and were accordingly designated as HbAA, HbBB or HbAB. All the the three haemoglobin genotypes (HbAA, HbAB, HbBB) were observed in this study.



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Fig 10: Haemoglobin electrophoregram in goats

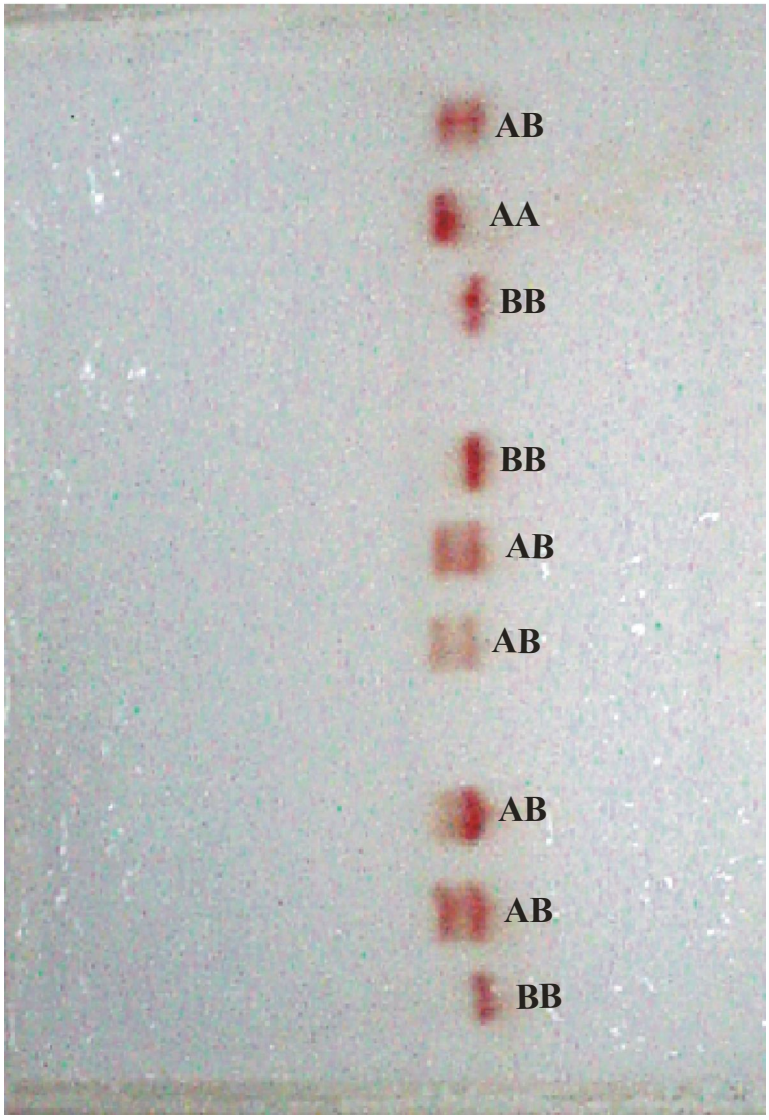


Fig 11: Haemoglobin electrophoregram in goats

4.5 Haemoglobin types, Gene and Genotypic Frequencies

Table 4.18 shows the gene (allelic) and genotypic frequencies of haemoglobin variants of goats in Katsina and Jigawa States. Both states showed similar distribution of haemoglobin alleles. The allelic frequency was higher for HbA than HbB. The genotypic frequencies were 0.47, 0.431 and 0.099 for HbAA, HbAB and HbBB, respectively. The Chi-square test showed that the population as a whole was in Hardy-Weinberg equilibrium (Table 4.19).

Table 4.18: Gene and Genotypic Frequencies of Haemoglobin types of Goats in Jigawa and Katsina States

Population	No of Animals	Gene frequencies		Genotypic Frequencies		
		Hb^A	Hb^B	HbAA	HbAB	HbBB
Overall	250	0.656	0.344	0.432	0.448	0.120
				(108)	(112)	(30)
Katsina	100	0.615	0.385	0.43	0.37	0.20
				(43)	(37)	(20)
Jigawa	150	0.683	0.317	0.433	0.50	0.067
				(65)	(75)	(10)

Figures in parenthesis indicate the number of animals

Table 4.19: Observed and Expected number of Haemoglobin Genotypes of Goats in Jigawa and Katsina State

Population/sample Size	Hb Phenotype	Observed No.	Expected No.	df=2 χ^2
Overall 250	HbAA	108	107.6	0.809^{ns}
	HbAB	112	112.83	
	HbBB	30	29.58	
Katsina 100	HbAA	43	37.82	0.626^{ns}
	HbAB	37	47.36	
	HbBB	20	14.82	
Jigawa 150	HbAA	65	69.97	1.074^{ns}
	HbAB	75	64.95	
	HbBB	10	15.07	

Ns = not significant, *P < 0.001

The phenotypic frequency of HbAB was the highest 44.80%, followed by HbAA 43.20% and the least was HbBB 12% in the overall population (Table 4.20), but in Katsina states the phenotypic frequencies were 43%, 37% and 20% for HbAA, HbAB and HBB, respectively.While in Jigawa, the frequencies were 43.33%, 50.00%, and 6.67% for HbAA, HbAB and HbBB, respectively.

Table 4.20: The Phenotypic Distribution of Goats in Jigawa and Katsina State based on Haemoglobin Types

Hb types	Observed Overall	Frequency	Observed Katsina	Frequency	Observed Jigawa	Frequency
No	250		100		150	
HbAA	108	43.20	43	43	65	43.33
HbAB	112	44.80	37	37	75	50.00
HbBB	30	12.00	20	20	10	6.67

4.6 Potassium Types, Gene and Genotypic Frequencies

Table 4.21 shows the gene and genotypic frequencies of potassium types in goats. The overall gene frequencies were 0.844 and 0.156 for HK and LK, respectively. The gene frequencies were 0.83 and 0.17 in Katsina and 0.853 and 0.146 in Jigawa for HK and LK, respectively. Genotypic frequencies were 0.91 for HK and 0.01 for LK types of animals in the overall population. In Katsina, the genotypic frequencies were 0.91 and 0.01 for HK and LK respectively, and in

Jigawa State the frequencies observed were 0.92 and 0.01for HK and LK respectively. The observed frequencies of potassium types were in Hardy Weinberg equilibrium (Table 4.22).

Table 4.21: Gene and Genotypic Frequencies of potassium types of Goats Jigawa and Katsina States

Population	No of Animals	Gene Frequencies		Genotypic Frequencies	
		HK	LK	K^H	K^L
Overall	250	0.84	0.16	0.91	0.01
Katsina	100	0.83	0.17	0.91	0.01
Jigawa	150	0.85	0.14	0.92	0.01

Table 4.22: Observed and Expected number of Potassium Genotypes of Goats in Jigawa and Katsina States

Population/sample Size	Potassium Phenotype	Observed No.	Expected No.	df=1 χ^2
Overall(250) 250	K^H	211	178.00	0.946^{ns}
	K^L	39	65.78	
Katsina(100)	K^H	83	68.80	0.871^{ns}
	K^L	17	28.2	
Jigawa(150)	K^H	128	109.05	6.747^{ns}
	K^L	22	3.19	

Ns = not significant; p □ 0.001

4.7 Effect of Haemoglobin and Potassium Polymorphism on Milk Yield Characteristics in goats

Table 4.23 shows the mean values of milk yield characteristics of goats on the bases of haemoglobin genotypes and potassium types. Only ADY and PY were significantly ($P<0.05$) influenced by Hb types. Does with HbAA and HbAB were similar and significantly had ($P<0.05$) higher ADY and PY than HbBB. Observation on effect of potassium types on milk yield characteristics indicated that potassium types had no significant ($P>0.05$) effect on all milk yield characteristics measured.

Table 4.23: Lactation characteristics of goats in Jigawa and Katsina States Based on Haemoglobin and potassium Types (mean ±se)

Factor		ADY(g)	TY(kg)	IY(g)	PD(days)	PY(g)	LL(days)	LDY(g)
Hb -type		*				*		
	HbAA	253.70±2.92[a]	30.19±0.59	241.00±4.93	34.60±0.69	359.72±5.66[b]	119.00±1.57	107.13±0.61
	HbAB	257.00±2.76[a]	30.32±0.58	244.42±0.58	32.88±0.67	385.00±38.15[a]	118.73±1.54	106.17±0.60
	HbBB	240.55±5.55[b]	27.32±1.13	247.43±9.20	32.79±1.27	350.170±7.89[b]	113.60±2.99	106.96±1.16
K-type								
	HK	248.41±2.01	29.65±0.59	244.36±3.39	33.09±0.47	360.41±4.05	118.32±1.12	106.94±0.43
	LK	247.19±4.69	29.25±0.99	239.33±7.90	32.80±1.11	349.64±9.43	117.87±2.62	106.64±1.01

ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, Hb-type = haemoglobin type, K-type = potassium types

4.8 Effect of Haemoglobin and Potassium Polymorphism on Blood biochemical profiles in goats

Table 4.24 shows the blood biochemical profiles of goats based on haemoglobin and potassium types. Hb types significantly ($P<0.05$) influenced PCV and HB. Animal with HbAA had significantly ($P<0.05$) higher PCV values than those with HbAB and HbBB which were similar. Haemoglobin concentration (HB) was also significantly influenced by Hb types. Animals with HbAA had significantly ($P<0.05$) higher concentration of haemoglobin (HB) than animals with HbAB and HbBB. Hb-types had no significant ($P>0.05$) influence on Na, total protein, albumin, globulin and glucose.

On the other hand potassium types had no significant ($P>0.05$) effect on all the blood biochemical profiles measured except on Na. HK animals had significantly ($P<0.05$) lower Na concentration than LK potassium animals.

Table 4.24: Blood biochemical profiles of Goats in Jigawa and Katsina states according to heamoglobin and potassium types (mean±se)

Factor		PCV %	HB g/dl	Na Mmol/L	Total protein g/L	Albumin g/L	Globulin g/L	Glucose g/L
H-type	HbAA	29.95±0.42[a]	10.00±0.15[a]	133.76±0.64	65.25±0.76	31.34±0.56	34.00±0.92	4.46±0.06
	HbAB	27.36±0.42[b]	9.12±0.15[b]	136.68±0.63	64.09±0.74	31.47±0.55	32.64±0.90	4.48±0.06
	HbBB	27.33±0.81[b]	9.11±0.28[b]	137.67±1.22	62.87±1.43	31.10±1.10	31.77±1.74	4.31±0.12
K – type	HK	28.32±0.31	9.45±0.11	134.03±0.46[b]	64.56±0.54	31.39±0.39	33.62±0.66	4.48±0.05
	LK	29.31±0.71	9.76±0.25	138.41±1.03[a]	63.85±1.26	33.39±39	30.46±1.53	4.25±0.20

H-ty pe= heamoglobin type, K-type = potassium type, PCV = pack cell volume,HB = heamoglobin concentration, Na = Sodium

4.9 Blood Biochemical Profiles in Goats

The means and CV for concentration of blood biochemical profiles are presented in Table 4.25. Average PCV, HB, Na, total protein, albumin, globulin and glucose were 28.48%, 9.49g/dl, 136.40mmol/l, 64.44g/L, 31.12g/L, 33.12g/L and 4.44g/L, respectively. Measures of blood biochemical profile exhibited low-moderate variability: from 6.02 to 28.72 (Table 4.25). The lowest variability was recorded for Na concentration while the highest was globulin concentration. There were no significant ($P>0.05$) difference between blood biochemical profiles of goats across locations (Table 4.26).

Table 4.25: Blood Biochemical profiles of goats in Katsina and Jigawa States (Mean±se)

Characteristic	No	Mean±se	CV	Min	Max
PCV (%)	250	28.48±0.28	15.03	4.00	42.00
HB (g/dl)	250	9.49±0.09	15.58	4.66	14.00
Na (Mmol/L)	250	136.40±0.42	6.02	125.00	141.00
TP (g/L)	250	64.44±0.49	12.21	46.00	94.00
Albumin (g/L)	250	31.12±0.37	18.32	20.00	51.00
Globulin (g/L)	250	33.12±0.60	28.72	13.00	65.00
Glucose (g/l)	250	4.45±0.04	14.92	2.80	6.60

PCV = pack cell volume, HB =haemoglobin concentration, Na = sodium, TP = Total protein

4.26: Blood biochemical profiles of goats according to location (Means ± se)

Blood biochemical profiles	Jigawa	Katsina	LOS
HB	8.98±0.12[b]	10.27±0.13[a]	**
PCV	26.91±0.33[b]	30.86±0.39[a]	**
K	19.95±1.39	18.48±0.39	ns
Na	138.36±0.54	136.96±0.64	Ns
Total protein	65.27±0.60	63.20±0.83	Ns
Albumin	31.28±0.50	31.50±0.51	Ns
Globulin	34.07±0.74	31.70±0.99	Ns
glucose	4.67±0.04	4.11±0.09	Ns

**= p<0.001; a,b = means within the same row with different superscripts differ significantly, n= no of observation; ns = not significant, LOS = level of significant

4.9.1 Blood Biochemical Profiles and Goat Breeds

Breed of does had non-significant (P□0.05) effect on all the blood biochemical profiles measured except Na, total protein and albumin (Table 4.27). Na concentrations in Kano brown was significant (P□0.05) higher than Sahel, but statistically similar to other breeds. The Sahelian goats had the highest total protein and was significantly (P<0.05) higher than the concentration in the crosses, but similar to the concentration in the Red Sokoto and Kano Brown.

Phenotypic correlation between blood biochemical profiles and milk yield characteristics in goats are presents in Table 4.28. PCV had significantly (P<0.05) low, but positive correlation with ADY, TY and IY. It also had positive though not significant relationship with PD and PY,

but a negative correlation with LL and LDY. HB had a positive and significant ($P<0.05$) relationship with TY, non- significant, though positive relationship with PD and PY but negative correlation with IY, LL and LDY. Na concentration had negative correlation with all the milk yield characteristics measured. Total protein had positive and significant ($P<0.05$) relationship with IY and LL, positive though not significant correlation with ADY and TY, but negative correlation with PD, PY and LDY. Albumin had negative correlations with all the milk yield characteristics measured. Globulin had negative correlations with ADY ($r = -0.101$) and PY ($r =-0.066$), but had very low and positive correlation with every other trait measured. Glucose had a positive and significant ($P<0.05$) correlation with LL, positive though not significant relationship with ADY, TY, IY and LDY, but was negatively correlated with PD and PY. The phenotypic correlation among blood biochemical profiles are shown in Table 4.29. Positive and significant ($P < 0.05$) correlations were observed between PCV and HB; HB and albumin; Total protein with albumin and globulin. But albumin was significant ($P < 0.05$) but negatively correlated with globulin.

Table 4.27: Mean values (±se) of Blood biochemical Profiles of Goats in Jigawa and Katsina States according to breed

Factor		PCV	HB	Na	Total protein	Albumin	Globulin	Glucose
Breed	Crs	26.87±0.51	8.96±0.18	133.67±0.77^{ab}	64.09±0.91^{b}	31.71±0.67^{ab}	32.56±1.10	4.720±0.08
	Sh	26.67±2.57	8.89±0.89	125.67±387^{b}	73.00±4.55^{a}	35.67±3.34^{a}	37.33±5.53	4.800±0.39
	RS	29.28±1.99	9.77±0.77	135.26±0.52^{ab}	64.45±0.61^{ab}	31.36±0.45^{ab}	33.09±0.85	4.325±0.06
	Kb	25.60±2.10	8.53±8.53	139.20±3.00^{a}	66.20±3.53^{ab}	25.60±2.59^{b}	32.56±4.29	4.200±0.31

*P < 0.05; a, b, = column means under the same factor with different superscripts differ significantly, Crs = crosses; Sh = Sahel; RS = Red Sokoto; Kb = Kano brown; PCV = pack cell volume; HB = haemoglobin concentration; Na= Sodium

Table 4.28: Coefficients of Phenotypic Correlation between Blood Biochemical Profiles and lactation Characteristics in Goats

Characteristics	PCV	HB	Na	TP	Albumine	Globulin	Glucose
ADY	0.284*	0.289*	-0.024	0.166	-0.051	-0.101	0.122
TY	0.247*	0.291*	-0.218	0.006	-0.028	0.019	0.194
IY	0.291*	-0.251	-0.176	0.401*	-0.034	0.049	0.218
PD	0.176	0.149	-0.099	-0.038	-0.038	0.018	-0.151
PY	0.092	0.096	-0.036	-0.112	-0.055	-0.066	-0.194
LL	-0.381	-0.360	-0.193	0.720**	-0.023	0.076	0.346*
LDY	-0.075	-0.075	-0.177	-0.002	-0.012	0.005	0.059

*P < 0.05, ADY = Average Daily Yield, TY = Total Yield, IY = Initial Yield, PD = Peak Day, PY =Peak Yield, LL = Lactation Length, LDY = Last Day Yield, PCV = pack cell volume, HB =haemoglobin concentration, Na = sodium, TP = total protein

Table 4.29: Coefficients of Phenotypic Correlation amongst Blood Biochemical Profiles in Goats

Characteristics	PCV	HB	Na	TP	Albumine	Globulin
Hbcon	0.962**					
Na	0.058	0.041				
TP	-0.102	-0.069	0.125			
Albumine	0.064	0.510**	0.057	0.454*		
Globulin	-0.120	-0.085	0.067	0.796**	-0.563*	
Glucose	-0.105	-0.106	-0.154	-0.029	0.147	-0.117

*P < 0.05, **P < 0.01, PCV = pack cell volume, HB =haemoglobin concentration, Na = sodium, TP = total protein

4.10 Polymorphic genes as suitable genetic markers

The variation of mean values of body conformation and milk yield traits with combined haemo-potassium type (Hb-K type) is shown in Table 4.30. The combined effect of haemoglobin and potassium types on body conformation traits was significant ($P<0.05$) except on HG. It was identified that goats with homozygote Hb allele AA and high potassium (HK) were heavier (BWT) and longer (BL) than the other Hb-K types, while those with homozygote Hb allele AA and low potassium (LK) were lighter in weight (BWT) and shorter in length (BL) and had lower milk yield than their counterpart with other Hb-K combinations. However, does whose Hb-K type was HbAB and HK, respectively had the highest milk yield.

The combined effect of haemoglobin type and coat colour (Hb-CC) on body conformation and milk yield traits is shown in Table 4.31. The combined effect of Hb-CC on body conformation traits was not significant ($P>0.05$) except on BWT. The white coat colour goats with homozygote Hb type AA (AAW) had higher BWT, while those with heterozygote Hb type AB (ABW) had the lowest BWT. The combined effect of Hb-CC on milk yield characteristics was significant ($P<0.05$) except on TY. All goats with brown-white (BW) CC irrespective of their Hb types had higher PY and longer LL, while those with dark brown (DB) coat colour had higher ADY and PY. Goats with white CC irrespective of their Hb type had lower milk yield characteristics.

The variation of mean values of body conformation and milk yield traits with combined potassium and coat colour type (K-CC type) is shown in Table 4.32. The combined effect of K and CC type (K-CC type) on body conformation traits was not significant ($P<0.05$) except on BWT. Goats with white coat colour and high potassium (HKW) had higher BWT than the other K-CC type, while the dark brown coat colour (DB) goats irrespective of their K-type had the

lowest BWT. The combined effect of K-CC type on milk yield characteristics was significant ($P<0.05$) except ADY and TY. Does with high potassium and black brown coat colour (HKBB) had the longest LL, while those with high K and white coat colour (HKW) had the shortest LL. The dark brown coat colour goats, irrespective of their K type (HKDB and LKDB) had higher PY than the other K-CC types.

The combined effect of haemoglobin, potassium and coat colour type (Hb-K-CC type) on milk yield characteristics was not significant ($P>0.05$) except on IY and LL. The brown white (BW) coat colour goats with homozygote Hb type AA and heterozygote AB with high potassium HK (AAHKBW and ABHKBW) had higher TY and longer LL than the other HB-K-CC types, while those with dark brown (DB) coat colour and high K, irrespective of Hb type (AAHKDB, ABHKDB and BBHKDB) had lower IY and shorter LL (Table 4.33).

Table 4.30: Body conformation and lactation characteristicss of goats in Jigawa and Katsina States in relation to heamoglobin and potassium types combinations (mean±se)

CMT	OBS	BWT	HG	BL	ADY	TY	IY	PY	LL
AAHK	90	29.142±0.23^{a}	71.79±0.39	68.23±3.35^{a}	253.91±0.31^{b}	30.30±0.22	240.92±0.55	360.77±6.32^{b}	119.34±1.72^{a}
AALK	18	28.53±0.33^{ab}	70.09±0.08	60.25±0.55^{ab}	254.34±1.58^{b}	28.06±1.14	245.11±2.74	354.50±3.18^{b}	110.33±3.77^{a}
ABHK	95	27.72±0.06^{ab}	70.42±0.07	59.41±0.12^{ab}	284.79±9.49^{a}	33.69±0.79	253.95±1.89	430.00±19.06^{a}	118.27±1.67^{a}
ABLK	17	26.55±0.35^{ab}	67.97±0.41	59.82±0.59^{ab}	234.86±1.67^{b}	29.16±1.21	241.29±2.89	337.35±3.36^{b}	123.92±3.96^{a}
BBHK	26	27.53±0.07^{ab}	70.79±0.27	60.85±0.39^{ab}	256.03±1.09^{b}	31.24±0.21	244.99±0.51	388.27±2.20^{ab}	122.00±3.20$_{a}$

AAHK=Combination of HbAA and HK, AALK=Combination of HbAA and LK, ABHK= Combination of HbAB and HK, ABLK= Combination of HbAB and LK, BBHK= Combination of HbBB and HK, CMT = combinations, obs = observation, BWT = Body weight, HG = Heart girth, BL = Body length, ADY = Average daily yield, TY= Total yield, IY= Initial yield, PD= Peak day, PY= Peak yield a, b, = column means under the same factor with different superscripts differ significantly.

Table 4.31: Body conformation and lactation characteristicss of goats in Jigawa and Katsina States in relation to heamomoglobin types and coat colours combinations (mean±s.e)

Combination	obs	BWT	HG	BL	ADY	TY	IY	PY	LL
AABB	6	33.33±1.96^{ab}	71.66±2.36	58.33±3.34	249.50±9.52^{ab}	23.41±9.52	271.00±15.20^{ab}	370.00±19.08^{a}	94.00±3.67^{b}
AADB	65	26.49±0.09^{ab}	70.30±0.10	57.34±0.14	254.72±0.41^{a}	28.91±0.30	226.37±0.67^{b}	366.12±0.84^{a}	113.51±1.72^{ab}
AAW	6	36.33±1.96^{a}	76.93±33	72.00±10.03	227.74±9.52^{ab}	26.82±6.8	243.33±15.20^{ab}	323.33±19^{ab}	117.43±8.21^{ab}
AABW	31	29.28±0.18^{ab}	70.16±0.22	59.88±0.31	254.52±0.89^{a}	32.48±0.63	269.34±1.42^{ab}	350.28±0.22^{a}	126.00±2.51^{a}
ABDB	63	26.71±0.08^{ab}	70.204±0.09	59.09±0.14	258.77±1.24^{a}	33.51±4.08	233.25±0.64^{ab}	395.87±2.48^{a}	129.50±1.65^{a}
ABBW	33	29.25±0.16^{ab}	69.80±0.19	60.67±0.27	241.65±0.79^{ab}	30.87±0.56	319.60±9.12^{a}	343.75±1.59^{a}	127.75±2.36^{a}
ABLB	8	29.75±1.47^{ab}	71.75±1.77	58.75±2.50	234.18±7.14^{ab}	25.49±5.10	242.50±11.40^{ab}	341.25±14.31^{a}	108.87±7.10^{ab}
BBDB	20	27.39±0.25^{ab}	69.26±0.31	60.38±0.43	241.68±0.40^{ab}	22.71±0.88	235.43±1.98^{ab}	355.24±0.80^{a}	94.00±2.96^{b}
BBBW	5	34.00±1.18^{ab}	76.80±1.41	65.20±2.00	238.54±5.71^{ab}	27.53±0.28	268.19±1.26^{ab}	386.00±11.45^{a}	116.20±6.37^{a}

AABB= combination of HbAA and brown/black colour, AADB= combination of HbAA and dark brown colour, AAW= combination of HbAA and White colour, AABW = combination of HbAA and brown/white colour, ABDB = combination of HbAB and dark brown colour, ABBW = combination of HbAB and brown/white colour, ABLB = combination of HbAB and light brown colour,BBDB= combination of HbBB and dark brown colour, BBBW = combination of HbAA and brown/white colour, obs = observation, BWT = Body weight, HG = Heart girth, BL = Body length, ADY = Average daily yield, TY= Total yield, IY= Initial yield, PD= Peak day, PY= Peak yield, a, b, = column means under the same factor with different superscripts differ significantly.

Table 4.32: Body conformation and lactation characteristicss of goats in Jigawa and Katsina States in relation to potassium types and coat colours combinations (mean ±s.e)

CMBS	Obs	BWT	HG	BL	ADY	TY	IY	PY	LL
HKBB	10	31.25±1.48^{ab}	72.25±1.77	58.75±2.50	237.51±7.30	32.720±5.07	263.25±20^{a}	355.00±14.57^{ab}	135.50±7.13^{a}
HKDB	125	26.84±0.04^{b}	70.19±0.05	58.25±0.07	259.58±0.20	33.39±0.34	231.11±0.28^{ab}	364.69±0.41^{a}	129.92±1.20^{ab}
HKW	9	34.67±1.97^{a}	76.00±2.36	68.00±3.33	240.37±9.78	25.71±6.76	250.00±13.33^{ab}	320.00±19.43^{ab}	105.66±8.2^{4b}
HKBW	55	29.42±0.10^{ab}	70.10±0.12	60.52±0.16	247.54±0.49	28.66±0.14	273.76±0.67^{a}	354.15±0.98^{ab}	116.33±1.85^{ab}
HKLB	12	29.40±1.18^{ab}	71.60±1.41	61.40±2.00	233.08±5.87	29.94±4.05	250.00±8.00^{ab}	343.00±11.66^{ab}	127.40±6.39^{ab}
LKDB	23	25.83±0.24^{b}	69.20±0.29	60.97±0.41	250.93±1.22	28.04±0.84	231.42±1.66^{ab}	368.00±2.42^{a}	112.58±2.91^{ab}
LKW	2	27.67±1.97^{ab}	67.33±2.36	56.33±3.33	219.24±9.70	27.45±6.76	196.67±13.33^{b}	285.00±19.43^{b}	124.00±8.24^{ab}
LKBW	14	30.41±0.49^{ab}	72.00±0.59	61.17±0.83	246.71±2.40	29.725±1.69	265.83±3.33^{a}	329.08±4.85^{ab}	119.92±4.12^{ab}

HKBB = combination of HK and brown/black colour, HKDB = combination of HK and dark brown colour, HKW = combination of HK and white colour, HKBW = combination of HK and brown/white colour, HKLB = combination of HK and light brown colour, LKDB = combination of LK and dark brown colour, LKW = combination of LK and white colour, LKBW = combination of LK and brown/white colour , obs = observation, BWT = Body weight, HG = Heart girth, BL = Body length, ADY = Average daily yield, TY= Total yield, IY= Initial yield, PD= Peak day, PY= Peak yield; a, b, = column means under the same factor with different superscripts differ significantly.

Table 4.33: Lactation characteristics of goats in Jigawa and Katsina states according to combined heamoglobin type, potassium type and coat colour (mean±s.e)

Cmb	No	ADY	TY	IY	PY	LL	LDY
AAHKW	6	240.00±20.32	22.56±15.62	230.00±31.54^{b}	305.00±40.50	94.00±9.86^{c}	106.0±4.48
AAHKDB	47	254.81±3.72	29.28±3.72	228.35±5.94^{b}	364.07±7.46	114.93±1.80^{b}	106.4±0.82
AAHKBW	31	253.36±5.77	33.94±4.43	319.60±20.65^{a}	386.00±25.79	134.00±2.80^{a}	108.52±1.27
ABHKW	4	240.00±28.85	26.97±22.19	230.00±46.06^{b}	350.00±57.52	110.00±14.02^{b}	110.00±6.37
ABHKDB	46	240.99±3.69	27.32±2.84	231.10±5.89^{b}	350.93±7.36	113.37±1.79^{b}	108.40±0.81
ABHKBW	33	245.37±5.77	31.83±4.43	277.00±9.21^{ab}	356.00±11.50	129.72±2.80^{ab}	106.44±1.27
BBHKDB	16	261.76±6.45	28.75±4.95	236.25±10.30^{b}	390.75±12.86	109.65±3.13^{b}	106.15±1.42
BBHKBW	5	238.54±12.94	31.29±9.95	268.36±9.21^{ab}	356.20±11.50	131.20±6.28^{ab}	108.40±2.85

AAHKW = COMBINATION OF HbAA, HK-type and white coat colours, AAHKDB = COMBINATION OF HbAA, HK-type and dark brown colours, AAHKBW = COMBINATION OF HbAA, HK-type and brown/white coat colours, ABHKW = COMBINATION OF HbAB, HK-type and white coat colours, ABHKDB = COMBINATION OF HbAA, HK-type and dark brown coat colours, ABHKBW = COMBINATION OF HbAB, HK-type and brown/white coat colours, BBHKDB = COMBINATION OF HbBB, HK-type and white coat colours, BBHKBW = COMBINATION OF Hb-BB, HK-type and brown/ white coat colours, cmbs = combination, BWT = Body weight, HG = Heart girth, BL = Body length, ADY = Average daily yield, TY= Total yield, IY= Initial yield, PD= Peak day, PY= Peak yield; a, b, = column means under the same factor with different superscripts differ significantly.

Table 4.34 shows the combined effect of haemoglobin, potassium and coat colour type (Hb-K-CC type) on body conformation traits. The combined effect of the Hb-K-CC on body conformation traits was significant ($P<0.05$) except HG. Goats with homozygote Hb genotypes AA and BB with high potassium (HK) and dark brown (DB) coat colour (AAHKDB and BBHKDB) were smaller in size (HW and BL) and lighter in weight (BWT), while those with homozygote Hb allele AA (HbAA) and high potassium (HK) and white coat colour (AAHKW) were heavier (BWT) and bigger in size (HW, HG, BL) than the other Hb-K-CC types.

Table 4.34: Mean values (±s.e) for body conformation traits of goats in Jigawa and Katsina states according to combined heamoglobin type, potassium type and coat colour

Combination	No.	BWT	HW	HG	BL
AAHKW	6	38.50±4.25^{a}	71.50±3.73^{a}	77.50±4.60	72.50±6.15^{a}
AAHKDB	47	27.01±0.78^{b}	59.44±0.68^{b}	70.36±0.84	55.50±1.12^{b}
AAHKBW	31	28.72±1.20^{b}	61.16±1.06^{b}	69.36±1.30	59.72±1.75^{ab}
ABHKW	4	27.00±6.03^{b}	58.00±5.30^{b}	73.00±6.54	59.00±8.74^{b}
ABHKDB	46	27.09±0.77^{b}	58.64±0.67^{b}	69.49±0.83	55.61±1.12^{b}
ABHKBW	33	30.2±1.20^{ab}	61.92±1.06^{b}	71.04±1.31	61.32±1.74^{ab}
BBHKDB	16	27.94±1.34^{b}	59.87±1.18^{b}	71.72±1.46	53.40±1.96^{b}
BBHKBW	5	34.0±2.70^{ab}	65.00±2.23^{b}	76.80±2.93	65.20±3.91^{ab}

AAHKW = COMBINATION OF HbAA, HK-type and white coat colours, AAHKDB = COMBINATION OF HbAA, HK-type and dark brown colours, AAHKBW = COMBINATION OF HbAA, HK-type and brown/white coat colours, ABHKW = COMBINATION OF HbAB, HK-type and white coat colours, ABHKDB = COMBINATION OF HbAA, HK-type and dark brown coat colours, ABHKBW = COMBINATION OF HbAB, HK-type and brown/white coat colours, BBHKDB = COMBINATION OF HbBB, HK-type and white coat colours, BBHKBW = COMBINATION OF HbBB, HK-type and brown/ white coat colours, cmbs = combination, BWT = Body weight, HW = Height at wither, HG = Heart girth, BL = Body length; a, b, = column means under the same factor with different superscripts differ significantly.

CHAPTER FIVE

5.0 DISSCUSSION

5.1 Milk yield characteristics

The average daily yield (ADY) recorded in this study 248.22g is higher than 188.22g, 135.3g and 140.6g reported by Zahradden *et al*. (2009), Makun *et al*. (2008) and Tendonkeng-Pamo *et al*. (2006), respectively, but lower than 300-600g reported by Ehoche and Buvanendran (1983), Akpa (1999), Akpa *et al*. (2002) and Greying *et al*. (2004). The observed differences in ADY are probably due to frequency of milking, the breed used as well as method of milk collection. In the present study partial morning milking was done, while in a previous study (Akpa, 1999; Akpa *et al*., 2002) does were milked twice daily and only the Red Sokoto goats were studied. Akpa *et al*. (2003) reported that once a day milking reduces milk yield by 52.7%. Holmes *et al*. (1992) similarly reported that cows milked once a day produced 35-50% less milk than those milked twice a day. In the study of Ehoche and Buvanendran (1983) oxytocin was administered to the dam before milking, which would have greatly enhanced the milk expressed from the udder. Greyling *et al.*(2004) used improved breeds of goats. It has been reported that genetic make-up and nutritive intake of different breeds of goats greatly influenced the milk yield and its composition (Mia *et al*., 1994; Eknaes *et al*., 2006). The observed total yield (TY) 29.35kg agrees with existing reports on Nigerian indigenous goat breeds (25- 40kg; Egwu *et al*., 1995). However, TY in this study was higher than those reported by Makun *et al*. (2008) in Red Sokoto and Sahalian goats, and Ethiopian Adals (Awgichew *et al*., 1991). However, it was lower than the range of 45-75kg reported by Osinowo and Abubakak (1989). The observed differences could be attributed to frequency of milking, lactation length, nutrition as well as breeds of the animals.

The observed peak day (PD) of 33.04days was within the range reported by other authors, 35 days (Akinsoyinu *et al*., 1981) in Red Sokoto, and 34.5 days (Ngere, 1985) in West African Dwarf (WAD) and 33 days (Akpa, 1999) in Red Sokoto goats. The average lactation length (118.26) days was influenced by the quantity of milk produced by the does; any animal producing less than 100 ml a day was automatically stopped from being milked. But even at that, the lactation lengths of these animals were in agreement with the reports of Osinowo and Abubakar 1989 (48-100 days); but higher than 70 days the reported by Egwu *et al*. (1995) in WAD and 80 days in Sahel goats. The low milk yield in the present study as compared to other tropical breeds could be due to the fact that these animals have not been selected for milk yield. However, the moderate variability in this study suggests that these milk yield characteristics could respond to selection and should be exploited.

The location effect on milk yield traits may be attributed to differences in the climatic conditions of these locations as well as managements in the various herds in the two locations. Waheed and Khan (2011) reported that 27-37% differences in milk yield of different herd were influenced by feeding and management.

The significant effect of parity on milk yield characteristics observed in indigenous goats have been reported by other authors (Butswat *et al*., 2002; Zahradden *et al*., 2009; Garcia *et al*., 1976; Akpa *et al*., 1999; Akpa *et al*., 2003). The observed lowest yield in the first parity and highest in the third parity are in line with previous reports on milk yield in goats (Yadav *et al*., 1983; Julio, 1991; Zeng and Escobar, 1995; Akpa *et al*., 2002).

The effect of breed in this study was significant (P□ 0.05) on ADY, TY, PY and LL; the Crosses and Red Sokoto does were superior to Kano Brown and Sahel does. The Red Sokoto goats had

been reported to have better milk production potentials than all other breeds in Nigeria (Osinowo and Abubakar, 1989; Akpa, 1999), hence the observed high milk production. Also the high performance of the crosses could be attributed to the combining ability (heterosis) of these crosses. The result of this study agrees with that of Zahraddeen *et al*. (2009), who reported significant differences in milk production of different goat breeds. The mean average daily yield (ADY) according to breeds 248.755g, 236.030g, 246.796 and 231.248g for Crosses, Sahel, Red Sokoto, and Kano Brown, respectively in the present investigation were higher than 142.5g, 150.9g and 118.7g reported by James and Osionowo (2004) and 188.28g, 207.74g, 168.63g reported by Zahraddeen *et al*. (2009) in Red Sokoto, Sahel and West African Dwarf goats, respectively.

All the characteristics for milk yield capacity in the goat population studied (except relationship between peak day (PD) and initial yield (IY)) were positively correlated. These positive correlations among milk yield characteristics suggest strong association among the traits. Therefore, selection to improve any one of these traits might lead to an improvement in the others. The interrelationships between ADY, TY, PD, PY and LL, which were positive with correlation coefficients ranging from 0.425-0.926, suggest that these traits measure the milking capacity of the goats. Positive relationships between milk yield characteristics had been reported in goats (Akpa *et al*., 2003; Merkhan and Alkass, 2011).

5.2 Udder characteristics

Udder is the main body part of a dairy animal that is related to its milk producing capacity. The variability of udder dimensions in this study implies that udder characteristics have adequate

variation to allow selection response. The measured udder characteristics of these indigenous goats were comparable to other tropical breeds like Beetal goats (Waheed and Khan, 2011).

The observed influence of parity on udder characteristics observed in this study had also been reported in goats (Akpa *et al*., 1998, Akpa, 1999, Akpa *et al.,* 2002) sheep (Fernandez *et al*., 1995, Manvrogenis *et al*., 1988) and cattle (Alphonsus, 2008). However Dag and Zulkadir (2004) observed that parity did not affect udder measurement in Awassi sheep. Amao *et al*.,(2003) observed that parity had no significant effect on udder characteristics. The observed increase of udder traits as the animal advanced in parity, apart from influence of milk yield could be related to growth. It could also be due to proportion of mammary alveoli that developed in previous lactations which did not regress completely but were added to those which developed in the subsequent lactations, thus increasing the size of the udder (Peris *et al*., 1999).

The influence breed on udder characteristics in the population of goats studied could be due to genetic make up of the different breeds. The Red Sokoto goats have been reported to have better milk production potentials than other breeds in Nigeria (Akpa, 1999; Osinowo and Abubakar, 1989). The effect of heterosis also aided milk production in the crosses. Fernandez *et al*. (1995) explained that increase in milk production leads to increase in udder size; therefore this could have led to increase in the sizes of udder in the Red Sokoto goats and the crosses. The positive (r = 0.211 – 0.653) correlations amongst udder characteristics suggest high dependency among the traits, that is, as udder height increases, udder circumference, teat length and teat circumference would correspondingly increase. Thus, it may not be necessary to incorporate all these traits in a selection index, since selection for increase in one may result in corresponding increase in the others. These favourable relationships amongst udder conformation traits had also been reported in goats (Fernandez *et al*., 1995; Akpa, 1999; Akpa *et al*., 2003), sheep (Dag and Zulkadir, 2004)

and cattle (Alphonsus, 2008). The positive correlation between udder conformation traits and milk yield characteristics (IY, ADY, PY, and LL) had been reported by Akpa, (1999) and Dag and Zulkadir (2004).

5.3 Body conformation traits

The body conformation traits measured in the present study were similar to those reported by Ibrahim (2010) for Red sokoto goats. These measurements were less variable than previous measurements on Red Sokoto goats (Ibrahim 2010, Akpa *et al*., 1998). This is probably because the previous reports by Ibrahim (2010) and Akpa *et al*. (1998) included both lactating and dry does, while the present study concentrated only on lactating does. The variability of body weight suggests possibility of improving this trait through careful selection.

The average body weight (BWT) of 28.835 kg agrees with the range of 20-40 kg reported by Osuhor *et al*., (2002) for both males and females goats, but Hassan and Ciroma (1990) gave a range of 16-30 kg for both males and females from ages 1-5 years. The average height at wither (HW) in this study (60.82 cm) is within the range reported by Hassan and Ciroma (1990) whose observation ranged between 56-67 cm. This is in line with the reports of Ibrahim (2010) in Red Sokoto goats (57.7 cm height at wither). The slight difference may be because the author worked with only Red Sokoto goats.

The body length (60.68 cm) was within the range reported by Kunwar (2000) in Hill goats, Katongole *et al*. (1996) for indigenous goats in Kenya, Semakula *et al*. (2010) for Mubende and South East African goat breed, and Abubakar (2009) in Red sokoto goats. However, Ibrahim (2010) reported a shorter body length in Red Sokoto goats. This could probably be due to the ages of the animals used in the study. In the work of Ibrahim (2010), animals from three months

to adult were used whereas in the work of Abubakar, (2009) and the present study only adult does were used. In normal animals, increase in age leads to increase in size; this may be the cause of variation in body length. The observed mean heart girth (69.83cm) in this study is within the range of 61-76 cm reported by Hassan and Ciroma (1990). The body depth (BD) of 79.042 cm in this study is within 68.17-79.76 cm range reported by Katongole *et al*. (1996) in Tswana goats.

The influence of parity on lactation characteristics observed in this study was in line with the reports of Semakula *et al*. (2010). The result showed increase in all measurements as the parity of the animal increased. This was expected since as the animal grows, size and shape are also expected to increase with age. This is in agreement with the earlier reports of Semakula *et al*. (2010), Hamayun *et al*. (2006) and Brown *et al*. (1983). The fact that skeletal measurements like height at withers and tissue measurements (circumference) like heart girth were increasing as the animal parity reflects that the studied animals could be said to have normal skeletal development and normal body condition. Reports indicate that, height at withers at any given time reflects the animal's skeletal size, and that heart girth reflects body condition (Ozoje and Mgbere, 2002; Tegbe and Olurunju, 1986; Chineke, 1996).

Effect of breed on conformation traits was only significant on body weight and heart girth. Although there was no significant difference, the body measurements of Red Sokoto and the crosses were significantly higher than that of the Sahel and Kano brown in most of the conformation traits. Most of the conformation traits in the population of goats studied were positively correlated. Therefore, selection to improve any one of these traits may lead to the improvement in the others. The inter-relationships between stature, body depth, height at wither, heart girth and body weight which were positive (0.615-0.911) suggest that these variables

measure the conformation of the goats. Positive relationships between body conformation traits had been reported (Markovic, 1997; Akpa, 2000; Khan *et al*., 2006; Abubakar, 2009; Zujovic *et al*., 2011).

The phenotypic correlation between milk yield characteristics and conformation traits in goats were low to moderate. There was significant positive correlation between initial and peak yields with all the conformation traits measured. This indicates that selection for these conformation traits will also lead to improvement in these milk yield characteristics. The relationship between body conformation traits and peak day was negative; this indicates that as body conformation traits increase the PD will be earlier, and if persistency is maintained could lead to a higher TY. The results of this study is very close to the findings of Iloeje and Van Vleck (1978) and Zujovic *et al*.(2011).

5.4 Eletrophoretic haemoglobin pattern

In the present study, three haemoglobin genotypes were observed (HbAA, HbAB and HbBB). The presence of these three haemoglobin genotypes is in agreement with the findings of other authors (Salako, 2002; Hrinca, 2010; Bindu and Raghaven, 2010). However, this report is contrary to the reports of Ibrahim (2010) and Johnson *et al*. (2002), who reported the presence of four haemoglobin types (HbAA, HbAB, HbBB and HbAC) in Red Sokoto goats. The absence of HbAC in the present study could be due to the facts that only adult does that were lactating were used in the work. HbAC have been reported to be found mostly in young (pre-adult) animals before maturity known as foetal haemoglobin types (Das *et al*., 2004; Salako *et al*., 2007). There

are also reports that HbAC is always associated with incidence of anemia due to illness and environmental stress (Huisman *et al*., 1969; Salako *et al*., 2007).

5.5 Haemoglobin types, gene and gene frequencies

The distributions of the haemoglobin alleles in the two locations were similar. The gene frequency of Hb A alleles was higher in both Katsina (0.615) and Jigawa (0.656) than the Hb B alleles 0.385 and 0.344, respectively. The similarity in the distribution pattern of the Hb-type in the two locations is probably due to similarity in topography and climatic condition, the altitude of Katsina and Jigawa are 464m and 400-600m, respectively.

The gene frequencies in this study were 0.683 for haemoglobin A and 0.316 for haemoglobin B. This was very close to the previous reports (Ibrahim, 2010; Akpa *et al*., 2011) who reported gene frequencies of 0.60 for haemoglobin A and 0.40 for haemoglobin B, in Red Sokoto goats. The result of this study was similar to the reports of Abdussamad *et al*. (2004); Alphonsus *et al*. (2011) in cattle and Evans *et al*. (1957) in sheep. Evans *et al*. (1957) reported a higher frequency of HbA (0.61) in Scottish Black Face sheep. This was in contrast to the gene frequencies of 0.349 and 0.561 for haemoglobin A and B, respectively in cross bred ewes reported by Dally *et al*. (1980). The observed genotypic frequencies of HbAA, HbAB and HbBB in the population of goats studied were 0.47, 0.43 and 0.099 respectively. The high frequencies of Hb AA and AB in the population of goats studied suggest that the genotypes are favoured by natural selection in the study area (Katsina and Jigawa states). Evans and Warren (1958), explained that HbA genes are favoured in environment with high altitudes, while HbB are favoured by lower altitudes. The population sampled in this study came from high altitude of Katsina (1525ft) and Jigawa (1387ft)

above sea level. This may explain the higher frequency of HbA than HbB. Salako *et al*.(2007) reported higher frequency of HbB than HbA in their study, they sampled animals from a lower altitude (Ibadan is -780ft above sea level; Falling Rain Genomics Inc. 1996-2006). Das *et al*., (2004) also reported a higher frequency of HbB in Kolkata, West Bengal India (altitude 42ft).

The distribution of haemoglobin genotypes AA, AB and BB observed in this study differs when compared with the findings of other authors. The HbAB genotype was just slightly higher than HbAA (44.80 and 43.20 respectively) to be the most frequently occurring genotype in the population of goats studied, while HbBB genotype was 12%. This finding is contrary to report of Ibrahim (2010) that 58.2%, 30.5% and 10.3% for HbAB, HbAA and HbBB, respectively in Red Sokoto goats. This report is also contrary to the reports of Das *et al*., (2004) and Hrinca (2010) that greater population of HbBB genotypes in Garole sheep (97.3%) and Carpathian goats (52.36%), respectively. Hrinca (2010) explained that, the polymorphism degree of haemoglobin system of goat breed is defined by the number of alleles, the ratio between them, the interallelic combinatory capacity, the number of genotypes expressed, their distributions, the grouping mode, variability ranges and dispersion degree. Elisa *et al*. (2010) stated that expression of these Hb-types are related to the suitability of the animal under particular environmental conditions. The results of the present study suggest that the low frequency of the HbBB genotype might be a form of some adaptive superiority of HbAA and HbAB over HbBB. Evans and Warren (1957) reported that HbA has selective advantage in sheep at higher altitudes because it constitutes the most common allele in highland breeds of English and Scottish sheep. Hrinca (2010) explains that extreme temperature (acute cold or sultry heats), the extreme forms of relief (dessert or mountain) and precarious nutrition conditions favour the fixing of the allele HbA, and the temperature situated in the biological comfort zone, the moderate forms of relief (forest steppe,

hill, etc) or the optimal breeding technologies are correlated with a more emphasized fixing of the allele HbB. The present study was done in the northwest of Nigeria where the temperature could be as high as 38-45^{o}C. This high temperature could probably favour the fixing of HbA over HbB. Salako *et al*. (2007) reported that Red Sokoto goats sample in the South West of Nigeria (Rain forest zone) had a higher frequency of HbB than HbA, suggesting that they best fit in that zone where the temperature is not so high.

The Chi-square test revealed non- significant differences between the observed and expected frequencies of haemoglobin and alleles, therefore the population as a whole was in Hardy Weinberg equilibrium. This suggests that there was no significant change in the gene frequencies.

5.6 Potassium types, gene and genotypic frequencies

The results indicated that genotypic frequencies were 0.91 for high potassium (HK) and 0.01 for low potassium (LK) types of animals in the population. The gene frequencies were 0.844 for HK and 0.156 for LK. This finding is in agreement with the reports of Cobanoglu *et al*. (2011) that reported allele frequencies 0.80 and 0.20; 0.85 and 0.15; 0.87 and 0.13 for HK and LK respectively in Saanen, Maltase and Turkish Hair goats, respectively in Turkey. Although LK type of potassium is dominant to its counterpart HK genetically (Khattab *et al*., 1964; Al-Samarrae and Younis, 2011), the majority of the animals were observed as HK type in the goat population studied. Khattab *et al*. (1964) reported that there was an excess of high potassium types amongst carriers of haemoglobin A genes. They went further to explain that sheep with HbA had significantly more potassium in their blood than those possessing either HbB or HbAB.

This suggests that HbA is strongly associated with HK; the fact that gene frequency for Hb allele A in the population studied was 0.683 could explain the reason for the observed high frequency of HK than LK type in the population of goats studied. This situation could also suggest that HK-type animals might naturally have selective advantage in the studied area. It had been observed (Shahrbabak *et al*., 2009) that HK allele is predominant in dry region with harsh temperature while LK allele pre-dominates region with normal and humid climate.

5.7 Haemoglobin and potassium polymorphism and their effects on milk yield characteristics in goats

The results showed that only average daily yield (ADY) and peak yield (PY) were significantly ($P<0.05$) influenced by Hb types. However, potassium type had no significant ($P>0.05$) effect on all the milk yield characteristics measured. The observed variation in milk yield characteristics (ADY and PY) with Hb-type had earlier been reported in other species. Samarineanu *et al.* (1982) and Gootwine (1988) in cow and ewe, respectively observed that HbAB was superior to both HbAA and HbBB in milk yield. However, Essien (2011) observed that cows with HbAA were superior to HbAB and HbBB in some milk yield characteristics in cows studied in Zaria. On the contrary, Dally *et al*. (1980) reported that there were no differences in the milk production of ewes with different haemoglobin genotypes. The variation in the performance of the animals due to differences in Hb-types suggests that different Hb-types may have selective advantage in different geographical region (Ndamukong, 1995). Therefore, haemoglobin, which is one of the simplest genetic markers can be explored to help in improving the dairy performance of the indigenous goat breed by identifying the Hb-type that is more adaptive to a particular environment and has a comparative advantage in milk yield characteristics. The observation in this study suggests that in the study area, Jigawa and Katsina

states indigenous goats with HbAA and HbAB have high potential for milk yield than those with HbBB.

The observed non-significant influence of potassium types with milk yield characteristics in this study is contrary to the reports of Gunes *et al*. (2008) on the significant influence of potassium type on total milk yield of Awassi sheep, with LK being superior to HK. Limited literature is available on the influence of potassium types and milk yield characteristics in small ruminants. Shahrbabak *et al.* (2010) explained that HK alleles are predominant in dry climatic areas with high temperature while LK alleles are favoured in humid zones, the study area is a dry area, suggesting that K-alleles is more of adaptive trait.

5.8 Haemoglobin and potassium polymorphism and blood biochemical profile in gaots

In the present study, Hb type only influenced packed cell volume (PCV) and haemoglobin concentration, animals with HbAA being superior to the other haemoglobin types. Carriers of haemoglobin AA genotype have been reported to have better functional properties such as affinity for oxygen, higher haemoglobin concentration and packed cell volume (FAO, 1988; Akinyemi and Salako, 2010)

The effect of potassium types significantly influenced only Na concentration. It had been observed that HK animals had less concentration of Na than LK (Galip and Elmaci, 2001). This observation is in agreement with the reports of Gurcan *et al*. (2010) that noted significant difference in the mean Na concentration of HK and LK, which they observed to be 174 and 150 mmol/l for LK and HK, respectively. This variation could be attributed to Na – K pump sites per unit cell membrane surface. Sharbabak *et al*. (2009) explained that HK type animals had low number of Na – K pump sites which lead to a lower concentration of Na in the cell while LK

type animals have a higher number of Na – K pump sites, hence the increase in Na concentration of these animals.

5.9 Blood biochemical profiles in goats

All the blood biochemical constituents measured were within the range of normal values of serum electrolytes of goats as reported by (Boyd, 1984; Rodostis *et al*., 2000; RAR, 2011). The percentage of PCV (28.47%) in this study was similar to the 29.4% obtained by Daramola *et al*. (2005) in WAD goats. However, this is higher than 25.7% obtained in Red Sokoto goats (Tambuwal *et al*., 2002). Earlier reports in Baladi goats (Azab and Abdel – Maksoud 1999) show ed PCV values of 27.25%. The HB concentration in this study (9.49g/dl) was within the range of normal values obtained in Red Sokoto goats (7-15g/dl) (Tambuwal *et al*., 2002 and Daramola *et al*., 200*5).* This is an advantage in terms of oxygen carrying capacity of the blood, which may lead to better functioning and performance of these animals.

The Na concentration obtained in this study (136.40mmol/L) is within the range reported by Daramola *et al*. (2005) as 135.1 mmol/l of Na in WAD goats. Tambuwal *et al*., (2002) reported 138.0 mmol/l in Red Sokoto goats. Sodium makes up about 93% of the basic mineral elements in the blood serum and is chief cation regulating blood pH (Swartz, 2010). The ability of muscles to contract is dependent on proper sodium concentration. Therefore, these indigenous goats could be said to have normal sodium concentration in the blood. Total protein in this study (64.44g/l) was within the range reported by Tambuwal *et al*. (2002), in Red Sokoto goats and Oduye and Adadevoh (1976) reported same in WAD sheep. Albumin concentration in this study (33.12g/L) was within the range reported by other authors (25 – 34g/l), (Oduye and Adadevoh 1976;

Tambuwal *et al*., 2002; Daramola *et al*., 2005). Proteins are the basic components of enzymes, many hormones, antibodies and clotting agents. They act as transport substances for hormones, vitamins, minerals, lipids and other materials. In addition, proteins help balance the osmotic pressure of the blood and tissue (Kaslow, 2011). Total protein in the blood which represents the sum of albumin and globulin is a very strong indicator of the health status of the animals; low albumin is a sign of poor health.

The glucose concentration of 4.44 g/l determined in this study is higher than those detected by Jovanovic *et al*. (1998) 2.3mmol/L and McDongall *et al*. (1991) 3.9mmol/L. Zubcic (2001) established that glucose level decreases with age of goats, and most of the animals in this study were between ages 2 – 6 years which probably explains the high concentration of glucose. Glucose is the major precursor of lactose synthesis in the mammary gland, and lactose is the major carbohydrate and osmolyte of milk which controls milk volume and its concentration (Shahbazkial *et al*., 2010).

Generally there were low correlations between blood biochemical profiles and milk yield. However, ADY, TY and IY had significant correlation with PCV. Similarly, Hb concentration was correlated with ADY; Total protein with IY and LL, as well as glucose with and LL. The correlation between glucose and LL could be attributed to the fact that lactose which is the major precursor of glucose controls milk volume (Shahbazkial *et al*., 2009). The negative and very low correlation between milk yield characteristics and albumin had earlier been observed by Hassan *et al*., (1986) in Egyptian Baladi goats. There were weak correlations among the blood constituents, however, PCV showed a positive and significant correlation with HB. This explains that increase in PCV led to increase in Hb concentration.

5.10 Polymorphic genes as suitable genetic markers

Haemoglobins had been identified as one of the important blood protein, some authors even tag it "evergreen red protein" (Bettati *et al*., 2009) because of the role it plays in transporting oxygen to all parts of the body. Potassium on the other hand is the principal intracellular ion responsible for osmotic regulation in most body tissues. Researches on Hb and K polymorphic nature have been widely reported. Haemoglobin and potassium polymorphism can only be determined through laboratory test. Coat colour which have been reported to be associated with productivity in animal (Becerril *et al*., 1994), can be identify visually without any cost. There is limited information on combined effect of haemoglobin and potassium types and coat colour variation on production traits in literature. However, Al-Saamarrae and Younis (2011) reported that ewes with HbB and HK phenotype had significantly higher lambing percentage and fleece weight and ewes with HbB and LK phenotypes had significantly more female lambs, higher weaning and birth weight compared with HbB-HK types. In a study by Watson and Khattab (1964) only few associations depended on haemoglobin and potassium types. Animals with LK showed marginally better growth than HK phenotypes, while animals possessing HbA had greater fleece weights than others.

In the present study, generally animals of HK phenotypes performed better than LK phenotypes in milk yield and conformation characteristics. Animals with HK phenotypes possessing either heterozygous haemoglobin HbAB or homozygous HbBB were identified as best for body size and milk production (meat and dairy) combined. Animals with homozygous haemoglobin HbAA and HK (AA-HK) phenotype favoured body size alone. When coat colour was combined with

haemoglobin and potassium type to test their combined effect on milk yield and conformation traits, only few of the combinations reached significance at generally accepted levels of probability. Animals with Hb allele AA(HbAA), high potassium (HK) and white coat colour (AAHKW) were heavier in bodyweight and bigger in size (HW, HG,BL) than other Hb-K-CC types. Adu and Ngere, (1979) documented that the Sahel goats are largest in size within the Nigerian breeds of goats, and the white coat colour in the present study were the Sahel goats. Evans and Warren (1958) as mentioned earlier reported that Hb allele A are favoured by geographical location of high altitude. Hrinca (2010) also reported that HbAA are also favoured at location with harsh weather condition. Potassium allele HK have been reported to fit most in environment with high temperature (Gurcan *et al*., 2010). All these description fit the geographical location in which this study was carried out, and could have contributed to AAHKW superior performance in body conformation and being intermediate in milk yield.

The combined effect of Hb-K-CC on milk yield traits indicated that brown white (BW) goats with HK irrespective of their Hb-types performed slightly better than other Hb-k-CC types, but had significantly higher TY and LL. Mba *et al*. (1980) explained that the lactation milk yield (total milk yield) for a particular lactation determines the productivity of the animal. And the total yield is determined by the average daily yield and lactation length of the animal. In the present study AAHKBW animals had the highest record for total yield though not significant, and their lactation length was longer than ABHKBW and BBHKBW. The brown white (BW) goats are possible crossbreds between Red Sokoto goats and the Sahel goats. Akpa (1999) indicated that the Red Sokoto goats are most efficient in terms of milk production among the Nigerian breeds. Adu and Ngere (1979) further reported that the Sahel goats were intermediate or moderate in terms of milk production. Therefore, heterosis resulting from this crossbreeding

probably enhanced the performance of the brown white (BW) animals in terms of milk yield. Mukundan *et al*. (1983) and Awgichew *et al*. (1991) explained that crossbred animals tend to give more milk than the purebreds. The inclusion of the coat color in the analysis was to encourage the rural farmer who may not have the resources and facilities to carry out any laboratory test, to know which colour to select in terms of meat or dairy production. Selection of animals for milk and conformation traits based on combination of polymorphic genes and coat color (Hb-K-CC) would reduce the time and resources spent on keeping inferior animals in the stock to take records, as these polymorphic genes and coat colour types can be identified early age in life.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

This research was conducted at Jigawa and Katsina States for a period of one year**.** Lactation characteristics of 250 small-holder agropastoral goats were evaluated. The data collected included milk yield, udder characteristics, body conformation traits, blood metabolites profile, haemoglobin and potassium gene and genotypic frequencies. The suitability of using these polymorphic genes and coat colour variations as markers for milk yield was also determined. The effects of location, parity and breed on milk yield, udder and conformation traits were also evaluated. The correlation coefficients between lactating characteristics with udder and body conformation traits were also evaluated. The data obtained in this work were analysed using General Linear Model of SAS.

The average milk yield characteristics in this study were 29.56kg, 248.22g, 243.57g, 33.04 days, 358.72g, and 118.25 days, for total yield, average daily yield, initial yield, peak day, peak yield, lactation length and last test day yield, respectively. Udder characteristics in the population of goats studied were 12.8cm, 31.86cm, 8.76cm, 3.52cm and 5.00cm for udder height, udder circumference, distance between teat, teat length and teat circumference, respectively. Variability in udder characteristics were low to moderate. The parity and breed of the doe, all influenced udder traits significantly.

The body conformation traits of indigenous goats were 28.83kg, 65.42, 79.04, 60.82, 69.80 and 60.68cm for bodyweight, stature, body depth, height at withers, heart girth and body length, respectively. The conformation traits of the population of goats studied showed low variability. Factors affecting body conformation traits were location, age, parity, coat colours and breed.

Blood biochemical profiles of the indigenous goats were 28.47%, 9.49g/dl, 136.40mmol/l, 64.44g/l, 33.12g/l and 4.44g/l for PCV, HB, Na, total protein, albumin, globulin and glucose, respectively. The phenotypic correlation amongst milk yield characteristics (ADY, TY, IY, PD, PY, LL and LDY) were positive and ranged from low to high (r =0.005 - 0.926). The coefficient of phenotypic correlation amongst udder characteristics (UH, UC, DT, TL and TC) were positive and significant (r = 0.211 – 0.653); their phenotypic correlation with milk yield characteristics were positive and range from moderate to high (r =0.214-0.559), the relationships between UH and UC with ADY, TY, IY and PY were high. However, the relationship between all udder characteristics and peak day were mostly negative (r = 0.007 to -0.007). The coefficients of phenotypic correlation among blood constituents (PCV, HB, Na, total protein, albumin, globulin and glucose) were mostly negative, only few were significantly positive (between PCV and HB, total protein with albumin and globulin). Their relationships with milk yield characteristics were low and mostly negative. However, the relationships between PCV and HB with ADY and TY were significantly positive, but moderate. The relationship between total protein and glucose with LL was positive and range from moderate to high (r = 0.346 – 0.720). The coefficient of phenotypic correlation among body conformation traits (BWT, ST, BD, HW, HG and BL) were highly significant (r = 0.563 – 0.911), their relationships with milk yield characteristics (ADY, TY, IY and PY) were moderate to high (r = 0.201 – 0.407).

Two haemoglobin alleles were identified, HbA and HbB, with three genotypes HbAA, HbAB and HbBB. The gene frequencies were 0.683 and 0.316 for haemoglobin A and B, respectively; while the genotypic frequencies were 0.467, 0.431 and 0.099 for haemoglobin genotype AA, AB and BB, respectively. The gene frequencies of potassium types were 0.84 and 0.16 for HK and LK, respectively. There was significant influence of haemoglobin types on some milk yield

characteristics (ADY and PY), HbAA and HbAB had higher milk yield. Haemoglobin types significantly influenced PCV and HB among the blood constituents measured, does with HbAA recorded higher values of PCV and HB.Potassium types had no influence on milk yield characteristics measured, but only significantly (P□0.05) influenced Na concentration in the blood. The combined effect of haemoglobin types, potassium types and coat colour on milk yield and conformation traits showed that does with HbAA, HK and brown/white (AAHKBW) recorded the highest values in terms of milk yield characteristics, while does with HbAA, HK and white coat colour (AAHKW) recorded the highest values in terms of conformation traits.

6.2 CONCLUSION

- Milk yield and udder characteristics in the population studied showed moderate variations in which improvement can be made; blood biochemical profiles were within the range of normal reference values for goats (28.47% PCV, 9.49g/dl HB, 136.40mmol/L Na, 64.44g/l Total protein, 31.12 g/l Albumin, 33.12 g/l globulin and 4.44 g/l glucose).
- Parity and breel affected udder and milk yield characteristics significantly indicating that these factors are important in selecting or culling goats for milk yield characteristics.
- The moderate to high relationship between UH, UC, TL and TC with ADY, TY, IY and PY suggests that these traits can be used as indirect selection criteria for milk yield characteristics in goats.
- There was high preponderance of allele HbA and HK than HbB and LK in the study area, suggesting that these alleles are favoured by natural selection in North West zone of Nigeria.
- The non significant variation of most milk yield characteristics with haemoglobin and potassium genotypes suggests that haemoglobin and potassium genotypes are more of adaptive traits than productive traits.
- The combination of haemoglobin genotype AA, HK and brown/white coat colour (AAHKBW) performed best in terms of milk yield, while haemoglobin genotype AA, HK and white coat colour (AAHKW) were superior in terms of body conformation traits, suggesting that these polymorphic genes and coat colour can be used as indirect selection criteria for milk yield and body conformation characteristics.

6.3 RECOMMENDATIONS

- The moderate variability of milk yield characteristics in goats should be explored for possible improvement of these characteristics.
- The parity and breed should be considered in selection programmes aimed at improving udder and milk yield characteristics in goats.
- The moderate relationship between morphological udder and body conformation traits with milk yield characteristics should be explored as indirect selection criteria for milk yield characteristics in goats.
- Haemoglobin genotypes AA or AB should be taken into consideration in selection programmes aim at improving milk yield characteristics in goats within North west Nigeria.

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Appendix 1

ANOVA for effect of haemoglobin and potassium genotype on lactation characteristics

Dependent Variable: ADY ADY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	12696.1421	4232.0474	5.18	0.0017
Error	246	200896.5036	816.6525		
Corrected Total	249	213592.6458			

R-Square	Coeff Var	Root MSE	ADY Mean
0.059441	11.51272	28.57713	248.2222

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	12637.95223	6318.97612	7.74	0.0006
K- type	1	58.18991	58.18991	0.07	0.7897

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-type	2	12647.28466	6323.64233	7.74	0.0005
K-type	1	58.18991	58.18991	0.07	0.7897

Dependent Variable: TY TY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	32637010	10879003	0.28	0.8391
Error	246	9523063137	38711639		
Corrected Total	249	9555700147			

R-Square	Coeff Var	Root MSE	TY Mean
0.003415	21.04696	6221.868	29561.83

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	27565249.43	13782624.71	0.36	0.7008
K- type	1	5071760.49	5071760.49	0.13	0.7177

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-type	2	28091369.35	14045684.67	0.36	0.6961
K- type	1	5071760.49	5071760.49	0.13	0.7177

Dependent Variable: IY IY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1721.0731	573.6910	0.23	0.8730
Error	246	604493.9829	2457.2926		
Corrected Total	249	606215.0560			

R-Square	Coeff Var	Root MSE	IY Mean
0.002839	20.35138	49.57109	243.5760

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	940.8255767	470.4127884	0.19	0.8259
K- type	1	780.2475691	780.2475691	0.32	0.5736

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb- type	2	889.3094049	444.6547024	0.18	0.8346
K-type	1	780.2475691	780.2475691	0.32	0.5736

Dependent Variable: PD PD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	85.13106	28.37702	0.58	0.6263
Error	246	11961.38494	48.62352		
Corrected Total	249	12046.51600			

R-Square	Coeff Var	Root MSE	PD Mean
0.007067	21.10234	6.973056	33.04400

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hbn	2	82.96414815	41.48207407	0.85	0.4273
potass	1	2.16691192	2.16691192	0.04	0.8330

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hbn	2	82.26313395	41.13156698	0.85	0.4304
potass	1	2.16691192	2.16691192	0.04	0.8330

Dependent Variable: PY PY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Model	3	36127.5012	12042.5004	3.58	0.0145
Error	246	827564.0028	3364.0813		
Corrected Total	249	863691.5040			

R-Square	Coeff Var	Root MSE	PY Mean
0.041829	16.16843	58.00070	358.7280

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	32607.25102	16303.62551	4.85	0.0086
K- type	1	3520.25019	3520.25019	1.05	0.3073

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-type	2	32311.91944	16155.95972	4.80	0.0090
K- type	1	3520.25019	3520.25019	1.05	0.3073

Dependent Variable: LL LL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	905.13050	301.71017	1.13	0.3389
Error	246	65888.48550	267.83937		

Corrected Total	249	66793.61600

R-Square	Coeff Var	Root MSE	LL Mean
0.013551	13.83930	16.36580	118.2560

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	893.8276402	446.9138201	1.67	0.1906
K- type	1	11.3028559	11.3028559	0.04	0.8374

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-type	2	898.3094895	449.1547447	1.68	0.1891
K- type	1	11.3028559	11.3028559	0.04	0.8374

Dependent Variable: LDY LDY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	56.15309	18.71770	0.46	0.7098
Error	246	9989.51091	40.60777		
Corrected Total	249	10045.66400			

R-Square	Coeff Var	Root MSE	LDY Mean
0.005590	5.972951	6.372422	106.6880

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	53.35209524	26.67604762	0.66	0.5194
K-type	1	2.80099205	2.80099205	0.07	0.7931

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hbn	2	53.01211560	26.50605780	0.65	0.5215
potass	1	2.80099205	2.80099205	0.07	0.7931

Appendix 2

ANOVA effect of haemoglobin and potassium genotype on blood biochemical profiles

Dependent Variable: PCV PCV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	441.540917	147.180306	8.03	<.0001
Error	246	4506.815083	18.320387		
Corrected Total	249	4948.356000			

R-Square	Coeff Var	Root MSE	PCV Mean
0.089230	15.03102	4.280232	28.47600

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-types	2	415.2065291	207.6032646	11.33	<.0001
K-types	1	26.3343874	26.3343874	1.44	0.2317

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-types	2	409.5779169	204.7889585	11.18	<.0001
K- types	1	26.3343874	26.3343874	1.44	0.2317

Dependent Variable: HB HB

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	51.0520897	17.0173632	7.77	<.0001
Error	246	538.8475219	2.1904371		
Corrected Total	249	589.8996116			

R-Square	Coeff Var	Root MSE	HBCONC Mean
0.086544	15.58308	1.480013	9.497560

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-types	2	48.46270443	24.23135222	11.06	<.0001
K- types	1	2.58938525	2.58938525	1.18	0.2780

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-types	2	47.85703844	23.92851922	10.92	<.0001
K-types	1	2.58938525	2.58938525	1.18	0.2780

Dependent Variable: Tprotein Tprotein

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	178.64086	59.54695	0.96	0.4116
Error	246	15237.07514	61.93933		
Corrected Total	249	15415.71600			

R-Square	Coeff Var	Root MSE	Tprotein Mean
0.011588	12.21239	7.870154	64.44400

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-types	2	158.8921905	79.4460952	1.28	0.2792
K-types	1	19.7486724	19.7486724	0.32	0.5728

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-types	2	162.1250087	81.0625044	1.31	0.2720
K-types	1	19.7486724	19.7486724	0.32	0.5728

Dependent Variable: albumine albumine

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	190.309671	63.436557	1.92	0.1267
Error	246	8124.094329	33.024774		
Corrected Total	249	8314.404000			

R-Square	Coeff Var	Root MSE	albumine Mean
0.022889	18.31799	5.746719	31.37200

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	3.4602831	1.7301415	0.05	0.9490
K-types	1	186.8493876	186.8493876	5.66	0.0181

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Hb-types	2	3.1364399	1.5682199	0.05	0.9536
K-types	1	186.8493876	186.8493876	5.66	0.0181

Dependent Variable: globulin globulin

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	505.70628	168.56876	1.86	0.1364
Error	246	22257.44972	90.47744		
Corrected Total	249	22763.15600			

R-Square	Coeff Var	Root MSE	globulin Mean
0.022216	28.71623	9.511963	33.12400

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Hb-type	2	164.0750476	82.0375238	0.91	0.4052
K- type	1	341.6312338	341.6312338	3.78	0.0531

Source	DF	Type III SS	Mean Square	F Value	Pr > F

Hb- types	2	178.1478024	89.0739012	0.98	0.3751
K-types	1	341.6312338	341.6312338	3.78	0.0531